AMERICAN COLLEGE OF OCCUPATIONAL AND ENVIRONMENTAL MEDICINE

HAND, WRIST, AND FOREARM DISORDERS GUIDELINE

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Impact

Hand, wrist, and forearm symptoms in the workforce are common problems presented to health care providers and are among the five most common causes of reported work-related health symptoms and workers' compensation claims. According to 2010 US Census data, there was an incidence rate of 67.6 upper extremity fractures per 10,000 persons.(1) In 2013, there were 345,560 work-related upper extremity disorders for an incident rate of 32.5 per 10,000 full-time workers.(2) This was the leading cause of work-related injury,(2) and it is estimated that 20% of the population in any given month will complain of at least one type of upper limb disorder.(3) In 1998, a study involving more than 10,800 participants concluded that 30.5% had a self-reported neck or limb disorder.(4) Results from another study concluded that in 2000, 5.3 out of every 1,000 workers would take an absence due to sickness because of a musculoskeletal upper limb disorder; by 2004 this number had risen to 6.3.(5) These disorders account for nearly one-third (31.4%) of the missed days of work.(2) They also account for about 7 to 8% of total lost workdays in workers' compensation and 17 to 23% of cases and claims, ranking them in the top five for financial severity.

Overview

Recommendations on assessing and treating adults with hand, wrist, and forearm disorders are presented in this clinical practice guideline. Topics include the initial assessment and diagnosis of patients with acute, subacute, and chronic hand, wrist, and forearm disorders that are potentially work-related, identification of red flags that may suggest the presence of a serious underlying medical condition, initial management, diagnostic considerations and special studies to identify clinical pathology, work-relatedness, modified duty and activity, and return to work, as well as further management considerations including delayed recovery. The majority of peer-reviewed literature categorizes acute as <1 month duration, subacute as 1 to 3 months duration, and chronic as >3 months duration. These definitions have been adopted throughout this document. Throughout the Guideline, we refer to costs in the rationale for the recommendation – costs are defined as low (<$100), moderate ($100-$500), and high (>$500).

Algorithms for patient management are included and schematize how to generally manage acute, subacute, or chronic hand, wrist, and forearm disorders. It is important to realize that there are few studies that evaluate patients with work-related hand, wrist, and forearm disorders; therefore, studies that include different populations were used to develop the recommendations. In addition, most studies that focus on pharmaceuticals, appliances, and specific devices are industry sponsored. In certain areas, this may have made little difference as the comparisons were between the medication and placebo and the results may be stark. However, in other studies, the comparison groups may have been suboptimally treated (e.g., a low-dose of ibuprofen) and produced a bias in favor of the medication or device. In addition, industry-sponsored studies have been shown to frequently have better results and lower complication rates than studies conducted by independent investigators. Readers should refer to the Low Back Disorders, Chronic Pain and Opioids guidelines for more information regarding medications, including adverse effects.

General Approach and Basic Principles

The principal recommendations for assessing and treating patients with acute, subacute, or chronic hand, wrist, or forearm symptoms are as follows:

- The initial assessment focuses on detecting indicators of potentially serious disease, termed red flags, which require urgent assessment and treatment as indicated.
- The foci for treatment of patients with hand, wrist, or forearm symptoms include optimal medical care, monitoring for complications, facilitating the healing process, assisting stay at work or early return to work in a modified or full-duty capacity, and include surgical intervention(s) when indicated.
- Relieving discomfort can frequently and most safely be accomplished by modifying activities and using either topical or systemic nonprescription analgesics.
- Encourage patients recovering from hand, wrist, or forearm problems to stay at work or consider early return to modified work as their condition permits.
- Address occupational factors where the disorder is believed to be caused by work.

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- Address nonphysical factors (e.g., psychosocial, workplace, or socioeconomic problems) in an effort to resolve delayed recovery (see Cornerstones of Disability Prevention and Management and Chronic Pain guidelines).

This Guideline addresses the following hand, wrist, and forearm disorders which may present to the health care provider.

Carpal Tunnel Syndrome

CTS is the most common and widely known of the entrapment neuropathies in which the body's peripheral nerves are compressed or traumatized,(6-11) affecting an estimated 4 to 10 million Americans.(9) Carpal tunnel syndrome (CTS) occurs when symptoms occur that are attributable to abnormal median nerve compression within the carpal tunnel – a narrow, rigid passageway of ligament and bones at the base of the hand, which houses the median nerve and flexor tendons. The median nerve supplies sensations to the palmar aspect of the thumb, index, middle and radial half of the ring finger, as well as the dorsal segment of each of those four digits from the DIP distally, but not the fifth digit, as well as innervation to some small muscles (lateral two lumbricals, opponens pollicis, abductor policis brevis and flexor pollicis brevis.) in the hand that allow the fingers and thumb to move. Often, the condition arises without apparent cause.(6, 12, 13) Patients who have open injuries, unstable fractures, wrist fractures, or acute gout attack that results in acute CTS require immediate referral to a surgeon since improvement may only be obtained through surgery. Sometimes, synovial thickening around tendons or other swelling narrow the carpal tunnel and cause the median nerve to become variously compressed or enlarged through poorly understood processes. The result may be tingling, numbness, pain, or weakness in the digits. Tingling and numbness are essential symptoms. Pain is not an essential symptom and it may indicate other conditions, but if present, may also radiate proximally.

Triangular Fibrocartilage Complex (TFCC) Tears

Triangular fibrocartilage complex (TFCC) tears are frequent wrist injuries involving the cartilaginous meniscus between the radius and ulna with symptoms often described as occurring on the ulnar side of the wrist joint. TFCC is apparently susceptible to the same anatomic, pathophysiologic, and degenerative issues as the knee menisci. Vascular supply is similarly analogous to a meniscus with radial penetration into the meniscal periphery and central avascularity(14, 15) and evidence that degeneration increases with age.(16) Since abnormalities are commonly found on MRI and/or arthrography,(17) indications for surgical interventions are somewhat unclear.

Crush Injuries and Compartment Syndrome

Crush injuries as well as compartment syndrome are usually surgical emergencies.(18, 19) Mild cases of crush injuries may be treated similar to non-specific hand, wrist, forearm pain with particular emphasis on RICE (rest, ice, compression, elevation). Not all crush wounds, especially those more extensive and prone towards swelling are sutured as additional problems may ensue from suturing including possible tissue necrosis and the intervention may help to inhibit expansion to relieve pressure.

Kienböck Disease

Kienböck disease involves changes in the lunate that eventually lead to collapse of the lunate bone, which results in progressive pain and disability. It is a controversial condition from the standpoint of work-relatedness, as it is a disease and there are no quality studies on cause.

Wrist Sprains

Wrist sprains (which are partially or totally disrupted ligaments) are a common result of occupational slips, trips, and falls. Evaluation for occult fracture should be considered especially as fracture(s) may be present in a minority of cases.

Mallet Finger

Mallet finger is a common occupational and sports injury,(20) although it may occur with minimal apparent trauma.(21) The injury involves rupture of the extensor mechanism of a digit at the distal upper extremity

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joint with or without fracture of the distal phalangeal segment. The mechanism of injury most typically involves forcefully striking the tip of the extended digit on an object including balls, or from falls.(22)

Flexor Tendon Entrapment (Tenosynovitis and Trigger Digit)

Stenosing tenosynovitis is a generally non-inflammatory condition caused by hypertrophy of the A-1 pulley with ensuing narrowing of the canal through which the digital flexors travel, with resulting symptoms of pain and snapping of the digit particularly with extension of a flexed digit.(23-28) While some cases are thought to be occupational(29) and many cases have been reportedly idiopathic, there are other less frequent reported causes and associated conditions, including diabetes mellitus, rheumatoid arthritis, CTS, Dupuytren's disease, osteoarthrosis, amyloidosis, hypothyroidism, heredity, and partial tendon laceration.(30-35) There also is evidence these may be connective tissue disorders.(36, 37) Diabetes mellitus reportedly portends a worse prognosis for glucocorticosteroid injection.(38, 39)
The disorder includes a spectrum from localized pain in the flexor compartment to triggering to locking of a digit.(40) The most common abnormality is thickening at or of the A1 pulley.(40) Less common pathophysiologic abnormalities include metacarpal-phalangeal joint abnormalities, disorders at the level of the carpal tunnel, and other pulley anomalies.(40)

Extensor Compartment Tenosynovitis (Including de Quervain's Stenosing Tenosynovitis and Intersection Syndrome)

De Quervain's stenosing tenosynovitis involves hypertrophy of the extensor retinaculum of the first extensor compartment(41) involving the abductor pollicis longus and extensor pollicis brevis tendons with signs of tenosynovial and retinacular fibrosis usually present.(41, 42) The condition may be occupational when jobs require repeated forceful gripping or sustained wrist extension. However, most cases are not likely occupational. Extensor compartment tenosynovitis, including de Quervain's tenosynovitis, is considered a comparable disorder to trigger digit with somewhat similar pathophysiology, clinical presentation, and treatment issues. De Quervain's is the most common of the extensor compartment tendinoses. Intersection syndrome with a reported prevalence of 0.37% of all patients with arm or hand pain is substantially less common(43) and is somewhat controversial regarding the actual site of entrapment of the dorsal compartment(44-46) with the principle site appearing to involve the musculotendinous junction of the first extensor compartment and the tendons of the 2nd extensor compartment.(47)

Similar clinical and pathophysiological conditions are believed to affect the flexor carpi ulnaris and flexor carpi radialis tendons at the wrist. There is a strong predisposition in women and among those in their 5th through 7th decades of life.(41, 48, 49) De Quervain's is also considered a generally non-inflammatory condition caused by hypertrophy of extensor retinaculum and parietal layer of the tenosynovium with resulting symptoms of pain on use of the affected digit. Systemic diseases are potential causes, including rheumatoid arthritis, other rheumatic disorders, diabetes mellitus, amyloidosis, heredity and anatomic variants.

Ulnar Nerve Entrapment at the Wrist (Including Guyon's Canal Syndrome and Hypothenar Hammer Syndrome)

Ulnar nerve entrapment involves delayed conduction of the ulnar nerve combined with symptoms. It has no quality evidence of work-relatedness, but theories of work-relatedness are proposed. Guyon's canal is the space in which the ulnar nerve accompanied by the ulnar artery traverses the wrist. It is anatomically defined as the proximal medial wall formed by the pisiform, the distal lateral wall formed by the hook of the hamate, the floor formed by the flexor retinaculum and transverse carpal ligament, and the roof formed by the pisohamate carpal ligament.(50) Within the canal, the nerve bifurcates into the superficial (sensory) branch, and the deep (motor) branch. The superficial branch leaves the canal and provides a branch to the Palmaris brevis, and then continues subcutaneously to provide sensation to the fifth digit and the ulnar half of the ring finger. The deep branch loops around the hook of the hamate, and innervates the abductor digiti quinti, flexor digiti quinti, lumbricales and interossei as it crosses the palm in a curvilinear direction.(51) This canal is dissimilar to the carpal canal in that the tendons and their tenosynovium do not accompany the nerve, thus most of the usual postulated causal mechanisms for carpal tunnel syndrome

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are not possible. However, use of the hypothenar area of the hand as a hammer is a postulated occupational mechanism.(52-56)

The location of the lesion affecting the ulnar nerve as it crosses through Guyon's canal and the wrist is predictive of clinical symptoms, and has resulted in several classification schemes. Much of the current literature references the classification scheme proposed by Wu, which details five locations for lesions identified in collective published case reports. Lesions proximal to the bifurcation of the ulnar nerve (Type I) will exhibit mixed motor and sensory involvement. Type II lesions involve only the superficial branch; therefore, clinical presentations are purely sensory. Type III lesions occur at the outlet of the canal and involve only the deep branch, thus they are purely motor. Type IV lesions occur involving the deep branch distal to the branch innervating the hypothenar, thus are purely motor with sparing of the hypothenar muscles. Finally, Type V lesions occur proximal to the branches innervating the first digital interosseous and abductor pollicis muscles, so that only the distal motor symptoms are involved.(51)

Guyon's canal syndrome is relatively uncommon, occurring about 20 times less frequently than ulnar lesions at the elbow.(57) Pathological lesions resulting in ulnar entrapment at the wrist reportedly are associated with concurrent compression of the median nerve in the carpal tunnel in approximately one-third of patients;(50) although there is no quality evidence that median nerve neuropathy is similarly associated with ulnar nerve involvement.

Radial Nerve Entrapment

There are no quality studies linking radial nerve entrapment with work factors, although direct, significant trauma would be a presumptive cause. Radial nerve palsies affecting the hand and wrist usually occur at points along the course of the arm and forearm, well proximal to the wrist.(58-60) Upper arm lesions are generally associated with humeral fractures and related trauma or subsequent callous formation. **Radial Tunnel Syndrome**, or posterior interosseous nerve entrapment, occurs in the proximal forearm (see Elbow Disorders Guideline). **Wartenberg's Syndrome,** or radial sensory nerve entrapment in the distal forearm, is uncommon.(60)

Compression of the radial sensory nerve has been attributed to wearing a tight wrist or forearm band, anomalous brachioradialis tendon,(61, 62) repeated wrist flexion and ulnar deviation, external compression and trauma,(60, 63, 64) or from mass or bony lesions.(65) Case studies have also hypothesized an association with de Quervain's tenosynovitis, which occurs in roughly 50% of cases diagnosed with Wartenberg Syndrome.(66)

Non-Specific Hand/Wrist/Forearm Pain

Non-specific pain is thought to be common in initial presentations in primary occupational health clinical settings, although work-relatedness is naturally unclear for condition that is not well defined.(67) The initial step is a careful history and physical examination, particularly to attempt to ascertain a specific musculoskeletal disorder.

Scaphoid Fracture

Scaphoid fractures, also known as wrist navicular fractures, are among the most common fractures of the carpal bones,(68) occurring most commonly in young males. Most are not occupational, but some clearly are work-related. The scaphoid is located at the base of the thenar eminence (thumb side), just distal to the volar wrist crease, and acts to transfer the compression loads between the hand and forearm. It also maintains normal wrist motion, carpal stability and function of the wrist flexor and extensor tendons.(69) The primary mechanism of scaphoid injury is a fall on the outstretched hand, or from axial loading with a closed fist such as grasping a steering wheel in an auto accident.(70) Scaphoid fractures are prone to non-union and avascular necrosis, particularly those involving the proximal third of the navicular, and especially if displaced. Healing problems in the proximal third have been attributed to limited blood supply that is disrupted by the fracture plane.(71) A history of fracture, as well as non-union both increase risk for development of osteoarthrosis.

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Distal Phalanx Fractures and Subungual Hematoma

Fingertip or distal phalangeal fractures are frequently cited as the most common fractures of the hand, with the tuft being the most common.(22) Fractures may or may not be occupational. There are no recent quality incidence data available for tuft fractures, but estimates are between 15 to 30% of all hand fractures are tuft fractures.(72, 73) Tuft fractures are most often usually due to a crush injury of the fingertip,(74) resulting in comminuted or transverse fractures and are a common occupational injury. Often, they are accompanied with nail bed laceration and subungual hematoma.(75, 76) Tuft fractures are generally stable and heal uneventfully because of the soft tissue support of the fibrous septae and nail plate.(77, 78) Crush fractures or avulsion fractures involving the proximal base of the distal phalanx however may also involve flexor or extensor tendons and may require surgical intervention.(78)

Mallet fracture or mallet finger is a common fracture-dislocation injury of the distal phalanx involving loss of continuity of the extensor tendon over the distal interphalangeal joint. This common hand injury results in a flexion deformity of the distal finger joint and may lead to an imbalance between flexion and extension forces more proximally in the digit.

Middle and Proximal Phalangeal and Metacarpal Fractures

Fractures of the proximal and middle phalanges represent approximately 46% of fractures of the hand and wrist.(22, 79) The more severe fractures are among the most challenging injuries that hand surgeons and therapists treat.(80) Fortunately, most are uncomplicated and are non-surgical cases.(81-83) Fractures may or may not be occupational. Physicians who encounter hand fractures must be able to properly diagnose and manage these hand fractures, as improper management may result in permanent impairment and disability from bone shortening, permanent angulation, joint and finger stiffness, and loss of hand function. Proximal phalangeal fractures particularly have a significant potential for hand impairment particularly if suboptimally managed because of the importance of this bone in longitudinal transfer of axial forces between the carpal and distal phalangeal joints,(77) and the PIP joint for digit mobility. Decisions for surgical intervention should be offered upon careful consideration balancing risk of superior radiographic reduction with higher risk of debilitating stiffness from the post-operative rehabilitative state, with confidence that non-operative therapy can be improved upon.(84)

Metacarpal fractures comprise roughly 1/3 of hand fractures, with fifth metacarpal neck fractures (sometimes called “Boxer’s fracture”) accounting for 1/3 to 1/2 of these injuries,(79, 85) and fractures of the thumb constituting another 25%.(86) They occur most commonly from a direct blow to the bone causing transverse shaft fracture or through an axial loading blow such as striking an object with a closed fist. Isolated fractures of the third and fourth metacarpals are uncommon and usually involve one or more the neighboring metacarpals.

Fracture type and displacement can be partially predicted by the underlying anatomic structures of the affected digit. Fractures of the proximal phalanx, which has no tendinous attachments, typically result in volar angulation. In contrast, the middle phalanx has insertions of the flexor digitorum superficialis along the volar surface, such that fractures at the base and shaft usually have a dorsal angulation because of the action of the flexor tendons, whereas fractures of the distal neck will usually have a volar angulation as the flexors act to pull the distal fragment.(87) Fifth metacarpal fractures usually displace at a volar angle because of the action of the interosseous muscles.(88) Other metacarpal fractures tend to angulate dorsally owing to the unbalanced pull of the interosseous muscles and extrinsic finger flexors on the distal fragment.(89)

Distal Forearm Fractures

Fractures of the distal forearm make up a significant proportion of injuries and fractures treated in the emergency room,(90) although no quality data regarding incidence or injury type in the workplace were found. Fractures may or may not be occupational, but most distal forearm fractures are not work-related. There are several types of distal forearm fractures in adults, the most common being Colles’ fracture, named after the surgeon and anatomist Dr. Abraham Colles who described it in 1814.(91, 92) Because it is the most common, the eponym Colles’ fracture is often mistakenly used as a generic reference term for

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all forearm or wrist fractures in adult populations. However, Colles' fracture specifically refers to a transverse fracture of the distal radial metaphysis, with or without extension into and disruption of the radiocarpal or radioulnar articular surfaces. ***The distinguishing feature for Colles' fracture is that fracture fragments are displaced or angulated dorsally on a lateral view x-ray***. Other adult distal radial fractures include displaced fracture fragments that have an anterior angulation and displaced fracture fragments that are displaced palmarly and may have an anterior angulation. A fracture of the distal radius with carpal displacement can be dorsal or palmar displaced, the latter being more common. That type of fracture is caused by a fall on an extended and pronated wrist increasing carpal compression force on the dorsal rim. Some fractures are limited to the radial styloid and some are frequently associated with fracture of the ulnar styloid,(91, 93, 94) as well as a high incidence of triangular fibrocartilage complex (TFCC) disruption.(95) In one report of 118 distal fracture cases, TFCC tears occurred in 53% of extra-articular distal radius fractures and 35% of intra-articular fractures.(96) Failure to recognize a torn TFCC may result in inadequate immobilization or surgical repair, resulting in distal radioulnar joint instability. Despite the severity of these injuries, with proper diagnosis and management most patients will have a satisfactory outcome.(97)

Distal radial fractures are the result of traumatic forces, most commonly related to falling on the outstretched hand. The typical mechanism for Colles' fracture is breaking the fall with the hand outstretched and wrist in dorsiflexion, although a minority occur due to an impact on the dorsal aspect of the hand while the wrist is flexed (jam injury into the dorsum of hand) or a direct blow to the radial stylus.(91, 93, 94) In modern times, this injury more often results from a fall with the hand in ulnar deviation and midway between pronation and supination, or as a result of other force that is transferred axially from the scaphoid into the radial facet. Distal radial fractures are up to 6 times more common in women, with incidence of 7.3 vs. 1.7 per 1,000 human years.(98) In addition, people who walk regularly, which increases exposure to falling, have an associated higher incidence of fractures. Osteoporosis and low bone-mineral density is also an associated risk factor for fracture,(99) and likely explains much of higher incidence of fracture in women. A large population longitudinal study of osteoporosis has shown elderly women with high risk factors such as diabetes mellitus, cognitive impairment, and history of falls are at high risk for fall and distal forearm fracture, and should be considered for selective preventive strategies to reduce the incidence of these fractures.(100)

The triangular fibrocartilage complex (TFCC) plays a somewhat analogous role in the wrist to the meniscus and collateral ligaments in the knee. It is formed by a network of ligaments and articular cartilage originating on the medial border of the distal radius with insertion into the base of the ulnar styloid, and includes a meniscus at the distal radioulnar joint (DRUJ). The TFCC plays an important role in load bearing across the wrist as well as in DRUJ stabilization,(101) and in allowing for pronation and supination of the hand.(102)

Fracture Classification and Diagnostic Criteria

Several classification systems for distal radial fractures have been developed in an effort to evaluate treatment outcomes. However, studies of interobserver reliability and intraobserver reproducibility for the better-known classification systems (such as Frykman, Melone, Mayo, AO, and Fernandez) have demonstrated unsatisfactory reliability and reproducibility.(103, 104) Therefore, the key to recommending a treatment course is to determine the following criteria: is a fracture open or closed, stable or unstable, or likely to become unstable. Treatment can then be provided based on these criteria until better information is available to compare outcomes using a classification system that is reliable and reproducible.

In describing or in considering a specific treatment course of distal radial fractures, it may be more useful to determine the stability of fracture patterns according to radiological measurements rather than a specific classification system.(105) Stable fractures are most often defined as dorsal angulation of less than 10°, radial shortening of 2mm maximum, and no radial shift.(106) Fractures outside of these limits generally require reduction, with larger angulation, articulation step-offs, dorsal comminution, and lateral shift of more than 2mm considered contributory factors for fracture instability and indication for more aggressive therapies.(107, 108) Despite the importance placed on these criteria, not surprisingly there are conflicting

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opinions regarding the reliability of these measurements, which provides reduced confidence that these are absolute criteria, and leads to some uncertainty regarding measurements used in comparison studies as well as in general practice.(109-112)

Ganglion Cyst

Ganglion cysts occur in nearly any joint of the hand and wrist and have an estimated prevalence rate of 14%,(113) although prevalence rates based on MRIs are approximately 50%, with asymptomatic ganglia more likely to be volar (palmar) than dorsal.(114) Symptomatic onset is a common work-related claim, but quality studies linking ganglia with work continue to be lacking. Wrist ganglia account for 50 to 70% of all wrist masses identified.(115) Other causes include giant cell tumors also known as localized nodular tenosynovitis and fibrous xanthoma, epidermal inclusion cysts and fibromas. Wrist ganglia are generally classified as either dorsal or palmar, with dorsal ganglia comprising up to 80% and volar ganglia making up approximately 20% of clinically detected ganglia.(116) Approximately 10% of all hand and wrist ganglia are found on a flexor tendon sheath of the fingers.(117)

A ganglion is a cystic structure, although is not technically a cyst as it has no synovial lining.(118) Electron microscopy shows the walls to be composed of randomly oriented collagen fibers. The gelatinous cystic fluid is likened to synovial fluid, although the composition of hyaluronic acid, glucosamine, globulins, and albumin is not the same.(118)

The pathogenesis of ganglia is unknown and the epidemiology sparse. Contributing factors are also unknown. There are several theories of origin, although each has significant weaknesses and none have been proven. These include the cyst being formed: 1) as a simple herniation of the joint capsule; 2) as a result of an inflammatory process from overuse; 3) as a tear in the joint capsule with subsequent release of synovial fluid and subsequent reaction to the mucinous fluid; 4) as a result of mucoid degeneration of adjacent extra-articular connective tissue; and 5) from joint stress causing mucin secretion by mesenchymal cells in surrounding tissue.(118-121) Each of these theories fails to wholly explain all of the known facts, particularly because there seems to be no inflammatory process.

Most wrist ganglia are asymptomatic. Many patient visits are primarily for aesthetic reasons. A cross sectional study of asymptomatic volunteers who underwent wrist MRI revealed a ganglion prevalence rate of 51%.(114) A symptomatic ganglia were more likely to be volar (palmar) than dorsal.(114)

Hand Arm Vibration Syndrome

The term “hand arm vibration syndrome (HAVS)” has been used since the 1980s to describe the constellation of adverse physiological responses causally associated with high-amplitude vibratory forces, such as those experienced through the use of various hand tools including pneumatic drills, riveters and chain saws(122-124) or from vibratory rich activities such as driving off-road vehicles.(125) Other terms commonly used to describe these responses include Raynaud’s phenomenon of occupational origin, white fingers, dead fingers, traumatic vasospastic disease (TVD), and “vibration-induced white finger.”(126)

The adverse effects of HAVS are characterized by circulatory disturbances associated with digital arteriole sclerosis and manifest as vasospasm with local finger blanching; sensory and motor disturbances manifest as numbness, loss of finger coordination and dexterity, clumsiness and inability to perform intricate tasks; and musculoskeletal disturbances manifest as swelling of the fingers, bone cysts and vacuoles.(127, 128) There are also several reports of association of CTS with HAVS and exposure to vibration.(127, 129-132)

Epidemiologic evidence indicates there is a latency period of from 1 to 16 years of exposure before onset of HAVS, with a trend for decreasing prevalence as changes in work-practice and anti-vibratory tools and dampening actions have been implemented.(133) The direct pathophysiological basis for the observed vascular responses of HAVS is not known, but several theories are proposed including vibration causing direct trauma to smooth muscle and smooth muscle vacuoles,(134) vascular spasm related to activation of alpha-2 adrenoreceptor in the vessel walls,(135) or the release of a potent vasoconstrictor known as salivary endothelin.(136) The pathophysiology of neurologic deficits is also unknown, but presumably is related to vibration induced microvascular changes and demylelination.(133)

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The pathophysiologic changes related to vibration are initially reversible, but with increasing duration and intensity of exposure, the disorder may continue to progress or become permanent.(137) According to the International Organization for Standardization, the risk for developing HAVS is proportional to the total vibration energy measured in magnitude, duration, and frequency.(138) The range of vibration frequencies thought to be harmful is 4Hz to 5000Hz(127, 139, 140) dependent on the intensity, and whether or not it is oscillatory or impact force, with impact vibratory force thought to be more hazardous. There are several exposure limit guidelines for vibration, including for the United States.(141-143) There are other guidelines adopted in the UK and Japan. There is limited epidemiological data to better define the exposure-response relationships for each of the various components of HAVS, however, recent animal models provide some insights into exposure-response patterns.(140, 144-146)

Laceration Management

Traumatic injuries resulting in skin lacerations of the upper extremity are a common reason for patient visits to an urgent care, occupational medicine clinic or emergency department. Lacerations result from blunt or crush injuries that produce shear forces, or more commonly from sharp objects which are abundant in the workplace.(147) The majority of lacerations can be treated on an outpatient basis. The primary purpose of wound and laceration management is to avoid infection, detect if a nerve injury has occurred, manage tendon lacerations, and achieve a cosmetically acceptable result with the highest degree of function(148) and patient satisfaction.(149) The most optimal results are accomplished by preventing infection through thorough wound cleansing, approximating wound edges with appropriate closure techniques, and providing a proper dressing with a clean moist environment to accelerate wound healing.(150-152)

Human and Animal Bites and Associated Lacerations

There are no recently reported rates of human and animal bites in the United States. However, extrapolation of emergency department visits and other epidemiological studies from the 1990s indicate there are an estimated 5.0 million dog bites annually, with roughly 750,000 to 800,000 of those bites of significant severity to require medical treatment.(153-155) Data on cat bites are more limited, but they are the second most common animal bite, with an estimated 66,000 emergency room visits,(156) followed closely by human bites.

Although most bites occur from animals known to the victim, occupations that may be at higher risk for animal bites include veterinarians,(157) animal handlers, police officers, utility services personnel who access private property, mail carriers, and other similar professions. Human bites are common in care givers,(158, 159) educators,(160) law enforcement officers,(161) and in instances of accident or workplace violence that may involve the fist or hand being cut by contact with teeth.

Other than deep destruction of tissue requiring reconstruction, risk of infection is the primary concern for animal bites. There also are other zoonotic diseases such as rabies, cat scratch fever, and human blood borne pathogens exposures that should also be considered. The reported incidence of infection from non-complicated bite wounds from dogs is between 3 and 10%,(162, 163) from cats is 20 to 50%,(153) and from humans is up to 50%.(164) Rates may be higher for wounds of the hand, depth of penetration into the skin, and length of time before wound is irrigated and cleaned. For purposes of this guideline, discussion and recommendations are made based on bites to the extremities or trunk as well. Facial injuries are not considered in this guideline and there may be somewhat different indications as the significance of complications is generally more severe.

Hand/Finger Osteoarthrosis

Hand and finger osteoarthrosis is extraordinarily common affecting over 50% of the aged population. These are believed to be largely non-occupational issues,(165, 166) but some may be covered under some workers' compensation jurisdictions, usually under fairly limited circumstances. This is particularly true for mono-articular arthrosis as a consequence of an occupational injury.

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Initial Assessment

Thorough medical and work histories as well as focused physical examinations (see General Approach to Initial Assessment and Documentation Guideline) are sufficient for the initial assessment of the majority of patients with a potentially work-related hand, wrist, or forearm symptom(s). These evaluations should consider assessments of red flags, including the possibility of referred pain to the hand, wrist, or forearm from a disorder in another part of the body (e.g., cervical nerve root or heart). The absence of red flags largely rules out the need for special studies, surgical intervention, or inpatient care the first 4 weeks, as during this time, spontaneous recovery is common (provided any inciting workplace or other factors are addressed).

Hand, wrist, and forearm symptoms can be classified into one of four working categories:

- **Potentially serious hand, wrist, or forearm condition:** fracture, acute dislocation, infection, neurovascular compromise, or tumor.
- **Mechanical disorders:** derangements of the hand, wrist, or forearm related to acute trauma, such as ligament sprain or muscle-tendon unit strain.
- **Degenerative disorders:** resulting from aging or symptoms associated with use, or a combination thereof, such as osteoarthrosis, other arthritides, tendinosis, or tenosynovitis.
- **Nonspecific disorders:** occurring in the hand or wrist without clear, specific pathophysiological correlates (most typically includes non-specific pain and sometimes erroneously called “forearm tendinitis”).

Carpal Tunnel Syndrome

CTS patients typically have a constellation of symptoms with some variation in clinical presentations(8, 167, 168) and a lack of a criterion standard.(10) Symptoms most typically start gradually in the thumb, index, and middle fingers with tingling, numbness, or burning.(11, 167) Symptoms may also include subjective hand swelling.(169) Symptoms often first appear during sleep, possibly due to sleeping with wrists flexed, edema, venous pooling or a combination of factors. The patient may awaken with the desire to “shake out” the hand or wrist. As symptoms worsen, patients may experience tingling during the day particularly after a sustained hand grasp (such as when using a steering wheel or hand tool). Wrist flexors are innervated by the median nerve *proximal* to the wrist. However, decreased thumb and grip strength sometimes occurs and may make it difficult to form a firm fist, sustain grasp particularly of small objects, or perform other manual tasks. In chronic, advanced, and/or untreated cases, the muscles of the thenar eminence may atrophy. Some severely affected patients are unable to differentiate between hot and cold. Symptoms are most commonly documented through detailed recording of symptoms and digits affected or with a hand symptom diagram.(168, 170-174) With the Katz hand diagram, the patient is provided with a form that shows outlines of the arms, and the palmar and dorsal surfaces of the hands. The patient identifies areas of discomfort on the diagrams and characterizes the symptoms (e.g., pain, numbness, tingling, or other). The results are scored by the clinician as “probable,” “possible,” or “unlikely,” depending upon specified criteria.

Patients with CTS should have paresthesias (tingling and/or numbness)(10, 167, 168) but pain in the wrist hand or fingers may or may not be present. In patients with only wrist or hand pain without paresthesias, a diagnosis other than carpal tunnel syndrome may be present. Symptoms of tingling, numbness and pain in the median nerve distribution of the hand are common in the general population (prevalence approximately 14 to 37%). However, based on clinical examination and electrophysiologic testing, CTS prevalence rates range from 2.7% to as high as 13.0%(175-187) while the incidence rate for working populations is near 2.3 per 100 person-years.(188) Differences in diagnostic criteria and population characteristics between these studies may play a role in the differences in reported CTS prevalence.(189)

Triangular Fibrocartilage Complex (TFCC) Tears

TFCC tears appear to occur either with acute discrete traumatic events and/or as degenerative cartilaginous changes. A primary focus of the patient history is ascertaining whether the TFCC is significantly torn, and if so, whether it is sufficiently symptomatic to require intervention(s). Following the

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patient's symptoms for healing without immediate surgical intervention is generally the most common approach. Some do not heal, continue to be symptomatic and do well with surgical repair or removal.

Crush Injuries and Compartment Syndrome
Patients with more severe injuries present with severe pain and may have vascular compromise. The initial assessment should focus on the degree of injury severity and if the injury requires surgical evaluation and treatment. Milder injuries may be managed non-operatively; however, the threshold for surgical consultation should be low. Those with milder injuries should be monitored for neurovascular compromise.

Kienböck Disease
Patient typically presents with progressive pain and disability and have characteristic wrist x-rays demonstrating changes in the lunate.

Wrist Sprains
Wrist sprains typically occur with acute traumatic events. The diagnosis is sometimes applied as a diagnosis of exclusion among patients with pain in the setting of trauma with negative fractures. However, the specific entity is properly defined as a partial ligamentous disruption rather than undefined pain generators. Sprains may also occur as an accompaniment to fracture.

Mallet Finger
Mallet finger is readily diagnosed based on the presentation of inability to extend the distal interphalangeal joint, generally in the context of trauma or distal interphalangeal joint arthrosis.(21)

Flexor Tendon Entrapment (Tenosynovitis and Trigger Digit)
Flexor tendon entrapment generally presents as a relatively simple clinical presentation. Some occur after acute injury, but most occur without specific inciting event.(40, 190-193)

Extensor Compartment Tenosynovitis (Including de Quervain's Stenosing Tenosynovitis and Intersection Syndrome)
Extensor tendon entrapment generally presents as a relatively simple clinical presentation. Some occur after acute injury, but most occur without specific inciting event.

Ulnar Nerve Entrapment at the Wrist (Including Guyon's Canal Syndrome and Hypothenar Hammer Syndrome)
Ulnar nerve entrapment at the wrist generally presents as numbness and/or tingling in the fourth and fifth digits. Certain patients may also experience a weakened grip or difficulty with finger coordination.

Radial Nerve Entrapment
Radial nerve entrapment usually presents as radial nerve palsies affecting the hand and wrist, most commonly occurring at points along the course of the arm and forearm, well proximal to the wrist.(58-60) The medical history should include a search for sensory symptoms. Symptoms may also include pain over the course of the nerve.

Non-Specific Hand/Wrist/Forearm Pain
Non-specific hand/wrist/forearm pain typically occurs in the absence of discrete trauma. Instead, it frequently occurs in settings of high physical job demands or ill-defined exposures. This is a "diagnostic" category to be utilized when symptoms are present, but in the absence of an identified, specific disorder. Most cases will resolve without significant difficulty. If there is no improvement after several weeks of treatment, focused diagnostic testing should be considered. Non-specific pain lasting more than 2 months is fairly rare. The search for a specific diagnosis should include proximal pathology including spine-related (e.g., radiculopathy, spinal tumor, infection) as well as psychological disorders particularly when widespread symptoms are elicited or a pattern or recurrent unexplained illnesses is present (see Chronic Pain Guideline).

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Scaphoid Fracture
The main initial tasks are to confirm a fracture, identify those patients with fractures best treated with surgery, and treat those with a high clinical suspicion of fracture with appropriate splinting. A history of sufficient injury potential is important. Patients frequently complain of persistent swelling and tenderness near the thumb base in the area of the scaphoid. Gripping and wrist motion may be painful.

Distal Phalanx Fractures and Subungual Hematoma
Patients have swelling, reduced range of motion, and tenderness of the fingertip. Patients with accompanying subungual hematoma may have severe throbbing pain and obvious discoloration of the affected nail.

Middle and Proximal Phalangeal and Metacarpal Fractures
The initial assessment involves a search for confirmation of fracture. Limited or guarded range of motion with pain, local tenderness, swelling, deformity and possibly ecchymosis over the affected area are common.

Distal Forearm Fractures
Wrist injuries associated with significant pain, swelling, ecchymosis, crepitance, or deformity should be considered to be fractured until proven otherwise. Forearm fractures may also result in concomitant vascular, neurological, ligament and tendon injuries. Further, as distal forearm fractures are the result of trauma, careful inspection for other traumatic injuries should be included, such as elbow, shoulder, neck, head, and hip. In general, most distal forearm fractures should be managed by an orthopedic or hand surgeon and consultation is recommended.

Ganglion Cyst
Most ganglia present as a bump or mass. Occasionally patients with noticeable ganglia will complain of mild nuisance pain, and less often of severe pain. In the assessment of wrist pain in the absence of palpable ganglia, the unexplained wrist pain may be a result of occult ganglia and should be included in the differential diagnosis. The pain from an occult dorsal lesion has been linked to the compression of the posterior interosseous nerve.(194) Ganglia have also resulted in compression of the median and ulnar nerves as they pass through the carpal tunnel and condylar groove respectively (see section on Ulnar Nerve Entrapment and Elbow Disorders Guideline).

Hand Arm Vibration Syndrome
Initial assessment for HAVS is a detailed history and examination focusing particularly on high-amplitude vibratory exposure and sensorineural or vascular symptoms. The clinical symptoms may include episodic tingling, numbness, blanching white fingers, pain and paresthesia, burning sensation, clumsiness, poor coordination, sleep disturbance, hand weakness measured in grip strength, and diffuse muscle, bone and joint pain from the fingers to the elbow.(42) Differential diagnosis should consider other causes of Raynaud's phenomenon, including the connective tissue diseases of scleroderma, systemic lupus erythematosus, rheumatoid arthritis, dermatomyositis, and polyarteritis nodosa.

Laceration Management
A thorough history of the injury, with particular attention to mechanism, potential degree of wound contamination, potential for foreign bodies, and presence of other trauma should be obtained. Crush wounds may be more susceptible to infection, and contamination. Additionally, inquiry of personal factors that may contribute to delayed healing or increased risk for infection, such as diabetes mellitus, chronic renal failure, or the use of immunosuppressive medications should be included.(195) Tetanus immunization status should be noted and are recommended to be updated per CDC guidelines (see Table 1).

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Table 1. Guide to Tetanus Prophylaxis in Routine Wound Management

History of adsorbed tetanus toxoid (doses)	Clean minor wounds Tdap or Td†	Clean minor wounds TIG§	All other wounds* Tdap or Td†	All other wounds* TIG§
Less than 3 or unknown	Yes	No	Yes	Yes
3 or more doses¶	No**	No	No††	No

* Such as (but not limited to) wounds contaminated with dirt, feces, soil, and saliva; puncture wounds; avulsions; and wounds resulting from missiles, crushing, burns, and frostbite.
† For children younger than 7 years of age, DTaP is recommended; if pertussis vaccine is contraindicated, DT is given. For persons 7-9 years of age, Td is recommended. For persons >10 years, Tdap is preferred to Td if the patient has never received Tdap and has no contraindication to pertussis vaccine. For persons 7 years of age or older, if Tdap is not available or not indicated because of age, Td is preferred to TT.
§ TIG is human tetanus immune globulin. Equine tetanus antitoxin should be used when TIG is not available.
¶ If only three doses of fluid toxoid have been received, a fourth dose of toxoid, preferably an adsorbed toxoid, should be given. Although licensed, fluid tetanus toxoid is rarely used.
** Yes, if it has been 10 years or longer since the last dose.
†† Yes, if it has been 5 years or longer since the last dose. More frequent boosters are not needed and can accentuate side effects.

Reprinted from Tiwari T. Chapter 16: Tetanus. In: Roush S, Baldy L, eds. *Manual for the Surveillance of Vaccine-Preventable Diseases*. Atlanta, GA: Centers for Disease Control and Prevention; 2011. Available at: http://www.cdc.gov/vaccines/pubs/surv-manual/.

Human Bites, Animal Bites and Associated Lacerations

A careful history for time and location of the bite should be obtained as it will help guide clinical decisions regarding prophylaxis. If possible, information about the type of animal and its health status as well as the circumstances related to why the bite occurred should be obtained. Tetanus and rabies immunization status should be established.

Hand/Finger Osteoarthrosis

Most cases of osteoarthrosis are believed to result from genetic factors, although discrete trauma is a potential cause. The initial assessment is usually relatively concise and generally involves securing a diagnosis and initiating treatment.

Medical History

Asking the patient open-ended questions allows gauging of the need for further discussion or make specific inquiries to obtain more detailed information. Hand dominance should be noted. Consider initiating the clinical visit with an open-ended question such as “What can I do for you?” to assure that the chief complaint is addressed. More specific questions for hand, wrist, and forearm conditions include:

Symptoms:

What symptoms are you having? For how long?

- Do you have pain, numbness, tingling, weakness, or limited movement?
- For traumatic injuries: Did the area swell? If swollen, how quickly did it swell (immediately or delayed)? Was the hand/finger deformed?
- Are your symptoms located primarily in the hand, wrist, or forearm? Do you have pain or other symptoms in the elbow, shoulder, or neck? Anywhere else?
- Are your symptoms constant or intermittent?
- What causes your symptoms to increase?
- What time of the day are your symptoms best? Worst? On getting out of bed? Morning? Mid-day? At work? Evening? While sleeping?
- If symptoms awaken you, how often a week? Each night?
- What makes the symptoms better or worse?
- Have your symptoms changed? How have they changed?
- Can you quantify your pain on a scale of 1 to 10 (10 being unbearable or worse possible pain). It is important to quantify and track the patient’s response to evaluate the effectiveness of treatment.
- What have you done to reduce your symptoms?

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Onset (Occupational and Avocational):
How did your symptoms begin? Was there a single, sudden event (e.g., slip, trip, or fall) when your symptoms started or did the symptoms begin gradually?

- Are you able to do your usual job? How do these symptoms limit you?
- Can you do hand intensive activities? Job? Hobbies? Housework? Yard work? For how long?
- Do you work out and use weights/weightlifting while working out?
- Can you perform activities of daily living (e.g., dressing, bathing, grooming, etc.) or instrumental activities of daily living (e.g., shopping, food preparation, housekeeping, etc.)?
- What stops you from doing activities? Are the symptoms worse with workplace activities?
- Can you grasp? How much? Are you dropping things?
- What is your job? What are your specific job activities? Do you use your hand, wrist, or forearm to perform them? What are the most forceful hand activities? How? How often?
- Are there differences in exposures between hands (are symptoms not dissimilar or vice versa)?
- (For discrete trauma): Exactly how did you injure the hand/finger? (Record in detail)
- (For non-discrete trauma): What do you think caused these symptoms? (Record in detail) Proceed with other questions, but return to record details of maximum and typical force, repetition, posture, vibration as appropriate after securing a provisional diagnosis.
- Have the symptoms limited your activities? For how long?
- What are your hobbies? How often?
- Do you use vibrating tools or devices at work or at home (especially high amplitude, low frequency such as older model chain saws)? Do you ride a motorcycle or four wheeler? Do these activities seem to affect your symptoms?

Current Treatments Used:
What have you used to treat the current symptoms?

- Medications? Splints? Ice/heat? Rest? Relative rest?
- Has any treatment helped? Or, not helped?

Prior Injuries and Prior Treatments:

- Have you had this problem or similar symptoms previously with this hand? The other hand?
- What makes it better and what makes it worse? Do you have symptoms at night? On weekends? On vacations?
- Have you had previous testing or treatment? Which? What were the results? What seemed to work best in the past?
- What do you think caused your symptoms? Do you think your symptoms are related to work?

Other Relevant Disorders:

- Do you have other medical conditions? (For example, overweight/obesity, diabetes mellitus, hypothyroidism, other endocrinopathy, pregnancy, osteoarthrosis, rheumatoid arthritis, other arthritides, renal disease etc.)

Carpal Tunnel Syndrome

There are numerous purported risk factors for CTS (see Table 2), although many have not been confirmed in prospective studies as true independent risk factors. Evidence appears most consistent in the retrospective studies for age, obesity, female gender, diabetes mellitus, and combinations of forceful and repetitive grasping.(6, 12, 196-210, 211, 212) Recent prospective cohort studies of CTS have confirmed the above five factors as apparently true risk factors, including repeated high force grasping, overweight or obesity, female gender, and psychosocial factors.(146, 213-219)

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Table 2: Possible Risk Factors for Carpal Tunnel Syndrome

This list is based on prospective, cross-sectional, and case-control studies, case series, and case reports. Note, this table is not meant to be all inclusive.

Risk Factor	
Trauma	Any past or recent fracture of the wrist Carpal-metacarpal dislocation Casting following a fracture Crush injury Repeated contusions to the wrist Volkmann's ischemic contracture
Developmental or Genetic Causes (Heredity)	Female gender, pregnancy, menopause Age >40 Persistent median artery Enlarged lumbrical or/flexor digitorum superficialis muscle(s) Smaller cross sectional carpal tunnel area – females particularly have smaller wrists Squarer wrists – wrist depth to width ratio of more than or equal to 0.70 Primary familial carpal tunnel syndrome due to thickening of the transverse carpal ligament – thus runs in families Hereditary neuropathic pressure palsies
Swelling and Masses	Ulnar bursitis Ganglion cysts Lipoma or fatty tumor/other tumors Overweight or obesity – usually measured with Body Mass Index – weight (kg)/height (m^2) Acromegaly with oversized bones and soft tissues in the wrist Hypertrophic polyneuropathy with median nerve enlargement Proximal lesion of the median nerve (double crush syndrome)
Rheumatological Disorders, including Inflammatory and Non-Inflammatory Arthropathies	Nonspecific tenosynovitis with synovial swelling and thickening Osteoarthrosis Rheumatoid arthritis Scleroderma Chondrocalcinosis Dermatomyositis Amyloidosis with amyloid deposits Multiple Myeloma Paget's disease Gout, as well as other crystal arthropathies
Other Inflammatory and Infectious Conditions	Histoplasmosis Sporotrichosis Coccidiomycosis Rubella Leprosy with enlargement of the median nerve Hepatic disease Fibromyalgia Polymyalgia rheumatica Raynaud's disease Infections of the wrist joint or other compartments Lyme disease Tuberculosis
Metabolic, Nutritional, and Alterations in Fluid Balance	Diabetes Mellitus Alcoholism Vitamin B_6 deficiency Pregnancy – presumably due to increased body fluid and swelling Menopause with hormonal imbalance Eclampsia of pregnancy Hypothyroidism – particularly with fluid retention, although other history of thyroid disorders appears to be a risk Renal disease and renal failure – especially with fistulae for hemodialysis Oral contraceptive and estrogen use Glucocorticosteroid use

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Activities and Avocations	Musical instrument use (e.g., violin, piano) Prolonged driving Prolonged writing Bowling Motorcycle riding (e.g., vibration and handle bar grasp) Snowmobiling Sewing, knitting and crocheting Bicycling
Vocational Activities	Combinations of high force and high repetition especially meat and shellfish processing and some manufacturing positions. Some grocery scanning positions may also be at risk, particularly if handling high volumes of heavy product) High force grasping on a stereotypical basis Highly repeated grasping

Triangular Fibrocartilage Complex (TFCC) Tears

Patients commonly complain of non-radiating ulnar sided pain and clicking. It is important to correlate the symptoms with the physical examination and mechanism of injury since MRI studies suggest TFCC tears are both prevalent while also apparently frequently asymptomatic.(14, 220, 221) Ulnar deviation with axial loading tends to increase pain. A “click” or “clunk” in the ulnar wrist joint may be reproduced with forearm rotation (supination/pronation). Commonly reported mechanisms of injury include a fall on an outstretched hand(222-224) as well as sports.(225, 226) Thus, some work-related accidents are reported causes of these tears. Those with occupational cases will tend toward symptomatic onset after a discrete traumatic event such as a slip and fall.

Crush Injuries and Compartment Syndrome

Patients have pain, and may have paresthesias. Those with vascular compromise may have a cool extremity compared with the unaffected limb. Crush injuries have clear mechanisms of injury on history. However, there are many causes of compartment syndrome including trauma, excessive traction from fractures, tight casts, bleeding disorders, burns, snakebites, intraarterial injections, infusions, and high-pressure injection injuries.(19, 227-231)

Kienböck Disease

Patient complains of increasing wrist pain, pain with movement, pain with use, and limited range of motion.

Wrist Sprains

Patients invariably have incurred an acute traumatic event, usually a slip, trip, or fall with forceful loading of the wrist joint usually in a fully deviated position (e.g., full extension). They have pain in the wrist joint, and generally have no swelling.

Mallet Finger

The mechanism of injury most typically involves forcefully striking the tip of the extended digit on an object (e.g., balls caught by the hands in sports), as well as from falls.(22) Unless there is a fracture, most cases present without significant, post-traumatic pain. Some occur without any trauma and are thought to mostly occur with osteoarthrosis and Heberden’s nodes or other chronic joint pathology.

Flexor Tendon Entrapment (Tenosynovitis and Trigger Digit)

Epidemiological evidence is weak, thus lines of query are unclear and causal conclusions tenuous.(40, 232) The mechanism of injury for many appears to be typically idiopathic(40, 190, 192, 233) or as a complication of medical conditions (especially diabetes mellitus and rheumatoid arthritis).(33) However, available epidemiological and biomechanical evidence suggests that the disorder may also occur as a complication of repeated forceful use of a digit,(35, 40, 190, 192, 234-244) or unaccustomed use,(35, 40) thus many cases may be work-related.(29, 40, 245) A careful history of occupational tasks as well as non-occupational exposures is recommended. Symptoms are variable and may include pain, stiffness, clicking, snapping, and locking.(28, 35, 192, 234, 244, 246-249) Pain is generally in the volar digit and/or metacarpophalangeal joint area.(244, 246-248) Certain patients report worse symptoms in the morning or after lack of use.(40)

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Extensor Compartment Tenosynovitis (Including de Quervain's Stenosing Tenosynovitis and Intersection Syndrome)

Patients present with wrist pain that is augmented by movement and generally non-radiating,(42) although occasionally pain may spread along the course of the affected tendon sheath.(41, 42) Patients rarely have paresthesias unless there is an accompanying swelling or other mechanism to affect the superficial radial nerve or other digital nerves.(41) Some repeated hand postures with thumb pinching may be associated with de Quervain's disease.(250) There is belief that superficial radial nerve entrapment may accompany de Quervain's and may then produce paresthesias in the first dorsal web space. Triggering is rare.(251)

Ulnar Nerve Entrapment at the Wrist (including Guyon's Canal Syndrome and Hypothenar Hammer Syndrome)

Ulnar nerve entrapment at Guyon's canal typically first presents with symptoms of paresthesias followed by late symptoms of weakness. It is reportedly usually not associated with pain, in contrast with carpal tunnel syndrome that appears to more frequently involve pain. Patients with traumatic causes of ulnar neuropathy tend to have motor symptoms, whereas those with idiopathic or non-trauma related causes usually manifest sensory symptoms.(50)

Radial Nerve Entrapment

Successful localization of radial nerve entrapment can frequently be accomplished through a careful history and physical exam. The medical history should search for sensory symptoms including paresthesias with precision of the location of the paresthesias to a typical radial nerve distribution on the dorsal hand, particularly in the first dorsal web space.(59) Symptoms may also include pain over the nerve. Distinguishing from other sources of sensory symptoms is usually possible, particularly including radiculopathies and other entrapment syndromes. An assessment of motor symptoms, including wrist extensor weakness as well as wrist drop, are also helpful, particularly in conjunction with absence of weakness in other distributions.

Non-Specific Hand/Wrist/Forearm Pain

Patients most commonly give a history of gradual onset of pain or other symptoms in the absence of discrete trauma. Symptoms are most often in the forearm, and frequently are not well localized.

Scaphoid Fracture

Historical features most commonly involve a high-energy injury such as a fall on an outstretched, extended hand with immediate, non-radiating pain in the radial carpus. Other common mechanisms include grasping a steering wheel in a frontal motor vehicle crash, or direct blow to the scaphoid such as when using the heel of the wrist as a hammer.

Distal Phalanx Fractures and Subungual Hematoma

Tuft fracture should be suspected when a patient presents with a crush injury or perpendicular shearing force injury to the fingertip, particularly if there is a subungual hematoma. Injuries resulting in avulsion of the nail plate can also be associated with tuft fractures.

Middle and Proximal Phalangeal and Metacarpal Fractures

Careful history regarding the mechanism of injury including and direct axial blow or angular or rotational trauma will reflect substantially on the nature of the fracture and its inherent stability.(78)

Distal Forearm Fractures

There are several types of distal forearm fractures (see Distal Forearm Fractures in the section on General Approach and Basic Principles). There can be a high incidence of TFCC tears with these fractures.

Ganglion Cyst

Ganglion cysts are usually asymptomatic. The cause is unknown, although the condition appears associated with aging.

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Hand Arm Vibration Syndrome (HAVS)
HAVS can manifest as vasospasm with local finger blanching; sensory and motor disturbances such as numbness, loss of finger coordination and dexterity, clumsiness and inability to perform intricate tasks; and musculoskeletal disturbances such as swelling of the fingers, bone cysts, and vacuoles.(128, 252)

Laceration Management
Lacerations of sufficient size, depth and those occurring over joints usually require suturing. Tetanus immunization status should be addressed.

Human Bites, Animal Bites and Associated Lacerations
A detailed medical history pertaining to tetanus and in the case of animal bites, rabies immunization status, and underlying medical conditions such as diabetes mellitus or other immune-compromising conditions is important. Most wounds are puncture wounds, but some wounds may be considered for suturing.

Hand/Finger Osteoarthrosis
Patients usually have no recalled acute traumatic event. A minority have a history of significant trauma, such as a fracture or dislocation. Regardless of cause, symptoms usually consist of gradual onset of stiffness and non-radiating pain. Gradual joint enlargement is often present, although frequently unnoticed by the patient. Swelling, erythema, warmth and other signs of infection or inflammation are not present, and if present signal an inflammatory, crystalline arthropathy, septic arthritis or other cause. The history should include symptoms affecting any other joints in the body, presence of other potential causes (e.g., psoriasis, rheumatoid arthritis, gout) to help ascertain the correct diagnosis.

Physical Examination
Guided by the medical history, the physical examination includes:
- General observation of the patient; and
- Appropriate regional examination of upper limbs (hands, wrists, forearms, elbows, arms, shoulders, and neck).

The general observation involves specification of which distal upper extremity is affected and observation of how much the affected hand or arm is used versus how much activity is avoided – e.g., does the patient shake the examiner's hand or avoid all use of the hand or arm? Does the patient hold the arm without using it? Are there differences in use depending on whether there is active rather than casual observation and examination? These aspects of the physical examination are under-rated, yet perhaps the most important aspects for ascertainment of degrees of impairment and severity of the condition. Most components of the examination are at least in part, subjective since the patient must exert voluntary effort or state a response to a stimulus such as the sensory examination or tenderness. In many cases of hand, wrist, or forearm problems, there are no strictly objective findings. Exceptions include palpable trigger finger, ganglia, thenar atrophy, and fracture-related deformities.

The physician should seek objective evidence of pathology that is consistent with the patient's symptoms. In some cases, careful examination will reveal one or more truly objective findings, such as swelling, deformity, atrophy, reflex changes or spasm, fasciculations, trophic changes, or ischemia. Regardless of whether completely objective findings are present, all findings should be documented in the medical record.

A. Regional Examination of Hand, Wrist, and Forearm
The inter-related hand, wrist, forearm, arm, shoulder, and neck should be examined individually and functionally together for observation of use, function, swelling, masses, redness, deformity, asymmetry, or other abnormality. The examination should extend to the proximal upper limb and neck. This examination may be followed by evaluating active and passive range of motion within the patient's limits of comfort with the area as relaxed as possible for passive range of motion. Local tenderness may be accentuated by specific motions or stresses on specific joints, and active muscle contraction may produce pain, indicating

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a specific tendinosis. If this latter finding is on the dorsoradial side of the wrist, it suggests a diagnosis of de Quervain's tenosynovitis. Specific areas of decreased pinprick sensation may indicate median or ulnar nerve compression. Flexing the wrist for 60 seconds with elicitation of dysesthesias in the median innervated digits is considered a positive Phalen's test.

Several purported signs of carpal tunnel syndrome (CTS) have limited specific diagnostic value and the history is believed to be of critical importance in securing a presumptive diagnosis of CTS. The various signs for CTS show a broad range of positive predictive value that is especially dependent on the patient population assessed. Physicians should primarily rely on the clinical history as well as the physical examination. The most sensitive screening methods appear to combine night discomfort, abnormal Katz hand diagram, and abnormal sensibility by monofilament Semmes-Weinstein testing comparing affected with unaffected nerve distributions. Hypalgesia in the median nerve distribution and thumb abduction strength testing also have been found to be helpful in establishing the diagnosis of CTS. The flick "sign" is another diagnostic tool. It reportedly has high sensitivity and specificity; however, it is a historical finding rather than a true physical examination sign. The historical feature is positive when a patient reports shaking his or her hand in an effort to relieve paresthesias.(253) The diagnostic utility of physical examination tests for CTS is unclear as the underlying studies supporting meta-analyses have methods that are not well described. Phalen's maneuver is thought to be superior to Hoffmann-Tinel's ("Tinel's") sign over the median nerve, although neither perform particularly well.(254)

Trigger finger (tendon) nodules may be palpable with both active and passive range of motion. However, some patients only have tenderness over the flexor surface of the metacarpal phalangeal joints, which may make this examination more difficult. A ganglion may be present on either inspection, or for smaller ganglia, only on palpation. The severity of symptoms on physical examination is usually the basis for aspiration or surgical excisions.

Fractures are most commonly discovered by deformity in the context of focal pain and an inciting trauma history. Some occur without deformity and are only found on x-rays, although most have focal tenderness on a careful palpatory examination.

B. Neurovascular Screening

The neurologic and vascular status of the hand, wrist, forearm, and upper limb should include peripheral pulses, motor function, reflexes, and sensory status. Examining the neck and cervical nerve root function is also recommended for most patients. For example, a C6 radiculopathy may cause tingling in the thumb and index finger and may affect the wrist extensors while T1 radiculopathy can present as dysfunction of the intrinsic muscles of the hand.

C. Assessing Red Flags

Potentially serious conditions for the hand, wrist, and forearm are listed in Table 3. Early consultation by a hand or upper limb specialist, rheumatologist, or other relevant specialist is recommended depending on the provider's training and experience in dealing with the particular disorder.

Table 3. Red Flags for Potentially Serious Hand, Wrist, or Forearm Conditions

Disorder	Medical History	Physical Examination
Fracture	History of significant trauma History of deformities with or without spontaneous reduction or self-reduction Focal, severe non-radiating pain combined with history of trauma Inability to use the joint	Significant swelling Deformity with displaced, rotated or spiral fractures Point tenderness Swelling, hematoma Ecchymosis
Dislocation	History of significant trauma History of deformities with or without spontaneous or self-reduction Inability to use the joint	Deformity present Tenderness and instability with history of deformity with reduction Hemarthrosis
Infection	History of systemic symptoms: fever, chills/rigor	Tenderness with motion

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	History of immunosuppression (e.g., transplant, chemotherapy, HIV) Diabetes mellitus Portal of infection (e.g., laceration, distant infection)	Systemic signs of sepsis Local heat, swelling, erythema Drainage of a sinus tract Painful, red, swollen area(s)
Tumor	History of rapidly growing, painful, firm or hard mass of hand or wrist not consistent with ganglion History of immunosuppression (e.g., transplant, chemotherapy, HIV) History of cancer	Mass of hand, wrist, or forearm, not consistent with ganglion or other benign lesion
Joint Inflammation	History of inflammatory arthropathy or crystal arthritis Clinical history consistent with inflammatory or crystal arthropathies	Swelling and deformity Mostly symmetrical joint involvement for more common inflammatory arthropathies (e.g., rheumatoid arthritis) Erythematous, swollen, warm usually solitary joint for acute crystal arthropathy Painful swollen joints, usually without systemic symptoms
Rapidly Progressive Neurologic Compromise	Rapidly progressive numbness, paresthesias, or weakness in radial, ulnar, or median nerve distribution Inciting traumatic event or history to produce acute neurological compromise Progressive weakness Stroke, cervical spine disorders or other central nervous system compromise	Sensory deficit in ulnar, median, or radial distribution Loss of finger or grip strength when picking up objects Atrophy
Vascular Compromise	History of vascular disease History of diabetes mellitus Compartment syndrome Inflammatory arthropathies with vasculitis	Decreased pulses Decreased capillary filling Cold, cool, or pale hand
Severe Carpal Tunnel Syndrome	Continuous median distribution tingling and numbness after acute trauma, especially fracture Severe flexor compartment pain after repeated, unaccustomed, forceful use with continual median distribution tingling and numbness	Reduced median distribution sensation Muscle atrophy (late) and severe weakness of thenar muscles

Carpal Tunnel Syndrome

The physical examination is particularly helpful for assuring other condition(s) are not present. Some believe the physical examination is highly useful(255) while others suggest the physical examination findings are of limited use in securing a diagnosis as compared with a careful history, and add little to a careful history combined with electrodiagnostic evidence.(10, 254) A recent analysis of signs of carpal tunnel syndrome reported considerable methodological issues, including spectrum biases that likely result in overstatement of the clinical utility of common tests for CTS.(256) Clinical testing for CTS may include several items outlined below. The following describes pertinent history and clinical testing:

- Thenar atrophy – Thenar eminence should appear small compared with the hypothenar eminence and the contralateral hand. This is an advanced sign.
- Hand sensibility – Multiple tests are tested to attempt to determine clinical sensibility. These include Semmes-Weinstein monofilament test, Ten Test, 2-point discrimination, paper clips and various devices. However, sensibility (ability to sense or detect cutaneous stimuli) decreases with age resulting in challenges in interpreting results. Comparison with unaffected digits or the opposite hand is often helpful.(257-260)
- Hypoalgesia in the median nerve territory – Diminished ability to perceive painful stimuli in the median nerve distribution (e.g., palmar aspect of the index finger compared with the ipsilateral fifth digit).
- Monofilament test – A test involving nylon monofilaments that collapse at specific amounts of force when pushed perpendicularly against the palm or fingers. A positive test results when a filament of greater than normal size is required in order for its application to be perceived by the patient.

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- Vibration Testing – Diminished ability to perceive vibratory sensations using a standard vibrating tuning fork comparing the distal interphalangeal joint of the index finger to ipsilateral fifth finger.
- Weak thumb abduction strength – Weakness of resisted abduction (i.e., palm horizontal, thumb lifted as vertically as possible, then patient resists examiner pushing the thumb down towards the index finger).
- Hoffmann-Tinel's Sign ("Tinel's") – Up to 6 taps of a reflex hammer or tip of examiner's finger to the soft tissue overlying the carpal tunnel. A positive test occurs when the taps cause paresthesias or shooting pain in the median nerve distribution.(261)
- Phalen Sign – As originally described, flexion of the wrist by having the examiner passively flex the wrists of the patient for up to 60 seconds.(262) Clinically, this is more commonly performed by having the patient press the dorsal aspect of both hands together with approximately 90° of flexion for 60 seconds. It is unclear if these two means of performing this sign result in different sensitivities and specificities. A positive test produces paresthesias in the distribution of the affected median nerve.
- Carpal Compression Test – The examiner holds the supinated wrist in both hands, flexes the wrist 45° and applies direct, even pressure over the transverse carpal ligament with both thumbs for up to 30 seconds. A positive test is indicated by tingling or paresthesia into the thumb, index finger, and middle and lateral half of ring finger within 30 seconds.(263)
- Tourniquet Test – Paresthesias developing in the distribution of the median nerve when a blood pressure cuff is inflated above systolic pressure for 60 seconds.
- Hand volume – Hand volume change measured by water displacement in a graduated cylinder.

Triangular Fibrocartilage Complex (TFCC) Tears

The exam may reveal dorso-ulnar wrist joint tenderness that is not focally tender over an extensor compartment. Swelling is generally not present, although it may be present with an acute, large tear. The examiner should generally attempt to reproduce catching or snapping in the ulnar wrist joint, either by having the patient place the wrist into a position that elicits the symptoms and/or moving the wrist and forearm through a combined supination movement with simultaneous movement of the wrist from flexion to extension.

Crush Injuries and Compartment Syndrome

The physical examination ranges from mild abnormalities with mild injuries (e.g., contusions) to severe with fractures, limited range(s) of motion and neurovascular compromise.

Kienböck Disease

The physical examination may be normal early, but generally the patient has mild to moderate dorsal wrist tenderness while also having asymmetric, limited range of motion. Tenderness and limited range of motion tend to progress.

Wrist Sprains

The exam may include wrist capsule tenderness, or it may be normal. Deformity suggests fracture. Scaphoid tubercle tenderness suggests scaphoid fracture.

Mallet Finger

The patient is unable to extend the distal phalangeal segment. Swelling often signifies a fracture fragment, while most are extensor tendon ruptures(264) and have no significant swelling.

Flexor Tendon Entrapment (Tenosynovitis and Trigger Digit)

Patients without triggering will typically have tenderness localized over the A1 pulley.(265) A palpable tendon nodule is frequently present. Triggering often occurs upon arising in the morning or after lack of use. Active movement is often required to demonstrate triggering as passive motion is often normal. Those rare cases with a locked digit are unable to extend (or flex) the digit.(31, 33-35, 40, 190-192, 198, 237, 242, 249, 266-282)

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Extensor Compartment Tenosynovitis (Including de Quervain's Stenosing Tenosynovitis and Intersection Syndrome)

The hand is usually normal in appearance, although there is visible tendon sheath swelling in a minority of cases. Swelling is more common with inflammatory conditions (e.g., rheumatoid arthritis) or infections. Some believe swelling and crepitus are also only present among those with peritendinitis if there is no inflammatory or infectious disease. Focal tenderness over the compartment is present. Finkelstein's maneuver is the classic provocative maneuver and is nearly always present,(41) however, the predictive values are unclear. Pain in the affected compartment is generally present with use or any provocative maneuver (e.g., resisted use of the muscle-tendon unit).(42) Triggering may be demonstrated on rare occasions.

Ulnar Nerve Entrapment at the Wrist (including Guyon's Canal Syndrome and Hypothenar Hammer Syndrome)

Dependent on the location of the lesion, motor, sensory, or mixed motor-sensory findings are detectable. Muscle atrophy may be present in the interosseous and hypothenar areas. Point tenderness may be present. Sensory loss is typically most prominent at the palmar tip of the 5th finger, in contrast with ulnar neuropathies at the elbow which present with sensory loss on the palmar and dorsal surfaces of the 5th digit. Motor weakness may be demonstrated by resisting spreading of the fingers to assess intrinsic muscle strength. A positive Tinel's is purportedly helpful, but there are no quality studies evaluating the utility of this clinical test and its utility elsewhere has been questioned. Associated carpal tunnel compression should also be examined. A vascular exam and auscultation for bruits should be performed,(283) particularly for those cases thought to involve vascular symptoms and hypothenar hammer-like symptoms.

Radial Nerve Entrapment

The physical examination attempts to localize the site of nerve entrapment and should include sensory (especially sensation) and motor components (movement, range of motion, strength, reflexes) to localize the entrapment. Comparisons to the unaffected limb should be made. Differentiation from de Quervain's tenosynovitis is a primary differential diagnostic consideration, yet Finkelstein's is not particularly helpful as it may be positive with both conditions.

Non-Specific Hand/Wrist/Forearm Pain

The examination is generally without any unequivocally objective evidence. Instead, tenderness is most often the only physical examination finding. Qualitative muscle strength testing may be weak compared with the unaffected side. Precise documentation of the location of the pain should be made with consideration for photographing the location for future reference. In cases where the pain does not migrate, the probability of specifically defined pathology is believed to increase.

Scaphoid Fracture

Physical examination findings include antalgic behavior with avoidance of use of the hand, and tenderness over the scaphoid tubercle.(284-286) Scaphoid tubercle tenderness may be more sensitive and specific than snuffbox tenderness. The scaphoid tubercle is located at the volar wrist at the junction of the distal wrist crease under the flexor carpi radialis. The tubercle becomes prominent and readily palpable with radial deviation of the wrist. Patients may also have tenderness over the snuffbox, absence of tenderness in the distal radius, wrist joint effusion,(287-289) and scaphoid pain on axial loading of the thumb ("scaphoid compression test").(285, 290) However, many of these findings may also be present without scaphoid fracture. An isolated finding of snuffbox tenderness appears to be sensitive, but has poor positive predictive value for scaphoid fracture.(71, 286, 291)

Distal Phalanx Fractures and Subungual Hematoma

Physical examination should include inspection and identification of localized swelling and open wounds. Neurovascular status should be described. The DIP joint should be palpated in each plane to assess point tenderness over ligament insertions. Passive range of motion and joint stability should be assessed through dorsal, volar, and lateral stressing. An estimate of subungual hematoma size relative to the nail bed surface should be noted. A case series demonstrated fractures in 63% of patients with hematomas

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greater than 50% of surface area, 43% of patients with hematomas 25 to 50% of nail surface, and 10% in those with less than 25% of nail bed surface involvement.(75) The DIP joint should be evaluated for flexion and extension range of motion.

Middle and Proximal Phalangeal and Metacarpal Fractures

Prior to fracture manipulation, physical examination includes evaluation of digital nerves using two point discrimination or pin prick, tendon and ligament integrity with active and passive range of motion at each joint, vascular status with capillary refill, and surrounding soft tissue structures of affected areas.(77) Finger shortening or knuckle depression may be present. Bone alignment should be checked for rotational deformity by finger flexion of hand, with the nails pointing toward the scaphoid tubercle. The natural alignment will be disrupted if a rotational fracture is present, such that one finger will overlap another.

Distal Forearm Fractures

Comprehensive physical examination for traumatic injuries at the wrist as well as elbow, shoulder, neck, head, and hip should be included. Examination of the injured wrist and hand should include neurological and vascular exam, as well as testing for tendon and ligament integrity. The ulnar styloid should be palpated for tenderness as well as the radial head. TFCC should be suspected for displaced or complex fractures, and DRUJ instability may be noted dependent on extent of pain and nature of fracture.

Ganglion Cyst

Wrist ganglia are usually well demarcated, firmly tethered, and have a consistency similar to a rubber ball, and are translucent. Lack of translucency should raise suspicion of other tumor type. The mass and surrounding skin should be inspected and palpated for erythema and infection. Examination should also include close inspection for mass effect, including neurovascular involvement, impairment of wrist or finger joint range of motion, impairment of tendon function, and triggering. Small occult dorsal wrist ganglia may result in tenderness over the scapholunate ligament and pain with hyperextension of the wrist.(292)

Hand-Arm Vibration Syndrome

A complete examination should include close attention to motor, sensory and vascular functions of the affected extremities. Evaluation should be extended to the shoulder and neck for upper extremity symptoms including tests for vascular insufficiency. Particular note should be made for blanching, coordination of movement, grip strength, tenderness and swelling of the digits and forearm tissue, and trophic changes of the skin. The value of cold provocation or neurophysiological tests in the diagnosis is controversial.(293, 294)

Laceration Management

Close inspection of the wound should be performed under proper lighting. Control of bleeding may be required, generally by applying appropriate pressure and elevation to the wound. The wound should be evaluated for damage to underlying structures including joint involvement, vessels, tendons, bone and nerves. Sensory examination should be accomplished prior to anesthetic administration. Examination of involved muscles should be conducted if nerve injury is suspected. Close inspection should be made for foreign bodies.

Human Bites, Animal Bites and Associated Lacerations

The wound should be carefully cleaned and inspected for depth of injury, potential associated crush injury or fracture, tendon or tendon sheath involvement, foreign body (e.g., teeth, fur, soil), and joint space involvement.

Hand/Finger Osteoarthrosis

Mild cases may show few, if any abnormalities. However, as the disease progresses, more findings develop. Boney enlargement of the affected joint(s) is present on inspection and range of motion is usually reduced. The most commonly affected joint is the thumb carpometacarpal (CMC) joint, which may become enlarged and deformed. Boney enlargement of the distal interphalangeal joints is termed “Heberden’s nodes” while of the proximal interphalangeal joints is called “Bouchard’s nodes.” Crepitus on range of

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motion is often present. Joints are generally not warm, have no significant joint effusion and are usually non-tender.

Diagnostic Criteria

The criteria presented in the Diagnostic Criteria for Hand, Wrist, or Forearm Disorders table (Table 4) list the probable diagnosis or injury, potential mechanism(s) of illness or injury, symptoms, signs, and appropriate tests and results to consider in assessment and treatment.

Table 4. Diagnostic Criteria for Hand, Wrist, or Forearm Disorders

Probable Diagnosis or Injury	Unique Mechanism (includes only physical factors; in some cases there are other factors)	Unique Symptoms	Unique Signs	Tests and Results
Ligament Sprain	Acute excess loading, generally from falling onto an extremity. Increased pain with motion.	Focal pain in ligament	Tenderness over ligament(s) Pain or weakness on strength testing of the affected ligament(s)	X-rays (normal)
Tuft Fracture	Crush injury to distal phalangeal segment	Pain and deformity of tip of digit. May have subungual hematoma or other deformity(ies)	Crush injury to tip of digit	X-rays with tuft fracture.
Mallet Finger	Forceful flexion of DIP joint while digit is extended. Ball striking tip of digit or digit extended during fall. Some rupture spontaneously, usually over a Heberden's node from osteoarthrosis.	Unable to extend digit at DIP joint. Usually pain-free if no accompanying fracture.	Incapable of extension at DIP joint. May be swollen, particularly with fracture	X-ray occasionally may show fracture, but usually normal. May not have fracture if extensor mechanism ruptured without fracturing bone
Myotendinous Strain	Unaccustomed forceful use. May be from acute loading or fall. Worse pain with motion	Focal pain at a discrete myotendinous junction	Tenderness over myotendinous junction. Pain or weakness on strength or resistance testing of the affected myotendinous junction. Crepitus on motion particularly if accompanied by tenosynovitis or peritendinitis.	None
Tendinosis/ Tendinitis/ tenosynovitis	High force and repetition, stereotypical awkward motions, combinations of physical factors Direct pressure (unusual) Blunt trauma (rare) (Diagnosis of "tendinitis" also frequently used as a diagnostic label for "pain" without pathophysiological correlation.)	Pain localized to flexor or extensor compartment. Triggering may be present if digital flexor compartment involved	Tenderness over discrete flexor or extensor compartment tendon (usually not more than 1 or 2 compartments) Synovial thickening Triggering or locking Crepitus Pain or weakness on strength testing of the affected tendon	None
De Quervain's Tenosynovitis	High force and repetition with forceful wrist and thumb motion Direct pressure (unusual) Blunt trauma (rare)	Pain over radial styloid in area of first dorsal compartment	Tenderness over radial styloid Mass over radial styloid (rare) Crepitus over extensor compartment Thick tendon sheath	None

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			Pain upon passive abduction Triggering (rare) Pain worse with ulnar deviation, thumb flexion, adduction, stretch of first dorsal compartment (Finkelstein test)	
Trigger Finger, Trigger Thumb	High force and repetition Blunt trauma (rare)	Triggering Pain at volar metacarpal phalangeal joint Locked finger	Triggering Tender volar metacarpal crease Tendon nodule Synovial thickening of specific parts of flexor retinaculum	None
Carpal Tunnel Syndrome	High force and repetition, combinations of physical factors Vibration (Associated factors include cold temperatures and glove use. Posture is unclear factor, thought to be a relatively weak factor.)	Numbness/tingling in thumb, index, middle, radial half of ring finger, especially at night or with activity Volar hand pain radiating into forearm may be present. Decreased grip strength Difficulty picking up small objects Hand symptoms diagram	Atrophy or decreased strength of abductor pollicis brevis, opponens (advanced cases) Decreased sensation in median nerve distribution (including monofilaments)	Electrodiagnostic studies
Ulnar Neuropathy at the Wrist and Hypothenar Hammer Syndrome	Repeated striking of the heel of the hand/hypothenar region on a tool or object	Pain in hypothenar region, blanching of ulnar artery distribution (especially 5th digit), Paresthesias in small and ring fingers	Tender hypothenar region, blanching of ulnar artery distribution (especially 5th digit), decreased sensation in small and ring fingers	Ulnar artery Doppler/ultrasound, electrodiagnostic studies
Hand-Arm Vibration Syndrome	Repeated, prolonged use of low-frequency, high-amplitude vibrating tool, especially in cold environments	Pain in the fingers, episodic finger blanching	Blanching of fingers, worse with cold provocation. Ulceration of finger tips when severe.	None
Nonspecific Pain	Unknown as condition is idiopathic; possibly resulting from combination of risk factors. May be psychological condition.	Pain, but non-specific	None	None
Ganglion	Unknown	Painful or painless mass on wrist, hand, or any other joint	Tender (or non-tender) mass most commonly over dorsal or volar wrist or hand	None

Special Studies and Diagnostic Considerations

For most patients presenting with non-traumatic hand, wrist, and forearm disorders, special studies are not needed during the first 4 weeks. Most patients improve quickly, provided red flag conditions are ruled out. Exceptions include the following:

- In cases of wrist injury, with tenderness over the scaphoid (especially over the scaphoid tubercle), but minimal other findings, a scaphoid fracture may still be present. Initial radiographic images should be obtained, but may appear negative in the presence of nondisplaced scaphoid fracture. If clinical symptoms continue, a re-evaluation with new radiographs is advised in approximately 2 weeks.

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- An acute injury to the metacarpophalangeal joint of the thumb, accompanied by tenderness on the ulnar side of the joint and laxity when that side of the joint is stressed (compared to the other side), may indicate a gamekeeper's thumb or rupture of the ulnar collateral ligament of the MCP joint. Radiographic images may show a fracture or stress views, if obtainable, may show laxity. The diagnosis may necessitate surgical repair of the ligament and surgical referral is warranted.

Also, of note, a number of patients with hand, wrist, and forearm symptoms will have associated disease such as diabetes mellitus, hypothyroidism, renal disease, and one or more of the arthritides which are often heretofore undiagnosed. When medical history and/or physical examination findings indicate or other risk factors are present, testing for these or other comorbid condition(s) is recommended.

Work-Relatedness

There are numerous occupational and non-occupational risk factors for hand, wrist, and forearm (upper limb) musculoskeletal disorders (MSDs).(6, 12, 196-198, 201, 202, 205, 206, 208-210, 212, 232, 295, 296) Most available quality evidence has been reported on CTS, with sparse information on other disorders. While some risk factors (e.g., age, obesity,(175, 213) diabetes mellitus, and metabolic syndrome(297)) generally appear in common with most MSDs, other risk factors do not appear in common across the disorders (e.g., low density lipoprotein,(298) thyroid disorders, pregnancy). The lack of common risk factors across the spectrum of disorders raises questions about the accuracy of generalizing any risk factor, whether occupational or non-occupational across all disorders. Some of these inconsistencies among studies may also be due to lack of statistical power to identify relationships between these factors and upper extremity MSDs.(29, 145, 175, 213, 215, 217, 299, 300)

Work-relatedness of hand, wrist and forearm MSDs is dependent on the precipitating exposure(s). For acute, traumatic injuries (e.g., dislocations, true ligamentous sprains, mallet finger, fractures), the work-relatedness is determined by whether the inciting event occurred out of, or in the course of employment. Such determinations of work-relatedness are rarely difficult or controversial.

Non-traumatic MSDs (e.g., CTS, tendinoses, tendinitis, trigger digit) are often difficult to attribute to work to a medical degree of certainty. There are many retrospective studies of these CTS and tendinoses. However, recently there are several prospective cohort studies evaluating risk. One cohort in industrial and clerical workers found the greatest predictors of upper extremity tendinosis were older age, body mass index over 30, shoulder or neck discomfort at baseline, history of CTS and a higher shoulder posture rating.(300) Another prospective study of production workers reported associations of hand/wrist tendonitis to repeated forceful pinching at work.(301) A prospective study of automobile workers found increased risks for incident cases of CTS included a history of wrist/hand/finger tendinoses, diabetes mellitus, nonneutral wrist and elbow postures, lower social support, and greater differences between baseline median and ulnar nerve peak latencies across the wrist.(185) One cohort study of repetitive work in Denmark found incidence rates over 3 to 4 years were too low to compare the risk among those doing highly repetitive work (0.62%) versus more variable work (0.44%).(302) However, combinations of forceful and repetitive hand activities at work as combined in the American Conference of Governmental Industrial Hygienists hand-activity level have been found to increase risk of CTS in several prospective studies(145, 146, 213, 216, 218, 219, 303) which is consistent with findings from numerous cross sectional studies.(197, 199, 204, 207, 304-310) Attributable CTS risk from high-risk occupations in France is estimated to range from 36 to 93%.(311)

A thorough work history is crucial to a foundation for establishing work-relatedness. Determining whether a complaint of a hand, wrist, or forearm disorder is related to work requires a careful analysis and weighing of all associated or possible causal factors operative at the time.(232, 312) A predominance of work factors suggests that worksite evaluation may be appropriate.

A broad range of ergonomic surveys and instruments is available for measuring range of activity, strain, weights, reach, frequency of motion, flexion, and extension, as well as psychological factors such as organizational relationships and job satisfaction (e.g., Motion Time Measurement analyses, ACGIH TLV for Hand Activity Level, Strain Index).(143, 313, 314) However, physicians should be aware that currently,

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no job evaluation method has been fully validated. Nevertheless, documentation of job physical factors in conjunction with adverse health effects is often necessary to facilitate and substantiate engineering and organizational changes (see individual sections for discussions of work-relatedness of specific hand, wrist and forearm disorders).

Carpal Tunnel Syndrome

There are numerous occupational and non-occupational risk factors for CTS, as well as other hand, wrist, and forearm musculoskeletal disorders.(197, 199, 204, 211, 212, 232, 296, 304, 306) Many studies on CTS have not used objective measures that included electrodiagnostic testing in case definitions, rather they relied solely on symptoms or combinations of symptoms and physical examination findings (e.g., Hoffman-Tinel's sign).(197)

A thorough work history is crucial to a foundation for establishing work-relatedness (see Work-Relatedness Guideline for a method to determine work-relatedness). Non-occupational risk factors that have been most consistently identified in numerous studies for CTS include age, gender, body mass index (BMI), diabetes mellitus, and wrist depth/width ratio.(6, 12, 196-198, 201, 202, 205, 206, 208-211, 295, 311, 315-318) Physicians should also be aware of the high prevalence of CTS in the general population, its strong relationship with age, and the relatively high prevalence of nerve conduction abnormalities in the population, some of which are asymptomatic.(319) Determining whether a complaint of a hand, wrist, or forearm symptoms are related to work requires a careful analysis and all associated or possible causal factors operative at the time must be weighed.(232, 312) A predominance of work factors suggests that worksite evaluation is likely appropriate and intervention may also be appropriate. A careful ergonomic assessment, work management, and other preventive measures are also suggested when a cluster of cases in a work group occurs.

Based on recent prospective studies, the sustained or repeated application of forceful pinching or gripping is thought to be the most potent work-place activity related risk factor for CTS and hand or wrist tendinosis, particularly when combined with high rates of repetition.(145, 146, 185, 213, 216, 218, 219, 301) The risk appears present when pinch forces are greater than 10 N (1kg).(204, 216, 301) Carpal tunnel syndrome risk appears most strongly increased in jobs involving high-force gripping such as meat processing, manufacturing, and farming.(311, 320-322)

Keyboard use is often a highly repetitive, but very low-force task with very different physical exposures than non-computer work and having many mostly retrospective epidemiological studies previously reported.(302, 318, 323-336) Prospective cohort studies have failed to find associations between CTS and keyboard use,(318, 323, 337, 338) however, one of these studies reported increased risk with increased mouse use in both its baseline/cross-sectional analyses and cohort analyses.(323) Case-control studies have reported conflicting results, with one reporting reduced risk with increased hours spent typing(326) and one reporting increased risk with typing more than 4 hours per day.(333) In several large prospective studies, increasing hours of computer work was associated with tendinosis, de Quervain's disease, and non-specific hand, wrist, forearm and elbow, neck and shoulder pain.(337, 339, 340) Split keyboards have been associated with reduction in pain and disorders.(341, 342)

Triangular Fibrocartilage Complex (TFCC) Tears

Work-relatedness of an acute TFCC tear sustained in the course of a slip, trip, fall, or heavy and awkward lift at work is generally considered an occupational injury and is not usually controversial, although apportionment is a consideration in applicable jurisdictions due to the prevalence of pre-existing degenerative abnormalities, as well as presence and degree of ulnar positive variance (longer ulna than radius, which is thought to be a risk factor for TFCC tears). However, other TFCC tears occurring without an acute, inciting event are of unclear etiology, as the injuries are more analogous to a disease or disorder and there is no quality epidemiological evidence to link them with work. Chronic TFCC tears in the presence of a positive ulnar variance are generally not thought to be occupational.

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Acute Trauma, including Fractures (e.g., scaphoid, phalangeal, distal forearm), Crush Injuries, Compartment Syndrome, Subungual Hematomas, Lacerations, and Animal Bites

Causation is based on the specific major incident that produced the injury. Wrist sprains do not occur without an acute, precipitating significant mechanism of injury.

Kienböck Disease

This disorder is a disease without sound epidemiological support for work-relatedness. It may be reasonable to hypothesize work-relatedness in those cases where the onset is promptly after a discrete, significant traumatic event. However, in most cases, a physical cause is speculative.

Mallet Finger

Work-relatedness is generally non-controversial and is based on having an acute accident at work. However, in cases without precipitating injury, work-relatedness is speculative.

Flexor Tendon Entrapment (Tenosynovitis and Trigger Digit)

As the epidemiological evidence is weak, the etiological fraction for occupational tasks is unknown.(37) Thus, work-relatedness is somewhat unclear.(232) The available biomechanical evidence suggests pinch force may be a risk factor.(35, 40, 190, 192, 234-245)

Extensor Compartment Tenosynovitis (Including de Quervain's Stenosing Tenosynovitis and Intersection Syndrome)

Work-relatedness is thought to be present in a significant proportion of cases,(277, 343, 344) although more recent studies have suggested less work-relatedness.(232) Risk factors have not been confirmed in cohort studies, but are thought to particularly involve combinations of force, repetition and posture.(41, 277, 337, 343-345) Direct trauma over the affected extensor compartment is reported in a minority of cases.(41) Risks for intersection syndrome are not well defined. Purported risks appear to be high-force sports related particularly if unaccustomed including rowing, canoeing, racket sports, and weight lifting.(346, 347) Work tasks reported to be risks appear similar with intensive agricultural workers (threshing, planting, hammering, hand washing, spraying, cementing)(43) and recent job change to supermarket cashiering being examples of reported risks.(348) Discontinuation of the high force, unaccustomed activity has been frequently reported to resolve intersection syndrome.(43, 45, 349, 350) Increasing hours of computer work has been associated with extensor compartment tenosynovitis, de Quervain's disease, and non-specific wrist and forearm pain.(337, 339) Those risks may be due to contact stress at the wrist or sustained wrist postures. Split keyboards, which reduce awkward postures, have been associated with reduction in pain and disorders.(341, 342)

Ulnar Nerve Entrapment at the Wrist (Including Guyon's Canal Syndrome and Hypothenar Hammer Syndrome)

Ulnar neuropathy at the wrist is reportedly most often caused by a space occupying lesion such as ganglion, scar, abnormal ulnar artery or aneurysm, and trauma(51, 57, 63) (i.e., resulting from hamate fracture). Experimental studies suggest that the nerve moves within the canal with wrist motion, thus traction on the nerve may be possible.(64) In a case series of 47 patients, suspected "cumulative trauma" was attributed to nearly 75% of cases. However, no definition or quantification of physical factors was given. Activities included both mechanisms with potential significant localized compression (e.g., cycling, wheelchair use), those without apparent compression (e.g., piano, truck driving), and those that may or may not have involved compression (e.g. boiler operator, machine press operator, and steel cutter).(50) Other described causes include aberrant muscles at the wrist affecting both median and ulnar nerves,(351) and distal neuropathy caused by systemic diseases, particularly diabetes mellitus and systemic sclerosis (scleroderma).(352-354) As there are no quality epidemiological studies among non-traumatic patients, work-relatedness is speculative in those populations.

Radial Nerve Entrapment

Radial neuropathy at the wrist is reportedly caused by local mechanical compression of the nerve at the wrist from external trauma, a tight wrist or forearm band, or anomalous brachioradialis tendon.(61, 62) It

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has been attributed to repeated wrist flexion and ulnar deviation, however, there is no quality epidemiological evidence and thus when occurring in the absence of trauma, work-relatedness is speculative. There may be a better basis for work-relatedness for radial neuropathy with entrapment just above the wrist in the context of concomitant de Quervain's tenosynovitis that is considered work-related.

Non-Specific Hand/Wrist/Forearm Pain

Work-relatedness is unclear as there are no quality studies of this condition. However, it is generally recommended that the condition be treated and it will generally resolve. Thus, in the absence of costly testing and/or treatment protocols or prolonged duration, the condition is generally non-controversial.

Ganglion Cyst

No quality epidemiological studies have shown work relatedness. However, ganglia may be accepted as work related in some legal jurisdictions. In a cross-sectional survey of more than 30,000 workers in the 1988 National Health Interview Survey, the prevalence of clinical ganglion cyst was estimated at 14%.(113) Of all cases, it was estimated based on patient report of physician diagnosis that nearly 6% were attributed to work. However, there were no analyses based on occupation or activity. There were no quality epidemiologic studies addressing work place or occupational physical factors.

Hand Arm Vibration Syndrome

Work-relatedness is based on confirmation of the diagnosis and a mechanism of occupational injury where there is an appropriate exposure which is generally low frequency high amplitude vibration.

Hand/Finger Osteoarthrosis

There is one cross sectional study from the textile industry that suggests some cases of hand osteoarthrosis may have a component of occupational tasks;(355) however, those jobs are likely no longer present in the U.S. In most patients, multiple joints are symmetrically affected. Yet, occupational exposures are frequently not symmetrical and do not explain this association, thus these cases are usually believed to be non-occupational. However, there are cases of monoarticular osteoarthrosis occurring in a joint affected by a remote, traumatic event such as a fracture involving the joint or adjacent to the joint, dislocation or significant sprain. Work-relatedness of those cases is generally non-controversial as it is believed to be a consequence of the acute traumatic event.

Job Analysis

Some hand, wrist, and forearm symptoms are occupational in origin, with the occupational aspect differing by industry, job task, or by the disorder in question. Decisions about which jobs to analyze, and their prioritization, is of increasing importance as the proportion of affected individuals has been identified as in excess of 50% of the workforce per annum in settings of combinations of high force and high stereotypical occupational activity. In general, prioritization of job analyses in workplace settings is based on the numbers of affected individuals, reported and perceived rates of MSDs, costs and severity of the disorders, and planned job redesigns. From an occupational health care perspective, ergonomic analysis of a job may also be indicated for failure to improve in the absence of other plausible explanations. The employer's role in accommodating activity limitations and preventing further problems through ergonomic changes may be a key factor in hastening the employee's return to full activity, particularly among workers with a history of high job physical factors. In some cases, it may be desirable to conduct an ergonomic analysis of the activities that may be contributing to the symptoms.

Carpal Tunnel Syndrome

In certain cases, conduct an ergonomic analysis of the activities that may be contributing to the symptoms should be conducted. A broad range of ergonomic surveys and instruments is available for estimating duration of hand intensive activities, grasp repetition rates, pinch force, part or tool weights, reach distance, frequency of motion, wrist and hand postures, as well as psychological factors such as organizational relationships and job satisfaction.(313) As the most robust data support two of those ergonomic instruments, it would appear most wise to utilize one or both of them (i.e., American Conference of Governmental Industrial Hygienists Threshold Limit Value for Hand Activity,(218, 356) and Strain Index(314)). Such

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detailed measures may be necessary or useful for modifying work activity, selecting tools, redesigning the workstation, or recommending organizational and management initiatives. Such situations may call for referral to certified professional ergonomists or a human factors engineer, either through the patient or the employer. Some occupational therapists, physical therapists, occupational medicine physicians and other professionals also may have appropriate credentials and experiences to accomplish these evaluations.

Triangular Fibrocartilage Complex (TFCC) Tears

Job analysis is generally not indicated for most cases, particularly if the focus of the analysis is unclear. However, where there is potential to eliminate a hazard that precipitated the event (e.g., slippery surface), job analysis is recommended.

Acute Trauma, including Fractures (e.g., scaphoid, phalangeal, distal forearm), Crush Injuries, Compartment Syndrome, Subungual Hematomas, Lacerations, and Animal Bites

Job analyses may be of benefit to attempt to prevent future occurrences of these types of injuries (e.g., machine guarding, icy walkways, tool kickback). Some of these, particularly compartment syndrome and fractures should generally be analyzed for root cause and potential remediation, as these injuries are generally viewed as critical incident cases.

Kienböck Disease

As physical risk factors are undefined, job analyses are unhelpful.

Mallet Finger

Job analysis is generally not indicated for most cases, although where there is potential to eliminate a risk for slips, trips of falls it should be resolved.

Flexor Tendon Entrapment (Tenosynovitis and Trigger Digit)

Job analyses may be useful for evaluating for forceful finger use and localized contact stress (e.g., compression by sharp objects).(35, 40, 190, 192, 234-245) There is now prospective evidence that the Strain Index is predictive for trigger digit.(29)

Extensor Compartment Tenosynovitis (Including de Quervain's Stenosing Tenosynovitis and Intersection Syndrome)

Job analyses may be useful to identify repeated, forceful digit use, sustained extreme digit postures, or localized compression by sharp objects.

Ulnar Nerve Entrapment at the Wrist (Including Guyon's Canal Syndrome and Hypothenar Hammer Syndrome)

Job analyses may be useful to identify tasks involving considerable hypothenar area localized mechanical compression, as well as us of the hand as a hammer.

Radial Nerve

Job analysis may be useful to identify tasks involving external compression of the radial nerve at the wrist due to occupational tasks.

Non-Specific Hand, Wrist, or Forearm Pain

Job analysis is difficult for many of these conditions, particularly as the discrete entity to be evaluated and job analysis methods are unclear. However, job analyses may also be revealing particularly when there is a high exposure situation (i.e., high force or combinations of high force and other ergonomic risk factors). This may be especially indicated where other cases of musculoskeletal disorders are present in the workforce and may help with the treatment plan.

Ganglion Cyst

There is no quality evidence that the cause of these cysts is work related, thus job analyses are not generally indicated.

Hand Arm Vibration Syndrome

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Job analyses are generally indicated for cases with this diagnosis, particularly for primary, secondary and tertiary prevention. The analyses are fairly technical and usually require special equipment to measure vibration exposures.

Hand/Finger Osteoarthrosis

Job analysis is generally not indicated for most cases, although where there is potential to eliminate a hazard that precipitated an acute event (e.g., icy sidewalk, tripping hazards), it should be resolved. There have been no quality job analysis tools developed to analyze jobs for risk of hand osteoarthrosis.

Ergonomic Interventions for Distal Upper Extremity Musculoskeletal Disorders with an Occupational Basis

In order to facilitate recovery and prevent recurrence of distal upper extremity musculoskeletal disorders, one may recommend work and activity modifications or ergonomic redesign of the workplace.(357) The employer's role in accommodating activity limitations and preventing further problems through ergonomic changes is crucial in hastening the employee's return to full activity. In some cases it may be desirable to conduct an ergonomic analysis of the activities that may be contributing to symptoms. A broad range of ergonomic surveys and instruments is available for estimating duration of hand intensive activities, grasp repetition rates, pinch force, part or tool weights, reach distance, frequency of motion, and wrist and hand postures, as well as psychological factors such as organizational relationships and job satisfaction. Such detailed measures may be necessary or useful for modifying activity, redesigning the workstation, or recommending organizational and management relief. Such situations may call for referral to a certified ergonomist or a human factors engineer. Alternate keyboard layouts have been used to reduce disorders.(358-361)

1. *Recommendation: Ergonomic Interventions for CTS and Common Distal Upper Extremity Tendinoses*
   In settings with combinations of risk factors (e.g., high force combined with high repetition), ergonomic interventions are recommended to reduce risk factors for CTS and common distal upper extremity tendinoses.

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – Low

2. *Recommendation: Typing Posture for Prevention and Treatment of CTS and Common Distal Upper Extremity Tendinoses*
   Mandating typing in a 90° traditional posture is not recommended for prevention or treatment of CTS and distal upper extremity tendinoses.

   Strength of Evidence – **Not Recommended, Evidence (C) – Prevention**
   Not Recommended, Insufficient Evidence (I) – Treatment
   Level of Confidence – Low

3. *Recommendation: Split Keyboards for Treatment of Common Distal Upper Extremity Tendinoses*
   The use of alternate or split keyboards is recommended among select patients with common distal upper extremity tendinoses.

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – Low

4. *Recommendation: Forearm Support for Typing to Prevent Neck/Shoulder Symptoms*
   Forearm support for frequent computer keyboard users is recommended for potential prevention of neck and/or shoulder symptoms (see Figure 1).

   Strength of Evidence – **Recommended, Evidence (C)**
   Level of Confidence – Low

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Figure 1. Forearm Support for Typing

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5. *Recommendation: Trackballs for Treatment of Select Patients with CTS*
   A trackball (instead of a mouse) is recommended for treatment of select patients with symptoms of CTS (see Figure 2).

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – Low

Figure 2. Trackball

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6. *Recommendation: Computer Typing Breaks for Patients with CTS, Other Common Extensor and Flexor Hand/Wrist Tendinoses, or for Primary Prevention*
   Computer typing breaks are recommended for select patients with symptoms of CTS or other common extensor and flexor hand/wrist tendinoses as well as for primary prevention.

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – Low

7. *Recommendation: Ergonomics Training in Moderate- or High-risk Manufacturing Settings*
   Ergonomics training is recommended in moderate- or high-risk manufacturing settings.

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – Low

8. *Recommendation: Ergonomics Training for Prevention of MSDs in Office Settings*
   There is no recommendation for or against the use of ergonomics training for the prevention of MSDs in office settings.

   Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**
   Level of Confidence – Low

Rationale for Recommendations
Ergonomics interventions have been attempted in numerous occupational settings.(362-365) Randomized controlled trials (RCTs) of changes to manufacturing and production positions have not been reported. However, a few RCTs have been reported of keyboard workstations ("office ergonomics").(342, 362, 363, 366) There is one RCT regarding comparing a dental pick and finding lower pain in the group with the lighter tool that has a wider handle.(365) There also have been quality studies reported regarding participatory ergonomics programs. However, those are mainly reports of patients with spine disorders in programs whose purpose is return to work (see Low Back Disorders Guideline).(367) Despite the lack of quality evidence in most settings, reductions in job physical factors, particularly high force, are thought to be beneficial(365, 368) (see Work-Relatedness). There also are experimental studies of different equipment,(369) although reductions in injuries have not been shown in quality studies.

There are no quality studies of ergonomic interventions for common distal upper extremity MSDs in physically demanding occupations. Interventions which reduce forceful, repeated pinching or alleviating localized compression by sharp objects may be theoretically helpful.(35, 40, 190, 192, 234-245) Quality evidence is not available for effectiveness of ergonomic interventions on MSD injury rates in typical manufacturing settings. However, given available evidence of risk factors, interventions are recommended

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where there are combinations of risk factors; particularly combined high force and high repetition (see Work-Relatedness). Management/supervisor and labor/employee support are often necessary for optimal success of these programs.

Quality evidence has reported no beneficial effects of the 90° typing posture (seated erect, feet on floor, knees, hips, and elbow joints all at 90° angles), instead it has been found to have the same injury rates as a “laid back” posture.(366) “Ergonomic keyboards” involve a split design that produces a neutral wrist posture in comparison with a standard keyboard that requires approximately 15° of ulnar deviation. However, those keyboards have not been reported in quality studies to result in injury reductions, with the exception of a physically split keyboard with sharply angled keyboard faces (Figure 3).(362) Evidence of superiority of these interventions is currently weak. Providers should be aware that not all split designs are equivalent and there is evidence that a widely split keyboard with sharply angled keyboard faces is not well tolerated.(342) Additional quality studies are needed. Forearm supports for typing have been reported to result in fewer neck/shoulder symptoms.(363, 370) Quality evidence suggests reductions in symptoms may be realized from use of a trackball; however, providers should also be aware that there was a small, non-statistically significant increase in pain complaints among a minority of users.(363) This suggests that careful worksite or clinical observation, combined with instructions to discontinue use if symptoms materially increase, may be desired during this intervention. It also suggests that having multiple options available for workstations is desirable. Quality evidence suggests reductions in neck/shoulder symptoms may be realized through utilization of a forearm support.(363, 370)

Breaks from computer typing have been addressed in a low-quality study which reported reductions in symptoms, but no additional benefit from utilizing exercise during breaks.(371) Various types of breaks have been utilized including stretching breaks and exercise programs.(372, 373, 374, 375-380) Quality evidence supporting the efficacy of breaks is weak, especially for symptomatic patients.(371-373) One low-quality randomized study among an apparently asymptomatic population of temporary data-entry workers suggested fewer symptoms among those taking breaks; however, compliance was low (ranging from 25 to 39%). Breaks are not invasive, have no substantial adverse effects, are low cost, and do not appear to impair productivity.(371, 373, 378, 380-385) Widespread use of these programs has not been reported in quality studies; however, with no apparent significant cost impacts and studies suggesting potential benefits, breaks are recommended for both primary prevention and treatment of symptomatic patients.

While quality evidence is lacking for the use of ergonomics training, it is thought to be beneficial in high-risk settings. One study suggested that training is inferior to a combination of other interventions in an office setting(363) and another found benefits for the neck, but not distal upper extremity.(386) Thus, other benefits of training may be possible. However, an RCT comparing wrist splinting with ergonomic education found splinting superior.(387) Thus, if there is a benefit, it may be modest, and it is suggested that such training should consist of quality information.

Figure 3. Split Keyboard

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Evidence for the Use of Ergonomic Interventions

There is 1 high-(365) and 5 moderate-quality(342, 362, 363, 366, 370) RCTs incorporated into this analysis. There are 4 low-quality RCTs(372, 388-390) in Appendix 2.

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Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Rempel 2012 Cluster RCT Sponsored in part by grant from National Institute for Occupational Safety and Health (CDC). No mention of COI.	8.0	N = 110 (100 females/10 males) dentists and dental hygienists. Mean±SD age: narrow handle 42.9±10.8 years; wide handle 46.6±9.8 years.	Heavy Instrument, Narrow Handle (34g, 8mm diameter handle) (n = 56) vs. Light Instrument, Wide Handle (14g (curette tips and 11mm–diameter handle) (n = 54). Follow-up for 4 months.	Mean (SEM) adjusted score change shoulder pain: Heavy instrument 0.19 (0.16) vs. light instrument 0.52 (0.17); p = 0.02. Mean (SEM) adjusted score change wrist/hand pain: Heavy instrument 0.14 (0.17) vs. light 0.40 (0.18); p = 0.15.	"To prevent or reduce arm pain, practitioners should consider using lightweight instruments with large diameters when performing scaling and root planning procedures."	Data suggest use of wider handled and lighter instrument associated with improved pain scores for distal upper extremity and shoulder.
Rempel 1999 RCT Sponosred by Northwest Trade Adjustment Assistance Center and by Key Tronic Corporation. No mention of COI.	7.5	N = 20 (13 females/7 males) with hand or wrist symptoms who used keyboard ≥10 hours per week. Mean age 42.6 years.	Keyboard A-Protouch keyboard, Key Tronic Corporation) (n = 12) vs. Keyboard B-MacPro Plus keyboard with 2-ounce rubber domes, Key Tronic Corporation (n = 12). Both keyboards were of conventional layout (101 keys). Follow-up for 3 months.	Pain ratings significantly lower (p = 0.05) for keyboard A (6 weeks: 2.7 vs. 2.9; 12 weeks: 1.9 vs. 4.3).	"We conclude that use of keyboard A for 12 weeks led to a reduction in hand pain and an improved physical examination finding when compared with keyboard B."	Small sample size. Keyboard associated with fewer symptoms required modestly greater force (0.71N vs. 0.58N) and greater displacement (1.69mm vs 0.58mm) to activate. Suggests lower typing force may not be helpful.
Rempel 2006 RCT Sponosred in part by a grant (RO1 OH04253) from Centers for Disease Control/National Institutes for Occupational Safety and Health. COI: Dr Rempel has done consulting work for Logitech Corp., company which markets trackball tested in the study.	5.5	N = 182 (173 females and 8 males) customer service works who perform 20 hours or more of computer work per week. No neck, shoulder or upper extremity workers compensation claims. Mean Age was 40.02 years.	Ergonomic Training only: included conventional recommendations such as chair height and position (n = 46) vs Ergonomic training and trackball (n = 45) vs Ergonomic training and arm board-arm board is wraparound, padded arm support that attaches to top, front edge of work surface (n = 46) vs Ergonomic training and trackball and arm board (n = 45). Follow-up for 1 year.	Sixty-three (63) participants diagnosed with 1 or more incident MSDs. 12 month incidence rates for any upper body MSD by intervention group (47.7% vs. 35.7% vs. 29.5% vs. 31.8%). Adjusted hazard rate ratios for armboard for neck/shoulder disorders (HR = 0.49, 95% CI 0.24 to 0.97), reduced neck/shoulder pain (p = 0.01) and right upper extremity pain (p = 0.002).	"Providing a large forearm support combined with ergonomic training is an effective intervention to prevent upper body musculoskeletal disorders and reduce upper body pain associated with computer work among call centre employees."	Dropout rate 31.3%. Return on investment estimated at 10.6 months.

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Conlon 2008 RCT No mention of sponsorship or COI.	5.0	N = 206 (57 females/149 males) engineers who worked at a computer for at least 20 hours per week. Mean Age 42.87 years.	Conventional Mouse Group (n = 52) vs. Alternative Mouse Group- neutral forearm posture (n = 52) vs. Board and conventional mouse- Forearm support board (n = 51) vs. Board and alternative mouse- Forearm support board (n = 52). Follow-up for 1 year.	No significant differences for use of an alternative mouse or use of forearm ergonomic support board vs. use of conventional mouse for both crude and adjusted hazard ratios (p> 0.05). Unadjusted model showed significant decrease in discomfort score in right upper extremity using forearm support board; -0.41 (-0.83 to -0.001) (p ≤0.05).	"In engineers who use a computer for more than 20 h per week, a forearm support board may reduce right upper extremity discomfort attributed to computer use."	No meaningful differences in outcomes between conventional mouse and experimental mouse designs.
Gerr 2005 RCT Sponsored by the US National institute for Occupational Safety and Health. No COI.	4.5	N = 362 (279 females/83 males) workers who operated a computer for at least 15 hours or more per week. Age ≥18 years.	Group A: Alternate Intervention based on protective factors for both neck/shoulder and hand/arm (n = 122) vs. Group B: Conventional Intervention based on recommendations from OSHA, NIOSH and private industry (n = 125) vs. Group C-Control group, no intervention (n = 115). Follow-up for 6 months.	Among other differences, alternative involved greater elbow extension and keyboard position further recessed from edge of desk. No significant differences in distal upper extremity or neck/shoulder symptoms (p >0.05).	"This study provides evidence that two specific workplace postural interventions are unlikely to reduce the risk of upper extremity musculoskeletal symptoms among computer users."	Suggests 90° posture not superior.
Tittiranonda 1999 RCT No mention of sponsorship or COI.	4.5	N = 80 (46 females/34 males) with CTS and/or tendonitis. Mean age 43.65.	Placebo Group- Standard Keyboard (slope 8.0°) (n = 20) vs. Keyboard 1- Apple adjustable keyboard (slope 3.8 to 7.0°) (n = 20) vs. Keyboard 2- Comfort Keyboard System (slope -44.0 to 38.5°) (n=20) vs. Keyboard 3- Microsoft natural keyboard (slope 5.5 or -2.6°) (n = 20). Follow-up for 6 months.	High dropouts among keyboard that was completely split in two with sharply angled, but somewhat adjustable slopes. Changes in overall pain severity: placebo (-0.29±1.5) vs. split1 (0.52±2.0) vs. split/sharply angled (0.84±1.9) vs. split2 (1.21± 3.1), p = 0.11. More differences present in tendonitis subgroup (p = 0.088) than CTS (p = 0.57).	"These results provide evidence that keyboard users may experience a reduction in hand pain after several months of use of some alternative geometry keyboards."	CTS and tendinitis were combined. Dropouts high in keyboard group with widely separated hands and more steeply angled surfaces.

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Return-To-Work Programs

Return-to-work programs have not been well studied among patients with hand, wrist, or forearm injuries (see Chronic Pain Guideline for discussion of principles). Several studies suggest that job physical demands, lack of job accommodation, and psychosocial conditions are the most important factors in predicting work disability.(391-393)

1. *Recommendation: Return-to-Work Programs for Subacute or Chronic Hand, Wrist, or Forearm MSDs*
   Return-to-work programs are recommended for treatment of subacute or chronic hand, wrist, or forearm MSDs, particularly patients with significant lost time.

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – Moderate

2. *Recommendation: Return-to-Work Programs for Acute Hand, Wrist, or Forearm MSDs*
   Return-to-work programs are not recommended for treatment of acute hand, wrist, or forearm MSDs.

   Strength of Evidence – Not Recommended, Insufficient Evidence (I)
   Level of Confidence – Moderate

Rationale for Recommendations
There are no quality studies that review the types of return-to-work programs typically found in the U.S. There is one quality study from Spain;(394) however, most patients had spine disorders and the program otherwise may have limited applicability due to longstanding, early active management of these issues in the U.S. These programs are thought to reduce morbidity and improve function. They are not invasive, have minimal potential for adverse effects, and are not costly. Return-to-work programs are recommended for management of select patients with hand, wrist, and forearm musculoskeletal disorders with lost time, and may be helpful for proactive emphases on functional recovery.

Evidence for the Use of Return-to-Work Programs
There is 1 moderate-quality RCT incorporated into this analysis.(394) There is one other study(395) in Appendix 2 (see Chronic Pain Guideline for additional studies).

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Abasolo 2007 RCT Sponsored by grants from Fondo de Investigaciones Sanitarias of the Spanish Ministry of Health. No mention of COI.	4.0	N = 13,077 (gender not specified) workers on sick leave with diagnossi of MSD. Mean age for intervention and control groups: 40.8 and 40.6.	Multifaceted intervention program vs non-interventional control	Mean durations of temporary work disabilities for CTS patients (n = 74) 100.4 in controls vs. 27.8 days in intervention group ($p < 0.001$).	"The implementation of this type of specialist-run, protocol-based early intervention program would be very beneficial in the treatment of patients with work disability related to MSDs, except for those with knee pain (excluding osteoarthritis)."	Scored for CTS patients within trial. Overall participation rate 62.8%.

Work Activities

Key factors to consider in disability duration are age and job activities. By communicating with patients and employers, physicians can make it clear that:

- Forceful repetitive grasping may increase forearm, hand, and wrist symptoms.
- Modified work and workplace activity guides may allow for recovery or time to (re)build activity tolerance through exercise.

Significant reductions in unnecessary lost work time can occur when the patient, physician, and employer work together to develop and apply modified work activities.(396-398, 399,400)

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Carpal Tunnel Syndrome

Some physicians place work restrictions on patients with CTS; others do not. There is no quality evidence to suggest that restrictions are required.

Recommendation: Work Restrictions for CTS

For patients with CTS, it is recommended that their work be restricted to those tasks that do not involve high-force, stereotypical hand gripping or pinching or the use of high acceleration vibrating hand-held tools.

Indications – Select patients with combined forceful and repeated, stereotypical use of the hands or use of high amplitude vibrating tools. Of note, these types of jobs involve a minority of patients with CTS.

Indications for Discontinuation – Resolution, lack of improvement, or desire of the patient to remove limitations.

Strength of Evidence – **Recommended, Insufficient Evidence (I)**
Level of Confidence – Moderate

Rationale for Recommendation

There are no quality studies evaluating workplace restrictions; thus, whether patients improve more quickly with activity limitations has not been proven. However, based on available evidence associating combined forceful and repeated, stereotypical use of the hands or use of high amplitude vibrating tools with CTS, work restrictions are recommended for select patients with CTS. These types of jobs involve a minority of patients with CTS. Restrictions are not invasive, likely have few adverse effects, and may be moderate to high cost depending on length.

Evidence for Work Restrictions

There are 5 moderate-quality RCTs incorporated into this analysis. (342, 362, 363, 366, 370) There are 2 low-quality RCTs in Appendix 2.(389, 390)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL and Cochrane Library without date limits using the following terms: work restriction, ergonomics, carpal tunnel syndrome, median neuropathy, CTS, carpal tunnel, median nerve, compression, entrapment, neuropathy, nerve disease, syndrome, burning, tingling, itching, numbness, hand, palm, finger, pain controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 37 articles in PubMed, 609 in Scopus, 13 in CINAHL, and 45 in Cochrane Library. We considered for inclusion 3 from PubMed, 3 from Scopus, 1 from CINAHL, 0 from Cochrane Library and 6 from other sources. Of the 13 articles considered for inclusion, 7 randomized trials and 6 systematic studies met the inclusion criteria.*

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Author/Year Study Type Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Rempel 1999 RCT Sponsored by Northwest Trade Adjustment Assistance Center and by Key Tronic Corporation. No mention of COI.	7.5	N = 20 (13 females/7 males) with hand or wrist symptoms who used a keyboard ≥10 hours per week. Mean age 42.6 years.	Keyboard A- Protouch keyboard, Key Tronic Corporation) (n = 12) vs.Keyboard B-MacPro Plus keyboard with 2-ounce rubber domes, Key Tronic Corp. (n = 12). Both keyboards conventional layout (101 keys). Follow-up for 3 months.	Pain ratings significantly lower (p = 0.05) for keyboard A (6 weeks: 2.7 vs. 2.9; 12 weeks: 1.9 vs. 4.3).	"We conclude that use of keyboard A for 12 weeks led to a reduction in hand pain and an improved physical examination finding when compared with keyboard B."	Small sample size. Keyboard associated with fewer symptoms required modestly greater force (0.71N vs. 0.58N) and greater displacement (1.69mm vs 0.58mm) to activate. This suggests lower typing force may not be helpful.
Rempel 2006 RCT Sponosred in part by grant from Centers for Disease Control/National Institutes for Occupational Safety and Health. COI: Dr Rempel has done consulting work for Logitech Corp., company which markets trackball tested in study.	5.5	N = 182 (173 females/8 males) customer service works who perform 20 hours or more of computer work per week. No neck, shoulder or upper extremity workers compensation claims. Mean age 40.02 years.	Ergonomic Training only: Included conventional recommendations such as chair height and position (n = 46) vs. Ergonomic training and trackball (n = 45) vs. Ergonomic training and arm board- arm board is a wraparound, padded arm support that attaches to the top, front edge of work surface (n = 46) vs. ergonomic training and trackball and arm board. Follow-up for 1 year.	Sixty-three (63) participants diagnosed with 1 or more incident MSDs. 12 month incidence rates for any upper body MSD by intervention group (47.7% vs. 35.7% vs. 29.5% vs. 31.8%). Adjusted hazard rate ratios for armboard for neck/shoulder disorders (HR = 0.49, 95% CI 0.24 to 0.97), reduced neck/shoulder pain (p = 0.01) and right upper extremity pain (p = 0.002).	"Providing a large forearm support combined with ergonomic training is an effective intervention to prevent upper body musculoskeletal disorders and reduce upper body pain associated with computer work among call centre employees."	Dropout rate 31.3%. Return on investment estimated at 10.6 months.
Conlon 2008 RCT No mention of sponsorship or COI.	5.0	N= 206 (57 females/149 males) engineers who worked at computer for at least 20 hours per week. Mean age 42.87 years.	Conventional Mouse Group- (n = 52) vs. Alternative Mouse Group- neutral forearm posture (n = 52) vs. Board and conventional mouse- Forearm support board (n = 51) vs. Board and alternative mouse- Forearm support board (n = 52). Follow-up for 1 year.	No significant differences for use of alternative mouse or forearm ergonomic support board vs. use of conventional mouse for crude and adjusted hazard ratios (p>0.05). Unadjusted model showed significant decrease in discomfort score in right upper extremity using forearm support board; -0.41 (-0.83 to -0.001) (p ≤0.05).	"In engineers who use a computer for more than 20 h per week, a forearm support board may reduce right upper extremity discomfort attributed to computer use."	No meaningful differences in outcomes between conventional mouse and experimental mouse designs.

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Gerr 2005 RCT Sponsored by US National institute	4.5	N = 362 (279 female/83 male) workers who operated a computer at least 15 hours or more per week. Age ≥18 years.	Group A: Alternate Intervention- based on protective factors for both neck/shoulder and hand/arm (n = 122) vs. Group B: Conventional Intervention based on recommendations from OSHA, NIOSH and private industry (n = 125) vs. Group C- Control group, no intervention (n = 115). Follow-up for 6 months.	Among other differences, alternative involved greater elbow extension and keyboard position further recessed from edge of desk. No significant differences in distal upper extremity or neck/shoulder symptoms (p>0.05).	"This study provides evidence that two specific workplace postural interventions are unlikely to reduce the risk of upper extremity musculoskeletal symptoms among computer users."	Suggests 90° posture not superior.
Tittiranonda 1999 RCT No mention of sponsorship or COI.	4.5	N = 80 (46 female/34 male) with CTS syndrome and/or tendonitis. Mean age 43.65 years.	Placebo Group- Standard Keyboard (slope 8.0°) (n = 20) vs. Keyboard 1: Apple adjustable keyboard (slope 3.8-7.0°) (n = 20) vs. Keyboard 2: Comfort Keyboard System (slope -44.0-38.5°) (n = 20) vs. Keyboard 3: Microsoft natural keyboard (slope 5.5 or -2.6°) (n = 20). Follow-up for 6 months.	High dropouts among keyboard that was completely split in two with sharply angled, but somewhat adjustable slopes. Changes in overall pain severity: placebo (-0.29±1.5) vs. split1 (0.52±2.0) vs. split/sharply angled (0.84±1.9) vs. split2 (1.21± 3.1), p = 0.11. More differences present in tendonitis subgroup (p = 0.088) than CTS (p = 0.57).	"These results provide evidence that keyboard users may experience a reduction in hand pain after several months of use of some alternative geometry keyboards."	CTS and tendinitis were combined. Dropouts were high in the keyboard group with widely separated hands and more steeply angled surfaces.

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Triangular Fibrocartilage Complex (TFCC) Tears
TFCC tears may not require work limitations. However, the more forceful the work and more significant the symptoms, the more likely work limitations will be needed. Work limitations typically include reducing forceful use, wrist rotation, or other activities that provoke symptoms.

Crush Injuries and Compartment Syndrome
These injuries generally require work limitations depending on task demands. More severe cases require time away from work for recovery from surgery, pain management, and generally require a gradual resumption of usual activities dependent on injury severity and rate of healing.

Kienböck Disease
There is no evidence that work restrictions are helpful, yet as the condition often progresses, patients typically incur increasing degrees of disability with a progressive need for work limitations. Advanced cases generally require temporary removal from work and surgery, with return to work post-operatively. Post-operative limitations are generally based on a combination of the clinical results (i.e., severity of pain and symptoms) and work demands. Patients with light to medium work may require no limitations, while those with medium to heavy work, particularly with post-operative pain may require significant limitations.

Wrist Sprains
This injury may or may not require work limitations depending on task demands. However, moderate to severe wrist sprains likely necessitate splinting and limitations.

Mallet Finger
This injury requires splinting; however, whether there is any need for work limitations involving the digit other than a requirement to wear the splint continuously is unclear. Provided there is no difficulty with wearing the splint, no work limitations are generally needed.

Flexor Tendon Entrapment (Tenosynovitis and Trigger Digit)
Whether work limitations are indicated or helpful is unknown, but may be reasonable for select cases, particularly where contributions from physical factors are more probable such as localized compression from sharp objects or tools.

Extensor Compartment Tenosynovitis (Including de Quervain's Stenosing Tenosynovitis and Intersection Syndrome)
Job modifications are thought to be needed in most of these work-related cases to facilitate recovery.(42)

Recommendation: Modification of Work Activities for Extensor Compartment Tenosynovitis
Removal from job tasks thought to have caused extensor compartment tenosynovitis is recommended.

Indications – Patients with combined forceful and repeated use of the hands or combined use with substantially non-neutral wrist postures.

Indications for Discontinuation – Resolution, lack of improvement, or desire of the patient to remove limitations.

> *Strength of Evidence* – **Recommended, Insufficient Evidence (I)**
> *Level of Confidence* – Low

Rationale for Recommendation
There are no quality studies evaluating the modification of work activities for extensor compartment tenosynovitis. However, where occupational factors are significant, a trial of removal from that type of work may be indicated.(43, 45, 349)

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Ulnar Nerve Entrapment at the Wrist (including Guyon's Canal Syndrome and Hypothenar Hammer Syndrome)

Job modifications are thought to be needed in some cases to facilitate recovery.

Recommendation: Modification of Work Activities for Ulnar Neuropathy
Removal from job tasks thought to have caused ulnar neuropathy at the wrist is recommended.

Indications – Patients with forceful use of the hand, especially use of the hand as a hammer with striking of the hypothenar area and development of hypothenar hammer syndrome.

Indications for Discontinuation – Resolution, lack of improvement, or desire of the patient to remove limitations.

> *Strength of Evidence* – **Recommended, Insufficient Evidence (I)**
> *Level of Confidence* – Low

Rationale for Recommendation
There are no quality studies evaluating the modification of work activities for ulnar neuropathies at the wrist. However, where occupational factors are significant, especially for patients with hypothenar hammer syndrome, a trial of removal from that type of work may be indicated.

Radial Nerve Entrapment

Job modifications are thought to be needed in a few cases to facilitate recovery.

Recommendation: Modification of Work Activities
Removal from job tasks thought to have caused radial neuropathy at the wrist is recommended.

Indications – Patients with radial neuropathies thought to be caused by an ongoing job physical exposure (e.g., striking the radial nerve).

Indications for Discontinuation – Resolution, lack of improvement, or desire of the patient to remove limitations.

> *Strength of Evidence* – **Recommended, Insufficient Evidence (I)**
> *Level of Confidence* – Low

Rationale for Recommendation
There are no quality studies evaluating the modification of work activities for radial neuropathies at the wrist. However, where occupational factors are significant, a trial of removal from that type of work may be indicated.

Non-Specific Hand/Wrist/Forearm Pain

Non-specific pain may or may not require work limitations depending on task demands. For patients with high exposures, work limitations are more likely to be helpful. However, in the absence of high force or high force combined with other ergonomic factors, work limitations are at times counterproductive because they enforce debility and do not produce meaningful improvements. In those settings, work limitations may be trialed; however, in the absence of improvement, resumption of regular work activities may be helpful for long-term functional gain.

Scaphoid Fracture

Activities should be modified to allow for the splinting and immobilization of the carpal bones. In a moderate-quality study comparing surgical fixation to non-operative treatment,(401) the mean range of time for Scottish patients with non-displaced scaphoid fracture to return to normal daily activities living with non-operative treatment was 1 week for dressing, 1 week for washing, 2.8 weeks for shopping, and 2.7 weeks for housework. The mean time for returning to full employment was 11.4 weeks, and to full sports 15.5 weeks. The mean return time of the operative group was not statistically different except to full employment and full sports, which were 3.8 weeks and 6.4 weeks respectively.(401) While operative fixation of non-displaced scaphoid fracture may reduce short term disability, there is a reported 11-fold increased risk of scaphotrapezial arthritis compared with those non-operatively treated.(402)

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Distal Phalanx Fractures and Subungual Hematoma

All work activities that can be accomplished while wearing a finger splint are appropriate. Athletes may return to sports after the initial swelling and pain have resolved, approximately 7 to 10 days. Activities requiring full distal joint mobility and forceful use may be delayed as long as 4 to 6 weeks. Residual tenderness may be present for up to 6 months.(78)

Middle and Proximal Phalangeal and Metacarpal Fractures

Activities restrictions should provide for immobilization of affected finger or hand, but otherwise activities should be allowed.

Distal Forearm Fractures

Functional restrictions of the affected extremity are limited by immobilization technique. Activities should be modified to allow for splinting and immobilization of the forearm. Return to work will likely be influenced by the patient and provider's subjective assessment of disability and perception of job difficulty. It may be helpful to refer the patient to an occupational therapist to address the appropriate activity modification, compensatory strategies, adaptive equipment, and environmental modification throughout the period of the patient's recovery and rehabilitation.

Ganglion Cyst

There is no indication for limiting work activity except for ganglia that are causing significant pain, as there is no reported strong association between activity and exacerbation or causation of ganglia. Those with considerable pain may require limitations to avoid activities provoking increased symptoms, most typically involving forceful use.

Hand-Arm Vibration Syndrome (HAVS)

1. *Recommendation: Vibration Exposure Work Restrictions for HAVS*
   For patients with HAVS, it is recommended that their work be restricted to those tasks that do not involve high-amplitude, low-frequency vibration exposures from hand-held tools.

   Indications – HAVS from high-amplitude, low-frequency vibration exposures through vibrating hand-held tools.

   Indications for Discontinuation – Resolution or desire of the patient to remove limitations. If the exposure(s) are confirmed and the clinical findings are significant, re-exposure is not believed to be indicated.

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – Moderate

2. *Recommendation: Cold Exposure Work Restrictions for HAVS*
   For select patients with HAVS, it is recommended that their work be restricted to those tasks that do not involve cold exposures.

   Indications – HAVS that is not controlled through avoidance of vibration exposures, or patients having recurring problems with vasospasm or other complications that are unresolved with other treatments.

   Indications for Discontinuation – Resolution or desire of the patient to remove limitations.

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – Moderate

Rationale for Recommendations

Limitation of exposure to total vibration dose should be achieved particularly by limiting the duration and frequency to high-amplitude, low-frequency vibration. Reducing transmission of vibration through isolation and damping techniques may also be attempted, although in a patient with established HAVS, avoidance is generally preferable. Avoidance of cold temperatures that provoke symptoms or wearing gloves if sufficient to control symptoms is warranted.(127) Anti-vibration gloves are sometimes utilized.

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Recognition and reduction of other ergonomic factors including repeated and sustained exertion, forceful exertions, contact stress, and stressful postures may be helpful.

Laceration Management

There are no quality studies on return to work and restrictions for upper extremity laceration repair. Movement of injured body parts is thought to promote earlier recovery and minimize disability. Most patients should be able to return to work with appropriate task specific restrictions while the wound is healing. Accommodation for prescribed medications, elevation, splinting and modalities such as use of heat or ice may be necessary. While there is no quality evidence for any of these modalities, keeping the wound dry for the first few days, splinting, elevation, and heat or ice are simple techniques that are believed to be helpful. Splinting is generally limited to extensor surface lacerations that cross a joint and involve sufficient tension to pull wound edges apart.(403)

Human and Animal Bites

Work activities are expected to be minimally impacted except for limitations related to treatment of laceration or infection.

Hand/Finger Osteoarthrosis

Hand osteoarthrosis generally requires no work limitations. When the disease progresses to moderate or severe disease, work limitations may be required due to the impairment and or pain.

Initial Care

Initial treatment should generally be guided by implementing the strongest evidence-based recommendations that are considered first-line interventions. Exceptions include those treatments that are accepted as best practices, but have not been subjected to RCTs or crossover trials (e.g., antibiotics for diabetics with “dirty” lacerations). Careful consideration of the indications and limitations described in the full text for each recommendation is critical to understanding the best application for each intervention. If treatment response is inadequate (i.e., if symptoms and activity limitations continue), second- and third-line recommendations may be considered. Physicians should consider the possibilities of diagnosed and previously undiagnosed medical diseases such as diabetes mellitus, hypothyroidism, and various arthritides. Adverse effects, cost, and provider and patient preferences should be considerations in guiding the choice of recommendations. Part of the initial treatment plan for all disorders should include patient education. For most diagnoses, this is critical to successful treatment.

Recommendation: Education for Hand, Wrist, or Forearm Disorders
Education is recommended for select patients with hand, wrist, or forearm disorders.

Frequency – One or 2 appointments for educational purposes. Additional appointments may be needed if education is combined with occupational or physical therapy treatments. Follow-up educational visit(s) for more severe disorders as part of a progression towards normal functional use is sometimes helpful.

> *Strength of Evidence* **– Recommended, Insufficient Evidence (I)**
> *Level of Confidence* – Low

Rationale for Recommendation
There are no quality studies specifically evaluating efficacy of patient education for utility or necessity in treatment of hand, wrist, or forearm disorders. Yet, for many disorders (e.g., criticality of maintaining splinting of mallet finger, cast management, monitoring for signs of infection) education appears essential. Some physicians accomplish this in the course of extended patient visits, while others routinely refer patients to an occupational or physical therapist for education. Regardless of the approach, a few appointments for educational purposes are recommended for select patients. The number of appointments is dependent on the diagnosis, severity of the condition, and co-existing conditions. Although education is usually incorporated as part of the overall treatment plan, an additional 1 or 2 appointments for purely educational purposes may be helpful midway through a treatment course for the more severely affected patient. In addition, education is low cost and thus is recommended.

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Follow-up Visits

Patients with potentially work-related hand, wrist, and forearm symptoms should generally have a follow-up visit approximately every 3 (severe disorders) to 7 days (typical disorder severity) to monitor function, medication use and/or a physical or occupational therapist visit for counseling regarding contributing physical factor avoidance (e.g., reducing force, avoiding static positions), sleep posture, and other concerns. More frequent follow-up is usually required for patients who are not working. Care should be taken to answer questions and make these sessions interactive so that the patient is involved in his or her recovery including identifying potential barriers to recovery and return to normal function and work. More specific guidance for follow-up visits may be included in the discussion of each disorder topic.

Amputations and Indications for Replantation

The decision for amputation or replantation should be made by a physician who has training and experience in treating amputations and replantations. The key for the initial physician or health care provider is to reduce the warm ischemia time of the amputated part – the time without any preparation of the amputated part. This is best done by washing the amputated part in saline and wrapping it in saline soaked gauze, putting it into a plastic bag if possible, and then placing it onto cardboard that is laid over ice in a cooler or jug. The part of the body where the amputation has occurred should be covered with a compression dressing. Vascular control is important. Attempts to use clamps to control bleeding often damage the neurovascular structures and should not be used. Indicators that are used to suggest replantation success include thumb amputation, multiple digit amputations, amputation at a metacarpal amputation, almost any body part amputated in a child, wrist or forearm amputation, and individual digit amputated distal to flexor digitorum superficialis (FDS) insertion.

Contraindications may include ring avulsion injuries, severely crushed or mangled parts, amputations at multiple levels, amputations in patients with other serious injuries or diseases, arteriosclerotic vessels, mentally unstable patients, distal amputations (finger tip injuries), individual finger in adult proximal to the FDS insertion and prolonged warm ischemia. Prolonged warm ischemia is defined as more than 6 hours for proximal replantations (wrist), and 12 hours for digits, although some physicians will attempt replantation after 6 hours of warm ischemia, and 24 to 30 hours ischemia time (time from amputation until replant with the digit stored in cool container as described above) for digital replantations.

Carpal Tunnel Syndrome (CTS)

Diagnostic Criteria

Patients with a presumptive diagnosis of CTS should have both paresthesias in the median nerve distribution and symptoms that are either nocturnal or provoked. Paresthesias are tingling or numbness in a median nerve distribution, (vibrotactile testing has been utilized to attempt to objectify sensory findings, but appears to not perform particularly well)(404) generally involving at least two median nerve-served digits (they may also have pain – pain is not the primary symptom, there is also some evidence for more non-neurologic pain in workers' compensation patients(405)– or burning in a median nerve distribution, but should have paresthesias); and 2) symptoms that are provoked either nocturnally or with sustained grasp (e.g., holding a tool, steering wheel or newspaper).

Patients with a confirmed diagnosis of CTS should have both symptoms as with a presumptive diagnosis above, and either: 1) a confirmatory electrodiagnostic study (EDS) interpreted as consistent with CTS, or 2) largely or completely resolved symptoms with injection of a glucocorticosteroid.

The differential diagnosis for carpal tunnel syndrome (CTS) particularly includes pronator syndrome; C6 and C7 cervical radiculopathies; and other neurological entrapments located between the spinal cord and median nerve in the carpal canal including thoracic outlet syndrome, diabetic neuropathy, neuropathy from alcohol, other systemic neuropathies, stroke, other cerebrovascular events, and central nervous system tumors. Most other causes may be eliminated or the probability reduced by conducting a careful history, physical exam, or focused testing.

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Special Studies and Diagnostic and Treatment Considerations

ELECTRODIAGNOSTIC STUDIES

Appropriate electrodiagnostic studies (EDS), including nerve conduction studies (NCS), may help differentiate CTS from other conditions such as cervical radiculopathy, other median nerve neuropathies, or ulnar neuropathy at the elbow.(10, 177, 180, 183, 184, 406-448) In select or more difficult cases, especially if cervical radiculopathy is a concern, electromyography (EMG) studies should be incorporated.(406) NCS and EMG may be normal particularly in some mild cases of CTS. If EDS are negative, tests may be repeated later in the course of treatment if symptoms persist. It is also important to recognize that electrodiagnostic studies are abnormal in a large proportion of patients who are without symptoms and thus without CTS.(171) Thus, EDS testing in a patient with a low pre-test probability of CTS may result in inappropriate diagnosis of CTS. EDS has been purportedly not useful in diagnosing clear-cut CTS cases.(449)

The American Association of Electrodiagnostic Medicine, the American Academy of Neurology, and the American Academy of Physical Medicine and Rehabilitation jointly published a practice parameter for electrodiagnostic studies in CTS.(406) However, the quality of EDS varies widely in practice(450) and this practice guideline is sometimes not adhered to, requiring the treating physician to be familiar with these issues to better interpret the findings in a clinical context. Additionally, cut-off points for abnormal values have yet to be fully standardized and the correlations between symptom severity and EDS severity are not uniformly strong.(11, 167) In patients with suspected CTS where electrodiagnostic confirmation would alter treatment plans, the following EDS studies are recommended (in the majority of these studies, the hand temperature should be 32°C or warmer):(406)

1. Perform a median sensory NCS across the wrist with a conduction distance of 13 to 14cm. If the result is abnormal, compare the result of the median sensory NCS to the result of a sensory NCS of one other adjacent sensory nerve in the symptomatic limb.
2. If the initial median sensory NCS across the wrist has a conduction distance greater than 8cm and the result is normal, one of the following additional studies is recommended:
   a. Comparison of median-sensory- or mixed-nerve conduction across the wrist over a short (7 to 8cm) conduction distance to the ulnar sensory-nerve conduction across the wrist over the identical 7 to 8cm conduction distance, or
   b. Comparison of median sensory across the wrist with ipsilateral radial or ulnar sensory conduction across the wrist, or
   c. Comparison of median sensory or mixed nerve conduction through the carpal tunnel to sensory or mixed NCS of proximal or distal segments of the ipsilateral median nerve.
3. Motor conduction study of the median nerve recording from the thenar muscle and of one other ipsilateral nerve with distal latency.
4. Optional comparisons may include ipsilateral median-ulnar motor nerve distal latencies and median-ulnar motor conduction differences.
5. Needle EMG is optional as it is primarily used for evaluation of cervical radiculopathy.(406)

1. Recommendation: EDS for Diagnosis and Pre-operative Assessment of CTS

Quality EDS (see above) are recommended to assist in securing a firm diagnosis for those patients without a clear diagnosis of CTS. EDS are also recommended to objectively secure a diagnosis of CTS prior to surgical release in workers compensation patients.(451) **If EDS is elected, in most cases of CTS, only the sensory and motor conduction studies are necessary for diagnosis confirmation. If the examination is more complex, then addition of the EMG component of the EDS should be obtained.**

Strength of Evidence – **Recommended, Evidence (C)**
Level of Confidence – Moderate

2. Recommendation: EDS for Initial Evaluation of CTS Patients

EDS is not recommended for initial evaluation of most CTS patients with a confirming history and clinical signs as it does not change the management of the condition. EDS is also not

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recommended prior to glucocorticosteroid injection as a good history and clinical suspicion is believed to be sufficient to warrant the intervention which would not likely be altered by EDS.

Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
Level of Confidence – High

3. *Recommendation: Commercial Products for Performing EDS for CTS Patients*
Automated devices to accomplish EDS is recommended for highly selected CTS patients.(452, 453)

Indications – EDS that is not readily obtainable by an American Board of Electrodiagnostic Medicine-certified electrodiagnostician (e.g., geographic distance). There also should be no concern about other potentially confounding conditions such as cervical radiculopathy.

Strength of Evidence – **Recommended, Evidence (C)**
Level of Confidence – Low

Rationale for Recommendations
EDS are the only unequivocally objective measures of median nerve function.(10, 406, 451, 454-456) However, there are both false-positive and false-negative test results that demand that the physician understand the pre-test probabilities and be capable of interpreting the results and placing them in an appropriate clinical context. For example, EDS should not be ordered in settings where the clinical history suggests a low likelihood of CTS because the probability of a false-positive test result may be well above 50%. EDS are primarily of assistance in: 1) identifying an anatomic location of nerve conduction slowing; 2) identifying objective evidence for alternate diagnostic considerations (e.g., cervical radiculopathy); and 3) quantifying nerve function to assure the physician that an operative state such as CTS is present. EDS are not invasive or minimally invasive (depending on whether the EMG component is required), have minimal adverse effects, and are high cost. They are recommended for evaluation of select cases, especially if the diagnosis is unclear or surgery is planned.

There are other commercial diagnostic products;(452, 453, 457, 458) and some studies have suggested there may have sufficient accuracy,(445, 452) however, there are relatively few studies available and thus the use of these studies may be currently limited to where there is both no concern about radiculopathy and other disorders and the EDS test is not readily available (e.g., due to distance geographical issues).

Evidence for the Use of Electrodiagnostic Studies
There are 20 moderate-quality studies incorporated into this analysis.(319, 445, 451-453, 455, 456, 459-471) There are 4 low-quality studies in Appendix 2.(472-475)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL and Cochrane Library without date limits using the following terms: electrodiagnostic studies, nerve conduction study (NCS), electromyography (EMG); carpal tunnel syndrome, median neuropathy, CTS, carpal tunnel, median nerve, compression, entrapment, neuropathy, nerve disease, syndrome, median nerve, median neuropathy; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 96 articles in PubMed, 371 in Scopus, 23 in CINAHL, and 23 in Cochrane Library. We considered for inclusion 20 from PubMed, 30 from Scopus, 5 from CINAHL, 6 from Cochrane Library and 30 from other sources. Of the 91 articles considered for inclusion, 67 trials and 7 systematic studies met the inclusion criteria.*

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Author/Year Study Type	Score (0-11)	Population/ Case Definition	Investigative Test	Gold Standard / Comparative Test	Results	Conclusion	Comments
Dale 2015 Diagnostic Sponsored by CDC/NIOSH and Washington University Institute of Clinical and Translational Sciences Award (CTSA) grant from NCATS of NIH. No COI.	7.0	N = 62 (19 females and 43 males) subjects that originally underwent NC-Stat automated NCS; mean age 33.66 (9.43).	NC-Stat an automated Nerve Conduction Studies (NCS) machine	Traditional NCS using a NeuroMax 1002 device in an electrodiagnostic lab.	Higher agreement between Median nerve parameter rather than Ulan nerve parameter. Highest reciever operating curve (ROC) area 0.97 and 0.96 for median nerve parameter. 100% sensitivity and 74% specificity for Ulnar Distal Motor latency and Distal sensory latency. Highest specificity in median ulnar sensory difference, 100%.	"In conclusion, the NC-stat device has been previously shown to have excellent agreement with traditional methods of median nerve testing in clinical populations; this study shows that this excellent agreement extends to use in a general worker population with low prevalence of disease."	Study reports automated nerve conduction study was comparable to the traditional EDS for detection of median nerve conduction abnormalities in a general worker population.
Buch-Jaeger 1994 Diagnostic No mention of sponsorship or COI.	7.0	N = 112 with signs of carpal tunnel, 60 bilaterally. Patients confirmed through clinical analysis.The mean age of 52 years, ranging from 29-81 years.	Nerve Conduction studies (NCS), positive when distal motor latency in the abductor brevis muscle was greater than 4ms.	Clinical evaluation focusing on 11 different criteria including paraesthesiae in territory of median nerve, occasional pain, nocturnal recrudescene of symptoms, numbness leading to clumsiness of hand, Phalen's test, Tinel's test, dealt, Vibratory sensibility, Thershold sensibility, Gilliat's test, McMurthry's sign, Static 2-point discrimination.	NCS positive in 68 cases (61%) and negative in remaining 44 cases (39%). Of negative NCS patients, 10 spontaneously recovered, 4 unchanged, 5 had symptoms after heavy tasks, 3 thought to be malingering, and 20 diagnosed with other disease. Of NCS confirmed CTS group 33 had surgical findings; 40 (93%) had complete disappearance and intervention.	"Our findings suggest that typical clinical features and positive provocation tests are not sufficient to lead a surgeon to decompress the carpal tunnel, and we feel that electrodiagnostic examination is necessary in every case."	Study supports nerve conduction studies to be a key component in diagnosis of CTS as other clinical tests have fair sensitivity and specificity.

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Atroshi 2003 Diagnostic Sponsored by research grants from the Skåne and Kristianstad County Councils. No mention of COI.	7.0	N = 125 (gender not specified) CTS group and symptomatic controls with possible/unlikely CTS (n = 155) and asymptomatic Control group (n = 124) no signs of CTS (n = 124) Mean age 51±14. All participants collected from 3,000 sample in Sweden. Mean age 52 ± 13.	Bilateral Nerve Conduction Tests including median nerve distal motor latency (M) DML. Long Finger-wrist sensory latency, and sensory conduction velocity (SCNV) in forearm, wrist-Palm, and palm digit segments. Also an ulnar nerve small finger-wrist sensory latency.	Patients clinically diagnosed using Phalen's Test, Tinels Test, recurrent numbness or tingling, and filled out a hand diagram.	Receiving operating Characteristic (ROC) area under curve Median-ulnar nerve SL difference test (Area (95% CI)): 0.80 (0.01-0.08) (p=0.004). Median-ulnar nerve digit-wrist SL difference had a sensitivity of 70%, specificity of 82%, a Positive predictive value of 19%, and a negative predictive value of 98%.	"Using the clinical diagnosis of CTS as the criterion standard, nerve conduction tests had moderate sensitivity and specificity and a low positive predictive value in population-based CTS. Measurement of median-ulnar sensory latency difference had the highest diagnostic accuracy."	Study suggests nerve conduction study to diagnose CTS had only modest sensitivity and specificity and measuring the median-ulnar sensory latency difference was a better predictor of true CTS diagnosis.
Leffler 2000 Diagnostic	6.5	N = 75 symptomatic hands referred to electrophysiological lab; Mean age 49 ± 12 vs. n = 22 asymptomatic volunteers.	An automated electro diagnostic device (AEND).	A conventional diagnostic device conducted within a lab by a neurologists.	Linear regression showing AEND and conventional results correlation was 0.90 (p <0.001). AEND sensitivity for very symptomatic hands 89% specificity 90%. Lower severe had sensitivity of 87%, also 90% specificity.	"This study demonstrated that the Distal Motor latency provided by an AEND is highly correlated with the Distal Motor Latency obtained by conventional testing."	Study suggests MNW diagnosis is improved with addidtion of AEND as compared to modeling based solely on clinical findings.
Graham 2008 Diagnostic	6.5	N = 143 clinically diagnosed with with CTS	Standard electrodiagnostic tests, Sensory nerve conduction by technician and evaluated by neurologist, use of stringent and Lax criteria used to confirm CTS.	CTS-6 evaluation which is a clinical diagnosis aid.	Using CTS-6 the pretest probability was 0.81 ± 0.22. After the Stringent Criteria posttest probability was 0.91 and Lax was 0.83. Average change in probability was -0.02 ± 0.10 with stringent and -0.06 ± 0.16 with lax.	"For the majority of patients who are considered to have carpal tunnel syndrome on the basis of their history and physical examination alone, electrodiagnostic tests do not change the probability of diagnosing this condition to an extent that is clinically relevant."	Study suggests if there is a high CTS probability based on history and physical exam, electrodiagnostic tests do not change the probability of this diagnosis to a clinically meaningful extent.

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Pastare 2009 Diagnostic	6.5	N = 66 consecutive patients investigated for sensory hand symptoms. Mean Age; 51 years	Nerve Conduction Studies vs. Ultrasound	Clinical Diagnosis of CTS	Nerve Conduction studies showed greater diagnostic sensitivity than ultrasound; 54 wrists 82% vs. 41 62% for highly likely clinical diagnosis of CTS.	"In summary, our study shows that NCS have better sensitivity in supporting a diagnosis of CTS. However, because of its high positive predictive value, lack of discomfort, and ease of use, US can be used as a screening method for CTS."	Reports nerve conduction studies superior to sonography in detecting CTS. But, sonography may be used as first-line screening tool if clinical index of suspicion for CTS is high.
Nathan 1993 Diagnostic	6.5	N = 2,334 hands of industrial workers, workers' compensation patients, and students. Mean age 40.6 years.	Maximum latency difference (MLD) determined by centimetric technique.	Clinical diagnosis of CTS. MLD was compared with 8-cm latency (S8) and 14-cm latency (S14).	MLD most sensitive measurement (86%) and had greatest efficiency of correct classification (84%). The S14 was most specific measurement (94%)	"Based on these findings, we recommend that confirmatory nerve conduction studies be performed in all cases where CTS is suspected."	Controls younger than CTS group. Study reports maximum latency difference (MLD) most reliable measurement for prediciting CTS. Study recommends nerve conduction studies be performed when high index of suspicion for CTS.
Lee 2009 Diagnostic	6.0	N = 153 with clinically suspected CTS. Mean age 52.5±12.3 vs. 100 clinically healthy volunteers; mean age 48.5±11.4.	Electrodiagnostic testing including Median Terminal latency differences, motor conduction study and sensory conduction study.	Clinical criteria and diagnosis was used as the parameter to test for sensitivity.	Sensitivity of top EDX testing: Wrist-Palm Sensory Conduction Velocity (SCV): 90.5%, Distal-Proximal ratio SCV 92.3%, Wrist-Digit 2 SCV 89.1%, Wrist-Digit 3 89.1%. Terminal Latency ratio of Wrist-Palm Motor conduction 81.8%.	"The terminal latency ratio of the wrist to the palm is a valuable technique for the diagnosis of carpal tunnel syndrome, and it requires only a simple additional stimulus compared to existing methods."	Study suggests median terminal latency ratio in the third finger as the most sensitive thechnique for detection of CTS.

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Concannon 1997 Diagnostic	6.0	N = 349 (460 hands) patients who underwent carpal tunnel release.	Electrodiagnostic Studies	N/A	398/460 hands had positive electrodiagnostic studies. 60 clinical CTS diagnosis but normal electro-diagnostic studies. Phalen's only significant test with regression coefficient: -0.91; OR 0.40 CI: 0.17 – 0.96 (p = 0.04). Indicated model predicts higher probability of negative electromyogram than positive electromyogram. 76% (n = 348) of affected hands had mild to moderate electrodiagnostic findings, 11% had severe CTS (n = 50), and 13% had normal electrodiagnostic findings. Patients who were older teneded to have severe electrodiagnostic findings (p = 0.0001). Significant association between gender and maximal electrodiagnostic findings (p = 0.02). Patients with severe CTS had highest incidence of muscle wasting (22%, p <0.02).	"[E]lectrodiagnostic studies in suspected carpal tunnel syndrome should be reserved for use in the patient with equivocal findings and should not be considered a necessary criterion when history and clinical examination provide this diagnosis."	Approximately 13% of patients receiving electrodiagnostic studies only to diagnose CTS would be excluded and should be used only in cases of equivocal findings.

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Chang 2006 Diagnostic	6.0	N = 280 suspected CTS patients (360 hands).	Median wrist–palm motor conduction velocity (W–P MCV)	Standard sensory conduction techniques	Abnormal hand number, sensitivity (%), and specificity (%) of Motor DL/ Sensory DL (D1)/ Sensory DL (D2)/ Sensory DL (D4)/ W–P MCV/ W–P SCV/ W–P SCT/ median–radial sensory latency difference/ median–ulnar sensory latency difference were: 234, 65, and 99.3/ 289, 80.3 and 98.7/ 261, 72.5 and 99.3/ 276, 76.7 and 100/ 294, 81.7 and 100/ 265, 73.6, and 100/ 291, 80.8 and 100/ 312, 86.7 and 98.7/ 314, 87.2 and 96.7	"W–P MCV is a valuable motor conduction technique for the diagnosis of CTS and it is confirmed again that W–P MCV is equal to or more sensitive than W–P SCV and W–P SCT."	Data suggest W-P-MCV as being a tool for electrodiagnosis of CTS with reported comparable sensitivity to W-R-SCV and W-P-SCT.
Wang 2013 Diagnostic	6.0	N = 162 CTS patients (248 hands) and 83 controls (166 hands).	Median-to-ulnar comparative Nerve conduction studies: Sensory median-ulnar difference (MS-US), Mixed median-ulnar palm latency difference (PM-PU), and Distal latency differences between second lumbrical and interossei (2L-INT).	N/A	168/248 (67.7%) hands had abnormal findings. 80 (32.3%) hands received 2L-INT, MS-US, and PM-PU additional tests. 88.3% symptomatic hands had at least an abnormal findings. The sensitivity of MS-US/ 2L-INT/ PM-PU were: >0.5 ms in 21.3% of hands/ >0.4 ms in 27.5% of hands/ >0.4 ms in 47.5% of hands. MP-UP had the greatest sensitivity in contrast to L2-INT and MS-US (p = 0.014 and p<0.001). Conventional EDX with PM-PU had a sensitivity of 83%.	"For CTS patients with normal results from the standard methods, PM-PU is a good additional comparative test to further improve diagnostic rate."	Data suggest PM-PU may be beneficial in testing CTS patients who tested normal from traditional testing methods to further identify true positives.

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Lew 2005 Diagnostic	5.5	control healthy hands; Mean Age 44.0 ± 12.9 (n = 44) vs. symptmatic hands suspected of CTS; Mean Age 51.5 ± 18.2 (n = 136).	Nerve Conduction Studies varying in segment length. Sensory Nerve conduction velocity of Long segment from wrist to Digiti 1, 2, 3, and 4. transcarpal mixed nerve conduction velocity of Short segement palm to wrist. Transcarpal sensory Nerve Conduction Velocity wrist-digit and palm to digit difference.	Nerve Conduction Study (NCS) results from control group.	Average Sensitivity of the different segment lengths: Long segment 39.5%. Short segment 56%. Two segment 40.5%	"Our Study showed that among the 8 median NCV tests, the short, segment, onset latency-based transcarpal NCV was most sensitive in diagnosing CTS. This study also suggests that direct measurement of a single nerve segment is superior to either long-segment studies or differential subtraction between 2 segments of the same nerve."	3:1 matched study suggests a single short nerve segment measurement was superior to both long segment studies or differential subtraction between 2 segments of the same nerve for CTS diagnosis.
Kuntzer 1994 Diagnostic	5.5	N = 75 healthy subjects with no symptoms of CTS vs. 102 patients suspected on clinical grounds of having CTS	19 different sensorimotor and sympathetic parameters in electrodiagnostic studies.	Normal control group values for different electrophysiological tests. (EDX)	Specificity (%) and Sensitivity (%) of the following EDX tests: Median Motor Distal Latency 98.6 and 47. Thenar CMAP amplitude 100 and 15. Median Nerve Palm to wrist velocity 97 and 83. Median nerve digit to wrist velocity, 100 and 49. Median nerve digit to wrist amplitude 100 and 61. Median-Ulnar digit to wrist latency difference 100 and 10. Median sensory distal index, 99 and 69. SSR amplitude ratio, 100 and 10.	"The results obtained in this study demonstrate that patients with CTS form a heterogeneous group with a wide variation in a specific nerve conduction parameter between individual patients, reflecting the different degrees of nerve pathology. It is therefore not recommended to use a specific procedure for the evaluation of each patients suspected of CTS, but (i) to use only sensitive parameters with high specificity as an optimal routine for the investigation of the average CTS patient, (ii) to perform needle EMG in	Data suggest median sensory nerve conduction studies appear abnormal compared to motor nerve conduction studies in CTS patients. Study does not recommend use of a specific procedure for all suspected CTS patients.

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						forearm and arm muscles for each patient suspected to have CTS with radiating pain to the arm, and (iii) to perform ulnar motor and sensory nerve conduction studies in order to exclude superimposed peripheral neuropathy."	
Bodofsky 2005 Diagnostic	5.5	Patients randomly sampled from electrodiagnostic studies. Divided into 3 groups. 1) Normal Patients (Confirmed using physical exam, history, EMG and NCS) 2) Probable CTS (Symptoms, Physical Exam consistent with CTS. Normal EMG and NCS) 3) Definite CTS (Symptoms, Physical Exam consistent with CTS. EMG and NCS also consistent with CTS)	(Median Sensory -Ulnar Motor) Latency difference (MSUMLD) as a more sensitive and specific diagnostic tool for CTS.	Other Electrodiagnostic techniques including, Median Sensory Latency, Ulnar sensory latency, Ulnar Motor Latency, (Median-Ulnar) Sensory Latency Difference.	MSUMLD had a median value of 0.4 msec in group 1, 1.0 msec in group 2, 2.0 in group 3 ($p<0.0001$). 95% CI for MSUMLD in normal group is 0.1-0.7 msec. 83% of group 2 patients were added to diagnostically confirmed CTS. 100% of group 3 were diagnosed with CTS using MSUMLD. Sensitivity and Specificity of MSUMLD is 95% and 100%, respectively.	"[T]he results in this study strongly suggest that, in patients with symptoms and signs of CTS, the (Median Sensory-Ulnar Motor) Latency difference is an easy simple, highly sensitive and specific test."	Data suggest median sensory ulnar latency is obtainable and yields a good sensitivity and specificity in the detection of mild CTS.

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Khosrawi 2013 Diagnostic	5.0	N = 100 healthy hand volunteers and 64 hands of patients with clinical symptoms of CTS	Electrodiagnostic tests (EDX) including Sensory Distal Latency (SDL), Distal Motor Latency (DML), Motor Nerve Conduction velocity (MNCV), Residual Latency (RL)	Clinical Diagnosis of Carpal Tunnel Syndrome. Also comparison of values of Electrodiagnostic readings in control vs diagnosed patients.	Sensitivity and Specificity (%) (95% CI) of EDX tests: SDL 87.3 (83.6-89.1) and 91.2 (89-95.6), DML 70.3 (65.6-71.9) and 100 (96.5-100), MNCV 97.2 (94.4-98.6) ad 90.4 (88.5-94.2), RL 85.9 (84.4-87.5) and 91.1 (87.8-92.2). Median-Ulnar DML difference 84.0 (82.6-85.1) and 89.9 (89-91.1). Median and Ulnar SDL 90.5 (88.1-93.4) and 93.7 (90.2-95.6).	“It seems that, in mild cases of CTS which traditional NCS shows abnormalities only in sensory studies, RL may better demonstrate the effect on median nerve motor fibers.”	Data suggest in mild CTS cases, RL may be a tool to demonstrate the effect on the median nerve motor fibers thus increasing the sensitivity of NCS.

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Zagnoli 1999 Diagnostic	5.0	N = 20 patients (40 wrists) with CTS. Mild (n = 13), moderate (n = 12), severe (n = 8). Follow-up at 31 months.	Electrodiagnostic Studies (Vickers HME device)	MRI	33/40 wrists showed abnormal electrodiagnostic findings. 11 had isolated sensory abnormalities, and 13 cases showed sensory and motor abnormalities. 2 symptomatic wrists showed normal electrodiagnostic findings (sensitivity 94%) and 2 asymptomatic wrists showed mild to moderate findings (specificity 94%). 32 cases (94%) had sensory abnormalities, 25 had decreased sensory nerve conduction velocity, 29 had decreased sensory nerve potential amplitude. MRI: 20 control wrists normal, 9 clinical symptoms of CTS, 10 had electrodiagnostic abnormalities. 73% sensitivity and 92% specificity of MRI for the diagnosis of CTS. Of 26 MRI studies, 70% had bowing of the transverse carpal ligament. There were 55% of median nerve enlargement and 57% of high median nerve signal. These were correlated with moderate or severe CTS (p <0.001).	"When electrodiagnostic abnormalities suggest more severe disease than expected otherwise discordant with clinical findings, demonstration by magnetic resonance imaging of high median nerve signal and/or median nerve enlargement may help to select those patients most likely to benefit from surgical treatment."	Small sample size. Data suggest MRI is useful in diagnosing more severe CTS diseases after electrodiagnostic abnormalities have been found.

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Violante 2004 Diagnostic	5.0	114 meat workers (228 hands) at risk of CTS; mean age 38.0±10.0 years.	median nerve conduction studies (NCS)	N/A	Significant difference between symptomatic and asymptomatic hands in WSL, SCV-WP, WML, MCV-WP, and the SCV-WP/SCV-EW ratio (all p <0.001). NCS parameters and symptoms had more agreements in non-dominant hand, which was shown in WSL (95% CI: 0.31–0.82) and SCV-WP (95% CI: 0.22–0.59), (p <0.001 and p <0.001).	"Given the importance of the dominant hand in working populations, these data support use of SCV-WP (or WSL) as an informative NCS parameter for occupational studies on CTS."	Study population of meat workers with no prior diagnosis of CTS found use of SCV-WP (WSL) a useful NCS parameter for occupational CTS studies in the dominant hand of these workers.
Sheu 2006 Diagnostic	5.0	N = 131 hands of CTS patients and 136 hands of controls. Mean age 49.5 years.	Nerve conduction studies	Carpal tunnel diagnosis.	The distoproximal latency ratio (DPLR) of the median nerve showed the highest sensitivity (77%) but had a misclassification rate of 6.9%). The sensitivity of DPLR was not significantly greater than D1M-D1R (p>0.05).	"Optimal transformation of NCS data is mandatory to diminish the effect of skewness and enhance the diagnostic accuracy. As compared to the comparative tests, the segmental study of the median nerve is more easily applied and yields higher sensitivity in detecting mild CTS."	Data suggest segmental study of median nerve has application ease and has a higher sensitivity when detecting mild CTS.
Aydin 2004 Diagnostic	4.5	N = 525 (818 hands) with suspected CTS confirmed through electrophysiologic evaluation. Mean age 49.1± 11.7 years.	Compared sensitivity of first 3 digital branches of median nerve.	Electrophysiological testing was used as the standard diagnostic test in this study.	Most common abnormal physiological findings in Sensory Nerve Conduction Velocity over palm-wrist segment and Digit 1-Wrist segment with sensitivity of 98.5% and 95.4%, respectively.	"The sensory nerve conduction velocity test of the digit 1–to-wrist segment has the most sensitivity among the three digital branches of the median sensory nerve, and it may be used more widely in the electrodiagnosis of carpal tunnel syndrome."	Data suggest sensory nerve conduction velocity test if digit 1 to the wrist segment is the most sensitive among the 3 digital branches of the median sensory nerve.

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Elkowitz 2005 Diagnostic	4.0	N = 72 who had traditional electrodiagnostic testing (EDX) as well as portable NC-Stat testing	A portable Electrodiagnostic testing device 9NC-Stat)	Traditional Electrodiagnostic testing as the ccomparison.	All patients who underwent both types of testing indicated that NC-Stat more comfortable. Both tests had a significantly ($p<0.001$) linear relationship between Distal motor latencies.	"This portable electrodiagnostic device provides a reliable, convenient, and relatively inexpensive way to obtain objective data and that can be used in diagnosing, evaluating, and terating CTS."	Data suggest portable NC-Stat is reliable and convenient for diagnosing, evaluating and treating CTS.

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ULTRASOUND (DIAGNOSTIC)
Ultrasound and high resolution sonography have been investigated for the evaluation and diagnosis of CTS.(476-487)

Recommendation: Ultrasound for Evaluation and Diagnosis of CTS
Ultrasound is not recommended for diagnosing CTS.

Strength of Evidence – **Moderately Not Recommended, Evidence (B)**
Level of Confidence – Moderate

Rationale for Recommendation
Multiple moderate-quality comparative studies report that ultrasound does not outperform and often modestly underperforms compared with EDS for the diagnosis of CTS.(465, 482, 484, 488, 489) Thus, ultrasound is not recommended for diagnosing CTS. There are other diagnostic uses of ultrasound at the wrist (e.g., evaluating a cyst).

Evidence for the Use of Ultrasound
There are 4 moderate-quality studies incorporated into this analysis. (465, 488-490) There are 3 low-quality studies in Appendix 2.(475, 491, 492)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL and Cochrane Library without date limits using the following terms: ultrasound diagnostic studies; carpal tunnel syndrome, median neuropathy, CTS, carpal tunnel, median nerve, compression, entrapment, neuropathy, nerve disease, syndrome, median nerve, median neuropathy, burning, itching, numbness, tingling, hand, palm, finger, wrist, pain; diagnostic, sensitivity and specificity, positive predictive value, negative predictive value, Predictive Value of Tests, efficacy, efficiency. We found and reviewed 304 articles in PubMed, 370 in Scopus, 4 in CINAHL, and 13 in Cochrane Library. We considered for inclusion 35 from PubMed, 15 from Scopus, 3 from CINAHL, 0 from Cochrane Library and 0 from other sources. Of the 53 articles considered for inclusion, 43 diagnostic studies and 10 systematic review met the inclusion criteria.

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Author/Year Study Type	Score (0-11)	N	Area of Upper Extremity	Diagnoses	Type of Ultrasound	CT used	MRI Used	More than on rater	Blinding of rater	Myelography	Surgery Performed	Clinical outcomes assessed	Long term follow-up (mean when noted)	Results	Conclusion	Comments
Ziswiler 2005 Diagnostic No mention of sponsorship or COI.	7.0	N=74 (gender not specified) (107 wrists).	Wrist	CTS. Mean age 51±16 years.	5-12 MHz linear array transducer (ATL 3500, Philips Medical System)	-	-	-	-	-	-	-	-	CTS present wrists: 81. CTS absent wrists: 26. ROC curve area under the curve: 0.89 (95% CI 0.82, 0.96); cutoff value 10 mm^2; sensitivity 82%; specificity 87%. Likelihood ratios (LR): cutoff of 8 mm^2 satisfactory power to rule out CTS, fitted-negative LR 0.13 for cross-sectional areas <8 mm^2; cutoff of 12 mm^2 excellent power to rule in CTS, fitted-positive LR 19.9 for areas ≥12 mm^2.	"Depending on setting and purpose, different cutoff values for the largest cross-sectional area may be used to accurately rule in or rule out CTS."	Data suggest high correlation between sonography and nerve conduction studies with almost equal sensitivity and specificity.

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Pastare 2009 Diagnostic No mention of sponsorship or COI.	6.5	N = 66 (gender not specified) consecutive patients investigated for sensory hand symptoms. Mean age 51 years.	W	Carpal tunnel Syndrome	Ultrasound was performed using a 12-MHz linearray transducer	-	-	-	+	-	-	+	-	Nerve Conduction studies showed greater diagnostic sensitivity than ultrasound; 54 wrists 82% vs. 41 62% for highly likely clinical diagnosis of CTS.	"In summary, our study shows that NCS have better sensitivity in supporting a diagnosis of CTS. However, because of its high positive predictive value, lack of discomfort, and ease of use, US can be used as a screening method for CTS."	Data suggest nerve conduction studies are superior to sonography in detecting CTS.
Visser 2008 Diagnostic No mention of sponsorship. No COI.	6.0	N= 168, N=137 volunteer controls. 53 men and 84 women. Mean age at onset, 52 (± 14).	Forearm ,Wrist	CTS based on clinical signs and symptoms without previous splinting or surgical treatment for CTS. Mean age 52±14 years, controls 46±15 years.	5-12 mHz linear-array transducer	-	-	-	-	-	-	-	-	Sensitivity/specificity (%, 95% CI) Sonography – wrist: cross-sectional area >0.1 cm^2: 78 (70-84)/91 (86-95). Sensitivity/specificity (%, 95% CI) EMG: DSL digit 4 >3.2 msec 54 (46–62)/ 97 (89–100); Median-ulnar digit 4 difference >0.4 msec 82 (75–88)/ 88 (78–95); DML median nerve >3.8 msec 74 (66–81)/ 97 (88–100).	"In patients with a clinical diagnosis of CTS, the accuracy of sonography is similar to that for EMG."	Data suggest sonography is comparable to EMG in patients with a clinical diagnosis of CTS but study states EMG should still be first diagnostic test utilized in patients with atypical symptoms.

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Wang 2008 Diagnostic No mention of sponsorship or COI.	6.0	N = 37 (20 controls). Mean age CTS patients (44±9.4 years) and healthy subjects (43.7 ± 12.91 years).	Wrist	Classic or probable symptoms of CTS for 1-60 months	Sequoia 512 with 8-15 MHz broad line transducer	-	-	-	-	-	-	-	-	Cross-sectional area at pisiform level (P-CSA): ROC curve area under curve (AUC) = 0.901 (p<0.001); optimal cut-off of 9.875 mm^2; sensitivity 82%; specificity 87.5%. Longitudinal compression sign (LCS): ROC curve AUC = 0.842 (p<0.001); optimal cut-off value ≥1.5; sensitivity 50%; specificity 95.8%. Retinacular bowing: ROC curve AUC = 0.781 (p<0.001); optimal cut-off ≥2.11 mm; sensitivity 77%; specificity 75%.	"CTS can be diagnosed by HRUS. The most useful diagnostic criterion is a median nerve CSA of ≥9.875 mm^2 at the pisiform level."	Small sample suggesting HRUS can be useful in diagnosing CTS. The most useful criterion is when the median nerve CSA is of ≥ 9.875 mm^2 at pisiform level.

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MAGNETIC RESONANCE IMAGING AND DIFFUSION TENSOR IMAGING

MRI and especially diffusion tensor imaging ("diffusion MRI) are being investigated for the evaluation and diagnosis of CTS.(493-543)

Recommendation: MRI and Diffusion Tensor Imaging for Evaluation and Diagnosis of CTS
MRI and Diffusion Tensor Imaging is moderately not recommended for diagnosing CTS.

> *Strength of Evidence* – **Moderately Not Recommended, Evidence (B)**
> *Level of Confidence* – Moderate

Rationale for Recommendation
Multiple moderate-quality comparative studies report that MRI and Diffusion Tensor Imaging do not outperform and often modestly underperform compared with EDS for the diagnosis of CTS.(469, 544-546) Thus, MRI and Diffusion Tensor Imaging are not recommended for diagnosing CTS. There are other diagnostic uses of MRI at the wrist.

Evidence for the Use of Magnetic Resonance Imaging and Diffusion Tensor Imaging
There are 6 moderate-quality studies incorporated into this analysis.(469, 544-548) There are 5 low-quality studies in Appendix 2.(475, 549-552)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL and Cochrane Library without date limits using the following terms: magnetic resonance imaging, carpal tunnel syndrome, median neuropathy, CTS, carpal tunnel, median nerve, compression, entrapment, neuropathy, nerve disease, syndrome, median nerve, median neuropathy,; diagnostic, sensitivity and specificity, positive predictive value, negative predictive value, predictive value of tests, efficacy, efficiency. We found and reviewed 287 articles in PubMed, 383 in Scopus, 8 in CINAHL, and 5 in Cochrane Library. We considered for inclusion 66 from PubMed, 6 from Scopus, zero from CINAHL, zero from Cochrane Library and 3 from other sources. Of the 75 articles considered for inclusion, 68 diagnostic studies and 1 systematic review met the inclusion criteria.

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Author/Year Study Type	Score	Number	Area of Upper Extremity	Diagnoses	Type of MRI used	Type of CT used	T1 weighted images	T2 weighted images	X-ray	Myelography	More than one rater	Surgery Performed	Clinical outcomes assessed	Long term follow-up (mean when noted)	Results	Conclusion	Comments
Jarvik 2002 Diagnostic Sponsored by Royalty Research Fund, University of Washington. No mention of COI.	7.0	N = 120 (gender not specified) with clinically suspected CTS. Age <18 or >70 years.	W	CTS	MRI using 1.5 Tesla Magnets	-	+	+	-	-	+	-	-	-	Intrareader reliability was substantial to near perfect (kappa = 0.76 - 0.88). Interreader lower but still substantial (kappa = 0.60 - 0.67). Sensitivity of MRI was greatest for the overall impression of the images (96%) followed by increased median nerve signal (91%) and with lower specificities (33 - 38%).	"The reliability of MRI is high but the diagnostic accuracy is only moderate compared with a research-definition reference standard."	Study used a mixed cohort (both men and women) to anhance diagnostic accuracy (those who were true positive for CTS) using high resolution MRI. Data suggest MRI has a "moderate" diagnostic accuracy at best compared to the reference standard for CTS. Also, assumption that a high STIR signals within the palmar bursa as being a marker for CTS was likely incorrect as normal signals within palmar bursa were associated with CTS presence.

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Bulut 2014 Diagnostic No mention of sponsorship or COI.	5.5	N = 120 (90 females and 30 males) with CTS. The mean ages of the CTS and control, 43.07 ± 7.40 (25–57) and 41.85 ± 7.81 (31–55).	W	Carpal Tunnel Syndrome	1.5-T whole-body MRI system was used for all MRI examinations.	-	+	-	-	-	-	-	-	-	Diffusion tensor imaging (DTI) showed significant correlations with electrophysiological studies (EPS). DTI parameter (Fractional anisotropy-FA and apparent diffusion coefficients (ADC)) evaluated and significant difference between CTS and controls with CTS patients showing significantly lower FA and ADC scores (p ≤0.001).	"DTI parameters can provide helpful information for CTS. The correlations of FA and ADC measurements versus EPS measurements based on severity were significant."	Data suggest significant differences between all subgroups for mean FA and ADC suggesting FA and ADC threshold values could be useful for diagnosing and grading CTS. The DTI parameters well significant versus EPS for assessment of severity.
Uchiyama 2005 Diagnostic	5.5	105 wrists of 105 women. 36 wrists of 36 female volunteers.	W	Idiopathic CTS	1.5 Tesla with a circular extremity coil.	-	+	+	-	-	-	+	-	-	Flattening of nerve more significant at distal TCL level than other levels. Cross sectional area larger in mild to moderate group vs. controls at DRUJ/ pisiform/hook of hamate/distal TCL levels: 14.1 (4.8) vs. 9.0 (2.5)/14.6	"Severity of the disease could be judged by evaluating not only longitudinal changes of signal intensity and configuration of the median nerve, but also palmar bowing of the TCL. Increased palmar bowing of the TCL was found to be associated with an increase in the area of the carpal tunnel."	Data suggest disease severity associated with palmar bowing of TCL as well as longitudinal changes of signal intensity and median nerve confirmation as study found bowing of TCL in CTS group larger than in controls. Studied only female subject as CTS more prevalent in females.

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															(4.8) vs. 9.1 (2.3)/10.8 (3.0) vs. 8.8 (1.8)/ 10.9 (3.2) vs. 8.3 (2.0); (p <0.05 all levels). Severe and extreme groups cross sectional area progressively larger from hook of hamate level, had high signal intensity. At pisiform and hook of hamate, correlation between average of carpal tunnel and palmar bowing of TCL in CTS groups (0.489, p <0.0001).		
Zagnoli 1999 Diagnostic	5.0	20	W	Carpal tunnel syndrome	MRI vs. electrodiagnosic (Vickers HME device)	-	+	+	-	-	-	+	-	31 months	33/40 wrists showed abnormal electrodiagnostic findings. 11 cases showed isolated sensory abnormalities, and 13 cases showed sensory and motor abnormalities. 2	"When electrodiagnostic abnormalities suggest more severe disease than expected otherwise discordant with clinical findings, demonstration by magnetic resonance imaging of high median nerve signal and/or median nerve	Small sample size. Data suggest MRI may detect abnormalities after electrodiagnostic abnormalities have been found.

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															symptomatic wrists showed normal electrodiagnostic findings (sensitivity 94%) and 2 asymptomatic wrists showed mild to moderate findings (specificity 94%). 32 (94%) had sensory abnormalities, 25 had decreased sensory nerve conduction velocity and 29 had decreased sensory nerve potential amplitude. In MRI, 20 control wrists normal, 9 had clinical CTS symptoms and 10 wrists had electrodiagnostic abnormalities. 73% sensitivity and 92% specificity of MRI for diagnosis of CTS. Of 26 MRI studies, 70% had bowing of transverse	enlargement may help to select those patients most likely to benefit from surgical treatment.”	

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															carpal ligament. 55% of median nerve enlargement and 57% of high median nerve signal. These were correlated with moderate or severe CTS (p <0.001).		
Brienza 2014 Diagnostic	4.5	30 Subjects, 15 with CTS and 15 healthy controls.	W	Carpal tunnel syndrome	3-Tesla magnetic resonance imaging with diffusion tensor imaging (DTI)	-	-	-	-	-	+	-	-	-			Results do not reflect MRI, focused only on Electroneurography. Data suggest a high degree of correlation between DTI and ENG of the peripheral nervous system.
Wang 2012 Diagnostic	4.0	40, 21 patients and 19 asymptomatic volunteers.	W	Carpal tunnel syndrome	Diffusion tensor imaging (DTI). 1.5-T whole body with a microscopy coil.	-	+	+	-	-	-	-	-	-	Overall results of FA and ADC at different levels (distal radius, pisiform bone, middle of tunnel, and hamate bone) were similar. Only CTS had significant effects on FA and ADC (p <0.05). Linear correlation between distal latency of motor conduction	“FA and ADC measurements at the distal radius, pisiform bone, in the carpal tunnel and at the hamate bone were independent of the finger posture in symptomatic patients and healthy volunteers. Mean FA was decreased while mean ADC was increased by CTS. The correlations of FA and ADC	Small study population (n = 40). Data suggest FA and ADC were independent of finger posture and measuring location. Mean FA was decreased by CTS and ADC was increased by CTS. Study reports DTI imaging of FA and ADC were significant as compared with EP for CTS.

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															velocity of median nerve (MNDL) and length of abnormal intensity of median nerve (N_Len). If N_Len >15mm used as criteria for CTS, there was 1 false negative case and no false positive cases (r^2= 0.529, p <0.001).	versus EPS parameters were significant.”	

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Monitoring Progress

The clinical evaluation and progress of patients is most commonly monitored qualitatively from appointment to appointment. Particularly, physicians seek information regarding the degree to which symptoms are present and whether the patient believes there has been improvement. However, there are several instruments that may be utilized for monitoring the progress of patients with CTS.(553) These include the DASH(554-575) and Boston Carpal Tunnel Questionnaire.(407, 517, 554, 555, 558, 559, 563-565, 567, 569, 570, 572, 575-596) Michigan Hand Outcomes Questionnaire (MHQ) has been used in many studies as a measurement outcome of CTS.(566, 574, 578, 597) The Short Form-36 (SF-36),(561, 567, 576) the Flinn Performance Screening Tool (FPST),(598) the Patient Evaluation Measure questionnaire (PEM),(560, 575) the Amadio questionnaire,(571) the Historical-objective-distribution based scale (Hi-Ob-Db),(579, 591) and the Alderson-McGali hand function questionnaire (AMHFQ)(576) have been used to diagnose CTS. VAS symptoms and pain scores may also be used(561, 565, 576) even though many patients with CTS have no pain. Functional status scores(407, 554, 567, 571, 577, 582, 586, 587, 589, 592, 594, 598-600) and Global Symptom Scores(601) are also used, particularly in some research studies. Grip strength(560, 565, 576, 583, 584, 589, 596, 602-605) and pinch strength measures(560, 565, 576, 581, 583, 584, 588, 596, 602, 604) may be utilized. However, patients who have mild symptoms generally have normal grip strength. All of these questionnaires are subjective and strength measures are effort-dependent, although the strength measures attempt to provide a quantitative measure that may help to gauge improvement over time especially post-operatively.(554, 558, 564, 578, 586, 594, 601, 606-609)

Recommendation: Instruments for Monitoring the Progress of Patients with CTS
There is no recommendation for or against the use of instruments to monitoring the progress of patients with CTS.

Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**
Level of Confidence – Low

Rationale for Recommendation
There is no quality evidence that any of these instruments meaningfully contribute to improving clinical care. They may be more useful in the post-operative setting.

Evidence for the Use of Monitoring Progress
There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL and Cochrane Library without date limits using the following terms: monitoring progress: disabilities of the arm, shoulder and hand questionnaire, Boston carpal tunnel questionnaire, VAS symptoms score; VAS pain score, functional status scores, global symptom scores, grip strength, pinch strength, carpal tunnel syndrome, median neuropathy, carpal tunnel syndrome/diagnosis, CTS, carpal tunnel, median nerve, compression, entrapment, neuropathy, nerve disease, syndrome, median nerve, median neuropathy, diagnostic, diagnosis, sensitivity, specificity, positive predictive value, negative predictive value, predictive value of tests, efficacy, efficiency. We found and reviewed 527 articles in PubMed, 123 in Scopus, 32 in CINAHL, and 23 in Cochrane Library. We considered for inclusion 59 from PubMed, 2 from Scopus, zero from CINAHL, zero from Cochrane Library and zero from other sources. Of the 61 articles considered for inclusion, 59 diagnostic studies and 1 systematic review met the inclusion criteria.

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Specific Treatment Interventions

Activity Modification and Exercise

EXERCISES

Various exercise regimens have been utilized to treat patients with CTS, most commonly tendon-gliding and nerve-gliding exercises.(610-617) These exercises are thought to help prevent adhesion formation.(615, 618-620)

1. *Recommendation: Exercises for Treatment of Acute, Subacute, or Chronic CTS*
   There is no recommendation for or against the use of exercises for treatment of chronic CTS as quality evidence is lacking.

   Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**
   Level of Confidence – Low

2. *Recommendation: Exercises for Rehabilitation of Post-operative CTS Patients with Significant Deficits*
   Exercise is recommended for rehabilitation of post-operative CTS patients with significant deficits.

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – Low

Rationale for Recommendations
There are multiple moderate quality studies, but none has clearly found benefit of exercises, including tendon-gliding, for treatment of CTS. One moderate-quality study suggested no statistically significant incremental benefit from adding tendon-gliding exercises to wrist splinting,(610) although modest trends towards benefit appear present. Another moderate-quality study found a combination of tendon-gliding exercise with ultrasound and splinting superior to two other combinations.(611) Thus, it is unclear if there is an independent benefit from tendon-gliding exercises. Additionally, as many believe that physical activity is a risk factor for CTS, the logic of performing exercises for treatment is somewhat dissonant. However, exercise programs are not invasive, have few if any adverse effects, and are low cost if performed independently after receiving initial instructions.

Evidence for the Use of Exercise for CTS
There are 5 moderate-quality RCTs incorporated into this analysis.(610, 611, 621-623) There are 4 low-quality RCTs in Appendix 2.(624-627)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL and Cochrane Library without date limits using the following terms: gliding exercise, tendon-gliding, tendon gliding, nerve-gliding, nerve gliding, neurodynamic mobilization, upper limb tension test, ULTT; carpal tunnel syndrome, median neuropathy, CTS, carpal tunnel, median nerve, compression, entrapment, neuropathy, nerve disease, syndrome, median nerve, median neuropathy, controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 26 articles in PubMed, 19 in Scopus, 8 in CINAHL, and 31 in Cochrane Library. We considered for inclusion 13 from PubMed, 1 from Scopus, 1 from CINAHL, 1 from Cochrane Library and 1 from other sources. Of the 17 articles considered for inclusion, 10 randomized trials and 4 systematic studies met the inclusion criteria.*

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Author/Year Study Type Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Brininger 2007 RCT Sponsored by the School of Health and Rehabilitation Science Development Fund, School of Health and Rehabilitation Sciences, University of Pittsburg, PA. No COI.	6.0	N = 61 (41 females and 10 males) with a positive Tinel sign or Phalen maneuver and complaints of nocturnal numbness and tingling. Mean age 50 years.	Neutral wrist and meta-carpophalangeal (MCP) splint, custom splint positioning MCP joints from 0º to 10º of flexion, NW/MCP (n =17) vs. neutral wrist and MCP exercise group (tendon and nerve gliding exercises 3 to 5 times a day with 10 repetitions in each position, and to hold each position for 5 seconds), NW/MCP-X (n=16) vs. wrist cock-up splint prefabricated that immobilized the wrist in 20º of extension, WCU (n=12) vs. wrist cock-up splint and exercise, WCU-X (n=16). All groups wore the splint during sleep for 4 weeks and received and educational brochure on CTS. Assessments at baseline, 4 weeks, and 8 weeks.	All groups saw significant decrease in CTS symptoms (no p-value reported).	"Our results provide further evidence of the effectiveness of splinting, designed to target an underlying anatomic problem, for reducing symptoms and improving functional status in patients with mild-to-moderate CTS."	Small group numbers. No table or graphic for results. Baseline comparability for group strength different between groups.
Baysal 2006 RCT No mention of sponsorship or COI.	5.5	N = 36 females EDS confirmed CTS, all bilateral, all right handed. Mean age: Group I 47.8±5.5 years, Group II: 50.1±7.3 years, Group III: 51.4±5.2 years.	Group I: tendon- and nerve-gliding exercises 5 sessions daily, each exercise repeated 10 times/session for 3 weeks plus splinting full-time for 3 weeks (n = 12) vs. Group II: ultrasound 15 minutes per session to palmar carpal tunnel at frequency pf 1 MHz and intensity of 1.0 W/cm^2 once a day 5 days a week, 3 weeks plus splinting (n = 12) vs. Group III: ultrasound, splinting and tendon-nerve-gliding exercises (n = 12). Follow-up at end of treatment at after 8 weeks.	Pain score before treatment/after treatment I/after treatment II: Group I: 4.8±2.3/3.3±2.9/ 2.6±2.8; Group II: 5.7±2.7/ 2.2±1.9/ 2.5±2.8; Group III: 5.6±3.5/ 1.3±1.8/ 0.8±0.9. Functional status score: Group I: 20.6±7.8/14.8±7.5/ 14.9±6.6; Group II: 21.9±9.1/16.1±8.5/ 16.1±8.7; Group III: 20.5±7.1/11.7±3.6/ 12.6±3.4. NS between groups.	"The result of this study emphasizes the efficacy of conservative treatment in CTS. In all patients groups, the treatment combinations were significantly effective immediately and 8 weeks after the treatment."	All groups were splinted precluding judgment of utility of splinting. Unclear if there is an independent effect of exercise.
Bialosky 2009	5.5	N = 40 females with >12weeks	Neurodynamic technique (n = 20) vs. Sham technique (n	Values for between-group comparisons of clinical	"Collectively, these findings suggest that NDT specific to	Few differences between treatment arms were seen.

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RCT No sponsorship. No mention of COI.		signs and symptoms of CTS. Mean age: 46.90+10.25 years.	= 20). Assessment at baseline and 3weeks. No long-term follow-up.	pain and disability were not reported.	the median nerve in individuals with CTS is no more effective than a sham technique that produces adequate blinding and similar expectations for treatment effect over a 3-week period."	Relatively short follow-up time (3 weeks).
Schmid 2012 RCT No sponsorship or COI.	4.5	N = 21 with mild to moderate CTS. Mean age: 53.9 years.	Nerve and tendon gliding exercise home program (n = 11) vs. Night splinting (n = 10). Follow-up at 1-week.	No significant differences present between groups. Within group Baseline vs. Follow-up – Exercise: Pain intensity VAS (0.7 vs. 0.8; p>0.16). Numbness VAS (1.5 vs. 1.6; p >0.16). Splinting: Pain intensity VAS (1.2 vs. 1.1; p>0.16). Numbness VAS (2.3 vs. 1.9; p >0.16).	"The findings of this study suggest that a reduction in intraneural edema is a therapeutic mechanism of both nerve and tendon gliding exervises and splinting… there seems to be no preference for splinting or nerve and tendon gliding exervises."	Small sample size (N=21). Data suggest no differences.
Akalin 2002 RCT No mention of sponsorship or COI.	4.0	N = 28 EDS confirmed CTS. Mean age 51.93±5.1 years.	Full-time splint (n=14) vs. full-time splint plus nerve tendon gilding exercises 5 sessions daily with each exercise repreated 1- times per session (n=14) for 4 weeks. Follow-up 8 weeks after treatment.	Grip strength (mean ± SD) – Pre-/post-treatment: Group I (splint): 38.44±14/ 49.88±15.3; Group II (exercise + splint): 38.61± 13.8/54.94±17 p (between groups) = 0.14. Symptom severity score (mean ± SD): Group I: 36.11±9.0/21.88 ±8.8; Group II: 35.9±6.0/18.2±5.85 p (between groups) = 0.210	"Although the results in group 2 were better than group 1, the difference was not statistically significant. Further investigations are required to establish the role of nerve and tendon gliding exercises in the treatment of carpal tunnel syndrome."	No clear evidence of benefit.

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YOGA
Yoga has been used to treat CTS,(628) although its main uses have been in treating spine pain and other more widespread MSDs (see Chronic Pain and Low Back Disorders Guidelines).

Recommendation: Yoga for Treatment of Acute, Subacute, or Chronic CTS
There is no recommendation for or against the use of yoga for treatment of acute, subacute, or chronic CTS.

Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**
Level of Confidence – Low

Rationale for Recommendation
There is one moderate-quality RCT that suggested improvements in grip strength; however, the comparative population had an inactive splint for treatment which may have created an artificial difference in grip strength.(628) While yoga appears beneficial for treatment of spine patients,(629) there is no evidence of efficacy for distal upper extremity MSDs. Yoga is not invasive, has low potential for adverse effects, and is low cost. Compliance and adherence are reportedly not good, as patient motivation must be high and there is much self-selection in studies assessing yoga's efficacy.

Evidence for the Use of Yoga for CTS
There is 1 moderate-quality RCT incorporated into this analysis.(628)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL and Cochrane Library without date limits using the following terms: yoga and carpal tunnel syndrome, CTS, median nerve neuropathy, median neuropathy, meadian nerve disease, entrapment, neuropathy, nerve compression, burning, itching, numbness, tingling, controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random, randomized, randomization, randomly; systematic, systematic review, retrospective studies, prospective studies, epidemiological studies, epidemiological research, and Nonexperimental Studies. We found and reviewed 16 articles in PubMed, 183 in Scopus, 7 in CINAHL, 17 in Cochrane Library and zero in other sources. We considered for inclusion 2 from PubMed, zero from Scopus, zero from CINAHL, zero from Cochrane Library and zero from other sources. Of the 2 articles considered for inclusion, 1 randomized trials and 1 systematic studies met the inclusion criteria.*

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Garfinkel 1998 RCT Sponsored by Commonwealth of Pennsylvania. No mention of COI.	6.0	N = 51 (28 female/13 male) with CTS, EDS confirmed. Median age 52 years.	Standard splint to supplement current treatment (n = 26) vs. Iyengar yoga focused on upper body, 1-1.5 hour, 2x a week for 8 weeks; current treatment not described (n = 25). Follow-up at 8 weeks.	Grip strength yoga (161.6±70.4 to 187.4±68.8) vs. splint (183.9±69.5 to 190.5±68.2mm Hg). Pain reduced (p = 0.02). Median nerve sensory conduction yoga (4.40±1.5ms to 3.97±1.5) vs. splint (4.66±1.4 to 4.36±1.6ms) (NS).	"In this preliminary study, a yoga-based regimen was more effective than wrist splinting or no treatment in relieving some symptoms and signs of carpal tunnel syndrome."	Grip strength improvement may be from activity in yoga as comparison was presumably an inactive splint which may have caused greater improvement not related to CTS. Lack of description of controls limits interpretations.

Medications
NSAIDS/ACETAMINOPHEN
Nonsteroidal anti-inflammatory drugs (NSAIDs) have been widely used to address beliefs in inflammatory mechanisms of CTS or to manage pain associated with CTS(630-635) (see Chronic Pain Guideline for detailed discussion on mechanisms of action, classes of medications, adverse effects, etc.). Acetaminophen and paracetamol are sometimes utilized to treat CTS, although their effects on cyclooxygenase activity are minimal and they are not anti-inflammatory.

1. *Recommendation: NSAIDs or Acetaminophen for Subacute or Chronic CTS*

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NSAIDs or acetaminophen are not recommended as a primary treatment for subacute or chronic CTS.(636)

Strength of Evidence – **Not Recommended, Evidence (C)**
Level of Confidence – Low

2. *Recommendation: NSAIDs for Post-operative Management of CTS-related Pain*
NSAIDs are moderately recommended for post-operative management of CTS-related pain.

Indication – Patients having recently undergone carpal tunnel surgical release. Generally, treat 2 weeks up to 6 weeks post-op unless complications occur.

Frequency/Dose – See manufacturer's recommendations.

Indications for Discontinuation – Resolution of pain, adverse effects, intolerance.

Strength of Evidence – **Moderately Recommended, Evidence (B)**
Level of Confidence – High

3. *Recommendation: Acetaminophen for Post-operative Management of CTS-related Pain*
Acetaminophen is recommended for post-operative management of CTS-related pain.

Indication – Patients having recently undergone carpal tunnel surgical release. Generally treat 2 weeks up to 6 weeks post-op unless complications occur.

Frequency/Dose – See manufacturer's recommendations.

Indications for Discontinuation – Resolution of pain, adverse effects, intolerance.

Strength of Evidence – **Recommended, Evidence (C)**
Level of Confidence – Low

Rationale for Recommendations
While NSAIDs have been widely used to attempt to address a theoretical inflammatory basis for CTS and/or to treat pain associated with CTS, the one quality study comparing an NSAID to placebo found no benefit from the NSAID.(636) This same study also found no difference between NSAIDs and diuretics which also appear ineffective. There is also no quality evidence that there is a difference among NSAIDs (see Hip and Groin Disorders Guideline). Thus, there is quality evidence that NSAIDs do not have a role in the treatment of typical cases of CTS.(636)

Other studies comparing NSAIDs with manipulation plus ultrasound(637) and lidocaine patch(638) did not find benefits of NSAIDs compared with those treatments. A trial combining splinting (which appears effective) plus NSAID versus glucocorticosteroid injection did not find one arm to be superior.(631) While some patients may benefit from NSAIDs, evidence is lacking that there is any beneficial effect of NSAIDs for treatment of CTS and aggregate analyses of these studies also suggest NSAIDs are ineffective.(636-638) Acetaminophen is thought to also be ineffective.

NSAIDs are not invasive and have low adverse effects profiles, particularly when used for short courses in occupational populations. Generic or over-the-counter formulations are low cost. However, there is quality evidence that other interventions are effective. A short course of an over-the-counter NSAID may be reasonable for select patients; however, routine use of NSAIDs for treatment of CTS is not recommended. Select patients with acute CTS due to unaccustomed forceful use may be potential candidates for treatment with NSAIDs; however, that population has not been studied in quality trials.

There is one high-quality study in post-operative patients indicating that for post-operative pain management, naproxen is superior to acetaminophen, which in turn is superior to placebo.(639) NSAIDs and acetaminophen may also facilitate the rehabilitation process without the impairments associated with opioids. Thus, NSAIDs and acetaminophen are recommended for post-operative pain management.

Evidence for the Use of NSAIDs and Acetaminophen for CTS
There are 2 high-(639, 640) and 5 moderate-quality(631, 636-638, 641) RCTs incorporated into this analysis. There is 1 low-quality RCT in Appendix 2.(642)

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A comprehensive literature search was conducted using PubMed, Scopus, CINAHL and Cochrane Library without date limits using the following terms: anti-inflammatory agents, non-steroidal, non-steroidal, anti-inflammatory, NSAIDS, aspirin, diflunisal, salsalate, ibuprofen, dexibuprofen, naproxen, fenoprofen, ketoprofen, dexketoprofen, flurbiprofen, oxaprozin, loxoprofen, indomethacin, tolmetin, sulindac, etodolac, ketorolac, diclofenac, nabumetone, piroxicam, meloxicam, tenoxicam, droxicam, lornoxicam, isoxicam, celecoxib, etodolac, etoricoxib, lumiracoxib, meclofenamic acid, mefenamic acid, nimesulide, parecoxib, rofecoxib, tolfenamic acid, valdecoxib; carpal tunnel syndrome, median neuropathy, CTS, carpal tunnel, median nerve, compression, entrapment, neuropathy, nerve disease, syndrome, burning, tingling, itching, numbness, hand, palm, finger, wrist, pain; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 41 articles in PubMed, 302 in Scopus, 10 in CINAHL, and 2 in Cochrane Library. We considered for inclusion 11 from PubMed, 0 from Scopus, 1 from CINAHL, 0 from Cochrane Library and 1 from other sources. Of the 13 articles considered for inclusion, 9 randomized trials and 1 systematic studies met the inclusion criteria.*

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Author/Year Study Type Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
NSAIDs vs. Placebo						
Chang 1998 RCT Sponsored by NSC 86-2314-B-075B-012 to Ming-Hong Chang. No mention of COI.	7.0	N = 73 (53 female/20 male) with clinical signs and symptoms of CTS, EDS confirmed without abnormalities in radial and ulnar nerves. Mean age diuretic 45.7±4.8 years, NSAID-SR 47.4±5.7 years, steroid 45.4±5.2, placebo 44.2±5.4.	Trichlor-methiazide (diuretic), 2mg daily for 4 weeks (n = 16) vs. Tenoxicam-SR (NSAID-SR), 20mg daily for 4 weeks (n=18) vs. prednisolone (steroid) 20mg/day for 2 weeks, then 2-week dose of 10mg daily (n = 23) vs. placebo for 4 weeks (n = 16). Assessments at baseline, 2 weeks and 4 weeks.	Mean±SD global symptom score (GSS) baseline/2 weeks/4 weeks: placebo 22.9±5.9/21.6±6.4/20.8± 6.6 vs. diuretics 26.0±3.8/22.3±5.5/21.6±6.3 vs. NSAID-SR 29.7±8.4/24.7±8.6/24.0±9.7 vs. steroid 27.9±6.9/15.0±6.8/10.0±7.5 (p <0.0005 at week 2 steroid vs. other treatment groups; p <0.00001 at week 4 steroid vs. placebo).	"For patients with mild to moderate CTS who opt for conservative treatment, corticosteroids are of greater benefit."	Suggests oral steroids effective but diuretic and NSAID are not effective compared with placebo.
NSAID vs. Other Treatments						
Yildiz 2011 RCT No mention of sponsorship or COI.	8.0	N = 51 (43 females/8 males) with signs and symptoms of CTS for more than a month and mild-to-moderate CTS after electrodiagnostic test confirmation. Age range 39-66 years.	Group 1: sham ultrasound (US), ultrasound in off mode 15 minute sessions 1x a day, 5x a week for 2 weeks plus splinting with neutral custom-molded thermoplastic volar wrist splint at night and during day for 8 weeks (n = 17, 25 median nerves) vs. Group 2: US, pulse mode (1:4) with gel without medication at 1 MHz frequency and 1 W/cm^2 intensity plus splinting (n = 17, 26 median nerves) vs. Group 3: ketoprofen phonophoresis (PH), US pulse mode (1:4) with 2.5% ketoprofen gel at 1 MHz frequency	Mean±SD VAS (baseline/2 weeks/8 weeks): Group 1, 5.76±2.45/2.72±2.07/3.28±2.74 vs. Group 2, 4.96±2.50/2.41±2.43/2.77±2.74 vs. Group 3, 6.04±2.40/3.03±1.96/0.98±1.65 (p = 0.002, Group 3> Group 1; p = 0.004, Group 3 > Group 2).	"Our results suggest that ketoprofen PH in addition to splinting is superior to the combination of US and splinting with respect to pain only in middle term patients with CTS."	Ultrasound plus splinting not superior to splinting alone. Ketoprofen plus splinting was associated with a reduction in pain at 8 weeks.

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			and 1 W/cm^2 intensity plus splinting (n = 17, 25 median nerves). Follow-up for 8 weeks.			
Chang 1998	See above.					
Jarvik 2009 RCT Sponsored by the Intramural Research Program of the NIH Clinical Center. No COI.	7.0	N = 116 (62 female/54 male) considering surgery for diagnosed carpal tunnel syndrome. Mean age 50.7 years.	Surgery group: open surgery or endoscopic surgery depending on surgeon's preference (n = 57) vs. non-surgical therapy group: 6 visits with hand therapist focused on ligament stretching, tendon gliding, and review of splint use (splint use at night) plus prescribed NSAIDS, ibuprofen 200mg 3x a day. If no improvement after 6 weeks, received 12 sessions (2-4 per week for up to 6 weeks) of focused ultrasound at 1 Mhz, 1·0 W/cm^2 in pulsed mode 1:4, 15 minutes each (n = 59). Follow-up at 3, 6, 9, 12 months.	Primary outcome was Carpal Tunnel Syndrome Assessment Questionnaire (CTSAQ). Surgical group showed significantly lower CTSAQ function score vs. non-surgical group at 6 months; 1.91 vs. 2.44 (p = 0.0006) and at 12 months; 1.74 vs. 2.17 (p = 0.0081). Secondary outcome of CTSAQ symptoms was also significantly lower in surgery group vs. non-surgical group at 6 months; 2.02 vs. 2.42 (p = 0.018) and 12 months; 1.74 vs. 2.07 (p = 0.036).	"Overall, these data indicate that, in patients with carpal tunnel syndrome without denervation, surgery modestly improves hand function and symptoms by 3 months compared with a multimodality non-surgical treatment regimen, and this benefit is sustained through 1 year."	At 12 months, surgical group was significant for impoved symptoms and function.
Celiker 2002 RCT No mention of sponsorship or COI.	5.5	N = 23 with unilateral or bilateral CTS, EDS confirmed. Mean age Group A 49.6±15.3 years, Group B 46.9±10.0 years.	Group A: acemetacine 120mg a day with splints at night, light-weight, neutral-positioned (n=11) vs. Group B: 40mg methylpred-nisolone acetate 1ml (n=12). Follow-up at 2 weeks and 8 weeks.	VAS pain scores (baseline/2nd week/8th week): NSAID plus splint 7.9±1.4/4.3±0.9/1.7±1.0 vs. injection 7.0±2.2/3.1±2.5/1.8±1.9 (p>0.05). Symptom severity scale results similar.	"Both splinting combined with the use of a nonsteroidal anti-inflammatory drug and steroid injection into the carpal tunnel resulted in significant improvement in carpal tunnel syndrome."	Not placebo controlled. Suggests splinting and NSAID may be as effective as injection.
Davis 1998 RCT Sponsored by a grant from the National Chiropractic Mutual Insurance Company. No mention of COI.	5.0	N = 91 with self-reported symptoms of CTS and EDS confirmed CTS. Mean age ibuprofen group 38±5 year, manipulation	Ibuprofen (800mg 3x a day for 1 week, then 2x a day for 1week, then PRN 7 weeks) and nocturnal cock-up wrist supports (n = 46) vs. high velocity, low amplitude manual thrust procedures:	CTS outcome assessment physical distress (mean±SD) baseline to end of study: IBU and splint 14.66±9.89 to 5.74± 6.28 vs. ultrasound and manipulation 12.47±8.07 to 9.25±8.14 (p = 0.0132). CTS outcome assessment mental distress	"Carpal tunnel syndrome associated with median nerve demyelination but not axonal degeneration may be treated with commonly used components of conservative medical or chiropractic care."	Baseline did not exclude prior ibuprofen use or manipulation, but prior use of these treatments is likely differential between the 2 groups and is a potentially fatal study flaw. Ibuprofen use was PRN after 2 weeks and subject contact differed

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		group 36±6 years.	manipulation to upper extremity and spine (3 treatments a week for 2 weeks; 2 treatments a week for 3weeks; 1 treatment a week for 4 weeks) plus ultrasound applied over carpal tunnel for half of chiropractic treatment visits, 1 MHz and 1.0-1.5 W/cm at 50% duty cycle for 5 minutes plus nocturnal wrist supports (n = 45). Study duration 9 weeks. Assessments at baseline and end of study.	(mean±SD) baseline to end of study: IBU and splint 33.61±12.02 to 14.94±11.33 vs. ultrasound and manipulation 28.94±11.69 to 17.29±13.24 (p = 0.0085). No significance between group difference in EDS.		between groups, providing bias in favor of manipulation/ultrasound. High dropout rates. Study mainly compares variable dose ibuprofen vs. manipulation plus ultrasound as both splinted. Since ibuprofen not effective and evidence that ultrasound is, results suggest manipulation is not effective.
Nalamachu 2006 MedGenMed RCT Sponsored by Endo Pharmaceuticals. COI, Nalamachu received research grants and consulting fee from Endo Pharmaceuticals. PharmD is employed by Endo Pharmaceuticals as Senior Director, Medical Affairs, and receives annual stock options from Endo. Gould is employed by Endo Pharmaceuticals as Associate Director, Medical Affair, and receives annual stock options from Endo.	4.5	N = 100 age 18-75 with CTS, clinical and EDS confirmed. Mean age lidocaine patch 55.7±16.0 years, naproxen 51.5±11.8 years.	Lidocaine patch 5% up to a maximum of 3 patches, 420 cm^2, per day (n=52) vs. naproxen 500 mg twice daily (n = 48) for 6 weeks. Assessments at baseline after 1, 3, and 6 weeks of treatment.	Brief Pain Inventory (BPI) scores reduced between baseline and Week 6 for both lidocaine patch 5% (p <0.0001) and naproxen 500 mg twice daily (p = 0.0004), but no between group differences (p = 0.083). Clinical Global Impression of Improvement (CGI-I) scores also favored patch (51.1% vs. 24.3%, p = 0.016). Percentages satisfied or very satisfied 71.8% lidocaine patch vs. 63.2% naproxen (NS).	"This study demonstrates that the lidocaine patch 5% is effective in significantly relieving the pain associated with CTS and is well tolerated. The patch may offer patients an effective, non-systemic, noninvasive treatment for the management of their symptoms. Further controlled studies are warranted."	More diabetics in naproxen group (23.59% vs. 9.6%). Severity (39.69% vs. 32.7%) and mean pain intensity somewhat worse in naproxen group (4.9±2.6 vs. 4.5±2.5). Excluded pain patch use, but not prior NSAID use. All appears to bias in favor of patch. Potential other painful diagnoses being treated appear possible.
Post-operative NSAIDs						
Husby 2001 RCT	8.0	N = 77 who underwent surgery for CTS	Post-op naproxen 500mg BID (n = 26) vs. paracetamol 1,000mg	Postoperative CTS swelling as a percentage of preoperative volume 3.5±3.3	"Naproxen might have a clinical relevant effect on swelling when used on	Results suggest a beneficial effect of naproxen over paracetamol, which is

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No mention of sponsorship or COI.		of Dupuytren's contracture (DC). Mean age 59 years.	QID (n = 26) vs. placebo tablets (n = 25) for 3 days immediate post-op carpal tunnel release surgical treatment; 2nd trial included 35 with Dupuytren's contracture. Opioid analgesic allowed for supplementary analgesic. No mention of follow-up time.	vs. 4.6±3.2 vs. 3.8±2.6. For Dupuytren's contracture releases: 5.6±3.8 vs. 6.9±3.7 vs. 8.2±5.1. Additional analgesics used were 0, 2, and 8 in naproxen, paracetamol, and placebo groups.	minor surgery in the hand, unlike paracetamol. Naproxen might be a useful analgesic during the immediate post-operative phase."	superior to placebo, which the studies were not powered to detect.

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Systemic Glucocorticosteroids (AKA “Steroids”)

Oral

Glucocorticosteroids are used to treat CTS and other tendinoses through both oral and injection routes (injections for CTS and other tendinoses).(636, 643-648) Although these medications are considered to be anti-inflammatory corticosteroids, absent an inflammatory arthropathy or infection, CTS does not typically evidence inflammation. Thus, the exact mechanism of action is uncertain. Regardless, evidence indicates that carpal tunnel injections are superior to oral steroids for treatment of CTS.(648)

Recommendation: Oral Glucocorticosteroids for Treatment of Acute, Subacute, or Chronic CTS
Oral glucocorticosteroids are moderately recommended for treatment of acute, subacute, or chronic CTS among patients who decline carpal tunnel injection.

Indication – CTS unresponsive to splinting. Most patients should be injected rather than given oral steroids.(648) However, for patients declining injection, oral glucocorticosteroids may be warranted. Oral glucocorticosteroids are relatively contraindicated for patients with diabetes mellitus and may worsen glucose intolerance among those who are pregnant.

Frequency/Dose – It is unclear what dose and duration of treatment is optimal. Two trials used 10 days of treatment with prednisolone acetate 25mg a day.(646, 648) A third used prednisolone 20mg a day for 2 weeks, then 10mg a day for 2 weeks.(636, 647) Another used prednisone 20mg a day for 1 week, then 10mg a day for 1 week.(644) Another used prednisolone 20mg a day for 2 weeks on one treatment arm.(643) There is evidence that 2 weeks of treatment is as effective as 4 weeks.(643) It is recommended that one course (10 to 14 days) of oral glucocorticosteroid be prescribed rather than repeated courses. Prescriptions of low rather than high doses are recommended to minimize potential for adverse effects.

> *Strength of Evidence* – **Moderately Recommended, Evidence (B)**
> *Level of Confidence* – Moderate
>
> (Note: Injections are recommended as superior to oral forms.)

Rationale for Recommendation
There is strong evidence that injected glucocorticosteroids are more effective(648) with longer duration of benefits. Nevertheless, there is consistent evidence that oral glucocorticosteroids are superior to placebo,(636, 643, 644, 646) as well as compared with diuretics and NSAIDs.(636) Unlike glucocorticosteroid injections, long-term follow-up studies have not been reported, thus duration of benefit is unclear. However, oral glucocorticosteroids are not invasive, have relatively few adverse effects for a short course, and are low cost.

Evidence for the Use of Oral Glucocorticosteroids
See Intracarpal Tunnel Glucocorticosteroid Injections (“Steroid Injections”) Section.

Diuretics

Diuretics have been used to treat CTS, in part due to observations of swelling in some patients.(359, 634, 636, 649-652)

Recommendation: Diuretics for Treatment of Acute, Subacute, or Chronic CTS
Diuretics are moderately not recommended for treatment of acute, subacute, or chronic CTS in the absence of fluid retention states.

> *Strength of Evidence* **– Moderately Not Recommended, Evidence (B)**
> *Level of Confidence* – Moderate

Rationale for Recommendation
There are two quality studies evaluating diuretics for treatment of CTS patients and both failed to find evidence of efficacy compared with placebo.(636, 652) Thus, diuretics are not recommended for routine treatment of CTS patients. Whether they are effective for treatment of patients with CTS accompanied by

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fluid retention states, such as third trimester pregnancy, has not been determined in quality studies, and thus their use in select cases may be a reasonable intervention.

Evidence for the Use of Diuretics for CTS
There are 2 moderate-quality RCTs incorporate into this analysis. (636, 652)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL and Cochrane Library without date limits using the following terms: Diuretics, Trichlormethiazide, Hydrochlorothiazide, carpal tunnel syndrome, CTS, median nerve neuropathy, median neuropathy, median nerve disease, entrapment, neuropathy, nerve compression, burning, itching, numbness, tingling, wrist, hand, palm, finger, pain, controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random, randomized, randomization, randomly; systematic, systematic review, retrospective studies, and prospective studies. We found and reviewed 14 articles in PubMed, 1556 in Scopus, 3 in CINAHL, 27 in Cochrane Library and 2 in other sources. We considered for inclusion 2 from PubMed, 1 from Scopus, 0 from CINAHL, 1 from Cochrane Library and 2 from other sources. Of the 6 articles considered for inclusion, 2 randomized trials and 4 systematic studies met the inclusion criteria.*

Author/Year Study Type Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Chang 1998 RCT Sponsored by the National Science Council Grants. No mention of COI.	7.0	N = 91 (53 female/20 male) with confirmed CTS via electrodiagnosis ; Mean (±SD) age 44.2 (±5.4) for placebo group, 45.7 (±4.8) for diuretic group, 47.4 (±5.7) for NSAID-SR group and 45.4 (±5.2) for steroid group.	Trichlor-methiazide, 2mg daily (n = 16) vs. Tenoxicam-SR, 20mg daily (n = 18) vs. 2 weeks prednisolone at 20mg daily, followed by 2-week dose 10mg daily (n = 23) vs. Placebo or control group (n = 16). Assessments at baseline, 2 and 4 weeks.	No significant reduction from baseline GSS seen at 2nd and 4th weeks in placebo, NSAID-SR, and diuretic groups. However, mean score at 4 weeks in steroid group decreased significantly from a baseline of 27.9±6.9 to 10±7.54, ($p < 0.00001$).	"For patients with mild to moderate CTS who opt for conservative treatment, corticosteroids are of greater benefit."	Suggests oral steroids effective but diuretic and NSAID are not.
Pal 1988 RCT No mention of sponsorship or COI.	6.0	N = 48 (43 female/5 male) with CTS diagnosed via nerve conduction tests; Mean (±SD) age 41 (±13) for Bendrofluazid group and 53 (±13) for placebo control group.	Bendrofluazide 5 mg a day (n = 23; 41 hands) vs. Placebo (N =25; 40 hands) for 4 weeks. Assessments at baseline, 4 weeks and 6 months.	No significant difference in clinical improvement outcomes between the two groups at follow-up assessments.	"Bendrofluazide 5mgm daily for one month does not confer additional clinical benefit in the idiopathic CTS, but further trials with stronger diuretics and/or longer periods of treatment are warranted."	Study suggests no short or long-term benefit.

OPIOIDS – Oral, Transdermal, and Parenteral (includes Tramadol)
Opioids have occasionally been used to treat pain for patients with CTS. Opioids are addressed in a separate Guideline. The treatment recommendations are summarized below. See Opioids Guideline for all supporting evidence.

Acute Pain (Up to 4 Weeks)

1. *Recommendation: Routine Use of Opioids for Treatment of Non-Severe Acute Pain*

Routine opioid use is strongly not recommended for treatment of non-severe acute pain (e.g., low back pain (LBP), sprains, or minor injury without signs of tissue damage).

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Harms – May inadequately treat acute, severe pain.
Benefits – Faster recovery, less debility, reduced accidents risks, risks of dependency or addiction.
Strength of Evidence – **Strongly Not Recommended, Evidence (A)**
Level of Confidence – High

2. Recommendation: Opioids for Treatment of Acute, Severe Pain
Opioids are recommended for treatment of acute, severe pain (e.g., crush injuries, large burns, severe fractures, injury with significant tissue damage) uncontrolled by other agents and/or with functional deficits caused by pain. They also may be indicated at the initial visit for a brief course for anticipated pain accompanying severe injuries (i.e., failure of other treatment is not mandatory). A Schedule IV[i] opioid may be indicated if there is true allergy to NSAIDs and acetaminophen, other contraindication to an alternative medication, or insufficient pain relief with an alternative. Recommend to taper off opioid use in 1 to 2 weeks.

Indications **–** Patients should meet all of the following:

1) Severe injury with a clear rationale for use (objective functional limitations due to pain resulting from the medical problem, e.g., extensive trauma such as forearm crush injury, large burns, severe radiculopathy).[ii]
2) Other more efficacious treatments should have been instituted,[iii] and either: a) failed; and/or b) have reasonable expectations of the immediate need for an opioid to obtain sleep the evening after the injury.
3) Where available, prescription databases (usually referred to as Prescription Drug Monitoring Program (PDMP)) should be checked and not show evidence for conflicting opioid prescriptions from other providers or evidence of misreporting.[iv]
4) Non-opioid prescriptions (e.g., NSAIDs, acetaminophen) absent contraindication(s) should nearly always be the primary treatment and accompany an opioid prescription.
5) Low-dose opioids may be needed in the elderly who have greater susceptibility to the adverse risks of opioids. Those of lower body weight may also require lower opioid doses.
6) Dispensing quantities should be only what is needed to treat the pain. Short-acting opioids are recommended for treatment of acute pain. Long-acting opioids are not recommended.
7) Due to greater than 10-fold elevated risks of adverse effects and death, considerable caution is warranted among those using other sedating medications and substances including: i) benzodiazepines, ii) anti-histamines (H_1-blockers), and/or iii) illicit substances.(653-656) Patients should not receive opioids if they use illicit substances unless there is objective evidence of significant trauma or moderate to severe injuries. Considerable caution is also warranted among those who are unemployed as the reported risks of death are also greater than 10-fold.(654, 655) Due to elevated risk of death and adverse effects, caution is also warranted when considering prescribing an opioid for patients with any of the following characteristics: depression, anxiety, personality disorder, untreated sleep disorders, substance abuse history, current alcohol use or current tobacco use, attention deficit hyperactivity disorder (ADHD), post-traumatic stress disorder (PTSD), suicidal risk, impulse control problems, thought disorders, psychotropic medication use, chronic obstructive pulmonary disease (COPD), asthma, or recurrent pneumonia.(654, 657-678) Considerable caution is also warranted among those with other comorbidities such as chronic hepatitis and/or cirrhosis,(679) as well as coronary artery disease,

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[i]USA classifies controlled substances that includes a classification system, ranging from Class 1 to Class V corresponding to lower risks of abuse and dependence. Class I includes substances with a high potential for abuse and without a recognized medical use (e.g., heroin, marijuana, LSD). Class II includes most opiates, amphetamines and cocaine. Class III includes buprenorphine, dihydrocodeiene, hydrocodone/codeiene when compounded with an NSAID, Marinol. Class IV includes tramadol (in some states), carisoprodol, benzodiazepines, and long-activing barbiturates. Class V includes small amounts of codeine (e.g, 30mg, 60mg).
[ii]Other indications beyond the scope of this guideline include acute myocardial infarction or agitation interfering with acute trauma management.
[iii]Treatments to have tried generally include NSAIDs and acetaminophen. For LBP patients, additional considerations include muscle relaxants, progressive aerobic exercise, and directional exercise.
[iv]Exceptions such as acute, severe trauma should be documented.

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dysrhythmias, cerebrovascular disease, orthostatic hypotension, asthma, recurrent pneumonia, thermoregulatory problems, advanced age (especially with mentation issues, fall risk, debility), osteopenia, osteoporosis, water retention, renal failure, severe obesity, testosterone deficiency, erectile dysfunction, abdominal pain, gastroparesis, constipation, prostatic hypertrophy, oligomenorrhea, pregnancy, human immunodeficiency virus (HIV), ineffective birth control, herpes, allodynia, dementia, cognitive dysfunction and impairment, gait problems, tremor, concentration problems, insomnia, coordination problems, and slow reaction time. There are considerable drug-drug interactions that have been reported (see Appendices 2-3 of Opioids Guideline).

Frequency/Duration – Generally, opioids should be prescribed at night or while not working.(680) Lowest effective, short-acting opioid doses are preferable as they tend to have the better safety profiles, less risk of escalation,(681) less risk of lost time from work,(682) and faster return to work.(683) Short-acting opioids are recommended for treatment of acute pain and long-acting opioids are not recommended. Recommend opioid use as required by pain, rather than in regularly scheduled dosing.

If parenteral administration is required, ketorolac has demonstrated superior efficacy compared with opioids for acute severe pain,(684, 685) although ketorolac's risk profile may limit use for some patients. Parenteral opioid administration outside of obvious acute trauma or surgical emergency conditions is almost never required, and requests for such treatment are clinically viewed as red flags for potential substance abuse.

Indications for Discontinuation – Resolution of pain, sufficient improvement in pain, intolerance or adverse effects, non-compliance, surreptitious medication use, consumption of medications or substances advised to not take concomitantly (e.g., sedating medications, alcohol, benzodiazepines), or use beyond 2 weeks.
Harms – Adverse effects are many (see section below on "Opioids Benefits and Harms").
Benefits – Improved short-term pain control.

Strength of Evidence – **Recommended, Evidence (C)**
Level of Confidence – High

3. Recommendation: Screening Patients Prior to Initiation of Opioids
Initial screening of patients is recommended with more detailed screening for: i) requiring continuation of opioids beyond 2 weeks for those with an acute severe injury, and ii) at consideration of initiation for severe pain but no objective evidence. Screening should include history(ies) of depression, anxiety, personality disorder, other psychiatric disorder, substance abuse, sedating medication use (e.g., anti-histamine/anti-H_1 blocker(654)), benzodiazepine use, opioid dependence, alcohol abuse, current tobacco use, other substance use history, COPD, PTSD, other psychotropic medications, (severe) obesity, cognitive impairment, balance problems/fall risk, osteoporosis, and renal failure (see Appendix 1 of Opioids Guideline). Those who screen positive, especially to multiple criteria, are recommended to: i) undergo greater scrutiny for appropriateness of opioids (may include psychological evaluation), ii) consideration of consultation and examination(s) for complicating conditions and/or appropriateness of opioids, and iii) if opioids are prescribed, more frequent assessments for compliance, achievement of functional gains,(655, 686, 687) adverse effects, and symptoms and signs of aberrancy.

Harms – Negligible. If a consultation is needed, there are additional costs that are incurred.
Benefits – Improved identification of more appropriate candidates for opioids. Identification of patients at increased risk of adverse effects. In cases where someone has elevated, but potentially acceptable risk, may alert the provider to improve surveillance for complications and aberrant behaviors.

Strength of Evidence – **Recommended, Insufficient Evidence (I)**
Level of Confidence – High

4. Recommendation: Opioid Dose Limits in Acute Pain
Dispense only that which is required. The maximum daily oral dose recommended for opioid-naïve, acute pain patients based on risk of overdose/death is 50mg morphine equivalent dose

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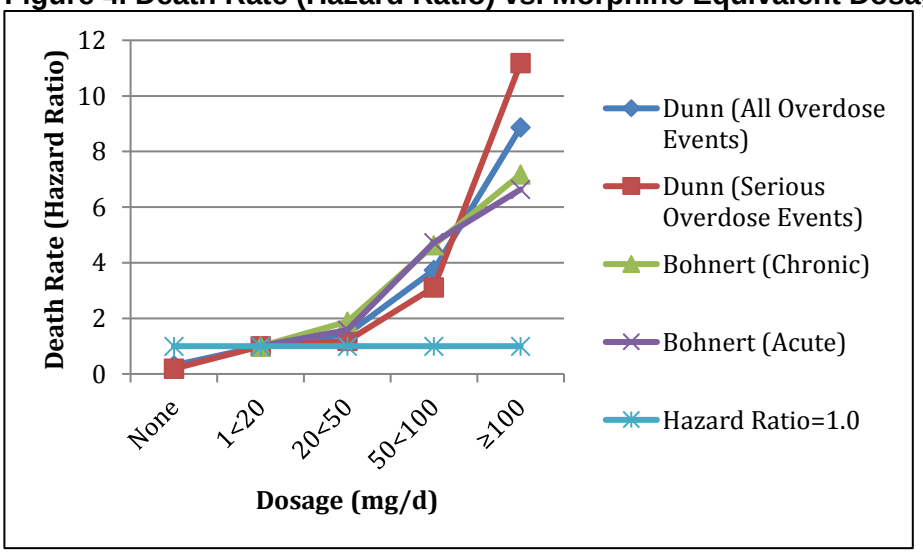
(MED)[v](688) (see Figure 4). In rare cases with documented functional improvement (see Appendix 1 of Opioids Guideline), higher doses may be considered, however, risks are substantially higher and greater monitoring is also recommended (see Subacute/Chronic Opioid recommendations below). Lower doses should be used for patients at higher risk of dependency, addiction and other adverse effects. Monitoring is also recommended and consultation may be considered for those patients on higher doses.
Harms – Theoretical potential to undertreat pain in some patients with increased pain sensitivity.
Benefits – Reduced risk for adverse physical and cognitive effects, dependency, addiction and opioid-related overdoses and deaths.

Strength of Evidence – **Recommended, Evidence (C)**
Level of Confidence – Moderate

Figure 4. Death Rate (Hazard Ratio) vs. Morphine Equivalent Dosage (mg/d)*



Adapted from Dunn 2010 and Bohnert 2011.
*Statistical significance present for acute and chronic pain at and above 50 mg per day of oral morphine equivalent dose.

Post-Operative Pain (Up to 4 Weeks) (After 4 weeks, see Subacute Pain)
Oral opioids are commonly prescribed after sinus surgery,(689) major noncardiac surgical procedures,(690) mastectomy and immediate breast reconstruction (IBR),(691, 692) coronary artery bypass graft surgery,(693) major abdominal surgery (abdominal laparoscopic, abdominal hysterectomy, bowel resection or radical hysterectomy), (694-697) orthopedic surgery,(698) and molar extraction.(699)

1. Recommendation: Limited Use of Opioids for Post-operative Pain
Limited use of opioids is recommended for post-operative pain management as adjunctive therapy to more effective treatments.

Indications – For post-operative pain management, a brief prescription of short-acting opioids as adjunct to more efficacious treatments (especially Cox-2 NSAIDs such as celecoxib, non-selective NSAIDs after risk of bleeding is no longer a concern).[vi] A brief course of opioids is often needed for minor surgical procedures. However, minor wound laceration repairs often require no opioids. Evidence suggests perioperative pregabalin for 14 days and/or continuous femoral nerve catheter analgesia instead of solely using oral opioids results in superior knee arthroplasty functional outcomes with less venous thromboses.(700) Additional considerations include:

1) Non-opioid prescriptions (e.g., NSAIDs, acetaminophen) should nearly always be the primary treatment and accompany an opioid prescription. Computerized programs may also assist in optimal management.(701)

[v]Statistical significance present for acute and chronic pain at and above 50 mg per day of oral morphine equivalent dose.
[vi]More efficacious treatments also include therapeutic exercises, e.g., progressive ambulation especially for moderate to extensive procedures (e.g., arthroplasty, fusion).

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2) The lowest effective dose of a short-acting opioid should be used,(681) as well as weaker opioids if possible.(682, 683)
3) Short-acting opioids are recommended for treatment of acute pain.
4) Dispensing should be only what is needed to treat the pain.[vii]
5) Long-acting opioids are not recommended.
6) Low-dose opioids may be needed in the elderly who have greater susceptibility to the adverse risks of opioids. Those of lower body weight may also require lower opioid doses.
7) Where available, prescription databases (usually referred to as Prescription Drug Monitoring Program (PDMP)) should be checked for other opioid prescriptions. Due to greater than 10-fold elevated risks of adverse effects and death, considerable caution is warranted among those using other sedating medications and substances including: i) benzodiazepines, ii) anti-histamines (H_1-blockers), and/or iii) illicit substances.(653-656) Patients should not receive opioids if they use illicit substances unless there is objective evidence of significant trauma or moderate to severe injuries. Considerable caution is also warranted among those who are unemployed as the reported risks of death are also greater than 10-fold.(654, 655)

   Due to elevated risk of death and adverse effects, caution is also warranted when considering prescribing an opioid for patients with any of the following characteristics: depression, anxiety, personality disorder, ADHD, PTSD, suicidal risk, impulse control problems, thought disorders, psychotropic medication use, substance abuse history, current alcohol use or current tobacco use, untreated sleep disorders, COPD, asthma, or recurrent pneumonia. .(654, 657-678) Considerable caution is also warranted among those with other comorbidities such as chronic hepatitis and/or cirrhosis,(679) as well as coronary artery disease, dysrhythmias, cerebrovascular disease, orthostatic hypotension, thermoregulatory problems, advanced age (especially with mentation issues, fall risk, debility), osteopenia, osteoporosis, water retention, renal failure, severe obesity, testosterone deficiency, erectile dysfunction, abdominal pain, gastroparesis, constipation, prostatic hypertrophy, oligomenorrhea, pregnancy, HIV, ineffective birth control, herpes, allodynia, dementia, cognitive dysfunction and impairment, gait problems, tremor, concentration problems, insomnia, coordination problems, and slow reaction time. There are considerable drug-drug interactions that have been reported (see Appendices 2-3 of Opioids Guideline). Inpatient management may moderate these recommendations provided there is careful monitoring, although these same management issues then apply post-discharge.
8) For patients taking opioids chronically prior to surgery, consultations with anesthesiology and/or pain management are generally needed as post-operative dosing may be very high and management is often quite challenging.
9) Ongoing prescriptions of opioids after the immediate post-operative period should generally be for patients who have undergone a major surgery or have other condition(s) necessitating opioids. Most patients should be making progress towards functional restoration, pain reduction and weaning off the opioids. Patients who have not progressed should be carefully evaluated for physical complications or psychiatric comorbidity, adherence to active treatments, and pending development of addiction or dependency.

Frequency/Duration – For moderate and major surgeries, opioids are generally needed on a scheduled basis in the immediate post-operative period. Other post-operative situations may be sufficiently managed with an as needed opioid prescription schedule. Provision of opioids sufficient to participate in therapeutic exercise (e.g., progressive ambulation) and allow sleep may be needed. However, high dose use at night is not recommended due to respiratory depression and disruption of sleep architecture. Weaning should begin as soon as function is recovering and pain is subsiding. Subsequent weaning to as needed opioid use is recommended.

Indications for Discontinuation – The physician should discontinue the use of opioids based on sufficient recovery, expected resolution of pain, lack of efficacy, intolerance or adverse effects, non-compliance, surreptitious medication use, self-escalation of dose, or use beyond 3 to 5 days for minor procedures, and

[vii]Generally, this should be sufficient to cover two weeks of treatment. Prescriptions of 90-day supplies in the post-operative setting are not recommended.

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2 to 3 weeks for moderate/less extensive procedures. Use for up to 3 months may occasionally be necessary during recovery from more extensive surgical procedures (e.g., spine fusion surgery). However, with rare exceptions, only nocturnal use is recommended in months 2 to 3 plus institution of management as discussed in the subacute/chronic guidelines below. For those requiring opioid use beyond 1 month, the subacute/chronic opioid use recommendations below apply.
Harms – Adverse effects are many (see section on "Opioids Benefits and Harms").
Benefits – Improved short-term, post-operative pain control. Some studies suggest this may modestly improve functional outcomes in the post-operative population.

Strength of Evidence – **Recommended, Evidence (C)**
Level of Confidence – High

2. Recommendation: Screening Patients Prior to Continuation of Opioids
Screening of patients is recommended for patients requiring continuation of opioids beyond the second post-operative week. Screening should include history(ies) of: depression, anxiety, personality disorder, pain disorder, other psychiatric disorder, substance abuse history, sedating medication use (e.g., anti-histamine/anti-H_1 blocker), benzodiazepine use, opioid dependence, alcohol abuse, current tobacco use, and other substance use history, COPD, PTSD, other psychotropic medications, (severe) obesity, cognitive impairment, balance problems/fall risk, osteoporosis, and renal failure (see Appendix 1 of Opioids Guideline). Those who screen positive, especially to multiple criteria, are recommended to: i) undergo greater scrutiny for appropriateness of opioids (e.g., may include psychological and/or pain evaluation); ii) compliance with active therapies (e.g., ambulation and other exercise after arthroplasty); iii) consider consultation examination(s) for complicating conditions and/or appropriateness of opioids; and iv) if ongoing opioids are prescribed, ensure more frequent assessments for treatment compliance, achievement of functional gains,(655, 686, 687) and symptoms and signs of aberrancy.

Harms – Negligible. If a consultation is needed, there are additional costs that are incurred.
Benefits – Identification of patients at increased risk of adverse effects. Improved identification of more appropriate and safe candidates for opioids compared with attempting post-operative pain control with non-opioids. This should reduce adverse effects. In cases where someone has elevated, but potentially acceptable risk, this may alert the provider to improve surveillance for complications and aberrant behaviors.

Strength of Evidence – **Recommended, Insufficient Evidence (I)**
Level of Confidence – High

3. Recommendation: Opioid Dose Limits in Post-operative Pain
The maximum daily oral dose recommended for opioid-naïve, acute pain patients based on risk of overdose/death is 50mg morphine equivalent dose (MED)[viii](688) (see Figure 4). Post-operative patients particularly require individualization due to factors such as the severity of the operative procedure, response to treatment(s) and variability in response. Higher doses beyond 50mg MED may be particularly needed for major surgeries in the first two post-operative weeks to achieve sufficient pain relief, however, greater caution and monitoring are warranted and reductions below 50mg MED at the earliest opportunity should be sought. Lower doses should be used for patients at higher risk of dependency, addiction and other adverse effects. In rare cases with documented functional improvement, ongoing use of higher doses may be considered, however, risks are substantially higher and greater monitoring is also recommended (see Subacute/Chronic Opioid recommendations below).

Harms – Theoretical potential to undertreat pain, which could modestly delay functional recovery.
Benefits – Reduced risk for adverse effects, dependency, addiction and opioid-related deaths.

Strength of Evidence – **Recommended, Insufficient Evidence (I)**
Level of Confidence – Low

Subacute (1-3 Months) and Chronic Pain (>3 Months)

1. *Recommendation: Routine Use of Opioids for Subacute and Chronic Non-malignant Pain*

[viii]Statistical significance present for acute and chronic pain at and above 50 mg per day of morphine equivalent dose.

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Opioid use is moderately not recommended for treatment of subacute and chronic non-malignant pain. Opioid prescription should be patient specific and limited to cases in which other treatments are insufficient and criteria for opioid use are met (see below).

Harms – May inadequately treat severe subacute or chronic pain.
Benefits – Less debility, fewer adverse effects, reduced accident risks, lower risks of dependency, addiction, overdoses, and deaths.

Strength of Evidence – **Moderately Not Recommended, Evidence (B)**
Level of Confidence – High

2. *Recommendation: Opioids for Treatment of Subacute or Chronic Severe Pain*
The use of an opioid trial is recommended if other evidence-based approaches for functional restorative pain therapy have been used with inadequate improvement in function.(702, 703) **Opioids are then recommended for treatment of function impaired by subacute or chronic severe pain (e.g., inability to work due to any of the following: chronic severe radiculopathy, chronic severe peripheral neuropathies, complex regional pain syndrome (CRPS), and severe arthroses)**(686) **(see Appendix 1 of Opioids Guideline).**

Indications **–** Patients should meet all of the following:

1) Reduced function is attributable to the pain. Pain or pain scales alone are insufficient reasons.(655, 686, 704-715)
2) A severe disorder warranting potential opioid treatment is present [e.g., CRPS, severe radiculopathy, advanced degenerative joint disease (DJD)].(706)
3) Other more efficacious treatments have been documented to have failed.(706) Other approaches that should have been first utilized include physical restorative approaches, behavioral interventions, self-applied modalities, non-opioid medications (including NSAIDs, acetaminophen, topical agents, norepinephrine adrenergic reuptake blocking antidepressants or dual reuptake inhibitors; also antiepileptic medications particularly for neuropathic pain) and functional restoration. For LBP patients, this also includes[ix] fear avoidant belief training and ongoing progressive aerobic exercise, and strengthening exercises. For CRPS patients, this includes progressive strengthening exercise. For DJD, this includes NSAIDs, weight loss, aerobic and strengthening exercises.
4) An ongoing active exercise program is prescribed and complied with.
5) Non-opioid prescriptions (e.g., NSAIDs, acetaminophen) absent a contraindication should nearly always be the primary pain medication and accompany an opioid prescription. Other medications to consider include topical agents, norepinephrine adrenergic reuptake blocking antidepressants or dual reuptake inhibitors; also antiepileptic medications particularly for neuropathic pain).
6) The lowest effective dose should be used.(681) Weaker opioids should be used whenever possible.(682, 683) Meperidine is not recommended for chronic pain due to bioaccumulation and adverse effects.
7) Low-dose opioids may be needed in the elderly who have greater susceptibility to the adverse risks of opioids. Those of lower body weight may also require lower opioid doses.
8) Dispensing should be only what is needed to treat the pain.[x]
9) Extended-release/long-acting opioids are recommended to be used on a scheduled basis, rather than as needed.(706) As needed opioids should generally be avoided for treatment of chronic pain, although limited use for an acute painful event (e.g., fracture, sprain) is reasonable. Sublingual fentanyl is not recommended for treatment of subacute or chronic pain. Caution is warranted with fentanyl patches due to unpredictable absorption.
10) Where available, prescription databases (usually referred to as Prescription Drug Monitoring Program (PDMP)) should be checked for conflicting opioid prescriptions from other providers or evidence of misreporting.

[ix]A previous trial of a muscle relaxant is generally recommended. However, if an opioid trial is contemplated, cessation of all depressant medications including muscle relaxants is advisable.
[x]Generally, this should be sufficient to cover one week of treatment at a time during the trial phase. If a trial is successful at improving function, prescriptions for up to 90-day supplies are recommended.

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11) Due to greater than 10-fold elevated risks of adverse effects and death, considerable caution is warranted among those using other sedating medications and substances including: i) benzodiazepines, ii) anti-histamines (H_1-blockers), and/or iii) illicit substances.(653-656) Patients should not receive opioids if they use illicit substances unless there is objective evidence of significant trauma or moderate to severe injuries. Considerable caution is also warranted among those who are unemployed as the reported risks of death are also greater than 10-fold.(654, 655)

    Due to elevated risk of death and adverse effects, caution is also warranted when considering prescribing an opioid for patients with any of the following characteristics: depression, anxiety, personality disorder, untreated sleep disorders, substance abuse history, current alcohol use or current tobacco use, ADHD, PTSD, suicidal risk, impulse control problems, thought disorders, psychotropic medication use, COPD, asthma, recurrent pneumonia.(654, 657-678) Considerable caution is also warranted among those with other comorbidities such as chronic hepatitis and/or cirrhosis,(679) as well as coronary artery disease, dysrhythmias, cerebrovascular disease, orthostatic hypotension, asthma, recurrent pneumonia, thermoregulatory problems, advanced age (especially with mentation issues, fall risk, debility), osteopenia, osteoporosis, water retention, renal failure, severe obesity, testosterone deficiency, erectile dysfunction, abdominal pain, gastroparesis, constipation, prostatic hypertrophy, oligomenorrhea, pregnancy, HIV, ineffective birth control, herpes, allodynia, dementia, cognitive dysfunction and impairment, gait problems, tremor, concentration problems, insomnia, coordination problems, and slow reaction time. There are considerable drug-drug interactions that have been reported (see Appendices 2-3 of Opioids Guideline).

Frequency/Duration – Opioids use is generally initiated as a “trial” to ascertain whether the selected opioid produces functional improvement (see Appendix 1 of Opioids Guideline). Opioid use is generally prescribed on a regular basis,(716) at night or when not at work.(680) Only one opioid is recommended to be prescribed in a trial. More than one opioid should rarely be used. Lower opioid doses are preferable as they tend to have the better safety profiles, less risk of dose escalation,(681) less work loss,(682) and faster return to work.(683) Patients should have ongoing visits to monitor efficacy, adverse effects, compliance and surreptitious medication use. Opioid prescriptions should be shorter rather than longer duration.(717)

Indications for Discontinuation – Opioids should be discontinued based on lack of functional benefit(703) (see Appendix 1 of Opioids Guideline), resolution of pain, improvement to the point of not requiring opioids, intolerance or adverse effects, non-compliance, surreptitious medication use, medication misuse (including self-escalation and sharing medication), aberrant drug screening results, diversion, consumption of medications or substances advised to not take concomitantly (e.g., sedating medications, alcohol, benzodiazepines).

Harms – Adverse effects are many (see section on “Opioids Benefits and Harms”). May initiate path to opioid dependency.

Benefits – Improved short-term pain ratings. Theoretical potential to improve short-term function impaired by a painful condition.

Strength of Evidence – **Recommended, Insufficient Evidence (I)**
Level of Confidence – Low

3. Recommendation: Screening Patients Prior to Initiation of Opioids

Screening of patients is recommended prior to consideration of initiating a trial of opioids for treatment of subacute or chronic pain. Screening should include history(ies) of depression, anxiety, personality disorder and personality profile,(683, 718, 719) other psychiatric disorder, substance abuse history, sedating medication use (e.g., anti-histamine/anti-H_1 blocker),(667) benzodiazepine use, opioid dependence, alcohol abuse, current tobacco use, and other substance use history, COPD, PTSD, other psychotropic medications, (severe) obesity, cognitive impairment, balance problems/fall risk, osteoporosis, and renal failure (see Appendix 1 of Opioids Guideline). Those who screen positive, especially to multiple criteria, are recommended to: i) undergo greater scrutiny for appropriateness of opioids (may include psychological and/or psychiatric evaluation(s) to

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help assure opioids are not being used instead of appropriate mental health care); ii) consideration of consultation and examination(s) for complicating conditions and/or appropriateness of opioids; and iii) if opioids are prescribed, more frequent assessments for compliance, achievement of functional gains and symptoms and signs of aberrant use.

Harms – Negligible. If a consultation is needed, there are additional costs that are incurred.
Benefits – Identification of patients at increased risk of adverse effects. Improved identification of more appropriate and safe candidates for treatment with opioids. This should reduce adverse effects. In cases where someone has elevated, but potentially acceptable risk, this may alert the provider to improve surveillance for complications and aberrant behaviors.

Strength of Evidence – **Recommended, Insufficient Evidence (I)**
Level of Confidence – High

4. Recommendation: Opioid Dose Limits in Subacute and Chronic Pain
The maximum daily oral dose recommended for subacute or chronic pain patients based on risk of overdose/death is 50mg Morphine Equivalent Dose (MED).(657, 688) In rare cases with documented functional improvements occurring with use above 50mg MED, subsequent doses up to 100mg may be considered, however, risks of death are much greater and more intensive monitoring is then also recommended. Lower doses should be considered in high-risk patients. Caution appears warranted in all patients as there is evidence the risk of dose escalation is present even among patients enrolled in a “hold the line (stable dose) prescribing strategy” treatment arm.(720)

For those whose daily consumption is more than 50mg MED, greater monitoring is recommended to include: i) at least monthly to not more than quarterly appointments with greater frequencies during trial, dose adjustments and with greater co-morbid risk factors and conditions; ii) at least semiannual attempts to wean below 50mg MED if not off the opioid; iii) at least semiannual documentation of persistence of functional benefit; iv) at least quarterly urine drug screening (see drug screening section); and v) at least semiannual review of medications, particularly to assure no sedating medication use (e.g., benzodiazepine, sedating anti-histamines).

Harms – None in a short-term trial. For chronic pain patients, theoretical potential to undertreat pain and thus impair function. However, there is no quality literature currently available to support that position.
Benefits – Reduced risk for adverse effects, dependency, addiction, and opioid-related deaths.

Strength of Evidence – **Recommended, Evidence (C)**
Level of Confidence – High

5. Recommendation: Use of an Opioid Treatment Agreement (Opioid Contract, Doctor/Patient Agreement, Informed Consent)
The use of an opioid treatment agreement (opioid contract, doctor/patient agreement, or informed consent) is recommended to document patient understanding, acknowledgement of potential adverse effects, and agreement with the expectations of opioid use (see Appendix 1 of Opioids Guideline).(702, 721-725, 726,727-732) **If consent obtained, it is recommended appropriate family members be involved in this agreement.**
Harms – Negligible.
Benefits – Educates the patient and significant others that these medications are high risk, with numerous adverse effects. It allows for a more informed choice. It provides a framework for initiation of a trial, monitoring, treatment goals, compliance requirement, treatment expectations, and conditions for opioid cessation. It should reduce risk of adverse events and opioid-related deaths, although that remains unproven to date.

Strength of Evidence – **Recommended, Insufficient Evidence (I)**
Level of Confidence – Moderate

6. Recommendation: Urine Drug Screening

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Baseline and random urine drug screening, qualitative and quantitative, is recommended for patients prescribed opioids for the treatment of subacute or chronic pain to evaluate presence or absence of the drug, its metabolites, and other substance(s) use. In certain situations, other screenings (e.g., hair particularly for information regarding remote use(733-738) **or blood (for acute toxicity) may be appropriate.**

Indications – All patients on opioids for subacute or chronic pain.

Frequency – Screening is recommended at baseline, randomly at least twice, and up to 4 times a year and at termination. More intensive screening is recommended for those consuming more than 50mg MED (see above). Federal guidelines recommend at least 8 tests a year among those utilizing opioid treatment programs.(739) Screening should also be performed "for cause" (e.g., provider suspicion of substance misuse including over-sedating, drug intoxication, motor vehicle crash, other accidents and injuries, driving while intoxicated, premature prescription renewals, self-directed dose changes, lost or stolen prescriptions, using more than one provider for prescriptions, non-pain use of medication, using alcohol for pain treatment or excessive alcohol use, missed appointments, hoarding of medications, and selling medications). Standard urine drug/toxicology screening processes should be followed (consult a qualified medical review officer).(740-742) If there is an aberrant drug screen result (either positive for unexpected drugs or unexpected metabolites or unexpectedly negative results), there should be a careful evaluation of whether there is a plausible explanation (e.g., drug not tested, drug metabolite not tested, laboratory cutpoint and dosing interval would not capture the drug/metabolite, laboratory error). In the absence of a plausible explanation, those patients with aberrant test results should have the opioid discontinued or weaned.(703)

Harms – No adverse clinical effects if properly interpreted.
Benefits – Identifies aberrant medication(s) and substance(s) use. Such uses are high-risk for opioid events including fatalities (see tables below). It provides objective evidence to cease an opioid trial or ongoing treatment. Identifies patients who may be diverting medication (those screening negative for prescribed medication).

Strength of Evidence – **Recommended, Evidence (C)**
Level of Confidence – High

Evidence for the Use of Opioids
See Opioids Guideline.

VITAMINS (Including Pyridoxine)

Treatment of CTS with pyridoxine (Vitamin B_6) has been attempte(634, 650, 743-746) as there has been some association between pyridoxine deficiencies and peripheral neuropathies, as well as some reports of associations of deficiencies with CTS in some,(747) but not all studies.(748) Vitamin B_{12} has also been reported as a successful treatment for stroke patients with CTS.(749)

1. *Recommendation: Pyridoxine for Treatment of Acute, Subacute, or Chronic CTS*
   Pyridoxine is not recommended for routine treatment of acute, subacute, or chronic CTS in patients without vitamin deficiencies.

   Strength of Evidence – **Not Recommended, Evidence (C)**
   Level of Confidence – Low

2. *Recommendation: Other Vitamins for Treatment of Acute, Subacute, or Chronic CTS*
   There is no recommendation for or against the use of other vitamins for treatment of acute, subacute, or chronic CTS.

   Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**
   Level of Confidence – Low

Rationale for Recommendations
There are two quality studies that reviewed pyridoxine to treat CTS patients. However, benefits have not been shown in the highest quality study.(745) The moderate-quality crossover trial reported

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improvements in symptoms in 7 patients; however, 3 patients did not receive the placebo although their symptoms scores on pyridoxine were lower than in a control period.(743) While vitamin B-6 is relatively low risk and patients may use it without prescription, available evidence does not support its use for the routine treatment of CTS, thus it is not recommended. However, it may be a reasonable treatment option among patients with presumptive pyridoxine deficiency (e.g., malnutrition, alcoholism, malabsorption, especially jejunal disorders such as sprue, etc.).

Evidence for the Use of Pyridoxine for CTS
There is 1 high-quality RCT(745) and 1-moderate-quality randomized crossover trial(743) incorporated into this analysis. There is 1 low-quality RCT in Appendix 2.(746)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL and Cochrane Library without date limits using the following terms: vitamin B6, Vitamin B12, Pyridoxine, carpal tunnel syndrome, CTS, median nerve neuropathy, median neuropathy, median nerve disease, entrapment, neuropathy, nerve compression, burning, itching, numbness , tingling , , controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random, randomized, randomization, randomly; systematic, systematic review, retrospective studies, prospective studies, epidemiological studies, epidemiological research, and Nonexperimental Studies. We found and reviewed 15 articles in PubMed, 3,114 in Scopus, 6 in CINAHL, 251 in Cochrane Library and 0 in other sources. We considered for inclusion 4 from PubMed, 0 from Scopus, 1 from CINAHL, 0 from Cochrane Library and 0 from other sources. Of the 5 articles considered for inclusion, 3 randomized trials and 2 systematic studies met the inclusion criteria.*

Author/Year Study Type Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Spooner 1993 RCT Sponsored by the Clinical Teaching and Research Fund of the College of Medicine at the University of Saskatchewan in Saskatoon. No mention of COI.	8.5	N = 35 (22 female/ 13 male) with CTS, EDS confirmed; mean age 42.5 years.	200mg pyridoxine once daily (n = 18) vs. Placebo (N = 17) for 12 weeks. Assessments at 6 and 12 weeks.	Mean score (SD) of night discomfort symptoms in treatment group: Entrance: 2.4 (1.4); 12 weeks: 1.9 (1.2) vs. control: Entrance 2.6(1.3); 12 weeks: 2.4 (1.3), NS. Mean score of median palmar distal latency (ms) in treatment group: Entrance 2.5(0.6); 12 weeks: 2.6(0.4) vs. control: Entrance 2.8 (0.6); 12 weeks: 2.7 (0.4), NS. Mean (SD) swelling treatment: entrance 2.1 (1.6); 12 weeks: 1.3 (1.4) vs. control: entrance 2.6 (1.3); 12 weeks: 2.3 (1.2) (p <0.05). Mean (SD) movement discomfort treatment: 3.1 (1.2); 1.7 (1.4) vs. control 3.1 (1.3); 2.7 (1.3) (p <0.001).	"Our findings do not support the use of pyridoxine for treating carpal tunnel syndrome."	No statistical differences. Symptoms trended in favor of pyridoxine.
Ellis 1982 RCT Crossover Trial Sponsored by Rovert A Welch Foundation. No mention of COI.	6.5	N = 7 males with evidence of entrapment of median nerve, symptoms in ulnar nerve region with or without evidence of entrapment of median nerve. Age 43-77.	Pyridoxine 50mg vs Placebo for 12 weeks.	Aggregate mean symptom scores control 53 ± 10 (n = 4) vs. pyridoxine 11 ± 6 (n = 7), p <0.001.	"Clinical improvements of the syndrome with pyridoxine therapy may frequently obviate hand surgery."	Small sample size. Variable timeframes for measurements limit strength of conclusions.

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TOPICAL MEDICATIONS: LIDOCAINE PATCHES

Topical lidocaine patches have been increasingly used to treat numerous pain conditions through transdermal application of topical anesthetic.(638, 750, 751)

Recommendation: Lidocaine Patches for Treatment of Acute, Subacute, or Chronic CTS
Lidocaine patches are recommended for treatment of select cases of acute, subacute, or chronic CTS with pain.

Indications – Moderate to severe CTS with pain as a central complaint when other treatable causes of the pain have been eliminated and after more efficacious treatment strategies, such as splinting and glucocorticosteroid injection(s), have been attempted.

Frequency/Duration – Usually 3 patches per day. Duration of use for chronic, localized pain may be as long as indefinitely, although most patients do not require indefinite treatment, as symptoms usually resolve, improve, or require surgery. Caution is warranted regarding widespread use of topical anesthetics for potential systemic effects from widespread administration.(752) For the hand this may require both patches and other applications or use in other body locations.

Indications for Discontinuation – Resolution, intolerance, adverse effects, lack of benefits, or failure to progress over a trial of at least 2 weeks.

> *Strength of Evidence* – **Recommended, Insufficient Evidence (I)**
> *Level of Confidence* – Low

Rationale for Recommendation
Topical lidocaine has been suggested to improve pain associated with CTS although the case diagnoses do not appear well substantiated in the available study as pain complaints as an overriding symptom among CTS patients raise concerns about alternate explanations for the symptoms.(751) In one moderate-quality study, lidocaine patches were suggested to be somewhat more effective than naproxen;(638) however, naproxen does not appear particularly effective and the study had a number of weaknesses. In the other study, injection was comparable to the patch, yet injections are likely a more effective strategy than naproxen, thus this body of evidence somewhat conflicts. Lidocaine patches are not invasive and have low adverse effects although some patients may experience local reactions such as skin irritation, redness, pain, or sores. These patches are also moderately or even high cost over time. While there are other lower cost topical treatments that provide analgesia (including heat, ice, and capsaicin), lidocaine patches may be a reasonable treatment option for pain related to CTS. Patients should be monitored to ensure that they are receiving benefit and to ascertain if there are any untoward local skin changes as a result of use.

Evidence for the Use of Topical Lidocaine Patches for CTS
There are 2 moderate-quality RCTs incorporated into this analysis. There are 2 low-quality RCTs in Appendix 2.(753, 754)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL and Cochrane Library without date limits using the following terms: lidocaine or lidocaine patch, carpal tunnel syndrome, median neuropathy, CTS, carpal tunnel, median nerve, compression, entrapment, neuropathy, nerve disease, syndrome, meadian nerve, median neuropathy, burning, itching, numbness, tingling, hand, palm, finger, wrist, pain; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random, randomized, randomization, randomly; systematic, retrospective, and prospective studies. We found and reviewed 56 articles in PubMed, 14 in Scopus, 2 in CINAHL, and 40 in Cochrane Library. We considered for inclusion 3 from PubMed, 1 from Scopus, 0 from CINAHL, Cochrane Library and other sources. Of the 4 articles considered for inclusion, 4 randomized trials and 0 systematic studies met the inclusion criteria.*

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Author/Year Study Type Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Nalamachu MedGenMed 2006 RCT No mention of sponsorship or COI.	4.5	N = 40 (28 female/12 male) neuropathic pain associated with CTS. Age 18-75.	Lidocaine patch 5%, up to 3, every 24 hours (n = 52) vs. Naproxen 500mg twice daily for 6 weeks (n = 48). Follow-up for 6 weeks.	Reductions in API scores between baseline and Week 6 for both lidocaine patch 5% (p <0.0001) and naproxen (p = 0.0004), but no differences between treatments (p = 0.083). Significant difference in CGI-I for lidocaine patch 5% (51.1%) compared with naproxen 500mg 2x daily (24.3%) (p = 0.016); 71.8% lidocaine patch patients "satisfied" to "very satisfied" vs. 63.2% naproxen (NS).	"This study demonstrates that the lidocaine patch 5% is effective in significantly relieving the pain associated with CTS and is well tolerated."	More diabetics in naproxen group (23.59% vs. 9.6%) suggest potential randomization failure and subsequent confounding. Severity (39.69% vs. 32.7%) and mean pain intensity somewhat worse in naproxen group (4.9±2.6 vs. 4.5±2.5). Excluded pain patch use, but not prior NSAID use. All appear to bias in favor of patch. Potentially, may have included treatment of other painful confounding diagnoses.
Nalamachu J Fam Prac 2006 RCT Sponsored by Endo Pharmaceuticals. Dr. Nalamachu has served as consultant to Endo, Dr. Crockett is a statistician for B&B Clinical Innovations.	4.5	N = 40 (28 female/12 male) electrodiagnostic evidence of CTS included median motor nerve distal latency >4.10m sec. Mean age 48.	Lidocaine patch 5% (n = 20) vs methylprednisolone acetate 40mg depot injection (n = 20). Follow-up for 4 weeks.	Not significant between-group differences. Mean pain scores at 4 weeks: 2.2 patch vs. -2.1 injection (NS). Global improvements 88% patch vs. 74% injection.	"This pilot trial demonstrated that the lidocaine patch 5% was efficacious in reducing pain associated with CTS."	Unclear whether patients had other painful diagnoses that explained the results.

GABAPENTIN

Gabapentin has been used to treat carpal tunnel syndrome.(755)

Recommendation: Gabapentin for treatment of Carpal Tunnel Syndrome
Gabapentin is moderately not recommended for treatment of carpal tunnel syndrome.

Strength of Evidence – **Moderately Not Recommended, Evidence (B)**
Level of Confidence – Moderate

Rationale for Recommendation
There is one high-quality, placebo-controlled study evaluating the use of gabapentin for treatment of CTS and finding it ineffective, thus gabapentin is moderately not recommended.

Evidence for the Use of Gapabentin for CTS
There is 1 high-quality RCT incorporated into this analysis.(755)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL and Cochrane Library without date limits using the following terms: Gabapentin, Neurontin, Fanatrex, Gabarone, Neupentin, Neogab, Horizant, Gralise, carpal tunnel syndrome, CTS, median nerve neuropathy, median neuropathy, median nerve disease, entrapment, neuropathy, nerve compression, burning, itching,

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numbness, tingling, wrist, hand, palm, finger, pain, controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random, randomized, randomization, randomly; systematic, systematic review, retrospective studies, and prospective studies. We found and reviewed 7 articles in PubMed, 627 in Scopus, 1 in CINAHL, 41 in Cochrane Library and 0 in other sources. We considered for inclusion 1 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library and 0 from other sources. Of the 1 articles considered for inclusion, 1 randomized trials and 0 systematic studies met the inclusion criteria.*

Author/Year Study Type Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Hui 2011 RCT Sponsored by Pfizer, Inc. No COI.	8.0	N = 140 (114 males/26 males) with diagnosed CTS lasting >3 months; Mean (SD) age 52.3 (10.6) for gabapentin group and 51.0 (8.3) for placebo.	Gabapentin group receiving 300mg daily for first week, 600mg daily 2nd week and 900mg daily remaining treatment weeks (n = 71) vs. Placebo control group (n = 69). Assessments at baseline, 2 and 8 weeks.	During 2 and 8 weeks assessment, no significant difference reported between groups for global symptom scores reduction. Both groups showed improvement from baseline.	"As gabapentin appears to have limited efficacy and would be required to be taken for a long time (because the majority of patients symptoms persist if left untreated), current evidence does not support its routine use for CTS"	Gabapentin not effective.

Physical Methods/Rehabilitation

Devices

MAGNETS

Treatment of CTS and other hand, wrist, and forearm MSDs with magnets(756-758) and pulsed magnetic field therapy(759-761) has been attempted to manage pain.(612, 651, 762)

1. Recommendation: Magnets for Management of Pain from of Acute, Subacute, or Chronic CTS
Magnets are moderately not recommended for management of pain from acute, subacute, or chronic CTS.

Strength of Evidence – **Moderately Not Recommended, Evidence (B)**
Level of Confidence – High

2. Recommendation: Pulsed Magnetic Field Therapy for Management of Pain from of Acute, Subacute, or Chronic CTS
Pulsed magnetic field therapy is not recommended for management of pain from acute, subacute, or chronic CTS.

Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
Level of Confidence – Moderate

Rationale for Recommendation
Quality evidence suggests magnets(756, 757) are ineffective for treatment of CTS. Low-quality evidence suggests pulsed magnetic field therapy(759, 761) is not effective for treating CTS.(756) Magnets are not invasive, have no adverse effects, and are low cost, but other interventions have been shown effective. Thus, magnets are not recommended for treatment of CTS.

Evidence for the Use of Magnets for CTS
There are 1 high-(757) and 2 moderate-quality RCTs incorporated into this analysis.(756, 758) There are 3 low-quality RCTs in Appendix 2.(759-761)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL and Cochrane Library without date limits using the following terms: Magnet, pulsed magnetic field therapy, carpal tunnel

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syndrome, CTS, median nerve neuropathy, median neuropathy, median nerve disease, entrapment, neuropathy, nerve compression, burning, itching, numbness, tingling, controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 34 articles in PubMed, 33 in Scopus, 9 in CINAHL, and 865 in Cochrane Library. We considered for inclusion 8 from PubMed, 0 from Scopus, 2 from CINAHL, 0 from Cochrane Library and 0 from other sources. Of the 10 articles considered for inclusion, 6 randomized trials and 4 systematic studies met the inclusion criteria.*

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Author/Year Study Type Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Magnet vs. Placebo						
Carter 2002 RCT Sponsored by The Oklahoma Center for Family Medicine Research. No mention of COI.	6.0	N = 30 (26 female/4 male) with wrist pain attributed to CTS. Mean age magnet 50.7±15.5 years, placebo 48.5±11.7 years.	Placebo magnet (N=15) vs. 1,000 gauss magnet (N=15); 45 minute treatment. Follow-up at 2 weeks.	Magnet mean (SD) vs. placebo mean (SD): Post-treatment pain: 3.6(3.1) vs. 2.6(2.7), NS; Pain at 2 weeks follow-up: 4.3(2.9) vs. 4.3(3.5), NS.	"The use of a magnet for reducing pain attributed to carpal tunnel syndrome was no more effective than use of the placebo device."	Short-term study. Data suggest lack of efficacy.
Static Magnetic Field Therapy						
Colbert 2010 RCT Sponsored by National Institutes of Health and Oregon Clinical and Translational Research Institute. No COI.	8.5	N = 60 (45 female/15 male) with clinical evidence of carpal tunnel syndrome. Mean age: 50 years.	All magnets neodymium magnetized to deliver Static Magnetic Field (SMF). All devices applied at night. 15 mT (n = 20) vs. 45 mT (n = 20) vs. 0 mT aluminum disk (control) (n = 20). Outcomes measured after 6 week treatment period and 12 week no-treatment period.	No significant differences between groups for symptom severity or functional status at either 6 weeks (end treatment) or 12 weeks post-treatment.	"Participants in the active magnet groups and the control group experienced clinically relevant improvement after 6 weeks of treatment, but no significant between-group differences in outcome measures were shown."	Data suggest lack of efficacy as groups (including sham) showed similar results.
Weintraub 2000 RCT Crossover No sponsorship or COI.	5.0	N = 8 (4 females/1 male) hands from 6 patients with moderately severe carpal tunnel syndrome. Mean age: 62.5 years for females and 75 years for males.	Static (sub-maximal) magnetic field therapy applied 24hrs/day for 4 weeks (n = 8 hands) vs. Placebo device applied 24 hrs/day for 4 weeks (n = 8 hands). No long-term follow-up.	Magnet vs. Placebo – Mean neuropathic pain score improvement: 57% vs. 13% (p = 0.046).	"In conclusion, this novel treatment has the potential to positively influence mild cases of acroparesthesias of hands secondary to carpal tunnel syndrome and 57% of moderately advance cases."	Small sample size (n=8). Pilot study

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WRIST SPLINTING

Wrist splinting has been utilized to treat CTS.(387, 611, 628, 634, 647, 762-766, 767,768-771) A precise mechanism of action is unclear, although it is believed to prevent hyperflexed postures, particularly while sleeping, that provoke symptoms.(766, 768) Placement of the wrist in functional neutral posture (approximately 15° of extension) is most typically performed;(634) however, most studies do not specify the posture and at least one study utilized a neutral posture of 0°(614) which actually is a modest degree of flexion. Whether those differences in postures are clinically meaningful is unknown.

Recommendation: Nocturnal Wrist Splinting for Acute, Subacute, or Chronic CTS
Nocturnal wrist splinting is moderately recommended for treatment of acute, subacute, or chronic CTS.(772)

Indications – Symptoms consistent with carpal tunnel syndrome.

Frequency/Dose – Wrist splints are recommended to be worn while sleeping.(387, 763-766) There is no recommendation for or against the use of splints during the daytime; however, splints theoretically increase force requirements needed to perform some jobs and have demonstrated alterations in other upper extremity postures;(773) thus, they may have a relative contraindication to daytime use. However, one study testing nocturnal versus full-time use suggested modestly better results in electrodiagnostic parameters, but not symptoms, with full-time use.(765) There are numerous models and trials using different types of splints with all trials showing benefits and head-to-head trials, suggest there is, as yet, no identified optimal type of splint.(622, 774, 775)

Discontinuation – Splints should be re-adjusted if no response within 2 weeks of starting treatment, particularly to assure that the patient is wearing them properly as well as to assess fit. If there is only partial improvement and symptoms are sufficient for additional treatment, consideration of glucocorticosteroid injection and/or electrodiagnostic testing is indicated. If there is no improvement, splints should be discontinued and the accuracy of the diagnosis re-evaluated.

> *Strength of Evidence* – **Moderately Recommended, Evidence (B)**
> *Level of Confidence* – High

Rationale for Recommendation
Wrist splints have been shown to be effective compared to not splinting(764, 766) or to ergonomic education.(387) Splinting is also comparable to and in some measures superior to oral steroids.(647) One trial found splinting combined with NSAIDs comparable to glucocorticosteroid injection.(631) Both trials evaluating exercises and splinting used splinting for all subjects, precluding a comparison between those interventions. One trial suggested no superiority of a combination of tendon-gliding exercises combined with splinting combined with splinting alone.(610) Another trial suggested modest superiority of surgery over 18 months of follow-up; however, there may have been a slight bias in favor of surgery due to a baseline trend towards longer duration of symptoms in the splint group,(763) particularly in light of a subsequent report that those with shorter duration of symptoms had superior results with splinting.(776) Another trial compared splinting versus injection versus surgery and found few differences except for a modest trend favoring surgery over the long term.(777) A trial conducted in the Netherlands comparing splinting with surgery found little clinical difference, but concluded surgery was more cost-effective.(778) A recent report suggests splinting is more likely to be effective in those with milder symptoms of less than 1-year duration.(776) Wrist splints are not invasive, have no significant adverse effects, and are not costly. They are moderately recommended for treatment of CTS.

Evidence for the Use of Wrist Splinting for CTS
There is 1 high-(763) and 18 moderate-quality(387, 611, 622, 628, 631, 647, 764-766, 774, 775, 777-783) RCTs incorporated into this analysis. There are 9 low-quality RCTs and 1 prospective randomized blinded trial(614, 626, 767, 768, 784-789) in Appendix 2.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL and Cochrane Library without date limits using the following terms: wrist joint, wrist, wrists, splints, splint, splinting,

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nocturnal splint; carpal tunnel syndrome, median neuropathy, CTS, carpal tunnel, median nerve, compression, entrapment, neuropathy, nerve disease, syndrome, burning, tingling, itching, numbness, hand, palm, finger, pain; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random, randomized, randomization, randomly; systematic, and systematic review. We found and reviewed 71 articles in PubMed, 499 in Scopus, five in CINAHL, and 77 in Cochrane Library. We considered for inclusion 27 from PubMed, eight from Scopus, zero from CINAHL, zero from Cochrane Library and four from other sources. Of the 39 articles considered for inclusion, 23 randomized trials and five systematic studies met the inclusion criteria.*

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Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Splints vs. No Treatment or Different Timing of Wearing Splints						
Manente 2001 RCT Sponsored by a grant from the Italian Ministry for Scientific and Technological Research. COI, Manente is owner of patent for brace.	6.5	N = 83 (69 female/11 male) with CTS, EDS confirmed or signs, symptoms of CTS. Mean age splint group 46.10±12.94 years, control group 50.0±12.65 years.	Nocturnal hand brace called Manu every night for 4 weeks (N=41) vs. No treatment, observational period before starting any treatment (N=42), for 4 weeks. Assessments at 2 weeks and 4 weeks.	BCTQ symptomatic score (baseline/4 weeks): splint 2.75±0.7 to 1.54±0.4 at 4 weeks vs. controls 2.77±0.7 to 2.61±0.6 (p <0.001). Sensory conduction velocities not different (p = 0.55). BCTQ function scores improved more in treated group from 1.89 to 1.48 vs. control from 2.02 to 2.03 (p < 0.001).	"The study demonstrates that this hand brace is highly efficient in relieving symptoms and functional loss in CTS."	Study evaluated a unique hand brace. Non-intervention controls may bias in favor of intervention.
Premoselli 2006 RCT No mention of sponsorship or COI.	6.0	N = 50 (23 female/2 male) with CTS electrodiagnostic study confirmed. Mean age splint group 53.1±13.3 years, control group 46.5±13.8 years.	Nocturnal splint (custom molded) for a minimum of 6 hours (N=25) vs. No treatment (N=25) for 6 months. Assessments at baseline, 3 months, and 6 months.	Follow-up symptoms splint vs. control group (mean±SD): 3 months: 1.63±0.25 vs. 2.57±0.31 (p = 0.001); 6 months: 1.48±0.19 vs. 2.38±0.40 (p = 0.001); Sensory latency (ms): Recruitment: 2.74± 0.28 vs. 2.79±0.38 (p = 0.63); 3 months: 2.59±0.39 vs. 2.85±0.336 (p = 0.02); 6 months: 2.61 ±0.37 vs. 2.71±0.43 (p = 0.50)	"Symptom relief and neurophysiological improvement after night-only splint wear therapy lasted up to the six-month follow-up visit."	Dropout rate 28% over 6 month trial. Non-intervention controls may bias in favor of intervention.
Walker 2000 RCT No sponsorship or COI.	5.0	N = 21 (30 hands) with unilateral or bilateral CTS, EDS confirmed. Mean age 60±11.2 years.	Nocturnal splints (N=13) vs. Full-time splints (N=11). Follow-up for 6 weeks.	Symptoms severity (baseline/ follow-up): night only (2.89±0.96/2.30±0.93) vs. full-time (2.79±0.69/2.09±0.62) (NS). Functional deficits: night (2.75± 1.01/2.14±0.87) vs. full time (2.27±1.03/1.93± 0.77) (NS). Motor (p = 0.04) and sensory (p = 0.05) distal latencies improved more in full-time use.	"The study provides added evidence to support the efficacy of neutral wrist splints in CTS and suggests that physiologic improvement is best with full-time splint wear instructions."	Symptoms/function data suggest no difference in efficacy. NCS data favor full-time use. High noncompliance with full-time use (27% completely compliant with daytime use) raises questions about validity of conclusions.
Werner 2005 RCT Sponsored by the United Auto Workers (UAW) and General Motors (GM) National Joint	4.5	N = 161 with signs/symptoms suggestive of CTS for >1 week or >3 times in last 6 months. No EDS used for inclusion but performed after entry. Mean age splint group	Nocturnal splints custom made that maintained wrist in neutral posture (n = 86) vs. Ergonomic education on line (n = 75); 6 week trial. Both groups given instruction on how to reduce ergonomic stressors in	Wrist, hand, finger discomfort in prior 30 days (baseline/follow-up): splints (7.24±2.08/ 4.43±3.71) vs. controls (6.60±2.51/5.58±3.30), p = 0.03. Splinted group had more visits to plant medical department (15.5±7.1 visits vs. 3.6±4.3 visits, p = 0.02)	"Benefit from a 6-weeks nocturnal splinting trial, and the benefits were still evident at the 1-year follow-up.."	High dropout rate (30.4%) and 50% questionnaires incomplete may sharply limit the value of the data.

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Committee on Health and Safety. No COI.		44.74±1.02 years, ergonomic education group 43.77±1.44 years.	work and home environments. Follow-up at 3, 6, and 12 months.			
Hall 2013 RCT No mention of sponsorship or COI.	4.5	N = 62 age 18 and older with paresthesia in median nerve distribution in night or day, clumsiness, grasp weakness, sleep disturbances, not pregnant, and no medical (surgery or injections) and conservative (wearing hand splints) treatments in past 6 months. Mean age: 53.8 years.	Conservative treatment group: full-time wrist splint (neutral position with full finger and thumb motion) and education sessions (pathology of CTS, risk identification, goal setting for self-management of CTS symptoms) by an occupational therapist (2 treatment session in 1st week and between weeks 2 and 4 plus a 20 minute phone call at week 7) for 8 weeks (n = 31) vs. Control group: assessed and observed but given no intervention for 8 weeks (n = 31). Assessments at end of 8 weeks.	Boston Questionnaire for Assessment of Carpal Tunnel Symptom Severity (BQSS), mean±SD (pre-treatment/post-treatment): splint 2.80±0.63/ 2.38±0.77 vs. control 2.57±0.52/ 2.60±0.62 (p <0.001). Boston Questionnaire for the Assessment of Carpal Tunnel Symptom Functional Status Scale (BQFSS), mean±SD (pre-treatment/post-treatment): splint 2.24±0.78/ 2.04±0.74 vs. control 2.00±0.71/ 2.08±0.70 (p = 0.015). VAS, mean±SD (pre-treatment/post-treatment): splint 5.84±2.46/ 4.26±2.67 vs. control 5.00±2.62/ 5.65±2.54 (p = 0.001). Phalen's test, mean±SD (pre-treatment/post-treatment): splint 24.43±17.41/24.59±18.89 vs. control 27.00±15.36/22.56±15.36 (p = 0.031). Grip strength, kg force, mean±SD (pre-treatment/post-treatment): splint 23.94±8.55/25.01±9.37 vs. control 22.05±8.37/23.90±8.88 (p = 0.020). Purdue Pegboard Test score, min, mean±SD (pre-treatment/post-treatment): splint 46.87±16.41/51.40±15.30 vs. control 40.81±17.27/53.72±11.29 (p = 0.021). Semmes-Weinstein Monofilaments (SWM) score, palmar side, mean±SD (pre-treatment/post-treatment): splint 100.91±90.92/89.78±78.98 vs.	"A conservative treatment program including full-time splinting and formal education as key components can improve symptoms and hand function in patients with CTS."	Conservative treatment group better than control group for symptom improvement and function.

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				control 109.31±77.45/99.68± 87.96 (p <0.001).		
Splints vs. Medical Treatment including Injections						
MacDermid 2012 RCT Sponsored by IMAGINutrition/Meta Response Sciences. No mention of COI.	7.0	N = 63 age 18-65 with CTS verified by electro-physiology. Mean age astaxanthin group 49±7 years, placebo group 49±9 years.	Experimental group: astaxanthin 4mg capsules after evening meals for 9 weeks followed by 3 week wash-out plus neutral wrist splint at night and during day when wrist in at-risk position (n = 32) vs. Control group: placebo capsules plus neutral wrist splint (n = 31). Assessments at 3 week intervals.	No significant differences between groups for primary outcomes, CTS Symptom Severity Scale (p=0.18) and CTS Functional Scale (p=0.40).	"This study has not identified astaxanthin to be an effective adjunct to standard conservative management."	Comparable efficacy in groups. No benefit demonstrated for use of astaxanthin.
Celiker 2002 RCT No mention of sponsorship or COI.	5.5	N = 23 with unilateral or bilateral CTS, EDS confirmed. Mean age Group A 49.6±15.3 years, Group B 46.9±10.0 years.	Group A: (NSAID) acemetacine 120mg a day and nocturnal splint light-weight, neutral-positioned (n = 11) vs. Group B: 40mg methylprednisolone acetate injection (n = 12). Assessments at week 2 and week 8.	VAS pain scores (baseline/2nd week/8th week): NSAID plus splint 7.9±1.4/ 4.3±0.9/1.7±1.0 vs. injection 7.0±2.2/ 3.1±2.5/1.8±1.9 (p>0.05). Symptom severity scale results not different.	"Both splinting combined with the use of a nonsteroidal anti-inflammatory drug and steroid injection into the carpal tunnel resulted in significant improvement in carpal tunnel syndrome."	No placebo control. Results suggest splinting and NSAID may be as effective as injection.
Ucan 2006 RCT No mention of sponsorship or COI.	5.0	N = 67 hands of patients with mild, moderate, or advanced CTS confirmed by nerve conduction studies. Mean age splint 44.50±7.24 years, steroid injection plus splint 44.46±8.52 years, open carpal tunnel release 45.27±13.19 years.	Group A: Full-time splinting in neutral position with standard splint for 3 months (n = 23) vs.. Group B: Single steroid injection (20mg triamcinolone acetate with 20mg lidocaine) and splinted for 3 months (n = 23) Group C: Surgery, open carpal tunnel release (n = 11). Assessments at baseline, 3 months, and 6 months after treatment.	Boston Questionnaire scores (baseline/3rd month/6th month): splinting 2.66±0.35/ 1.39±0.37/ 1.54±0.31 vs. splint plus steroid 2.79±0.63/1.41±0.32/1.96±0.63 vs. CTR 3.09±0.5/1.86±0.6/1.41± 0.31 (p = 0.004). Palm-wrist median sensory nerve velocities: splint 27.26 ±5.3/29.6±7.16/ 29.56±4.83 vs. splint plus steroid 26.35±4.12/ 31.57± 4.33/28.74± 6.19 vs. CTR 23.98±4.28/ 32.20±4.17/ 33.15±4.1 (NS between groups). Those completely/almost satisfied 3rd/6th months splinting 69.6%/34.8% vs. splint plus	"All treatment methods were effective, but (open) CTR was superior to conservative methods in the long term despite complications and longer recovery time."	Baseline differences. Appears to have targeted lower enrollment for surgery without stating such.

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				steroid 100%/82.6% vs. CTR 45.5%/90.9%.		
Mishra 2006 RCT No mention of sponsorship or COI.	4.0	N = 66 with CTS EDS confirmed for at least 1 month. Mean age splint group 42.91 years, steroid group 41.57 years.	Full-time splint use for 4 weeks with commercially available carpal tunnel splint (n = 20) vs. oral prednisolone 20mg a day for 2 weeks followed by 10mg a day for 2 weeks (n = 20). Follow-up at 1 and 3 months.	Mean±SD for splint vs. Steroid: Symptom severity score (SSS): SSS 0-1: 0.34±0.42 vs. 0.40±0.30 (p = 0.52); SSS 0-3: 0.30±0.54 vs. 0.49±0.44 (p = 0.42). Sensory distal latency (SDL): SDL 0-1: 0.16±0.63 vs. 0.13±0.71 (p = 0.86); SDL 0-3: 0.35±0.76 vs. 0.55±0.66 (p = 0.25).	"There was significant improvement in both groups clinically during follow-up at 1 and 3 months as well as electrophysiologically, at 3 months.."	No blinding. Suggests splinting is as effective as oral steroid, though function slightly better with splinting.
Splints vs. Surgery						
Gerritsen 2002 RCT Sponsored by a grant from the Health Care insurance Council of the Netherlands. No mention of COI.	8.5	N = 176 with CTS, EDS confirmed without previous splinting treatment or surgery. Age 18 years or older, mean age surgery group 49±11 years, splinting group 49±12 years.	Open surgical release (N=87) vs. splinting, custom made or prefabricated to immobilize wrist in a neutral position, at night for at least 6 weeks but could also wear it during the day (N=89) for 12 months. Assessments at 3, 6, 12, and 18 months.	Surgery success rates superior other than first month (1/3/6/12/18 months) surgery vs. splinting: 29 vs. 42% (p = 0.07)/80 vs. 54% (p <0.001)/94 vs. 68% (p <0.001)/92 vs. 72% (p = 0.002)/90 vs. 75% (p = 0.02). Nights awakening due to symptoms (1/3/6/12/18 months) surgery vs. splinting (mean±SD): 0.8±3.2 vs. 2.0±3.0 (p = 0.008)/ 2.6±3.5 vs. 2.2±3.1 (p = 0.49)/3.6± 2.8 vs. 2.6±3.1 (p = 0.03)/3.6±2.9 vs. 2.9±3.0 (p = 0.13)/3.6±2.9 vs. 3.2±3.1 (p = 0.44). Severity of main complaint (1/3/6/12/18 months) surgery vs. splinting (mean±SD): 1.6±2.9 vs. 2.1±2.2 (p = 0.22)/5.1±3.3 vs. 3.2±2.7 (p <0.001)/6.6±2.4 vs. 4.4±3.2 (p <0.001)/6.4±2.7 vs. 5.1±3.1 (p = 0.005)/6.2±2.8 vs. 5.0±3.3 (p = 0.02). Paresthesia during day (1/3/6/12/18 months) surgery vs. splinting (mean±SD): 1.5±3.0 vs. 1.4±2.1 (p = 0.66)/4.8±3.2 vs. 2.2±3.2 (p <0.001)/5.5±2.9 vs. 3.7±3.2 (p <0.001)/5.5±2.9 vs. 4.0±3.4 (p = 0.004)/5.3±3.0 vs. 4.0±3.6 (p = 0.01). Paresthesia at night (1/3/6/12/18 months) surgery vs. splinting	"Treatment with open carpal tunnel release surgery resulted in better outcomes than treatment with wrist splinting for patients with CTS."	Duration of symptoms was somewhat worse in splinting group (median 52 vs. 40 weeks, NS). Both treatment arms document substantial improvement, which may reflect a good natural history.

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				(mean±SD): 1.3±3.1 vs. 2.5±3.0 (p = 0.02)/4.6±3.8 vs. 3.5±3.3 (p = 0.046)/5.4±3.5 vs. 4.1±3.7 (p = 0.02)/5.2±3.6 vs. 4.5±3.4 (p = 0.20)/5.0±3.6 vs. 4.4±3.6 (p = 0.35).		
Korthals-de Bos 2006 RCT Sponsored by a grant from the Health Care Insurance Council of the Netherlands. No COI.	4.0	N = 176 with CTS, EDS confirmed, 18 years of age or older.	Surgery, standard open carpal tunnel release (N=87) vs. nocturnal splinting with custom of prefabricated splint that immobilized wrist in neutral position for at least 6 weeks. Could wear splint during day if desired (n = 89). 1-year study. Assessments at baseline 3, 6, and 12 months.	Success rates higher at 12 months for surgery group, surgery 92% vs. splint 72% (95% CI 8-31). Nights awakening due to complaints not different (surgery 3.6±2.9 vs. splint 2.9±3.0), 95% CI -0.2-1.7. Severity of main complaint higher in surgery (6.4±2.7 vs. 5.1±3.1) 95% CI 0.4-2.2. Paraesthesia during the day: surgery 5.5±2.9 vs. splint 4.0±3.4 (95% CI 0.5-2.5). Paraesthesia at night: surgery 5.2±3.6 vs. splint 4.5±3.4 (95% CI -0.4-1.8). Mean aggregate costs 2,126€ surgery vs. 2,111€ splint, NS. Absenteeism comparable (50 vs. 52 days).	"In the Netherlands, surgery is more cost-effective compared with splinting, and recommended as the preferred method of treatment for patients with CTS."	Population-based study with likely relatively suboptimal control over treatments. Small sample size. Applicability of cost data to U.S. questionable.
Splints vs. Other Treatments including Exercise and Yoga						
Garfinkel 1998 RCT Sponsored by a grant from the Commonwealth of Pennsylvania. No mention of COI.	6.0	N = 52 with CTS signs and symptoms (at least 2 of 5 – positive Tinel sign, positive Phalen sign, pain in median nerve distribution, sleep disturbances resulting from hand symptoms, and numbness or paresthesias in median nerve distribution) EDS confirmed. Mean age yoga group 48.9, splint group 48.7 years.	Standard splint with metal insert to supplement current treatment (n = 25) vs. Iyengar yoga (1-1.5 hour, 2x a week for 8 weeks focused on upper body postures, improving flexibility, correcting alignment of hands, wrists, arms, and shoulders, stretching, increasing awareness of optimal joint position during use (n = 26). Current treatment not described. Timing of splinting not described. Assessments at baseline and 8 weeks.	Grip strength (pretest/posttest) mean±SD: 161.6±70.4/ 187.4±68.8 vs. splint 183.9±69.5/ 190.5±68.2mmHg (p=0.37). Pain reduced (pre-/post-test) mean±SD: yoga 5.0±2.8/2.9±2.2 (p = 0.02) vs. splint 5.2±2.1/4.3±2.2 (p = 0.16). Median nerve sensory conduction (pretest/posttest) mean±SD: yoga 4.40±1.5ms/ 3.97±1.5 (p = 0.18) vs. splint 4.66±1.4/ 4.36±1.6ms (p = 0.28).	"In this preliminary study, a yoga-based regimen was more effective than wrist splinting or no treatment in relieving some symptoms and signs of carpal tunnel syndrome."	Grip strength increase may be from activity in yoga as comparison presumably an inactive splint which may have caused greater improvement not related to CTS. Lack of description of controls limits interpretations.

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Brininger 2007 RCT Sponsored by the School of Health and Rehabilitation Science Development Fund, School of Health and Rehabilitation Sciences, University of Pittsburg, PA. No COI.	6.0	N = 61 at least 18 years of age with a positive Tinel sign or Phalen maneuver and complaints of nocturnal numbness and tingling. Mean age 50 years.	Neutral wrist and metacarpophalangeal (MCP) splint, custom splint positioning MCP joints 0º-10º flexion, NW/MCP (n = 17) vs. neutral wrist and MCP exercise group (tendon and nerve gliding exercises 3-5x a day with 10 reps in each position held for 5 seconds), NW/MCP-X (n = 16) vs. wrist cock-up splint prefabricated that immobilized wrist in 20º of extension, WCU (n = 12) vs. wrist cock-up splint and exercise, WCU-X (n = 16). All groups wore splint during sleep for 4 weeks and received educational brochure on CTS. Assessments at baseline, 4 and 8 weeks.	All groups saw significant decrease in CTS symptoms (no p-value reported).	"Our results provide further evidence of the effectiveness of splinting, designed to target an underlying anatomic problem, for reducing symptoms and improving functional status in patients with mild-to-moderate CTS."	Small group numbers. No table or graphic for results. Baseline comparability for group strength different between groups.
Baysal 2006 RCT No mention of sponsorship or COI.	5.5	N = 36 (72 wrists) females with bilateral CTS, EDS confirmed. Mean age Group 1 47.8±5.5 years, Group 2 50.1±7.3, Group 3, 51.4±5.2 years.	Group 1: tendon- and nerve-gliding exercises 5 daily sessions, each exercise repeated 10x each session for 3 weeks plus splinting with custom made neutral volar splint for 3 weeks all night and during day (n = 12) vs. Group 2: ultrasound 15 minutes a session to palmar carpal tunnel area, frequency 1 MHz, intensity 1.0 W/cm^2, 15 treatments 1x a day, 5x a week for 3 weeks plus splinting (n =12) vs. Group 3: ultrasound, splinting and exercises n = 12). Full-time splint use; 8 week treatment.	Pain score before treatment/after treatment/after 8 weeks follow-up: Group I: 4.8±2.3/3.3±2.9/ 2.6±2.8; Group II: 5.7±2.7/2.2±1.9/ 2.5±2.8; Group III: 5.6±3.5/1.3±1.8/ 0.8±0.9. Functional status score: Group I: 20.6±7.8/14.8±7.5/ 14.9±6.6; Group II: 21.9±9.1/16.1±8.5/ 16.1±8.7; Group III: 20.5±7.1/11.7±3.6/ 12.6± 3.4. NS between groups for study outcomes.	"The result of this study emphasizes the efficacy of conservative treatment in CTS. In all patient groups, the treatment combinations were significantly effective immediately and 8 weeks after the treatment."	All groups were splinted precluding judgment of utility of splinting. Unclear if there is an independent effect of exercise.

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			Assessments at first treatment, end of therapy, and after 8 weeks follow-up.			
Fusakul 2014 RCT Sponsored by a grant from the Research Support Funding of the Faculty of Medicine at Vajira Hospital, Navamindradhrirja University, Thailand. No COI.	5.5	N = 66 (126 hands) aged 18 and older with CTS symptoms and a mild-to-moderate diagnosis made with clinical exams and electrodiagnosis. Mean age Group I – 50.70±1.39 years, Group II – 50.79±1.38 years.	Group I: low level laser therapy (LLLT), 18J per session over carpal tunnel area, 15 sessions for 5 weeks plus neutral wrist splint at night and during day for 12 weeks (n = 63) vs. Group II: placebo treatment, red light without laser power output over carpal tunnel, 15 sessions for 5 weeks plus neutral wrist splint at night and during day for 12 weeks (n = 63). Both groups encouraged to perform tending gliding exercises. Follow-up 5 and 12 weeks after treatment.	Symptom Severity Scale (SSS) mean±SD (baseline/week 5/week 12): Group I 2.10±0.68/1.68±0.66/1.49±0.58 vs. Group II 1.68±0.56/1.43±0.49/1.35±0.51 (p=0.031 at week 5). Distal motor latency (DML) mean ±SD (baseline/week 12): Group I 4.84±0.15/4.73±0.13 vs. Group II 5.20±0.18/6.63±1.10 (p=0.015).	"[B]oth LLLT and splints improved the clinical parameters of our study, but LLLT was electroneuro-physiologically superior to splints with regard to the conduction of the median motor nerve fibers."	LLLT significantly better than sham at 3 months for median nerve distal motor latency and better for grip strength. Both groups splinted, precluding assessment of splint's utility.
Soyupek 2012 RCT No mention of sponsorship or COI.	4.5	N = 52 (81 wrists) with CTS, EDS confirmed. Mean age splinting, PCS, PNSAI: 47.95±6.93 years, 50.50±8.71 years, 53.79±10.40 years.	Phonophoresis with corticosteroid (betamethasone valerate %0.1 cream), CS (PCS) over carpal tunnel for 10 minutes/session at frequency 3 MHz, intensity 1.5 W/cm^2 5x a week for 3 weeks (n = 28) vs. phonophoresis with non-steroidal anti-inflammatory drug (diclofenac diethyl ammonium gel), NSAI (PNSAI) over carpal tunnel for 10 minutes/session frequency 3 MHz, intensity 1.5 W/cm^2 5x a week for 3 weeks (n = 23) vs. wrist splinting in neutral position during	VAS difference from baseline to after 3 months, mean±SD (baseline/after 3 months): splinting group 50.69±23.45/37.91±23.94 (NS); PCS 60.35±18.95/30.35±18.15 (p <0.017); PNSAI 69.13±16.21/45.65±23.65 (p <0.017). Boston Questionnaire total difference from baseline to after 3 months, mean±SD (baseline/after 3 months): splinting group 43.34±10.89/39.26±10.03 (NS); PCS 54.21±11.34/39.14±10.33 (p <0.017); PNSAI 53.69±41.86/41.86±10.03 (p <0.017). Tinel's sign, %, difference from baseline to after 3 months (baseline/after 3 months): splinting group	"[T]he most effective treatment modality for CTS was P-CS according to ultrasonographic investigations and other findings."	PCS group better than splinting or PNSAI groups.

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			day and at night first 15 days and then when CTS symptomatic (n = 23). Follow-up 3 months after treatment.	65.2/60.9 (NS); PCS 82.1/50.0 (p <0.017); PNSAI 82.6/65.2 (NS). Phalen's sign, %, difference from baseline to after 3 months (baseline/after 3 months): splinting group 60.9/52.2 (NS); 89.3/50.0 (p <0.017); PNSAI 78.3/39.1 (p <0.017).		
Kumnerddee 2010 RCT Sponsored by Pramonkutklao Hospital's Foundation under Her Royal Highness Princess Maha Chakri Sirindhorn's Patronage. No mention of COI.	4.0	N = 61 with mild-to-moderate CTS, EDS confirmed. Mean age acupuncture – 50.37±9.01years; night splinting – 51.73±8.92 years.	Acu group: 10 sessions of electro-acupuncture 2x a week on meridian of affected area (n = 30) vs. NS group: prefabricated volar neutral wrist splint worn at night for 5 weeks (n = 31). Assessments at baseline and end of treatment.	Mean±SD VAS (baseline/end of treatment): acupuncture 22.57±22.27/7.97±14.99 vs. night splinting 22.59±26.09/17.60±22.37 (p = 0.028). NS between groups for Symptom Severity Scale (p = 0.295) and Functional Status Scale (p=0.663).	"Electro-acupuncture provides more pain attenuating effect than night splinting in mild-to-moderate degree CTS."	Comparable efficacy, but pain symptoms relieved slightly better with acupuncture group. Study susceptible to significant contact time bias.
Comparing Types of Splints						
Storey 2013 RCT No mention of sponsorship. No COI.	4.5	N = 49 diagnosed with CTS from history and clinical exam confirmed with nerve conduction studies. Mean age C-Trac splint 47 years, BWB 39 years.	C-Trac splint (C-shaped, tubular, semirigid frame contoured around dorsum of wrist and hand with air pressure bladder to control pressure to 180-190mmHg for 2 minutes) 3x a week first 4 weeks then as necessary (n = 25) vs. Beta Wrist Brace (BWB) resting splint at night and during activities that provoke symptoms first 4 weeks then as necessary (n = 24). Follow-up at 4, 8, 26, and 52 weeks.	No significant differences between groups for primary outcomes, Levine symptom (p = 0.213) and function (p = 0.308) scores by week 8. No significant differences between groups for secondary outcomes at 8 weeks, Semmes-Weinstein monofilament scores (p = 0.0567), grip strength (p = 0.568), lateral pinch (p = 0.728), tripod pinch (p = 0.183).	"These results suggest that C-Trac splint is not dissimilar in efficacy to a resting Beta Wrist Brace."	Pilot study showing similar efficacy between C-Trac splints compared to Beta wrist braces at 8 weeks, 6 months and 12 months.
De Angelis 2009 RCT	4.0	N = 120 age 18 or older with possible CTS, pain, numbness, and paresthesias	Hand brace MANU® that does not impede thumb-index finger pinch, thumb-little finger opposition, and wrist	No significant differences between groups for the primary study outcomes (p = 0.097-0.821).	"Our findings demonstrate that a conservative treatment by the hand brace or a splint is effective as	High dropout rate. At 3 months, comparable efficacy

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Sponsored by the AGF Orthopaedic Devices s.r.l. company. No COI.		and/or hypoesthesia in the median nerve distribution, positive Phalen test, exclusive or predominant in one, and electrophysiological diagnosis of CTS. Mean age MANU® 46.0±11.8 years, CAMP TIELLE® 46.3±7.9 years.	flexion and extension worn every night for 3 months (n = 59) vs.wrist splint CAMP TIELLE® that immobilizes wrist in dorsiflexion position with external angle of 30º and internal angle of 16º worn every night for 6 months (n = 61). Follow-up at 3 months and 6 months after treatment.		long as they are employed as already shown in other studies.”	

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Allied Health Therapies

ACUPUNCTURE

Acupuncture has been used to treat CTS and other hand, wrist, and forearm MSDs.(790, 791) There is evidence of its efficacy for treatment of chronic spine disorders, although the evidence suggests traditional acupuncture is not superior to other acupuncture methods (see Chronic Pain and Low Back Disorders Guidelines).

Recommendation: Acupuncture for Acute, Subacute, or Chronic CTS
Acupuncture is not recommended for treatment of acute, subacute, or chronic CTS.

Strength of Evidence – **Not Recommended, Evidence (C)**
Level of Confidence – Low

Rationale for Recommendation
There are quality trials of acupuncture compared with placebo or sham acupuncture and they have failed to show benefit of acupuncture for treatment of CTS.(792) One trial found no differences between acupuncture and oral steroid.(793, 794) Another trial susceptible to contact time bias found minimal differences between acupuncture and nocturnal wrist splinting.(781) Thus, the highest quality evidence suggests acupuncture is ineffective for treatment of CTS and acupuncture is not recommended.

Evidence for the Use of Acupuncture
There are 4 moderate-quality RCTs incorporated into this analysis.(781, 792-794) There are 3 low-quality RCTs in Appendix 2.(795-797)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL and Cochrane Library without date limits using the following terms: Acupuncture, Acupuncture Therapy, carpal tunnel syndrome, CTS, median nerve neuropathy, median neuropathy, median nerve disease, entrapment, neuropathy, nerve compression, burning, itching, numbness, tingling, wrist, hand, palm, finger, pain, controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random, randomized, randomization, randomly; systematic, systematic review, retrospective studies, and prospective studies. We found and reviewed 40 articles in PubMed, 411 in Scopus, 83 in CINAHL, 46 in Cochrane Library and 0 in other sources. We considered for inclusion 7 from PubMed, 2 from Scopus, 0 from CINAHL, 0 from Cochrane Library and 0 from other sources. Of the 9 articles considered for inclusion, 8 randomized trials and 2 systematic studies met the inclusion criteria.*

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Author/Year Study Type Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Yao 2012 RCT Sponsoredby the Department of Physical Medicine and Rehabilitation, university of California and by the National Institute of Disability Research grant.	7.0	N = 41 (gender not specified) acupuncture-naïve adult patients with mild to moderate CTS. Found through electro diagnostic testing; mean age: Group 1 48.5±10.5; Group 2 – 53.6±7.65.	Acupuncture group given treatment during 6 weekly sessions for 20 minutes. Group asked to feel a de-qi sensation; heaviness (n = 21) vs. Placebo acupuncture group acupuncturists stopped manipulate needle for 2 seconds. Both groups given wrist splints for sleeping (n = 20). Follow-up baseline, immediately after 6 weeks treatment, 2 weeks and 3 months after last treatment.	Comparing baseline to three months after the last treatment carpal Tunnel Self-Assessment Questionnaire (CTSAQ) scores improved in both groups. Group 1, 0.58 improvement (p = 0.03), Group 2 improved by 0.81 (p = 0.001). Analyzing CTSAQ hand function 3 months after last treatment group 1, improvement by 0.45 (p = 0.17) and group 2, improvement by 0.48 (p = 0.02) both improved significantly.	"Both treatment and placebo groups demonstrated improvements from baseline."	Splints given to all participants. Small sample size with 20% dropout in 1 arm. Acupuncture not superior to placebo acupuncture.
Yang 2009 RCT Sponsored by Kuang Tien General Hospital grant. No COI.	5.5	N = 77 (63 females/14 males) consecutive and prospective patients with mild to moderate CTS and naïve to acupuncture treatment (confirmed by NCS); mean age: Group 1 – 9.3±8.9; Group 2 – 49.9±10.3.	Acupuncture 8 sessions of 30 minutes duration for 4 weeks (2x a week) (n = 38) vs. Steroid treatment group: 20mg daily of prednisolone for 2 weeks and 10mg daily for following 2 weeks. 4 weeks total (n = 39). Follow-up baseline, 2 weeks, 4 weeks for Global Symptom Score and nerve conduction study (NCS) scores at baseline and 4 weeks.	At study end, there was a high percentage of improvement in both acupuncture and steroid groups at 2 weeks and 4 weeks (p < 0.01). Although there was no statistical significance between the two group at these follow ups. Nocturnal awakening week 4, acu group 3.5 ± 3.8 vs steroid group 1.5 ± 1.9, (p < 0.03).	"Despite the limitations, this randomized, controlled study indicates that short-term acupuncture treatment is as effective as short-term low-dose steroid for mild-to-moderate CTS."	Minimal differences between groups observed. Population poorly described.
Yang 2011 RCT Sponsoredby Kuang Tien General Hospital grant. No COI.	5.0	N = 70 whom had not done any other type of intervention since the other study. (Yang 2009); Mean age: Group 1 – 49.3±8.9;	Acupuncture consisted of 8 sessions of 30 minute duration administered for 4 weeks (twice a week) (n = 38) vs. Steroid treatment group prescribed 20mg daily of prednisolone for 2	Global Symptom Score (GSS) month 7, group 1 3.4±5.8 vs group 2 7.2±5.4 (p <0.01). GSS at month 13 group 1, 4.5±7.7 vs group 2, 11±8.6 (p <0.01). Month 13 – Baseline improvement in GSS group 1, -11.53±7.63 vs group 2, 3.-28±10.64 (p <0.01). Distal	"[T]herefore, we conclude that acupuncture treatment can be considered as an alternative therapy to other conservative treatments for those who do not opt for	Long term follow up of prior study. No statistical difference between groups at any time point.

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		Group 2 – 49.9±10.3.	weeks and given 10mg daily for following 2 weeks. 4 weeks total (n = 39). Follow-up at 7 months and 13 months after treatment.	Motor Latency (DML) Month 13 – Baseline improvement; group 1, -1.44±1.07 vs group 2 - 0.18±1.04 (p <0.01). Compound Muscle Action Potential (CMAP) group 1 improvement 0.56 ±1.25 (p <0.01). Motor Nerve Conduction Velocity (MNVC) at Month 13, group 52.7±4.0 vs group 2 49.7±4.6. Month 13 – Baseline group 1, -0.47±4.00. Sensory Nerve Action Potential (SNAP) Month 13 – Baseline, acupuncture improvement 2.75±6.15 (p<0.01). Distal Sensory Latency (DSL) Month 13 – Baseline acupuncture vs steroids, -0.36±0.62 vs 0.23±0.71 (p <0.01). Both groups improved significantly Month 13 – Baseline in Wrist Palm Sensory nerve conduction velocity, (p <0.01).	early surgical decompression."	
Kumnerddee 2010 RCT Sponsoredby Pramonkutklao Hospital's Foundation under Princess Maha Chakri Sirindhorn's Patronage	4.0	N = 61 with mild to moderate CTS who have not participated in surgical treatment, steroid injections, or were pregnant, all patients asked to discontinue use of NSAIDs during study; age: Group 1: 50.37±9.01; Group 2: 51.73±8.92	Acupuncture group, 10 sessions 2x a week, needles placed around median nerve and received 1 Hz current for 30 minutes (n =30) vs. Night Splinting group for 5 weeks, use of metal bar splint to restrict wrist flexion during sleep (n = 30). Follow-up at baseline and immediately after treatment period (5 weeks).	Boston Carpal Tunnel Outcome Scale (BCTS) decreased significantly, 1.92± 0.54 (baseline) to 1.53±0.34 (treatment end) Acu group (p <0.001) vs. 1.88±0.48 (baseline) to 1.61±0.43 (end) (p <0.007) splint group. Acu group Symptom Severity Scale (SSS) 2.03±0.61(baseline) to 1.57±0.39 (end), Functional Status Scale (FSS) 1.76±0.63 (baseline) to 1.50±0.39 (end) and VAS 22.57±22.67 (baseline) to 7.97±14.99 (end) scores all decreased significantly (p <0.05) vs. night splinting for which only SSS decreased significantly (p = 0.008) at 5 weeks. Comparing groups: VAS reduction Acu group 14.60±19.31 vs 4.97±24.37 NS group (p = 0.028).	"Electro-acupuncture provides more pain attenuating effect than night splinting in mild-to-moderate degree CTS."	Comparable efficacy, but pain symptoms relieved slightly better with acupuncture group. Study susceptible to significant contact time bias.

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BIOFEEDBACK
Biofeedback is a behavioral medicine method of providing automated information and training to improve control of certain physiologic processes which are normally inaccessible to a subject's perception. Audible electromyographic (EMB) biofeedback has been used to treat CTS.(798)

Recommendation: Biofeedback for Acute, Subacute, or Chronic CTS
There is no recommendation for or against the use of biofeedback for treatment of acute, subacute, or chronic CTS.

Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**
Level of Confidence – Low

Rationale for Recommendation
There are no quality studies regarding the utilization of biofeedback for treating CTS patients. Biofeedback is not invasive, has no adverse effects, and is moderate cost. However, in the absence of quality evidence, there is no recommendation for or against its use.

Evidence for the Use of Biofeedback
There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL and Cochrane Library without date limits using the following terms: Biofeedback or psychology; carpal tunnel syndrome, median neuropathy, CTS, carpal tunnel, median nerve, compression, entrapment, neuropathy, nerve disease, syndrome, median nerve, median neuropathy, burning, itching, numbness, tingling, hand, palm, finger, wrist, pain; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 14 articles in PubMed, 92 in Scopus, 3 in CINAHL, and 1 in Cochrane Library. We considered for inclusion 3 from PubMed, 0 from Scopus, CINAHL, Cochrane Library or other sources. Of the 3 articles considered for inclusion, 0 randomized trials and 0 systematic studies met the inclusion criteria.*

LOW LEVEL LASER THERAPY
Low level laser treatment (LLLT) has been used to treat MSDs including CTS.(790, 799, 800) It usually involves laser energy that does not induce significant heating (the theory is that the mechanism of action is through photoactivation of the oxidative chain).(801)

Recommendation: Low Level Laser Therapy for Acute, Subacute, or Chronic CTS
Low level laser therapy is not recommended for treatment of acute, subacute, or chronic CTS.

Strength of Evidence – **Not Recommended, Evidence (C)**
Level of Confidence – Low

Rationale for Recommendation
There are multiple moderate-quality studies evaluating LLLT with all of the higher quality studies demonstrating lack of efficacy. There are 5 trials comparing LLLT with sham/placebo laser and the 3 highest quality studies found lack of benefit.(802-804) One trial found no differences when compared with ultrasound(805) and a second trial found ultrasound superior.(806) Another study found no additive benefits of LLLT over splinting.(807) Thus, higher quality evidence indicates LLLT is not effective for treatment of CTS. Low-level laser is not invasive, has low adverse effects, but is costly. It is not recommended for the treatment of CTS.

Evidence for the Use of Low-Level Laser Therapy for CTS
There are 11 moderate-quality RCTs and 1 moderate-quality crossover trial incorporated into this analysis.(779, 799, 802-811) There is 1 low-quality RCT in Appendix 2.(812)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL and Cochrane Library without date limits using the following terms: laser or low-level laser therapy, carpal tunnel, medial

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*nerve, median carpal, median nerve neuropathy, median neuropathy, median nerve disease, entrapment, neuropathy, nerve compression, burning, itching, numbness, or tingling**;** controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly**;** systematic, systematic review, retrospective studies, prospective studies, epidemiological studies, epidemiological research, and Nonexperimental Studies. We found and reviewed 41 articles in PubMed, 541 in Scopus, 29 in CINAHL, 38 in Cochrane Library and. We considered for inclusion 9 from PubMed, 5 from Scopus, 0 from CINAHL, and Cochrane Library. Of the 14 articles considered for inclusion, 13 randomized trials and 0 systematic review met the inclusion criteria.*

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Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Irvine 2004 RCT Double-blind No mention of sponsorship. One of the authors (K. M. C.) funded by Alberta Heritage Foundation for Medical Research as clinical investigator.	7.5	N = 15 (12 female/3 male) with CTS. Ranging in age from 34 to 67 years, (46 ± 11).	Gallium/aluminum/ arsenide laser treatment (n = 8) vs. Control group or treatment with a sham laser (n = 7). Follow-up for 4 weeks.	Improvement in sham laser (p = 0.034) and LLLT treatment groups, (p = 0.043). NS between group differences, (p = 0.69).	"[L]LLT is no more effective in the reduction of symptoms of CTS than is sham treatment."	No difference between groups.
Tascioglu 2012 RCT Placebo-controlled No mention of sponsorship or COI.	7.5	N = 60 (46 female/14 male) with CTS symptoms shorter than 6 months. Aged between 28 and 68 years.	First group received Ga-Al-As laser irradiation at each point, once daily, 5 days a week (N = 20) vs. Second group treated with same low-power laser, but painful points irradiated with duration of 1 minute, once daily, 5 days a week (n = 20) vs. Third group received placebo laser, with duration of 2 minutes irradiation, 1x daily, 5 days a week (n = 20). Follow-up for 15 days.	Pain scores decreased significantly in all groups at Study end for group I, II and III, (p < 0.001, p <0.001, and p < 0.01). FSS scores improved in all groups, (p <0.05).	"In conclusion, the results of this study indicate that low level laser, given at two different dosages, was no more effective than placebo in the treatment of CTS."	Comparable results showing LLL not superior to placebo.
Bakhtiary 2004 RCT Sponsored by a grant from Semnan Medical Sciences University. No mention of COI.	7.0	N = 40 and 10 (gender not specified) with bilateral and unilateral CTS confirmed by electromyography or 90 wrists. Age means for laser/ultrasound groups: 48	Ultrasound,15 minute sessions with frequency of 1 MHz and intensity of 1.0W/cm^2, pulsed mode duty cycle of 1:4 and transducer area 5cm^2 (N = 45) vs. Low-level laser therapy, applied low intensity 9J, infrared laser diode, 830nm at 5 points, 1.8J/point, daily 15	Thumb sensory latencies favored ultrasound: -0.7 vs-0.2, (p = 0.003). Other electrodiagnostic measures all favored ultrasound. VAS pain scores -6.3 in the ultrasound group vs. -2.0 in laser group, (p < 0.001) at 4 weeks after completion of treatment.	"[U]ltrasound treatment is more effective than low level laser therapy in patients with mild to moderate carpal tunnel syndrome."	Suggests laser not effective compared with ultrasound.

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		(13.4) / 45 (17.1).	minute sessions 5 times a week (n = 45). Follow-up for 3 weeks.			
Naeser 2002 RCT Double-blind Crossover Sponsored in part by the American Society for Lasers in Surgery and Medicine's 16th Annual Meeting. No COI.	6.5	N = 11 (2 female/9 male) with mild to moderate CTS, EDS confirmed. Age range from 40 to 68 years (mean 53.5 y).	Device 1: Red-beam laser, continuous 15-mW, applied to shallow acupuncture points located on the fingers and hand, 3 times weekly (n = 11) vs. Device 2: Infrared pulsed laser, 180ns, 9.4W, located on the elbow, shoulder, upper back, and cervical paraspinal areas, 3 times weekly (n = 11) Device 3: Microamps TENS 580µA-3.5mA device, applied to the affected wrist, 3 times weekly (n = 11). Follow-up for 3 to 4 weeks.	McGill Pain Questionnaire scores were significantly lower with real treatment, (p = 0.0035). Sensory latencies were improved with real treatment, (p = 0.009), but not motor latencies, (p = 0.27).	"[LLLT] appears to be an affective substitute for surgery…especially when this new conservative treatment is applied in the early stages of CTS (preferably within 1y of symptom onset) and with middle to moderate cases (as defined with NCSs and where there is no abnormality on needle electromyography)."	Small sample size. Combined therapy precludes assessment of value of laser. Variable numbers treatments. 27% incomplete data.
Evcik 2007 RCT Placebo-controlled Double-blind No mention of sponsorship or COI.	6.5	N = 81 (70 female/11 male) with CTS diagnosis, on both clinical examination and electromyographic (EMG) study. Age range, 26-78.	Group 1 or laser group received 7 joules/per point over carpal tunnel area at wrist (n = 41) vs. Group 2 or placebo received placebo laser therapy (n = 40). Follow-up at 4 and 12 weeks.	VAS scores for day and night showed significant decrease in both groups at end of therapy, (p < 0.001). Statistically significant improvement in sensory nerve velocity, and sensory and motor distal latencies in laser group, (p <0.001), and sensory nerve velocity meaningful in placebo group, (p <0.05).	"In using LLLT, (1) there was no difference relative to pain relief and functional capacity during the follow-up in CTS patients; (2) there were positive effects on hand and pinch grip strengths."	Comparable results for pain relief. Although LLLT group showed some improvement in hand and pinch grip strength over placebo.
Ekim 2007 RCT No mention of sponsorship or COI.	6.5	N = 19 (18 female/1 male) with clinical and electrophysiologic evidence of CTS with RA. Age 33-72 years.	Group 1 or LLLT with dosage 1.5J / per point once daily for 10 days (n = 10 hands) vs. Group 2 or placebo laser therapy group once daily for 10 days (n = 9 hands). Follow-up at 3 months.	Mean differences at 3 months significant; 95% CI, (-15 – (-5)) and placebo (-5 – (-2)). No other statistically significant improvements in the other clinical symptoms and electrophysiological assessments.	"CTS only add to the suffering of RA patients with disorganized hand functions."	Small sample size. Rheumatoid arthritis population, with utility for occupational or general populations unclear.
Yagci 2009 RCT	6.0	N = 45 (hands) with symptoms and signs of suspected	Splinting or S group splinted in neutral position with standard cotton–polyester splints	No differences at baseline and third month, (p >0.05). Symptom severity score of SLLLT group statistically	"As a conclusion, both SLLLT and splinting provided improvements in clinical parameters but	Comparable efficacy.

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Masked-controlled No mention of sponsorship or COI.		CTS over 3 months. Mean age for S/ and SLLLT groups: 51.75±12.09/ 49.47±6.32.	(n = 24) vs. splinting plus low-level laser therapy SLLLT an infrared Ga–Al–As diode laser device wavelength 830nm (n = 21). Follow-up for 3 months.	lower than S group, (p = 0.03). S group had improvement in only BQ symptom severity score, (p = 0.001), and there was a significant decrease in grip strength (p = 0.016).	SLLLT is electrophysiologically superior to splinting."	
Chang 2008 RCT Placebo-controlled Double-blind Sponsored by the National Science Council of the Republic of China. No COI.	5.5	N = 36 with mild to moderate degree of CTS. Age mean for laser/ and placebo groups; 46.01 ± 11.65 / 49.07 ± 11.28.	Laser group received laser treatment (10 Hz, 50% duty cycle, 60 mW, once daily for two weeks (N = 20 wrists) vs. Placebo group received sham laser treatment (N = 20 wrists). Follow-up after 2 weeks of treatment for 18 week.	No significant differences seen in motor latency and sensory peak latency between groups, (p >0.05). Statistically significant reduction in VAS scores in laser group after treatment and at 2-week, (p <0.05 and 0.051). At 2 weeks, statistically significant differences in reductions in Symptom Severity Scale and Functional Status Scales scores between groups, (p <0.05).	"LLLT was effective in alleviating pain and symptoms, and in improving functional ability, as well as finger and hand strength, in those with mild to moderate CTS, and the therapy had no side effects."	Small sample size and short follow up period. CTS diagnosis not standardized. Trends of longer duration disease and less nocturnal awakening in placebo group. Unusual finding of increases in symptoms in placebo group.
Saeed 2012 RCT No mention of sponsorship or COI.	5.5	N = 100 with unilateral CTS diagnosed clinically and electrophysiologically. The mean age was 35.59 ± 6.1.	Group A, treated by Ultrasound therapy 1MHz, 1.0 Watt/cm2, 5x a week for 4 weeks (n = 50) vs. Group B, treated with LLLT or 830 nm infrared, 5x a week for 4 weeks (n = 50). Follow-up for 4 weeks.	Distal motor latency and sensory latencies were found to be statistically improved in ultrasound treated group, (p <0.001). Change from baseline for pain/symptom severity scale/functional status scale, (p <0.001).	"Ultrasound treatment proved to be more effective than Laser treatment."	Ultrasound group better than laser at 4 weeks. Unclear compliance and dropouts.
Fusakul 2014 RCT Double-blind Sponsored by grant from Research Support Funding of the Faculty of Medicine at Vajira Hospital, Navamindradhriraj University, Thailand. No COI.	5.5	N = 66 with mild to moderate carpal tunnel syndrome (CTS). Mean age for group I / II: 50.70 ± 1.39 / 50.79 ± 1.38.	Group I, LLLT with a splint of 15 sessions, 3 times weekly for 5 weeks (n = 63 hands) vs. Group II, placebo treatment with splint for 15 sessions, 3x a week for 5 weeks (n = 63 hands). Follow-up for 5 weeks.	At 5 and 12 week follow-up significantly better improvements in LLLT-treated group compared to placebo, especially for grip strength, T0/T5/T12; (p = 0.414/0.313 / 0.554). Distal motor latency of median nerve significantly improved in LLLT vs placebo group, (p < 0.05).	"[B]oth LLLT and splints improved the clinical parameters of our study, but LLLT was electro-neurophysiologically superior to splints with regard to the conduction of the median motor nerve fibers."	LLLT significantly better than sham at 3 months for median nerve distal motor latency and better for grip strength.

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Shooshtari 2008 RCT No mention of sponsorship or COI.	4.0	N = 80 with CTS based on clinical examination and electromyographic (EMG) findings. Age range 30-70.	Group A received low power laser waves by physiolaser Olympic with multiple probe five times weekly (n = 40) vs. Group B received flash laser (n = 40).	Median transcarpal sensory NCV after/before treatment, (p <0.001). Hand grip power increased 15.39% Group A with no meaningful improvements in Group B. NCV of median nerve in Group A improved about 3.25% ms, 1.99% ms, 6.43 m/s, with no meaningful changes in Group B.	"Laser therapy as a new conservative treatment is effective in treating CTS paresthesia and numbness and improved the subjects' power of hand grip and electrophysiological parameters."	Sparse methodological details. Hand grip improved in LPL group.
Raeissadat 2010 RCT Single-blind No mention of sponsorship or COI.	4.0	N = 65 (hands) with mild or moderate CTS. The mean age of patients was 43.9 years.	Group I received local corticosteroid injection or Hydrocortisone 50mg (n = unknown) vs. Group II, received low level laser therapy or 20J/cm² in 11 seconds/session for each of 5 points, 775nm, 10 sessions and 3sessions / week (n = unknown). Follow-up for 10 months.	Severity of disease in injection group based on electrodiagnostic findings; mild in 41.2%, moderate in others. After 10 months, electrodiagnostic studies normal in 32.4% (38.7% before treatment), mild in 23.5% (22.6%), moderate in 41.2% (35.5%), severe in 2.9% (3.2%). Median nerve distal sensory latency before (DSL1) and 10 months after accomplishing treatment and comparison of 2 groups: injection therapy vs laser therapy: 4.28±0.36 vs 4.25±0.43 DSL1, and 3.9±0.5 vs 4±0.6, DSL2, (p >0.05). Distal motor latency: 4.3±0.6 vs 4.33±0.65 (MDL1) and 4.2±0.7 vs 4.17±0.8 (DML2), (p <0.05). Before vs. 10 months after treatment severity of disease: mild 45.2% vs 22.6%.	"Low level laser therapy can be as effective as local injection in reducing pain and severity of disease (based on electrodiagnostic medicine classification) in patients with mild and moderate CTS even in long term (after 10 months)."	Comparable efficacy. Patient blinding not possible due to different treatments (injection vs. laser).

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MANIPULATION AND MOBILIZATION

Manipulation and mobilization are two types of manual therapy which have been used for treatment of CTS.(613, 627, 813-818) These include wide arrays of different techniques and schools of thought. Some consider these two interventions to be on a spectrum of velocity and applied force. In general, mobilization involves assisted, low-force, low-velocity movement. Manipulation involves high-force, high-velocity, and low-amplitude action with a focus on moving a target joint (see Chronic Pain and Low Back Disorders Guidelines for more details).

1. Recommendation: Manipulation of the Wrist Acute, Subacute, or Chronic CTS

There is no recommendation for or against the use of manipulation of the wrist for treatment of acute, subacute, or chronic CTS.

Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**
Level of Confidence – Low

2. Recommendation: Manipulation of the Spine for Acute, Subacute, or Chronic CTS

Manipulation of the spine is not recommended for treatment of acute, subacute, or chronic CTS.

Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
Level of Confidence – High

Rationale for Recommendations

There are two moderate-quality studies that evaluate manipulation for treatment of CTS. However, both have considerable methodological problems. One study compared manipulation plus ultrasound versus ibuprofen. Exclusion criteria did not exclude prior ibuprofen use, which is may well have been widespread, resulting in a comparison analogous to no treatment, which biases towards the other treatment arm, ibuprofen use was PRN after 2 weeks, subject contact time differed between groups, all biasing in favor of manipulation plus ultrasound. That study failed to find improvements compared with ibuprofen(637) which as noted previously appear ineffective. The other moderate-quality study had two active-treatment arms.(819) Thus, there is no quality study showing manipulation is effective as a treatment for CTS. Manipulation is not invasive, is moderately costly, but does have rare adverse effects from cervical manipulation. Cervical manipulation is not recommended for treatment of CTS. There is no recommendation for or against manipulation of the wrist as there is an absence of quality evidence.

Evidence for the Use of Manipulation and Mobilization for CTS

There are 2 moderate-quality RCTs incorporated into this analysis.(637, 819) There are 3 low-quality RCTs in Appendix 2.(625, 820, 821)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL and Cochrane Library without date limits using the following terms: manipulation or mobilization / carpal tunnel, median nerve, median, carpal, disease, entrapment, neuropathy, syndrome, compression, CTS, burning, itching, numbness, tingling, hand, palm, finger, wrist, and pain; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 38 articles in PubMed, 172 in Scopus, 26 in CINAHL, and 10 in Cochrane Library. We considered for inclusion 3 from PubMed, 8 from Scopus, 3 from CINAHL, 1 from Cochrane Library and 0 from other sources. Of the 15 articles considered for inclusion, 3 randomized trials and 8 systematic studies met the inclusion criteria.*

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Davis 1998 RCT Sponsored by a grant	5.0	N = 91 (gender not specified) age 21-45 years with self-	Ibuprofen (800mg 3x a day for 1 week, then 2x a day for 1week, then PRN 7 weeks) and nocturnal cock-up	CTS outcome assessment physical distress (mean±SD) baseline to end of study: IBU and	"Carpal tunnel syndrome associated with median nerve demyelination but not axonal	Baseline did not exclude prior ibuprofen use or manipulation, but prior use of these treatments is likely

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from the National Chiropractic Mutual Insurance Company. No mention of COI.		reported symptoms of CTS and EDS confirmed CTS. Mean age ibuprofen group 38±5 year, manipulation group 36±6 years.	wrist supports (n = 46) vs. high velocity, low amplitude manual thrust procedures: manipulation to upper extremity and spine (3 treatments a week for 2 weeks; 2 treatments a week for 3weeks; 1 treatment a week for 4 weeks) plus ultrasound applied over carpal tunnel for half chiropractic treatment visits, 1 MHz and 1.0-1.5 W/cm at 50% duty cycle 5 minutes plus nocturnal wrist supports (n = 45). Study 9 weeks. Assessments at baseline, end of study.	splint 14.66±9.89 to 5.74± 6.28 vs. ultrasound and manipulation 12.47±8.07 to 9.25±8.14 (p = 0.0132). CTS outcome assessment mental distress (mean±SD) baseline to end of study: IBU and splint 33.61±12.02 to 14.94±11.33 vs. ultrasound and manipulation 28.94±11.69 to 17.29±13.24 (p = 0.0085). No significance between group difference in EDS.	degeneration may be treated with commonly used components of conservative medical or chiropractic care."	differential between the 2 groups and is a potentially fatal study flaw. Ibuprofen use PRN after 2 weeks and subject contact differed between groups, providing bias in favor of manipulation/ultrasound. High dropout rates. Study mainly compares variable dose ibuprofen vs. manipulation plus ultrasound as both splinted. Since ibuprofen not effective and evidence that ultrasound is, results suggest manipulation is not effective.
Burke 2007 RCT Sponsored by the TherapyCare Resources, Inc. No COI.	5.0	N = 24 with clinically suspected CTS. Mean age TISTM 39.8±8.75 years, STM 43.4±5.32 years.	Graston Instrument-assisted soft tissue mobilization surgery (GISTM) (N=14) vs. soft tissue mobilization (STM) surgery administered with clinician hands (N=12). 6 week treatment (2 times a week for 4 weeks, then once a week for 2 weeks). Follow-up at 3 months.	VAS pain ratings (baseline/post-treatment/3months): CISTM 61.5±26.6/9.8±12.5/9.2±11.0 vs. STM 60.5±17.9/15.4±19.6/33.7±28.8 (p <0.05).	"Although the clinical improvements were not different between the 2 manual therapy techniques, which were compared prospectively, the data substantiated the clinical efficacy of conservative treatment options for mild to moderate CTS."	This study's two arms are both active treatment, precluding ability to address efficacy of manual therapy.

MASSAGE AND SOFT TISSUE MASSAGE

Massage has been used to treat patients with CTS, particularly when combined with other forearm symptoms.(361)

1. *Recommendation: Massage for Acute, Subacute, or Chronic CTS*
   Massage is not recommended for most patients for treatment of acute, subacute, or chronic CTS.

   Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
   Level of Confidence – Moderate

2. *Recommendation: Massage for Acute, Subacute, or Chronic CTS with Forearm Myofascial Pain*
   Massage is recommended for treatment of select patients with acute, subacute, or chronic CTS who have significant myofascial pain.

   Indications – Symptoms of carpal tunnel syndrome combined with forearm myofascial pain sufficient for the patient to require treatment. Generally, the patient should have failed other treatments including splints and glucocorticosteroid injection.

   Frequency/Dose – Three to 4 appointments. Objective evidence of improvement should be followed. Additional 3 or 4 treatments should be based on improvement in objective measures.

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Discontinuation – Resolution, failure to objectively improve, or intolerance.

Strength of Evidence – **Recommended, Insufficient Evidence (I)**
Level of Confidence – Low

Rationale for Recommendations
There is no quality evidence of efficacy for massage as a treatment for CTS. There is one moderate-quality trial that suggested Madenci hand massage (author same as the named massage technique) was effective as a combined therapy, however, the study design includes significant contact time biases and multiple unquantified co-interventions.(822) Regardless, massage is not thought to be helpful for typical CTS patients. However, some patients with forearm myofascial pain are thought to potentially derive some benefits. Objective measures should be followed documenting improvement in order for additional treatments to be added. Massage is not invasive, has few adverse effects, but is moderately costly over time.

Evidence for the Use of Massage
There is 1 moderate-quality RCT incorporated into this analysis.(822) There are 2 low-quality RCTs in Appendix 2.(823, 824)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL and Cochrane Library without date limits using the following terms: Massage, soft tissue massage and carpal tunnel syndrome, CTS, median nerve neuropathy, median neuropathy, median nerve disease entrapment, neuropathy nerve compression, burning, itching, numbness, tingling, and pain; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random, randomized, randomization, randomly; systematic, systematic review, retrospective studies, prospective studies, epidemiological studies, epidemiological research, and Nonexperimental Studies. We found and reviewed 22 articles in PubMed, 209 in Scopus, 13 in CINAHL, 128 in Cochrane Library and 0 in other sources. We considered for inclusion 3 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library and 0 from other sources. Of the 3 articles considered for inclusion, 3 randomized trials and 0 systematic studies met the inclusion criteria.*

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Madenci 2012 RCT No mention of sponsorship or COI.	4.5	N = 80 (76 females/4 males) with CTS with symptoms for longer than 6 weeks and at least 1 positive test of following: Tinel, Phalen, Buda, and Carpal compression test. Between the ages of 31 and 65	Group I, splint plus massage; Madenci hand massage technique (MHMT) self-applied for 6 weeks with weekly follow-up visits (n = 40) vs. Group II, splint (n = 40). Both groups received tendon and nerve gliding exercises and analgesic drugs. All wore wrist-hand resting splint during sleep at night for 6 months.	Patient global assessment (PGA, pre-treatment/post-treatment, mean±SD): Group I (8.5±1.1/2.3±0.8) v. Group II (8.2±1.2/4.1±0.7), p = 0.001. Physician global assessment (MDPGA, pre-treatment/post-treatment, mean±SD): Group I (5.9±0.8/1.2±0.5) v. Group II (5.1±0.9/2.7±0.8), p = 0.002. Grip strength right: Group I (25.4±6.3/30.3±5.2) vs. Group II (25.7±5.9/28.2±3.2), p = 0.042. Grip strength left: Group I (21.2±3.2/26.9±2.6) vs. Group II (20.5±3.3/24.1±2.3), p = 0.041. Boston symptom severity scale: Group I (3.9±1.1/1.8±0.4) v. Group II (3.7±1.0/2.5±0.5), p = 0.001. Boston functional capacity scale: Group I (3.2±0.8/2.0±0.4) v. Group II (3.2±0.6/2.6±0.6), p = 0.001.	"Statistically more significant improvement was observed in PGA, MDPGA, hand grip strength scores, and electrophysiological parameters in the group applied MHMT as compared to the group applied splint therapy only."	Data suggest "splint+massage" treatment superior to splint along for global score outcome but not for any other outcomes including objective electrodiagnostic measures. Study susceptible to significant contact time bias. Both groups also provided exercises and analgesics.

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THERAPEUTIC TOUCH
Therapeutic touch, considered an alternative healing technique, involves the use of the practitioner's hands to focus and facilitate healing.(825)

Recommendation: Therapeutic Touch for Acute, Subacute, or Chronic CTS
Therapeutic touch is not recommended for treatment of acute, subacute, or chronic CTS.

Strength of Evidence – **Not Recommended, Evidence (C)**
Level of Confidence – Low

Rationale for Recommendation
There are no quality studies suggesting therapeutic touch is effective for treatment of CTS.(825) Therapeutic touch is not invasive, has no adverse effects, and is low cost. However, it has not been shown to be efficacious and other treatments have documented benefit, thus therapeutic touch is not recommended for the treatment of CTS.

Evidence for the Use of Therapeutic Touch for CTS
There are no quality studies. There is 1 low-quality RCT in Appendix 2.(825)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL and Cochrane Library without date limits using the following terms: Therapeutic touch and carpal tunnel syndrome, CTS, median nerve neuropathy, median neuropathy, median nerve disease entrapment, neuropathy nerve compression, burning, itching, numbness, tingling, and pain; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random, randomized, randomization, randomly; systematic, systematic review, retrospective studies, prospective studies, epidemiological studies, epidemiological research, and Nonexperimental Studies. We found and reviewed 22 articles in PubMed, 209 in Scopus, 13 in CINAHL, 128 in Cochrane Library and 0 in other sources. We considered for inclusion 1 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library and 0 from other sources. Of the 1 article considered for inclusion, 1 randomized trials and 0 systematic studies met the inclusion criteria.*

ICE/SELF-APPLIED ICE
Ice has been rarely used to treat CTS.

Recommendation: Ice for Treatment of Acute, Subacute, or Chronic CTS
There is no recommendation for or against use of ice for treatment of acute, subacute, or chronic CTS.

Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**
Level of Confidence – Low

Rationale for Recommendation
There are no quality studies suggesting ice is effective for treatment of CTS. Ice is not invasive, has no adverse effects, and is low cost when self-applied. However, it has not been shown to be efficacious and other treatments have documented benefit, thus it is suggested other treatments should be used in preference.

Evidence for the Use of Ice
There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL and Cochrane Library without date limits using the following terms: ice; self-applied ice, cold therapy, carpal tunnel syndrome, median neuropathy, CTS, carpal tunnel, median nerve, compression, entrapment, neuropathy, nerve disease, syndrome, median nerve, median neuropathy, burning, itching, numbness, tingling, hand, palm, finger, wrist, pain; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found, reviewed and*

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considered for inclusion 19 articles in PubMed, 7 in Scopus, 0 in CINAHL, 0 in Cochrane Library and 0 from other sources. Zero articles met the inclusion criteria.

HEAT/SELF-APPLIED HEAT

Various forms of heat treatment have sometimes been used to treat CTS.(626)

Recommendation: Heat for Treatment of Acute, Subacute, or Chronic CTS

There is no recommendation for or against use of heat for treatment of acute, subacute, or chronic CTS.

Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**
Level of Confidence – Low

Rationale for Recommendation

There are no quality studies suggesting heat is effective for treatment of CTS. There is one trial with paraffin as a cointervention.(626) Heat is not invasive, has no adverse effects, and is low cost when self-applied. However, it has not been shown to be efficacious and other treatments have documented benefit, thus it is suggested other treatments should be used in preference.

Evidence for the Use of Heat

There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL and Cochrane Library without date limits using the following terms: Self applied heat, heat therapy, electrical induced heat, dielectric heating, self-applied heat therapy, carpal tunnel syndrome, CTS, median nerve neuropathy, median neuropathy, median nerve disease, entrapment, neuropathy, nerve compression, burning, itching, numbness, tingling, and pain; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 44 articles in PubMed, 34 in Scopus, 2 in CINAHL, and 38 in Cochrane Library. We considered for inclusion 1 from PubMed, 1 from Scopus, 0 from CINAHL, 0 from Cochrane Library and 0 from other sources. Of the 2 articles considered for inclusion, 0 randomized trials and 0 systematic studies met the inclusion criteria.*

DIATHERMY

Diathermy is a type of heat treatment that has been used clinically to heat tissue.(826, 827) There are two forms of diathermy – short wave and microwave. High-dose diathermy is also used to coagulate tissue. Proponents of diathermy utilize it to treat a wide range of conditions, believing it penetrates deeper than hot packs or heating pads and stimulates healing. (827, 828)

Recommendation: Diathermy for Treatment of Acute, Subacute, or Chronic CTS

There is no recommendation for or against use of diathermy for treatment of acute, subacute, or chronic CTS.

Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**
Level of Confidence – Low

Rationale for Recommendation

There are no quality studies clearly demonstrating that diathermy is effective for treatment of CTS. The two available trials have considerable methodological flaws (e.g., represented as double blinded). Diathermy is not invasive, has no adverse effects, but becomes moderately costly with repeated applications. It has not been clearly shown to be efficacious and other treatments have documented benefit, thus it is suggested other treatments should be used in preference.

Evidence for the Use of Diathermy

There are 2 moderate-quality RCTs incorporated into this analysis.(829, 830)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL and Cochrane Library without date limits using the following terms: diathermy; carpal tunnel syndrome, median

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neuropathy, CTS, carpal tunnel, median nerve, compression, entrapment, neuropathy, nerve disease, syndrome, median nerve, median neuropathy, controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 33 articles in PubMed, 153 in Scopus, 0 in CINAHL, and 3 in Cochrane Library. We considered for inclusion 0 from PubMed, 2 from Scopus, 0 from CINAHL, 1 from Cochrane Library and 0 from other sources. Of the 3 articles considered for inclusion, 2 randomized trials and 0 systematic studies met the inclusion criteria.*

Author/Year Study Type Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Frasca 2011 RCT Double-blind No sponsorship or COI	5.0	N = 22 (19 females/3 males) with idiopathic unilateral or bilateral, mild to moderate carpal tunnel syndrome (CTS). Mean age HT group 50.8±13.8 and for SC group 56.4±13.8	Hyperthermia treatment or HTG for 8 sessions, 20 minutes each (n = 11) vs. sham-controlled groups or SCG for 8 sessions, 20 minutes each (n = 11). Follow-up at baseline and 3 weeks.	At final visit of HTG improvement in pain severity vs. baseline (VAS: p = 0.002, Levine-Boston I p <0.0001) and functional impairment (Levine-Boston II p = 0.002) No significant difference in SCG vs. baseline value (VAS p = 0.713 Levine-Boston I p = 0.14). Comparisons of changes in outcome measures for HTG pain severity (VAS p = 0.004, Levine-Boston I p = 0.009) No significant difference for SCG. VAS for HTG 17.9mm.	"Hyperthermia produced short-term improve-ments in pain and function in patients with mild to moderate carpal tunnel syndrome in the absence of any sizeable change in neurophysiologic al parameters."	Small sample size. Study represented as double blinded, but cannot blind this type of study design using heat.
Incebiyik 2014 RCT Double-blind No mention of sponsorship or COI.	4.5	N = 31 females with mild and moderate CTS. Mean age for Group 1 51±10.07 and for Group 2 44.92±10.84.	Group 1 hot pack, Short-wave diathermy or SWD, and gliding exercises for 15 sessions, 5 times weekly (n = 15) vs. Group 2 hot pack, placebo for SWD, and gliding exercises for 15 sessions, 5 times weekly (n = 13). Follow-up at baseline and at 3 weeks.	At baseline vs. 3 weeks, between-group comparison: Tinel test/ Phalen test/Reverse Phalen test/Carpal compression test/VAS/ Levine-Boston Symptom Severity Scale or SSS/ Functional Status Scale or FSS; p <0.001 group 1 vs. p = 0.500 group 2/p <0.001 vs p = 1.000/ p< 0.001 vs p=1.000/p < 0.001 vs p = 1.000/p < 0.001 vs p = 1.105/p < 0.001 vs p = 0.234/p < 0.001 vs p = 0.204.	"SWD provided short-term improvements in pain, clinical symptoms, and hand function in patients with mild and moderate CTS."	Data suggest treatment superior to placebo. Many cointervention s poorly tracked. Trial susceptible to contact time bias.

ULTRASOUND (Therapeutic)

Ultrasound has been used to treat many MSDs including CTS.(805, 831-834)

Recommendation: Ultrasound for Acute, Subacute, or Chronic CTS in Select Patients Who Fail Splint Use or Decline Injection

There is no recommendation for or against ultrasound for treatment of acute, subacute, or chronic CTS.

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Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**
Level of Confidence – Low

Rationale for Recommendation
The highest quality trial found ultrasound to be ineffective compared with sham ultrasound where both groups were treated with splinting.(640) One moderate-quality study found modest efficacy comparing ultrasound with placebo.(831) Another study had no placebo control and found ultrasound superior to low level laser therapy.(805) One trial found ultrasound comparable to glucocorticosteroid injection.(835) The remaining quality studies included co-interventions(611, 637) or had a lower quality rating and mostly suggested lack of efficacy.(832)

Ultrasound is not invasive, has few adverse effects, and is moderate to high cost depending on the number of treatments (which were numerous in the quality studies). As the available studies substantially conflict, there is no recommendation for or against therapeutic ultrasound. However, some evidence suggests possible efficacy of phonophoresis (see phonophoresis).

Evidence for the Use of Ultrasound for CTS
There are 1 high-(640) and 7 moderate-quality(611, 637, 805, 831, 833, 835, 836) RCTs incorporated into this analysis. There are 4 low-quality RCTs in Appendix 2.(785, 832, 837, 838)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL and Cochrane Library without date limits using the following terms: ultrasound therapy, carpal tunnel syndrome, median nerve neuropathy, median neuropathy, median nerve disease entrapment, neuropathy nerve compression, burning, itching, numbness, tingling, controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random, randomized, randomization, randomly; systematic, systematic review, retrospective studies, prospective studies, epidemiological studies, epidemiological research, and Nonexperimental Studies. We found and reviewed 56 articles in PubMed, 6329 in Scopus, 8 in CINAHL, 43 in Cochrane Library and 0 in other sources. We considered for inclusion 11 from PubMed, 0 from Scopus, 2 from CINAHL, 0 from Cochrane Library and 0 from other sources. Of the 18 articles considered for inclusion, 13 randomized trials and 1 systematic review met the inclusion criteria.*

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Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Ultrasound vs. Placebo						
Yildiz 2011 RCT No mention of sponsorship or COI.	8.0	N = 51 (25 median nerves; 43 female/8 male) with signs and symptoms of CTS for more than a month and mild-to-moderate CTS after electrodiagnostic test confirmation. Age range 39-66 years.	Group 1: sham ultrasound (US), ultrasound system in off mode 15 minute sessions once a day 5 times a week for 2 weeks plus splinting with a neutral custom-molded thermoplastic volar wrist splint at night and during the day for 8 weeks (n = 17, 25 median nerves) vs. Group 2: US, pulse mode (1:4) with gel without medication at 1 MHz frequency and 1 W/cm^2 intensity plus splinting (n = 17, 26 median nerves) vs. Group 3: ketoprofen phonophoresis (PH), US pulse mode (1:4) with 2.5% ketoprofen gel at 1 MHz frequency and 1 W/cm^2 intensity plus splinting (n = 17, 25 median nerves). Follow-up for 8 weeks.	Mean±SD VAS (baseline/2 week/8 week): Group 1, 5.76±2.45/2.72±2.07/3.28±2.74 vs. Group 2, 4.96±2.50/2.41±2.43/2.77±2.74 vs. Group 3, 6.04±2.40/3.03±1.96/0.98±1.65 (p = 0.002, Group 3> Group 1; p = 0.004, Group 3 > Group 2).	"Our results suggest that ketoprofen PH in addition to splinting is superior to the combination of US and splinting with respect to pain only in middle term patients with CTS."	Ultrasound plus splinting not superior to splinting alone. Ketoprofen plus splinting was associated with a reduction in pain at 8 weeks.
Ebenbichler 1998 RCT No mention of sponsorship. No COI.	6.5	N = 45 (gender not specified) with mild to moderate CTS. Mean age51.	Ultrasound daily 15 minute sessions, 5x a week for 2 weeks then twice a week for 5 more weeks, 1MHz with intensity 1.0W/cm^2, pulsed mode duty cycle of 1:4 and transducer area of 5cm^2 (n = 45 wrists) vs. sham ultrasound (n = 45 wrists). Follow-up period 6 months.	Main changes in symptom complaints were (active/sham): Week 2 (-1.05/0.05, p = 0.015), end of therapy (-0.17/-2.14, p = 0.001) and 6 months (-0.08/-2.76, p <0.0005). Grip strength measures improved (p <0.0005). EDS measures improved (p <0.05).	"There are satisfying short to intermediate term effects due to ultrasound treatment in patients with mild to moderate idiopathic carpal tunnel syndrome."	Suggests ultrasound efficacious. High numbers of treatments (20). No assessment of blinding provided.
Ultrasound vs. Injection						
Bilgici 2010 RCT No mention of sponsorship or COI.	5.5	N = 34 (22 female/9 male) with CTS. Mean age for Groups A and B; 47.33 (7.44) and 44.15 (9.30).	Group A, ultrasound treatment given under water, 5x a week, for 4 weeks, intensity of 1.5 watt/cm^2 for 5 minutes, with 2.5 cm^2 soundhead, frequency 3 MHz (n = 16) vs. Group B, local corticosteroid injection (single 4mg dexamethasone without lidocaine) plus splinting (n = 18). Follow-up for 8 weeks.	VAS pain / severity of symptoms / functional status / grip strength, (p < 0.001) and two point discrimination (p <0.016). Group A, improved for all clinical outcomes, (p <0.001), except the grip strength.	"Both ultrasound treatment and corticosteroid injection plus splinting were effective on the clinical symptoms and the electrophysiological findings of CTS."	Both groups improved meaningfully over time, but differences between groups minimal with only one significant difference.
Ultrasound vs. Other Treatments or in Combination(s)						
Bakhtiary 2004	7.0	N = 40 (age not specified) and	Ultrasound,15 minute sessions with frequency of 1 MHz and	Thumb sensory latencies favored ultrasound: -0.7 vs. -	"Ultrasound was more effective than laser	Suggests ultrasound efficacious. Numbers of

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RCT Sponsored by grant from Semnan Medical Sciences University. No mention of COI.		10 with bilateral and unilateral CTS confirmed by electromyography or 90 wrists. Age means for laser/ultrasound groups: 48 (13.4)/45 (17.1).	intensity of 1.0W/cm^2, pulsed mode duty cycle of 1:4 and transducer area 5cm^2 (N = 45) vs. low-level laser therapy, applied low intensity 9J, infrared laser diode, 830nm at 5 points, 1.8J/point, daily 15 minute sessions 5 times a week (n = 45). Follow-up for 3 weeks.	0.2, p = 0.003. Other electrodiagnostic measures all favored ultrasound. VAS pain scores were -6.3 vs. -2.0, p <0.001 at 4 weeks after treatment completion.	therapy for treatment of carpal tunnel syndrome."	treatments (15) in protocol is high.
Baysal 2006 RCT No mention of sponsorship and COI.	5.5	N = 36 (72 wrists) females with bilateral CTS, EDS confirmed. Mean age Group 1 47.8±5.5 years, Group 2 50.1±7.3, Group 3, 51.4±5.2 years.	Group 1: tendon- and nerve-gliding exercises 5 daily sessions, each exercise repeated 10 times at each session for 3 weeks plus splinting with custom made neutral volar splint for 3 weeks all night and during the day (n = 12) vs Group 2: ultrasound administered 15 minutes per session to the palmar carpal tunnel area at frequency of 1 MHz and intensity of 1.0 W/cm^2, 15 treatments once a day, five time a week for 3 weeks plus splinting (n = 12) vs. Group 3: ultrasound, splinting and exercises (n = 12). Full-time splint use; 8 week treatment. Assessments at first treatment, end of therapy, and after 8 weeks follow-up.	Pain score before treatment/after treatment /after 8 weeks follow-up: Group I: 4.8±2.3/3.3±2.9/ 2.6±2.8; Group II: 5.7±2.7/2.2±1.9/ 2.5±2.8; Group III: 5.6±3.5/1.3±1.8/ 0.8±0.9. Functional status score: Group I: 20.6±7.8/14.8±7.5/ 14.9±6.6; Group II: 21.9±9.1/16.1±8.5/ 16.1±8.7; Group III: 20.5±7.1/11.7±3.6/ 12.6± 3.4. NS between groups for study outcomes.	"The result of this study emphasizes the efficacy of conservative treatment in CTS. In all patient groups, the treatment combinations were significantly effective immediately and 8 weeks after the treatment."	Results suggest ultrasound may have some benefits, although it was not compared to a sham, placebo or no treatment. All groups were splinted.
Davis 1998 RCT Sponsored by a grant from the National Chiropractic Mutual Insurance Company. No mention of COI.	5.0	N = 91 with self-reported symptoms of CTS and EDS confirmed CTS. Mean age ibuprofen group 38±5 year, manipulation group 36±6 years.	Ibuprofen (800mg 3x a day for 1 week, then 2x a day for 1 week, then PRN 7 weeks) and nocturnal cock-up wrist supports (n = 46) vs. high velocity, low amplitude manual thrust procedures: manipulation to upper extremity and spine (3 treatments a week for 2 weeks; 2 treatments a week for 3weeks; 1 treatment a week for 4 weeks) plus ultrasound applied over the carpal tunnel for half of chiropractic treatment visits, 1 MHz and 1.0-1.5 W/cm at 50% duty cycle for 5 minutes plus nocturnal wrist supports (n = 45). Study duration: 9 weeks.	CTS outcome assessment physical distress (mean±SD) baseline to end of study: IBU and splint 14.66±9.89 to 5.74± 6.28 vs. ultrasound and manipulation 12.47±8.07 to 9.25±8.14 (p = 0.0132). CTS outcome assessment mental distress (mean±SD) baseline to end of study: IBU and splint 33.61±12.02 to 14.94±11.33 vs. ultrasound and manipulation 28.94±11.69 to 17.29±13.24 (p = 0.0085). No significance between group difference in EDS.	"Carpal tunnel syndrome associated with median nerve demyelination but not axonal degeneration may be treated with commonly used components of conservative medical or chiropractic care."	Baseline did not exclude prior ibuprofen use or manipulation, but prior use of these treatments is likely differential between 2 groups and potentially fatal study flaw. Ibuprofen use PRN after 2 weeks and subject contact differed between groups bias in favor of manipulation/ ultrasound. High dropout rates. Study mainly compares variable dose ibuprofen vs. manipulation plus ultrasound as both splinted. Since ibuprofen not effective and evidence

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			Assessments at baseline and end of study.			that ultrasound is suggest manipulation not effective.
Chang 2014 RCT Sponsored by grant of Taipei Tzuchi Hospital, Buddhist Tzuchi Medical Foundation (TCRD-TPE-99-25) and partially supported by grant from National Science Council, Executive Yuan, Taiwan (NSC102-2314-B-303-001) No COI.	4.0	N = 60 diagnosed with CTS. Mean age: Group1: 51.9 years. Group 2: 48.8 years	Group1: Paraffin therapy, Twice per week. (N = 30) vs. Group 2: ultrasound +splint only, twice per week. (n = 30) Follow up period: 8 weeks after treatment.	Significant improvements in symptom severity scores seen in both groups. The effect size (ES) of the symptom severity scores was 0.63 for both groups. However, significant improvements in functional status scores (ES 0.38) and pain scales (ES 0.74) only seen in US therapy group. An effect size of 0.3 to 0.8 is considered a "moderate" effect.	"To improve the functional status of CTS patients, a combination of ultrasound therapy and a wrist orthosis may be more effective than a combination of paraffin therapy and a wrist orthosis. Since this is an exploratory trial, further confirmatory testing is suggested to justify the efficacy of these two treatments."	Minimal differences seen between groups. Data suggests ultrasound and splint not superior to paraffin and splint.
Ultrasound vs. Ultrasound plus NSAID						
Piravej 2004 RCT Sponsored by Asahi Glass Foundation, Japan and Faculty of Engineering, Chulalongkorn University. No mention of COI.	4.5	N = 18 females (30 hands) with mild to moderate CTS for less than 12 months (mean 6.53±4.33 months), no treatment for at least 1 month and no steroid injections in last 3 months. Age range 33-68 years, mean age 46.97±8.37 years.	Ultrasound 0.5 W/cm^2 for 10 minutes, 5 days a week for 4 weeks plus placebo (n = 15 hands) vs ultrasound 0.0 W/cm^2 plus diclofenac 75mg a day (n =15 hands). Follow-up within 5 days after 4 weeks of treatment.	Night pain/paresthesias (pre/post): US 1.47±0.83/0.53±0.64 vs. placebo US/NSAID 1.53±0.92/0.60±0.63 (p = 0.89). Frequency of awakening US 0.80±1.15/0.27±0.80 vs. placebo US/NSAID 1.07±1.22/0.20±0.56 (p = 0.36).	"The therapeutic efficacy of low intensity ultrasound thermotherapy was satisfied for mild to moderate CTS. However, the electrophysiological changes after ultrasound treatment need further investigation."	Low sample size. Blinding unclear. Diagnostic criteria unclear, including NCS and 9 other criteria that seem unlikely fulfilled for all. No non-treatment comparison. No between group differences. Conclusion regarding ultrasound not clearly supported. If bilateral CTS (12/30), both treated the same and double-counted in results, weakening conclusions.

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Electrical Therapies

PHONOPHORESIS

Phonophoresis involves the use of ultrasound to deliver topically applied drugs and has been used to treat patients with CTS.(839)

Recommendation: Phonophoresis for Acute, Subacute, or Chronic CTS
Phonophoresis is recommended for treatment of acute, subacute, or chronic CTS.

Indications – CTS that is sufficiently symptomatic to warrant treatment. Patients should generally be given splints and/or a glucocorticosteroid injection prior to considering phonophoresis as a splint or injection are believed to be more effective.

Frequency – The regimen in the highest quality study consisted of 5-15 sessions per week for 4-8 weeks with ketoprofen phonophoresis (PH),(840) US pulse mode (1:4) with 2.5% ketoprofen gel at 1 MHz frequency and 1 W/cm2 intensity.(640) Dexamethasone has also been successfully used,(783, 840) with one trial suggesting the steroid is superior to NSAID (diclofenac).(783) Other NSAIDs and glucocorticoids are presumably equally efficacious.(640)

Discontinuation – Resolution, failure to objectively improve or intolerance.

Strength of Evidence – **Recommended, Evidence (C)**
Level of Confidence – Low

Rationale for Recommendation
One high-quality comparative trial found ketoprofen phonophoresis plus splinting superior to ultrasound plus splinting.(640) One moderate quality comparative trial found dexamethasone administered by phonophoresis superior to iontophoresis.(840) One moderate quality comparative trial found phonophoresis with glucocorticoid superior to phonophoresis with diclofenac or splinting.(783) Phonophoresis is not invasive, has low adverse effects, and is moderately costly. However, phonophoresis with either NSAID or dexamethasone is recommended particularly where splinting is insufficiently controlling symptoms and an injection is declined.

Evidence for the Use of Phonophoresis
There is 1 high-(640) and 2 moderate-quality(783, 840) RCTs incorporated into this analysis. There are 2 low-quality RCT in Appendix 2.(786, 839)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL and Cochrane Library without date limits using the following terms: Phonophoresis or phonophoresis, carpal tunnel syndrome, CTS, median nerve neuropathy, median neuropathy, median nerve disease entrapment, neuropathy nerve compression, burning, itching, numbness, tingling, controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random, randomized, randomization, randomly; systematic, systematic review, retrospective studies, prospective studies, epidemiological studies, epidemiological research, and Nonexperimental Studies. We found and reviewed 19 articles in PubMed, 6 in Scopus, 11 in CINAHL, 43 in Cochrane Library and 0 in other sources. We considered for inclusion 0 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library and 0 from other sources. Of the 4 articles considered for inclusion, 4 randomized trials and 0 systematic studies met the inclusion criteria.*

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Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Yildiz 2011 RCT No mention of sponsorship or COI.	8.0	N = 51 (25 median nerves; 43 female/8 male) with signs and symptoms of CTS for more than a month and mild-to-moderate CTS after electrodiagnostic test confirmation. Age range 39-66 years.	Group 1: sham ultrasound or US, ultrasound in off mode 15 minute sessions once a day 5x a week for 2 weeks plus splinting with neutral custom-molded thermoplastic volar wrist splint at night and during day (n = 17) vs. Group 2: US, pulse mode (1:4) with gel without medication at 1 MHz frequency and 1 W/cm2 intensity plus splinting (n = 17) vs. Group 3: ketoprofen phonophoresis (PH), US pulse mode (1:4) 2.5% ketoprofen gel at 1 MHz frequency and 1 W/cm2 intensity plus splinting (n = 17). Follow-up for 8 weeks.	Mean±SD VAS (baseline/2 week/8 week): Group 1, 5.76 ±2.45/2.72 ± 2.07/3.28 ± 2.74 vs. Group 2, 4.96 ± 2.50/2.41 ± 2.43/2.77 ± 2.74 vs. Group 3, 6.04 ± 2.40/3.03 ± 1.96/0.98 ± 1.65 (p = 0.002, Group 3> Group 1; p = 0.004, Group 3 > Group 2). Pain score significantly lower in Group 3 at 8th week compared to other treatment groups (Group 1 and Group 2) (p = 0.002, p = 0.004 and p = 0.001, p = 0.001).	"Ketoprofen PH as adjuvant therapy on splinting is effective with respect to reduction of pain."	Ultrasound plus splinting not superior to splinting alone. Ketoprofen plus splinting was associated with a reduction in pain at 8 weeks.
Bakhtiary 2013 RCT Sponsored by Research Deputy of Semnan University of Medical Sciences. No COI.	7.0	N = 34 (gender not specified) with mild to moderate CTS confirmed by electromyography. Mean age for Iontophoresis and Phonophoresis; 48.2 (14.5) and 44.6 (12.8).	Iontophoresis of Dex-P 0.4% (n = 26) vs. Phonophoresis of Dex-P 0.4%, plus applied over wrist chin, and pulsed (20%) ultrasound waves (n = 26). Follow-up for 4 weeks.	Pain at end of treatment and 4 weeks later significantly favored phonophoresis vs. iontophoresis of Dex-P intervention, (p <0.01). Motor latency/motor action potential amplitude/finger pinch strength/ hand grip strength/and pain relief: [mean difference 0.8 m/s; 95% (CI), 0.5-1.1]/(4.1 mV; 95% CI, 3.0 - 5.2)/(31.6 N; 95% CI, 15.9-47.3)/(27.1 N; 95% CI, 13.5-40.5)/and 2.1 points on 10-point scale; 95% CI, 1.3-2.9.	"Our clinical trials showed that phonophoresis of Dex-P is more effective than iontophoresis of Dex-p treatment in patients with mild to moderate CTS."	Data suggest phonophoresis superior to iontophoresis
Soyupek 2012 RCT No mention of sponsorship or COI.	4.5	N = 52 with CTS, EDS confirmed. Mean age splinting, PCS, PNSAI: 47.95±6.93 years, 50.50±8.71 years, 53.79±10.40 years.	Phonophoresis with corticosteroid (betamethasone valerate %0.1 cream), CS (PCS) over carpal tunnel for 10 min/session at frequency of 3 MHz and intensity of 1.5 W/cm^2 5 times a week for 3 weeks (n = 28) vs. phonophoresis with non-	VAS difference baseline to after 3 months, mean±SD (baseline/after 3 months): splinting group 50.69±23.45/37.91±23.94 (NS); PCS 60.35±18.95/30.35±18.15 (p <0.017); PNSAI 69.13±16.21/45.65±23.65 (p <0.017). Boston	"[T]he most effective treatment modality for CTS was P-CS according to ultrasonographic investigations and other findings."	PCS group better than splinting or PNSAI groups.

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			steroidal anti-inflammatory drug (diclofenac diethylammonium gel), NSAI (PNSAI) over carpal tunnel for 10 min/session at frequency of 3 MHz and intensity of 1.5 W/cm^2 5x a week for 3 weeks (n = 23) vs. wrist splinting in neutral position during the day and at night for the first 15 days and then when CTS was symptomatic (n = 23). Follow-up 3 months after treatment.	Questionnaire total difference from baseline to after 3 months, mean±SD (baseline/after 3 months): splinting group 43.34±10.89/39.26±10.03 (NS); PCS 54.21±11.34/39.14±10.33 (p <0.017); PNSAI 53.69±41.86/41.86±10.03 (p <0.017). Tinel's sign, %, difference from baseline to after 3 months (baseline/after 3 months): splinting group 65.2/60.9 (NS); PCS 82.1/50.0 (p <0.017); PNSAI 82.6/65.2 (NS). Phalen's sign, %, difference from baseline to after 3 months (baseline/after 3 months): splinting group 60.9/52.2 (NS); 89.3/50.0 (p <0.017); PNSAI 78.3/39.1 (p <0.017).		

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IONTOPHORESIS

Iontophoresis, a drug-delivery system that utilizes electrical current to transdermally deliver either glucocorticosteroids or NSAIDs, has been used to treat distal upper extremity MSDs including CTS.(839, 841, 842) It is believed to be more efficacious in situations where the dermis and adipose tissue overlying the target tissue is thin which facilitates penetration of the pharmaceutical to the target tissue and may be somewhat of an obstacle for treatment of CTS.

Recommendation: Iontophoresis for Acute, Subacute, or Chronic CTS

There is no recommendation for or against the use of iontophoresis for treatment of acute, subacute, or chronic CTS.

Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**

Level of Confidence – Low

Rationale for Recommendation

Iontophoresis has been studied for the treatment of CTS. There is one moderate-quality study comparing iontophoresis with dexamethasone versus distilled water which reported no benefit.(841) However, it was small in size (n = 20) and appears underpowered. The other moderate-quality study found injection to be superior.(842) There is no quality study of sufficient size comparing iontophoresis with placebo, precluding an assessment of quality evidence of efficacy. Iontophoresis with glucocorticosteroid may be a reasonable option for treating patients who decline injection; however, oral glucocorticosteroids have quality evidence of efficacy and may be recommended preferentially as iontophoresis is believed to be less effective than glucocorticosteroid injections.(842) Iontophoresis is not invasive, has low adverse effects, and is of moderate cost. However, other treatments have documented efficacy and should be used preferentially.

Evidence for the Use of Iontophoresis for CTS

There are 2 moderate-quality RCTs incorporated into this analysis.(841, 842) There are 2 low-quality RCT in Appendix 2.(786, 839)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL and Cochrane Library without date limits using the following terms: Iontophoresis or phonophoresis, carpal tunnel syndrome, median nerve neuropathy, median neuropathy, median nerve disease entrapment, neuropathy nerve compression, burning, itching, numbness, tingling, controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random, randomized, randomization, randomly; systematic, systematic review, retrospective studies, prospective studies, epidemiological studies, epidemiological research, and Nonexperimental Studies. We found and reviewed 19 articles in PubMed, 6 in Scopus, 11 in CINAHL, 43 in Cochrane Library and 0 in other sources. We considered for inclusion 2 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library and 0 from other sources. Of the 2 articles considered for inclusion, 2 randomized trials and 0 systematic studies met the inclusion criteria.*

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Amirjani 2009 RCT No mention of sponsorship or COI.	7.5	N = 20 (19 female/1 male) with mild to moderate NCS confirmed (19 females; 1 male). Mean age: 54 ±10 years	Dexamethasone sodium phosphate in distilled water 0.4% (n = 10) vs. distilled water iontophoresis 80mA a minute continuous DC current at 2mA a minute over carpal tunnel, 6 treatments QOD over 2 week (n = 10). Follow-up for 6 months.	Levine Self-Assessment Questionnaire scores median (25th-75th % CI) (baseline/post first treatment/post 6 treatments): Dex [38 (31-40)/33 (30-48), 26 (24-31)] vs. water controls (36 (33-54)/38 (27-44)/34 (22-41)), (p = 0.73, p = 0.91, p = 0.25))	"Although corticosteroid iontophoresis is feasible in clinical settings and is well-tolerated by patients, iontophoresis of 0.4% dexamethasone was not effective in the treatment of mild to moderate CTS."	Small sample size. Stratified baseline data not provided. Appears underpowered, although magnitude of a potential benefit also not likely high or moderate.

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Gökoğlu 2005 RCT No mention of sponsorship or COI.	4.0	N = 27 with clinical and electro physiologic evidence of CTS. Mean age: 46.2 ±8.0 years; group 2: 49.2±8.2 years.	40mg methylprednisolone acetate (1ml) injected into carpal tunnel (n = 15) vs. iontophoresis of DXM-P (n = 15). Follow up at 2 and 8 weeks.	Symptoms severity scores (baseline/Week 2/Week 8): injection 2.7±0.8/1.9±0.7/1.6 ±0.6 vs. iontophoresis 3.1±0.8/2.5±0.9/2.2±1 .0 (p <0.05) weeks 2 and 8 favor injection. Functional status scale and VAS scores similarly favored injection.	"Success of both iontophoresis of dexamethasone sodium phosphate and injection of corticosteroids, but symptom relief was greater at 2 and 8 wks with injection of corticosteroids."	Suggests injection superior to iontophoresis of dexamethasone.

Injection Therapies

Four major types of injections have been utilized to treat patients with CTS. These include: 1) carpal tunnel injections with glucocorticosteroids (discussed previously); 2) carpal tunnel injections with insulin among diabetics; 3) intramuscular glucocorticosteroid injections; and 4) botulinum injections.

Intracarpal Tunnel Glucocorticosteroid Injections ("Steroid Injections")

Steroid injections of the carpal canal are frequently performed to treat CTS patients,(631, 650, 777, 789, 839, 842-855) including those with acute cases (i.e., those that typically occur with fractures, trauma, or unaccustomed high-force use and present primarily with acute flexor wrist pain).(856-858) While various injection techniques have been utilized (including distal to proximal), the most common technical injection approach utilizes a fine gauge needle (e.g., 27- or 25-gauge) entering the skin near the distal wrist crease to the medial (ulnar) side of palmaris longus, and angled approximately 45 degrees distally. While it has been suggested that these injections are underutilized,(859) steroid injections should be done by those experienced with administering these injections.

1. *Recommendation: Carpal Tunnel Injections for Treatment of Subacute or Chronic CTS*
   Carpal tunnel injections are strongly recommended for the treatment of subacute or chronic CTS.

   Indications – CTS unresponsive to nocturnal wrist splinting, generally with symptoms lasting at least 3 weeks. It is not believed to be necessary to perform EDX prior to injections.

   Dose –One high-quality study found lower 1-year surgery rates with methylprednisolone 80mg vs. 40 mg of 73% vs. 81%, which were also superior to placebo.(860) Generally, at least 40mg of methylprednisolone or equivalent is recommended as the minimum initial dose. Although optimum dose remains unclear, evidence in total includes evaluations with methylprednisolone acetate (12, 15, 20, 40, 60mg, 80mg), betamethasone (6.0, 6.4mg), triamcinolone hexacetonide (20mg), and hydrocortisone (25, 100mg) in quality studies. Some physicians increase the dose in proportion to perceived symptom severity. However, there is no quality evidence to support this practice. The type of steroid to inject and whether to use a depot preparation, are also unclear as there are no quality studies comparing the various preparations commonly utilized. Most physicians include at least 1mL of an injectable anesthetic (e.g., 1% lidocaine). Lidocaine allows for rapid assessment immediately after the injection. The limitation of using an anesthetic as an adjuvant is that the numbness that ensues afterwards may limit a patient's activities. Thus, a shorter-duration anesthetic such as lidocaine is recommended.

   Frequency/Duration – A single injection and the results carefully evaluated to document improvement, even if short-term as it is believed to have considerable prognostic significance. There is no evidence that a series of injections is efficacious, although it has been argued that two injections are ideal.(861) There is no evidence that there is a limit to the number of injections to treat an episode or in a lifetime. Failure to respond, particularly if the median nerve was successfully

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anesthetized by the injection, should result in a careful re-assessment of the accuracy of the diagnosis of CTS. A second injection, typically utilizing a moderately higher dose, may be indicated if there has been insufficient but partial relief, or if the first injection was thought to have not entered the carpal canal.

Indications for Discontinuation – No partial response to carpal tunnel injection(s), then no recommendation for additional injection(s). Patients who fail to even partially respond to injections are *a priori* suspected to not have CTS and a thorough search for an alternate diagnosis should ensue. Patients who respond to carpal tunnel injections, but redevelop symptoms are believed to be ideal candidates for surgical release.

Strength of Evidence – **Strongly Recommended, Evidence (A)**
Level of Confidence – High

2. *Recommendation: Carpal Tunnel Injections for Treatment of Acute CTS without Fracture*
Carpal tunnel injections are recommended for treatment of acute CTS without fractures. (Acute CTS with fractures should be referred for potential emergent surgical release.)

Indications/Dose/Frequency – See above Recommendation #1.

Strength of Evidence – **Recommended, Insufficient Evidence (I)**
Level of Confidence – Moderate

Rationale for Recommendations
There is strong consistent evidence that carpal tunnel injections are efficacious with superiority to placebo.(631, 777, 839, 842, 843, 845, 849, 851, 854, 860) There also is evidence that injections are superior to oral glucocorticosteroids(648) and iontophoresis with glucocorticosteroids.(842) Duration of improvements after injection is controversial and may differ by CTS severity. Nearly all quality studies required electrodiagnostic confirmation and many had patients with symptoms lasting years, suggesting more severely affected patients benefited. In such patients, injections may be somewhat less efficacious than in patients with more recent or mild symptoms that are seen initially in primary care settings.

Aside from local tenderness among 50% of patients lasting a mean 1.2 days,(862) long-term complications are rare. Long-term outcomes are somewhat controversial. One study of 30 patients found 11.4% remained asymptomatic over an 80-week observation period with more undergoing surgery if treatment had been via an oral steroid than via an injection. Other studies reported only 22% of injected patients were subsequently referred for surgery during 1 year of follow-up.(845)

Steroid injections into the carpal tunnel are minimally invasive, have minimal adverse effects, and are moderately costly. These injections provide lasting relief of at least intermediate-term durations in a majority of CTS patients. They are strongly recommended for treatment of subacute or chronic CTS.

Carpal tunnel injections are also recommended by consensus of the Evidence-based Practice Hand, Wrist, and Forearm Panel for treatment of acute CTS in cases where there are no fractures. There are no quality studies of these clinical cases; however, these injections are thought to be the best treatment for acute CTS presentations.

Evidence for the Use of Glucocorticosteroids (Oral and Injection) for CTS
There are 8 high-(646, 648, 843-845, 851, 855, 860) and 19 moderate-quality(631, 636, 643, 644, 647, 777, 835, 840, 842, 848, 849, 852-854, 863-868) RCTs (one with two reports) incorporated into this analysis. There are 5 low-quality RCT and 1 prospective randomized blinded trial in Appendix 2.(786, 789, 839, 869-871)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL and Cochrane Library without date limits using the following terms: glucocorticoids, glucocorticosteroids, carpal tunnel syndrome, median neuropathy, CTS, carpal tunnel, median nerve, compression, entrapment, neuropathy, nerve disease, syndrome, median nerve, median neuropathy, burning, itching, numbness, tingling, hand, palm, finger, wrist, pain; controlled clinical trial, controlled trials, randomized controlled

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trial, randomized controlled trials, random allocation, random, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 109 articles in PubMed, 268 in Scopus, 5 in CINAHL, and 46 in Cochrane Library. We considered for inclusion 30 from PubMed, 0 from Scopus, CINAHL, Cochrane Library and other sources. Of the 30articles considered for inclusion, 30 randomized trials and 0 systematic studies met the inclusion criteria.*

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Author/Year Study Type Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Oral Glucocorticosteroids						
Hui 2001 RCT No mention of sponsorship or COI.	8.0	N = 36 (17 female/1 male) newly diagnosed CTS, EDS confirmed. Age mean for steroids/placebo groups: 44.9 (10.0)/42.9 (7.2).	Oral steroids or prednisolone 25mg a day (N = 18) vs. Placebo 10 day course for 10 days (N = 18). Follow-up at 2 and 8 weeks.	Median (IR) change at 2 weeks steroid -12.5 (-15 to -7) vs. placebo group -4.5 (-14 to 0), (p = 0.027). After 8 weeks, median (IR) reduction of GSS -9 (-14 to -6) vs. placebo -2 (-10 to 0), (p = 0.034).	"This study shows a small but statistically significant reduction in GSS in the group prescribed a short course of prednisolone as compared with placebo."	Brief report. Data suggest superiority of glucocorticosteroids.
Chang 1998 RCT Sponsored by NSC to Ming-Hong Chang. No mention of COI.	7.0	N = 91 (53 female/20 male) with clinical symptoms/signs of CTS and EDS confirmed. Mean age placebo/ diuretic/NSAID/ steroid groups: 44.2±5.4/45.7± 4.8/47.4±5.7/45.4± 5.2.	NSAID-SR with Tenoxicam-SR, 2mg daily (N = 18) vs. Diuretic treatment with Tenoxicam-SR, 20mg daily (N = 16) vs. Steroid or Prednisolone 2 weeks 20mg daily, then 10mg daily (N = 23) vs. Placebo group (N = 16). Follow-up for 4 weeks.	No significant reduction from baseline GSS seen at 2nd and 4th weeks in placebo, NSAID-SR, and diuretic groups. However, mean score at 4 weeks in steroid group decreased significantly from baseline of 27.9± 6.9 to 10±7.4.	"For patients with mild to moderate CTS who opt for conservative treatment, corticosteroids are of greater benefit."	Suggests oral steroids effective, but diuretic and NSAID are not.
Chang 2002 RCT Sponsored by grants VGHKS, NSC, and TCVGH. No COI.	6.5	N = 109 (81 female/18 male) with CTS, EDS confirmed. Mean age 4 and 2 week treatment: 46.2 (5.4)/45.9 (5.1).	Group 1, received prednisolone 20mg daily for 2 weeks then 10mg for 2 weeks (n = 53) vs. Group 2 received prednisolone 20mg daily and 2 weeks of placebo (n = 56). Follow-up for 4 weeks.	Overall improvement (%) (4 week/2 week): Month 1: 66.0/48.2 (35/27); Month 3: 64.1/44.6 (34/25); Month 6: 52/37.5 (28/21); Month 12: 49.0/35.7 (26/20), (NS). Global symptom scores (4-week treatment/2-week treatment): Baseline: mean (SD): 17.88 (6.06)/17.24 (4.95); Month 1: 8.1 (6.8)/ 9.54 (6.56); Month 3: 8.08(7.72)/ 9.1 (7.95); Month 12: 10.25 (10.6)/10.61 (9.15), (NS).	"In patients with CTS, a 2-week course of prednisolone was as effective as a 4-week course in improving symptoms." "Short term low dose oral steroids are effective treatment for carpal tunnel syndrome. The dose of steroids and the duration treatment are not key determinants of efficacy."	Suggests minimal difference with 4 week course vs. 2 weeks course.
Herskovitz 1995 RCT	6.0	N = 15 (12 female/3 male) suspected CTS. Mean for	Prednisone, 20mg daily 1st week followed by 2nd week of 10 mg daily (n = 6) vs. Placebo matched	Prednisone-treated group better at 2 weeks (p <0.05). After treatment discontinued, 4- and 8-week mean GSS not different.	"This approach may provide a treatment alternative in the short-term, conservative management of CTS."	Small sample size.

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No mention of sponsorship or COI.		prednisone/ placebo: 55/46.	treatment (n = 9). Follow-up for 2 weeks.			
Mishra 2006 RCT No mention of sponsorship or COI.	4.0	N = 66 with symptoms suggestive of CTS at least 1-month duration. Age range from 28 to 60 years.	Splint group carpal tunnel (n = 36 hands) vs. steroid or oral prednisolone 20mg a day for 2 weeks followed by 10mg a day for another 2 weeks (n = 36 hands). Follow-up for 3 months.	Mean±SD for splint vs. steroid: symptom severity score (SSS): 0-1: 0.34±0.42 vs 0.40±0.30 (p = 0.52); 0-3: 0.30±0.54 vs. 0.49±0.44 (p = 0.42). Sensory distal latency (SDL): 0-1: 0.16±0.63 vs. 0.13±0.71 (p = 0.86); 0-3: 0.35±0.76 vs. 0.55±0.66 (p = 0.25).	"There was significant improvement in both groups, clinically as well as electrophysio-logically, at 3 months."	No blinding. Suggests splinting is as effective as oral steroid, though function was slightly better with splinting.
Glucocorticosteroids vs. NSAIDs						
Celiker 2002 No mention of sponsorship or COI.	5.5	N = 23 with bilateral or unilateral CTS, EDS confirmed. Mean age for Group A and B; 49.6±15.3 and 46.9±10.0.	Group A: acemetacine 120mg a day with splints at night. Group B: 40mg methylpred-nisolone acetate (1ml)	VAS pain scores (baseline/2nd week/8th week): NSAID plus splint 7.9±1.4/4.3±0.9/1.7±1.0 vs. injection 7.0±2.2/3.1±2.5/1.8±1.9 (P>0.05). Symptom severity scale results similar (p>0.05).	"Both splinting combined with the use of a nonsteroidal anti-inflammatory drug and steroid injection into the carpal tunnel resulted in significant improvement in carpal tunnel syndrome."	No placebo controlled. Suggests splinting and NSAID may be as effective as injection.
Glucocorticosteroids vs. Anesthetics						
Karadas 2011 RCT No mention of sponsorship. No COI.	4.5	N = 99 with clinical and electrophysiolog ic evidence of CTS, older than 18 years.	Group 1 40mg triamcinolone acetonide (n = 34) vs. Group 2 4ml 1% procaine HCl (n = 32) vs. Group 3 both 40mg triamcinolone acetonide and 4ml 1% procaine HCl (n = 33). Follow-up at baseline, 2 and 6 months after injection.	VAS scores improved significantly in each group at 2 and 6 months after treatment, (p <0.05). No significant differences shown for electrophysiologic findings at baseline, 2, and 6 months, (p >0.05).	"Local procaine HCl injection and steroid injection effectively reduced the symptoms of CTS and equally improved electrophysiologic findings."	Combined triamcinolone acetonide and procaine HCL may be superior to individual medications alone.
Karadas 2012 RCT No mention of sponsorship or COI.	4.5	N = 57 with clinically suspected primary CTS. Age >18 years.	Group 1 injected with 1ml 0.09% saline (n = 19) vs. Group 2 injected with 40mg triamcinolone acetonide (n = 20) vs. Group 3 injected with 4ml 1% procaine HCl (N = 18). Follow-up at 1, 2 and 6 months.	Clinical/electrophysiological evaluations improved significantly in groups 2 and 3 at post-treatment, (p <0.05). No significant changes in group 1, (p >0.05). Groups 2 and 3 better scores vs. group 1 at 2, 6 months, (p <0.05). No difference between groups 2 and 3 in terms of change	"Triamcinolone acetonide and procaine HCl injections are effective regarding short- and long-term outcomes compared with placebo injections, and procaine HCl injection was as effective as steroid injection."	Both active interventions superior to saline injection.

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				scores of any terms at post-treatment, (p >0.05).		
Glucocorticosteroids vs. Iontophoresis						
Bakhtiary 2013 RCT Sponsored by Research Deputy of Semnan University of Medical Sciences. No COI.	7.0	N = 34 (gender not specified) mild to moderate CTS confirmed by electromyography. Mean age for Iontophoresis and Phonophoresis; 48.2 (14.5) and 44.6 (12.8).	Iontophoresis of Dex-P 0.4% (n = 26) vs. Phonophoresis of Dex-P 0.4%, plus applied over wrist chin and pulsed (20%) ultrasound waves (n = 26). Follow-up for 4 weeks.	Pain at end of treatment and 4 weeks later significantly favored phonophoresis vs iontophoresis of Dex-P intervention, (p <0.01). Motor latency/motor action potential amplitude/finger pinch strength/hand grip strength/ pain relief: [mean difference 0.8 m/s; 95% (CI), 0.5-1.1]/ (4.1 mV; 95% CI, 3.0 -5.2)/ (31.6 N; 95% CI, 15.9-47.3)/ (27.1 N; 95% CI, 13.5-40.5)/ and 2.1 points on 10-point scale; 95% CI, 1.3 - 2.9.	"Our clinical trials showed that phonophoresis of Dex-P is more effective than iontophoresis of Dex-p treatment in patients with mild to moderate CTS."	Data suggest phonophoresis superior to iontophoresis
Gökoğlu 2005 No mention of sponsorship or COI.	4.0	N = 30 with clinical and EDS evidence of CTS. Mean age 48.0 ± 8.2.	Group 1: 40mg methylprednisolone acetate injected (n = 15) vs. Group 2: iontophoresis of dexamethasone sodium phosphate (n = 15). Follow-up for 2 and 8 weeks.	Symptoms severity scores (baseline/week 2/week 8): injection 2.7±0.8/1.9±0.7/ 1.6± 0.6 vs. iontophoresis 3.1±0.8/2.5±0.9/ 2.2±1.0 (p <0.05) for Weeks 2 and 8 favoring injection. Functional status scale and VAS scores similarly favored injection.	"Success of both iontophoresis of dexamethasone sodium phosphate and injection of corticosteroids, but symptom relief was greater at 2 and 8 weeks with injection of corticosteroids."	Suggests injection superior to iontophoresis of dexamethasone.
Injection vs. Ultrasound						
Bilgici 2010 RCT No mention of sponsorship or COI.	5.5	N = 34 with CTS. Mean age for Groups A and B; 47.33 (7.44) and 44.15 (9.30).	Group A, ultrasound treatment (n = 16) vs. Group B, local corticosteroid injection plus splinting (n = 18). Follow-up for 8 weeks.	VAS pain/severity of symptoms/functional status / grip strength, (p <0.001) and two point discrimination (p <0.016). Group A, improved for all clinical outcomes, (p <0.001), except grip strength.	"Both ultrasound treatment and corticosteroid injection plus splinting were effective on the clinical symptoms and the electrophysiological findings of CTS."	Both groups improved meaningfully over time, but differences between groups minimal; one statistically significant difference.
Glucocorticosteroids vs. Range of Doses						
Dammers 2006 RCT No mention of sponsorship or COI.	9.0	N = 136 (102 female/30 male) EDS confirmed diagnosis of CTS. Mean age for 20/40/and 60mg groups: 45/43/and 44.	20mg methyl-prednisolone injections (n = 45) vs. 40mg methylprednisolone injections (n = 43) vs. 60mg methyl-prednisolone injections (n = 44). Follow-up for 3 months.	73% of 60mg, 53% of 40mg and 56% of 20mg groups symptom free or requiring no further treatment at 6 months. Only 22% treated with 1-2 injections methylprednisolone during first year referred to surgery (p <0.05).	"One injection of methylprednisolone close to the carpal tunnel reduces the number of patients requiring surgery." 60mg dose more effective than lower doses, with 2nd injection possibly increasing	Injection site 4cm proximal to distal wrist crease.

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					recurrence of symptom-free patients.	
Injection Method						
Üstün 2013 RCT No mention of sponsorship. No COI.	4.0	N = 46 with idiopathic CTS. Mean age for US-guided/Palpation-guided group: 45.96±10.49/ 42.71±11.38.	US-guided device of 20mg methylprednisolone (n = 23) vs. Palpation-guided approach or blind injection group of 20mg methylprednisolone using ulnar side approach (n = 23). Follow-up at 6 and 12 weeks.	Scores for symptom severity and functional status improved at 6 and 12 weeks after the treatment, (p < 0.05). Boston Carpal Tunnel Questionnaire (BCTQ) symptoms / function: 6 weeks; 1.33±0.55 and 12 weeks; 1.30±0.45 vs 1.41± 0.59 and 1.67±0.73 Palpation group, (p <0.001)/1.33±0.46 and 1.36±0.49 vs 1.52±0.87 and 1.86±1.09, (p <0.001).	"[B]oth US-guided and blind steroid injections were effective in reducing the symptoms of CTS and improving the function, an earlier onset/better improvement of symptom relief suggests that US-guided steroid injection may be more effective than are blind injections in CTS."	Data suggest ultrasound guided injection superior to blind for providers with this level of experience.
Glucocorticosteroids (Injection vs. Oral or by Injection Sites)						
Wong 2001 RCT No mention of sponsorship or COI.	9.0	N = 62 (53 female/7 male) with newly diagnosed CTS >3 months.	Steroid or prednisolone 25mg PO QD for 10 days (n = 30) vs. Oral steroid or prednisolone acetate 15mg injection (n = 30). Follow-up for 12 weeks.	Global symptom scores (injection/oral): baseline (25.0±6.4/25.7±8.3), 2 weeks (13.6±7.5/17.8±10.0), 8 weeks (13.7±8.3/20.8±8.7), and 12 weeks (14.3±8.4/ 21.4±9.6). GSS scores borderline significant at 2 weeks (p = 0.07), but significant at 8 and 12 week follow-ups (p = 0.002 and p = 0.004).	"Local steroid injection was superior to oral corticosteroids over a 3-month period in patients with CTS."	Suggests injections superior to oral glucocorticosteroids.
Habib 2006 RCT No mention of sponsorship or COI.	5.0	N = 42 with symptoms of CTS and EDS confirmed. Age >18 years old.	Local corticosteroid classic injection (n = 21) vs. 2-3cm distal to the wrist crease. Both with 12mg methyl-prednisolone acetate with 0.15ml lidocaine (n = 21). Follow-up for 12 months.	81 % of classical injection and 71% new method injection patients had favorable response rate after 3 weeks (p = 0.468). Procedure time 8.48±1.123 seconds in new method group vs. 26.71±32.83 in classical group (p = 0.021). Mean±SD grade of pain: new method 4.38±1.523 vs. classic method 3.62±1.071 (p = 0.065).	"Local corticosteroid injection using the novel approach for the treatment of carpal tunnel syndrome is helpful, and the favorable response rates are comparable to those using the classic approach after 1, 3, 6, and 12 weeks."	Suggests traditional injection technique may be superior.
Glucocorticosteroids vs. Intramuscular Injection						
Özdoğan 1984 RCT	6.0	N = 37 with idiopathic CTS. Mean age 45.8±8.7 years.	Steroid injection, 1.5mg betamethasone disodium phosphate and acetate	7 from carpal injection group and 6 from IM injection group returned with symptoms after 1 month and	"Steroid injected at the site of entrapment is effective and suggest superiority to the	Carpal injections appear superior to intramuscular steroids.

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No mention of sponsorship or COI.			suspension (n = 18) vs. Placebo into deltoid double dummy (N = 19). Follow-up for 10-12 months.	required second shot. One from first group and 2 from second group required third shot after 7.3±3.7 months. Response rate 50% in hand injections vs. 15.8% IM.	intramuscular route in the management of ICTS."	
Intracarpal Tunnel Injection with Glucocorticosteroids vs. Saline or No Injection						
Armstrong 2004 RCT Sponsored by Southern California Kaiser Permanente Department of Research and Evaluation. No mention of COI.	9.5	N = 81(63 female/18 male) with typical symptoms of CTS and EDS confirmed. Age 18-80.	Steroid injections or Betamethasone 6mg (n = 43) vs. Placebo group or saline (n = 36). Follow-up for 18 months.	Changes in median sensory latencies -0.19±0.27 vs. -0.04±0.14 (p = 0.01). Changes in symptoms scores also favored corticosteroid injections -0.78 ±0.80 vs. -0.19 ±0.62 (p <0.01). Satisfaction rates 70% vs. 34% (p = 0.001). In subsequent open label follow-up, additional injections performed per patient requests (up to 7 injections for a few); 18 (39.1%) referred for surgery, 37.0% reported adequate symptom relief.	"Steroid injections are a safe and effective treatment for temporary relief of CTS symptoms for patients who did not improve with splinting and activity modification."	Unblinded after 2 weeks.
Peters-Veluthamaningal 2010 RCT No mention of sponsorship. No COI.	7.5	N = 69 (53 female/16 male) with clinical diagnosis of CTS. Mean age: NaCl group = 57.6 years, TCA group = 56.5 years.	1ml triamcinolonacetonide (TCA) 10mg/ml (n = 36) vs. 1ml saline (NaCl) 0.9%, placebo 1-2 injections (n = 33). Follow-up 1, 3, 6 and 12 months	Steroid-group showed better direct treatment response (p = 0.013), perceived improvement (p = 0.01) and more improvement than NaCl-group in outcomes SSS BCTQ score (from 2.872 to 1.948 in TCA group vs. from 2.815 to 2.529 in NaCl group) and FSS BCTQ score (2.456 to 1.881 in TCA group vs. 2.353 to 2.366 in NaCl group). Mean difference in change score 0.637 (95% CI: 0.320, 0.960; (p <0.001)) for SSS BCTQ and mean difference in change score 0.588 (95% CI: 0.232, 0.944; p = 0.02) for FSS BCTQ. Number Needed to Treat to achieve satisfactory partial treatment response or complete	"Corticosteroid injections for CTS provided by general practitioners are effective regarding short-term outcomes when compared to placebo injections."	Multiple injections given if patient result was "not satisfactory" Data suggest steroid injections superior to NaCl for short term outcomes.

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				resolution of symptoms and signs 3 (95% CI: 1.83, 9.72).		
O'Gradaigh 2000 RCT No mention of sponsorship or COI.	5.0	N = 32 with suspected CTS and EDS confirmed. Age not reported.	Hydrocortisone 25mg or 100mg (A), hexacetonide 20mg (B), plus phase II; Triamcinolone 20mg or Hydrocortisone 100mg (n = 33) vs. Control no injection (n = 20). Follow-up 6 weeks and 6 months.	Results from Phase 1 (25mg/ 100mg/no injection) 66% vs. 63% vs. 5% better or much better (NS between injected groups' differences). Symptoms improved in Phase 2 in 72% vs. 67% (NS).	"As low dose steroid is as effective, and potentially less toxic, this should be the recommended dose for injection of carpal tunnel syndrome."	Two studies in one report with the first finding benefits of injection. Second trial found minimal incremental gain for higher dose.
Girlanda 1993 RCT No mention of sponsorship or COI.	4.0	N = 32 with clinical and EDS evidence of CTS. Age 36-60 years.	Methylpred-nisolone acetate 15mg acetate injection locally (n = 9) vs. saline solution same amount as treatment group (n = 8). Study on long-term effects (n = 8). Follow-up at 2 months and 2 years.	Paresthesias significantly improved from baseline in both groups, but more improved in steroid group (p <0.0001 vs. p <0.01); statistical significance of improvements in saline disappeared at 1 month; persisted through 2 months in steroid. 50% of nerves worse within 6 months; 90% within 18 months; 8% of nerves remained improved at 2-year.	"Only a small percentage (8%) of the nerves remained improved at the 2-years follow-up."	Methods details sparse, especially for long duration components of study. Patients had symptoms over 4 years.
One vs. Two Injections						
Wong 2005 RCT No mention of sponsorship or COI.	9.0	N = 40 (24 female/6 male) with newly diagnosed CTS and NCS confirmed, mean age for single and double injection groups: 46.4 (5.6)/47.3 (9.6).	Single injection group or methylprednisolone 15 mg injection (n = 20) vs. Double-injection group at 8 weeks of steroid or placebo (n = 20). 40 week follow-up.	Global Symptom Score Single vs. Double injections (pre/8/24/ 40 weeks): Single 26.7±10.1/ 15.2±9.9/15.9±10.6/12.6±9.1 vs. Double 25.6±11.6/11.4± 7.6/13.0±9.7/14.1±11.0 (p> 0.19) all times. No differences in grip strengths or in NCS other than right hand which was borderline different at baseline (p = 0.08).	"The results suggest that an additional steroid injection confers no added benefit to a single injection in terms of symptoms relief."	Both arms had active treatment
Steroid vs. Placebo						
Atroshi 2013 RCT Sponsored by grant from Region of	8.5	N = 111 (81 female/30 male) with idiopathic CTS not previously treated with	80mg methylprednisolone (n = 37) vs. 40mg methylprednisolone (n = 37) vs. placebo (n = 37).	At baseline CTS symptom severity score at 10 weeks improved those who received methylprednisolone vs. placebo (p = 0.003 for 80mg; p = 0.001 for 40mg	"Methylprednisolone injections for CTS have significant benefits in relieving symptoms at 10 weeks and reducing the rate of surgery 1 year after	Data suggest both active treatments superior to placebo, no statistical differences between 80 mg and 40 mg steroid

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Scania Research and Development Foundation and Ha¨ssleholm Hospital Organization. No COI.		steroid injections. Age 18-70 years.		methylprednisolone). At 1-year rates of surgery 73%, 81%, and 92% in 80mg methylprednisolone, 40mg methylprednisolone, and placebo groups. Those who received 80mg methylprednisolone less likely to have surgery (OR, 0.24 [CI, 0.06 to 0.95], (p = 0.042).	treatment, but 3 out of 4 patients had surgery within 1 year."	
Dammers 1999 RCT No sponsorship and no COI.	8.0	N = 60 with carpal tunnel symptoms >3 months and NCS confirmed.	Intervention group or methylprednisolone 40mg plus 10mg lidocaine (n = 30) vs. Control group or lidocaine alone (n = 30). Follow-up for one year.	Percentage not needing 2nd treatment (1/3/6/9/12 month): steroid (77/63/57/53/50%) vs. placebo (20/7/7/7/7%), significant but no p-value reported. In open phase, 24 of 28 crossed over from controls and 50% of those had surgery, no p-value reported.	"A single injection with steroids close to the carpal tunnel may result in long term improvement and should be considered before surgical decompression."	Data suggest injection effective and 50% need no treatment for 1 year.
Splinting vs. Steroid vs. Surgery						
Ucan 2006 RCT No mention of sponsorship or COI.	5.0	N = 57 with CTS diagnosis, mean age for Group A, B, and C: 44.50±7.24, 44.46±8.52, and 45.2±13.19.	Group A or Splinted (S) hands splinted in neutral position with standard cotton polyester splint (n = 23) vs. Group B or single steroid injection (20mg triamcinolone acetate plus 20mg lidocaine) and splinted (SLSI) (n = 23) vs.Group C: Surgery (OCTR) (N = 11). Follow-up for 3 and 6 months.	Boston Questionnaire scores (baseline/3rd month/6th month): splinting 2.66±0.35/ 1.39±0.37/1.54±0.31 vs. splint plus steroid 2.79±0.63/1.41± 0.32/1.96±0.63 vs. CTR 3.09± 0.5/1.86±0.6/1.41± 0.31 (p = 0.004). Palm-wrist median sensory nerve velocities: splint 27.26±5.3/29.6±7.16/29.56± 4.83 vs. splint plus steroid 26.35±4.12/31.57±4.33/28.7 4± 6.19 vs. CTR 23.98±4.28/ 32.20±4.17/33.15±4.1 (NS between groups). Those completely/almost satisfied 3rd/6th months splinting 69.6%/34.8% vs. splint plus steroid 100%/82.6% vs. CTR 45.5%/90.9%.	"All treatment methods were found to be effective, but despite the complications and the relatively long period to return to work, OCTR was superior to conservative methods in long term."	Baseline differences present. Appears to have targeted lower enrollment for surgery without stating such.

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Glucocorticosteroid vs. Surgery						
Hui 2005 RCT No mention of sponsorship or COI.	8.0	N = 50 (48 female/2 male) with EDS confirmed idiopathic CTS.	Steroid injection or methylprednisolone acetate 15mg (n = 25) vs. Decompression or open CTR (n = 25). Follow-up at 6 and 20 weeks.	Mean improvements in global symptoms scale: 24.2±11.0 vs. 8.7±13.0 (p <0.001). Grip strengths were: surgery 23.4±8.2 to 21.8±7.9 vs. injection 24.2±7.0 to 26.6±7.4 (p = 0.009). Sensory nerve conduction velocities: surgery 34.2±7.9 to 42.2±8.0 m/s vs. injection 37.3±8.0 to 40.5±6.3 (p = 0.003).	"Open carpal tunnel release resulted in better symptomatic and neurophysiologic outcome but not grip strength in patients with idiopathic carpal tunnel syndrome over a 20-week period."	Suggests surgery superior.
Ly-Pen Arth Rheum 2005; Ly-Pen Med Clin 2005 RCT No mention of sponsorship or COI.	6.5	N = 123 (163 wrists) with CTS. Mean age 51.9 years.	Betamethasone 6.4mg, 2 injections 2 weeks apart (n = 83 wrists) vs. Open Carpal Tunnel Release (n = 80). One year study. Follow-up at 3, 6, and 12 months.	70% improvements in nocturnal paresthesias present (3/6/12 months): injection 86.7/69.9/61.4% vs. surgery 61.3/68.8/ 73.8% (p = 0.001/p = 1.0/p = 0.098).	"Over the short term, local steroid injection is better than surgical decompression for the symptomatic relief of CTS. At 1 year, local steroid injection is as effective as surgical decompression for the symptomatic relief of CTS."	Details sparse. Most patients had 2 injections. No clear surgical benefit vs. injection.
Ly-Pen 2012 RCT No mention of sponsorship or COI.	6.0	N = 101 with clinical diagnosis and neuro-physiological confirmation of CTS.	Surgical decompression (n = 83 wrists) vs. Local steroid injection (n = 83 wrists). Follow-up of 2 years.	56 underwent surgery, 24 had CTS in both hands. 84% required 2 injections. At 24-months follow-up, 60.2% of wrists in injection group and 68.8% in surgery group achieved 20% response in nocturnal paraesthesias, (p = 0.256). Surgery more effective than injection for self-perceived functional impairment, with mean VAS score of 6.21 (8.81) in injection group vs. 2.02 (7.23) in surgery group, (p = 0.008).	"Our findings suggest that both local steroid injection and surgical decompression are effective treatments in alleviating symptoms in primary CTS at 2-year follow-up."	High drop out at 24 months. Injection superior at 3 months' time point but release superior at 12 months and 24 months.

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INTRAMUSCULAR INJECTIONS

Intramuscular injections have been used to treat CTS.(854)

Recommendation: Intramuscular Injections for Acute, Subacute, or Chronic CTS
Intramuscular injections are not recommended for treatment of acute, subacute, or chronic CTS.

Strength of Evidence – **Not Recommended, Evidence (C) – Chronic CTS**
Not Recommended, Insufficient Evidence (I) – Acute, subacute CTS
Levels of Confidence – Moderate

Rationale for Recommendation
Intramuscular injections for CTS are not recommended as they have been found to be inferior to carpal tunnel injections.(854)

Evidence for the Use of Intramuscular Injections for CTS
There is 1 moderate-quality RCT incorporated into this analysis.(854)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL and Cochrane Library without date limits using the following terms: intramuscular injections, carpal tunnel syndrome, CTS, median nerve neuropathy, median neuropathy, median nerve disease, entrapment, neuropathy, nerve compression, burning, itching, numbness, tingling, wrist, hand, palm, finger, pain, controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random, randomized, randomization, randomly; systematic, systematic review, retrospective studies, prospective studies, epidemiological studies, epidemiological research, and Nonexperimental Studies. We found and reviewed 36 articles in PubMed, 722 in Scopus, 3 in CINAHL, 40 in Cochrane Library and 0 in other sources. We considered for inclusion 8 from PubMed, 0 from Scopus, 1 from CINAHL, 2 from Cochrane Library and 0 from other sources. Of the 11 articles considered for inclusion, 3 randomized trials and 1 systematic study met the inclusion criteria.*

Author/Year Study Type Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Glucocorticosteroids vs. Intramuscular Injection						
Özdoğan 1984 RCT No mention of sponsorship or COI.	6.0	N = 37 females: symptoms: burning pain, tingling, numbness in thumb, index and long fingers and palm. Mean age 45.8 years	Group A: 1.5mg betamethasone disodium phosphate and acetate suspension into carpal tunnel and same volume of placebo (0.5 ml saline) into the deltoid muscle on same side (n = 18) vs. Group B: 1.5mg betamethasone disodium phosphate and acetate suspension into deltoid muscle and same volume of placebo into carpal tunnel (n = 19). Follow-up at 1 week, 1 month, and 10 months after study completion.	Seven patients from carpal injection group and 6 patients from IM injection group returned with symptoms after 1 month and required 2nd shot. One from 1st group and 2 from 2nd group required 3rd shot after 7.3±3.7 months. Response rate 50% in hand injections compared to 15.8% IM.	"Steroid injected at the site of entrapment is effective and suggest superiority to the intramuscular route in the management of ICTS."	Data suggest intracarpal tunnel injections much more effective.

INSULIN INJECTIONS

Treatment of CTS with carpal tunnel insulin injections has been attempted.(634, 872)

Recommendation: Insulin Injections for Acute, Subacute, or Chronic CTS
There is no recommendation for or against use of insulin injections for treatment of acute, subacute, or chronic CTS.

Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**
Level of Confidence – Low

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Rationale for Recommendation
There is one quality study which included CTS patients that suggests benefit from 7 weekly injections of insulin.(872) A second moderate quality trial found a lack of benefits compared with physiotherapy.(873) The consensus of the Evidence-based Practice Hand, Wrist, and Forearm Panel is that these results require replication. Applicability of these results, even if confirmed, are suggested to be relatively limited to a narrow subset of diabetic patients with CTS who fail to improve with other therapies and either decline surgery or have significant symptoms of focal intracarpal nerve dysfunction after surgery. These injections are invasive, may have adverse effects that also require ascertainment, and are moderate to high cost. There is no recommendation for or against insulin injections for treatment of diabetic patients with CTS.

Evidence for the Use of Insulin Injections for CTS
There are 2 moderate-quality RCT incorporated into this analysis.(872, 873)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL and Cochrane Library without date limits using the following terms: Insulin injections and carpal tunnel syndrome, CTS, median nerve neuropathy, median neuropathy, median nerve disease entrapment, neuropathy nerve compression, burning, itching, numbness, tingling, controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random, randomized, randomization, randomly; systematic, systematic review, retrospective studies, prospective studies, epidemiological studies, epidemiological research, and Nonexperimental Studies. We found and reviewed 6 articles in PubMed, 836 in Scopus, 1 in CINAHL, 39 in Cochrane Library and 0 in other sources. We considered for inclusion 3 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library and 0 from other sources. Of the 3 articles considered for inclusion, 2 randomized trials and 1 systematic studies met the inclusion criteria.*

Author/Year Study Type Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Intracarpal Tunnel NPH Insulin vs. Saline Injection						
Ozkul 2001 RCT No mention of sponsorship or COI.	6.0	N = 43 (gender not specified) with non-insulin-dependent diabetes mellitus (NIDDM) with mild to moderate CTS. Mean age: insulin 47.1±1.3 years placebo 48.4±0.9 years	NPH insulin (0ml-12 U) (n = 22) vs. placebo injected into carpal tunnel weekly for 7 weeks after initial gluco-corticosteroid injection for all (n = 21). Follow-up 23 weeks.	Mean±SD median nerve motor distal latency (MNMDL): decrease 5 weeks insulin group 4.52±0.12 vs. placebo 4.80±0.03ms (p <0.05) and continued to 23 weeks (p <0.01). Mean±SD median nerve sensory velocity (MNSV): difference more significant insulin group vs placebo over whole study (p <0.01).	"[L]ocal insulin injections more significantly decreased MNMDL [median nerve motor distal latency], increase MNSV [median nerve sensory velocity] and reduces GSS [global symptom score] than the placebo in NIDDM patients with CTS."	All had gluco-corticosteroid injection. Suggestive results that need confirmation.
Ashraf 2009 RCT No mention of sponsorship or COI.	4.0	N = 50 with non-insulin dependent diabetes mellitus; 20 had bilateral involvement, had symptoms and signs of CTS confirmed by standard electro diagnosis.	Group 1 received injection into carpal tunnel (10IU of NPH insulin) (n = N/A) vs. Physiotherapy (2 periods with 10 sessions) (n = N/A). Follow-up period not mentioned.	In both groups decrement of distal motor latency (DML) of median nerves statistically significant. In both groups the increment of sensory nerve conduction velocity was statistically significant. Also, decrement of pain, paresthesia, numbness, weakness/	"In conclusion, in the present study, local insulin injections significantly reduced symptoms as the physiotherapy in NIDDM patients with CTS. But clinical significant difference in compare with physiotherapy was not seen. In summary two local insulin injections had no significant difference with compare to 20	No differences between groups.

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		Mean age 51.3.		clumsiness and nocturnal awaking was statistically significant in both groups. But no significant difference between two groups.	sessions physiotherapy. Although these findings are promising, further studies with insulin are needed to verify its effectiveness as a treatment for CTS and other degenerative nerve diseases."	

BOTULINUM INJECTIONS

Botulinum injections have been used to treat CTS.(874, 875)

Recommendation: Botulinum Injections for Acute, Subacute, or Chronic CTS

Botulinum injections are not recommended for treatment of acute, subacute, or chronic CTS.

Strength of Evidence **– Not Recommended, Evidence (C) – Chronic CTS**
Not Recommended, Insufficient Evidence (I) – Acute or subacute CTS

Level of Confidence – Low

Rationale for Recommendation

There is one quality study that included CTS patients that does not show clear benefit from botulinum injections, but did show weakness in two patients lasting a few weeks.(874) There are no other quality studies identified for management of other distal upper extremity disorders, including tendinoses. Botulinum injections are invasive, have adverse effects when the effects of the toxin are beyond the site where they were injected that include fatalities,(752, 876) and are costly. They are not recommended for management of CTS.

Evidence for the Use of Botulinum Injections for CTS

There is 1 moderate-quality RCT incorporated into this analysis.(874)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL and Cochrane Library without date limits using the following terms: botulinum toxin, botox or botulinum Injection, carpal tunnel syndrome, median neuropathy, CTS, carpal tunnel, median nerve, compression, entrapment, neuropathy, nerve disease, syndrome, median nerve, median neuropathy, burning, itching, numbness, tingling, hand, palm, finger, wrist, and pain; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 11 articles in PubMed, 201 in Scopus, 2 in CINAHL, and 1 in Cochrane Library. We considered for inclusion 1 from PubMed, 0 from Scopus, CINAHL, and Cochrane Library. Of the 1 article considered for inclusion, 1 randomized trials and 0 systematic studies met the inclusion criteria.*

Author/Year Study Type Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Breuer 2006 RCT Sponsored by Elan Pharmaceuticals, San Francisco, California. No mention of COI.	7.5	N = 20 (gender not specified) with hand pain and discomfort associated with CTS. Age range 18-90.	2,500 units of botulinum toxin B (n = 11) vs. Placebo or normal saline solution (n = 9). Follow-up for 13 weeks.	Response rates for botulinum toxin B and placebo groups: 126/143 (88.1%) vs. 117/117 (100%).	"Botulinum toxin B is not dramatically superior to placebo for the relief of CTS symptoms."	Small sample size. Few screened (20/388) randomized. Suggests not effective.

Surgery

CARPAL TUNNEL SURGICAL RELEASE

Surgical consultation may be indicated for CTS patients who:

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- Have red flags of a serious nature;
- Fail to respond to non-surgical management including worksite modifications; or
- Have clear clinical and special study evidence of a lesion that has been shown to benefit, in both the short and long term, from surgical intervention.

Surgical considerations depend on the confirmed diagnosis of the presenting hand or wrist complaint. If surgery is a consideration, counseling regarding likely outcomes, risks, and benefits, and especially expectations is important. If there is no clear indication for surgery, referring the patient to a provider experienced in non-operative treatment of CTS may aid in formulating a treatment plan.

Treatment of CTS with surgical release of the carpal flexor retinaculum has been utilized for many decades with surgical case series suggesting significant benefits.(762, 877-903) In the late 1980s, endoscopic releases were reported, gained prominence, utilized various equipment,(894, 895, 904-913) and were initially reported as superior to open releases.(907, 911, 914-918) However, the endoscopic technique reportedly has a higher incidence of injuries to the nerve, particularly in inexperienced surgical hands, as well as higher rates of incomplete surgical releases.(919) A large endoscopically treated case series of 2,402 cases involving 1,698 patients reported an overall success rate of 95% and recurrence rate of 0.5% in experienced hands.(920) More recently, the open technique has been revised towards a minimal incisional technique(921) and continues to be successfully performed with little apparent difference in outcome versus endoscopic releases.(922-925) Currently, there is a trend towards performing these minor surgical releases in uncomplicated patients in clinics as opposed to in hospitals or ambulatory surgical centers that is facilitating return to work on the same day as surgery.

Many adjunctive procedures and modifications of surgical release have been attempted in order to obtain better clinical results. These include neurolysis, epineurotomy, epineurectomy, tenosynovectomy, excision of the carpal ligament, cutaneous nerve sparing, two small open incisions, use of a Knifelight, hypothenar fat pad and other flaps, and concomitant release of the ulnar nerve in Guyon's canal.(926-941)

Most, but not all surgical studies required patients to have preoperative confirmation with electrodiagnostic studies (EDS), although the EDS criteria are usually not specified. How results compare among those without EDS confirmation is unclear. Risks of surgical decompression include complications of anesthesia (addressed separately in this document), wound infection, complex regional pain syndrome, and damage to the median nerve.(894, 895, 942, 943) Incomplete decompression or recurrence of symptoms can lead to the need for further surgery. Early return to work is the main cost driver regardless of the type of carpal tunnel surgical approach utilized. Early return to work appears more dependent on the attitude of the employer and patient than on the surgical technique,(944) with self-employed patients incurring less lost work time.(944) The durations of lost time have been shown to vary from days to weeks, further suggesting that surgical approaches are not the primary determinants of return-to-work status.

1. *Recommendation: Surgical Release for Treatment of Subacute or Chronic CTS*
   Surgical release is strongly recommended for patients who fail non-operative treatment for subacute or chronic CTS.(911, 914-918, 922-925, 945, 946) **It is also recommended for patients who have emergent or urgent indications (e.g., acute compression due to fracture, arthritides, or compartment syndrome with unrelenting symptoms of nerve impairment).**

   Indications – Failure of non-operative treatment or severe symptoms such as continuous tingling and numbness. Many surgeons will not operate on a patient without a positive EDS. Most patients should have had at least 1 glucocorticosteroid injection with documentation of at least partial or complete relief followed by a return of symptoms. Patients should have an electrodiagnostic study (EDS) consistent with CTS (see Electrodiagnostic Studies). The decision to undergo surgery is typically driven by nocturnal symptoms.(947) Mild CTS with normal EDS exists, but a clinical impression of moderate or severe CTS with normal EDS is very rare and generally indicates a mistaken diagnosis. Positive EDS in asymptomatic individuals is very common, is not CTS, and suggests the need to carefully select patients for EDS and properly interpret the results.

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Strength of Evidence – **Strongly Recommended, Evidence (A)**
Level of Confidence – High

2. *Recommendation: Open or Endoscopic Release for Subacute or Chronic CTS*
Either open or endoscopic release is moderately recommended for treatment of subacute or chronic CTS. With either open or endoscopic, the effectiveness results from complete division of the flexor retinaculum. The procedure that the surgeon is most comfortable performing is recommended.(922, 923, 925, 945, 946)

Indications – See indications above for Recommendation #1.

Strength of Evidence – **Moderately Recommended, Evidence (B)**
Level of Confidence – Moderate

3. *Recommendation: Knifelight for Subacute or Chronic CTS*
The use of a Knifelight is recommended for treatment of subacute or chronic CTS.

Indications – See indications above for Recommendation #1.

Strength of Evidence – **Recommended, Evidence (C)**
Level of Confidence – Low

4. *Recommendation: Other Adjunctive Procedures or Techniques for Subacute or Chronic CTS*
While there may be limited indications for the following procedures or techniques, their routine use is not recommended for treatment of subacute or chronic CTS.

Epineurotomy is moderately not recommended.

Strength of Evidence – **Moderately Not Recommended, Evidence (B)**
Level of Confidence – Moderate

Internal neurolysis is strongly not recommended.

Strength of Evidence – **Strongly Not Recommended, Evidence (A)**
Level of Confidence – High

Flexor retinacular lengthening is moderately not recommended.

Strength of Evidence – **Moderately Not Recommended, Evidence (B)**
Level of Confidence – Moderate

Ulnar bursal preservation is moderately not recommended.

Strength of Evidence – **Moderately Not Recommended, Evidence (B)**
Level of Confidence – Moderate

The mini palmar incision using the ring finger as a guide does not require any special changes in the location of the incision.(940) **Therefore, altering the location of the incision to "superficial nerve-sparing incision" is not recommended.**

Strength of Evidence – **Not Recommended, Evidence (C)**
Level of Confidence – Low

As discussed above, an incision that is placed too far ulnarly may result in damage to the ulnar nerve or artery; therefore, an ulnar incisional approach is not recommended.

Strength of Evidence – **Not Recommended, Evidence (C)**
Level of Confidence – Low

Flexor tenosynovectomy is not recommended.

Strength of Evidence – **Not Recommended, Evidence (C)**
Level of Confidence – Moderate

5. *Recommendation: Biopsy of Abnormal Tenosynovium for Subacute or Chronic CTS*
Biopsy of abnormal tenosynovium is recommended for treatment of subacute or chronic CTS.

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Indications – Abnormal appearing tenosynovium, including potential amyloidosis, infectious agents, or evidence for inflammatory conditions.

Strength of Evidence **– Recommended, Insufficient Evidence (I)**
Level of Confidence – Moderate

Rationale for Recommendations
Evidence that surgery is effective is strong. Six quality studies have compared carpal tunnel release with other interventions. Three quality studies document superiority compared with splinting.(763, 777, 778) Two of three studies suggest superiority of surgical release compared with injection(777, 851-853) over longer timeframes mostly of 1 year. One study suggested superiority compared with physical therapy.(641) These appear to indicate a slight superiority of surgery to injection over 1 year and a modestly stronger benefit compared with nocturnal splinting. Longer-term outcomes are believed to further favor surgery.

Seventeen quality trials have compared open versus endoscopic techniques.(907, 911, 914-918, 922-925, 945, 946, 948-952) Six of 11 studies reported since 2000 have failed to demonstrate better outcomes with endoscopic releases,(922, 923, 925, 945, 946, 948-952) which appears to be due to the successful use of minimal incisional techniques that utilize incisions as small as 2cm. These small incisions appear to have removed the primary advantage of endoscopic releases. Quality evidence of superiority of endoscopic versus minimal incisional releases is now lacking and one study has reported no differences at 5-year follow-up, also importantly documenting no differences in reoperation rates.(945) Differences in recovery time between the endoscopic or minimally invasive techniques reported mostly in the 1990s appear to have largely or completely disappeared in the 2000s with 4,(922, 923, 925, 945, 946) of 6 studies(917, 918) showing a lack of superiority of the endoscopic release.(922-925, 945, 946) However, it is the surgeon's experience and comfort that are the determining factors in the selection of the procedure performed.

Overall, the available evidence suggests either the open or endoscopic procedures are successful surgical procedures. Thus, the Evidence-based Practice Hand, Wrist, and Forearm Panel agreed regarding the overall recommendation for surgery. The mini-procedures continue to improve outcomes,(921) while most early studies compared endoscopic to the traditional open procedure. Outcome measures vary with each study making a direct comparison difficult. Studies have shown that with well-motivated individuals and a mini-palm technique, return to modified work the next day is possible.(398)

Recently, a Knifelight has been utilized for carpal tunnel releases.(928, 932) This technique involves use of an instrument through a small palmar incision to perform a blinded division of the flexor retinaculum. While there is sufficient quality evidence to document efficacy and recommend the procedure,(928, 932) further studies are needed comparing the Knifelight with a standardized, minimal incisional technique and using larger sample sizes.

There have been many alterations on standard operative techniques(953) and/or adjunct surgical procedures performed to attempt to derive superior outcomes for patients who have been subjected to quality studies. Without exception, none of the following were found beneficial – epineurotomy,(929, 930, 935, 954, 955) neurolysis,(937, 938) flexor tenosynovectomy,(939) flexor retinacular lengthening,(956) nerve sparing incisions,(940) double-limited incisions,(941) ulnar incisions,(957) and ulnar bursal preservation.(931) Evidence indicates that even in the presence of synovial hypertrophy and histological changes, tenosynovectomy has not been shown to be beneficial in a moderate-quality study.(939) However, biopsy of abnormal tissue is indicated for diagnostic and therapeutic purposes. Examples of potential findings to be sought include amyloidosis, infectious agents, and evidence for inflammatory conditions.

The primary cost driver for CTS claims is lost work time.(778) CTS is not different from other MSDs, with reportedly worse outcomes and greater delays in return to work among patients receiving workers' compensation.(914, 925) In quality studies, lost time ranged from 12 days for open releases in the Netherlands(778) to 88 days for endoscopically treated patients in Sweden,(922) with most trials

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reporting these data between 12 and 40 days.(778, 907, 914, 916-918, 923, 924, 928, 932, 958) There is no clear pattern by country or procedure, other than a propensity for greater lost time in the 1990s in the open release groups compared with the endoscopic releases, prior to the dissemination of limited incisional techniques.

Evidence for the Use of Carpal Tunnel Surgical Release
There are 7 high-(763, 851, 931, 937, 938, 955, 956) and 36 moderate-quality (one with two reports)(641, 777, 778, 852, 853, 907, 911, 914-918, 921-925, 928, 929, 932, 935, 936, 939-941, 945, 946, 948-954, 957, 959, 960) RCTs and crossover trials incorporated into this analysis. There are 13 low-quality RCTs(407, 846, 913, 930, 961-969) in Appendix 2.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL and Cochrane Library without date limits using the following terms: carpal tunnel surgical release, Knifelight, open release, endoscopic, epineurotomy, neurolysis, flexor retinacular, ulnar bursal preservation, mini palmer incision, flexor tenosynovectomy, biopsy of abnormal tenosynovium and carpal tunnel syndrome, median nerve neuropathy, median neuropathy, median nerve disease entrapment, neuropathy nerve compression, burning, itching, numbness, tingling, controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random, randomized, randomization, randomly; systematic, systematic review, retrospective studies, prospective studies, epidemiological studies, epidemiological research, and Nonexperimental Studies. We found and reviewed 179 articles in PubMed, 84 in Scopus, 17 in CINAHL, 45 in Cochrane Library and 0 in other sources. We considered for inclusion 56 articles from PubMed, 2 from Scopus, 2 from CINAHL, 1 from Cochrane Library and 3 from other sources. Of the 64 articles considered for inclusion, 51 randomized trials and 12 systematic studies met the inclusion criteria.*

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Author/Year Study Type Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Carpal Tunnel Release vs. Non-surgical Therapy						
Gerritsen 2002 RCT Sponsored by a grant from the Health Care Insurance Council of the Netherlands. No mention of COI.	8.5	N = 176 (143 female/33 male) EDS confirmed. Mean age 49 years.	Open release (n = 87) vs Splinting for 12 months (n = 89). Follow-up at 1, 3, 6, 12 and 18 months.	Overall success rates statistically superior for all 5 measurements other than 1st month (1/3/6/12/18 months): 29 vs. 42% (p = 0.07)/80 vs. 54% (p <0.001)/94 vs. 68% (p<0.001)/92 vs. 72% (p = 0.002) / 90 vs. 75% (p = 0.02). Nights awakening with symptoms and paresthesias not significantly different at 12 or 18 months. Five (5.7%) in surgery group had wound infection; CRPS/RSD in one. Median-ulnar latency differences borderline favored splinting (baseline: 1.7 vs. 1.8 months; 12 months: 1.1 vs. 0.7months), as did other measures.	"Treatment with open carpal tunnel release surgery resulted in better outcomes than treatment with wrist splinting for patients with CTS."	Duration of symptoms was somewhat worse in splinting group (median 52 vs. 40 weeks, NS). Both treatment arms document substantial improvement, which may reflect a good natural history.
Jarvik 2009 RCT Sponsored by the Intramural Research Program of the NIH Clinical Center. No COI.	7.0	N = 116 (62 female/54 male) considering surgery for diagnosed CTS. Mean age 50.7 years.	Surgery Group: Open surgery or Endoscopic surgery depending on surgeon's preference. (n = 57) vs. non-Surgical therapy group: 6 visits with physical therapy and prescribed NSAIDS. (n = 59). Follow-up 3, 6, 9 and 12 months.	Primary outcome Carpal Tunnel Syndrome Assessment Questionnaire (CTSAQ). Surgical group significantly lower CTSAQ function score vs. non-surgical group at 6 months; 1.91 vs. 2.44 (p = 0.0006) and at 12 months; 1.74 vs. 2.17 (p = 0.0081). Secondary outcome of CTSAQ symptoms also significantly lower in surgery vs. non-surgery at 6 months; 2.02 vs. 2.42 (p = 0.018) and 12 months; 1.74 vs. 2.07 (p = 0.036).	"Overall, these data indicate that, in patients with carpal tunnel syndrome without denervation, surgery modestly improves hand function and symptoms by 3 months compared with a multimodality non-surgical treatment regimen, and this benefit is sustained through 1 year."	At 12 months, surgical group was statistically significant for improved symptoms and function.
Korthals-de Bos 2006 RCT Sponsored by grant from Health Care Insurance Council of the Netherlands. No COI.	4.0	N = 13 EDS confirmed. Mean age not provided.	Open release: Incision size not specified. Numerous specialists performed (n = 73) vs. Nocturnal splinting plus daytime "if they wished to." Follow-up 3, 6, 12 months.	Success rates higher at 12 months for surgery group, 92% vs. 72%, difference is 20% (8-31 95% CI). Night awakening due to complaints not different (3.6±2.9 vs. 2.9±3.0). Severity of main complaint higher in surgery group (6.4±2.7 vs. 5.1±3.1). Mean aggregate costs 2,126€ surgery vs. 2,111€ splint. Absenteeism comparable (50 vs. 52 days).	"In the Netherlands, surgery is more cost-effective compared with splinting, and recommended as the preferred method of treatment for patients with CTS."	Population-based study with likely relatively suboptimal control over treatments. Small sample size. Applicability of cost data to US is questionable.

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7Carpal Tunnel Release vs. Injections						
Hui 2005 RCT No mention of sponsorship or COI.	8.0	N = 50 (48 female/2 male) EDS confirmed. Mean age 49.5 years.	Injection Group- Methylpred-nisolone acetate 15mg (n = 25) vs. Open carpal tunnel release (n = 25). Follow-up at 6 and 20 weeks.	Mean improvements in the global symptoms scale 24.2±11.0 vs. 8.7±13.0 (p <0.001). Grip strengths: surgery 23.4 ±8.2 to 21.8±7.9 vs. injection 24.2±7.0 to 26.6±7.4 (p = 0.009). Sensory nerve conduction velocities: surgery 34.2±7.9 to 42.2±8.0 m/s vs. injection 37.3±8.0 to 40.5±6.3 (p = 0.003).	"Open carpal tunnel release resulted in between symptomatic and neurophysiologic outcome but not grip strength in patients with idiopathic carpal tunnel syndrome over a 20-week period."	Suggests surgery superior.
Ly-Pen Arth Rheum 2005; Ly-Pen Med Clin 2005 RCT No mention of sponsorship or COI.	6.5	N = 123 (163 wrists) with CTS. Mean age 51.9 years.	Bethamethasone 6.4mg, 2 injections 2 weeks apart (n = 83 wrists) vs. Open Carpal Tunnel Release (n = 80). 1 year study. Follow-up 3, 6, and 12 months.	70% improvements in nocturnal paresthesias present (3/6/12 months): injection 86.7/69.9/61.4% vs. surgery 61.3/68.8/ 73.8% (p = 0.001/p = 1.0/p = 0.098).	"Over the short term, local steroid injection is better than surgical decompression for the symptomatic relief of CTS. At 1 year, local steroid injection is as effective as surgical decompression for the symptomatic relief of CTS."	Details sparse. Most patients had 2 injections. No clear surgical benefit.
Ucan 2006 RCT No mention of sponsorship or COI.	5.0	N = 57 (57 hands) with mild or moderate idiopathic carpal tunnel syndrome. Mean age 44.6 years.	Group A: splinted for 3 months (n = 23 Hands) vs. Group B: Single steroid injection (20mg triamcinolone acetate with 20mg lidocaine) and splinted for 3 months (n = 23 Hands) vs. Group C: surgery (n = 11 Hands). Follow-up assessments 3 and 6 months.	Boston Questionnaire scores (baseline/ 3rd month/6th month): splinting 2.66± 0.35/1.39±0.37/ 1.54±0.31 vs. splint plus steroid 2.79±0.63/1.41±0.32/1.96± 0.63 vs. CTR 3.09±0.5/1.86±0.6/1.41± 0.31 (p = 0.004 at 6 months). Palm-wrist median sensory nerve velocities: splint 27.26±5.3/29.6±7.16/29.56±4.83 vs. splint plus steroid 26.35±4.12/31.57± 4.33/28.74± 6.19 vs. CTR 23.98±4.28/ 32.20 ±4.17/33.15 ±4.1 (NS). Completely satisfied/ almost satisfied (3rd/6th months): splinting 69.6%/34.8% vs. splint plus steroid 100%/82.6% vs. CTR 45.5%/90.9%.	"All treatment methods were found to be effective, but despite the complications and the relatively long period to return to work, OCTR was superior to conservative methods in long term."	Baseline differences present. Appears to have targeted lower enrollment for surgery without stating.
Endoscopic vs. Open Release						
Saw 2003 RCT No mention of sponsorship or COI.	7.5	N = 123 with carpal tunnel syndrome. Mean age 51.9 years.	Open Carpal Tunnel Release Group: Open incision 2cm (n = 76) vs. 1-portal endoscopic release (n = 74). Follow-up at 1, 3, 6 and 12 weeks.	Anterior carpal tenderness not significantly different 22±7 vs. 24±6 (p = 0.18). Grip strength was also not different, but favored endoscopic (p = 0.21). Endoscopic group returned to work average 8 days (95% CI 2-13, (p = 0.005)) sooner than open. Lost time offset	"On the basis of these findings, we recommend that endoscopic carpal tunnel release should be considered in the employed as a cost-effective procedure, but perhaps not in the	Endoscopic recommended due to earlier return to work in employed.

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				increased costs of endoscopic surgery, resulting in net savings of 438£ ($661.63 USD 2009) per patient.	general population as a whole."	
Atroshi 2006 RCT Sponsored by research grants from Skane county council's research and development foundation, Kristianstad University, and Swedish Society of Medicine. No COI.	7.0	N = 128 (88 female/40 male) with idiopathic CTS. Mean age 44 years	Open Surgery Group-4cm open (n = 65) vs. 2-portal endoscopic release-1cm endoscopic (n = 63). Follow-up at 3 and 6 weeks and 3 and 12 months.	Post-operative pain scores (3 weeks/6 weeks/ 3 months/12 months): open 60.5±23/51.3±23/ 36.2±20/13.9±22 vs. endoscopic 52.1±23/43.3±23/ 23.5±26/8.7 ±21 (p = 0.028, p = 0.03, p <0.001, p = 0.13 respectively). Lost time median 28 days in both groups (range 17-44).	"In carpal tunnel syndrome, endoscopic surgery was associated with less postoperative pain than open surgery, but the small size of the benefit and similarity in other outcomes make its cost effectiveness uncertain."	Minimal advantage to endoscopic of less pain, but not earlier return to work.
Atroshi 2009 RCT Sponsored by research grants from Skane County Council's research and development foundation, Kristianstad University, and The Swedish Society of Medicine. No mention of COI.	7.0	Same as above Atroshi 2006	Same as above Atroshi 2006	Symptom severity scores at 5 years were endoscopic 1.45±0.7 vs. open 1.42±0.7 (NS). 52/61 open vs. 53/63 endoscopic had "no pain" (NS). No differences in functional status scores, although both improved from pre-operative status (p <0.001). In 1st year, 1 open and 2 endoscopic required repeat surgery; between Years 1 and 5, 2 open and 1 endoscopic required repeat surgery.	"The improvements in symptoms of CTS and hand-related disability 5 years after open and 2-portal endoscopic carpal tunnel release were equivalent."	Very high response rate for 5-year study (only missing 2 who died). Suggests no long term differences. Same rates of palmar pain for both groups. No differences in reoperation rates.
Brown 1993 RCT No sponsorship or COI.	6.5	N = 145 (169 hands) with CTS. Mean age 56 years.	Open Carpal Tunnel Release: Open incisions 3.5-4.5cm (n = 75, 85 hands) vs. 2-portal endoscopic release-endoscopic incisions 2cm and 1.5cm (n = 76, 84 Hands). Follow-up at 21, 42, 84 days.	Symptoms relieved in 98-99% among each group. Open group more likely to have incisional tenderness (61% vs. 36%). Return-to-work occurred earlier for endoscopic group (p <0.05).	"Preliminary analysis suggests that functional outcomes are achieved more quickly when the endoscopic method is used. However, the greater rate of complications indicates that intraoperative safety must be improved before endoscopic carpal-tunnel release is performed on a widespread basis."	Suggested endoscopic superior.
Ferdinand 2002 Crossover Trial	6.5	N = 25 (50 hands; 20 female/5 male) with	Open carpal tunnel release (n = 25) vs 1-portal endoscopic release (n = 25).	Data presented graphically. Persisting symptoms in 1 (4%) of open vs. 0% endoscopic. Persisting pain in 1 in each group. No	"In comparison with open release, single-portal endoscopic carpal tunnel release has a similar	No differences between groups in strength or return to hand function.

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No mention of sponsorship. No COI.		bilateral CTS. Age 31-85.	Incision sizes not specified. Follow-up at 6, 12, 26, 62 weeks.	differences in grip strength. Mean operating time 10±2 minutes open group vs. 13±4 minutes endoscopic group. Difference significant (p<0.005).	incidence of complications and a similar return of hand function, but is a slightly slower technique to undertake."	
Trumble 2002 RCT No mention of sponsorship. COI, one or more authors received grants or outside funding from Orthopaedic Research and Education Foundation, American Society for Surgery of the Hand, and Boeing Foundation. No author received payments or other benefits or commitment or agreement to provide such benefits from a commercial entity.	6.5	N = 147 (192 hands) with idiopathic CTS. Mean age 56 years.	Open carpal tunnel release group: Open incision 3-4 cm (n = 72, 95 hands) vs. 1-portal endoscopic release (n = 75, 97 hands). Follow-up assessments made at 2, 4, 8, 12, 26, and 52 weeks.	Symptom severity scores different for weeks 2; 3.1 vs. 2.3 (p <0.01), 4; 3.0 vs. 2.0 (p <0.01), 8; 2.7 vs. 1.9 (p <0.01), and 12; 2.5 vs. 1.8 (p <0.01) among open group vs. endoscopic group. Open group also showed significant increase in functional status score vs. endoscopic group at week 2; 3.0 vs. 2.2 (p<0.01), 4; 2.6 vs. 1.9 (p<0.01), 8; 2.5 vs. 1.9 (p <0.01), and 12; 2.4 vs. 1.7 (p <0.01). Median time to return to work 38 vs. 18 days, (p = 0.0086), favoring endoscopic group.	"Good clinical outcomes and patient satisfaction are achieved more quickly when the endoscopic method of carpal tunnel release is used. Single portal endoscopic surgery is a safe and effective method of treatment carpal tunnel syndrome."	Data suggest the long-term outcomes were identical, although the benefits were short-term for the endoscopic technique.
Wong 2003 Crossover Trial No sponsorship. No mention of COI.	6.5	N = 30 (60 hands) with bilateral idiopathic CTS. Mean age 47 years.	Open Group: using Strickland instrumentation. 1.5cm open incision (n = 15, 30 hands) vs. 2-portal endoscopic release (n = 15, 30 hands). Follow-up 2, 4, 8, 16 weeks, 6 and 12 months.	At 1 year, 17 (57%) of endoscopic vs. 19 (63%) of limited open had complete resolution (p = 0.65). Trend toward increased strength in open group (NS). Pain scores lower in limited open group 2 weeks: 2.5 vs. 3.3 (p = 0.004) and 4 weeks: 1.5 vs. 2.5 (p = 0.008).	"The results showed that the outcome was similar at follow-up of one year using both techniques. However, the LOCTR group had significantly less tenderness of the scar at the second and fourth postoperative week. There was also less thenar and hypothenar (pillar) pain after LOCTR)."	Suggests limited open technique modestly beneficial compared with endoscopic.
Erdmann 1994 RCT	6.0	N = 105 with CTS. Mean age 53.4 years.	Open carpal tunnel release (n = 52) vs. 2-portal endoscopic release (n = 53). Incision sizes not	Symptoms relieved in 1.1 vs. 1.75 days. Return to work in 14 vs. 39 days (p <0.005) for the endoscopic group vs. the open group. Grip strength returned to preoperative	"This trial illustrates that endoscopic carpal tunnel release has distinct advantages over open surgery, in a select group	Long incision likely used in 1994.

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No mention of sponsorship or COI.			specified. Follow-up at 1 and 2 weeks; 1, 3, 6 and 12 months.	values for the endoscopic group vs. the open group 28 vs. 90 days (p <0.005).	of patients, particularly relating to earlier recovery of hand strength and return to work."	
MacDermid 2003 RCT Sponsored by physicians of Ontario through Physicians Services Incorporated Foundation. No COI.	6.0	N = 123 with CTS. Mean age 47.1 years.	Open carpal tunnel syndrome (n = 32) vs. 2-portal endoscopic release (n = 91). Incision sizes not specified. Follow-up assessments at 1, 6 and 12 weeks.	McGill Pain Questionnaire scores favored endoscopic release, e.g., Week 1: 13 vs. 28 and Week 6:12 vs. 22, both (p <0.05). Symptom Severity Scale scores not significantly different. Grip strengths at 1 and 6 weeks favored endoscopic release (e.g., week 1, 11 vs. 15kg, (p <0.05)).	"No substantive difference in benefit was shown for these 2 methods of carpal tunnel release."	The data indicate less pain and better grip strength at 1 to 6 weeks in the endoscopically treated group
Sennwald 1995 RCT No mention of sponsorship or COI.	5.5	N = 47 with CTS. Mean age 52.6 years.	Open carpal tunnel release (n = 22) vs. 1-portal endoscopic release- Endoscopic incision 2cm (n = 25). Follow-up at 4, 8 and 12 weeks.	Grip strength recovery significant at 4 weeks (p = 0.005), 8 weeks (p = 0.003) and 12 weeks (p = 0.0002) in favor of endoscopic group compared to open group. Endoscopic group could use operated hand normally after 24 days vs. 42 days after open procedure (p <0.001).	"The study is strongly in favour of endoscopic release. However, this technique does not allow any analysis of the pathology or structure to be treated."	Baseline mean grip strength approximately 26 vs. 32 (p = 0.29). Appears to have contributed to post-operative differences.
Ejiri 2012 RCT No mention of sponsorship or COI.	5.5	N = 79 with CTS with distal motor latency to abductor pollicis brevis muscle greater than 4.5ms. Mean age 58.5.	Endoscopic carpal tunnel release (ECTR group) (n = 40, 51 hands) vs. Open carpal tunnel release (OCTR) (n = 39, 50 hands). Follow-up assessments at week 4 and 12.	At week 12, rate of improved cases higher in OCTR group vs. ECTR group (p = 0.08), however not significant. No significant differences between groups for improvement in ADL impairment. At week 4, mean improvement in grip strength significantly higher in ECTR group vs. OCTR; -4.6 vs. -8.1 (p = 0.04). But not significant at 12 weeks: -1.2 vs. -3.6 (p = 0.27).	"These results suggest that while no difference exists between ECTR and small incision methods in terms of improved subjective symptoms, sensation, or electrophysiological findings, recovery of muscle strength is superior with ECTR."	At 4 weeks, ECTR was significantly better than OCTR for muscle strength, but ECTR may increase the risk of transient nerve dysfunction which resolved at 6 months.
Larsen 2013 RCT No sponsorship or COI.	5.5	N = 90 with CTS. Mean age not provided.	Classic incision group 7cm curved incision (n = 30) vs. short incision group: incision 3cm in mid-palm (n = 30) vs. Endoscopic group-using Linvatec system (n = 30). Follow-up at 1, 2, 3, 6, 12, 24 weeks.	No significant difference between groups for post-op pain at any time point (p >0.05). No significant difference for disappearance of paresthesia between treatment groups (p >0.05). Tendency for earlier return of grip strength (significant at weeks 2 and 3 only (p >0.05)), as well as ROM (significant at weeks 1 and 3) in endoscopic groups vs. other two groups.	"These results are in accordance with the findings in the literature: faster rehabilitation and earlier return to work after ECTR… (Endoscopic Carpal Tunnel Release), few complications but a risk of nerve branch neuropraxy with transient neurological problems."	At 24 weeks, the endoscopic group had quicker return to work and faster rehabilitation.

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Dumontier 1995 RCT No mention of sponsorship or COI.	5.0	N = 96 with idiopathic CTS. Mean age 52.3 years.	Open carpal tunnel release group: Open incisions 3-4cm (n = 40) vs. 2-portal endoscopic release (n = 56). Follow-up assessments made at 2 weeks, 1, 3, 6 months.	Loss of grip strength conventional group vs. endoscopic group (mean±SD): 2 W-pre-op: -15.02±10.27/-13.84±9.50 (p = 0.67); 1 M-pre-op.: -12.80± 9.84/ -6.25±6.81 (p <0.01)3 M-pre-op: -8.26±6.37/-3.66±6.84 (p = 0.02).	"No statistically significant differences were found regarding pain, disappearing of paresthesiae or time to return to work. However, better recovery of grip strength was observed in the endoscopic group at 1 and 3 months."	Possibly 2:1 assignment, not noted. Variable follow-ups with 45.3% dropout at 3 months.
Jacobsen 1996 RCT No mention of sponsorship or COI.	5.0	N = 29 EDS confirmed (32 hands) with idiopathic CTS. Mean age 46 years.	Open carpal tunnel release group (n = 16 Hands) vs, 2-portal endoscopic release (n = 16 hands). Incision sizes not specified. Follow-up at 2 and 6 weeks and 6 months.	Sick length average 17 days (0-31) in endoscopic group vs. 19 days (0-42 days) in open group. No significant difference between groups for average sick day length (p >0.05). At final follow-up, 8 in endoscopic group returned to normal vs. 9 in open group (p >0.05).	No differences in surgical results were found, but three patients in the endoscopic group suffered transient numbness on the radial side of the ring finger."	Higher risks in endoscopic group.
Kang 2013 RCT No mention of sponsorship. No COI.	4.5	N = 59 with bilateral CTS. Each hand randomly assigned to different surgery. Mean age 55 years.	Endoscopic Group: carpal tunnel release surgery performed with Agee technique (n = 59 hands) vs. Mini-Open Group: release performed with small (1.5cm) incision. (n = 59 hands). Follow-up at 3 months post-op.	Boston Carpal Tunnel Questionnaire symptom (BCTQ-S) and function (BCTQ-F) score main outcome. No significant differences between endoscopic vs. mini-open at 3 months for BQTC-S; 1.5 vs. 1.4 (p = 0.774) or for BQTC-F; 1.5 vs. 1.7 (p = 0.832). No significant difference in mean DASH (Disabilities of the Arm, Shoulder and Hand) score (p = 0.978).	"Endoscopic and mini-incision open carpal tunnel releases seem to have comparable early subjective outcomes after carpal tunnel release has been performed in patients who had idiopathic carpal tunnel syndrome."	Sparse methodology. Comparable outcome efficacy at 3 months, but patient preference towards endoscopic procedure.
Agee 1992 RCT Sponsored in part by the 3M Orthopedic Products Division, St. Paul, Minn. No mention of COI.	4.0	N = 122 (147 hands) with CTS. Mean age not provided.	Open carpal tunnel release-Control Group (65 hands) vs. 1-portal endoscopic release-Endoscopic incision 2cm (n = 82 hands). Follow-up at weeks 1, 2, 3, 6, 9, 13, and 26.	Median return to work 25 days vs. 46.5, (p <0.01). Stratified analyses 71 vs. 16.5 days for workers' comp vs. non-WC treated with endoscopic technique vs. 78 vs. 45.5 days in open group (WC vs. non-WC). Less immediate postoperative scar tenderness.	"Improvement in most of the variables measured translated into earlier return to work and to ADL."	Suggests endoscopic superior to open.
Open vs. Mini Incision						
Jugovac 2002 RCT Sponsored by Croatian Ministry of Science and Technology grant No. 0062076 to Dr	4.5	N = 72 with NCS finding of CTS. Mean age 53.4 years.	Open carpal tunnel release group (n = 36) vs. mini-incision group-using an operating microscope (n = 36). 3 month follow-up.	Symptomatic relief open (31/36 complete relief) vs mini (31/36) (NS). Hand function return to daily activities in 5 days with limited incision vs. 10 days open (p = 0.001). RTW 15 vs. 30 days (p = 0.001).	"Limited palmar incision CTR is as effective and safe as traditional CTR technique, but with better postoperative recovery and cosmetic results."	Some baseline differences. Follow-up timing unclear.

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Marin F. Stanèiæ. No mention of COI.						
Aslani 2012 RCT No mention of sponsorship. No COI.	4.0	N = 105 who qualified for carpal tunnel release surgery. Mean age 54.2 years.	Open surgery group (n = 36) vs. Endoscopic surgery group (n = 32) vs. Mini Palmer incision group (n = 28). Follow-up at 2 weeks, 4 weeks and 4 months.	Endoscopic (2 wrists showed weakness at 4 months) and Mini Palmer incision (0 wrists weakness) groups showed significant improvement in weakness vs. open surgery (4 wrists showed weakness) (p <0.05). No other significant differences for other variables (p >0.05). 0 participants expressed pain in the open group at final follow-up and 4 participants expressed pain in both endoscopic and mini-palmer groups.	"Satisfactory results with all three surgery techniques of open, mini-incision or endoscopic and has a low chance of complications. Endoscopic treatment and mid-palmar mini incision have less pain and greater satisfaction among patients in the first weeks, however, overall results are the same and satisfactory in all three groups after 4 months."	Cross-sectional study shows early patient satisfaction with endoscopic and mini techniques, but at 4 months comparable satisfaction between all groups.
Tarallo 2014 RCT Sponsored by National Institutes of Health (NIH), Wellcome Trust, Howard Hughes Medical Institute (HHMI) and other(s). No COI.	4.0	N= 120 with CTS with moderate-to-severe symptoms. Mean age 64 years.	Group A: carpal tunnel release by traditional open carpal tunnel release (TOCTR) (n = 60) vs. Group B: carpal tunnel release by minimal-access carpal tunnel release (MACTR) (n = 60) Follow-up at 7 days, 6 and 12 months.	At final follow-up mean static 2-point discrimination score difference not significant between Group A and B; 4.3 mm vs. 4.7mm (p >0.05). At final follow-up, 2 patients (3.6%) in Group A had evidence of recurrent disease vs. 1 (1.8%) in Group B (p <0.01). In each subsection of BCT questionnaire, Group B showed significantly better results than Group A at both 6 month follow-up 1.4 vs. 2.3 (p <0.001) and 12 month follow-up; 1.1 vs. 1.5 (p<0.001).	"In our opinion, median nerve release is strongly advocated by MACTR as a safe, easily reproducible, low-grade learning curve, low time and a low-cost surgery and it can be performed with standard surgical equipment. In our perspective randomised study, MACTR showed statistically significant improvement compared to TOCTR."	MACTR group was significantly better than TOCTR group at 6 and 12 months.
1 vs. 2 Limited Open Incisions						
Zyluk 2006 RCT No mention of sponsorship or COI.	6.5	N = 79 (50 female/15 male; 82 hands) EDS confirmed CTS. Mean age 48.	1 limited incision group- Single (2cm) (n = 39, 44 hands) vs. 2 limited open incisions group 1 and 2cm incisions (n = 40, 40 hands). Follow-up at 1, 3, 6, 12 months.	Functional scores not different. Total grip strength (kg) Method 1/Method 2: Pre-op: 16.6/18.1; at 1 month: 16.1/14.9; at 3 months: 20.3/18.9; at 12 months: 24.2/24.1. No significant differences between groups for grip strength (p >0.05).	"We found that the single incision method offers better results in respect of grip and pinch strengths: less weakness at 1 month after surgery and a faster improvement relative to pre-operative values which is statistically significant."	Minor advantage to one small incision.
Epineurotomy						
Crnkovic 2012 RCT	9.0	N = 50 (33 female/17 male) with	Epineurotomy Group: Open field surgical release followed by	At 90 days, mean nerve volume increase somewhat higher in epineurotomy group vs. no	"In conclusion, in line with other reports, the results suggest that even	Failure to provide superiority for epineurotomy after carpal

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No mention of sponsorship. No COI.		CTS and verified narrowing of median nerve within tunnel. Mean age 51.75 years.	longitudinal epineurotomy of nerve (n = 25) vs. No epineurotomy Group- Control Group- Open-field release without an epineurotomy (n = 25). Follow-up at 90 and 180 days.	epineurotomy group; 10.5 mm3 vs. 7.2 mm3 (p = 0.056); not significant. No significant difference found at 180 day follow-up (p = 0.452). Both groups significantly increased in nerve volume size compared to baseline (p<0.001).	in selected patients longitudinal epineurotomy of the median nerve does not confer any relevant electrophysiological or clinical benefit (nor harm), as compared to a simple dissection of the carpal ligament."	tunnel release, but some pain relief in the control group compared to study group.
Leinberry 1997 RCT No sponsorship or COI.	7.0	N = 44 (gender not specified) EDS confirmed (50 hands) with CTS. Mean age 64.8 years.	Group 1: Release of transverse carpal ligament. No epineurotomy (n = 22, 25 hands) vs. Group 2: carpal tunnel release and adjuvant epineurotomy of median nerve (n = 22, 25 hands). Follow-up 1 and 6 weeks; 6 and 12 months.	At 12-months, 60% of non-epineurotomy group vs. 56% of epineurotomy group asymptomatic (p >0.05). Two-point discrimination, grip strength and sensory nerve latencies all not significantly different.	"This suggests that epineurotomy of the median nerve offers no benefit compared with sectioning of the transverse carpal ligament alone."	Patient blinding unclear, but seems probable.
Blair 1996 RCT No mention of sponsorship or COI.	6.0	N = 86 EDS confirmed (117 hands) with CTS. Mean age 48.7 years.	Open release group- 4cm incision (n = 48) vs. carpal tunnel release with epineurotomy. 4cm incision (n = 27). Follow-up for minimum of 24 months.	Synovial hypertrophy graded as marked or moderate in 18.8% of epineurotomy group vs. 33.3% of non-epineurotomy group. Non-significant trends in favor of epineurotomy present for pain (epineurotomy: 87.5% pre-op pain decreased to 12.5% 2 years post-op vs. no epineurotomy: 92.6% decreased to 29.6%). Nerve conduction velocities increased in both groups and did not differ between (pre/post-op): epineurotomy 31.1/ 43.8ms vs. 30.0/40.4 (p = 0.32). Patients happy/very happy with results in 73% epineurotomy vs. 70%.	"The study data do not support the use of Epineurotomy as an adjunctive procedure during carpal tunnel release."	The trial is described as a comparative trial, but appears to involve a randomization procedure based on hospital chart number. Demographic variables were balanced between the two groups; however, the group sizes were not.
Foulkes 1994 RCT No sponsorship or COI.	4.0	N = 33 (36 hands) with CTS who had not had previous surgery on same side.	Epineurotomy Group (n = 23, 26 hands) vs. Non-Epineurotomy Group- Non-treatment group (n = 10, 10 hands) Follow-up 6, 12 months post-op.	Results for sensibility not significant between groups at 6 months (p = 0.64) and 12 months (p = 0.99). No significant difference in grip strength between groups at 6 months (p = 0.79) or 12 months (p = 0.28).	"The addition of an adjunctive epineurotomy, although safe, offers no clinical benefit in the surgical treatment of carpal tunnel syndrome in our series of patients."	Sparse methodological details. Operating surgeons cannot be blinded. Epineurotomy not superior in carpal tunnel surgery.
Neurolysis						
Lowry 1988 RCT	8.0	N = 50 (gender not specified)	Standard ligament release Surgery alone group (n = 25) vs	Excellent or good results in 66.7% of neurolysis vs. 65.2% without. No electrodiagnostic parameters	"The results of this study indicate that standard surgical release of the	No benefit shown for severe CTS.

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No mention of sponsorship or COI.		hands EDS confirmed with CTS. Mean age not provided.	standard ligament release surgery with adjunctive interfascicular neurolysis (n = 25). 3 month follow-up after surgery.	significantly different between 2 groups (e.g., distal sensory latencies baseline/3 months' post-op): neurolysis (5.5±0.3/4.5±0.5) vs. no neurolysis (5.8±0.6/ 4.5±0.7). No significant differences were found between groups at follow-up. (p>0.05).	transverse carpal ligament is frequently warranted and usually beneficial in patients with severe carpal tunnel syndrome."	
Mackinnon 1991 RCT No sponsorship. No mention of COI.	8.0	N = 79 (gender not specified) with CTS. Mean age 58.5 years.	Open carpal tunnel release group with internal neurolysis (n = 29, 31 hands) vs. open carpal tunnel release without internal neurolysis (n = 30, 32 hands) Follow-up for 6 months.	Relief of symptoms 88% in release only group vs. 81% of neurolysis group. Among those with abnormal pre-op 2-point discrimination, 62% recovered normal sensation in open release group vs. 55% of neurolysis group. Grip strengths increase from 15-19kg in open release only group vs. from 14 to 17kg in neurolysis group.	"While the technique of internal neurolysis has been proven to be safe and is essential in the surgical evaluation of in continuity and in peripheral nerve reconstruction using interfascicular nerve grafting, it would appear from this study that it does not confer improved sensory or motor outcome in patients with primary CTS.	No benefit
Flexor Tenosynovectomy						
Shum 2002 RCT No sponsorship or COI.	4.5	N = 87 EDS confirmed (88 wrists) with idiopathic CTS. Mean age 58 years.	Open carpal tunnel release with flexor tenosynovectomy (n = 44 wrists) vs. Open carpal tunnel release without flexor tenosyno-vectomy (n = 44 wrists). Follow-up for 12 months.	Both groups' symptom severity scores improved after surgery (tenosynovectomy 3.0±0.88 to 1.6±0.68 vs. from 2.9±0.64 to 1.6±0.7, (p ≤0.0002)). No correlations between pre- or post-operative symptoms severity scores and the intraoperative tenosynovial ratings (r = 0.038) or subsequent pathological analyses (r = 0.004 to 0.032).	"We observed neither an added benefit nor an increased rate of morbidity in association with the performance of a flexor tenosynovectomy at the time of carpal tunnel release. We identified no clinical correlations that might predict which individuals would benefit from flexor tenosynovectomy on the basis of either the gross (intraoperative) or histological evaluation of the flexor tenosynovium."	No benefit. No relationship found with tenosynovial ratings of appearance.
Superficial Nerve Sparing						
Siegmeth 2006 RCT	6.5	N = 42 (84 hands) with bilateral idiopathic CTS. Age >18 years.	Open carpal tunnel release with superficial nerve sparing (n = 42, 42 hands) vs. open carpal tunnel release	No differences in pain scores at any follow-up interval (graphic presentations of data, 6 weeks; (p = 0.73), 3 months; (p = 0.59), and 6 months; (p = 0.13)). No differences found between groups in PEM	"Scar pain scores in this series of open carpal tunnel decompressions were similar, whether or not an attempt was made to identify and preserve	Small sample size. Comparable efficacy but the standard carpal tunnel decompression technique took less time to perform.

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No mention of sponsorship. No COI.			without superficial nerve sparing (n = 42, 42 hands). Follow-up at 6 weeks, 3 and 6 months after surgery.	scores at 6 weeks (p = 0.93), 3 months (p = 0.43), and 6 months (p = 0.38).	superficial nerve branches crossing the wound."	
Incisional and Other Intraoperative Techniques						
Forward 2006 RCT No sponsorship or COI.	8.5	N = 118 (84 female/34 male) with CTS. Mean age 57 years.	Preservation of parietal layer of ulnar bursa beneath flexor retinaculum during open release (n = 57) vs. Bursal division (n = 61). Final follow-up at 8-9 weeks.	Grip strengths at follow-up 79% of pre-op values in those with ulnar bursal preservation vs. 82% among other group (p >0.05). One surgeon operated without tourniquet and data indicated those patients had higher grip and thumb key pinch strengths as well as among men and younger patients.	"In this group of patients, preservation of the ulnar bursa around the median nerve during open carpal tunnel release produced no significant difference in grip strength or self-rated symptoms."	Suggests no benefits of preserving the ulnar bursa.
Dias 2004 RCT No mention of sponsorship or COI.	8.5	N = 26 EDS confirmed (52 hands) with bilateral CTS. Mean age 56 years.	Lengthening of retinaculum (n = 26 hands) performed on one hand vs. simple division of flexor retinaculum standard release (n = 26 hands) performed on other hand. Follow-up at 2, 6, 12, and 25 weeks.	Levine symptom scores (baseline/Weeks 2/6/12/25): open 3.1/ 1.3/1.4/1.2/1.3 vs. lengthen 2.8/1.4/1.3/ 1.2/1.3 (p = 0.63). Function scores were negative (p = 0.66). Grip strengths not different (p = 0.79).	"The study has failed to demonstrate any measurable benefit for this technique. Simple division of the retinaculum is adequate."	No advantage to lengthening retinaculum.
Menovsky 2004 RCT No mention of sponsorship or COI.	5.0	N = 61 EDS confirmed with CTS. Mean age 50.4 years.	Nylon sutures in open release (n = 17) vs. Polyglactin 910 sutures (n = 25) vs. 4-0 stainless steel 4-0 sutures (n = 19). Follow-up at 10 days and 6 weeks.	Mean pain scores at 10 days (nylon, polyglactin and stainless steel): 1.7 (+/-2.2), 3.1 (+/-2.3) and 1.9 (+/-2.3). At 6 weeks, pain scores were 3.6 (+/-3.1), 3.4 (+/-2.6) and 2.7 (+/-2.1). Infection rates were 0%, 8% and 0%. Suture granulomas more likely in polyglactin group (p <0.05). No differences in redness or wound hypertrophy.	"Nylon and stainless steel sutures are both suitable for skin closure after carpal tunnel surgery. Based on this study, absorbable vicryl sutures should not be used, since the incidence of infections and the presence of suture granulomas was much higher than in the nylon and steel suture groups."	Suggests nylon or steel sutures preferable to polyglactin.
Citron 1997 RCT No mention of sponsorship or COI.	4.0	N = 47 with CTS. Mean age 52.1 years.	Standard incision parallel to thenar crease (n = 26) vs. Ulnar L-shaped incision (n = 21). Follow-up at 6 weeks, 3, 6, 9 and 12 months	No differences in grip strength, pillar tenderness or scar sensitivity (p >0.05).	"No difference was found in pillar pain between the two incisions, but one had a lower incidence of scar sensitivity."	No benefits.
Macaire 2008	4.0	N = 60 undergoing	Ultrasound Group-Nerve blocks guided	Time to perform nerve block primary outcome. Ultrasound group took	"The present study demonstrates that	Similar efficacy, but procedure times shorter in

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RCT No mention of sponsorship or COI.		ambulatory endoscopic carpal tunnel release. Mean age 47.5 years	using ultrasound (n = 30) vs. Nerve Stimulation-Nerve blocks using sensory-motor stimulation. (n = 30). Follow-up immediately after surgery.	significantly less time (s) than nerve stimulation to perform median nerve block; 55 s vs. 100 s (p = 0.002) and time (s) to perform ulnar block; 58 s vs. 80 s (p = 0.02). Mean VAS pain score not significant between groups for venipuncture (p = 0.26) and block puncture (p = 0.72).	ultrasound-guided nerve blocks reduce the performance time while the total time until readiness for surgery remains unaltered compared with nerve stimulation."	ultrasound guided wrist blocks.
Open Release vs. Knifelight						
Bhattacharya 2004 Crossover Trial No mention of sponsorship or COI.	6.5	N = 26 (23 female/9 male) with bilateral CTS. Mean age 48 years.	2.5cm open incision (n = 26, 26 hands) vs. 1-1.5cm Knifelight incision (n = 26, 26 hands). Follow-up at 2 and 6 weeks.	Knifelight vs. Open release (Median): return to work (in weeks): 2.0 vs. 2.0 (p = 0.80); grip strength recovery (%): 89 vs. 84 (p = 0.25); scar tenderness: 1 vs. 10 (p = 0.01)	"There was little difference between the two techniques with regard to time taken to return to work, return of grip strength, symptom relief, complications, incidence of pillar pain and patient preference. However, the incidence of scar tenderness was significantly lower with the Knifelight technique."	No significant differences, other than less tenderness associated with Knifelight.
Helm 2003 RCT No mention of sponsorship of COI.	6.5	N = 82 (50 female/32 male) with CTS. Mean age 53 years.	Open release vs. Knifelight. Incision sizes not specified	Post-op CTS symptoms and grip strengths not different between groups. Mild or moderate scar tenderness Knifelight (89.7%) vs. open (48.8%) (p <0.001). Return to work Knifelight vs. open CTR: 20 vs. 28 days, (p <0.001).	"We found no difference in discomfort reported during surgery, in the operative time, in the grip strength measured at 2 and 6 weeks post-operatively or in the proportion of patients cured of their pre-operative symptoms. Knifelight group had a statistically significant improvement in the time to return to work and in scar tenderness at 6 weeks post-operatively."	Faster return to work and less scar tenderness with Knifelight.
Lorgelly 2005 RCT No mention of sponsorship or COI.	4.0	N = 185 with CTS. Mean age not reported	Knifelight (2cm incision) (n = 92) vs. Limited open (3-4cm) (n = 89). Mean 30 month follow-up.	First section Boston CTS questionnaire (baseline/19/30 months): Knifelight (3.84/1.46/1.28) vs. open (3.66/2.04/1.39). (NS other than 19 month, p <0.001). RTW 16.6 vs. 25.4 days (p <0.001). Recurrent disease in Knifelight 1% vs. 5% (p <0.01).	"Minimally invasive carpal tunnel decompression appears to be more effective but more costly."	Some details sparse. No workers' compensation patients.
Early vs. Delayed Surgery						

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Chandra 2013 RCT No sponsorship or COI.	5.0	N = 100 affected by CTS. Mean age 45.59 years.	Early surgery group (<1 week after diagnosis) (n = 51) vs. delayed surgery group (>6 months after diagnosis) (n = 49). Delayed determined by wait-listing. Follow-up after at least 6 months (range, 6-13.2 months; mean, 7.2 months).	Both groups improved in pre-op clinical score (p <0.0001). Mean post-op clinical score lower in early surgery group vs. late surgery group at final follow-up; 8.11 vs. 18.19 (p <0.001). Early group had 100% return to normal activity compared to the late group with 89% (43) with partial return of activity and 11% (6) with normal return to activity (p<0.001).	"On the basis of this study, we propose early surgical (1 week) intervention in patients with moderately severe (grade 3–4) CTS."	Early surgical intervention group superior to late surgical intervention group. Study only involved moderately severe CTS. Susceptible to wait-listed control bias. Non-operative management was NSAIDs, pregabalin "with or without splint" and PT, thus did not appear to follow highest quality evidence for treatment.

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PERIOPERATIVE ANTIBIOTICS

Perioperative antibiotics have been administered to patients undergoing carpal tunnel release, most commonly as pre-incisional antibiotics rather than post-operative antibiotic courses. Some surgeons use antibiotics in all patients. Also, some institutions have implemented policies mandating use in all cases.

1. *Recommendation: Perioperative Antibiotics for Patients Undergoing Carpal Tunnel Release*
   Pre-incisional antibiotics are recommended for consideration for patients with risk factors undergoing carpal tunnel release. Thresholds for use in other patients should be generally low.

   Indications – Patients with risk factors (e.g., diabetes mellitus, susceptibility to infections) who are undergoing carpal tunnel release surgery. Institutions may also mandate use through policies.

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – Low

2. *Recommendation: Routine Use of Antibiotics for Patients Undergoing Carpal Tunnel Release*
   Routine use of antibiotics for all patients undergoing carpal tunnel release is not recommended.

   Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
   Level of Confidence – Low

Rationale for Recommendations
There are no quality studies regarding the administering of peri-operative antibiotics to patients undergoing carpal tunnel release. Infections among these patients are quite uncommon. Antibiotics are invasive when administered intravenously, have low adverse effects, and are moderate to high cost depending on frequency and route of administration. Risk factors among patients, such as diabetics or those who are susceptibility to infections, should be considered. As noted, some institutions mandate the use of these antibiotics, and there is no quality evidence to overturn those policies. However, routine use is not generally recommended.

Evidence for the Use of Perioperative Antibiotics
There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL and Cochrane Library without date limits using the following terms: perioperative antibiotics or antibiotic prophylaxis, carpal tunnel syndrome, median neuropathy, CTS, carpal tunnel, median nerve, compression, entrapment, neuropathy, nerve disease, syndrome, median nerve, median neuropathy, burning, itching, numbness, tingling, hand, palm, finger, wrist, pain; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 3 articles in PubMed, 177 in Scopus, 0 in CINAHL, and 41 in Cochrane Library. We considered for inclusion 0 from PubMed, Scopus, CINAHL, and Cochrane Library and 0 from other sources. Zero articles met the inclusion criteria.*

ANESTHETIC ISSUES FOR CARPAL TUNNEL SURGICAL RELEASES

Anesthetic techniques for carpal tunnel release and other hand surgery have ranged from general anesthesia to axillary/regional blocks to local infiltration.(888, 970) Tourniquets have also been used.(971)

Recommendation: Anesthesia during Carpal Tunnel Release
Anesthesia, either local or regional, is recommended during carpal tunnel release.

Strength of Evidence – **Recommended, Insufficient Evidence (I)**
Level of Confidence – High

Rationale for Recommendation

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There are no head-to-head comparative trials for most of these anesthetic techniques, thus evidence-based recommendations are not supportable. Ketorolac has been found useful as an adjunt to bier blocks for hand surgery.(972)

Evidence for Use of Anesthesia during Carpal Tunnel Release
There is 1 high-(973) and 8 moderate-quality RCTs(974-981) incorporated into this analysis. There are 7 low-quality RCTs in Appendix 2.(982-988)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL and Cochrane Library without date limits using the following terms: anesthesia, local, carpal tunnel syndrome, median neuropathy, CTS, carpal tunnel, median nerve, compression, entrapment, neuropathy, nerve disease, syndrome, median nerve, median neuropathy, burning, itching, numbness, tingling, hand, palm, finger, wrist, pain; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random, randomized, randomization, randomly; systematic, retrospective, and prospective studies; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 15 articles in PubMed, 3165 in Scopus, 11 in CINAHL, and 44 in Cochrane Library. We considered for inclusion 15 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library and 0 from other sources. Of the 15 articles considered for inclusion, 15 randomized trials and 0 systematic studies met the inclusion criteria.*

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Author/Year Study Type Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Peng 2002 RCT No mention of sponsorship or COI.	9.5	N = 51 (24 female/16 male) undergoing hand surgery. Mean age for Lidocaine and Ropivacaine group: 43±19 and 42±13.	Ropivacaine 0.375% injected over a period of 1 minute (n = 20) vs Lidocaine 0.5% forearm regional anesthesia (n = 20). Follow-up for 15 minutes.	Onset of anesthesia 6.5±2.9 minutes for lidocaine vs. 8.0±4.1 minutes for ropivacaine. Pain ratings lower among ropivacaine group throughout first 90 minutes.	"0.375% ropivacaine provides effective anesthesia and superior postoperative analgesia compared with 0.5% lidocaine when forearm IVRA is used."	Study demonstrates ropivacaine provides superior anesthetic effect to lidocaine in IV regional anesthesia for hand surgery.
Bigat 2006 RCT Sponsored in part by Akdeniz University Scientific Research Project Unit, Antalya / Turkey. No mention of COI.	7.5	N = 50 (28 female/22 male) undergoing elective carpal tunnel release surgery. Mean age for group L/LD/and LDc: 42.3±15.8/40.6 ±14.0/45.1±12.4.	Group L received 3mg/kg lidocaine (n = 25) vs Group LD received 3mg/kg lidocaine plus 8mg dexamethasone (n = 25) vs. Group LDc received 3mg/kg lidocaine for IVRA and 8 mg dexamethasone IV (n = 25). Follow-up at 5, 10, 15, 30, 60, and 120 minutes.	Duration of motor blockade 13 minutes LD group vs. 8 IVRA and 6 LDC, p = 0.04. LD requested less analgesics post-operatively (36% vs. 72% and 60%), p = 0.033. Mean analgesics consumed: IVRA 520± 390 vs. LD 200±285 vs. LDC 420±445mg (p = 0.016 between LD and IVRA).	"The addition of 8mg dexamethasone to lidocaine for IVRA in patients undergoing hand surgery improves postoperative analgesia during the first postoperative day."	Baseline differences; blinding details sparse.
Alayurt 2004 RCT No mention of sponsorship or COI.	7.0	N = 60 (gender not specified) scheduled for surgery of hand or forearm. Mean age Group L/LS/ LT/and LC: 32±13/ 31±13/31±11/and 33±14.	Group L: 35ml 0.5% lignocaine with 5ml saline (n = 15) vs. Group LS: sufentanil 25µg (n = 15) vs. Group LT: tramadol 100mg (n = 15) vs. Group LC: clonidine 1µg.kg-1 (n = 15). Follow-up for 24 hours.	No difference between groups in intra-operative hemodynamic data, time to recovery of sensory block, onset and recovery of motor block, sedation scores or postoperative pain. Group with saline had a longer delay of sensory block (p<0.001).	"Addition of sufentanil, tramadol, or clonidine to lignocaine shortened the onset of the sensory block, delayed the onset time of the tourniquet pain and reduced the intraoperative consumption of opioid, but did not affect postoperative pain."	Blinding details sparse.
Bigat 2005 RCT Sponsored by the Akdeniz University Scientific Research Project Unit,	7.0	N = 50 (gender not specified) undergoing elective hand surgery for CTS. Mean age for Group L and R: 41.95 ± 16.44 and 49.40 ± 7.80.	Group R received 1% ropivacaine (n = 25) vs. Group L received 2% lidocaine intravenous regional anesthesia (N = 25). Follow-up for 24 hours after the surgery.	Pain scores elevated from 30-120 minutes lidocaine vs. ropivacaine group (graphic data, p <0.05). Time to first analgesics lidocaine 226.4±237.1 for ropivacaine vs. 91.7±214.2 minutes (p <0.05). (Data appear reversed between groups for that outcome). Mean paracetamol consumption 550±390 vs. 175±335mg, p <0.05.	"[R]opivacaine 1 mg/kg provided effective anaesthesia and long-lasting postoperative analgesia compared with lidocaine."	Randomization, allocation details sparse. No assessor blinding.

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Antalya/Turkey. No COI.				Most lidocaine patients (60%) used analgesics vs. 20% ropivacaine.		
Bernard 1997 RCT No mention of sponsorship or COI.	7.0	N = 56 (gender not specified) with CTS undergoing a release procedure. Mean age in saline group/30µg clonidine/90µg clonidine/and 51 in 300µg clonidine group: 48/49/49/and 51.	30µg clonidine in 400mg lidocaine group (n = 14) vs. 90µg clonidine in 400mg lidocaine group (n = 14) vs. 300µg clonidine in 400mg lidocaine (n = 14) vs. saline control group in 400mg lidocaine (n = 14). Follow-up at baseline, 20, 40, 60, 80, 140, 200 and 260 minutes post release.	Sensory blockage significantly more prominent at all assessments vs. saline group (p <0.01). At 20 and 30 minutes, all clonidine-dose groups significantly higher sedation rates vs. saline control group, (p <0.01). Those in 30µg and 300µg clonidine groups exhibited significantly higher sedation rates at 20, 40, 140 minute assessments vs. those who received saline: 20 (p <0.05), 40 (p <0.01), 140 (p <0.05). At 40 minute assessment, 300µg group had higher sedation rate vs. 90µg group (p <0.05).	"[A] small dose of clonidine enhances the quality of the peripheral blocks from local anesthetics (lidocaine) and limits the α_2-agonist side effects to the sedation. The best dose to use clinically is between 30 µg and 90 µg."	Allocation unclear; blinding details sparse.
Lawrence 2002 Sponsored by the Wishbone Trust. No mention of COI.	7.0	N = 56 (34 female/22 male) undergoing carpal tunnel decompression. Mean age EMLA 55 years, placebo 52 years.	Eutectic mixture off local aesthetics (EMLA) 5ml (n = 29) vs. placebo 5ml (n = 27) at least 1 hour before surgery. All then received 8ml 0.5% bupivacaine infiltrated over 60 second period. Follow-up post-op.	Lower pain scores with EMLA group, 23±10, vs placebo, 35±16 for both needle insertion (p = 0.0012) and anesthetic injection, EMLA 29±14 vs. placebo 46±19 (p = 0.0005).	"The results of this study show that EMLA is effective in reducing pain caused by the infiltration of local anesthetic prior to carpal tunnel release."	Baseline details sparse.
Reuben 1996 RCT No mention of sponsorship or COI.	7.0	N = 60 (gender not specified) undergoing either elective carpal tunnel release or tenolysis performed by the same surgeon. Mean age for group 1 / 2 and 3: 47.3 ± 13.6 /52.8 ± 18.3 / and 51.9 ± 15.8.	All 40mL 0.5% lidocaine IV regional anesthesia and 1% lidocaine infiltration. Group 1 or control: no adjuvant (n = 20) vs. Group 2: 60mg ketorolac with IVRA (n = 20) vs. Group 3: 60mg ketorolac infiltration to surgical site (n = 20). Follow-up 24 hours post-op.	VAS scores lower in 2 groups who received ketorolac (p <0.05). Mean time from tourniquet release to first medication 109+/-73 minutes for Group 1, 467+/-431 for Group 2, and 393+/-312 for Group 3 (p <0.05). Numbers of tablets taken: 4.1+/-1.3 Group 1; 1.8+/-1.2 Group 2; and 2.0+/-1.3 Group 3 (p <0.05).	"Ketorolac provides similar post-operative analgesia after ambulatory hand surgery when administered with lidocaine either by IVRA or by wound infiltration."	Author with multiple fabricated and retracted research papers. Randomization, blinding, allocation details sparse.
Patil 2006 RCT	5.5	N = 29 with bilateral carpal tunnel syndrome. Mean age 54 (35 – 81).	(Modified Gale) 6mL 2% lignocaine site infiltration (n = 14) vs. (modified Altissimi and	Six patients experienced intra-operative pain with the Gale technique, versus none with the Altissimi and Mancini technique (p = 0.02).	"The postoperative pain was not significantly different between the two groups, although the patients anaesthetised by the	Single blinding. Compliance rate unclear. Dropout rate high. Study described as crossover trial involving two

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No sponsorship or COI.			Mancini) 3.5mL 2% lignocaine infiltrated in incision line and 2.5mL 2% lignocaine infiltrated into carpal tunnel (n = 15). Follow-up 24 hours after surgery.		Altissimi and Mancini technique required significantly lower numbers of analgesic tablets."	surgical procedures of different hands at different times.
Nabhan 2011 RCT No mention of sponsorship. No COI.	5.0	N = 44 with CTS confirmed by nerve conduction testing and physical exam lasting >3 months with no prior surgery; Mean (±SD) age 55.0 (±14.0) for all participants.	Local anesthesia group receiving 20ml of pilocaine via 22 gauge needle (n = 22) vs. Intravenous regional anesthesia group receiving 30ml of 1% prilocaine via 20 gauge cannula (n = 22). Assessments at baseline, 2 weeks and 6 months post-op.	Both groups showed significant improvement at 2 weeks and 6 months after procedure for hand function, ADLs, work performance, pain, and patient satisfaction values when compared to baseline. Mean tourniquet inflation time significantly higher in IVRA group compared to LA group: 27.5 (±2.3) vs. 13.0 (±2.8) minutes, (p = 0.01). Mean operating room time also higher in IVRA group vs. LA group: 45 (±3.9) vs. 28 (±3.5) minutes, (p = 0.01).	"In the current study, the application of subcutaneous LA for ECTR was more effective than IVRA. Furthermore, LA is less invasive and simpler in comparison to surgery under IVRA."	Tourniquet and operating time were different between the 2 groups

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Follow-up Visits

Carpal tunnel surgical patients usually have a good recovery, although it can be variable and determined by many factors, including severity of the condition, surgical results, complications, coexisting medical conditions, motivation, pain tolerance, compliance with post-operative instructions, speed of returning to activities of daily living, and speed of returning to work. Carpal tunnel release patients have undergone numerous formal rehabilitation programs. However, as the surgical procedure has become less invasive, the overall trend is towards less formal rehabilitation or courses with fewer appointments. In an increasing number of cases this now includes home exercises and graded increased use. Rehabilitation has included range-of-motion exercises, strengthening exercises, splinting, and a virtual reality system.(989) Home exercise programs appear to be the most effective for regaining function.(990)

Most patients require one or two follow-up clinical appointments for wound care and instructions. Patients with less optimal outcomes may require additional appointments to monitor and facilitate recovery. Patients with physically demanding jobs whose initial restrictions are not accommodated may require a greater number of appointments to monitor their recovery and help facilitate their return to work at appropriate intervals.

While most recovery occurs within the first 3 months after surgery, a full functional recovery from carpal tunnel release including attaining a maximum grip strength is estimated to minimally occur at 6 months and for some patients as long as 1 year. For more information regarding post-operative rehabilitation, see section on Post-Operative Rehabilitation and Rehabilitation of Patients with Functional Deficits: CTS and Other Disorders.

Triangular Fibrocartilage Complex (TFCC) Tears

Diagnostic Criteria

The history should include ulnar wrist joint pain and a catching, snapping or popping sensation in the wrist with movement. The physical examination should reproduce these symptoms. Imaging studies should be consistent with a triangular fibrocartilage complex (TFCC) tear of sufficient magnitude to explain the symptoms. Other TFCC tears do not have all these features, yet are found in the course of imaging for wrist abnormalities.(14, 220, 221) These other tears generally represent asymptomatic prevalent tears discovered through imaging. Treatment of those tears is usually not indicated. TFCC tears are most commonly classified by the Palmer classification system(223) which has been utilized to develop treatment recommendations (see Table 5). However, overlap may be present between the types in particular due to concomitant degenerative and traumatic issues.

Table 5. Palmer Classification of TFCC Tears and Treatment Recommendations. Type I are acute, traumatic injuries and Type II are degenerative.*

Type	Anatomy	Treatment
IA	Avascular articular disc tear	Immobilization. Arthroscopic debridement if immobilization unsuccessful.
IB	Base of the styloid tear	Immobilization. Arthroscopic or open surgery if immobilization fails.**
IC	Carpal detachment	Immobilization. Arthroscopic or open surgery if immobilization fails.
ID	Detachment off the radius	Immobilization. Arthroscopic or open surgery if immobilization fails.
IIA	Thinning of the articular disc without tear	Address degenerative joint disease risks.*** Surgery rarely indicated. Possible ulna shortening in select cases.
IIB	Thinning of articular disc accompanied by chondromalacia of the lunate or ulna	Address degenerative joint disease risks. Surgery rarely indicated. Possible ulna shortening in select cases.
IIC	Central disc tear with chondromalacia	Address degenerative joint disease risks. Surgery for residual symptoms, including ulna shortening and wafer procedure.
IID	Central tear, chondromalacia and lunotriquetral ligament disruption	Address degenerative joint disease risks. Surgery for residual symptoms including ulna shortening and wafer procedures. Possible arthrodesis.

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IIE	Central tear, chondromalacia and lunotriquetral ligament disruption and ulnocarpal arthritis	Address degenerative joint disease risks. Surgery for residual symptoms

*Adapted from Ahn 2006, Bednar 1994, and Palmer 1990.
**Surgery of these is felt to be rarely necessary due to vascular supply.
***Degenerative joint disease risks include body mass index, gout, rheumatoid arthritis, other inflammatory arthropathies, and repeated forceful wrist use.

Special Studies and Diagnostic and Treatment Considerations

X-RAYS

Recommendation: X-rays to Diagnose Triangular Fibrocartilage Complex (TFCC) Tears
X-rays are recommended to diagnose triangular fibrocartilage complex (TFCC) tears.

Indications – Suspected TFCC tear and/or to rule out other sources of wrist pain.

Frequency/Duration – Obtaining x-rays once is generally sufficient.

Strength of Evidence – **Recommended, Insufficient Evidence (I)**
Level of Confidence – Moderate

Rationale for Recommendation
There are no quality studies evaluating x-rays for the diagnosis of triangular fibrocartilage complex (TFCC) tears. Some patients do not require initial x-rays and can be managed clinically. However, x-rays may assist particularly in ruling out other potential sources of wrist pain. They are also indicated for those who fail to improve or have other symptoms suggesting consideration of other potential diagnoses. X-rays also assist with analysis for evidence of other conditions such as osteoarthrosis. Positive ulnar variance (an ulna that extends more distally than the radius) is thought to increase risk.

MR ARTHROGRAPHY AND MRI
Recommendation: MR Arthrography or MRI to Diagnose Triangular Fibrocartilage Complex (TFCC) Tears
MR arthrography or MRI is recommended to diagnose triangular fibrocartilage complex (TFCC) tears.

Strength of Evidence – **Recommended, Insufficient Evidence (I)**
Level of Confidence – Moderate

Rationale for Recommendations
There are no quality studies evaluating MR arthrography or MRI for the diagnosis of triangular fibrocartilage complex (TFCC) tears. MR arthrography is thought to be superior. Traditional arthrography without MRI has mostly been replaced by MR arthrography and MRI.(991-996) Virtual MR arthroscopy is in development, but its utility is not yet demonstrated.(997)

ARTHROSCOPY
Diagnostic arthroscopy is often combined with surgical repair (see Surgery section).

Initial Care

Splinting has been used for treatment of TFCC tears(998) as have ice, heat and rest.

1. *Recommendation: Relative Rest for Acute, Subacute, or Chronic Triangular Fibrocartilage Complex (TFCC) Tears*
Relative rest is recommended for treatment of acute, subacute, or chronic triangular fibrocartilage complex (TFCC) tears.

Strength of Evidence **– Recommended, Insufficient Evidence (I)**
Level of Confidence – Low

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1. *Recommendation: Splinting for Moderate or Severe Acute or Subacute Triangular Fibrocartilage Complex (TFCC) Tears*
   Splinting is recommended for treatment of moderate or severe acute or subacute triangular fibrocartilage complex (TFCC) tears, particularly to reduce forearm rotation.

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – Low

2. *Recommendation: Self-application of Ice for Acute, Subacute, or Chronic Triangular Fibrocartilage Complex (TFCC) Tears*
   Self-application of ice is recommended for treatment of acute, subacute, or chronic triangular fibrocartilage complex (TFCC) tears.

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – Low
3. *Recommendation: Self-application of Heat for Acute, Subacute, or Chronic Triangular Fibrocartilage Complex (TFCC) Tears*
   Self-application of heat is recommended for treatment of acute, subacute, or chronic triangular fibrocartilage complex (TFCC) tears.

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – Low

Rationale for Recommendations
There is no evidence of the efficacy of wrist splints to treat acute, subacute, or chronic TFCC tears (knee menisci which are structurally similar, appear to heal with use). Yet, there may be cases where a wrist splint seems helpful and others have recommended immobilization (see Table 5). Splints may help with avoiding aggravating activities or actions that provoke symptoms and therefore, may be more appropriate for acute or moderate to severe injuries. There are also no quality studies evaluating relative rest, rest, ice, or heat for TFCC tears. However, limitations are often needed for more symptomatic cases. Though not invasive, limitations can be moderate to high cost over time; however, relative rest may preclude the need for surgical intervention. Ice and heat may help particularly with more acute symptoms. These treatments may help with symptomatic relief, are not invasive, have no adverse effects, and are not costly and are recommended.

Evidence for the Use of Initial Care
There are no quality studies incorporated into this analysis.

Rest
A comprehensive literature search was conducted using PubMed, Scopus, CINAHL and Cochrane Library without date limits using the following terms: Rest; relative rest / Triangular fibrocartilage complex (TFCC) tears ;controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed zero articles in PubMed, zero in Scopus, zero in CINAHL, and 1 in Cochrane Library. We considered for inclusion zero from PubMed, zero from Scopus, zero from CINAHL, zero from Cochrane Library and zero from other sources. Of the zero articles considered for inclusion, zero randomized trials and zero systematic studies met the inclusion criteria.

Splinting
A comprehensive literature search was conducted using PubMed, Scopus, CINAHL and Cochrane Library without date limits using the following terms: Splinting or Immobilization; Triangular fibrocartilage complex (TFCC) tears; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 6 articles in PubMed, 16 in Scopus, 1 in CINAHL, and 52 in Cochrane Library. We considered for inclusion 0 from PubMed, 1 from Scopus, 0 from CINAHL, 1 from Cochrane Library and 2 from other sources. Of the 4 articles considered for inclusion, 0 randomized trials and 2 systematic studies met the inclusion criteria.

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Ice
A comprehensive literature search was conducted using PubMed, Scopus, CINAHL and Cochrane Library without date limits using the following terms: Ice; Triangular fibrocartilage complex (TFCC) tears; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found, reviewed and considered for inclusion 0 articles in PubMed, 0 in Scopus,0 in CINAHL, 0 in Cochrane Library and 0 in other sources. Zero articles met the inclusion criteria.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL and Cochrane Library without date limits using the following terms: Heat, Self-application of heat; Triangular fibrocartilage complex (TFCC) tears controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found, reviewed and considered for inclusion zero articles in PubMed, zero in Scopus, zero in CINAHL, zero in Cochrane Library and zero in other sources. Zero articles met the inclusion criteria.

Follow-up Visits

Patients generally require from 1 to 6 appointments, depending on severity and need for workplace limitations. Greater numbers of appointments may be required for evaluating and treatment pain and monitoring function and work status over time. Severe TFCC tears, especially those that either are immobilized for many weeks or undergo surgery may require occupational or physical therapy typically for teaching mobilization exercises and strengthening exercises.

Medications

Over-the-counter medications are generally helpful. Prescription medications may be needed in moderate to severe cases.

NSAIDS/ACETAMINOPHEN

Recommendation: NSAIDs or Acetaminophen for Acute, Subacute, or Chronic Triangular Fibrocartilage Complex (TFCC) Tears
NSAIDs or acetaminophen are recommended to control pain associated with acute, subacute, or chronic TFCC tears particularly for patients with significant pain.

Indications – Pain due to acute, subacute, or chronic TFCC tears.

Frequency/Duration – Scheduled dosage rather than as needed is generally preferable.

Indications for Discontinuation – Resolution of pain, lack of efficacy, development of adverse effects particularly gastrointestinal.

> *Strength of Evidence* – **Recommended, Insufficient Evidence (I)**
> *Level of Confidence* – Moderate

Rationale for Recommendation
There are no quality studies evaluating NSAIDs or acetaminophen for controlling pain associated with TFCC tears. However, NSAIDs may help particularly with more acute symptoms. These medications are not invasive, have low adverse effects for short-term use in employed populations, and are not costly. Thus, NSAIDs or acetaminophen are recommended for treatment of pain from acute, subacute, or chronic TFCC tears.

Evidence for the Use of NSAIDs/Acetaminophen
There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL and Cochrane Library without date limits using the following terms: Acetaminophen, anti-inflammatory agents, non-steroidal, NSAIDS, triangular fibrocartilage, TFCC, triangular fibrocartilage complex, tears, injuries, lesions,

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triangular fibrocartilage injuries, controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found, reviewed and considered for inclusion zero articles in PubMed, zero in Scopus, zero in CINAHL, zero in Cochrane Library and zero in other sources. Zero articles met the inclusion criteria.

Physical Methods/Rehabilitation

EXERCISE

Exercise is generally not indicated acutely; however, exercise may be needed in the recovery or post-operative phases.

Evidence for the Use of Exercise

There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL and Cochrane Library without date limits using the following terms: Exercise; triangular fibrocartilage, TFCC, triangular fibrocartilage complex, tears, injuries, lesions, triangular fibrocartilage injuries,controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed zero articles in PubMed, zero in Scopus, zero in CINAHL, and 1 in Cochrane Library. We considered for inclusion zero from PubMed, zero from Scopus, zero from CINAHL, zero from Cochrane Library and zero from other sources. Of the zero articles considered for inclusion, zero randomized trials and zero systematic studies met the inclusion criteria.

Surgery

1. *Recommendation: Arthroscopic or Open Surgical Repair for Subacute or Chronic Triangular Fibrocartilage Complex (TFCC) Tears*
   Surgical repair (arthroscopic or open) is recommended for patients with instability, concomitant fractures, or symptoms that persist without trending towards resolution despite non-operative treatment and the passage of approximately 3 to 6 weeks.

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – Moderate

Rationale for Recommendation

There are no quality studies evaluating surgical repair for TFCC tears. Location of the TFCC tear is thought to be related to prognosis with peripheral tears having a better probability of success with non-surgical treatment due to vascular supply; however, central tears also may become asymptomatic.(999) Arthroscopic repair is most typically used with excellent or good results reported in 74% of a case series of 35 patients(1000) with other estimates of success up to 93%,(220, 1001-1004) although open repairs may be performed.(1005)

2. *Recommendation: Ulna Shortening and Wafer Procedures for Chronic Triangular Fibrocartilage Complex (TFCC) Tears*
   Ulna shortening(1006) **and wafer procedures are recommended for select cases of chronic Types IIC and IID (Table 5) TFCC tears for which non-surgical treatment is unsuccessful and there is a demonstrable ulna positive variance.**

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – Low

Rationale for Recommendation

There are no quality studies evaluating ulna shortening and wafer procedures for TFCC tears. However, in select cases with ulna positive variance and without resolution of considerable or incapacitating symptoms or lacking trending towards resolution, this procedure is recommended. This procedure is

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invasive, has adverse effects, may not be effective, but also may provide either cure or relief of symptoms and thus is recommended for select cases.

Evidence for the Use of Surgery
There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL and Cochrane Library without date limits using the following terms: Open surgical repair, triangular fibrocartilage, TFCC, triangular fibrocartilage complex, tears, injuries, lesions, tear, injury, triangular fibrocartilage injuries**,** controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 7 articles in PubMed, 29 in Scopus, 0 in CINAHL, and 0 in Cochrane Library. We considered for inclusion 3 from PubMed, 1 from Scopus, 0 from CINAHL, 0 from Cochrane Library and 0 from other sources. Zero articles met the inclusion criteria.

Crush Injuries and Compartment Syndrome

Special Studies and Diagnostic and Treatment Considerations

X-RAYS

Recommendation: X-rays for Evaluating Crush Injuries or Compartment Syndrome
X-rays are recommended for evaluating patients with crush injuries or compartment syndrome.

Strength of Evidence – **Recommended, Insufficient Evidence (I)**
Level of Confidence – High

Rationale for Recommendation
There are no quality studies evaluating the use of x-rays for crush injuries or compartment syndrome. However, x-rays are essential for evaluating the extent of injuries and identification of fractures.

Evidence for the Use of X-rays
There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: x-ray, crush injury, upper extremity; diagnostic, diagnosis, sensitivity, specificity, positive predictive value, negative predictive value, and predictive value of tests, efficacy, and efficiency. We found and reviewed 7 articles in PubMed, 2 in Scopus, 0 in CINAHL, 0 in Cochrane Library, 1580 from Google Scholar, and 0 from other sources. Zero articles met the inclusion criteria.

MRI/CT
Recommendation: MRI or CT for Crush Injuries or Compartment Syndrome
MRI or CT is recommended for follow-up of select patients with crush injuries or compartment syndrome.

Strength of Evidence – **Recommended, Insufficient Evidence (I)**
Level of Confidence – Moderate

Rationale for Recommendation
Initial evaluation of crush injuries or compartment syndrome generally does not require MRI or CT. However, some patients require MRI or CT for evaluation of symptoms and extent of injury and are recommended in select cases.

Evidence for the Use of MRI/CT
There are no quality studies incorporated into this analysis.

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A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: magnetic resonance imaging or MRI, CT, crush injury, upper extremity; diagnostic, diagnosis, sensitivity, specificity, positive predictive value, negative predictive value, predictive value of tests, efficacy, efficiency. We found and reviewed 5 articles in PubMed, 18 in Scopus, 6 in CINAHL, 1 in Cochrane Library, and 1490 from Google Scholar. Zero articles met the inclusion criteria.

Initial Care

1. *Recommendation: Elevation and Relative Rest for Acute Crush Injuries or Compartment Syndrome*
   Elevation and relative rest are recommended for treatment of acute crush injuries or compartment syndrome.

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – Moderate

2. *Recommendation: Splinting for Subacute Crush Injuries or Compartment Syndrome*
   Splinting is recommended after initial treatment for moderate or severe acute and subacute crush injuries or compartment syndrome.

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – Low

3. *Recommendation: Self-application of Ice for Acute Crush Injuries or Compartment Syndrome*
   Self-application of ice is recommended for treatment of acute crush injuries or compartment syndrome. Other cryotherapies may be required in hospital settings for more severe cases.

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – Low

4. *Recommendation: Self-application of Heat for Acute Crush Injuries or Compartment Syndrome*
   Self-application of heat is not recommended for treatment of acute crush injuries or compartment syndrome.

   Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
   Level of Confidence – Low

Rationale for Recommendations
There are no quality studies evaluating rest/elevation, splinting, or self-application of ice or heat to treat crush injuries or compartment syndrome. However, elevation, rest, and ice are believed to be helpful for treatment of these conditions and in milder cases may be the principal treatments administered. These interventions are not invasive, have no adverse effects, and are not costly (other than repeated administrations of cryotherapies in hospital settings where monitoring is required); thus, they are recommended. Splints may assist in symptomatic relief, are not invasive, have few adverse effects, and are low to moderate cost. The type of splint required depends on the type of injury and subsequent debility. Splints are frequently custom made for patients with these injuries. Splints are recommended particularly for patients with moderate to severe injuries.

Evidence for the Use of Initial Care
There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: rest, bed rest, initial elevation, initial care, controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found, reviewed and considered for inclusion zero articles in PubMed, zero

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in Scopus, zero in CINAHL, 197 in Cochrane Library, 266 in Google Scholar and zero in other sources. Zero articles met the inclusion criteria.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: splint, splints, nocturnal splint, splinting, upper extremity, wrist, wrist injury, crush injury, compartment syndrome, controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found, reviewed and considered for inclusion 22 articles in PubMed, 11 in Scopus, 0 in CINAHL, 52 in Cochrane Library, and 1,929 in Google Scholar and zero in other sources. Zero articles met the inclusion criteria.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: ice, self-application of ice, crush injuries, wrist injury, compartment syndrome, upper extremity, controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 43 articles in PubMed, zero in Scopus, 2 in CINAHL, 4 in Cochrane Library and 5,690 in Google Scholar. We considered for inclusion 1 from PubMed, zero from Scopus, zero from CINAHL, zero from Cochrane Library, zero from Google Scholar and zero from other sources. Of the 5,739 articles considered for inclusion, zero randomized trials and 1 systematic studies met the inclusion criteria.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: heat, self-application of heat, crush injuries, wrist injury, compartment syndrome, upper extremity, controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found, reviewed and considered for inclusion 4 articles in PubMed, 1 in Scopus, zero in CINAHL, 85 in Cochrane Library, 8252 in Google Scholar, and zero other sources. Zero articles met the inclusion criteria.

Follow-up Visits

Patients generally require multiple follow-up appointments with the number dependent on the severity of the injury. The mildest cases of crush injuries may require 1 to 3 follow-up appointments. Severe cases of compartment syndrome or crush injuries that have major medical complications and activity limitations may require dozens of appointments to evaluate, treat, advance activity limitations and otherwise monitor and actively facilitate clinical progress. Moderate and severe crush injuries and compartment syndrome usually require occupational or physical therapy for teaching mobilization and strengthening exercises. Therapy needs can be extensive (see below).

Medications

Over-the-counter medications may be helpful, but most patients require prescription medications for pain, particularly for moderate to severe injuries. Mannitol has been reported as a treatment.(1007)

NSAIDS/ACETAMINOPHEN

Recommendation: NSAIDs or Acetaminophen for Acute or Subacute Crush Injuries or Compartment Syndrome

NSAIDs or acetaminophen are recommended to control pain associated with acute or subacute crush injuries or compartment syndrome.

Indications – Pain due to acute or subacute crush injuries or compartment syndrome.

Frequency/Duration – Scheduled dosage rather than as needed is generally preferable.

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Indications for Discontinuation – Resolution of pain, lack of efficacy, development of adverse effects, particularly gastrointestinal.

Strength of Evidence – **Recommended, Insufficient Evidence (I)**
Level of Confidence – Moderate

Rationale for Recommendation
There are no quality studies evaluating NSAIDs or acetaminophen for patients with crush injuries or compartment syndrome. There is one trial with non-specific limb injury suggesting efficacy of diclofenac (Woo 05). These medications are helpful for numerous other musculoskeletal disorders and are believed helpful for these injuries. As NSAIDs and acetaminophen are non-invasive, have low adverse effects, and are low cost, they are recommended for treatment of pain associated with acute or subacute crush injuries or compartment syndrome.

Evidence for the Use of NSAIDs/Acetaminophen
There is 1 moderate-quality RCT incorporated into this analysis.(1008)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: NSAIDs; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 3 articles in PubMed, 0 in Scopus, 0 in CINAHL, 110 in Cochrane Library, 510 in Google Scholar, and 1 from other sources. We considered for inclusion 0 from PubMed, 0 from Scopus, 0 from CINAHL, 1 from Cochrane Library, 0 Google Scholar, and 1 from other sources. Of the 2 articles considered for inclusion, 1 randomized trials and 1 systematic studies met the inclusion criteria.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Woo 2005 RCT Double-blind No mention of sponsorship or COI.	5.5	N = 300 (No mention of Gender) w/ painful isolated limb injuries. Mean Age: Paracetamol group 35.6±12.2; Diclofenac group 38.2±13.1; Indomethacin group 34.2±11.0; Diclofenac and Paracetamol group 38.3±12.7	Paracetamol and placebo group monitored every 30 minutes for 2 hours, same dosage for 3 days. (N =66) Vs Diclofenac and placebo group monitored every 30 minutes for 2 hours, same dosage for 3 days. (N =69). Vs Indomethacin and placebo group monitored every 30 minutes for 2 hours, same dosage for 3 days. (N=71) Vs Diclofenac and paracetamol group monitored every 30 minutes for 2 hours, same dosage for 3 days. (N=94);	In stage 1 in the emergency department, analog pain scores and rest and with activity was >13 mm in all groups for the first hour. The diclofenac-paracetamol group achieved <13mm range at 90 minutes after ingestion as well as greatest pain reduction score in 2 hours. After 90 minutes all groups pain score was <13mm. No statistical difference between groups at any time. In stage 2, the diclofenac-paracetamol group was only group to achieve <13mm average pain reduction score within the first day. It also saw more abdominal pain than any other group. Median patient	"Analgesic benefit of oral paracetamol–nonsteroidal anti-inflammatory drug combinations over single nonsteroidal anti-inflammatory drugs or paracetamol treatment is small and of doubtful clinical significance."	Baseline comparability questionable as diagnoses and distribution of group. No placebo group.

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			Follow-up at baseline and at 5-8 days after initial presentation.	satisfaction scores (out of 10) with the oral analgesic treatment were 3.0 (3.0 to 4.0; P=.39) and with the study in general were 3.0 (3.0 to 4.0; P=.25).		

OPIOIDS
See Opioids recommendations in Carpal Tunnel Syndrome section.

Physical Methods/Rehabilitation

EXERCISE
Exercise is generally not indicated acutely; however, exercise may be needed in the recovery or post-operative phases.

Evidence for the Use of Exercise
There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Exercise; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 3 articles in PubMed, 43 in Scopus, 5 in CINAHL, 3 in Cochrane Library, 150 in Google Scholar, and 0 from other sources. We considered for inclusion 0 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 0 Google Scholar, and 0 from other sources. Zero articles met the inclusion criteria.

HYPERBARIC OXYGEN
Recommendation: Hyperbaric Oxygen for Acute or Subacute Crush Injuries or Compartment Syndrome
Hyperbaric oxygen is recommended for treatment of acute or subacute crush injuries or compartment syndrome depending on the nature of the injury. This frequently includes emergency fasciotomy for release of tension from compartment syndromes as well as other surgical procedures to address fractures and other remediable defects.

Strength of Evidence – **Recommended, Evidence (C)**
Level of Confidence – Low

Rationale for Recommendation
There is one quality study of hyperbaric oxygen (HBO) for treatment of crush injuries with considerable benefits demonstrated including improved healing and reduced need for additional surgeries.(1009) HBO is non-invasive and generally safe,(1010-1014) (Eskes 13, Eskes 11, Dougherty 13, Garcia-Covarrubias 05, Greensmith 04) although it is high cost. However, HBO is recommended for treatment of patients with moderate to severe crush injuries or compartment syndrome as risks are outweighed by benefits.

Evidence for the Use of Hyperbaric Oxygen for Crush Injuries or Compartment Syndrome
There is 1 moderate-quality RCT incorporated into this analysis.(1009)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Hyperbaric oxygen therapy, hyperbaric oxygenation, HBOT, crush syndrome, crush injury, compartment syndrome, compartment syndromes, upper extremity, hand, arm, forearm; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 15 articles

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in PubMed, 11 in Scopus, 15 in CINAHL, 5 in Cochrane Library, 1050 in Google Scholar, and 0 from other sources. We considered for inclusion 6 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 2 Google Scholar, and 0 from other sources. Of the 8 articles considered for inclusion, 1 randomized trial and 5 systematic studies met the inclusion criteria.

Author/Year Study Type Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Hyperbaric Oxygen vs. Placebo						
Bouachour 1996 RCT No mention of sponsorship or COI.	6.5	N = 36 (gender not specified) with Class II or III soft tissue injuries.	HBO therapy 100% O2 at 2.5 atmospheres vs. placebo	Complete wound healing without tissue necrosis requiring surgical excision in 17 HBO patients vs. 10 placebo (p <0.01). Tissue necrosis 1/18 HBO vs. 8/18 placebo. New surgical procedure = 2 (1 patient) vs. 8 (6 patients), p = 0.03 (p = 0.04).	"[T]his study shows the effectiveness of HBO in improving wound healing and reducing repetitive surgery."	Results suggest HBO beneficial for these more severe injuries with better healing and less repeat surgery required.

Surgery

Recommendation: Surgery for Acute or Subacute Crush Injuries or Compartment Syndrome

Surgery is recommended for treatment of acute or subacute crush injuries or compartment syndrome depending on the nature of the injury. This frequently includes emergency fasciotomy for release of tension from compartment syndromes as well as other surgical procedures to address fractures and other remediable defects.

Strength of Evidence – **Recommended, Insufficient Evidence (I)**

Level of Confidence – High

Rationale for Recommendation

There are no quality studies evaluating surgeries for crush injuries or compartment syndrome of the hand or forearm and the clinical variability between patients is large. However, fasciotomies are particularly essential for treatment of significant neurovascular compromise from compartment syndrome and is a surgical emergency.(19, 227, 1009-1014) Other procedures may be required based on remediable defects such as fractures, ligament tears, or other injuries.

Evidence for the Use of Surgery

There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library and Google Scholar without date limits using the following terms: Surgery, surgical procedures, operative, general surgery, crush, wrist injuries, wrist injury, compartment syndrome, compartment syndromes, upper extremity, controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 212 articles in PubMed, 250 in Scopus, 17 in CINAHL, and 0 in Cochrane Library. We considered for inclusion 5 from PubMed, 0 from Scopus, 2 from CINAHL, 0 from Cochrane Library and 0 from other sources. Of the 7 articles considered for inclusion, 0 randomized trials and 1 systematic study met the inclusion criteria.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library and Google Scholar without date limits using the following terms: Emergency fasciotomy, crush injuries, crush, injury, injuries, compartment syndrome, upper extremities, controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 2 articles in PubMed, 44 in Scopus, 0 in CINAHL, and 1 in Cochrane Library. We considered for inclusion 0 from PubMed, 3 from Scopus, 0 from CINAHL, 0 from Cochrane Library and 0 from other sources. Of the 3 articles considered for inclusion, 0 randomized trials and 2 systematic studies met the inclusion criteria.

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Kienböck Disease

Diagnostic Criteria

Patient has non-radiating wrist compartment pain, limited range of motion, and developed x-ray evidence of radiological collapse of the lunate.

Special Studies and Diagnostic and Treatment Considerations

X-RAYS

Recommendation: X-rays to Diagnose Kienböck Disease
X-rays are recommended to diagnose Kienböck disease.

Strength of Evidence – **Recommended, Insufficient Evidence (I)**
Level of Confidence – High

Rationale for Recommendation
There are no quality studies evaluating the use of x-rays to diagnose Kienböck disease. However, x-rays are used to confirm the diagnosis and are moderately costly, thus they are recommended. X-rays generally should be taken of both hands.

Evidence for the Use of X-rays
There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library and Google Scholar without date limits using the following terms: Kienböck's disease, X-ray, radiography, radiograph; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found, reviewed and considered for inclusion 3 articles in PubMed, 347 in Scopus, 2 in CINAHL, 12 in Cochrane Library, 140 in Google Scholar and zero in other sources. Zero articles met the inclusion criteria.

CT

Recommendation: CT to Diagnose Kienböck Disease
CT is recommended to diagnose Kienböck disease when xrays are negative or unclear.

Strength of Evidence – **Recommended, Insufficient Evidence (I)**
Level of Confidence – Moderate

Rationale for Recommendation
There is one quality study evaluating the use of CT scans that included patients with Kienböck disease suggesting 3-D CT may provide more information than x-ray or plain CT.(1025) (Nakamura 89) CTs are used to assist with diagnosis and management, thus they are recommended where xrays are negative or unclear.

Evidence for the Use of CT
There is 1 moderate-quality study incorporated into this analysis.(1025) (Nakamura 89)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: computed tomography or CT, Kienböck's disease; diagnostic, diagnosis, sensitivity, specificity, positive predictive value, negative predictive value, and predictive value of tests, efficacy, and efficiency. We found and reviewed 33 articles in PubMed, 3 in Scopus, 0 in CINAHL, 0 in Cochrane Library, and 295 from Google Scholar. We considered for inclusion 1 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 0 from Google Scholar, and 0 from other sources. Of the 1 article considered for inclusion 1 diagnostic study met the inclusion criteria.

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Author/Year Study Type	Score	Number	Area of Spine	Diagnoses	Type of CT	X-ray used	MRI Used	More than one rater	Blinding of rater	Myelography	Surgery Performed	Clinical outcomes assessed	Long term follow-up (mean when	Results	Conclusion	Comments
Nakamura 1989 Diagnostic No mention of sponsorship or COI.	4.5	N = 20 (3 female and 17 male) admitted for wrist problems; 3 with Kienbock's disease, 14 with fractures or dislocations of the carpal bones Age range from 18 to 64 years.	Wrist	Wrist problems due to altered bony or joint structures.	High resolution CT scanner (Somatom DRH) and accompanying software (3D Display; Version B or C)	-	-	-	-	-	-	-	-	16/17 cases of fracture a three-dimensional CT image was believe to be useful to detect the fracture line. 3 had a flattened lunate due to Kienbock disease. 13 had deformity of the hamate body seen on plain radiography and CT, but the three-dimensional CT image. Presence and location of small fragments not detected by plain radiographs and CT, but distinctly observed in seven cases by using three dimensional CT images.	"Three-dimensional CT imaging provides a great deal of information that cannot be obtained by conventional radiographs or CT images even at their present stage of technical development."	Small sample (N=20). Data suggest 3-D CT provides more diagnostic information than either plain radiography or conventional CT.

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MRI

Recommendation: MRI to Diagnose Kienböck Disease

MRI is recommended to diagnose Kienböck disease.

Strength of Evidence – **Recommended, Insufficient Evidence (I)**
Level of Confidence – Low

Rationale for Recommendation

There are 2 moderate-quality articles evaluating the use of MRIs to diagnose Kienböck disease. However, MRI was not shown to have superior performance for diagnostic purposes. MRIs are used to assist with diagnosis and management, thus they are recommended.

Evidence for the Use of MRI

There are 2 moderate-quality studies incorporated into this analysis.(1015, 1016)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Magnetic Resonance Imaging, MRI, Kienböck's disease or Kienbock disease, diagnostic, diagnosis, sensitivity, specificity, positive predictive value, negative predictive value, and predictive value of tests, efficacy, and efficiency. We found and reviewed 82 articles in PubMed, 68 in Scopus, 1 in CINAHL, 0 in Cochrane Library, and 523 from Google Scholar. We considered for inclusion 2 from PubMed, 0 from Scopus, CINAHL, Cochrane Library, Google Scholar, and from other sources. Of the 2 articles considered for inclusion 2 diagnostic studies met the inclusion criteria.

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Author/Year Study Type	Score	Number	Area	Diagnoses	Type of MRI used	Type of CT used	T1 weighted	T2 weighted	X-ray	Myelography	More than one	Surgery	Clinical	Long term follow-up (mean when	Results	Conclusion	Comments
Hashizume 1996 Diagnostic No mention of sponsorship or COI.	4.0	10 (2 female/8 male)	Wrist	Kienbock's Disease	1.5 Tesla signal, both T1 and T2 weighted images.	+	+	+	+	-	-	+	+	Mean follow-up 29.	Areas of collapse easily identified in x-ray, tomography, CT and microradiographic images. MRI showed complete loss of signal intensity in T1 images of lesion of lunate.	"MRI is at present unable to distinguish bone necrosis, the histological reactive interface or surrounding hyperaemia in detail."	Small sample size. Data suggest MRI unable to distinguish bone necrosis in detail.
Imaeda 1992 Diagnostic No mention of sponsorship or COI.	4.0	26 (7 female and 19 male)	Wrist	Kienbock's Disease	1.5 tesla signal with 3-inch surface coil. Both T1 and T2 weighted images.	-	+	+	-	-	-	+	+	-	For normal wrists, bone marrow showed high signal intensity on T1 and iso intensity on T2. For wrists with Kienbock's disease, T1 weighted images had decrease in signal intensity in all cases. After osteotomy of radius, signal intensity of lunate returned to normal in both T1 & T2.	"After osteotomy of the radius, the signal intensity of the lunate returned to normal and Lichtman's stage IL cases had better results than those in stage III. M.R. imaging is ideal for evaluating the lunate in Kienbock's disease."	Small sample. Data suggest a low signal intensity of lunate on T-1 weighted images is diagnostic of Kienböck's disease and signal intensity (if high) correlate to disease severity.

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SCREENING FOR SYSTEMIC DISORDERS

Recommendation: Screening for Systemic Disorders for Kienböck Disease

Screening for systemic disorders is recommended for patients with Kienböck disease.

Strength of Evidence – **Recommended, Insufficient Evidence (I)**
Level of Confidence – Moderate

Rationale for Recommendation

There are multiple disorders that are thought to predispose to Kienböck disease. These disorders may be otherwise asymptomatic, there may be potential to develop other manifestations of these diseases including in the other hand, and it may be possible to slow the rate of progression of this condition through active clinical management. Thus, the threshold for evaluations of systemic metabolic issues (e.g., diabetes, glucose intolerance), alcoholism, and rheumatological studies should be low, particularly as potentially modifiable risks may theoretically slow the rate of progression or prevent the disease in the other hand.

Evidence for the Use of Screening

There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Screening for Systemic Disorders, steroid, trauma, Kienböck's disease or Kienbock disease, diagnostic, diagnosis, sensitivity, specificity, positive predictive value, negative predictive value, predictive value of tests, efficacy, efficiency, diagnostic, diagnosis, sensitivity, specificity, positive predictive value, negative predictive value, and predictive value of tests, efficacy, and efficiency. We found and reviewed 13 articles in PubMed, 0 in Scopus, 0 in CINAHL, Cochrane Library, and 127 from Google Scholar. We considered for inclusion 0 from PubMed, Scopus, CINAHL, Cochrane Library, Google Scholar, and from other sources. Zero articles met the inclusion criteria.

Initial Care

Initial care of patients with Kienböck disease involves identification and elimination or control of potential systemic contributing factors. Patient's limitations should be based on their capabilities.

1. *Recommendation: Self-application of Ice for Acute, Subacute, or Chronic Kienböck Disease*
   Self-application of ice is recommended for treatment of acute, subacute, or chronic Kienböck disease.

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – Low

2. *Recommendation: Self-application of Heat for Acute, Subacute, or Chronic Kienböck Disease*
   Self-application of heat is recommended for treatment of acute, subacute, or chronic Kienböck disease.

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – Low

3. *Recommendation: Splints for Acute, Subacute, or Chronic Kienböck Disease*
   Splints are recommended for treatment of select patients with acute, subacute, or chronic Kienböck disease.

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – Low

Rationale for Recommendations

There are no quality studies evaluating the use of ice or heat for treatment of Kienböck disease. However, these treatments may help with symptomatic relief. These interventions are not invasive, have no adverse effects, and are not costly, thus they are recommended. There are no quality studies

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evaluating splinting for Kienböck disease. A trial may be helpful to assess whether splinting provides symptomatic relief. Splints are not invasive and have few adverse effects over the short term although over the long term there are concerns regarding the potential for accelerated debility disuse and weaknesss of the wrist. Splints are also low cost. Thus, they are recommended for select patients.

Evidence for the Use of Initial Care
There are no quality studies incorporated into this analysis.

Ice:
A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Kienböck's disease or Kienbock disease; Ice; Self Application; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found, reviewed and considered for inclusion 0 articles in PubMed, 0 in Scopus, 0 in CINAHL, 0 in Cochrane Library, 0 in Google Scholar, and 0 from other sources. Zero articles met the inclusion criteria.

Heat:
A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Kienböck's disease or Kienbock disease; HEAT/ Self-Application of Heat; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found, reviewed and considered for inclusion 0 articles in PubMed, 0 in Scopus, 0 in CINAHL, 0 in Cochrane Library and 0 in other sources. Zero articles met the inclusion criteria.

Splints:
A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Screening for Systemic Disorders, steroid, trauma, Kienböck's disease or Kienbock disease, diagnostic, diagnosis, sensitivity, specificity, positive predictive value, negative predictive value, predictive value of tests, efficacy, efficiency, diagnostic, diagnosis, sensitivity, specificity, positive predictive value, negative predictive value, and predictive value of tests, efficacy, and efficiency. We found and reviewed 13 articles in PubMed, 0 in Scopus, 0 in CINAHL, Cochrane Library, and 127 from Google Scholar. We considered for inclusion 0 from PubMed, Scopus, CINAHL, Cochrane Library, Google Scholar, and from other sources. Zero articles met the inclusion criteria.

Follow-up Visits

Patients with Kienböck disease generally require periodic appointments to follow the clinical course. Frequencies of appointments may be greater where workplace limitations are required. Post-operative rehabilitation can be considerable, with a requirement for occupational or physical therapy on a prolonged basis in order for the patient to recover as much function as possible.

Medications

Over-the-counter medications are generally helpful for pain associated with Kienböck disease. Prescription medications may be needed for moderate to severe cases. Patients with Kienböck disease often develop chronic pain (see Chronic Pain Guideline for a comprehensive approach to managing chronic pain). An abbreviated approach is noted below.

NSAIDS/ACETAMINOPHEN
Recommendation: NSAIDs and Acetaminophen for Acute, Subacute, or Chronic Kienböck Disease
NSAIDs and acetaminophen are recommended to control pain associated with acute, subacute, or chronic Kienböck disease.

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Indications – Pain due to acute, subacute, or chronic Kienböck disease.
Frequency/Duration – Scheduled dosage rather than as needed is generally preferable.
Indications for Discontinuation – Resolution of pain, lack of efficacy, development of adverse effects particularly gastrointestinal.

Strength of Evidence – **Recommended, Insufficient Evidence (I)**
Level of Confidence – Low

Rationale for Recommendation
There are no quality studies evaluating NSAIDs and acetaminophen for Kienböck disease. However, these medications may relieve pain and increase function. They are not invasive, have few adverse effects in employed populations, and are low cost, thus they are recommended.

Evidence for the Use of NSAIDs/Acetaminophen
There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: NSAIDS, Acetaminophen, Kienböck's disease; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found, reviewed and considered for inclusion 11 articles in PubMed, 2 in Scopus, zero in CINAHL, 3 in Cochrane Library, 132 in Google Scholar, and zero in other sources. Zero articles met the inclusion criteria.

TOPICAL MEDICATIONS
Recommendation: Topical Medications for Treatment of Acute, Subacute, or Chronic Kienböck Disease
Topical medications including topical creams, ointments, and lidocaine patches are recommended for treatment of pain associated with acute, subacute, or chronic Kienböck disease.

Strength of Evidence **– Recommended, Insufficient Evidence (I)**
Level of Confidence – Low

Rationale for Recommendation
There are no quality studies evaluating the use of topical medications for treatment of Kienböck disease. However, these treatments may provide symptom relief. They are not invasive, have few adverse effects in employed populations, and are low cost, thus they are recommended. Caution is warranted if there is use of anesthetic agents over large areas of the body, as adverse effects from systemic absorption have been reported.

Evidence for the Use of Topical Medications
There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Topical Cream, Topical Ointment, lidocaine patch, topical medication, Kienböck's disease, Kienbock disease; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found, reviewed and considered for inclusion 1 article in PubMed, 3 in Scopus, zero in CINAHL, 72 in Cochrane Library, 14 in Google Scholar and zero in other sources. Zero articles met the inclusion criteria.

OPIOIDS
See Opioids recommendations in Carpal Tunnel Syndrome section.

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Physical Methods/Rehabilitation

EXERCISE

Exercise is generally not utilized during acute presentations of Kienböck disease. However, exercise is nearly always necessary for post-operative patients and is frequently used for patients in the subacute and chronic phases.

Evidence for the Use of Exercise

There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: exercise, Kienböck's disease, Kienbock disease upper extremity, controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found, reviewed and considered for inclusion 35 articles in PubMed, 5 in Scopus, zero in CINAHL, zero in Cochrane Library, 492 in Google Scholar, and zero other sources. Zero articles met the inclusion criteria

Surgery

Recommendation: Surgical Repair for Chronic Kienböck Disease

Surgical treatment is recommended as an option for patients with moderate to marked impairment if not improved 8 weeks post-injury or after 6 weeks of non-operative treatment due to Kienböck disease.

Strength of Evidence – **Recommended, Insufficient Evidence (I)**
Level of Confidence – Low

Rationale for Recommendation

There are no quality studies evaluating surgical repair for Kienböck disease. There are many different surgical procedures and no quality comparative studies that have been reported. Surgical procedures utilized have included: lunate excision with silicone implants(1028-1030) (no longer recommended), excision with autogenous soft tissue implants including coiled palmaris longus tendon,(1028, 1031-1036) external fixation,(1035, 1037) arthrodesis,(1038, 1039) radial shortening,(1040, 1041) scaphoid-trapezium-trapezoid fusion,(1036, 1042, 1043) in advanced cases, proximal row carpectomy,(1044-1046), lunate core decompression,(1047, 1048) (Mehrpour 11, Rodrigues-Pinto 12) and vascularized bone transfers.(1049) A comparative clinical trial found superior clinical results and better preservation of carpal height ratio using palmaris longus tendon ball with a bone core compared with no bone core.(1034) In the absence of quality studies, the main determinant of surgical technique is the experience and comfort of the surgeon with specific treatment approaches.

Evidence for the Use of Surgery

There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: surgery, surgical fixation, surgical repair, kienbock's disease, Kienböck's disease, controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 127 articles in PubMed, 17 in Scopus, 9 in CINAHL, 809 in Google Scholar and 1,348 in Cochrane Library. We considered for inclusion 4 from PubMed, zero from Scopus, zero from CINAHL, zero from Cochrane Library, 4 in Google Scholar and zero from other sources. Of the 8 articles considered for inclusion, zero randomized trials and 8 systematic studies met the inclusion criteria.

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Wrist Sprains

Diagnostic Criteria

A history of an acute traumatic event with forceful loading of the wrist, combined with a negative examination other than ligamentous tenderness and negative x-rays.

Special Studies and Diagnostic and Treatment Considerations

X-RAYS

X-rays are traditionally the first diagnostic imaging study to evaluate wrist sprains and potential fractures.(1035)

Recommendation: X-rays for Wrist Sprains

X-rays are recommended to determine whether a fracture is present, particularly for patients with scaphoid pain or scaphoid tubercle tenderness.(1036)

> *Strength of Evidence* – **Recommended, Insufficient Evidence (I)**
> *Level of Confidence* – High

Evidence for the Use of X-rays

There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: X-Ray, Wrist Sprain, Wrist Sprains, diagnostic, diagnosis, sensitivity, specificity, positive predictive value, negative predictive value, and predictive value of tests, efficacy, and efficiency. We found and reviewed 15 articles in PubMed, 0 in Scopus, 2 in CINAHL, Cochrane Library, and 55 from Google Scholar. We considered for inclusion 0 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 0 from Google Scholar, and 0 from other sources. Of the 57 articles considered for inclusion 0 diagnostic studies met the inclusion criteria.

CT SCANS

Recommendation: CT scans for Wrist Sprains

CT scans are recommended to determine whether a fracture is present, particularly for patients with scaphoid pain or scaphoid tubercle tenderness with negative x-rays.(1036)

> *Strength of Evidence* – **Recommended, Insufficient Evidence (I)**
> *Level of Confidence* – Moderate

Evidence for the Use of CT Scans

There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Wrist Sprain, Wrist Sprain, Computed Tomography (CT), diagnostic, diagnosis, sensitivity, specificity, positive predictive value, negative predictive value, and predictive value of tests, efficacy, and efficiency. We found and reviewed 13 articles in PubMed, 0 in Scopus, 0 in CINAHL, Cochrane Library, and 432 from Google Scholar. We considered for inclusion 0 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 0 from Google Scholar, and 0 from other sources. Of the 445 articles considered for inclusion 0 diagnostic studies met the inclusion criteria. Zero articles met the inclusion criteria.

MR ARTHROGRAPHY

Recommendation: MR Arthrography for Wrist Sprains

MR arthrography is recommended for patients without improvement in wrist sprains after approximately 6 weeks of treatment.

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Strength of Evidence – **Recommended, Insufficient Evidence (I)**
Level of Confidence – Low

Rationale for Recommendations
There are no quality studies evaluating x-rays for wrist sprains. Mild wrist sprain may not necessitate x-rays. There is no evidence other studies are helpful in the acute setting (see discussion of scaphoid fractures for other studies in the presence of ongoing, non-resolving pain.) However, x-rays may assist in diagnosing and treating the condition and thus are recommended. There also are no quality studies evaluating MR arthrography. However, MR arthrograms are helpful to particularly identify ligamentous issues such as scapholunate, lunotriquetral, and TFCC tears that may be diagnosed as simple sprains. Thus, MR arthrography is recommended after approximately 6 weeks of clinical management.

Evidence for the Use of MR Arthrography
There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: MR Arthrography, Wrist Sprain, Wrist Sprain, diagnostic, diagnosis, sensitivity, specificity, positive predictive value, negative predictive value, and predictive value of tests, efficacy, and efficiency. We found and reviewed 4 articles in PubMed, 0 in Scopus, 0 in CINAHL, Cochrane Library, and 244 from Google Scholar. We considered for inclusion 0 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 0 from Google Scholar, and 0 from other sources. Of the 248 articles considered for inclusion 0 diagnostic studies met the inclusion criteria.

Initial Care

1. *Recommendation: Relative Rest for Acute Wrist Sprains*
   Relative rest is recommended for treatment of acute wrist sprains.

   Strength of Evidence **– Recommended, Insufficient Evidence (I)**
   Level of Confidence – Moderate

2. *Recommendation: Splinting for Moderate or Severe Acute or Subacute Wrist Sprains*
   Splinting is recommended for treatment of moderate or severe acute or subacute wrist sprains.

   Strength of Evidence **– Recommended, Insufficient Evidence (I)**
   Level of Confidence – Moderate

3. *Recommendation: Self-application of Ice for Acute Wrist Sprain*
   Self-application of ice is recommended for treatment of acute wrist sprain.

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – Low

4. *Recommendation: Self-application of Heat for Acute Wrist Sprain*
   Self-application of heat is recommended for treatment of acute wrist sprain.

   Strength of Evidence **– Recommended, Evidence (C)**
   Level of Confidence – Low

Rationale for Recommendations
There is one moderate-quality RCT that shows heat is effective in reducing pain from wrist sprains.(1037) There are no quality studies evaluating relative rest, splints, or ice for wrist sprains. However, these treatments may help with symptomatic relief. Splints are recommended particularly for patients with moderate to severe sprains. (Physicians should be aware that as early mobilization of ankle sprains results in improved clinical outcomes and those results may be applicable to the wrist.) These interventions are not invasive, have no adverse effects, and are low cost, thus they are recommended.

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Rest:
A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Rest, wrist sprains; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed zero articles in PubMed, 477 in Scopus, zero in CINAHL, zero in Cochrane Library, 1224 in Google Scholar, and zero from other sources. We considered for inclusion zero from PubMed, zero from Scopus, zero from CINAHL, and zero from Cochrane Library, zero Google Scholar, and zero from other sources. Zero articles met the inclusion criteria.

Splints:
A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: splint, splinting, Wrist Sprain, Wrist Sprain; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed zero articles in PubMed, 15 in Scopus, zero in CINAHL, zero in Cochrane Library, zero in Google Scholar, and zero from other sources. Zero articles met the inclusion criteria.

Ice:
A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Ice, hypothermia, cryotherapy, ice packs, wrist sprains, wrist sprain; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 614 articles in PubMed, 128 in Scopus, zero in CINAHL, 0 in Cochrane Library, 3243 in Google Scholar, and zero from other sources. We considered for inclusion 2 from PubMed, zero from Scopus, zero from CINAHL, and zero from Cochrane Library, zero Google Scholar, and zero from other sources. Of the 2 articles considered for inclusion, zero randomized trials and 2 systematic studies met the inclusion criteria.

Heat:
A comprehensive literature search was conducted using PubMed, Scopus, CINAHL and Cochrane Library without date limits using the following terms: Wrist sprains, heat, hot temperatures, therapeutics ; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 1290 articles in PubMed, 9 in Scopus, 1 in CINAHL, zero in Cochrane Library, and 2610 in Google Scholar. We considered for inclusion one from PubMed, zero from Scopus, zero from CINAHL, zero from Cochrane Library, zero from google scholar, and zero from other sources. Of the one article considered for inclusion, 1 randomized trial and zero systematic studies met the inclusion criteria.

Evidence for Heat for Wrist Sprain
There is 1 moderate-quality RCT incorporated into this analysis.(1037)

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Author/Year Study Type Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Heat vs. Other treatments vs. Placebo						
Michlovitz 2004 RCT Sponsored by Procter & Gamble Health Sciences Institute. COI Erasala, Hengehold, and Weingand are employees of Procter & Gamble. Michlovitz is a paid consultant for Procter & Gamble.	5.5	N = 69 (14 males, 15 females) with acute wrist pain, mostly from sprains, tendinosis, strains, osteoarthritis, or CTS; Mean (± SD) age 44.13 (± 10.23) years for all groups.	Self-applied heat wrap group at 104° F (40°C) for 8 hours daily (N= 29) vs. Oral placebo (N= 30) vs. 500mg acetaminophen group; 2 tablets 4x daily (N=5) vs. Unheated placebo wrap group (N=5) All groups received 3 days of treatment. Assessments at baseline, 3, 4 and 5 days.	Mean pain relief greater in heat wrap than oral placebo (mean pain relief 1.68±0.23 vs. 1.15±0.21 (p = 0.045). Grip strength improved more in heat wrap group 6.44± 1.34kg increase vs. 2.48±1.34 kg (p = 0.021).	"Continuous low-level heat therapy is a novel strategy in the treatment of musculoskeletal disorders. In this study, increased pain relief, functional gains, and grip strength along with decreased joint stiffness and symptom severity were observed in subjects with CTS treated with the heat wrap as compared to oral placebo. Additionally, subjects with SS/T/OA also had improved pain relief and significant improvements in grip strength as compared with placebo. These results support the benefit of continuous low-level heat wrap therapy in the treatment of common upper-extremity WRMSDs."	Short (3 days) treatment. Results for acetaminophen and unheated wrap not reported.

Follow-up Visits

Patients generally require 1 to 3 appointments, depending on severity of the sprain and the need for workplace limitations. Severe wrist sprains may require occupational or physical therapy mostly for teaching mobilization exercises. Wrist sprains that do not resolve or trends towards resolution by 6 weeks should have either further diagnostic evaluation or referral for consideration of other diagnostic testing and treatment options.

Medications

Over-the-counter medications are generally helpful for pain associated with wrist sprain. Prescription medications may be needed for moderate to severe cases.

NSAIDS/ACETAMINOPHEN

Recommendation: NSAIDs and Acetaminophen for Acute or Subacute Wrist Sprain

NSAIDs and acetaminophen are recommended to control pain associated with acute or subacute wrist sprain.

Indications – Pain due to acute or subacute wrist sprain.

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Frequency/Duration – Scheduled dosage rather than as needed is generally preferable.
Indications for Discontinuation – Resolution of pain, lack of efficacy, development of adverse effects particularly gastrointestinal.

Strength of Evidence – **Recommended, Evidence (C) – NSAIDs**
Strength of Evidence – **Recommended, Insufficient Evidence (I) – Acetaminophen**
Level of Confidence – Moderate

Rationale for Recommendations
There are no quality studies directly evaluating the use of NSAIDs and acetaminophen for pain associated with wrist sprain; however, there are moderate-quality studies of lower extremity sprains(1038, 1039) and these injuries are believed to be analogous (see Ankle and Foot Disorders Guideline). These medications may relieve pain and increase function. They are not invasive, have few adverse effects in employed populations, and are low cost, thus they are recommended for pain associated with acute or subacute wrist sprain.
Evidence for the Use of NSAIDs/Acetaminophen
There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: NSAIDs, non-steroidal anti-inflammatory drugs, Wrist Sprains; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 7 articles in PubMed, 0 in Scopus, 0 in CINAHL, 0 in Cochrane Library, 50 in Google Scholar, and 0 from other sources. Zero articles met the inclusion criteria.

OPIOIDS
See Opioids recommendations in Carpal Tunnel Syndrome section.

Physical Methods/Rehabilitation

EXERCISE
Exercise is generally not indicated acutely. Patients with deficits may require a home exercise program during recovery phases. Some patients require a formal exercise program.

Evidence for the Use of Exercise
There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: wrist, sprain, sprains, strain, strains, exercise, exercise therapy; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 22 articles in PubMed, 406 in Scopus, 3 in CINAHL, 5 in Cochrane Library, 330 in Google Scholar, and 0 from other sources. Zero articles met the inclusion criteria.

Surgery

Recommendation: Surgery for Treatment of Acute or Subacute Wrist Sprain
Surgery is not recommended for treatment of acute or subacute wrist sprain in the absence of a remediable defect.

Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
Level of Confidence – High

Rationale for Recommendation
There are no quality studies evaluating the use of surgery for wrist sprain. Other than among patients with other trauma necessitating surgery, wrist sprains are not believed to respond to surgery. Ongoing symptoms that do not resolve should be evaluated for other diagnoses.

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Evidence for the Use of Surgery
There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: surgery, surgeries, general surgery, general surgeries; wrist, sprain, sprains, strain, strains; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 213 articles in PubMed, 335 in Scopus, 2 in CINAHL, 0 in Cochrane Library, 2474 in Google Scholar, and 0 from other sources. Zero articles met the inclusion criteria.

Mallet Finger

Diagnostic Criteria

Mallet finger is a clinical diagnosis with a characteristic presentation of inability to extend the distal segment when the extensor tendon is damaged.

Special Studies and Diagnostic and Treatment Considerations

X-RAYS

Recommendation: X-rays for Mallet Finger
X-rays are recommended in most cases of mallet finger to determine if a fracture is present and to what extent.

Strength of Evidence – **Recommended, Insufficient Evidence (I)**
Level of Confidence – Moderate

Rationale for Recommendation
There are no quality studies evaluating the use of x-rays for mallet finger. X-rays may assist in identifying fractures and the magnitude of the involvement of the joint surface, which if large enough, alters management to surgery. It is reasonable to omit x-rays if there is no swelling or tenderness.

Evidence for the Use of X-rays
There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: x-ray, computed tomography, radiograph, mallet finger, baseball finger; diagnostic, diagnosis, sensitivity, specificity, positive predictive value, negative predictive value, and predictive value of tests, efficacy, and efficiency. We found and reviewed 22 articles in PubMed, 10 in Scopus, 2 in CINAHL, 0 in Cochrane Library, and 243 from Google Scholar. We considered for inclusion 0 from PubMed, 1 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 2 from Google Scholar, and 0 from other sources. Zero articles met the inclusion criteria.

ULTRASOUND
Recommendation: Ultrasound to Diagnose Mallet Finger
Ultrasound is not recommended to diagnose mallet finger.

Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
Level of Confidence – Low

Rationale for Recommendation
There are no quality studies evaluating the use of ultrasound to diagnose mallet finger. While ultrasound has been used for imaging,(1040) there is no evidence it alters treatment or prognosis and x-ray studies

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appear sufficient for diagnostic purposes. Thus, ultrasound is not recommended to diagnose mallet finger.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: ultrasonography, ultrasound, ultrasound scanning, sonography, mallet finger, baseball, hammer; diagnostic, diagnosis, sensitivity, specificity, positive predictive value, negative predictive value, and predictive value of tests, efficacy, and efficiency. We found and reviewed 0 articles in PubMed, 10 in Scopus, 0 in CINAHL, 0 in Cochrane Library, and 178 from Google Scholar. We considered for inclusion 0 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 3 from Google Scholar, and 0 from other sources. Zero articles met the inclusion criteria.

Initial Care

Care usually involves a splint and follow-up visits. Large fracture fragments are rare(264, 1041-1044) and necessitate surgery.

SPLINTS

1. *Recommendation: Splints for Acute or Subacute Mallet Finger*
   Extension splinting with the joint in a neutral or hyperextended position is moderately recommended for treatment of acute or subacute mallet finger.(264, 1044)
   Indications – Acute or subacute mallet finger.
   Frequency/Duration – Splinting for 6 to 8 weeks, possible nocturnal use for an additional 2 to 4 weeks.
   Indications for Discontinuation – Skin complications, non-compliance.

   Strength of Evidence – **Moderately Recommended, Evidence (B)**
   Level of Confidence – High

Rationale for Recommendation
There are 5 moderate-quality RCTs incorporated in this analysis. Splints must hold the finger in continuous, full extension for a minimum duration of 6 weeks.(1045) Some protocols involve 8 weeks, while some involve nocturnal use for an additional 2 to 4 weeks.(264, 1043-1047) There are many different types of(264, 1043, 1044, 1046, 1047) and no quality evidence of the unequivocal superiority of one versus another.(1048-1050) A padded aluminum splint was reportedly superior compared to a Stack (pre-fabricated plastic) splint due to easier fit and fewer skin complications.(264) Another trial found the Stack splint superior to the Abouna splint.(1044) Extension *must* be maintained even if the splint is removed for skin hygiene, which is often one of the times non-compliance occurs and is believed to cause many of the treatment failures.(1048) One quality study suggested better outcomes with fixation for patients presenting with delayed treatment.(1041)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: splint, splints, splinting, finger, mallet, baseball, drop, hammer; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 12 articles in PubMed, 68 in Scopus, 3 in CINAHL, 17 in Cochrane Library, 4,110 in Google Scholar, and 0 from other sources. We considered for inclusion 8 from PubMed, 3 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 1 from Google Scholar, and 0 from other sources. Of the 12 articles considered for inclusion, 1 randomized trials and 3 systematic studies met the inclusion criteria.

2. *Recommendation: Instructions for Splint Wear*
   It is recommended that careful instructions on splint wear be provided to patients.

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – High

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Rationale for Recommendation
There are no quality studies evaluating the use of instructions for splint wear for mallet finger. However, instructions appear critical for preventing treatment failures and are thus recommended.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: failed splints, splint failure, surgery, finger, mallet, baseball, drop, hammer; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 7 articles in PubMed, 2 in Scopus, 1 in CINAHL, 3 in Cochrane Library, 407 in Google Scholar, and 0 from other sources. We considered for inclusion 2 from PubMed, 1 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 3 from Google Scholar, and 0 from other sources. Of the 6 articles considered for inclusion, 0 randomized trials and 2 systematic studies met the inclusion criteria.

Follow-up Visits

Patients require a few appointments to reinforce importance of splinting and of not removing the splint unsupported. Multiple appointments are generally not required.

Medications

Nonprescription medications are usually not required as mallet finger is generally not painful. Prescription medications are rarely required as mallet finger is generally not painful.

Evidence for the Use of Medications
There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: mallet finger, baseball, hammer, NSAIDs, NSAID, acetaminophen, non-steroidal anti-inflammatory; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 0 articles in PubMed, 1 in Scopus, 0 in CINAHL, 13 in Cochrane Library, 75 in Google Scholar, and 0 from other sources. We considered for inclusion 0 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 0 from Google Scholar, and 0 from other sources. Zero articles met the inclusion criteria.

Physical Methods/Rehabilitation

EXERCISE
Exercise is not indicated acutely and most patients with mallet finger do not require participation in an exercise program. However, patients usually require careful education about splinting (see Education above). For patients with residual deficits, particularly post-operatively, see section on Post-Operative Rehabilitation and Rehabilitation of Patients with Functional Deficits: CTS and Other Disorders.

Evidence for the Use of Exercise
There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: exercise, physical activity, mallet finger, baseball, drop, hammer; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 3 articles in PubMed, 5 in Scopus, 3 in CINAHL, 1 in Cochrane Library, 187 in Google Scholar, and 0 from other sources. We considered for inclusion 1 from PubMed, 1 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 0

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from Google Scholar, and 0 from other sources. Of the 2 articles considered for inclusion, 01 randomized trials and 0 systematic studies met the inclusion criteria.

Surgery

1. *Recommendation: Surgical Interventions for Mallet Finger with Displaced Fractures*
   Surgical treatment with a fixation wire is recommended for patients with displaced fractures involving more than one third to one half of the articular surface of the DIP joint.

   Strength of Evidence **– Recommended, Insufficient Evidence (I)**
   Level of Confidence – Moderate

2. *Recommendation: Surgical Interventions for Failed Splinting Cases of Mallet Finger*
   Surgery is recommended for those cases that fail splinting yet have sufficient symptoms or concerns that an attempt at fixation is desired.

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – Moderate

Rationale for Recommendation
Quality studies to determine which patients with mallet finger would be optimal for surgical interventions are not currently available.(1048) One study reported a non-statistically significant trend suggesting preference for fixation among those presenting late for treatment;(1041) however, the dropout rate was high. A low-quality study also suggested no difference in splinting outcomes among those presenting late.(1042) Surgery is invasive, has relatively few adverse effects for this disorder, and is high cost; however, surgery is recommended for these select patients.

Evidence for the Use of Splints and Surgery for Mallet Finger
There are 5 moderate-quality RCTs incorporated into this analysis.(264, 1041, 1044, 1049, 1050) There are 3 low-quality RCTs in Appendix 2.(1042, 1043, 1051)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: surgical procedure, surgical intervention, surgery, displaced fracture, finger, mallet, baseball, drop, hammer; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 7 articles in PubMed, 75 in Scopus, 0 in CINAHL, 29 in Cochrane Library, 332 in Google Scholar, and 0 from other sources. We considered for inclusion 5 from PubMed, 4 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 0 from Google Scholar, and 0 from other sources. Of the 9 articles considered for inclusion, 8 randomized trials and 1 systematic studies met the inclusion criteria.

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Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
O'Brien 2011 RCT, Single blind Sponsored by the Alfred Allied Health Research Grant (A10602). No COI.	6.5	N = 64 (42 males, 22 females) with acute type 1a or 1b mallet finger; Mean (±SE) age 37.6 (±1.9).	Dorsal aluminum (13-mm wide padded aluminum) splint group (N= 21) Vs. Thermoplastic splint (1.6mm Orfit classic soft micro-perforated) group (N=22) Vs. Stack splint control group (N=21) All groups received a 4 week graduated exercise program after 8 weeks of splinting. Follow up 1 week, 8, 12 and 20 weeks.	No significant differences reported between groups for extension lag at 8, 10, 12 or 20 weeks. The dorsal splints and stack control group had significantly higher treatment failure rate compared to thermoplastic group: Dorsal split- 23.8% vs. Control- 23.8% vs. Thermoplastic - 0%, (p=0.04).	"Our findings demonstrate that the majority of mallet finger injuries treated with 8 weeks of immobilization and graded exercise thereafter achieve excellent or good results, adding weight to the argument that these injuries can be managed independently in hand therapist-led clinics. To enable patients to comply with this protocol, the splint provided must be robust enough for daily living requirements and must not cause complications which are intolerable to the patient. In this study, there was no significant difference in the outcomes achieved in the 3 trial splints; however, the custom-made thermoplastic splint was significantly less likely to result in complications that lead to treatment failure thus supporting its use in the treatment of mallet finger."	High dropout rate. Data suggests mallet finger splints should be designed to accommodate daily living and thus enhance compliance as these splints must be worn continuously for 6-8 weeks. Data found no extensor lag difference or pain or satisfaction between the three splints. Stack and dorsal splints had high treatment failure rates.
Tocco 2013 RCT No sponsorship or COI.	6.0	N = 57 (35 males, 22 females) with closed mallet fingers (60 fingers total); Mean age 45.	Low temperature thermoplastic lever-type orthosis group (LTTP) (N=30; 30 fingers) Vs. Quickcast orthosis group (QC) (N=27; 30 fingers) Both groups wore allocated orthotic 24 hours a day. Follow up at 3-4 weeks, 6-8 weeks, 7-9 weeks, 8-10 weeks, 10-12 weeks, 12-14 weeks and 24-28 weeks.	At 12 weeks follow up (follow up 5), the LTTP group had significantly higher extensor lag than the QC group, (p=0.05). The QC group had significantly higher average active extensions of 5 degrees or more compared with the LTTP group, (p=0.05). Success rates were higher in the QC group compared with LTTP group and approached significance; 60% vs. 81%, (p=0.08).	"The findings of this study demonstrate that full-time immobilization with QC of Type 1 mallet fingers was more effective than the traditional approach of fabricating an LTTP orthosis and instructing the patient to remove it daily for skin care."	Relatively small sample size. Compliance difficult to assess. Group instructions were different. Data suggest LTTP group had significantly greater extensor lag than QC subjects at 12 weeks and age and amount of edema negatively impacted D/P extensor lag.

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Pike 2010 Randomized clinical trial Sponsored by the Canadian Orthopedic Association. No COI.	5.5	N = 77 (51 males, 26 females) with acute mallet finger; Mean age 43.	Dorsal aluminum (with padding) splint group (N=26) Vs. Volar aluminum splint (without padding) group (N=27) Vs. Custom thermoplastic with circumferential coverage splint group (N=24) All groups received 6 weeks of treatment. No overnight splinting required. Follow up at 7 weeks, 12 weeks and 24 weeks.	No statistically significant differences reported between groups for radiographic lag differences or improved outcomes at follow ups.	"No lag difference was demonstrated between custom thermoplastic, dorsal padded aluminum splint and volar padded aluminum splinting for Doyle I acute mallet fingers. Clinical measurement overestimates true lag in mallet injuries. Increased lag occurs after discontinuation of splinting. Increased age and complications correlate with worse radiographic lag."	Data suggests comparable efficacy as no lag differences were observed between the three splint types. Data suggests increased lag occurs after the splint is discontinued.
Warren 1988 RCT No mention of sponsorship or COI.	5.0	N = 114 (73 males, 41 females) with mallet finger; Mean age 46.1.	Stack splint group (N=58) vs. Abouna splint group (N=49) Splints worn continuously for 6 weeks, then nightly for 2 weeks Follow up at 6 and 10 weeks.	Successes: Stack vs. Abouna splint: 19/58 (33%) vs 19/49 (39%) (NS); 20/70 (28.6%) without vs 17/33 (51.5%) with bony injury; Ages 10-39: 23/38 (60.5%); ages 40-79: 15/69 (21.7%)	"The two splints were equally effective, producing a cure or a significant improvement in approximately 50% of cases. However, the Stack splint was much preferred by the patients, who found it more comfortable, more robust and easier to keep clean."	Type of splint appears immaterial. Overall healing rates were somewhat low. Lack of fracture and increased age predict worse prognosis.
Maitra 1993 RCT No mention of sponsorship or COI.	4.0	N = 60 (37 males, 23 females) with mallet finger; Mean age 44.5 ± 16.6.	Aluminum splint group (N=30) vs. Stack splint group (N=30) All splints worn continuously for 6 weeks, then nightly for 3 weeks. Follow up at 3, 6 and 9 weeks.	Success rates 37% vs. 33% (NS); skin complications aluminum vs. stack splint: number of fingers with skin complications: 6.6% vs. 33%; dorsal ulcer: 3% vs. 10%; skin maceration: 3% vs. 20%	"Both splints were equally effective in correcting the deformity but the aluminium [KH1] alloy splint was able to be fitted to a wider variety of finger shapes and sizes and caused significantly fewer skin complications."	Both splints equally efficacious. Fewer skin complications with aluminum splint.
Splint vs. Surgical Fixation						

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Auchincloss 1982 RCT No mention of sponsorship or COI.	4.0	N = 41 (29 males, 22 females) with mallet finger injuries; Mean age 41.	Kirschner wire percutaneous fixation (6 weeks) group (N=19) vs. Pryor and Howard splint (6 weeks) (N=22) Follow up fourteen to eighteen months after injury.	K-wire group vs P&H splint group: Normal function: 19/19 (100%) vs. 20/22 (90.9%). Good objective results: 11 (57.9%) vs. 11 (50%). Unchanged objective results: 1 (5.3%) vs. 4 (18.2%)	"Trial showed no particular advantage for either method, but suggested that patients presenting after some delay may achieve better results after internal fixation."	High dropout rates preclude strong conclusions.
Displaced Fractures - Fixation						
Toker 2015 RCT No sponsorship or COI.	4.0	N = 22 (17 males, 5 females) with mallet fractures; Mean age 32.	Extension block pinning group (N = 16) vs Open reduction and hook plate fixation group (N = 6) Mean follow up 13 months.	No significant differences reported between groups at follow up for VAS, mean extensor lag or mean flexion. Extension block pinning found to be more cost-effective than hook plate fixation.	"Extension block pinning and open reduction hook plate fixation comparable in efficacy.The cost of open reduction and plate fixation was higher than that of extension block pinning. This difference would be even higher if plate removal is required."	Small sample (N=22). Data suggest similar efficacy between extensor block pinning versus open reduction for mallet fractures and pinning more cost effective than open reduction.

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Flexor Tendon Entrapment (Tenosynovitis and Trigger Digit)

Diagnostic Criteria

The diagnosis of flexor tendon entrapment is clinical. Patients without triggering will typically have only focal A1 pulley tenderness with or without a tendon nodule. Patients with triggering can usually demonstrate the triggering for the examiner.(36, 40)

Special Studies and Diagnostic and Treatment Considerations

There are no special tests that are typically performed.(36, 40) X-rays are usually not helpful. The threshold for testing for confounding conditions such as diabetes mellitus, hypothyroidism and connective tissue disorders should be low particularly to prevent other morbidity.(36, 40)

Evidence for the Use of Diagnostic Studies
There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Flexor Tendon Entrapment, Tenosynovitis, Trigger Finger Disorder, X-Rays, diagnostic, diagnosis, sensitivity, specificity, positive predictive value, negative predictive value, and predictive value of tests, efficacy, and efficiency. We found and reviewed 5 articles in PubMed, 24 in Scopus, 0 in CINAHL, 0 Cochrane Library, and 195 from Google Scholar. We considered for inclusion 0 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 0 from Google Scholar, and 0 from other sources. Zero articles met the inclusion criteria.

Initial Care

The initial care for this condition is not well defined. As quality evidence for efficacy of other interventions is lacking and success of injections is strong, arguably, the initial management should be glucocorticosteroid injection(39) in contrast with most other potentially occupational MSDs where non-invasive treatments are initially indicated.

SPLINTS

Recommendation: Splints for Select Cases of Acute, Subacute, or Chronic Flexor Tendon Entrapment
Splints are recommended for treatment of select cases (i.e., patients who decline injection) of acute, subacute, or chronic flexor tendon entrapment.

Strength of Evidence **– Recommended, Insufficient Evidence (I)**
Level of Confidence – Low

Rationale for Recommendation
There is one moderate-quality RCT evaluating the use of two different splints for flexor tendon entrapment with no apparent differences in outcomes between the types of splints.(1052) Historically splints were widely used for treatment of trigger digits;(27, 36, 40, 1053) however, prior to the advent of glucocorticosteroid injection, the lack of successful treatments often resulted in surgery. Splints have been used to treat trigger digits(27, 36) and they may be reasonable intervention for patients who decline injection, although it is recommended that patients be educated that the use of splints appears substantially less successful than injections (or surgery).

Evidence for the Use of Splints
There is 1 moderate-quality RCT incorporated into this analysis.(1052)

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A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Splints**,** Flexor Tendon Entrapment, Tenosynovitis, Trigger Finger Disorder, controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 20 articles in PubMed, 21 in Scopus, 5 in CINAHL, 1 in Cochrane Library, and 2130 from Google Scholar. We considered for inclusion 1 from PubMed, 1 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 1 from Google Scholar, and 0 from other sources. Of the 3 articles considered for inclusion, 1 randomized trials and 1 systematic studies met the inclusion criteria.

Author/Year Study Type Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Tarbhai 2012 RCT Supported by University Health Network Allied Health research fund.	4.0	N = 30 (17 females, 13 males) with trigger digit. Mean age 63.4 years.	MCP Group: metacarpophalangeal joint blocking splint (n = 15, 15 digits) vs. DIP Group: distal interphalangeal joint blocking splint (n = 15, 17 digits). Follow-up 3 and 6 weeks.	At 6 weeks, MCP group 77% success rate vs. 47% in DIP group, and slight decrease in grip strength; 4/13 MCP vs. 3/15 DIP (p >0.05). No identified functional limitations. No significant difference in pain intensity, severity of triggering, frequency of triggering, functional limitations (p >0.05).	"Initiating conservative treatment with the MCP joint blocking splint has value for patients with trigger finger and positive outcomes in 77% of subjects, whereas use of the DIP joint splint was effective in about half of subjects."	Small sample. Trends towards different severity at baseline in outcome measures. Data suggest increase comfort with MCP joint blocking splint but both groups showed significant improvement at 6 weeks maintained for 1 year. Data do not show substantive differences between types of splints.

Follow-up Visits

Follow-up visits are generally limited unless complications arise. Success of injections is usually high, thus 1 or 2 follow-up appointments are typical. Post-surgical outcomes for minimally invasive approaches are similarly excellent and necessitate few, if any follow-up appointments beyond 1 or 2. Additional appointments are required for complicated courses.

Medications

There are no quality studies on use of medications for this condition, although some have recommended NSAIDs.(36) Medications are generally not required as the condition is generally not substantially painful. NSAIDs may be a reasonable option to control pain; however, injections appear to be superior interventions. NSAIDs may be a more appropriate intervention for those who decline initial injection.

Evidence for the Use of Medications
There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Flexor Tendon Entrapment, Tenosynovitis, Trigger Finger Disorder, Anti-Inflammatory Agents, Non-Steroidal, non-steroidal anti-inflammatory, NSAIDS; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 12 articles in PubMed, 2 in Scopus, zero in CINAHL, one in Cochrane Library, 5730 in Google Scholar, and zero from other sources. We considered for inclusion 1 from PubMed, zero from Scopus, zero from CINAHL, zero from Cochrane Library, one from Google Scholar, and zero from other sources. Of the articles considered for inclusion, 1 randomized trial and 1 systematic studies met the inclusion criteria.

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Physical Methods/Rehabilitation

EXERCISE

Exercise is not generally indicated acutely and most patients with flexor tendon entrapment do not require an exercise program. For patients with residual deficits, particularly post-operatively, see section on Post-Operative Rehabilitation and Rehabilitation of Patients with Functional Deficits: CTS and Other Disorders.

Evidence for the Use of Exercise

There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: exercise, exercising; flexor tendon entrapment, trigger finger disorder, trigger thumb, trigger digit, thumb, thumbs, digit, digits; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 2 articles in PubMed, 0 in Scopus, 0 in CINAHL, 1 in Cochrane Library, 12,060 in Google Scholar, and 0 from other sources. Zero articles met the inclusion criteria.

Injections

GLUCOCORTICOSTEROID INJECTIONS

Recommendation: Glucocorticosteroid Injections for Acute, Subacute, or Chronic Flexor Tendon Entrapment

Glucocorticosteroid injections are s**trongly recommended for treatment of acute, subacute, or chronic flexor tendon entrapment.**

Indications – Triggering digit or symptoms of pain over the A-1 pulley thought to be consistent with stenosing tenosynovitis. Injection at the first appointment may be the most appropriate initial intervention.(39)

Dose – Optimal dose is unknown. Quality studies have included betamethasone 6mg,(38, 1054) depot preparation of methylprednisolone 20mg;(1055) and triamcinolone 1mL(1056) most of which were generally combined with an anesthetic. However, there are no quality comparisons of doses and the need for topical anesthetic is untested in quality studies. Subcutaneous injection over the A-1 pulley appears as efficacious as attempted intrasheath injection.(1057)

Frequency/Duration – A single injection and results evaluated to document improvement. Ultrasound-guidance is not shown to be helpful.(1079) (Cecen 15)

Indications for Discontinuation – If a partial response, consideration should be given to repeating the injection, typically at a modestly higher dose.

> *Strength of Evidence* – **Strongly Recommended, Evidence (A)**
> *Level of Confidence* – High

Rationale for Recommendation

There are 2 high-quality and 2 moderate-quality studies incorporated into this analysis.(38, 1075-1077) Glucocorticosteroid injection(s) are the most commonly used intervention for trigger digits.(39, 40) Quality studies have reviewed attempts to inject along the tendon, although a moderate-quality study failed to find superior results among the group with an attempt to inject within the sheath(1078) and a low-quality study performed subcutaneous injections that were efficacious.(1080) Further, ultrasound guidance has not been found to improve the results. (Cecen 15) It has been suggested that many injections are performed along, rather than within the sheaths(1081) and thus it may not matter how precisely these injections approximate the target tissue. Multiple studies have consistently demonstrated efficacy of these injections compared with placebo with estimates of success typically exceeding 80%.(31, 38, 1075-1077, 1082-1090) Two studies compared injection with surgery, but the recurrence rates while lower with surgery still showed strong efficacy of injection (0% vs. 11% recurrence(1090) and 0% vs. 14%.(1089) They are less effective in diabetics, although still are effective(38) and there is weak evidence that patients failing other medical treatments may respond at lower rates of approximately

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60%.(280) These injections are minimally invasive, have low adverse effects, and are moderate cost. Some caution is warranted regarding repeated administrations with adverse effects including atrophy that generally recovers over time. Nevertheless, quality studies have documented their efficacy and thus, they are strongly recommended.

Evidence for the Use of Glucocorticosteroid Injections for Flexor Tendon Entrapment
There are 2 high-(38, 1075) and 12 moderate-quality RCTs incorporated into this analysis.(1076, 1077, 1079, 1086, 1089-1096) (Jianmongkol 07; Cecen 15)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Glucocorticosteroid injection/ flexor tendon entrapment, trigger finger disorder, trigger thumb, trigger digit, tenosynovitis; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 31 articles in PubMed, 36 in Scopus, 0 in CINAHL, and 0 in Cochrane Library. We considered for inclusion 18 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 0 from Google Scholar, and 0 from other sources. Of the 18 articles considered for inclusion, 13 randomized trials and 3 systematic studies met the inclusion criteria.

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Author/Year Study Type Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Corticosteroid Injection vs. Placebo						
Baumgarten 2007 RCT Sponsored by Orthopaedic Research and Education Foundation (OREF). One or more authors received funding and grants.	9.0	N = 59 (37 female/22 male) with diabetes mellitus. Age nondiabetic/ diabetic and diabetic placebo groups: 63.1±11.7/ 62.9±9.00/61.4 ±9.12.	1ml (6mg) of betamethasone sodium phospate/acetate and 0.5ml (5mg) of 1% lidocaine vs 0.5ml (5mg) of 1% lidocaine and 1ml sterile saline	Non-diabetics: 22/29 (75.9%) responded to 1 injection; 6 required 2nd injection; 86% responded to 1 or 2 injections. Diabetics: 11/19 (57.9%) responded to 1 injection; 63.2% to 1 or 2 injections. Results after 2nd injection significant.	"Corticosteroid injections were significantly more effective in the digits of nondiabetic patients than in those of diabetic patients. In patients with diabetes, corticosteroid injections did not decrease the surgery rate or improve symptom relief compared with the placebo."	Glucocorticosteroids also effective in diabetics, though less effective.
Murphy J Hand Surg 1995 RCT No mention of sponsorship or CTO.	8.0	N = 24 (15 female/9 male) with primary TF; average age 56 years.	1mL of celestone (6mg) plus 3mL 1% lidocaine vs. 4mL 1% lidocaine only in the placebo group	At 3-week follow-up: steroid group 10/14 (71.4%) vs. 2/10 (20%) asymptomatic. 4-month follow-up, 9/14 (64.3%) vs. 2/10 (20%) asymptomatic (p <0.05).	"Since the treatment was well tolerated by patients and without complications, it is reasonable to offer steroid and lidocaine injection as the initial treatment for primary TF."	Modest sample size and intermediate-term follow-up.
Lambert 1992 RCT	6.0	N = 41(16 males, 25 females)	20mg methylprednisolone acetate plus lignocaine vs. 0.05ml 1% lignocaine injection.	Steroid group success rate 12/20 (60%) vs. 3/16 (18.8%) for placebo (p <0.02).	"Our prospective, controlled, double-blinded trial shows that steroid injection is a satisfactory treatment for trigger finger in 60% of patients. There were no complications and success rate may be even better if repeat injections are used."	Depot preparation may have unblinded the treating physician.
Peters-Veluthaman-ingal 2008 RCT	6.0	N = 50 (22 males, 28 females)	1ml triamcinolonacetonide (TCA) injection vs. 0.9 % NaCl.	Immediate reductions in triggering were 13/24 (54.2%) vs. 6/22 (27.3%), p = 0.053. Pain scores significantly improved with TCA (p <0.0005); 80% TCA group improved at 12 months.	"Local injection with triamcinolone-acetonide is effective and safe for treating trigger fingers as compared to placebo injection. The effects of steroid injections last up to 12 months."	Mean symptoms duration differ at baseline and favored placebo (7 vs. 24 weeks, p = 0.023).

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Injection vs. Other Treatments						
Goldfarb 2007 RCT No mention of study sponsorship. No COI.	7.5	N = 125 (88 trigger finger and 37 de Quervains tenosynovitis). Mean age 59.	Group 1: Injection of steroid, lidocaine, bupivacaine alone (standard injection, acidic pH) (n = 57) vs. Group 2: Injection of steroid, lidocaine, bupivacaine, bicarbonate (balanced injection, neutral pH) (n = 68). Follow-up for 6 weeks.	Both injections provided significantly immediate pain relief reflected in VAS scores (p <0.001). No significant difference between groups for pre-injection VAS (p = 0.89). Group 2 lower VAS scores than group 1 on each of first 7 days. But, differences in VAS scores between groups only significant at days 5, 6, and 7 (p = 0.4 on each day).	"Patients respond to extra-articular steroid injections with gradual improvement over the course of the first week…A pH-balanced injection did not significantly decrease the risk of a flare reaction."	Data suggest an extra-articular steroid injection gradually benefits patients over first week with about 1/3 of patients reporting a flare response in the days following the injection. A pH-balanced injection did not significantly decrease risk of flare response.
Zyluk 2011 RCT No mention of sponsorship. No COI.	5.5	N= 105 trigger digits in 95 patients (28 males, 67 females) with trigger finger. Mean age was 56 years.	Surgery Group: A1 pulley release (n = 43 patients, 46 digits) vs. Injection Group- Steroid injection of 1ml 2% plain lidocaine (n = 52 patients, 59 digits). Follow-up at 1 and 6 months.	At 1 month, surgery group significantly lower active ROM of fingers vs. injection group: 264 vs. 270 (p <0.05). Also significantly weaker in surgery group: 85% vs. 99% (p <0.05). No significant differences with regards to other parameters. At 6 months 11% recurrence rate in injection group vs. 0% in surgery group (p = 0.005). At 6 months, surgery group showed significantly lower VAS score; 0.4 vs. 1.3 (p <0.05) and significantly worse ROM: 265 vs. 270 (p <0.05) vs. injection group.	"We conclude that percutaneous A1 pulley release is more effective medium-term therapy for trigger digit than steroid injection, because of lower risk of recurrence."	Data suggest percutaneous A1 pulley release is better than steroid injection for trigger finger due to lower risk of recurrence (11% vs. 0%). Pain (VAS) was 0.4 in pulley release group vs 1.3 in steroid group at 6 months, and ROM varied only 5 degrees.
Sato 2012 RCT No mention of sponsorship. No COI.	5.0	N = 137 patients (18 males, 132 females) with 150 trigger fingers. Mean age 54.4 years.	Open: Conventional open surgery of A1 pulley (n = 56) vs. injection: 2ml of methylprednisolone acetate 40mg at site corresponding to A1 pulley (n = 49) vs. Percutaneous: percutaneous release of A1 pulley (n = 45). Follow-up after 1, 2 weeks and 1, 2, 4, and 6 months.	Cure of trigger finger (N): open 56 vs. 1 injection 28 vs. 2 injections 42 vs. percutaneous 45 (p = 0.004). Topical pain (N) open vs. injection vs percutaneous: 1 week 38 vs. 9 vs. 30 (p = 0.000); 2 weks 36 vs. 9 vs. 30 (p = 0.000); 1 month 22 vs. 5 vs. 15 (p = 0.008); 2, 4, and 6 months (p = NS). Joint pain (N) open vs. injection vs percutaneous: 1 week 17 vs. 3 vs. 13 (p = 0.014); 2 weeks 18 vs. 3 vs. 12 (p = 0.023); 1 month 15 vs. 3 vs. 13 (p = 0.029); 2, 4, and 6 months (p = NS). Total active motion (TAM) average open vs. injection vs. percutaneous: 1 month 176.41 vs. 207.18 vs. 201.76 (p = 0.012); 2 months 184.89 vs. 208.53 vs. 207.78 (p = 0.048); 4 months and 6 months (p = NS).	"The levels of effectiveness of open surgical and percutaneous methods were superior to the conservative method of using CSs based on the cure and reappearance rates of the trigger."	Data suggests comparable efficacy between percutaneous and open surgery and both invasive techniques were superior injection to treat trigger finger. Yet recurrence rates were 0% (open/percutaneous) vs. 86% 1-2 injections.
Ring 2008 RCT Sponsored by AO Foundation, Wright Medical, Joint Active Systems, Smith and Nephew,	4.0	N = 84 (44 males, 40 females) with idiopathic trigger finger. Mean age: dexamethasone= 63 years,	Dexamethaxone 4mg/ml (n = 40) vs. Triamcinolone 10mg/ml (n = 44). Follow-up at 6 weeks and 3 months after their initial injection.	NS between groups at 6 weeks for average DASH score (p = 0.43) and 3 months (p = 0.61). Absence of triggering rate at 6 weeks: triamcinolone 22 of 35 patients vs. dexamethasone 12 of 32 patients (p <0.05).	"Although there were no differences 3 months after injection, our data suggest that triamcinolone may have a more rapid but ultimately less durable effect on idiopathic	Data suggest at three months there were no differences between groups although triamcinolone acted fester but its effects wore off quicker than dexamethasone.

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Small Bone Innovations, and Biomet. No mention of COI.		triamcinolone= 65 years			trigger finger than does dexa-methasone."	
Shakeel 2012 RCT No sponsorship. No COI.	4.0	N = 100 patients (30 males, 70 females) clinically diagnosed with trigger digits at least grade 2 by Quinnell and without previous treatment of trigger digit. Mean age 57 corticosteroid group; 58 NSAID group..	20 mg triamcinolone acetonide (n = 50) vs. 12.5mg diclofenac sodium injection (n = 50). Follow up at 3 weeks and 3 months after injection.	Mean improvement in Quinnel grading corticosteroid vs. NSAID: 3 weeks 1.8 vs. 0.9 (p = 0.002); 3 weeks to 3 months 0.3 vs. 0.8 (p = 0.002).	"We concluded that, although steroids gave quicker relief, NSAID injections are equally effective at 3 months in the treatment of trigger digits. We were unable to detect a statistically significant difference in the response of patients with and without diabetes to either treatment"	Data suggest steroids act faster, but at 3 months, NSAIDS equally effective.
Callegari 2011 RCT Supported by IBSA Institut Biochimique SA, Pambio-Noranco, Switzerland. No COI.	4.0	N = 30 with ultrasound-confirmed diagnosis of trigger finger; mean age 52.5 years	Group A: ultrasound-guided injection of methylprednisolone acetate (40mg/mL) with 0.8mL lidocaine with 1mL hyaluraonic acid 0.8% 10 days later (n = 15) vs. Group B: open surgical release 1st annular pulley (n = 15). Follow-up for 12 months.	At 6 months complete symptom resolution seen in 14/15 (93.3%) in group A. All 15 in group B achieved complete resolution of impairment by 3 weeks after surgery, but 10 needed PT to reach complete resolutions of symptoms approximately 30-40 days after surgery. No significant differences between groups for VAS, DASH< and SVAS scores, (p >0.05).	"…the results of this explorative study suggest that ultrasound-guided injection of a corticosteroid and hyaluronic acid could be a safe and feasible approach for the treatment of trigger finger."	Open label study with small sample size. Data suggest US guided injection of corticosteroid and HA may be appropriate for trigger finger, but larger study required to confirm preliminary results.
Pataradool 2011 RCT No mention of sponsorship. No COI.	4.0	N = 40 with primary trigger fingers; mean age 57.5 years	CI Group: conventional injection technique 0.1% triamcinolone acetonide 1ml and 1% lidocaine hydrochloride without epinephrine 1ml (n = 20) vs. P1I Group: Proximal phalanx injection technique (n = 20). Follow-up 3 months	At final follow-up, mean VAS score 7.3 in CI group vs. 3.2 in P1I group. Difference significantly lower in P1I group (p <0.001). Rise of recurrent symptoms occurred in both groups at 3 month follow-up, 3/20 (15%) in CI group and 5/20 (25%) in P1I group. Difference not statistically significant (p >0.05).	"We concluded that the P1I technique is less painful than the CI technique without any significant difference in recurrence rate between the two groups at three months follow-up."	Data suggest P1I less painful than CI, but complication, recurrence rates and general outcome measures comparable.
Intrasheath Glucocorticosteroid Injection vs. Subcutaneous Injection						
Taras 1998 RCT	6.0	N = 95 patients (37 males, 58 females) with	Intrasheath glucocorticosteroid injection vs. subcutaneous injection	Intrasheath complete in 19/55 (37%), 24/55 (46%) partial, 9/55 (17%) no evidence of intrasheath injection. Intrasheath group overall: 27/52 (52%) good, 10/52 (19%) fair,	"The results of this study suggest that true intrasheath injection offers no apparent	Evidence suggests subcutaneous injections may be superior. Intrasheath injections

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		107 trigger digits	along sheath (betamethasone acetate suspension 6mg with 0.5mL 1% lidocaine with Omnipaque)	15/52 (29%) poor results. Complete intrasheath injection 47% good, 16% fair, 37% poor. Partial injection 50% good, 17% fair, 33% poor. Subcutaneous injection 70% good, 11% fair, 19% poor. Subcutaneous group: 39/55 (71%) good, 4/55 (7%) fair, 12/55 (22%) poor results.	advantage over subcutaneous injection in the treatment of trigger digits."	usually not completely successful. Excluded those >6 months duration, and diabetes.
Jianmongkol 2007 RCT No mention of sponsorship or COI.	4.5	N=103 trigger fingers (14 males, 87 females) CI Technique mean age was 53.68. MAI Technique mean age was 52.19.	Conventional technique of injection (CI technique) N=53, 23 thumb, 5 index, 13 long, 12 ring Vs. Mid-Axial injection technique (MAI technique) N=48, 21 thumb, 4 index, 15 long, 8 ring Follow-up at 1, 3, and 6 weeks.	After insertion of injections the mean pain score for the MAI technique group was 40.19 and the mean pain score for the CI technique group was 48.39. No statistical significance in mean paracetamal count during follow up periods for both groups. Chi-squared test revealed a score of 5.7 with statistical significance of p<0.05 for both groups. In CI technique group, two fingers had recurrent symptoms and no recurrent symptoms in the MAI technique group.	"In conclusion, the injection technique by Carlson and Curtis' approach can provide the good results of treatment and there were no complications from the injection. The technique can be easily used and safe for injection in the primary trigger finger."	Sparse methodological details. Baseline comparability is questionable. Data suggest MAI technique had less reported post injection pain associated with procedure compared to CI technique. But at 6 weeks there were no differences in reported VAS pain scores.
Ultrasound-Guided injection						
Cecen 2015 RCT No mention of sponsorship. No COI.	4.5	N=74 patients (15 males, 55 females) with persistent or increasing symptoms of a single trigger digit. Blinded group average age 54.31±10.96. Ultrasound group average age was 55.60±11.63.	Ultrasound-guided group (USG) N=37 Vs. Blinded group (BIG) N=37 Follow up at 6 weeks and 6 months.	Of the 35 patients treated in BIG, 29 responded to a single corticosteroid injection and 6 required a second injection. Thirty-two of the 35 USG group responded to a single injection and 3 required a second injection. There was no significant difference between BIG and USG for requirement of second injection (p>0.05). Both groups showed significant improvement in Quinnell grades, but no significant improvement between the pre-steroid, post-steroid 6 week, and post-steroid 6 month scores. Both groups showed significant improvement in VAS scores. BIG VAS scores decreased from 4.80 to 1.5 at 6 weeks and 0.5 after 6 months. USG VAS scores decreased from 4.7 to 1.6 at 6 weeks and to 0.5 after 6 months. VAS in each group showed significant reduction. (p<0.01).	"In conclusion, corticosteroid injection can be recommended as a sound, low-risk primary treatment option for trigger finger, which can be given in an office setting, as a low-cost procedure. The use of ultrasound-guided injection of corticosteroid may be associated with extra time and effort, and seems to have no superior clinical benefits compared to the blinded technique."	Higher rate of diabetics in BIG group and more females in USG group. Data suggest non superiority of US guided injections (USG) versus blinded injections (BIG).

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Surgery

Recommendation: Surgery for Persistent or Chronic Flexor Tendon Entrapment

Open release for persistent or chronic flexor tendon entrapment is moderately recommended. Percutaneous release is also a reasonable option.(1074)

Indications – Triggering digit or symptoms of stenosing tenosynovitis that has been unresponsive to at least 1 glucocorticosteroid injection, or with an inadequate response. Those without any response should be evaluated carefully for possible alternate conditions. Adjunctive surgical treatment with glucocorticosteroid injection could be considered, although that evidence relies on a single moderate-quality study.(1075)

Strength of Evidence – **Moderately Recommended, Evidence (B)**
Level of Confidence – High

Rationale for Recommendation

Both open (with a scalpel) and percutaneous (with a needle through the skin) releases are performed with evidence both are effective.(1099) Evidence is strong that percutaneous release is as effective, if not more effective than open release,(271, 1089, 1090, 1097, 1100-1105) (Gilberts 01) is faster to perform, requires fewer resources,(1097, 1104) involves less pain, and results in faster recovery.(1097) Failures are believed to be due to incomplete release of the A-1 pulley.(1106) There are concerns, however, that particularly in inexperienced hands, lacerations of digital nerves, arteries, and other structures and other complications have been reported with the percutaneous technique. The thumb appears more prone to these complications. A moderate-quality study attempted to identify which third of the pulley was responsible for triggering; however, failures occurred in all surgical groups regardless of which third of the pulley was released.(1106) A low-quality case series suggested repeat percutaneous release was reasonable for treatment of incomplete releases,(1107) although open release has been favored for percutaneous failures. One moderate-quality study compared injections with percutaneous release combined with glucocorticosteroid injection and reported surgical release was superior,(1098) although the success rates were both lower than other reports. Surgical release is invasive (though less invasive with percutaneous release),(1108) has low adverse effects, but is costly. For those patients failing glucocorticosteroid injection(s), surgery is recommended.

Evidence for Surgery for Flexor Tendon Entrapment

There are 10 moderate-quality RCTs incorporated into this analysis.(1090, 1091, 1097, 1098, 1102, 1103, 1106, 1108-1110) (Pegoli 08)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: flexor tendon entrapment, trigger finger disorder, trigger thumb, trigger digit, tenosynovitis Surgery, Open release surgery, percutaneous release surgery; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 147 articles in PubMed, 13 in Scopus, 8 in CINAHL, 23 in Cochrane Library, 570 in Google Scholar, and 3 from other sources. We considered for inclusion 5 from PubMed, 0 from Scopus, 0 from CINAHL, 1 from Cochrane Library, 1 Google Scholar, and 3 from other sources. Of the 10 articles considered for inclusion, 10 randomized trial and 0 systematic studies met the inclusion criteria.

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Author/Year Study Type Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Percutaneous Release with Steroid Injection vs. Steroid Injection						
Maneerit 2003	5.5	N = 115 patients with idiopathic trigger thumbs	Percutaneous release with steroid injection vs. steroid injection alone.	Surgical results satisfactory in 59/65 (90.8%) treated surgically vs. 28/60 (46.7%) treated with injection, p = 0.001. No significant differences in pain ratings or paracetamol tablets required post-procedure. After 2nd injection, success rate 56.7% for injections.	"We conclude that percutaneous trigger thumb release combined with steroid injection has a higher success rate than that of steroid injection alone."	Success rates, especially in injection arm, low compared with other quality evidence raising questions about subject selection/other issues. No mention of gender.
Open vs. Percutaneous Release						
Gilberts 2001	5.5	N = 96 patients (56 males, 44 females)	Open surgery vs. percutaneous surgery.	Open vs. percutaneous release – Operative time 11 vs. 7 minutes, p <0.0001. Mean post-op pain 5.7 vs. 3.1 days, p = 0.039. Motor recovery 18 vs. 7 days, p <0.002. Return to work 7.5 vs. 3.9 days, p <0.001. Complications 3 vs. 2. Success rate 98 vs. 100%, NS	"We conclude that percutaneous correction of trigger digits is a quicker procedure, is less painful, and shows significantly better results in rehabilitation than open surgery."	All measures favored percutaneous release. Discrepancy with patient number and gender.
Bamroongshawgasame 2010 RCT No mention of sponsorship or COI.	4.5	N= 142 patients (58 males, 84 females) with 160 trigger fingers. Mean age was 47.4 years.	Open Group: Open release surgery (n = 70/ 80 digits) vs. Percutaneous group (n = 72/80 digits). Follow-up 3 and 6 weeks.	Mean time of open surgery 2.2 mintes; percutaneous 1.8 minutes (p> 0.05). Post-op patient satisfaction scores similar at weeks 3 and weeks 6 (p> 0.05). Percutaneous surgery group had lower mean pain score vs. open group at weeks 1, 2, 3 and 4.	"Percutaneous trigger digit surgery using the full handle knife 45° is effective and safe, and results functional outcomes equal to those with open trigger digit surgery."	Data suggest comparable efficacy between open and percutaneous release in trigger digits
Dierks 2008 RCT No mention of sponsorship or COI.	4.5	N= 36 patients (16 males, 20 females) with trigger finger. Mean age was 62.9 years	Open group- Open surgical release of the A-1 pulley (n = 16) vs. Percutaneous group- percutaneous release of A-1 pulley (n = 20). Follow-up at 1 and 12 weeks.	Both groups showed decrease in pain level, but no significant difference between groups (p >0.05). Mean surgery time 26 s in percutaneous group; 4 minutes 17 s open group (p <0.05). Active ROM of PIP joint significantly lower open group at 1 week; 81 vs. 95 (p <0.05). No significant difference for ROM at 12 weeks.	"Because of lower costs and quicker procedure with equal functional outcome when compared with open surgery, we recommend the percutaneous technique using a L15 blade for trigger finger release."	Sparse methodological details. Data suggest percutaneous release of A1-pulley for stenosing tendovaginitis as it is quicker, less costly and has comparable efficacy to surgery.
Pegoli 2008 RCT	4.0	N=200 patients (60 males, 140 females)	Group A-open surgical release of the A-1 pulley (N=100) Vs.	Three patients in Group A reported dyesthesia for 10 days that resolved and 8 patients from Group B reported dyesthesia for 6 days that resolved. The sum of excellent and good results	"The main complaint of the patients after an open trigger finger release is a discomfort at the incision site. In this prospective study,	Sparse methodological details. Data suggest the endoscopic procedure showed faster recovery at all times of evaluation (7

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No mention of sponsorship or COI.		with a trigger finger. Mean age was 58.5 years.	Group B-endoscopic surgical release of the A-1 pulley (N=100) Follow-up pre-operatively and at 7, 30, and 90 days post-operatively.	(questionnaire) at 90 days post-operation was similar for both groups with a prevalence of excellent results in Group B. A higher difference in results was observed at 30 days post-operation. Group B showed faster recovery. Aesthetic appearance of incision site had significant statistical analysis (p<0.001) with a variable percentage of 30% between the groups and pain under load (p<0.017)	we compared the two consecutive groups of patients with trigger fingers. One was treated by an open approach and the other by the endoscopic release of the A1 pulley. Pre- and post-operative evaluation at seven, 30 and 90 days showed a faster recovery from the discomfort with a faster return to daily and working activities, after the endoscopic procedure."	days, 30 days & 90 days) compared to open procedure although surgical times for both procedures are similar.
Sectioning Different Thirds of the A1 Pulley						
Topper 1997	4.5	N = 19	Proximal and middle one-third vs. Distal one-third.	"In all 19 patients, a partial resection of the first annular pulley resulted in continued clinical triggering with active digital flexion. At this point, a standard complete first annular pulley release was performed, with resolution of clinical triggering of the involved digit in all patients."	"We conclude that there is no "critical third" of the first annular pulley responsible for clinical digital triggering."	Suggests release of the entire pulley is preferred treatment. No mention of gender.
Topical Anesthesia vs. Lidocaine Injection						
Yiannakopoulos 2006 RCT	5.5	N = 50 patients (20 males, 28 females) with trigger finger syndrome	EMLA anaesthesia vs 3ml lidocaine 1%	Visual analogue pain scale EMLA vs Lidocaine: VAPS: 0 vs. 5.96±2.41 (p <0.05); Patient Satisfaction: 4.6±0.2 vs. 4.4±0.3 (NS)	"Percutaneous trigger finger release can be performed as an office procedure with the use of EMLA avoiding the use of injectable local infiltration anaesthesia."	EMLA requires 2-3 hours for effectiveness potentially resulting in NS satisfaction scores despite marked differences in pain scores. *The number of males and females compared to the groups does not add up.
Injection vs. Surgical Release						
Zyluk 2011 RCT No mention of sponsorship. No COI.	5.5	N= 105 trigger digits in 95 patients (28 males, 67 females) with trigger finger. Mean age was 56 years.	Surgery Group- A1 pulley release (n = 43, 46 digits) vs. Injection Group- Steroid injection of 1ml 2% plain lidocaine (n = 52 patients, 59 digits). Follow-up at 1 and 6 months.	At 1 month, surgery group significantly lower active range of motion of fingers vs. injection group: 264 vs. 270 (p <0.05). Also significantly weaker group in surgery group: 85% vs. 99% (p <0.05). No significant differences with regards to other parameters. At 6 months, 11% recurrence rate in injection group vs. 0% in surgery group (p = 0.005). At 6 months surgery group showed significantly lower VAS score: 0.4 vs. 1.3 (p <0.05) and significantly worse range of motion; 265 vs. 270 (p <0.05) vs. injection group.	"We conclude that percutaneous A1 pulley release is more effective medium-term therapy for trigger digit than steroid injection, because of lower risk of recurrence."	Data suggest percutaneous A1 pulley release is better than steroid injection for trigger finger due to study suggesting a lower risk of recurrence. Pain (VAS) 0.4 in pulley release group vs 1.3 in steroid group at 6 months, and ROM varied only 5 degrees.

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Chao 2009 RCT No mention of sponsorship or COI.	4.5	N= 83 patients (26 males, 57 females,) with 93 trigger thumbs. Mean age was 48.5 years.	Group A- miniscalpel-needle percutaneous release (n = 41, 46 thumbs) vs. Group B: Steroid injection 1ml triamcinolone acetonide (10 mg/ml) injected (n = 42, 47 thumbs). Follow=up at 1 and 12 months	Group A achieved successful release in 93% at 1 month and 86% at 12 months. 45% of thumbs in group B satisfactory at 1 month and 26% were satisfactory at 12 months. The mean percent decrease in pain intensity was significantly higher in group A vs. group B at 1 month; 65.7% vs. 38.4% (p <0.001) and 12 months; 89.4% vs. 6.8% (p <0.001).	"Percutaneous release with a miniscalpel-needle had a higher success rate than steroid injection."	Data suggest percutaneous release via miniscalpel-needle had better efficacy than steroid injection.
Callegari 2011 RCT Supported by IBSA Institut Biochimique SA, Pambio-Noranco, Switzerland. No COI.	4.0	N = 30 patients (20 females, 10 males) with ultrasound -confirmed diagnosis of trigger finger. Mean age was 52.5 years.	Group A: ultrasound-guided injection of methylprednisolone acetate (40mg/mL) with 0.8mL lidocaine with 1mL hyaluraonic acid 0.8% 10 days later (n = 15) vs. Group B: Open surgical release of first annular pulley (n = 15). Follow-up for 12 months.	At 6 months complete symptom resolution observed in 14/15 (93.3%) in group A. All 15 in group B achieved complete resolution of impairment by 3 weeks after surgery, but 10 needed physical therapy to reach complete resolutions of symptoms approximately 30-40 days after surgery. No significant differences between groups for VAS, DASH< and SVAS scores (p >0.05).	"…the results of this explorative study suggest that ultrasound-guided injection of a corticosteroid and hyaluronic acid could be a safe and feasible approach for the treatment of trigger finger."	Open label study with small sample size. Data suggest US guided injection of a corticosteroid and HA may be appropriate for trigger finger, but a larger study is required to confirm preliminary results.

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Extensor Compartment Tenosynovitis (Including de Quervain's Stenosing Tenosynovitis and Intersection Syndrome)

Diagnostic Criteria

These diagnoses are clinical. Patients without triggering will typically have tenderness that is focal over the affected tendon(s) or compartment. Finkelstein's maneuver should be positive.

Special Studies and Diagnostic and Treatment Considerations

There are no special tests that are typically performed for extensor compartment tenosynovitis. X-rays are usually not helpful. The threshold for testing for confounding conditions such as diabetes mellitus and hypothyroidism should be low, particularly to prevent other morbidity. There are reports of MRI findings;(1086-1088) however, the utility of MRI has not been demonstrated in quality studies. Distinguish from de Quervain's.

There is 1 moderate-quality study incorporated into this analysis.(1111) (Chien 01)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: X-Rays, Tomography Scanners, X-Ray Computed, Extensor Compartment Tenosynovitis, De Quervain's Stenosing Tenosynovitis; diagnostic, diagnosis, sensitivity, specificity, positive predictive value, negative predictive value, and predictive value of tests, efficacy, and efficiency. We found and reviewed 13 articles in PubMed, 7 in Scopus, 1 in CINAHL, 0 in Cochrane Library, and 393 from Google Scholar. We considered for inclusion 1 from PubMed, 0 from Scopus, 0 from CINAHL, from Google Scholar, 0 from Cochrane Library and 0 from other sources. Of the 1 articles considered for inclusion, 1 diagnostic study met the inclusion criteria.

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Author/Year Study Type	Score	Number	Area of Spine	Diagnoses	Type of X-rays	CT used	MRI Used	More than on rater	Blinding of rater	Myelography	Surgery Performed	Clinical outcomes assessed	Long term follow-up (mean when noted)	Results	Conclusion	Comments
Chien 2001 Diagnostic No mention of sponsorship or COI.	6.5	N = 45, (11 Men (24%), 34 Women (76%)) with de Quervain tenosynovitis. Mean age, 43 years.	Wrist	de Quervain tenosynovitis confirmed	Not given	-	-	+	+	-	-	+	-	The association between focal radial styloid abnormality and de Quervain tenosynovitis, for both observers, ($p < 0.05$). The areas under the receiver operating characteristic curves for both observer: 0.71 (95% CI, 0.62–0.79%) and 0.76 (95% CI, 0.67–0.84%). The Kappa values for inter observer variability = 0.44 (moderate agreement), and intra observer variability = 0.62 (substantial).	"Focal radial styloid abnormality is an indicator of de Quervain stenosing tenosynovitis of the wrist."	A retrospective review of radiography Showed that focal radial steroid abnormalities to be an indicator of de Quervain stenosing tenosynovitis.

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Recommendation: MRI to Diagnose Extensor Compartment Tenosynovitis
MRI is recommended to diagnose extensor compartment tenosynovitis.

Strength of Evidence – **Recommended**
Level of Confidence – Low

Rationale for Recommendation
There are 2 moderate-quality articles evaluating the use of MRIs to diagnose extensor compartment tenosynovitis.

Evidence for the Use of MRI
There are 2 moderate-quality studies incorporated into this analysis.(1115, 1116) There is 1 low-quality study in the Appendix 2.(1117) (Hadidy 09)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: MRI OR Magnetic Resonance Imaging Extensor Compartment Tenosynovitis, De Quervain's Stenosing Tenosynovitis, diagnostic, diagnosis, sensitivity, specificity, positive predictive value, negative predictive value, and predictive value of tests, efficacy, and efficiency. We found and reviewed 12 articles in PubMed, 60 in Scopus, 0 in CINAHL, and 0 in Cochrane Library, and 1020 from Google Scholar. We considered for inclusion 2 from PubMed, 1 from Scopus, 0 from CINAHL, 0 from Cochrane Library and 0 from other sources. Of the 3 articles considered for inclusion, 3 diagnostic studies met the inclusion criteria.

Author/Year Study Type Conflict of Interest (COI)	Score	Number	Area	Diagnoses	Type of MRI used	Type of CT used	T1 weighted images	T2 weighted images	X-ray	Myelography	More than one rater	Surgery Performed	Clinical outcomes	Long term follow-up	Results	Conclusion	Comments
Nieuwenhuis 2015 Diagnostics Sponsored by EU Seventh Framework and DAF. Drs. Nieuwenhuis, Krabben, and van der Helm-van Mil's supported by DAF and Vidi grant, and Drs. Stomp and Reijnierse's sponsored by TRACER project grant. Dr. Stomp received speaking fees from GE health care.	6.5	N = 69 with RA. Mean age 54.2 ± 15.2.	Wrist	RA	1.5T	N/A	+	+	-	-	+	-	+	+	65% had MRI-detected tenosynovitis. RA patients had tenosynovitis vs. non-RA patients, (p = 0.023). Flexor tendons at MCP5/ extensor tendons at MCP2 and MCP4 in extensor compartment I of wrist affected in RA vs non-RA; 2.8, 95% CI: 1.9-42.8/14.2, 95% CI: 1.7 – 115.9 and 4.0, 95% CI: 1.4 – 11.1.	"MRI-detected tenosynovitis is commonly seen in early arthritis."	MRI-detected tenosynovitis occurrence frequently in early arthritis. RA patients found to have tenosynovitis more often than non RA patients. Flexor tendons at MCPs, extensor tendons at MCP2 and first extensor compartment of wrist most likely affected in RA patients.

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Parellada 2007 Diagnostics No mention of sponsorship or COI.	5.5	N = 5 with pain on the dorsal and radial aspect of the wrist. Mean age, 49 years.	Wrist	Tenosynovitis	1.5-T scanner	N/A	+	+	-	-	+	-	+	+	5 signs of tenosynovitis/ 4 had tendons of 2nd and 3rd extensor compartments affected/5 had signs of tenosynovitis of ELP tendon/3 showed tenosynovitis proximal and distal to point of intersection; 2 of 3 had discrete point of intersection.	"Distal intersection tenosynovitis may be related to the biomechanical pulley effect exerted by Lister's tubercle on the EPL tendon as it leaves the third compartment and crosses over the extensor carpi radialis tendons, as well as the constraining effect of the extensor retinaculum."	Distal intersection tenosynovitis may be related to pulley effect exerted by Lister's tubercle on EPL tendon as it leaves 3rd compartment and cross over extensor carpi radialis tendons.

Initial Care

Initial care usually involves limitation of the physical factors thought to be contributing.(42) Thumb spica splints for de Quervain's and wrist braces for the other compartment tendinoses are generally believed to be helpful.(42) Thumb spica splints have been widely used for treatment of wrist compartment tendinoses while non-spica wrist splints have been used for treatment of other compartment tendinoses.(42, 43, 45, 349, 1091) NSAIDs are often prescribed for initial treatment.(42) Perhaps the largest question in the management of these conditions is how soon to inject, including whether patients might not be most effectively treated by injection at initial clinical presentation, however, there are no quality studies to address that question.

SPLINTS

Recommendation: Thumb Spica and Wrist Splints for Acute and Subacute Thumb Extensor Compartment Tenosynovitis

Thumb spica splints for treatment of acute and subacute thumb extensor compartment tendinoses, and non-spica wrist splints for treatment of other extensor compartment tendinoses(42) **are recommended.**

Indications – Patients with extensor compartment tendinoses.

Frequency/Duration – Generally recommended to be worn while awake.

Indications for Discontinuation – Failure to respond or resolution.

Strength of Evidence – **Recommended, Insufficient Evidence (I)**
Level of Confidence – Low

Rationale for Recommendation

There is one moderate-quality RCT evaluating wrist splints for extensor compartment tenosynovitis with full-time compared with PRN use and found no differences.(1092) Wrist splints are not invasive, have few adverse effects, and are not costly; thus, they are recommended.

Evidence for the Use of Splints

There are 3 moderate-quality RCT incorporated into this analysis.(1119-1121) (Mardani-Kivi 14; Mehdinasab 10)

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A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Splinting, thumb spica, Extensor Compartment Tenosynovitis (Including De Quervain's Stenosing Tenosynovitis and Intersection Syndrome); controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 7 articles in PubMed, 3 in Scopus, 3 in CINAHL, 295 from Google Scholar, and 51 in Cochrane Library. We considered for inclusion 3 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library and 2 from other sources. Of the 359 articles considered for inclusion, 3 randomized trials and 6 systematic studies met the inclusion criteria.

Author/Year Study Type Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Menendez 2015 RCT No mention of sponsorship or COI.	5.0	N = 83 (49 females, 9 males in final randomization) with clinically diagnosed extensor compartment tenosynovitis, or de Quervain tendinopathy. Mean (±SD) age 50 (±13) for full-time group and 50 (±15) for as-desired group.	Forearm-based thumb spica splint to be worn full-time (n = 43) vs. forearm-based thumb spica splint to be worn as desired (n = 40). Both groups received allocated treatment for 6 weeks. Follow-up at 6 weeks.	No significant differences reported between full-time and as-desired groups for grip strength, pain intensity, disability and satisfaction with treatment.	"Our study supports the following concepts: (1) there is no difference in patient-reported outcomes and grip strength with full-time and as-desired splinting, and patients can wear the splint as they prefer; (2) de Quervain tendinopathy appears to be a self-limited condition in the majority of patients; (3) depressive symptoms are strongly associated with greater disability."	High dropout rate in full time splinting group. Data suggest strict splint vs. selective splint wear to treat de Quervain tendinopathy is palliative at best and should be left to patient preference as data suggest equal outcome efficacy.
Mardani-Kivi 2014 Randomized prospective trial No sponsorship or COI.	4.0	N = 67 patients (12 males, 47 females) with extensory compartment tenosynovitis, or de Quervain tendinopathy, radial pain of the wrist, a positive Finkelstein test, tenderness of the first dorsal compartment and a pain score >6 Mean (±SD) age 42 (±13) for CSI+TSC group and 45 (±12) for CSI only group.	Corticosteroid injection (CSI) and thumb spica cast (TSC) (3 weeks casted) group (n = 33) vs. Corticosteroid injection only group (n = 34). Both groups 40mg of methylprednisolone acetate with 1cc of lidocaine 2%. Follow-up at 3 weeks and 6 months.	At 3 weeks and 6 months follow-up, CSI+TSC group had significantly higher percentages of success compared to TSC alone group: 3 weeks-97% vs. 76%, (p = 0.027), 6 months- 93% vs 69%, (p = 0.021). At 6 months follow-up, CSI+TSC group had significantly higher percentages of decreased VAS scores vs. CSI-only group: 96% vs. 80%, (p	"The results of this study indicated that the CSI + TSC treatment method was superior to CSI alone with regards to success rate and functional outcomes."	Differences in success percentages at follow up due to dropout. Data suggest a combination of spica casting and corticosteroid injection was superior to injection alone.

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				<0.001). At 6 months, CSI+TSC group significantly higher mean (±SD) reduction of QuickDASH score vs. CSI only group: 74 (±15) vs. 66 (±18), (p <0.001).		
Mehdinasab 2010 RCT No mention of sponsorship or COI.	4.0	N= 73 patients (9 males, 64 females) with de Quervain's tenosynovitis. Mean age was 32.6 years.	Injection Group-Injection of methylprednisolone acetate in first dorsal compartment of wrist followed by wrist thumb spica cast (n = 37) vs. Casting Group-Casting only (n = 36). Follow-up for 6 months,	Overall success rate at final follow-up (6 months) 86.4% in injection group and 36% in casting group. Difference significant (p <0.001) with regards to final VAS pain score at 6 months: 6.70 vs. 17.3. Both groups showed significant differences in VAS pain score and cure rate vs. baseline (p <0.05).	"Support of the wrist with casting alone had less favorable outcome in de Quervain's tenosynovitis. Adding methylprednisolone acetate injection into the _rst dorsal compartment of the wrist is necessary for more optimal results."	Data suggest casting the wrist plus methylprednisolone injections was beneficial in the treatment of de Quervain's tenosynovitis over casting alone measured by improvement in wrist pain, tenderness and Finkelstein test.

Follow-up Visits

Follow-up visits are generally required every 1 or 2 weeks to evaluate efficacy of interventions until resolution of the condition.

Medications

There are few quality studies on use of medications for this condition, although they are frequently prescribed. Medications are more frequently needed compared with trigger digits, as these conditions are typically more painful.

NSAIDS

Recommendation: NSAIDs for Acute, Subacute, or Chronic Extensor Compartment Tenosynovitis
NSAIDs (oral or topical) are recommended to control pain associated with acute, subacute, or chronic extensor compartment tenosynovitides.

Indications – Patients with wrist compartment tendinoses.

Dose – Optimal dose is unknown and there are no quality studies comparing different NSAIDs. Regularly scheduled dosing is recommended for acute, significantly symptomatic presentations.

Indications for Discontinuation – Failure to respond, development of adverse effects, resolution.

Strength of Evidence – **Recommended, Evidence (C)**

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Level of Confidence – Low

Rationale for Recommendation
NSAIDs are often used to treat pain associated with wrist compartment tendinoses.(42, 43, 45, 349, 1091, 1093, 1094) There is one quality study demonstrating efficacy of a ketoprofen patch versus placebo.(1094) However, another study failed to demonstrate efficacy of injectable nimesulide as an adjuvant treatment to triamcinolone acetonide 10mg injection(1093) and another study of diclofenac gel for treating marathon kayakers prior to racing also was negative,(1095) although applicability to occupational populations is questionable. As an NSAID patch has been demonstrated to be efficacious compared to placebo, it is assumed that other topical forms are also efficacious. NSAIDs are not invasive, have low adverse effects in employed populations, and are low cost, thus they are recommended.

Evidence for the Use of NSAIDs for Extensor Compartment Tenosynovitis
There are 2 high-(1093, 1094) and 1 moderate-quality(1095) RCTs incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Extensor Compartment Tenosynovitis, De Quervain Disease, De Quervain Stenosing Tenosynovitis, Intersection Syndrome; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 3 articles in PubMed, zero in Scopus, 2 in CINAHL, zero in Cochrane Library, 163 in Google Scholar, and zero from other sources. We considered for inclusion 3 from PubMed, zero from Scopus, zero from CINAHL, and zero from Cochrane Library, zero Google Scholar, and zero from other sources. Of the 2 articles considered for inclusion, 3 randomized trials and zero systematic studies met the inclusion criteria.

Author/Year Study Type Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Diclofenac Gel vs. Placebo						
May 2007 RCT	6.5	N = 42 (36 males/ 6 females) with Kayakers in 5-day marathon. Mean age: 36±12 years	Diclofenac 2.5g 1% gel vs. placebo gel applied 3 times before each day's race. All received ice, massage, stretches, night bandage.	Pain higher on diclofenac than placebo gel especially in days 2 and 3. Comparisons with day 1: 2 (1.7), 3 (0.5), 4 (-0.1), 5 (-0.9).	"[S]tandard treatment appears to be sufficient for the management of wrist extensor tenosynovitis during competition."	Applications from kayaking marathon to occupational settings unclear. May be more analogous to acute, unaccustomed forceful use. Applications not throughout day may limit conclusions.
NSAIDs vs. Placebo						
Mazieres 2005 RCT No mention of sponsorship or COI.	10.0	N = 172 (98 female/74 male) with tendinitis of upper or lower limbs. Age 18-70 years.	Ketoprofen patch (n = 87) vslacebo (n = 85).	Changes from baseline in pain on daily activity (100mm VAS) in ketoprofen vs. placebo: D0: 69.1±12.9 vs 70.1±11.5 p = 0.5876; D3-4: 48.6±23.2 vs. 56.1±20.0 p = 0.0491; D7±1: 30.8±23.8 vs. 44.3±25.6 p = 0.0013; D14±2: 25.1±25.9 vs.	"This trial suggested that a 3-14 day course of treatment by ketoprofen patch is useful in nonarticular rheumatisms, the duration of treatment depending on the results obtained."	Many diagnoses included and results not stratified by diagnosis.

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				36.4±27.6 p = 0.0146.		
Injection with vs. without NSAID						
Jirarattanaphochai 2004 RCT No sponsorship. One or more authors received grants or outside funding from Faculty of Medicine, Khon Kaen University.	9.0	N = 160 (144 female/16 male) with de Quervain disease, positive Finkelsein test, radial styloid tenderness, pain on first extensor compartment with thumb abduction or extension. Mean (±SD) age 48.98 (±9.10) for nimesulide group; 46.87 (±12.79) placebo.	Injection 10mg of triamcinolone acetonide and 0.5mL of 1% lidocaine and either 200mg daily oral nimesulide group (= 80) vs. placebo control group (n = 80). Follow-up at 1 week, 6, 12, 18 and 24 months.	No significant differences reported between the nimesulide and placebo groups for VAS pain scores, success rates, adverse reactions and probability of recurrence.	"[S]teroid injection alone was safe and effective in the treatment of de Quervain's disease, but the oral administration of nimesulide did not provide any additional benefit beyond that of the injection."	Data suggest nimesulide does not enhance effectiveness of a single triamcinolone injection in de Quervain's disease treatment. Disease recurrence was correlated to the presence of crepitation in the first dorsal compartment at thumb extensor abduction.

Physical Methods/Rehabilitation

EXERCISE

Exercise is not generally indicated acutely and most patients with extensor tendon entrapment do not require an exercise program. For those with residual deficits, particularly post-operatively, see section on Post-Operative Rehabilitation and Rehabilitation of Patients with Functional Deficits: CTS and Other Disorders.

Evidence for the Use of Exercise

There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following term Exercise, Physical Activity, Extensor Compartment Tenosynovitis, De Quervain Disease, De Quervain's Stenosing Tenosynovitis, Intersection Syndrome, controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found, reviewed and considered for inclusion zero articles in PubMed, zero in Scopus, 1 in CINAHL, 1 in Cochrane Library, zero in Google Scholar and zero in other sources. Zero articles met the inclusion criteria.

IONTOPHORESIS

Recommendation: Iontophoresis for Acute and Subacute Extensor Compartment Tenosynovitis

Iontophoresis treatments using glucocorticosteroids and sometimes NSAIDs are recommended for extensor compartment tenosnovitis.

Indications – Patients with wrist compartment tendinoses. Generally those who either fail to respond adequately to NSAIDs, splints, and activity modifications or decline injection.

Dose – Glucocorticosteroid is generally used; however, quality studies have documented successful treatment of lateral epicondylalgia with NSAIDs administered via iontophoresis (see Elbow Disorders Guideline), thus they appear reasonable for this indication as well.

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Frequency/Duration – Generally 2 or 3 appointments to ascertain efficacy; an additional 4 to 6 appointments may be scheduled if efficacious. If improvements continue at 6 appointments, additional 4 to 6 appointments are reasonable.
Indications for Discontinuation – Failure to respond, development of adverse effects, resolution.

Strength of Evidence – **Recommended, Insufficient Evidence (I)**
Level of Confidence – Low

Rationale for Recommendation
There are no quality studies evaluating iontophoresis for extensor compartment tenosnovitis. Iontophoresis is not invasive, has low adverse effects, but is moderate to high cost depending on the number of treatments. Iontophoresis with either a glucocorticoid or NSAID is recommended for select patients who fail to respond to other treatments or who decline injection.

Evidence for the Use of Iontophoresis
There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Iontophoresis, Extensor Compartment Tenosynovitis, De Quervain Disease, De Quervain's Stenosing Tenosynovitis, Intersection Syndrome; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found, reviewed and considered for inclusion Zero articles in PubMed, Zero in Scopus, Zero in CINAHL, Zero in Cochrane Library, 25 in Google scholar and zero in other sources. Zero articles met the inclusion criteria.

OTHER NON-OPERATIVE INTERVENTIONS
Recommendation: Other Non-operative Interventions Including Manipulation and Mobilization, Massage, Deep Friction Massage, or Acupuncture for Acute, Subacute, or Chronic Extensor Compartment Tenosynovitis
There is no recommendation for or against the use of other non-operative interventions (i.e., manipulation and mobilization, massage, deep friction massage, or acupuncture) for the treatment of acute, subacute, or chronic extensor compartment tenosynovitis as other interventions have proven efficacy and are preferentially indicated for initial and subsequent treatment options.

Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**
Level of Confidence – Low

Rationale for Recommendation
There are no quality studies evaluating other non-operative interventions for extensor compartment tenosynovitis. Manual therapy has been attempted;(1096) however, there are no quality studies available to assess its efficacy. Deep friction massage has been used and does not appear successful.(1097)

Evidence for the Use of Acupuncture
There is 1 moderate-quality RCT on acupuncture.(1127) (Hadianfard 14) There are no quality studies incorporated into this analysis for manipulation and mobilization or massage.

Manipulation & Mobilization:
A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Manipulation and Mobilization, Extensor Compartment Tenosynovitis, De Quervain Disease, De Quervain's Stenosing Tenosynovitis, Intersection Syndrome; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found, reviewed and considered for inclusion Zero articles in

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PubMed, Zero in Scopus, Zero in CINAHL, Zero in Cochrane Library, 169 in Google Scholar, and zero other sources. Zero articles met the inclusion criteria.

Acupuncture:
A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms; Acupuncture, Extensor Compartment Tenosynovitis, De Quervain's Stenosing Tenosynovitis, controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 1 articles in PubMed, 6 in Scopus, 0 in CINAHL, and 2 in Cochrane Library, and 206 from Google Scholar. We considered for inclusion 1 from PubMed, 0 from Scopus, 0 from CINAHL, 1 from Cochrane Library and 0 from other sources. Of the 3 articles considered for inclusion, 1 randomized trials and 0 systematic studies met the inclusion criteria.

Massage:
A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Massage, Massage Therapy, Extensor Compartment Tenosynovitis, De Quervain Disease, De Quervain Stenosing Tenosynovitis, Intersection Syndrome; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found, reviewed and considered for inclusion Zero articles in PubMed, 38 in Scopus, 1 in CINAHL, 1 in Cochrane Library and 121 in other sources. Zero articles met the inclusion criteria.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Hadianfard 2014 RCT Supported by Vice-Chancellery of Research and Technology of Shiraz University of Medical Sciences, Shiraz, Iran. No mention of COI.	5.0	N= 35 (6 Males and 24 Females) patients with clinical diagnosis of De Quervain's tenosynovitis. Mean age was 40.7 years.	Acupuncture group- Received 5 acupuncture sessions of 30 minutes duration (N= 18) Vs. Injection Group- 1 methylprednisolone acetate injection in the first dorsal compartment of the wrist (N= 17) Follow-up for 6 weeks.	At the last follow-up the Q-DASH score decreased by 55.1 in the injection group vs. 54.6 in the acupuncture group. No significant differences between groups. The difference between baseline and final VAS score decreased significantly between groups, but was not significant between groups (p>0.05).	"We demonstrated short-term improvement of pain and function in both groups. Although the success rate was somewhat higher with corticosteroid injection, acupuncture can be considered as an alternative option for treatment of De Quervain's Tenosynovitis."	Acupuncture and Glucocorticosteroid related. Data suggests methylprednisolone injections somewhat better than acupuncture for improved pain and function in deQuervain's tenosynovitis although both groups improved from baseline at 2 and 6 weeks.

Injections

GLUCOCORTICOSTEROID INJECTIONS

Glucocorticosteroid injections are frequently used for the wrist compartment tendinoses.(43, 45, 280, 349, 1091, 1093, 1098-1104) Techniques vary slightly(1101, 1105) and have included attempted selective injection of the extensor pollicis brevis tendon,(1106) although there are no quality studies to compare techniques. Estimates of efficacy in case series and active treatment arms of trials range from 54-100%.(1100, 1101, 1105-1110)

Recommendation: Glucocorticosteroid Injections for Acute, Subacute, or Chronic de Quervain's or Other Wrist Compartment Tendinosis

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Glucocorticosteroid injections are recommended for treatment of acute, subacute, or chronic de Quervain's or other wrist compartment tendinosis.

Indications – Wrist compartment symptoms of pain over a compartment. Generally at least 1 week of non-invasive treatment to determine if condition will resolve without invasive treatment. It is reasonable to treat cases with an initial injection although there is no quality evidence to support that approach. Failure or suboptimal results with an initial injection result in a need for additional injection(s) in a minority of patients that is (are) usually successful.(1103, 1105, 1106)

Dose – Optimal dose is unknown. Studies have utilized methylprednisolone acetate 40mg,(1064, 1105, 1109) and triamcinolone acetonide 10mg.(1103, 1106) An adjuvant injectable anesthetic is typically used.(1093, 1105, 1106) Some providers splint the wrist afterwards, however, there is no quality evidence this improves efficacy or duration of benefits. Two low-quality studies suggest no greater efficacy with splinting; however, greater costs and lost time were incurred.(1099, 1111)

Frequency/Duration – It is recommended that a single injection be scheduled and the results evaluated to document improvement.(1103) Failure of a response within 1 or 2 weeks should result in reanalysis of the diagnosis and consideration of repeat injection.(1103) Recurrence of symptoms months later should result in consideration of re-injection.(1101, 1105) There is no maximum number of injections to treat an episode or over a lifetime demonstrated in quality studies. Therapeutic injection failures are reportedly strongly associated with the presence of a separate compartment for the extensor pollicis brevis tendon in 73% of cases.(1109)

Indications for Discontinuation – If a partial response, consideration should be given to repeating the injection, typically at a modestly higher dose.

Strength of Evidence – **Recommended, Evidence (C)**
Level of Confidence – High

Rationale for Recommendation

There is 1 moderate-quality study comparing glucocorticosteroid injections with placebo for treatment of de Quervain's stenosing tenosynovitis.(1103) The trial showed considerable benefits from active treatment that persisted for 12 months and allows for an evidence-based recommendation. One trial found steroid injection superior to acupuncture.(1112) Ultrasound-guidance has been suggested to be moderately superior.(1113) Two trials have found inconclusive evidence regarding whether splint use is required in addition to steroid injection(1114, 1115) A high-quality trial found the steroid flare was unrelated to pH;(1064) however, there was no placebo control group. Another high-quality trial found no additive benefit of NSAID in addition to injection to prevent recurrence but did not assess reductions in pain immediately after injection thus appears to have no bearing on use of NSAIDs for those purposes.(1093) A low-quality trial found glucocorticosteroid injection superior to splinting in pregnant and lactating femalies.(1098) These injections are minimally invasive, have low adverse effects, and are moderately costly; thus, they are recommended to treat de Quervain's or other wrist compartment tendinosis.

Evidence for the Use of Glucocorticosteroid Injections for Wrist Compartment Tendinoses

There are 2 high-(1064, 1093) and 5 moderate-quality(1103, 1112-1115) RCTs incorporated in this analysis. There are 3 low-quality RCTs and 1 longitudinal study(1098, 1099, 1109, 1116) in Appendix 2.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Glucocorticosteroid injection, corticosteroid injection, glucocorticoid injection, glucocorticoids, extensor compartment tenosynovitis, de Quervain's stenosing tenosynovitis, and intersection syndrome, de Quervain disease; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 10 articles in PubMed, 43 in Scopus, 0 in CINAHL, 0 in Cochrane Library, 19 in Google Scholar, and 2 from other sources. We considered for inclusion 7 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 0 Google Scholar, and 2 from other sources. Of the 7 articles considered for inclusion, 7 randomized trials and 0 systematic studies met the inclusion criteria.

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Author/Year Study Type Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Glucocorticosteroid vs. Saline Injections						
Jirarattanaphochai 2004 RCT No sponsorship. One or more authors received grants or outside funding from the Faculty of Medicine, Khon Kaen University.	10.5	N = 160 (144 female/16 male) with de Quervain disease, positive Finkelsein test, radial styloid tenderness, pain on first extensor compartment with thumb abduction or extension. Mean (±SD) age 48.98 (±9.10) nimesulide group, 46.87 (±12.79) placebo.	Injection of 10mg of triamcinolone acetonide and 0.5mL 1% lidocaine and either 200mg daily oral nimesulide group (n = 80) vs. placebo control group (n = 80). Both groups received allocated treatment for 7 days. Follow-up at 1 week, 6, 12, 18 and 24 months.	No significant differences reported between the nimesulide and placebo groups for VAS pain scores, success rates, adverse reactions and probability of recurrence.	"[S]teroid injection alone was safe and effective in the treatment of de Quervain's disease, but the oral administration of nimesulide did not provide any additional benefit beyond that of the injection."	Data suggest nimesulide does not enhance effectiveness of a single triamcinolone injection in de Quervain's disease treatment. Also, disease recurrence was correlated to the presence of crepitation in the first dorsal compartment at thumb extensor abduction.
Peters-Veluthamaningal BMC Musculoskelet Disord 2009 RCT No mention of sponsorship or COI.	7.5	N = 21 (13 female/21 male) clinical diagnosis of de Quervain's with Finkelstein's or crepitations on exam. Mean age 52.3 (12.6) for NaCl; 51.2 (20.2) for TCA group.	NaCl, 1-2 injection 1ml triamcinolonacetonide (n = 12) vs. placebo or TCA, 1mL NaCl at site of maximal tenderness. Second injection by different MD at 2 weeks if not satisfied with results; 12 month follow-up (n = 9).	Short-term results of mean pain severity in the past week of saline 4.3 vs. corticoid 1.3. Patients much better or better: 2/12 (33%) saline vs. 7/9 (77.8%), p = 0.047. Maintained improvement over 12 months.	"One or two local injections of 1 ml triamcinolonacetonide 10 mg/ml provided by general practitioners leads to improvement in the short term in participants with de Quervain's tenosynovitis when compared to placebo."	Under enrollment. Small sample size. Considerable differences nevertheless suggest efficacy.
Glucocorticosteroid with Normal vs. Acidic pH						
Goldfarb 2007 RCT No sponsorship or COI.	8.0	N = 125 (93 female/32 male) with trigger finger or de Quervain's.Average age was 59 years.	Balanced group, methylprednisolone acetate 40mg, lidocaine, bupivacaine alone (n = 68) vs. Standard group or injection except balanced solution and neutral pH (n = 57); 6 week follow-up.	All immediately responded to injection. Pain rebounded at one day, and then gradually decreased. 23/68 (33.8%) in balanced group vs. 18/57 (31.6%) in acidic pH group had flare reactions (NS).	"A pH-balanced injection did not significantly decrease the risk of a flare reaction."	No placebo group. Some trends in baseline differences of unclear significance. Purpose to assess steroid flare and whether normal pH could reduce this adverse effect. Study suggests steroid flare unrelated to pH.

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Glucocorticosteroid with vs. without NSAID						
Jirarattanaphochai 2004 RCT No sponsorship. One or more authors received grants or outside funding from the Faculty of Medicine, Khon Kaen University.	10.5	N = 160 (144 female/16 male) with de Quervain disease, positive Finkelsein test, radial styloid tenderness, pain on first extensor compartment with thumb abduction or extension. Mean (±SD) age 48.98 (±9.10) nimesulide group and 46.87 (±12.79) placebo group.	Injection of 10mg of triamcinolone acetonide and 0.5mL of 1% lidocaine and either 200mg daily oral nimesulide group (n = 80) vs. Placebo control group (n = 80). Both groups received allocated treatment for 7 days. Follow-up at 1 week, 6, 12, 18, and 24 months.	Success rates after 1 injection: 67% nimesulide vs. 68% placebo (NS). Overall success 95% both groups. Risk for recurrence doubles with crepitation (RR = 2.13, 95% CI 1.19-3.8).	"Supplemental oral administration of the nonsteroidal anti-inflammatory drug nimesulide does not improve the effectiveness of a single injection of triamcinolone acetonide in the treatment of de Quervain disease."	No placebo; no recording of pain scores for purposes of evaluating reduced pain after injection. Variable follow-up. Data suggest NSAID provides no incremental benefit to prevent recurrence in addition to steroid injection.
Injection vs. Other Treatments						
Hadianfard 2014 RCT Supported by Vice-Chancellery of Research and Technology of Shiraz University of Medical Sciences, Shiraz, Iran. No mention of COI.	5.0	N= 35 patients (6 males, 24 females) with clinical diagnosis of De Quervain's tenosynovitis. Mean age was 40.7 years.	Acupuncture group: Received 5 acupuncture sessions of 30 minutes duration (n = 18) vs. Injection Group: 1 methylprednisolone acetate injection in first dorsal compartment of wrist (n = 17). Follow-up for 6 weeks.	At last follow-up Q-DASH score decreased by 55.1 in injection group vs. 54.6 in acupuncture group. No significant differences between groups. Difference between baseline and final VAS score decreased significantly between groups, but not significant between groups (p> 0.05).	"We demonstrated short-term improvement of pain and function in both groups. Although the success rate was somewhat higher with corticosteroid injection, acupuncture can be considered as an alternative option for treatment of De Quervain's Tenosynovitis."	Data suggests methylprednisolone injections somewhat better than acupuncture for improved pain and function in deQuervain's tenosynovitis although both groups improved from baseline at 2 and 6 weeks.
Kume 2012 Randomized prospective trial No sponsorship or COI.	4.5	N = 44 wrists (5 males, 39 females) with diagnosed de Quervain's disease Mean (SD) age 45.3 (6.5) for ultrasound group and 44.2 (7.5) for manual group.	Ultrasound guided injection group (n = 22) vs. Manual injection group (n = 22). Both groups received 20 mg of triamcinolone and 1 ml of 1% lidocaine. Follow-up at 4 weeks.	Reduction in mean VAS pain from baseline to 4 weeks significantly higher in ultrasound guided group vs. manual injection group: 80.3 to 25.6 vs. 78.0 to 58.2, (p = 0.0007). No adverse reactions related to treatment for either group.	"[U]S-guided injection targeting the EPB of dQD with septation was found to be more effective than clinically guided manual injection."	Data suggest US guided injection targeting EPB in deQuervain's patients with septation is better than manual injection although both groups showed improvement in pain on VAS.

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Mardani-Kivi 2014 Randomized prospective trial No sponsorship or COI.	4.0	N = 67 patients (12 males, 47 females) with extensory compartment tenosynovitis, or de Quervain tendinopathy, radial pain of the wrist, a positive Finkelstein test, tenderness of the first dorsal compartment and a pain score >6 Mean (±SD) age 42 (±13) for CSI+TSC group and 45 (±12) for CSI only group.	Corticosteroid injection (CSI) and thumb spica cast (TSC) (3 weeks casted) group (n = 33) vs. Corticosteroid injection only group (n = 34). Both groups 40mg of methylprednisolone acetate with 1cc of lidocaine 2%. Follow-up at 3 weeks and 6 months.	At 3 weeks and 6 months follow-up, CSI+TSC group had significantly higher percentages of success compared to TSC alone group: 3 weeks-97% vs. 76%, (p = 0.027), 6 months- 93% vs 69%, (p = 0.021). At 6 months follow-up, CSI+TSC group had significantly higher percentages of decreased VAS scores vs. CSI-only group: 96% vs. 80%, (p <0.001). At 6 months, CSI+TSC group significantly higher mean (±SD) reduction of QuickDASH score vs. CSI only group: 74 (±15) vs. 66 (±18), (p <0.001).	"The results of this study indicated that the CSI + TSC treatment method was superior to CSI alone with regards to success rate and functional outcomes."	Differences in success percentages at follow up due to dropout. Data suggest a combination of spica casting and corticosteroid injection was superior to injection alone.
Mehdinasab 2010 RCT No mention of sponsorship or COI.	4.0	N= 73 patients (9 males, 64 females) with de Quervain's tenosynovitis. Mean age was 32.6 years.	Injection Group- Injection of methylprednisolone acetate in first dorsal compartment of wrist followed by wrist thumb spica cast (n = 37) vs. Casting Group- Casting only (n = 36). Follow-up for 6 months,	Overall success rate at final follow-up (6 months) 86.4% in injection group and 36% in casting group. Difference significant (p <0.001) with regards to final VAS pain score at 6 months: 6.70 vs. 17.3. Both groups showed significant differences in VAS pain score and cure rate vs. baseline (p <0.05).	"Support of the wrist with casting alone had less favorable outcome in de Quervain's tenosynovitis. Adding methylprednisolone acetate injection into the _rst dorsal compartment of the wrist is necessary for more optimal results."	Data suggest casting the wrist plus methylprednisolone injections was beneficial in the treatment of de Quervain's tenosynovitis over casting alone measured by improvement in wrist pain, tenderness and Finkelstein test.

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Surgery

Recommendation: Surgical Release for Subacute or Chronic Extensor Compartment Tenosynovitis
Surgical release is recommended for patients with subacute or chronic extensor compartment tenosynovitis who fail to respond to injection.(1101)

Indications – Wrist compartment tenosynovitis that fails to respond to non-operative interventions generally including at least 2 glucocorticosteroid injections.

Strength of Evidence – **Recommended, Insufficient Evidence (I)**
Level of Confidence – Moderate

Rationale for Recommendation
There are no quality studies evaluating the use of surgical release for extensor compartment tenosynovitis.(346, 1117) While surgery release is invasive, has moderate adverse effects, and is costly, it is usually clinically effective and recommended for patients who have failed glucocorticosteroid injection(s) and other non-invasive treatments.

Evidence for the Use of Surgery
There is 1 moderate-quality RCT incorporated into this analysis.(1145) (Abrisham 11)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: extensor compartment tenosynovitis, de Quervain's stenosing tenosynovitis, and intersection syndrome, de Quervain disease; Surgical release; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 1 articles in PubMed, 0 in Scopus, 0 in CINAHL, 0 in Cochrane Library, 30 in Google Scholar, and 0 from other sources. We considered for inclusion 0 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 1 Google Scholar, and 0 from other sources. Of the 31 articles considered for inclusion, 1 randomized trials and 0 systematic studies met the inclusion criteria.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Abrisham 2011 RCT No sponsorship or COI.	5.5	N = 120 (24 males, 96 females). Mean age is 45.3 years.	Transverse Incision (N = 60) vs Longitudinal Incision (N =60). Followed for three months. An additional follow up of 2 weeks to remove sutures and finally three months for final assessment.	Complications of surgical treatment with longitudinal incision were lower than the transverse incision. Longitudinal incision had five hypertrophic scars and no injury to nerve or vein reported. Transverse incision had 3 lesions to superficial branch of radial nerve, five injuries to vein in snuffbox area, and five hypertrophic scars.	Longitudinal incision can be recommended for surgical treatment of De Quervain disease.	Data suggest longitudinal incision is superior to transverse incision for treatments of De Quervain tenosynovitis in terms of post-op complication. After a period of 3 months, 14 patients (8 transverse and 6 longitudinal) did not cooperate in follow up from the first time.

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Ulnar Nerve Entrapment at the Wrist (Including Guyon's Canal Syndrome and Hypothenar Hammer Syndrome)

Diagnostic Criteria

There is no quality evidence comparing diagnostic testing for this disorder. Most case series report electrodiagnostic testing assisted in making a diagnosis. The characteristic finding is a prolonged distal motor latency. One report opined that idiopathic or "cumulative stress" cases have no characteristic pattern.(50) Electrodiagnostic calculations are complicated by the curvilinear course of the deep motor nerve. Witmer described a technique reducing the complexity that may be useful to the electromyographer.(1118)

Special Studies and Diagnostic and Treatment Considerations

ELECTRODIAGNOSTIC STUDIES

Recommendation: Electrodiagnostic Testing for Ulnar Nerve Entrapment at the Wrist

Electrodiagnostic testing is recommended to confirm clinical suspicion of ulnar nerve entrapment at the wrist.

Strength of Evidence **– Recommended, Evidence (C)**
Level of Confidence – Moderate

Rationale for Recommendation

There are 3 moderate studies supporting the use of electrodiagnostic testing.(1119-1121) However, studies need to be performed by well-trained electrodiagnosticians, preferably certified by the American Board of Electrodiagnostic Medicine.

Evidence for the Use of Electrodiagnostic Studies

There are 4 moderate-quality studies incorporated into this analysis.(1119-1122)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Electrodiagnostics nerve conduction study, electromyography, Ulnar Nerve Entrapment at the Wrist (Including Guyon's Canal Syndrome and Hypothenar Hammer Syndrome) diagnostic, diagnosis, sensitivity, specificity, positive predictive value, negative predictive value, and predictive value of tests, efficacy, and efficiency. We found and reviewed 0 articles in PubMed, 48 in Scopus, 2 in CINAHL, 3 Cochrane Library, and 350 from Google Scholar. We considered for inclusion 0 from PubMed, 2 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 0 from Google Scholar, and 2from other sources. Of the 4 articles considered for inclusion 4 diagnostic studies met the inclusion criteria.

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Author/ Year Study Type Conflict of Interest (COI)	Score	Study Design	Population / Case Definition	Investigative Test	Gold Standard / Comparative Test	Results	Conclusion	Comments
Lander 2007	6.0	Cross-sectional study	N = 162 referred for hand-arm vibration syndrome or HAVS assessment at specialist occupational health clinic, plus history of exposure to vibrating tools. Mean age onset of symptoms 38.4 (9.0).	Nerve conduction studies (NCS) and current perception threshold (CPT). Using Stockholm sensorineural or SSN scale and quantitative sensory tests (QSTs) measuring vibration and temperature perception.	NCS vs. CPT tests for both upper extremities. Perception measured at 5 Hz, 250 Hz and 2 kHz at index finger for median nerve and at little finger for ulnar nerve.	160 (99%) complained of numbness and/or tingling. CPT in left hand abnormal in 99 subjects, In left hand, overall CPT results (x^2 = 9.87, p = 0.007) and results from ulnar nerve (x^2 = 11.27, p = 0.004); significantly associated with SSN staging. CPT and NCS results significantly associated for each of ulnar, median and overall nerve results in right hand and left hand, (p = 0.0001).	"Workers being assessed for HAVS should have nerve conduction testing to detect neuropathies proximal to the hand."	Data suggests NCS and CPT significantly associated for the overall results and for ulnar and median results in each hand.
Hirata 2007	5.0	Age-matched	N = 75 males and controls with hand-arm vibration syndrome (VS). Mean age 58.7 years.	Sensory nerve conduction velocities (SCVs); 0.1-ms rectangular electric pulses at 1 Hz	Associations between frequency of slowed SCV and reduced AMP and frequency of neuropathy types	In median nerve, SCVfp-fd, SCVw-e, AMPw-fp and AMPw-fd significantly reduced vs. controls, (p = 0.005, 0.011, 0.024, 0.013). In ulnar nerve, SCVfp´–fd´, SCVw´–fp´, AMPw´–fp´, AMPw´–fd´, AMPfo´–fp´ and AMPup–fp´ significantly reduced in VS patients vs. controls (p = 0.000, 0.015, 0.007, 0.000, 0.027 and 0.008). In radial nerve, AMPfo´-th significantly reduced in	"These findings suggest that VS affects all three nerves in the hand. According to classification results, the main disorders of peripheral nerves comprise digital neuropathy."	Small sample size. Data suggests that vibration syndrome affects all three hand nerves and neuropathy due to VS may in fact represent a multi-focal neuropathy.

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						VS patients vs controls, (p = 0.003).		
Alaranta 1977	4.5	An automatic analysis of the electromyographic activity.	N = 38 forest workers and pneumatic-tool operators. Male workers aged 26 to 61 years.	Velocity of lower motor fibers (CVSF) of ulnar nerve and motor distal latency(DL) of median nerve	Subgroup 0 = normal conduction velocity of CVSF and distal latency DL Subgroup 1 = Only one CVSF of ulnar nerve or DL Subgroup 2 = polyneuropathic findings vs vibration syndromes, at least 2 abnormal CVSF or DL findings.	Exposed workers had statistically significantly lower CVSFs of ulnar nerve (p <0.001) and dSCVs of median nerve (p <0.001), longer DLs of median nerve (p < 0.01), and slightly slower dSCVs of ulnar nerve (p <0.05) and SCVs of median nerve (p <0.05) vs. none exposed, as a group.	"In accordance with previous reports the CVSF of the ulnar nerve was a potent factor in differentiating the vibration exposed workers from those nonexposed."	Data suggests conduction velocity of slower motor fibers of ulnar nerve, distal sensory conduction velocity and motor distal latency of median nerve most sensitive measurement for separation of those with traumatic vasospastic disease from those not exposed.
Chatterjee 1982	4.0	Exploratory/observational	N = 31 rock-drillers and controls. Age range 24-57, mean age 37.9 (9.6).	Exploratory electromyography; Disa-type 14 A 30 3-channel electromyography with a 14 G 01 digital average capable of averaging up to 1024 successive stimuli.	Motor and sensory conduction velocities in median and ulnar Nerves; and latency, duration, and the amplitude of evoked action potentials measured.	Significant difference between groups, in 1st (p <0.05), 2nd (p <0.01), fourth (p <0.05) digits supplied by median nerve in right hand and first and fourth digits, (p < 0.05). Sensory duration varied from 2.1msec to 2.6 msec in right hand and 1.9 msec to 2.2 msec in left hand vs. controls 1.8 msec and 2.1 msec. Vibration groups significant in first (p < 0.05), second (p < 0.05), third (p < 0.01), fourth (p < 0.01) digits supplied by median nerve and other half of fourth digit (p < 0 05) supplied by ulnar nerve in right hand vs. controls.	"The results showed that apart from sensory duration the control group had values that were closest to the students while the vibration group had values furthest away."	Small sample. Data suggests neurophysiological changes are frequent in those who regularly use vibrating tools and with the exception sensory duration, the median nerve is affected more than the ulnar nerve.

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MRI/ULTRASOUND

Recommendation: MRI or Ultrasound to Diagnose Ulnar Nerve Entrapment at the Wrist

There is no recommendation for or against the use of MRI or ultrasound to diagnose ulnar nerve entrapment at the wrist. Use of MRI for a suspected soft-tissue mass may be reasonable.

Strength of Evidence **– No Recommendation, Insufficient Evidence (I)**
Level of Confidence – Low

Evidence for the Use of MRI and Ultrasound

There are no quality studies incorporated into this analysis.

MRI:

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Magnetic resonance imaging, MRI, Ulnar Nerve Entrapment, Guyon's Canal Syndrome, Hypothenar Hammer Syndrome, diagnostic, diagnosis, sensitivity, specificity, positive predictive value, negative predictive value, and predictive value of tests, efficacy, and efficiency. We found and reviewed 88 articles in PubMed, 0 in Scopus, 0 in CINAHL, 3 in Cochrane Library, 85 from Google Scholar, and 0 from other sources. We considered for inclusion 0 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 0 from Google Scholar, and 0 from other sources. Zero articles met the inclusion criteria.

Ultrasound:

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Ultrasound, Ultrasonography, Ulnar Nerve Entrapment at the Wrist (Including Guyon's Canal Syndrome and Hypothenar Hammer Syndrome), diagnostic, diagnosis, sensitivity, specificity, positive predictive value, negative predictive value, and predictive value of tests, efficacy, and efficiency. We found and reviewed 69 articles in PubMed, 2 in Scopus, 0 in CINAHL, 0 in Cochrane Library, 95 in Google Scholar, and 0 from other sources. We considered for inclusion 0 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 0 from Google Scholar, and 0 from other sources. Zero articles met the inclusion criteria.

CT

Recommendation: CT to Diagnose Ulnar Nerve Entrapment at the Wrist

CT is recommended to diagnose ulnar nerve entrapment at the wrist if a hook of the hamate fracture is suspected based upon the history, a mechanism of potential fracture, focal pain at the hamate and where there are ulnar nerve symptoms.

Strength of Evidence – **Recommended, Insufficient Evidence (I)**
Level of Confidence – Low

Rationale for Recommendations

There are no quality studies evaluating the use of ultrasound or MRI for ulnar nerve entrapment at the wrist and therefore, there is no recommendation for or against the use of these tests. The use of ultrasound, MRI, or CT has also been reported useful in identifying suspected hamate fractures or mass lesions such as a ganglion cyst.(50, 57, 1118) MRI is generally preferable for soft tissue masses and CT is preferable for boney masses. These tests are moderate to high cost, but are recommended for evaluation of select patients suspected of having occult fractures of the hamate or mass lesions.

Evidence for the Use of CT

There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: CT, CAT, X-Ray CT, Ulnar Nerve Entrapment, Guyon's Canal Syndrome, Hypothenar Hammer Syndrome, diagnostic, diagnosis, sensitivity, specificity, positive predictive value, negative predictive value, and predictive value of tests, efficacy, and efficiency. We found and reviewed 0 articles in PubMed, 0 in Scopus, 0 in CINAHL, 0

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Cochrane Library, and 300 from Google Scholar. We considered for inclusion 0 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 0 from Google Scholar, and 0 from other sources. Zero articles met the inclusion criteria.

Initial Care

Ulnar neuropathy at the wrist that is not related to trauma, such as from the use of wheelchair, crutches, or other equipment may benefit initially from non-invasive therapies and activity adjustments including elimination or mitigation of significant pressure points (e.g., using padding, etc.) and splinting.

ACTIVITY MODIFICATION

Recommendation: Activity Modification for Ulnar Nerve Compression at the Wrist

Activity modification, with particular avoidance of significant localized mechanical compression of the nerve or use of the hand as a hammer is recommended for treatment of ulnar nerve compression at the wrist.

Strength of Evidence – **Recommended, Insufficient Evidence (I)**
Level of Confidence – Low

Evidence for the Use of Activity Modification

There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Rest, resting, Ulnar Nerve Entrapment at the Wrist (Including Guyon's Canal Syndrome and Hypothenar Hammer Syndrome; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 0 articles in PubMed, 1 in Scopus, 0 in CINAHL, 0 in Cochrane Library, 0 in Google Scholar, and 0 from other sources. We considered for inclusion 0 from PubMed, 1 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 0 from Google Scholar, and 0 from other sources. Of the 1 articles considered for inclusion, 0 randomized trials and 1 systematic study met the inclusion criteria.

SPLINTS

Recommendation: Neutral Wrist Splinting for Acute, Subacute, or Chronic Ulnar Nerve Compression at the Wrist

Neutral wrist splinting is recommended as a first-line treatment for acute, subacute, or chronic ulnar nerve compression at the wrist.

Strength of Evidence – **Recommended, Insufficient Evidence (I)**
Level of Confidence – Low

Evidence for the Use of Splints

There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: splint, splints, splinting; ulnar nerve compression syndromes, ulnar nerve entrapment, wrist, guyon's canal syndrome, guyon syndrome, ulnar tunnel syndrome, hypothenar hammer syndrome; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 68 articles in PubMed, 6 in Scopus, 0 in CINAHL, 9 in Cochrane Library, 283 in Google Scholar, and 0 from other sources. Zero articles met the inclusion criteria.

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Follow-up Visits

Follow-up visits are generally required every 2 to 4 weeks to evaluate efficacy of interventions until resolution of the condition.

Medications

NSAIDS

Recommendation: NSAIDS for Acute, Subacute, or Chronic Ulnar Nerve Compression at the Wrist

There is no recommendation for or against the use of NSAIDs to control pain associated with acute, subacute, or chronic ulnar nerve compression at the wrist.

Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**
Level of Confidence – Low

Rationale for Recommendation

There is no recommendation for or against the use of NSAIDs for acute or subacute ulnar nerve compression at the wrist as evidence of efficacy is lacking. NSAIDs do not work particularly well for other neuropathies (see Chronic Pain Guideline and CTS section), thus other options are generally preferable.

Evidence for the Use of NSAIDs

There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: NSAIDs, acetaminophen Ulnar Nerve Entrapment at the Wrist (Including Guyon's Canal Syndrome and Hypothenar Hammer Syndrome; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 0 articles in PubMed, 0 in Scopus, 0 in CINAHL, 0 in Cochrane Library, 150 in Google Scholar, and 0 from other sources. We considered for inclusion 0 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 0 from Google Scholar, and 0 from other sources. Zero articles met the inclusion criteria.

GLUCOCORTICOSTEROIDS

Recommendation: Glucocorticosteroids for Acute, Subacute, or Chronic Ulnar Nerve Compression at the Wrist

There is no recommendation for or against the use of oral and injected glucocorticosteroids for treatment of acute, subacute, or chronic ulnar nerve compression at the wrist.

Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**
Level of Confidence – Low

Rationale for Recommendations

There are no quality studies evaluating these treatments for ulnar nerve compression at the wrist. Activity modification to avoid focal mechanical compression and the use of the hypothenar area as a hammer are thought to be important and are recommended. NSAIDs have been utilized. However, evidence of efficacy for treatment of CTS and other neuropathic pain (see Chronic Pain guideline) is lacking, thus other options are generally preferable. The mechanism(s) of efficacy of glucocorticosteroids for treatment of CTS and other disorders is unclear. If the mechanism involves tendon sheaths and related structures, then these medications would be predicted to be ineffective for ulnar neuropathy at the wrist. However, if through another mechanism of action directly involving the nerve sheath, then these injections could be effective. These treatments are not invasive to low invasive, have few adverse effects and are low to moderate cost. They are recommended with the exceptions of NSAIDs and injections for which there is no evidence of efficacy and concerns that the available literature does not support those treatments as efficacious.

Evidence for the Use of Glucocorticosteroids

There are no quality studies incorporated into this analysis.

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A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Glucocorticosteroids, glucocorticoids, Ulnar Nerve Entrapment at the Wrist (Including Guyon's Canal Syndrome and Hypothenar Hammer Syndrome ; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 0 articles in PubMed, 3784 in Scopus, 0 in CINAHL, 1 in Cochrane Library, 150 in Google Scholar, and 0 from other sources. We considered for inclusion 0 from PubMed, 1 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 0 from Google Scholar, and 0 from other sources. Of the 1 articles considered for inclusion, 0 randomized trials and 1 systematic studies met the inclusion criteria.

Physical Methods/Rehabilitation

Recommendation: Physical Methods/Rehabilitation for Acute, Subacute, or Chronic Ulnar Neuropathy at the Wrist

There is no recommendation for or against the use of physical methods/rehabilitation (i.e., iontophoresis, self-application of ice or heat, manipulation, mobilization, massage, friction massage, or acupuncture) for treatment of acute, subacute, or chronic ulnar neuropathy at the wrist.

Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**
Level of Confidence – Low

Rationale for Recommendation
There are no quality studies evaluating the efficacy of physical methods/rehabilitation (i.e., iontophoresis, ice, heat, manipulation, mobilization, massage, friction massage, and acupuncture) for ulnar neuropathy at the wrist and therefore, there is no recommendation for or against the use of these treatments.

Evidence for the Use of Physical Methods/Rehabilitation
There are no quality studies incorporated into this analysis.

Iontophoresis
A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: iontophoresis; ulnar nerve compression syndromes, ulnar nerve entrapment, wrist, guyon's canal syndrome, guyon syndrome, ulnar tunnel syndrome, hypothenar hammer syndrome; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 2 articles in PubMed, 0 in Scopus, 0 in CINAHL, 2 in Cochrane Library, 41 in Google Scholar, and 0 from other sources. Zero articles met the inclusion criteria

Ice
A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Ice; Self Application, Ulnar Nerve Compression Syndromes, Ulnar Nerve Entrapment, Wrist, Guyon's Canal Syndrome, Guyon Syndrome, ulnar tunnel syndrome, Hypothenar Hammer Syndrome; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found, reviewed and considered for inclusion 1 articles in PubMed, 0 in Scopus, 0 in CINAHL, 0 in Cochrane Library, 350 in Google Scholar and 0 in other sources. Zero articles met the inclusion criteria.

Heat
A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Heat; Self Application, Ulnar Nerve

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Compression Syndromes, Ulnar Nerve Entrapment, Wrist, Guyon's Canal Syndrome, Guyon Syndrome, ulnar tunnel syndrome, Hypothenar Hammer Syndrome, controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found, reviewed and considered for inclusion 1 articles in PubMed, 0 in Scopus, 0 in CINAHL, 0 in Cochrane Library, 730 in Google Scholar, and 0 in other sources. Zero articles met the inclusion criteria.

Manipulation/Mobilization
A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: manipulation, mobilization, Ulnar Nerve Entrapment at the Wrist including Guyon's Canal Syndrome and Hypothenar Hammer Syndrome, controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 0 articles in PubMed, 0 in Scopus, 0 in CINAHL, 0 in Cochrane Library, and 0 in Google Scholar. We considered for inclusion 0 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 0 from Google Scholar, and 0 from other sources. Of the 0 articles considered for inclusion, 0 randomized trials and 0 systematic studies met the inclusion criteria.

Massage
A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library and Google Scholar without date limits using the following terms: Massage, Ulnar Nerve Compression Syndromes OR Ulnar Nerve Entrapment, Wrist, Or Guyon Syndrome or Guyon's Canal Syndrome or ulnar tunnel syndrome or Hypothenar Hammer Syndrome ;controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 0 articles in PubMed, 0 in Scopus, 0 in CINAHL, 0 in Cochrane Library, and 0 in Google Scholar. We considered for inclusion 0 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 0 from Google Scholar, and 0 from other sources. Of the 0 articles considered for inclusion, 0 randomized trials and 0 systematic studies met the inclusion criteria.

Acupuncture
A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: acupuncture, Ulnar Nerve Entrapment at the Wrist (Including Guyon's Canal Syndrome and Hypothenar Hammer Syndrome) ;controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 0 articles in PubMed, 0 in Scopus, 0 in CINAHL, 0 in Cochrane Library, and 0 in Google Scholar. We considered for inclusion 0 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 0 from Google Scholar and 0 from other sources. Of the 0 articles considered for inclusion, 0 randomized trials and 0 systematic studies met the inclusion criteria.

EXERCISE
Exercise is not generally indicated acutely. Many patients with chronic findings and functional deficits and post-operative patients require some appointments to at minimum help institute a home exercise program. For patients with residual deficits, particularly post-operatively, see section on Post-Operative Rehabilitation and Rehabilitation of Patients with Functional Deficits: CTS and Other Disorders.

Evidence for the Use of Exercise
There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: exercise, exercising, physical activity; ulnar nerve compression syndromes, ulnar nerve entrapment, wrist, guyon's canal syndrome, guyon syndrome, ulnar tunnel syndrome, hypothenar hammer syndrome; controlled clinical trial, controlled

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trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 9 articles in PubMed, 3 in Scopus, 0 in CINAHL, 16 in Cochrane Library, 468 in Google Scholar, and 0 from other sources. Zero articles met the inclusion criteria.

Surgery

Space occupying lesions with significant motor or sensory deficits generally have been reported in the literature as requiring surgical decompression (or needle aspiration of ganglia) with excellent results and rapid recovery of deficits. In addition to lesion type, consideration may be influenced by the presence of diabetes mellitus. Although there are not quality studies, there may be a stronger indication for decompression of peripheral nerve entrapment syndromes in diabetic patients. In a case series of diabetics with peripheral neuropathy, decompression surgery improved sensory function in 88% of upper extremities and 69% of lower extremities compared with 32% of patients that were treated non-operatively.(1123) Another case series demonstrated similar results, also favoring recovered function in the upper extremities.(1124)

Recommendation: Surgical Decompression for Subacute or Chronic Ulnar Nerve Compression at the Wrist

Surgical decompression is recommended for subacute or chronic ulnar nerve compression at the wrist after failure of non-operative treatment or if space-occupying lesions are present.

Strength of Evidence – **Recommended, Insufficient Evidence (I)**
Level of Confidence – Moderate

Rationale for Recommendation

There are no quality studies evaluating the efficacy of surgical intervention for ulnar nerve compression at the wrist. However, clinically many patients respond well to surgery. Surgery is invasive, has adverse effects and is costly. It is recommended for select patients who failed trials of other non-operative treatments or if space occupying lesions are present. It may also be preferential in those with diabetes mellitus.

Evidence for the Use of Surgery

There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: surgery, surgeries, surgical decompression; Ulnar Nerve Compression Syndromes, Ulnar Nerve Entrapment, Wrist, Guyon's Canal Syndrome, Guyon Syndrome, ulnar tunnel syndrome, Hypothenar Hammer Syndrome; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 224 articles in PubMed, 12 in Scopus, 3 in CINAHL, 12 in Cochrane Library, 628 in Google Scholar, and 0 from other sources. Zero articles met the inclusion criteria.

Radial Nerve Entrapment

Special Studies and Diagnostic and Treatment Considerations

ELECTRODIAGNOSTIC STUDIES

Electrodiagnostic studies can confirm the diagnosis of a radial nerve motor neuropathy.(58)

Recommendation: Electrodiagnostic Testing for Radial Nerve Motor Neuropathy

Electrodiagnostic testing is recommended to confirm clinical suspicion of a radial nerve motor neuropathy.

Strength of Evidence **– Recommended, Insufficient Evidence (I)**

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Level of Confidence – Moderate

Rationale for Recommendation
There is no quality evidence available for the use of electrodiagnostic testing; however, it is recommended as an objective test to evaluate radial nerve motor neuropathy.(58, 59, 1125) However, studies need to be performed by well-trained electrodiagnosticians, preferably certified by the American Board of Electrodiagnostic Medicine.

Evidence for the Use of Electrodiagnostic Studies
There are no quality studies incorporated into this analysis. There are 2 low-quality studies in Appendix 2.(1154, 1155) (Spindler 90; Verhaar 91)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: electrodiagnostic study, nerve conduction study, electromyography, radial nerve entrapment, radial tunnel syndrome, diagnostic, diagnosis, sensitivity, specificity, positive predictive value, negative predictive value, and predictive value of tests, efficacy, and efficiency. We found and reviewed 6 articles in PubMed, 86 in Scopus, 0 in CINAHL, 1 in Cochrane Library, and 160 from Google Scholar. We considered for inclusion 2 from PubMed, 1 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 0 from Google Scholar, and 0 from other sources. Of the 3 articles considered for inclusion 2 diagnostic studies met the inclusion criteria.

ULTRASOUND (DIAGNOSTIC)
Ultrasound has been used as an adjunct to electrophysiological studies for evaluation of radial nerve neuropathy.(446)

Recommendation: Diagnostic Ultrasound for Radial Nerve Neuropathy
There is no recommendation for or against ultrasound to confirm clinical suspicion of a radial nerve neuropathy.

Strength of Evidence **– No Recommendation, Insufficient Evidence (I)**
Level of Confidence – Moderate

Rationale for Recommendation
There is no quality evidence available that diagnostic ultrasound materially alters the ability to diagnose radial nerve entrapments and thus there is no recommendation for or against diagnostic ultrasound.

Evidence for the Use of Ultrasound
There is 1 moderate-quality study incorporated into this analysis.(446)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Ultrasound , diagnostic, diagnosis, sensitivity, specificity, positive predictive value, negative predictive value, and predictive value of tests, efficacy, and efficiency. We found and reviewed 7 articles in PubMed, 93 in Scopus, 0 in CINAHL, 0 in Cochrane Library, and 8540 from Google Scholar, and 0 from other sources. We considered for inclusion 2 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 0 from Google Scholar, and 0 from other sources. One article met the inclusion criteria.

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Author/Year Study Type Conflict of Interest (COI)	Score	N	Area	Diagnoses	Type of Ultrasound	CT used	MRI Used	More than on rater	Blinding of rater	Myelography	Surgery Performed	Clinical outcomes assessed	Long term follow-up (mean when noted)	Results	Conclusion	Comments
Lo 2008 Diagnostic No mention of sponsorship or COI.	7.0	10 (3 female/7 male) with suspected radial neuropathy	HWF	Radial nerve entrapment	Medtronic Keypoint EMG Machine	-	+	+	-	-	-	-	-	Ultrasound correctly identified all 6 with radial neuropathy. Significantly less mean (SD) time for US exam time vs. NCS/EMG: 6.1 (1.1) minutes vs. 30.3 (2.7), p <0.001.	"US is of value as a rapid diagnostic adjunct for the localization of radial nerve entrapment."	Data suggests US has adjunct value along with EP testing for radial entrapment neuropathy.Small sample. Data suggest US is beneficial as an adjunct in diagnosing radial nerve entrapment and takes less time than EP testing.

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Initial Care

Overall, the literature suggests patients most often appear to respond to non-operative treatments including no treatment; avoidance of exposures thought to be contributing (if present); avoidance of wearing a watch, tight jewelry or shirt sleeves on the affected side; corticosteroid injection;(1126) and temporary thumb spica splinting.(66, 1127)

SPLINTS

Recommendation: Wrist Extension or Thumb Spica Splint for Acute, Subacute, or Chronic Radial Nerve Compression Neuropathy

The use of a wrist extension or thumb spica splint is recommended for treatment of acute, subacute, or chronic radial nerve compression neuropathy.

> *Strength of Evidence* **– Recommended, Insufficient Evidence (I)**
> *Level of Confidence* – Low

Rationale for Recommendation

Splints appear to be helpful for many cases and thus are recommended, particularly wrist extension splints.

Evidence for the Use of Splints

There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: splint, splinting, thumb spica, radial nerve entrapment, radial tunnel syndrome; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 2 articles in PubMed, 3 in Scopus, 2 in CINAHL, 7 in Cochrane Library, 180 in Google Scholar, and 0 from other sources. We considered for inclusion 1 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 0 from Google Scholar, and 0 from other sources. Zero articles met the inclusion criteria.

Follow-up Visits

Follow-up visits are generally required every 2 to 4 weeks to evaluate efficacy of interventions until resolution of the condition.

Medications

NSAIDs

Recommendation: NSAIDS for Acute, Subacute, or Chronic Radial Nerve Compression Neuropathy

There is no recommendation for or against the use of NSAIDs to control pain associated with acute, subacute, or chronic radial nerve compression neuropathy.

> *Strength of Evidence* – **No Recommendation, Insufficient Evidence (I)**
> *Level of Confidence* – Low

Evidence for the Use of NSAIDs

There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: NSAIDs, acetaminophen, non-steroidal anti-inflammatory, radial nerve entrapment, radial tunnel syndrome; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 0 articles in PubMed, 10 in Scopus, 0 in CINAHL, 2 in Cochrane Library, 170 in Google Scholar, and 0 from other sources. We considered for inclusion 0 from PubMed, 0 from Scopus,

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0 from CINAHL, 0 from Cochrane Library, 0 from Google Scholar, and 0 from other sources. Zero articles met the inclusion criteria.

GLUCOCORTICOSTEROIDS

Recommendation: Glucocorticosteroids for Acute, Subacute, or Chronic Radial Nerve Compression at the Wrist

There is no recommendation for or against the use of oral and injected glucocorticosteroids for treatment of acute, subacute, or chronic radial nerve compression at the wrist.

Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**
Level of Confidence – Low

Rationale for Recommendations

Although there are no quality studies on which to rely for the treatment of distal radial neuropathies, non-invasive options are available and have few adverse effects and are low cost. NSAIDs are not unreasonable and are recommended by some;(60) however, evidence of efficacy is lacking, NSAIDs do not work particularly well for other neuropathies (see Chronic Pain guideline); thus, other options are generally preferable. The mechanism(s) of efficacy of glucocorticosteroids is unclear. If the mechanism involves tendon sheaths and related structures, then these medications would be predicted to be ineffective for distal radial neuropathies. However, if through another mechanism of action directly involving the nerve sheath, then these injections could be effective. These treatments are not invasive to low invasive, have few adverse effects, and are low to moderate cost. They are recommended, with the exception of NSAIDs and injections for which there is no evidence of efficacy and concerns that the available literature does not support those treatments as efficacious.

Evidence for the Use of MRI and Ultrasound

There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: oral, injection, intravenous, glucocorticosteroid, corticosteroids, steroid, radial nerve entrapment, radial tunnel syndrome; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 2 articles in PubMed, 53 in Scopus, 2 in CINAHL, 5 in Cochrane Library, 236 in Google Scholar, and 0 from other sources. We considered for inclusion 1 from PubMed, 2 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 0 from Google Scholar, and 0 from other sources. Of the 3 articles considered for inclusion, 0 randomized trials and 3 systematic studies met the inclusion criteria.

Physical Methods/Rehabilitation

Recommendation: Physical Methods (Iontophoresis, Self-application of Ice or Heat, Manipulation and Mobilization, Massage, Friction Massage, or Acupuncture) for Acute, Subacute, or Chronic Radial Neuropathy at the Wrist

There is no recommendation for or against the use of physical methods for treatment of acute, subacute, or chronic radial neuropathy at the wrist including iontophoresis, self-application of ice or heat, manipulation and mobilization, massage, friction massage, or acupuncture.

Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**
Level of Confidence – Low

Rationale for Recommendation

There are no quality studies evaluating the use of iontophoresis, self-application of ice and heat, manipulation and mobilization, friction massage, or acupuncture for radial neuropathy at the wrist and therefore, there is no recommendation for or against these treatments. There are reports of benefits from massage, but no quality studies, thus there is no recommendation for massage.

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Evidence for the Use of Physical Methods/Rehabilitation
There are no quality studies incorporated into this analysis.

Ice:
A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Ice; Self Application of Ice, Radial Nerve Entrapment, Radial Tunnel Syndrome, controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 0 articles in PubMed, 6 in Scopus, 0 in CINAHL, 0 in Cochrane Library, 5670 in Google Scholar, and 0 from other sources. We considered for inclusion 0 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 1 from Google Scholar, and 0 from other sources. Zero articles met the inclusion criteria.

Heat:
A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Heat; Self Application of Heat, Radial Nerve Entrapment, Radial Tunnel Syndrome; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 0 articles in PubMed, 0 in Scopus, 0 in CINAHL, 0 in Cochrane Library, 2384 in Google Scholar, and 0 from other sources. We considered for inclusion 0 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 1 from Google Scholar, and 0 from other sources. Zero articles met the inclusion criteria.

Manipulation & Mobilization:
A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Manipulation, mobilization, Radial Nerve Entrapment, Radial Tunnel Syndrome; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 0 articles in PubMed, 0 in Scopus, 0 in CINAHL, 0 in Cochrane Library, and 0 in Google Scholar. We considered for inclusion 0 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 0 from Google Scholar, and 0 from other sources. Of the 0 articles considered for inclusion, 0 randomized trials and 0 systematic studies met the inclusion criteria.

Massage:
A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Massage, friction massage, Radial Nerve Entrapment, Radial Tunnel Syndrome; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found, reviewed and considered for inclusion 0 articles in PubMed, 0 in Scopus, 0 in CINAHL, 0 in Cochrane Library, 0 from Google Scholar and 0 in other sources. Zero articles met the inclusion criteria.

Acupuncture:
A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Acupuncture, Radial nerve entrapment, Radial tunnel syndrome; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found, reviewed and considered for inclusion 0 articles in PubMed, 0 in Scopus, 0 in CINAHL, 0 in Cochrane Library, 0 from Google Scholar and 0 in other sources. Zero articles met the inclusion criteria.

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Iontophoresis:
A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Iontophoresis, Radial Nerve Entrapment, Radial Tunnel Syndrome, controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 0 articles in PubMed, 34 in Scopus, 0 in CINAHL, 0 in Cochrane Library, 60 in Google Scholar, and 0 from other sources. We considered for inclusion 0 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 0 from Google Scholar, and 0 from other sources. Zero articles met the inclusion criteria.

EXERCISE
Exercise is not generally indicated acutely. Many patients with chronic findings, functional deficits and post-operative patients require some appointments to at minimum help institute a home exercise program. For patients with residual deficits, particularly post-operatively, see section on Post-Operative Rehabilitation and Rehabilitation of Patients with Functional Deficits: CTS and Other Disorders.

Evidence for the Use of Exercise
There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: exercise, exercising, physical activity, radial nerve entrapment, radial tunnel syndrome; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 0 articles in PubMed, 94 in Scopus, 0 in CINAHL, 7 in Cochrane Library, 16,630 in Google Scholar, and 0 from other sources. Zero articles met the inclusion criteria.

Surgery
Recommendation: Surgical Release for Subacute or Chronic Radial Nerve Compression Neuropathy
Surgical release is recommended for subacute or chronic cases of radial nerve compression neuropathy that persist despite other interventions.(60)

Strength of Evidence – **Recommended, Insufficient Evidence (I)**
Level of Confidence – Moderate

Rationale for Recommendation
There are no quality studies available on the efficacy of surgical intervention. There are no quality studies evaluating the efficacy of surgical intervention for distal radial neuropathies. However, clinically many patients respond well to surgery. Surgery is invasive, has adverse effects and is costly. It is recommended for select patients who failed trials of other non-operative treatments or if space occupying lesions are present.

Evidence for the Use of Surgery
There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: surgical release, surgery release, surgery, surgical procedures, radial tunnel release, radial nerve entrapment, radial tunnel syndrome; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 6 articles in PubMed, 97 in Scopus, 8 in CINAHL, 10 in Cochrane Library, 423 in Google Scholar, and 0 from other sources. We considered for inclusion 2 from PubMed, 2 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 0 from Google Scholar, and 0 from

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other sources. Of the 4 articles considered for inclusion, 0 randomized trials and 2 systematic studies met the inclusion criteria.

Non-Specific Hand, Wrist, and Forearm Pain

Diagnostic Criteria

Non-specific pain is not a discrete diagnosis, per se, but the absence of a discrete diagnosis.

Special Studies and Diagnostic and Treatment Considerations

RHEUMATOLGICAL STUDIES AND JOINT ASPIRATION

1. *Recommendation: Rheumatological Studies for Arthralgias*
   Rheumatological studies are recommended for evaluation of patients with persistent unexplained arthralgias or tenosynovitis.
   Indications – Persistent unexplained arthralgias or tenosynovitis.
   Frequency/Duration – Repeat studies may be required after passage of time as some patients, particularly those with less severe diseases, tend to develop positive anti-bodies after months to years.

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – High

2. *Recommendation: Arthrocentesis for Joint Effusions*
   Arthrocentesis (joint aspiration) of inexplicable joint effusions, particularly for evaluation of infections and crystalline arthropathies is recommended.
   Indications – Joint effusions without a clear diagnosis including suspected infection or crystalline arthropathies.

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – High

Rationale for Recommendations
There are no quality studies evaluating rheumatological studies for evaluation of arthralgias; however, these studies have been helpful in diagnosing numerous rheumatological disorders. Arthrocentesis is also helpful for securing important diagnoses, such as septic arthritis and crystalline arthropathies.

Evidence for the Use of Rheumatological Studies and Joint Aspiration
There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Non-specific hand, wrist, and forearm pain, Arthocentesis, Joint Effusion, Nonspecific, Hydrarthrosis, diagnostic, diagnosis, sensitivity, specificity, positive predictive value, negative predictive value, and predictive value of tests, efficacy, and efficiency. We found and reviewed 0 articles in PubMed, 9 in Scopus, 1 in CINAHL, 6 in Cochrane Library, 50 from Google Scholar, and 0 from other sources. We considered for inclusion 0 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 0 from Google Scholar, and 0 from other sources. Zero articles met the inclusion criteria.

ELECTRODIAGNOSTIC STUDIES

Recommendation: Electrodiagnostic Studies to Evaluate Non-specific Hand, Wrist, or Forearm Pain in Patients with Paresthesias or Other Neurological Symptoms
Electrodiagnostic studies are recommended to evaluate non-specific hand, wrist, or forearm pain for patients with paresthesias or other neurological symptoms.

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Indications – Persistent tingling and pain, particularly symptoms characteristic of radiculopathies and entrapment neuropathies. Providers are cautioned that the prevalence rate of abnormal electrodiagnostic studies in asymptomatic populations are high (see CTS section above) and interpretations of abnormal findings should be cautious.

Frequency/Dose – Should generally be performed at least 3 weeks after symptom onset.

Strength of Evidence – **Recommended, Insufficient Evidence (I)**
Level of Confidence – Moderate

Rationale for Recommendation
There is 1 low-quality study evaluating electrodiagnostic studies for non-specific pain. However, electrodiagnostic studies may assist in diagnosing and treating the condition and thus are recommended.

Evidence for the Use of Electrodiagnostic Studies
There is 1 low-quality study in Appendix 2.(1128)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Electrodiagnostic, studies, Nerve conduction, study, NCS, Electromyography, EMG, Non-specific, hand, wrist, forearm, paint controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 31 articles in PubMed, 10870 in Scopus, 298 in CINAHL, 183 from Google Scholar, and 7 in Cochrane Library. We considered for inclusion 1 from PubMed, 0 from Scopus, 1 from CINAHL, 0 from Cochrane Library and 0 from other sources. Of the 11358 articles considered for inclusion, 1 randomized trials and 1 systematic studies met the inclusion criteria.

X-RAYS
Recommendation: X-rays for Evaluation of Non-specific Hand, Wrist, or Forearm Pain
X-rays are recommended for evaluation of cases in which non-specific hand, wrist, or forearm pain persists.

Indications – Persistent non-specific hand, wrist, or forearm pain.

Strength of Evidence – **Recommended, Insufficient Evidence (I)**
Level of Confidence – High

Rationale for Recommendation
There is 1 moderate-quality study evaluating x-ray studies for non-specific pain. X-rays may assist in diagnosing and treating the condition and thus are recommended.

Evidence for the Use of X-rays
There is 1 moderate-quality study incorporated into this analysis.(1129)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL and Cochrane Library without date limits using the following terms: X-ray, Non-specific, HWF, pain; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found, reviewed and considered for inclusion 7 articles in PubMed, 332343 in Scopus, 0 in CINAHL, 0 in Cochrane Library and 277000 in other sources. We considered for inclusion 1 from PubMed, zero from Scopus, zero from CINAHL, zero from Cochrane Library and zero from other sources. Of the 1 articles considered for inclusion, 0 randomized trials and 0 systematic studies met the inclusion criteria.

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Author/Year Study Type	Score	Number	Area of upper extremity	Diagnoses	Type of X-rays	CT used	MRI Used	More than on rater	Blinding of rater	Myelography	Surgery Performed	Clinical outcomes	Long term follow-up (mean when noted)	Results	Conclusion	Comments
Huellner 2013 Diagnostic	6.0	32	Hand and wrist	Non-specific hand or wrist pain.	Plain radio-graphs	x	x	x	x	-		x	20 months and 16 months (group dependent)	Plain radio-graphs accuracy (25%-31%), sensitivity (24%-30%), and specificity (20%-60%). PPV (66%-76%) SPECT/CT diagnostics resulted in 44%-77% accuracy, 41%-74% sensitivity, and 60%-90% specificity. PPV (88%-98%)	SPECT/CT resulted in the best imaging modality for non-specific hand and wrist pain. MRI showed better result when comparing typify-cation of lesion.	Data suggest inter-observer agreement for imaging non-specific wrist pain via SPECT/CT good and only MRI better.

Initial Care

RELATIVE REST

Recommendation: Relative Rest for Acute Non-specific Hand, Wrist, or Forearm Pain

Relative rest is a recommended treatment in select cases of acute non-specific hand, wrist, or forearm pain particularly where there are high ergonomic exposures (high force or high force combined with other risk factors).

Strength of Evidence **– Recommended, Insufficient Evidence (I)**
Level of Confidence – Low

Rationale for Recommendation

There are no quality studies and treatment is empiric. For patients with high ergonomic exposures, relative rest may be helpful. This intervention is not invasive, has low adverse effects, and for short periods is low to moderate cost, thus it is recommended.

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Evidence for the Use of Relative Rest
There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: rest or relative rest, bed rest, nonspecific, non-specific, hand pain, wrist pain, and forearm pain; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 2 articles in PubMed, 314 in Scopus, 0 in CINAHL, 2 in Cochrane Library, 34029 in Google Scholar, and 0 from other sources. Zero articles met the inclusion criteria.

SPLINTS
Recommendation: Splinting for Acute or Subacute Non-specific Hand, Wrist, or Forearm Pain
There is no recommendation for or against the use of splinting for treatment of acute or subacute non-specific hand, wrist, or forearm pain.

Strength of Evidence **– No Recommendation, Insufficient Evidence (I)**
Level of Confidence – Low

Rationale for Recommendation
There are no quality studies and treatment is empiric. Splinting may at times be helpful, but enforces debility, thus there is no recommendation for or against its use. It is generally not recommended for chronic use.

Evidence for the Use of Splints
There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: splint, splints or splinting; nonspecific, non-specific, hand pain, wrist pain, forearm pain; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 0 articles in PubMed, 43 in Scopus, 0 in CINAHL, 9 in Cochrane Library, 8,360 in Google Scholar, and 0 from other sources. Zero articles met the inclusion criteria.

ICE/HEAT
Recommendation: Self-application of Ice or Heat for Acute or Subacute Non-specific Hand, Wrist, or Forearm Pain
Self-application of ice or heat is recommended for treatment of acute or subacute non-specific hand, wrist, or forearm pain.

Strength of Evidence **– Recommended, Insufficient Evidence (I)**
Level of Confidence – Low

Rationale for Recommendation
There are no quality studies and treatment is empiric. Self-applications of heat or ice are sometimes helpful. These interventions are not invasive, have low adverse effects, and are low cost, and thus are recommended.

Evidence for the Use of Ice/Heat
There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: ice, icing; nonspecific, non-specific, hand pain, wrist pain, forearm pain; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 0 articles

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in PubMed, 11 in Scopus, 0 in CINAHL, 18 in Cochrane Library, 32,300 in Google Scholar, and 0 from other sources. Zero articles met the inclusion criteria.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: heat, heating, heat therapy, hot temperature; nonspecific, non-specific, hand pain, wrist pain, forearm pain; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 0 articles in PubMed, 75 in Scopus, 0 in CINAHL, 45 in Cochrane Library, 269 in Google Scholar, and 0 from other sources. Zero articles met the inclusion criteria.

Follow-up Visits

Patients may require 1 to 3 appointments depending on the severity or the pain and need for workplace limitations.

Medications

NSAIDS/ACETAMINOPHEN

Recommendation: NSAIDs or Acetaminophen for Acute or Subacute Non-specific Hand, Wrist, or Forearm Pain

NSAIDs or acetaminophen are recommended for control of pain associated with acute or subacute non-specific hand, wrist, or forearm pain.

Indications – Acute or subacute non-specific hand, wrist, or forearm pain.

Frequency/Duration – Scheduled dosage rather than as needed is generally preferable.

Indications for Discontinuation – Resolution of pain, lack of efficacy, development of adverse effects particularly gastrointestinal.

> *Strength of Evidence* **– Recommended, Evidence (C) – NSAIDs**
> *Strength of Evidence* **– Recommended, Insufficient Evidence (I) – Acetaminophen**
> *Level of Confidence* – Low

Rationale for Recommendation

There are two moderate-quality studies evaluating the use of NSAIDs or acetaminophen for treatment of non-specific lower extremity pain(1038, 1039) which is presumably analogous to upper extremity pain and showed benefits (see Ankle and Foot Disorders Guideline). These medications may relieve pain and increase function. They are not invasive, have few adverse effects in employed populations, and are low cost. Thus, they are recommended.

Evidence for the Use of NSAIDs/Acetaminophen

There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: NSAIDs, acetaminophen, non-steroidal anti-inflammatory, acetaminophen, ibuprofen, non-specific, hand, wrist, forearm, pain; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 0 articles in PubMed, 83 in Scopus, 0 in CINAHL, 9 in Cochrane Library, 420 in Google Scholar, and 1 from other sources. We considered for inclusion 1 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 1 from Google Scholar, and 1 from other sources. Of the 3 articles considered for inclusion, 2 randomized trials and 1 systematic studies met the inclusion criteria.

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OPIOIDS
See Opioids recommendations in Carpal Tunnel Syndrome section.

Physical Methods

Recommendation: Physical or Occupational Therapy for Acute, Subacute, or Chronic Non-specific Hand, Wrist, or Forearm Pain
There is no recommendation for or against the use of physical or occupational therapy for treatment of acute, subacute, or chronic non-specific hand, wrist, or forearm pain.

Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**
Level of Confidence – Low

Rationale for Recommendation
There are no quality studies evaluating any of the physical or occupational therapy modalities for treatment of non-specific hand, wrist, or forearm pain. (A case series of hand rehabilitation with occupational therapy services suggested benefits of occupational therapy for patients with heterogenous disorders.) Thus, treatments administered are empiric. These treatments are not invasive, have few adverse effects, but are moderate to high cost depending on number of treatments. They are generally not indicated for initial treatment. They may be more reasonable for more persistent cases. Trials of these modalities may be helpful in cases that do not resolve with initial treatment methods outlined above. However, these treatments are empiric and thus the success may be limited. Thus, there is no recommendation for or against these modalities.

Evidence for the Use of Physical or Occupational Therapy
There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library and Google Scholar without date limits using the following terms physical therapy, occupational therapy, nonspecific, non-specific, hand pain, wrist pain, forearm pain; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found, reviewed and considered for inclusion 13 articles in PubMed, 172 in Scopus, 8 in CINAHL, 3 in Cochrane Library, 150 in Google Scholar and 0 in other sources. Zero articles met the inclusion criteria.

EXERCISE
Exercise is not generally indicated acutely. One moderate quality study of mostly chronic patients found no differences between two types of exercise programs, but had no control group.(1130) Many patients with chronic findings, functional deficits and post-operative patients require some appointments to at minimum help institute a home exercise program. For those with residual deficits, particularly post-operatively, see section on Post-Operative Rehabilitation and Rehabilitation of Patients with Functional Deficits: CTS and Other Disorders.

Evidence for the Use of Exercise
There is 1 moderate-qualtiy RCT incorporated into this analysis.(1130)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL and Cochrane Library and Google Scholar without date limits using the following terms exercise, physical activity, non-specific Hand, Wrist, Forearm Pain, controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 14 articles in PubMed, 38 in Scopus, 1 in CINAHL, 3 in Cochrane Library, and 437 in Google Scholar. We considered for inclusion 0 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 1 in Google Scholar and 0 from other sources. Of the 1 articles considered for inclusion, 1 randomized trials and 0 systematic studies met the inclusion criteria.

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Author/Year Study Type Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
van Eijsden-Besseling 2008 RCT Sponsored by Research Stimulation Fund of University Hospital Maastricht, Institute for Rehabilitation Research, Hoensbroek, The Netherlands. No mention of COI.	5.0	N = 88 with non-specific upper limb disorders; Mean age PE group 33.3±7.7 and SFE group 34.8±7.7. PE group Gender, M:F. (19:25) SFE group Gender M:F (19:25)	Postural exercise group. Received 6 postural therapy sessions first 3 weeks, then tapered to 3 sessions in 3 weeks, 2 sessions in 2 weeks, then home exercise (n = 44) vs. strength/fitness exercise group. Received 9 strength/fitness therapy sessions first 3 weeks, then tapered to 6 sessions in 3 weeks, 2 sessions in 2 weeks, and finally home exercise (n = 44). Follow-up at baseline and months 3, 6, and 12.	No significant difference in decrease in pain between the groups at 3 months (0.6 cm, 95% CI 0.0 to 1.2), 6 months (0.2, 95% CI –0.3 to 0.7), or at 12 months (0.1, 95% CI –0.6 to 0.8)	"Postural exercises showed no additional benefits to recovery when compared to strength and fitness exercise. Roughly 55% of patients reported being complaint free after one year."	Data suggest no significant differences between types of exercises (comparable efficacy). Some baseline differences in groups for potentially compromising comparability.

Surgery

Not applicable.

Scaphoid Fracture

Diagnostic Criteria

A clinical impression is made upon history of appropriate injury mechanism, physical examination findings of substantial tenderness particularly over the scaphoid tubercle. Findings of snuffbox tenderness, positive axial compression of thumb test, and effusion in the wrist (possibly echymosis) should be sought. A fracture identified on imaging that includes a "scaphoid view" confirms that diagnostic impression. Fracture is not always confirmed on initial standard wrist x-rays, although those fractures identified later are by definition non-displaced and have good clinical outcomes with subsequent non-operative treatment. The differential diagnosis includes wrist sprain, undisplaced epiphyseal fractures of the distal portion of the radius in children, fracture of the hook of the hamate, avulsion fracture of the triquestrum, carpal instability, distal ulna subluxation, de Quervain's tensosynovitis, radioscaphoid arthrosis, scapholunate dislocation, and tri-scaphoid arthrosis.

Special Studies and Diagnostic and Treatment Considerations

X-RAYS

X-rays have been widely used as the first diagnostic test for scaphoid fractures.(285, 290, 1035)

1. *Recommendation: X-rays for Diagnosing Scaphoid Fractures*
   X-rays are recommended for diagnostic purposes that include at least 3 to 4 views including a "scaphoid view."(71)

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – High

2. *Recommendation: Follow-up X-rays for Scaphoid Fractures*
   Follow-up x-rays in 2 weeks are recommended for evaluation of potential scaphoid fractures,(1131) **particularly for patients with a high clinical suspicion of fracture, but negative initial x-rays.**

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Strength of Evidence – **Recommended, Insufficient Evidence (I)**
Level of Confidence – High

Rationale for Recommendations
There are no quality studies evaluating x-rays for scaphoid fractures. However, x-rays have been used for decades to evaluate these fractures, identify those requiring surgical treatment, and to evaluate healing; thus, they are recommended to diagnose scaphoid fracture.

Evidence for the Use of X-rays
There are 7 moderate-quality studies incorporated into this analysis.(1164-1170) (Herneth 01)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: x-ray, scaphoid fracture, diagnostic, diagnosis, sensitivity, specificity, positive predictive value, negative predictive value, predictive value of tests, efficacy, efficiency, diagnostic, diagnosis, sensitivity, specificity, positive predictive value, negative predictive value, and predictive value of tests, efficacy, and efficiency. We found and reviewed 2 articles in PubMed, 934 in Scopus, 2 in CINAHL, 9 Cochrane Library, and 0 from Google Scholar. We considered for inclusion 0 from PubMed, 0 from Scopus, 1 from CINAHL, 0 from Cochrane Library, 0 from Google Scholar, and 2 from other sources. Of the 3 articles considered for inclusion 3 diagnostic studies met the inclusion criteria.

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Author/Year Study Type Conflict of Interst (COI)	Score	Number	Area of Body	Diagnoses	Type of CT	X-ray used	MRI Used	More than on rater	Blinding of rater	Myelography	Surgery Performed	Clinical outcomes	Long term follow-up (mean when noted)	Results	Conclusion	Comments
Mallee 2011 Diagnostic	6.5	N = 34	Wrist	Suspected scaphoid fracture	Presence of sharp lucent line within trabecular bone pattern, break in continuity of cortex, sharp step in cortex, or dislocation of bone fragments	-	+	+	+	-	-	-	+	Follow-up for 6 weeks. CT imaging resulted in a diagnosis of 20 fractures in 17 patients. For scaphoid fractures there was a sensitivity of 67% and specificity of 96% with an accuracy of 91% in depicting scaphoid fractures. MRI showed sensitivity of 67% for scaphoid fracture, specificity 89% and accuracy 85%.	"CT and MRI had comparable diagnostic characteristics. Both were better at excluding scaphoid fractures than they were at confirming them, and both were subject to false-positive and false-negative interpretations. The best reference standard is debatable, but it is now unclear whether or not bone edema on MRI and small unicortical lines on CT represent a true fracture."	Data suggest comparable between CT and MRI for suspected scaphoid fractures.
Memarsadeghi 2006 Diagnostic	5.5	N = 29, mean age 34 years	Wrist	Wrist trauma accompanied by severe pain over scaphoid with negative radiograph.	Multi-detector with 4-detector row scanner	+	+	+	+	-	-	-	-	At 6-week follow-up with radiographs, 11 of 29 (38%) had scaphoid fracture; 8 had cortical fracture; 3 had trabecular involvement. MR imaging identified all 11 scaphoid fractures: 100% sensitivity and 100% specificity. 2 of 8 cortical fractures could be seen: 38% sensitivity,	"Multi-detector CT is highly accurate in depicting occult cortical scaphoid fractures but appears inferior to MR imaging in depicting solely trabecular injury. MR imaging is inferior to multidetector CT in depicting cortical involvement."	Small sample. Data suggest similar performance efficacy between CT and MRI for occult scaphoid fracture detection, but CT superior for cortical involvement detection.

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														100% specificity and 55% accuracy. Multidetector CT identified 8 cortical scaphoid fractures: 100% sensitivity/100% specificity. No trabecular fractures detected. MRI vs. CT p = 0.25 scaphoid fractures; p = 0.03 cortical involvement.		
Fotiadou 2011 Diagnostic	5.0	N = 34 mean age 23 years	Wrist	Wrist trauma, both acute and chronic.	16 multislice rows CT scanner	+	+	-	-	-	-	-	-	In 21 of 22 general hospital patients, MRI method of choice following x-rays. CT performed in 1 case. At university hospital CT solely performed in 5/12 cases and was first method of choice in another 3 cases, followed by MRI. Bone injury detected in 17/34 cases. In 7/9 (77.8%) fracture not detected on initial radiographs. Ligament trauma identified solely on MRI in 11 patients. In 4 patients with both MRI and CT, CT revealed 2 fractures not	"Both CT and MRI might be considered in patients with acute or chronic wrist injury, clinical dilemma and normal initial radiographs, depending on the availability and the individual institution policies."	Small sample. Data suggest similar efficacy between CT and MRI but both with limitations.

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														found on MRI.		
Temple 2005 Experimental	4.5	N = 11 cadavers	Wrist	Cadaveric wrists.	Sagital	+			+							Cadaveric study. Data suggest sagittal CT not superior to xray for detecting scaphoid fractures.
Smith 2009 Diagnostic	4.5	N = 31 mean age 29 at time of injury	Wrist	Scaphoid fracture	Pre-op CT scans performed in longitudinal axis of scaphoid. Used GE LightSpeed 16-slice helical scanner. Slice thickness 0.625mm with reconstructions every 0.50mm (120 per kilovoltage, 80 mili-amps, and 0.5 seconds per rotation).	-	-	+	+	-	+	-	+	Median time from injury to CT scan 6 months and median time from injury to surgery 6 months. 20 had histologic avascular necrosis according to criteria established by Ficat. With CT increased radiodensity of proximal pole had strongest correlation with avascular necrosis (p = 0.004). Increased radio density of proximal pole significantly correlated with post-op union rates.	"Preoperative longitudinal CT of scaphoid nonunion is of great value in identifying avascular necrosis and predicting subsequent fracture union."	Small sample. Data suggest CT effective for detecting avascular necrosis of scaphoid proximal pole and non-union after fixation.
Ilica 2011 Diagnostic	4.0	N = 54; mean age 22 years	Wrist	Clinically suspected scaphoid fracture with negative radiograph.	MDCT with a 64-detector multislice system.	+	+	+	+	-	-	-	-	In 20 of 55 (36%) wrists, MRI identified 22 fractures: 16 scaphoid fractures. MDCT identified 19 fractures in 17 of 55 (30%) wrists. 3 fractures missed: 2 scaphoid	"MDCT offers highly accurate results, especially concerning cortical involvement, and is a useful alternative in facilities lacking MRI."	Data suggest MDCT useful in detecting cortical involvement, but not superior to MRI for scaphoid fracture

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														fractures. MDCT 100% specificity, 86% sensitivity, 100% PPV, and 91% NPV.		detection.
Herneth 2001 Diagnostic No mention of sponsorship or COI.	4.0	N = 15 (7 male and 8 female) with acute wrist trauma had scaphoid fractures. Age range 15.8 – 55.2.	HWF	Wrist trauma and scaphoid fractures	High–spatial resolution 10-5-MHz probe	+	-	-	-	-	+	-	9 or 60% of the 15 patients with acute wrist trauma had scaphoid fractures. At high-spatial-resolution US, 7/9 or 78% had positive results, and 22% false negative. 8/9 or 89% had clinical signs of scaphoid fractures, 3/6 or 50% had false positive results, and 1/9 or 11% had false-negative results. Sensitivity of high-spatial-resolution US in depicting scaphoid fractures was 78%, and the specificity was 100% vs with 56% and 100% obtained for conventional	"High-spatial-resolution US is a reliable diagnostic tool for the evaluation of occult scaphoid fractures and should be considered an adequate alternative diagnostic tool prior to computed tomography or MR imaging."	Small sample size. Data suggest high spatial resolution US "may" assist in diagnosing scaphoid fractures when conventional radiography is negative for fractures.	

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													radiographs and 89% and 50% obtained for clinical examination.			

MRI
MRI has been used for the diagnosis of scaphoid fractures.(1138-1140)

Recommendation: MRI for Diagnosing Scaphoid Fractures
MRI is moderately recommended for diagnosis of occult scaphoid fractures when clinical suspicion remains high despite negative x-rays.(1133, 1141-1145)

Indications – Clinical suspicion of scaphoid fracture but negative x-rays.

Strength of Evidence – **Moderately Recommended, Evidence (B)**
Level of Confidence – Low

Rationale for Recommendation
MRI is not required for the majority of scaphoid fractures. However, for patients with a clinical suspicion of scaphoid fracture, but negative x-rays, current treatment recommendations are generally to splint the hand, thus often necessitating prolonged lack of use and lost productivity. A moderate-quality study has reported cost effectiveness of MRI to diagnose occult scaphoid fractures and reduce lost productivity for those without x-ray imaging evidence of fractures.(1146) Two moderate quality studies have suggested comparable results between CT and MRI,(1133, 1137) although two other studies suggested CT was better to evaluate cortical involvement.(1132, 1134) Thus, as there is evidence to support its use among these select patients, MRI is recommended.

Evidence for the Use of MRI for Scaphoid Fracture
There are 30 moderate-quality studies incorporated into this analysis.(1164, 1165, 1169, 1171, 1172'Beeres, 2008 #3210, 1179-1203) (Mallee 11; Fotiadou 11; Tiel-van Buul 96; Bergh 15; Ilica 11; Bretlau 99; Hunter 97; Jorgsholm 13; Kitsis 98; Kusano 02; Moller 04; Raby 01; Lozano-Calderon 06; Larribe 14) There are 6 low-quality studies in Appendix 2.(1027, 1173, 1204-1207) (Imaeda 92; Sharifi 15; Gaebler 96; Senevirathna 13; Schmitt 11)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Scaphoid Fracture, Magnetic Resonance Imaging, MRI, diagnostic, diagnosis, sensitivity, specificity, positive predictive value, negative predictive value, and predictive value of tests, efficacy, and efficiency. We found and reviewed 267 articles in PubMed, 762 in Scopus, 22 in CINAHL, 2 in Cochrane Library, and 1940 from Google Scholar. We considered for inclusion 10 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 1 from Google Scholar, and 29 from other sources. Of the 40 articles considered for inclusion 36 diagnostic studies met the inclusion criteria.

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Author/Year Study Type Conflict of Interst (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Brooks 2005 RCT Sponsored by Consultative Committee on Diagnostic Imaging. No COI.	6.5	N = 37 (24 female/13 male) suspected scaphoid fractures in 5 hospitals. Age for MRI and Control: 35.0 (27-41) and 29.0 (24.75-50).	MRI group (n = 11) vs. Control group (n = 17).	$44.37 (Australian) per day saved from unnecessary immobilization by use of MRI. Early MRI improved date of confirming diagnosis by 7 days, Day 3 vs. Day 10 (p = 0.003). When only subjects diagnosed as having no fracture included in analysis, median number of days unnecessarily in plaster in MRI group 3 days, which is significantly less than median of 10 days in control group (p = 0.006).	"Use of MRI in the management of occult scaphoid fracture reduces the number of days of unnecessary immobilisation and use of healthcare units."	Study may be biased toward justification of early MRI in universal health care models.

Author/Year Study Type	Score	n	Area of Body	Diagnoses	Type of MRI used	Type of CT used	T1 weighted images	T2 weighted images	X-ray	Myelography	More than one rater	Surgery Performed	Clinical outcomes assessed	Long-term follow-up (mean when noted)	Results	Conclusion	Comments
Ng 2013 Diagnostic	7.0	N=35 patients (34 male, 1 female) Mean age: 27.4± 9.4 years	Hand	Scaphoid fracture delayed-union or non-union who underwent surgery within 12 months of imaging.	Dynamic contrast-enhanced (DCE); 3T imaging system using phased array	-	+	+	-	-	-	+	-	-	Unenhanced MRI vascularity at surgery (sensitivity/ specificity/ PPV/ NPV/ accuracy): impaired 70/48/35/80/54; fair 25/74/11/89/69; poor 67/76/36/92/74. Contrast MRI vascularity at surgery (sensitivity/ specificity/	"Comparative relative enhancement in the proximal scaphoid fragment with that in the distal fragment on DCE MRI improved diagnostic accuracy for assessment of proximal fragment vascularity in scaphoid delayed and non-union compared to non-contract and contrast-enhanced MRI examination."	Data suggest DCE MRI is superior to both non-enhanced MRI or contrast enhance MRI for assessing proximal fragment vascularity in scaphoid delayed union and non-union fractures. Incorporation of the time frame between injury and MRI is essential to accurate interpretation.

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					wrist coil with 8 elements of 1.5T imaging system using 2 element surface flex coil.										PPV/ NPV/ accuracy): impaired 56/64/36/80/62; fair 25/73/11/88/68; poor 60/93/60/93/88. DCE MRI vascularity at surgery (sensitivity/ specificity/ PPV/ NPV/ accuracy: impaired 67/86/67/86/80; fair 67/96/67/96/93; poor 67/92/67/92/87.		
Low 2005 Diagnostic	7.0	N=50 patients (40 males, 10 females) Mean age: 29 years	Hand	Scaphoid fracture	0.2T dedicated extremity system	-	+	-	+	-	+	-	-	-	Observer agreement: 2 fractures identified by all 4 observers; 3 fractures by 3 observers; 5 fractures by 2 observers; incorrectly judged as normal 13 times by 4 observers. Observers saw poor sensitivities (11/9/43/49) and low NPV (31/30/39/40) but good specificities (93/93/87/80).	"[T]he present study findings show that follow-up radiography for detection of scaphoid fracture after normal initial radiographs, has poor sensitivity when MRI is adopted as the gold standard and poor reliability as assessed by reliability analysis of inter-observer agreement of four expert observer. "	Data suggest follow-up radiography for acute scaphoid fracture has suboptimal sensitivity, negative predictive value, and reliability for those patients who were initially diagnosed with normal radiographs.

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Gäbler 2001 Diagnostic	6.5	N= 121 patients (77 males, 44 females) Mean age: 30.3± 13.2 years	Hand	Occult scaphoid fracture	1.0 T unit and circular surface coil	-	+	+	+	-	-	-	+	6 weeks	MRI injury detection: none 39 patients, injuries detected 112 in 82 patients. 10 days after injury: of 62 patients with MRI detectable injures 39 diagnosed correctly and another 7 partially correct. 24 days after injury: 14 patients with MRI-detectable injuries, correct diagnosis in 6 cases and partially correct in 2, another 6 cases were diagnosed as negative which was incorrect. All 28 scaphoid fractures were diagnosed correctly; occult fractures diagnosed after a mean of 14.9±9.3 days. Negative diagnosis correctly achieved after mean 12.2±5.12 days. No false-positives in study	"[R]epeated clinical and radiographic examinations are still state of the art. They allow diagnosis of OFSs and other wrist injuries with high reliability."	Data suggests that when performed by experienced clinicians, standard clinical and radiological procedures are reliable in the diagnoses of occult fractures of the carpus and wrist MRIs are indicated for early diagnosis.

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Unay 2009 Diagnostic	6.5	187 (29 males, 12 females) Mean age: 28.9 years	Hand	History of fall on outstretched hand and tenderness upon palpation of anatomical snuffbox and scaphoid tubercle without angulation	1.5 T superconductor	-	+	+	+	-	+	-	-	-	Test-10: sensitivity 0.73, specificity 0.75, positive predictive value 0.96, negative predictive value 0.23, and accuracy 0.73.	"[T]he MRI results of patients presenting with tenderness at the anatomical snuffbox and scaphoid tubercle after a fall on the outstretched hand without a radiographically evident bony injury could indicate any of the following conditions: no bony injury, scaphoid fracture, distal radial fracture, bone-bruise, or triquetral fracture."	Data suggest pronation of the forearm and thumb-index pinch were highly correlate to MRI confirmed bone injury in patients with clinically suspected occult scaphoid fracture.
Mallee 2011 Diagnostic	6.5	N = 34 patients (25 males, 15 women)with suspected scaphoid fracture	Wrist	Scaphoid fracture	Presence of sharp lucent line within trabecular bone pattern, break in continuity of cortex, sharp step in	-	+	+	+	-	-	-	+	Follow-up for 6 weeks. CT imaging resulted in a diagnosis of 20 fractures in 17 patients. For scaphoid fractures there was a sensitivity of 67% and specificity of 96% with an accuracy of 91% in depicting	"CT and MRI had comparable diagnostic characteristics. Both were better at excluding scaphoid fractures than they were at confirming them, and both were subject to false-positive and false-negative interpretations. The best reference standard is debatable, but it is now unclear whether or not bone edema on MRI and small unicortical lines on CT represent a true fracture."	Data suggest comparable between CT and MRI for suspected scaphoid fractures. Follow up include only 34 patients of original 40.	

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					cortex, or dislocation of bone fragments									scaphoid fractures. MRI showed sensitivity of 67% for scaphoid fracture, specificity 89% and accuracy 85%.			
Patel 2013 Diagnostic	6.0	N=91 patients (37 males, 47 females	Hnad	Occult scaphoid fractures	1.0T Philips Intera using C3 surface coil	-	+	+	-	-	-	-	+	42 days	Scaphoid fractures: MRI 3, control group 4. Normal MRI scan: MRI 28.9% vs. control 84.6% (p=0.03). Mean±SD clinical fracture appointment: MRI 1.1±0.5 vs. control 2.3±0.8 (p=0.001). Mean±SD plain radiographs: MRI 1.2±0.8 vs. control 1.7±1.1 (p=0.03). Mean±SD perceived effect of injury (MRI vs. control): day 42, work 0.6±0.9 vs. 1.2±1.6 (p=0.03); hindrance 6.3 vs. 4.9 (p=0.03).	"Early MRI in occult scaphoid fractures is marginally cost saving compared with conventional management and may reduce potentially large societal costs of unnecessary immobilisation."	Data suggest early MRI minimally cost effective, driven by PT, r-rays and appts rather than lost work. Lost to follow up: 7 people

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Fox 2010 Diagnostic	6.0	N=29 patients (25 males, 4 females) Mean age: 21 years	Wrist	Scaphoid fracture	1.5 tesla MRI scan	-	+	+	-	-	+	+	-	-	The mean interval from the date of MRI to the date of surgery was 54 days. When comparing the MR and surgical findings, there were 6 true positive results, 17 true-negative results, 1 false-positive result and 5 false-negative results. There was a sensitivity of 55% and a specificity of 94%.	"T1-weighted unenhanced MRI is an acceptable alternative to delayed contrast-enhanced MRI in the preoperative assessment of the vascular status of the proximal pole of the scaphoid in patients with chronic fracture nonunions."	Data suggest T1 weighted MR images can be an acceptable alternativeto enhance MRI for preoperative assessment of the vascular status of scaphoid proximal pole in those with a non-union.
Fowler 1998 Diagnostic No mention of sponsorship of COI.	6.0	N=45 patients (21 males, 22 females) with acute trauma and clinical symptoms of scaphoid fractures. Mean age: 32 years.	Wrist	Acute wrist trauma and suspected scaphoid fracture	1.0 T unit	N/A	+	+	+	-	+	-	+	+	MRI results showed 100% sensitivity and 100% specificity while Bone Scintigraphy showed 83% sensitivity and 95% specificity.	MRI was found to be more effective than Bone Scintigraphy for the diagnostic potential for scaphoid fractures. MRI has increased convenience for the patient and no use of radiation.	Data suggest MRI more sensitive and specific for occult scaphoid waist fractures compared with bone scan. Two patients dropped.

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Bretlau 1999 Diagnostic No mention of sponsorship or COI.	6.0	N=52 patients (27 males, 25 females) Mean age: 44	Wrist	Clinical suspicion of scaphoid bone fracture after trauma	Dedicated E-MRI, 2 sequences: T1-weighted turbo gradient echo 3D and fast short inversion recover STIR	-	+	-	-	-	+	-	-	+	E-MRI detected occult fractures of the scaphoid in 9 patients, and of the distal radius in a further 6 patients. All these fractures were confirmed at follow-up radiographs. Furthermore, **E**MRI revealed a fracture of the capitate bone in **I** patient, and of the triquetrum in **2** patients, and in ***8*** patients, bone bruise in 1 or more of the carpal bones. However, these fractures and bone lesions could not be confirmed by the follow-up radiographs. The agreement between the two examiners was high (kappa = 0.8) for E-MRI detection of fractures.	"E-MRI seems to be better than radiographs in the early diagnosis of occult"	Data suggest extremity MRI (E-MRI) better than radiographs for early diagnosis of occult scaphoid fractures.

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Lozano-Calderon 2006 Prospective	6.0	30 Gender and age not mentioned	Wrist	Scaphoid fracture	Not mentioned	+	-	+	+	-	-	-	Not mentioned	CT scans had a interobserver reliability value of 0.44 (95% CI = 0.16 – 0.44. p<0.001) compared to the radiography value of 0.16 (95% CI = 0 – 0.25, p<0.01). CT had a sensitivity of 72% (95% CI = 58-87%), specificity of 80% (95% CI =72%-87%) and an accuracy of 77% (95% CI = 70%-83%). Radiography had values of 75% (95% CI = 67%-88%), 64% (95% CI =52%-70%), 68% (95% CI = 60%-74%), respectively. However, when both viewed at the same time, the sensitivity increased (80% (95% CI = 70%-94%) while the specific and accuracy decreased (73% (95% CI = 65%-89%) and 75% (95%	"This study suggests that computed tomography scans are useful for ruling out displacement but not for diagnosing it."	Data sugest CT is useful in ruling out scaphoid fractures displacement but not in the diagnosis of.

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															CI = 67% - 82%), respectively).		
De Zwart 2012 Diagnostic	5.5	N=62 MRI scans of 31 healthy volunteers (44 male scans, 20 female scans) Mean age: 28 years.	Wrist	Scaphoid fractures	1.5 Tesla MRI scanner was used.	-	+	+	-	-	+	-	-	-	Among 319 rated MRI scans 247 were diagnosed with no injury, 13 with scaphoid fracture, 23 with other fracture and 36 as a bone bruise. Based on these data, the specificity of MRI was estimated as 95.9%.	"The specificity of MRI for scaphoid fractures is high (96%), but falsepositives do occur. Radiologists have only moderate agreement when interpreting MRI scans from healthy volunteers. MRI is not an adequate reference standard for true fractures among patients with suspected scaphoid fractures."	Data suggest MRI has a high specificity but false positives occur. Even radiologists have only moderate consensus regarding MRI reults in healthy volunteers suggesting MRI is not the preferred reference standard for R/O scaphoid fractures.
Larribe 2014 Diagnostic	5.5	N=18 patients (16 males, 2 females) Mean age: 30.4± 8.5 years	Wrist	Acute scaphoid fracture	1.5-Tesla imaging system with a dedicated wrist coil	-	+	+	-	-	-	+	-	-	The mean interval between MRI and surgery was 0.7 days. 4 of the 6 necrotic fragments were correctly classified into the necrotic group and 2 patients into the viable group.	"Our data are consistent with previously reported data supporting contrast-enhanced MRI for assessment of viability, and showing that dynamic imaging with time–intensity curve analysis does not provide additional predictive	Data suggest dynamic gadolinium enhance MRI does not provide more information to increase the predictive value in evaluation of acute scaphoid fractures over standard delayed enhance imaging.

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					7 days or less before surgery.										The was a sensitivity of 67%, specific of 67%, positive predictive value of 50% and a negative predictive value of 80%.	value over standard delayed enhanced imaging for acute scaphoid fracture."	
Cook 1997 Diagnostic	5.5	N=18 patients (11 males, 7 females) skeletally immature with radiographic evidence of open physeal plates in distal ulna and radius and potential scaphoid fracture. Mean age:(11 years males, 12 years females)	H/W/F	Scaphoid fractures	1.5 T MR scanner (Gyroscan ACS II)	N/A	+	+	-	-	-	-	-	-	During MRI analysis, 10 with T1 and T2 signal intensities correlating to scaphoid fractures or bone marrow edema. Six had scaphoid fractures and 4 had scaphoid bone marrow edema; 5 with scaphoid fractures also had dorsal soft tissue edema affecting signal intensity.	"[I]t may be worth considering early application of MRI in the diagnostic algorithm of skeletally immature patients sustaining wrist trauma. A normal initial MR has a negative predictive value of 100% as early as 2 days after injury, whereas clinical and radiographic findings are not as reliable; also, scaphoid fractures may be identified on MR earlier than on radiographs in many patients. Additionally, MRI identified a large number of other injuries of both osseous and soft tissue structures."	Small sample size, all children. Data suggest normal MRI has 100% NPV.

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Kusano 2002 Diagnostic No mention of sponsorship or COI.	**5.5**	N=52 patients (32 males, 20 females) with suspected scaphoid fracture. Mean age: 36.7	WIRST	Scaphoid Fracture	MRI (0.2 T) coronal T1-weighted spin-echo and (2) T2-weighted turbo spin-echo.	**+**	**+**	**+**	**+**	**-**	**-**	**+**	**+**	**+**	In 18 of the 53 wrists, fracture was detected on MRI. Fracture was also found in the distal end of the radius in 11 patients and in the capitate in one patient. A bone contusion was found in the distal end of the radius in two patients. A fracture line was found in 13 of 16 diagnosed scaphoid fractures via CT.	"This study may provide useful information in choosing treatment methods. Three (19%) of 16 patients with fracture evidence on MRI but without a fracture line on the initial CT did well without surgery and demonstrated evidence of a healed fracture on the follow-up CT. The drawback of MRI and CT examination is its high cost; however, may avoid unnecessary treatment or decrease treatment period and thus reduce total expense.	Data suggest MRI as well as CT are useful when diagnosing occult carpal scaphoid fractures.
Fotiadou 2011 Diagnostic	5.0	N = 34 mean age 23 years	Wrist	Wrist trauma, both acute and chronic.	16 multislice rows CT scanner	+	+	-	-	-	-	-	-	In 21 of 22 general hospital patients, MRI method of choice following x-rays. CT performed in 1 case. At university hospital CT solely performed in 5/12	"Both CT and MRI might be considered in patients with acute or chronic wrist injury, clinical dilemma and normal initial radiographs, depending on the availability and the individual institution policies."	Small sample. Data suggest similar efficacy between CT and MRI but both with limitations. No mention of gender.	Small sample. Data suggest similar efficacy between CT and MRI but both with limitations

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														cases and was first method of choice in another 3 cases, followed by MRI. Bone injury detected in 17/34 cases. In 7/9 (77.8%) fracture not detected on initial radiographs. Ligament trauma identified solely on MRI in 11 patients. In 4 patients with both MRI and CT, CT revealed 2 fractures not found on MRI.			

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Brydie 2003 Diagnostic No sponsorship or COI.	5.0	N=195 patients (112 males, 83 females) with suspected scaphoid fracture. Mean age: 36 years	Wrist	Suspected scaphoid fracture	0.2-T low field scanner	N/A	+	+	+	-	+	-	+	+	Of 195 patients, 99 (51%) had normal MRI results, 20 (10%) showed carpal or distal radius bone bruising. 74 patients (38%) were diagnosed with fractures, 37 (19%) with scaphoid fractures and 28 (14.4%) with distal radius fractures.	"MRI can now justifiably be regarded as the gold standard investigation for clinical scaphoid fracture. Using MRI we have determined that the incidence of occult scaphoid fracture is 19%. MRI enables the correct diagnosis to be reached early and by directing appropriate patient management, prevents the unnecessary overtreatment of the majority of patients thus bringing both health and economic benefits."	Large sample size. Data suggest early MRI helpful for early management of scaphoid fractures.
Jorgsholm 2013 Diagnostic No mention of sponsorship or COI	**5.0**	N=300 wrists in 296 patients (179 males, 117 females) with posttraumatic radial wrist tenderness. Mean age: 39 years.	WRIST	Scaphoid Fracture	0.23-T low-field MRI unit with dedicated small joint coil and coronal short tau inversion	+	-	-	+	-	-	-	+	-	Two hundred twenty-four fractures were found in 196 of the 300 wrists. An isolated scaphoid fracture was shown in 107 wrists, and a scaphoid association with other fractures was found in 18 wrists. Other fractures were found in 71 wrists.. The most commonly found fracture	"Low-field MRI showed a high incidence of fractures in patients with posttraumatic radial wrist tenderness and demonstrated more fractures than radiographs and CT. A scaphoid fracture was by far the most common injury. However, it is not clear whether diagnosis of subtle injuries only demonstrated on MRI improves outcomes."	Data suggest MRI detected significant numbness of fractures in patient with posttraumatic radial wrist tenderness better than either CT or radiography.

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					recovery (STIR), 3-mm slice thickness; coronal T1 field echo 3-dimensional, 2-mm slice thickness; axial T1 fast spin-echo, 3.5-mm slice thickness; and sagittal T1 field echo 3-dimensional,										combinations were that of the scaphoid and distal radius, followed by scaphoid and capitate fracture. The sensitivity of radiographs for visualization of scaphoid fractures was 70% and the specificity was 98%. Radiographic sensitivity for other fractures was less than 60%. The sensitivity of CT for visualization of scaphoid fractures was 95%, and between 75% and 100% for other fractures. MRI revealed 9 wrists with bone edema in the scaphoid and capitate		

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					2-mm slice thickness.												
Møller 2004 Diagnostic No mention of sponsorship or COI.	5.0	N=224 patients (109 males, 115 females). Mean age: 31.5 years.	WRIST	Scaphoid Fracture	T1w and STIR coronal 3 mm thickness	-	+	-	+	-	+	-	+	-	The MRI radiographers reported 43 scaphoid fractures, whereas the radiologist ultimately diagnosed only 36 scaphoid fractures (16.1% of patients) (sensitivity, 100%; specificity, 96.3%). Six of the seven false-positive fractures occurred in patients with edema of the scaphoid. The seventh false-positive was a fracture of the capitate. The hospital saved at least €20,000 and the social care system €70.000.	"It is possible to provide an acute MRI service to patients with clinically suspected fracture of the scaphoid and a normal plain radiograph. The MR images can be primarily read by sufficiently trained MR radiographers. This new work-up protocol reduces the cost for society.	Data suggest MRI useful in diagnosing scaphoid fractures when plain radiographs are negative.

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Tiel-van Buul 1996 Diagnostic Articles	4.5	N=16 patients (11 males, 5 females)	Wrist	Clinical suspected scaphoid fracture	3-phase radionuclide bone scintigraphy was obtained after 72 hours following trauma using 200 MBq 99m Tc-methylene diphosphonate	-	+	+	-	-	+	-	72 hours after injury	MRI only available for 16 of 19 patients. X-ray also performed. Bone scintigraphy positive in 7 for scaphoid fractures while MRI only positive in 5.	"We conclude that in the diagnostic management of patients with suspected scaphoid fracture and negative initial radiographs, the use of MRI may be promising, but is not superior to three-phase bone scintigraphy."	Small sample size. Data suggest MRI not superior to 3-phase bone scan for scaphoid fracture detection.	
Tibrewal 2012 Diagnostic No mention of sponsorship and no COI.	4.5	N=137 patients (79 males, 57 females) with suspected scaphoid fractures, Mean age: 34.6 years.	Wrist	Suspected scaphoid fracture	1.5 T scanner	N/A	+	+	+	-	+	-	+	-	37 (27%) MRI exams normal, 59 (43.4%) diagnosed with soft tissue injuries. 17 (12.5%) resulted in scaphoid fractures and 30 (22%)	"MRI should be regarded as the gold standard investigation for patients in whom a scaphoid fracture is suspected clinically."	Data suggest MRI useful in diagnosis of scaphoid fractures and may detect occult in boney injuries.

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															resulted in fractures in carpal bones or distal radius.		
Hunter 1997 Diagnostic No mention of sponsorship or COI.	4.5	N=36 patients (28 males, 8 females) with wrist trauma injury suspected of scaphoid fracture. Mean age: 26	WRIST	Scaphoid Fracture	Sign a 1.5-T MR imager with a phased-array coil.	+	+	+	-	-	+	-	+	+	MR imaging revealed 22 occult fractures in 20 patients. Thirteen of these 22 fractures were in the scaphoid bone, and 9 were in the distal radius. On MR images, 16 patients had no evidence of fracture. Follow-up radiographs were available in 17 of the 20 patients who had occult fracture revealed by MR imaging. Eleven of the 13 occult fractures of the scaphoid bone were followed up(2 lost to follow-up), and three of these showed evidence of healing fracture. Three patients without	"MR imaging can reveal occult wrist fracture when findings on radiographs are normal or equivocal."	Data suggest in patients where ther is a clinically high index of suspicion of scaphoid fracture but the radiographs are either negative or indeterminant, MRI can be useful in detecting occult wrist fracture.

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															MR evidence of a fracture had follow-up radiographs that showed no fracture. Three patients had findings consistent with bone contusion on MR images; in two patients, the contusion was associated with other fractures, and in one patient, the contusion was isolated.		
Beeres 2008 Diagnostic	4.0	N=79 patients (43 males, 36 females) Mean Age: 41 years	Wrist	Scaphoid fractures	1.5 Tesla MR scanner	-	+	+	-	-	+	-	-	-	The pairwise and overall k statistic was 0.67 (0.44-0.90) for inter-observer variation for a scaphoid fracture. The intra-observer variation was calculated for 38 patients, and the k statistic was 0.96 (0.69-1.0) for a scaphoid fracture.	"In conclusion, the observer variation in MRI of suspected scaphoid fractures was low. The influence of expertise with MRI in daily practice should be taken into consideration."	Data suggest observer varation of scaphoid fractures low with MRI but over diagnosed suggesting the diagnosis should be made with a trained radiologist.
Ilica 2011 Diagnostic	4.0	N = 54 patients (54 males, 0 females); mean age: 22 years	Wrist	Clinically suspected scaphoid fracture with	MDCT with a 64-detector multislice	+	+	+	+	-	-	-	-	In 20 of 55 (36%) wrists, MRI identified 22 fractures: 16	"MDCT offers highly accurate results, especially concerning cortical involvement, and is a useful	Data suggest MDCT useful in detecting cortical involvement, but not superior to MRI for scaphoid fracture detection.	

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				negative radiograph.	system.									scaphoid fractures. MDCT identified 19 fractures in 17 of 55 (30%) wrists. 3 fractures missed: 2 scaphoid fractures. MDCT 100% specificity, 86% sensitivity, 100% PPV, and 91% NPV.	alternative in facilities lacking MRI."		
Querellou 2014 Diagnostic	4.0	N=57 patients (26 males, 31 females) with unilateral acute carpal trauma, hand pain or wrist pain. Mean age: 34 years	H/W/F	Wrist trauma occult fractures	1.5-T Scanner (Magnetom Avento 1.5 T; Siemens)	Dual-head gamma camera with	+	-	+	-	+	-	+	+6 months	26 presented wrist and hand fractures through SPECT/CT; 26 presented positive results for wrist and hand fractures or bruising during MRI scans; 17 had discordant results between MRI and SPECT/CT in regards to bruising vs. fracture diagnoses.	"This study highlights that bone scintigraphy associated with SPECT/CT is a very useful and sensitive imaging technique to depict occult wrist fracture in patients with carpal trauma. Its interest is to allow the detection of these specific fractures and reduces the secondary risks such as nonunion. When a carpal occult fracture is strongly suspected clinically, SPECT/CT might be proposed	Data suggest SPECT/CT more sensitive than MRI for detection of occult wrist fractures.

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						hbuiltinCT										as a sensitive follow-up examination."	
Bergh 2015 Diagnostic	4.0	N=125 patients (68 males, 56 females) with clinically suspected scaphoid fracture. Mean age: 30 years.	Wrist	Scaphoid fractures	1.5 Tesla whole-body scanner with a wrist coil.	-	?	?	-	-	+	-	+	-	7 diagnosed scaphoid fractures in MIR group vs. 4 in control group. For patients without fractures, those in MRI group used cast for fewer days (1 day) vs. control group (mean 14 days) (p <0.001). MRI group also had less days on sick leave than controls; 7 vs. 15 (p = 0.002).	"In a Norwegian setting, an early MRI was of value in patients with clinically suspected scaphoid fracture and normal plain radiographs."	Quasi-randomized cast analysis study in Norway, part of Bergh 2012, 14. Early MRI found cast effective largely due to lost work.
Bhat 2004 Diagnostic No sponsorship or COI.	4.0	N=50 with fractures of waist of scaphoid. Age not given.	Wrist	Isolated fracture of waist of scaphoid.	1.5 Tesla	Not given	-	-	-	-	+	-	-	+	Assessments of both observers showed: sensitivity of 100%, specificity of 74%-87%, negative predictive value of 100%, and accuracy of 76%-88% for predicting nonunion, but less satisfactory	"[T]he assessment of displacement of scaphoid fractures on MRI can probably be used to assess the likelihood of union although the small number of nonunions limits the power of the study."	Data suggest plain xray less accurate for degree of displacement for scaphoid fractures. No mention of gender.

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															positive predictive values (20% and 33%). Assessment of displacement on scaphoid series of radiographs had sensitivity between 33%-47% and positive predictive value between 27%-86%. Correct identification of displaced fractures from plain radiographs by both observers no more than 33%-47%.		
Breitenseher 1997 Diagnostic No mention of sponsorship or COI.	4.0	N=42 patients (23 males, 19 females) with clinical suspicion of scaphoid fracture after acute wrist injury. Mean age: 30.5±13.8 years	Wrist	Acute wrist injury	1.0-T unit	N/A	+	+	-	-	+		+	+	MI depicted occult fractures of scaphoid bone in 14 or 33%; capitate bone in 4 or 10%; and trapezium in 1 patient (5%). Sensitivity and specificity for detection of radiographically occult fractures of wrist; 100%, and 95% and 100% for second radiologist, (k = 0.953). Sensitivities for	“MR imaging has a high sensitivity for detection of fractures of the scaphoid bone and wrist not evident on plain radiographs and may enable early diagnosis and treatment.”	Data suggest MRI sensitive for occult scaphoid fracture detection and other fractures detection.

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															detection of cortical fracture tine; 21%, 100%, and 14% (T1 and T2* sequences, respectively). Ssensitivities for detection of bone marrow abnormality 100%, 100%, and 59%, respectively.		
Kitsis 1998 Diagnostic No mention of sponsorship or COI.	4.0	N=22 patients (9 males, 13 females) Mean age:34	WRIST	Scaphoid Fracture	The MRI scan was on a picker vista 0.5 tesla knee coil	-	-	-	+	-	-	-	-	+	Eight patients had no bone injury in either the MRI or the bone scan. Three scaphoid fractures were found on the MRI and the bone scan and one scaphoid fracture was diagnosed with bone scanner and not on the MRI.	"We feel that MRI gives the most information and is the closest to a gold standard that exists. If MRI is not available, bone scanning remains a sensitive method of detecting scaphoid fractures. Altough it is less specific in diagnosing other injuries and has a higher rate of false positives."	Small sample. Data suggest MRI provides more information for diagnosing scaphoid fractures which are negative on plain radiographs.
Raby 2001 Diagnostic	4.0	N=56 patients	WRIST	Scaphoid Fracture	0.2T extremity MR system. Spin echo T1 and STIR T1 70	-	-	-	+	-	+	-	+	-	The early MR group had seven scaphoid, six radial and four other fractures. Management was altered in 89%. The late MR group had 14 scaphoid, nine radial and three other fractures.	"MRI of the wrist when scaphoid fracture is suspected can be undertaken in all patients with negative radiographs and could be performed in most departments with an MRI machine. There are signi®cant patient bene®ts and overall costs would change little from	No mention of gender or mean age. Data suggest when scaphoid fracture is suspected but radiographs are negative, MRI is useful in diagnosing scaphoid fractures.

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															Management was altered in 69%. A cost model showed that overall costs are less with early rather than late scanning.	conventional practice.”	

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HIGH-SPATIAL RESOLUTION SONOGRAPHY

High-spatial resolution sonography has been used to diagnose scaphoid fractures.(1162)

Recommendation: High-spatial Resolution Sonography for Diagnosing Scaphoid Fractures
High-spatial resolution sonography is recommended to diagnose occult scaphoid fractures when clinical suspicion remains high despite negative x-rays.

Strength of Evidence – **Recommended, Evidence (C)**
Level of Confidence – Moderate

Rationale for Recommendation
There are a few quality studies regarding the use of high-spatial resolution sonography to diagnose scaphoid fractures, with data suggesting reasonable reliability.(1162)

Evidence for the Use of High-Spatial Resolution Sonography
There are 4 moderate-quality studies incorporated into this analysis.(1170, 1177, 1208, 1209) (Fusetti 05; Hauger 02; Herneth 01; Tiel Van-Buul 93)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: high spatial resolution sonography, scaphoid bone, fractures, bone or scaphoid fractures, diagnostic, diagnosis, sensitivity, specificity, positive predictive value, negative predictive value, and predictive value of tests, efficacy, and efficiency. We found and reviewed 2 articles in PubMed, 2 in Scopus, 1 in CINAHL, 0 from Cochrane Library, and 418 from Google Scholar. We considered for inclusion 2 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 5 from Google Scholar, and 0 from other sources. Of the 7 articles considered for inclusion 3 diagnostic studies met the inclusion criteria.

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Author/Year Study Type Conflict of Interest (COI)	Score	Number	Area of Body	Diagnoses	Type of CT	X-ray used	MRI Used	More than on rater	Blinding of rater	Myelography	Surgery Performed	Clinical outcomes	Long term follow-up (mean when noted)	Results	Conclusion	Comments
Fusetti 2005 Diagnostic No mention of sponsorship or COI.	6.5	N = 24 (11 female and 13 male) with clinically suspected fracture and normal radiographs.	Hand	Occult scaphoid fractures	MX-8000 16 Slices; High-spatial-resolution sonography (HSR-S)	-	-	+	+	-	-	+	-	10 (42%) presented high index of suspicion, 7 (29%) moderate index, and 7 (29%) a low index. RS effusion observed in 16 or 66% and STT effusion in 8 or 33%. Sensitivity / specificity / PPV/and NPV of HSR-S for early detection of occult SFs 100% (5/5), 79% (15/19), 56% (5/9), and 100% (15/15).	"HSR-S is a reliable, available, and cost-effective method in early diagnosis of occult fractures of the scaphoid."	Small sample size. Data suggest (HSR-S) is reliable as well as cost effective method in early diagnosis of occult fractures of the scaphoid and this method is not without problems and CT is still superior.
Tiel-Van Buul 1993 RCT	5.5	160 82 male 78 female Mean age = 38.6	Wrist	Scaphoid fracture	Scaphoid Radiography	-	-	+	+	-	-	+	Patients were reviewer after at least one year.	35 patients showed evidence for a scaphoid fracture on the initial radiographs. Overall, 21 patients were positive for a scaphoid fracture, 24 was positive for other bone fractures, and 80 were negative. The	"We advise scaphoid radiography using at least four views"	Data suggest at one year, suspected scaphoid fractures via posture bone scans or radiographs did not affect frequency or severity of late symptoms when compared to patients with normal bone scans.

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														bone scan revealed 41 patients with a scaphoid fracture, 49 with other bone fractures, and 41 negative results. No information about sensitivity and specificity were mentioned.		
Hauger 2002 Diagnostic No mention of sponsorship or COI.	4.5	N = 54 (35 males and 19 female) with clinically suspected scaphoid fracture and normal findings on initial radiographs, including specific scaphoid images. Age range 10 – 75.	HWF	Suspected scaphoid fracture	high-spatial-resolution 12-MHz transducer	+	-	-	-	-	+	-		11% showed cortical disruption of the scaphoid on sonography 15% showed hematoma alone, eight (15%) showed hemarthrosis alone, and 32 or 59% did not show any abnormality. The overall prevalence of occult fracture was 9.3% (5/54), ranging from 3.7% (1/27) for low suspicion to 6.3% (1/16) for moderate suspicion and to 27% (3/11) for high suspicion of fracture. Sensitivity / specificity / positive predictive value / and negative predictive value of sonography for early detection of occult scaphoid	"High-resolution sonography is a reliable and accurate method of evaluating occult fractures of the scaphoid waist."	Data suggest high spatial resolution sonography can be beneficial in diagnosing scaphoid fractures when plain radiographs are negative when there is a high index of suspicion for scaphoid fracture. However, findings support cortical disruption is key in making the diagnosis.

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														fractures to be 100% / 98% / 83% / and 100%, respectively.		
Herneth 2001 Diagnostic No mention of sponsorship or COI.	4.0	N = 15 (7 male and 8 female) with acute wrist trauma had scaphoid fractures. Age range 15.8 – 55.2.	HWF	Wrist trauma and scaphoid fractures	High–spatial resolution 10-5-MHz probe	+	-	-	-	-	+	-		9 or 60% of the 15 patients with acute wrist trauma had scaphoid fractures. At high-spatial-resolution US, 7/9 or 78% had positive results, and 22% false negative. 8/9 or 89% had clinical signs of scaphoid fractures, 3/6 or 50% had false positive results, and 1/9 or 11% had false-negative results. Sensitivity of high-spatial-resolution US in depicting scaphoid fractures was 78%, and the specificity was 100% vs with 56% and 100% obtained for conventional radiographs and 89% and 50% obtained for clinical examination.	"High-spatial-resolution US is a reliable diagnostic tool for the evaluation of occult scaphoid fractures and should be considered an adequate alternative diagnostic tool prior to computed tomography or MR imaging."	Small sample size. Data suggest high spatial resolution US "may" assist in diagnosing scaphoid fractures when conventional radiography is negative for fractures.

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CT IMAGING
CT has been used to diagnose scaphoid fractures.(1163)

Recommendation: CT Imaging for Diagnosing Scaphoid Fractures
CT imaging is moderately recommended to diagnose occult scaphoid fractures when clinical suspicion remains high despite negative x-rays.(1162, 1164, 1165) Quality studies include multiplanar reconstructive CT.(1165)

Strength of Evidence – **Moderately Recommended, Evidence (B)**
Level of Confidence – Moderate

Rationale for Recommendation
There are some quality studies regarding the use of CT to diagnose scaphoid fractures, although false positives occur.(1164) One comparative trial was unable to confirm CT as superior to bone scan.(1166) A retrospective case series study reported that 22% (n = 118) of patients with negative x-rays, but with clinical suspicion of scaphoid fracture, were confirmed positive by CT imaging.(1167) There are no studies comparing MRI with CT with bone scanning and no recommendation is made for one over the other. Two moderate quality studies have suggested comparable results between CT and MRI,(1133, 1137) although two other studies suggested CT was better to evaluate cortical involvement.(1132, 1134) For patients with continuing symptoms suggestive of scaphoid fracture, but absence of findings on repeat x-ray, CT scan has been reported to be an effective imaging technique.(1168, 1169) Therefore, CT imaging for those with clinical impression of fracture but negative x-rays is recommended.

Evidence for the Use of CT Imaging
There are 10 moderate-quality studies incorporated into this analysis.(1164-1166, 1208, 1211-1213, 1217-1219) (Mallee 11; Memarsadeghi 06; Ilica 11; Cruickshank 07)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: CT imaging, CT, CAT, scaphoid fracture, diagnostic, diagnosis, sensitivity, specificity, positive predictive value, negative predictive value, predictive value of tests, efficacy, efficiency, diagnostic, diagnosis, sensitivity, specificity, positive predictive value, negative predictive value, and predictive value of tests, efficacy, and efficiency. We found and reviewed 0 articles in PubMed, 20 in Scopus, 20 in CINAHL, 3 Cochrane Library, and 20 from Google Scholar. We considered for inclusion 0 from PubMed, 4 from Scopus, 3 from CINAHL, 0 from Cochrane Library, 0 from Google Scholar, and 4 from other sources. Of the 11 articles considered for inclusion, 10 diagnostic studies met the inclusion criteria.(1162, 1164-1166, 1170, 1171)

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Author/Year Study Type Conflict of Interest (COI)	Score	Number	Area of Body	Diagnoses	Type of CT	X-ray used	MRI Used	More than on rater	Blinding of rater	Myelography	Surgery Performed	Clinical outcomes	Long term follow-up (mean when noted)	Results	Conclusion	Comments
Adey 2007 Diagnostic Sponsored by unrestricted research grants from AO Foundation, Small Bone Innovations, Smith and Nephew, Wright Medical, Biomet, and Joint Active Systems. No mention of COI.	7.0	N = 13 (gender not specified) with nondisplaced scaphoid fractures and 17 diagnosed with suspected fractures, average age 33 years	Hand	Non-displaced scaphoid waist fractures	GE Lightspeed Qx/i CT Scanner; GE Medical Systems, Pewaukee, WI	-	-	+	-	-	-	-	-	Average sensitivity/ specificity/ and accuracy of CT for nondisplaced scaphoid fracture, for 1st round: 89% / 91% / and 90% 2nd round: 97% / 85% / and 88%. Positive predictive value or PPV for detection of radiographically occult scaphoid fractures with tomography of wrist 0.28 (95% CI, 0.23-0.32); NPV 0.99 (95% CI, 0.97- 0.99).	"Computed tomography should be used with caution for triage of nondisplaced scaphoid fractures because false-positive results occur, perhaps from misinterpretation of vascular foraminae or other normal lines in the scaphoid."	Data suggest CT as better for ruling out fractures that result in due to relative infrequency of time fractures in patients with suspected scaphoid fractures.
Fusetti 2005 Diagnostic No mention of sponsorship or COI.	6.5	N = 24 (11 female and 13 male) with clinically suspected fracture and normal	Hand	Occult scaphoid fractures	MX-8000 16 Slices; High-spatial-resolution sonography (HSR-S)	-	-	+	+	-	-	+	-	10 (42%) presented high index of suspicion, 7 (29%) moderate index, and 7 (29%) a low index. RS	"HSR-S is a reliable, available, and cost-effective method in early diagnosis of occult	Small sample size. Data suggest (HSR-S) is reliable as well as cost effective method in

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		radiographs.												effusion observed in 16 or 66% and STT effusion in 8 or 33%. Sensitivity / specificity / PPV/and NPV of HSR-S for early detection of occult SFs 100% (5/5), 79% (15/19), 56% (5/9), and 100% (15/15).	fractures of the scaphoid."	early diagnosis of occult fractures of the scaphoid and this method is not without problems and CT is still superior.
Hannemann 2013 Diagnostic Sponsored by a research grant from the Netherlands Organisation for Health Research and Development. No COI.	6.5	N = 44 (10 female/34 male) with radiologically proven unilateral scaphoid fracture. Age over 18.	Hand	Proven unilateral scaphoid fracture	Multiplanar reconstruction CT	-	-	+	-	-	-	-	+	All views combined (transversal, coronal, and sagittal) for: no union, partial union, or union was moderate overall inter-observer agreement (κ = 0.576) (95 % CI: 0.399–0.753). Overall inter-observer agreement (κ = 0.699, 95 % CI: 0.529–0.870). Average sensitivity of multiplanar reconstruction CT was 73% and average specificity 80%.	"In conclusion, for follow-up after a scaphoid fracture, multiplanar reconstruction computed tomography is a reliable and accurate method for assessing union or nonunion of scaphoid fractures."	Data suggest multiplanar reconstruction CT is accurate and reliable in the diagnosis of union and –non union scaphoid. Wrist fractures with respect to partial union fractures is significant variation between observers.

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Hannemann 2014 Diagnostic RCT Double-blind No sponsorship or COI.	6.5	N = 102 ≥18 years	Hand	Randomized to: Group A or active PEMF (n = 51) vs. Group B, or placebo (n = 51) Assessed functional and radiological outcomes (multiplanar reconstructed CT scans) at 6, 9, 12, 24 and 52 weeks.	Multiplanar reconstructed CT (MRCT)	-	-	+	+	-	-	+	+	Time to clinical union; median of 6 weeks (6-24, IQR 6-9) in group A vs. median of 6 weeks (6-52, IQR 6-9) in group B. The range of movement returned to normal at 12 week in both groups. Weighted mean inter observer agreement for union (κ = 0.683, 95% CI 0.473 - 0.893) and nonunion (κ = 0.791, 95% CI 0.599 - 0.984) for all CT scans, (p < 0.002). Median time to radiologically confirmed union in group A was six weeks vs 12 weeks in group B, (p = 0.30). Waist fractures proceeded to union earlier in group A vs B (median 12 weeks (6 to 12) vs 52 weeks (6 -	"[T]he addition of PEMF bone growth stimulation to the conservative treatment of acute scaphoid fractures does not accelerate bone healing."	Data suggest addition of PEMF bone growth stimulation did not accelerate bone healing when compared to placebo.

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														52), chi-squared test = 4.156, (p = 0.04).		
Mallee 2011 Diagnostic	6.5	N = 34	Wrist	Suspected scaphoid fracture	Presence of sharp lucent line within trabecular bone pattern, break in continuity of cortex, sharp step in cortex, or dislocation of bone fragments	-	+	+	+	-	-	-	+	Follow-up for 6 weeks. CT imaging resulted in a diagnosis of 20 fractures in 17 patients. For scaphoid fractures there was a sensitivity of 67% and specificity of 96% with an accuracy of 91% in depicting scaphoid fractures. MRI showed sensitivity of 67% for scaphoid fracture, specificity 89% and accuracy 85%.	"CT and MRI had comparable diagnostic characteristics. Both were better at excluding scaphoid fractures than they were at confirming them, and both were subject to false-positive and false-negative interpretations. The best reference standard is debatable, but it is now unclear whether or not bone edema on MRI and small unicortical lines on CT represent a true fracture."	Data suggest comparable between CT and MRI for suspected scaphoid fractures.
Cruickshank 2007 Prospective observational	6.5	47 patients with suspected scaphoid fractures 26 men 21 women	Wrist	Scaphoid fracture	Siemens Somatome Volume Zoom (4 slice) for first 13 patients. Rest of patients were scaned with	+	+ if patient continiued to have snuff box tenderness and normal x-ray	-	-	-	-	+	10-14 days post injury. Again at 7 days and 6-8 weeks if x-ray shows	CT had a positive predictive value of 100% (95% CI = 78%-100%) and the specificity was 100% (95% CI = 87%-100%).	"CT has the potential to limit the need for immobilization for the majority of patients with clinical Scaphoid fracture, who	Data suggest early CT is reliable for diagnosing scaphoid fractures and other fractures of the wrist and carpal.

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		Age not mentioned			Siemens 64 slices machine.								evidence of fracture	The negative predictive value for fractures are 96.7% (95% CI 82%-100%) with a sensitivity of 94.4% (95% CI = 72%-100%) One fracture was missed on the CT but was visible on a MRI.	do not actually have a fracture."	
Clementson 2015 Diagnostic RCT No sponsorship or COI.	5.5	N = 65 with scaphoid waist fractures.	Hand	Scaphoid waist fracture	Operative treatment (n = 26) and Cast immobilization (n = 39), followed with CT scans at 10 and 14 weeks and 6 and 12 months.	-	-	+	-	-	+	-	+	24 fractures immobilized 5-8 weeks, 11 for 10-12 weeks, 4 for 13-16 weeks. 6-week CT scan demonstrated 27/30 or 90% of non- or minimally displaced fractures had united, linear association, (p = 0.47). In operatively treated group, 17 fractures immobilized in plaster for 2 weeks, 2 for 3-4 weeks, 5 for 6 weeks, 2 for 10 weeks; union rate at 6 weeks for non- or minimally	"The majority of non- or minimally displaced scaphoid waist fractures are sufficiently treated with 6 weeks in a cast."	Data suggests most non or minimally displaced scaphoid wrist fractures adequately treated for 6 weeks in cast. Screw fixation did not appear to shorter time to fracture union. Conservative treated fractures with prolonged time to union comminuted.

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														displaced fractures 82%, dropping to 40% for severely displaced fractures. CT scan demonstrated 80% united at 6 weeks, increasing to 94% after 10 weeks. Significant difference in union rate between treatment groups at any measure point, (p = 1.00).		
Rhemrev 2010 Diagnostic No sponsorship or COI.	5.5	N = 100 with clinically suspected scaphoid fracture.	Hand	Evaluated with CT within 24 hours after injury and bone scintigraphy between 3 and 5 days after injury.	Lightspeed Qx/I CT Scanner, Pewaukee, WI	-	-	+	+	-	-	+	+	13 had positive bone scintigraphy and negative CT scan. CT galse negative in 5 and false positive in 1 patient. Bone scintigraphy has sensitivity of 93% (13/14) and a specificity of 91% (78/86). CT has sensitivity of 64% (9/14) and specificity of 99% (85/86).	“In conclusion, this study confirms that bone scintigraphy remains the gold standard to date.”	Data suggest bone scan 3-5 deep laser superior to CT within 24◦ of accident. Timing is different not a head to head comparison.

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Memarsadeghi 2006 Diagnostic	5.5	N = 29, mean age 34 years	Wrist	Wrist trauma accompanied by severe pain over scaphoid with negative radiograph.	Multi-detector with 4-detector row scanner	+	+	+	+	-	-	-	-	At 6-week follow-up with radiographs, 11 of 29 (38%) had scaphoid fracture; 8 had cortical fracture; 3 had trabecular involvement. MR imaging identified all 11 scaphoid fractures: 100% sensitivity and 100% specificity. 2 of 8 cortical fractures could be seen: 38% sensitivity, 100% specificity and 55% accuracy. Multidetector CT identified 8 cortical scaphoid fractures: 100% sensitivity/100% specificity. No trabecular fractures detected. MRI vs. CT p = 0.25 scaphoid fractures; p = 0.03 cortical involvement.	"Multi-detector CT is highly accurate in depicting occult cortical scaphoid fractures but appears inferior to MR imaging in depicting solely trabecular injury. MR imaging is inferior to multidetector CT in depicting cortical involvement."	Small sample. Data suggest similar performance efficacy between CT and MRI for occult scaphoid fracture detection, but CT superior for cortical involvement detection.

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Ilica 2011 Diagnostic	4.0	N = 54; mean age 22 years	Wrist	Clinically suspected scaphoid fracture with negative radiograph.	MDCT with a 64-detector multislice system.	+	+	+	+	-	-	-	-	In 20 of 55 (36%) wrists, MRI identified 22 fractures: 16 scaphoid fractures. MDCT identified 19 fractures in 17 of 55 (30%) wrists. 3 fractures missed: 2 scaphoid fractures. MDCT 100% specificity, 86% sensitivity, 100% PPV, and 91% NPV.	"MDCT offers highly accurate results, especially concerning cortical involvement, and is a useful alternative in facilities lacking MRI."	Data suggest MDCT useful in detecting cortical involvement, but not superior to MRI for scaphoid fracture detection.

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BONE SCAN

Bone scans have been utilized for years to diagnose occult fractures.(1172)

Recommendation: Bone Scanning for Diagnosing Scaphoid Fractures

Bone scanning is recommended to diagnose occult scaphoid fractures when clinical suspicion remains high despite negative x-rays.(1141-1145, 1173, 1174)

Indications – At least 48 hours after the injury with continuing clinic suspicion of scaphoid fracture.(1175)

Strength of Evidence – **Recommended, Evidence (C)**

Level of Confidence – Moderate

Rationale for Recommendation

There are few quality studies on bone scanning for scaphoid fracture and suggesting utility.(1173, 1175-1177) Bone scans are not required for evaluation of the majority of patients with scaphoid fractures; however, in those patients with a clinical suspicion of scaphoid fracture, but negative x-rays, bone scans may assist in securing an earlier diagnosis that may obviate prolonged splinting in those without a fracture. Thus, bone scans are recommended for these select patients.

Evidence for the Use of Bone Scans

There are 9 moderate-quality studies incorporated into this analysis.(1162, 1194, 1221-1223, 1225-1228) (Tiel van Buul 93; Murphy 95; Hiscox 14; Beeres 05; Beeres 07) There is 1 low-quality study in Appendix 2.(1224)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: bone scan, scaphoid fracture, scaphoid bone fracture, diagnostic, diagnosis, sensitivity, specificity, positive predictive value, negative predictive value, and predictive value of tests, efficacy, and efficiency. We found and reviewed 42 articles in PubMed, 85 in Scopus, 2 in CINAHL, 1 in Cochrane Library, and 96 from Google Scholar. We considered for inclusion 10 from PubMed, 1 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 0 from Google Scholar, and from 0 other sources. Of the 11 articles considered for inclusion 10 diagnostic studies met the inclusion criteria.

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Author/Year Study Type	Score	N	Area of Body	Diagnoses	Type of Bone Scans	CT used	MRI Used	More than on rater	Blinding of rater	Myelography	Surgery Performed	Clinical outcomes	Long term follow-up (mean when noted)	Results	Conclusion	Comments
Rolfe 1981 Diagnostic	5.0	99	Hand	Recent history of carpal trauma, clinical signs suggestive of scaphoid fracture, no identifiable fracture on initial radiographic.	Isotope bone imaging (IBI)	-	-	-	-	-	-	-	-	Of 99 cases, 47 had abnormal focal increased uptake (AFIU). Of the 47, 26 had evidence of scaphoid injury. Of those 19 had retrospective radiographic evidence of fracture.	"In select cases of carpal trauma, IBI provides a satisfactory alternative means of identifying the presence and site of localized injury within the carpus and may be used to confidently exclude those patients with nonoesseous symtomatology.	Data suggest IBI results are only reliable if imaging is performed at least 48 hours after injury but in cases of fracture, AFIU may persist for years. In certain selective cases of carpal trauma, IBI may be used as an alternative technique of identification of a localized injury within the carpus.

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Nielsen 1983 Diagnostic	4.5	100 (101 wrists)	Wrist	Scaphoid fracture. Mean age 33 years.	99m-Tc_MDP wrist scintigraphy performed with a Nuclear-Chicago Pho/Gamma 3 scanner.	-	-	-	-	-	-	+	2 months.	Scintigram result: 54 positive, 13 inconclusive, among which 25 fractures detected (11 were scaphoid).	"99m-TC-MDP wrist scintigraphy appears expedient to exclude scaphoid bone fracture, if performed in case of doubt after secondary clinical and radiographic assessment and guided by negative scintigrams, the number of clinical examinations, radiographies and superfluous casting days are reduced."	Data suggest wrist bone scan highly sensitive but low specificity for scaphoid fractures.
Tiel-van Buul 1996 Diagnostic Articles	4.5	19 patients	Wrist	Clinical suspected scaphoid fracture	3-phase radionuclide bone scintigraphy was obtained after 72 hours following trauma using 200 MBq 99mTc-methylene	-	+	+	-	-	+	-	72 hours after injury	MRI only available for 16 of 19 patients. X-ray also performed. Bone scintigraphy positive in 7 for scaphoid fractures while MRI only positive in 5.	"We conclude that in the diagnostic management of patients with suspected scaphoid fracture and negative initial radiographs, the use of	Small sample size. Data suggest MRI not superior to 3-phase bone scan for scaphoid fracture detection.

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					diphosphonate										MRI may be promising, but is not superior to three-phase bone scintigraphy."	
Tiel-Van Buul 1993 Diagnostic	6.5	78 35 male 43 female Mean age = 42	Wrist	Recent history of carpal trauma, clinical signs suggestive of scaphoid fracture, no identifiable fracture on initial radiographic.	Three phase radionuclide bone scintigraphy (72 hours after injury)	-	-	+	+	-	-	-	1 day, 2 weeks, 6 weeks	A total of 152 scaphoid radiographs were available for interpretation. In 18 patients the initial radiographs were judged positive for scaphoid facture, whereas 60 patients had negative initial radiographs. After 2 weeks, two more scaphoid factures were recognized, and one additional scaphoid facture was identified after 6 weeks. Bone scintigraphy was obtained in the 60 patients with initially negative radiographs and in 15 patients a "hot-spot" in the scaphoid region was seen.	"The best diagnostic strategy in the management of clinically suspected scaphoid fractures consist of initial radiography followed by bone scintigraphy in patients with negative radiographs."	Data suggest bone scan should be used only after failed radiograph. Bone scans should be used instead of multiple radiographs after a failing initial radiograph.

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Murphy 1995 Diagnostic	7.0	99 55 male, 44 female Mean age = 36	Hand and wrist	Clinical scaphoid fracture was defined as presence of "snuffbox tenderness" or pain on direct palpation of the anatomic snuffbox. Patients with normal repeat radiographs were referred for bone scanning.	Three-phase technetium methylene diphosphate bone scan	-	-	+	+	-	-	+	4 days, 14 days	Day 4 bond scans, when compared to the diagnosis made with a radiograph on day 14, had a sensitivity of 100%, specificity of 92%, positive predictive value of 65%, negative predictive value of 100%, accuracy of 93%.	"Day 4 bone scans are an accurate means of ruling out scaphoid fracture. However, because of a significant number of false-positive scans at day 4, they do not reliably confirm the diagnosis of scaphoid fracture. The bone scans also permitted identification of several other wrist fractures that had not been radiographically apparent.	Data suggest bone scans performed on day 4 detect more wrist fractures of all types not just scaphoid fractures.
Hiscox 2014 Bone Scan Vs. Radiograph Diagnostic	6.0	27 16 males, 11 females Mean age = 36	Wrist	Patients with clinical scaphoid fractures based on acute wrist injury and snuffbox tenderness and normal	Three-phase bone scan	-	-	-	+	-	-	+	10 to 14 days, then 6 weeks, then 12 months	Mean number of days immobilized was 26 in radiograph/traditional diagnosis group while the mean was 29 for bone scan/early diagnosis group. The Kaplan-Meier survival analysis using	"The current study suggests that the use of bone scans to help diagnose occult scaphoid fractures does not	Small sample so study aim cannot be adequately answered. Data suggest comparable efficacy and bone

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				radiographs.										the log-rank test revealed that there was no statistically significant difference between days immobilized between the radiograph and bone scan groups (p = 0.38).	reduce the number of days immobilized and that the differential diagnosis of occult scaphoid fractures should remain broad because other injuries are common."	scans do not appear to reduce the number of casted days for occult scaphoid fracture.
Beeres 2005 Diagnostic	5.5	56 36 male, 26 female Mean age = 38	Wrist	Patients with suspected scaphoid fracture that did not show on plain radiographs. Clinical signs of fracture include swollen and tender anatomical snuffbox.	Three-phase bone scan. Technetium-diphosphonate, Tc99m-HDP	-	-	+	+	-	-	+	Week 1, then week 6, and then month 3	Bone scans showed a fracture in 38/56 patients. 15 fractures were at the scaphoid bone.	"If there is a strong clinical suspicion of a scaphoid fracture, which cannot be confirmed by conventional radiology, BS is a valuable diagnostic tool."	Data support bone scans for detecting scaphoid fractures when there is a high clinical suspicion and radiographs are negative.

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Beeres 2007 Diagnostic	5.5	50 29 male, 21 female Mean age = 42	Wrist	Acute trauma and suspected scaphoid fracture. Tender anatomical snuffbox and pain when applying axial pressure	Palmar and dorsal images after injection of 500 MBq of Technetium-diphosphonate (Tc99m-HDP)	-	-	-	+	-	-	+	Depending on injury and grouping – between two weeks and 24 weeks	Bone scans revealed occult scaphoid factures in 16 out of 50 patients. Bone scans also identified other occult fractures in 20 out of 50 patients. Bone scans resulted in a false positive in five patients and one false negative for scaphoid facture.	"Bone scintigraphy in combination with protocolised physical examination is the gold standard for patients with signs of a scaphoid fracture that cannot be proven on scaphoid radiographs."	Data suggest bone scinctigraphy in combination with physical examination is the gold standard for diagnosing suspected scaphoid fractures when scaphoid radiographs cannot confirm the scaphoid fracture.
Stordahl 1984 Diagnostic Articles	4.0	30 mean age 31	Wrist	Clinical signs of fractured scaphoid and either negative or non-diagnostic initial x-rays.	Radionuclide imaging. administration of 10-15 mCi 99 mTc Dimethylene Phosphonate. We used a Pho/Gamma 4 Camera with divergent low energy collimator, or pinhole collimator.	-	-	+	-	-	-	-	Follow up at 2 and 6 weeks	9 had focal increased activity on bone scan located on the scaphoid bone, 4 of these had negative x-rays and 5 had inconclusive x-rays. These fractures did not show up until 2-6 weeks after trauma.	"We found bone scanning using 99 mTc a valuable diagnostic tool in the assessment of wrist trauma, in particular the early assessment of fractures in the presence of non-diagnostic radiographs."	Data suggest isotopic bone scan useful to for early scaphoid fracture detection.

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Initial Care

SPLINTS

Recommendation: Wrist Splinting for Scaphoid Tubercle Fractures
Wrist splinting is recommended for treatment of scaphoid tubercle fractures.

Strength of Evidence – **Recommended, Insufficient Evidence (I)**
Level of Confidence – High

Rationale for Recommendation
There are no quality studies evaluating wrist splinting for treatment of scaphoid tubercle fractures. However, clinical experience suggests splinting may suffice, as these fractures heal well due to adequate blood supply.(1229) (Symes 11) Splinting is not invasive, has few adverse effects, is low cost, and thus is recommended.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Splint, splinting, scaphoid fracture, Scaphoid Bone, controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 8 articles in PubMed, 68 in Scopus, 3 in CINAHL, 1 in Cochrane Library, 95 in Google Scholar, and 0 from other sources. We considered for inclusion 3 from PubMed, 1 from Scopus, 0 from CINAHL, 1 from Cochrane Library, 1 from Google Scholar, and 0 from other sources. Of the 6 articles considered for inclusion, 0 randomized trials and 1 systematic studies met the inclusion criteria.

CAST IMMOBILIZATION

Casting has been long been traditionally used as a primary intervention, with successful union being achieved 88 to 95% of the time.(1178) Typically, a Colles' cast is recommended with the wrist in approximately 20° anatomic extension (functionally neutral posture), although many practitioners prefer a thumb spica cast.(402, 1179, 1180) High-risk scaphoid fractures should be promptly referred to hand or orthopaedic surgical specialists for definitive treatment because of the higher risk of these fractures developing a nonunion, malunion, or degenerative joint disease.

1. *Recommendation: Wrist Casting for Stable Scaphoid Fractures*
   Immobilization of the wrist with casting is moderately recommended for treatment of documented stable scaphoid fractures which are displaced less than 1mm, are non-oblique, and do not include the proximal 1/3 of the scaphoid.

   Indications – Stable documented scaphoid fractures that include fractures with any of these properties:
   - Fragments displaced less than 1mm;
   - Fragments are non-oblique;
   - Fragment does not include the proximal 1/3 of the scaphoid.

   Frequency/Duration – Casting should be performed for 6 to 8 weeks, and then with the cast removed, imaging taken to assess healing.(402, 1131)

   Strength of Evidence – **Moderately Recommended, Evidence (B)**
   Level of Confidence – High

Rationale for Recommendation
There is no quality evidence comparing casting to no immobilization for scaphoid fractures. However, in cadaveric studies there is a significant difference in angulation and rotation when comparing casting with no-casting. There are 6 moderate-quality studies that include casting as a treatment with effective results in achieving successful union reported.(401, 402, 1178, 1181-1183) Casting is not invasive, has some associated stiffness, decreased grip strength, and atrophy due to disuse, and is of moderate cost; however, it is believed to be essential to healing. It also has been associated with lower rates of subsequent

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development of osteoarthrosis than operative fixation.(1184) Thus, casting is recommended for treatment of stable scaphoid fractures.

2. *Recommendation: Use of Thumb Immobilization with Casting for Scaphoid Fractures*
   There is no recommendation for or against concurrent immobilization of the thumb with the wrist for treatment of scaphoid fractures.

   Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**
   Level of Confidence – Low

Rationale for Recommendation
There is significant debate whether or not the thumb should be immobilized along with the wrist. There is one moderate-quality study that found no advantage to using a thumb spica compared with a Colles' cast in 392 patients.(1181) Another study included thumb immobilization in both groups when comparing long and short arm casts to evaluate the effect of pronation and supination.(1182) The authors concluded inhibition of pronation and supination during the first 6 weeks was beneficial. However, in a cadaveric model study, short arm casting was found to be just as effective as a thumb spica,(1185) in eliminating displacement and rotation of the fracture. Thus, there is no evidence of improved healing rates or reduced rates of non-union between the two types of cast, although thumb immobilization markedly reduces function.(1146, 1181, 1186, 1187)

3. *Recommendation: Colles' Casting or Supportive Bandaging for Suspected but Radiographically Negative Scaphoid Fracture*
   Colles' casting or supportive bandaging is recommended for patients with suspicion of scaphoid fracture, but with negative x-rays.(1188)

   Duration – 2 weeks, followed by cast removal, clinical examination, and re-x-ray.(1131, 1189) (Leslie 81; Gumucio 89)

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – Low

Rationale for Recommendation
The prognosis of occult fractures is thought to be very good as the fragments are by definition, well approximated.(288, 1131, 1190) For patients with suspicion of fractures, but negative x-rays, either Colles' casting or supportive bandaging(1188) is recommended for 2 weeks, followed by cast removal, clinical examination, and repeat x-ray.(1131, 1189) Reassessment in 2 weeks allows sufficient time for the fracture plane to be identifiable on repeat x-rays. Casting or splinting in 2 weeks is generally sufficient to prevent significant range of motion during the initial time the fracture would be healing and is recommended. If x-rays are again negative and symptoms persist, it is unlikely that there is a fracture and other diagnoses should be sought.

4. *Recommendation: Casting for High-risk Scaphoid Fractures*
   Long-arm casting at 90° of elbow flexion is recommended for high-risk scaphoid fractures that are displaced 1mm or more,(1191, 1192) **or fractures of the proximal 1/3 of the scaphoid and oblique fractures.**(1131, 1189) **It is recommended that high-risk scaphoid fractures be evaluated and treated by a specialist experienced in the management of these fractures.**

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – Moderate

Rationale for Recommendation
Scaphoid fractures are at a high risk for non-unions. High-risk scaphoid fractures have been treated surgically for many years as they tend to not heal well, thus fixation is believed to facilitate healing. While there are no quality studies supporting this belief, clinical experiences indicate superior results with this approach. Surgical intervention is invasive, has significant adverse effects including risk of non-union, and is costly. However, the risks of not operating appear higher and surgery is recommended. For non-displaced fractures, non-operative treatment is likely preferable, particularly as the long-term risk of osteoarthrosis is lower.

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Evidence for Casting with Thumb Immobilization for Scaphoid Fractures
There are 7 moderate-quality RCTs incorporated into this analysis.(1179, 1181-1183, 1186, 1193, 1194)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library and Google Scholar without date limits using the following terms: cast immobilization, scaphoid fracture, Scaphoid Bone, controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 29 articles in PubMed, 110 in Scopus, 11 in CINAHL, 15 in Cochrane Library, 6 in Google Scholar, and 0 from other sources. We considered for inclusion 29 from PubMed, 1 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 1 from Google Scholar, and 0 from other sources. Of the 31 articles considered for inclusion, 7 randomized trials and 1 systematic studies met the inclusion criteria.

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Author/Year Study Type Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Herbert Screws						
Saedén 2001 RCT No sponsorship. No mention of COI.	5.0	N = 61 with 62 (49 males, 13 females) acute fractures of scaphoid. Mean±SD age 29±13 years.	Short arm cast (n = 30) vs. Herbert screws (n = 30). 12-year follow-up.	Patients treated by surgery working at time of injury on sick leave an average of 6+3 weeks vs. 15+10 weeks in conservatively treated group (p = 0.002, t = -3.77). At 12-year follow-up, 90% surgical and 69% conservative groups reported no pain or wrist discomfort. Grip strength and ROM not different between groups. Radiographic evidence of osteoarthritis more common in surgical group (p = 0.049), but no difference in symptoms.	"In our study the fractures united whether they were treated operatively or conservatively. Internal fixation of an acute fracture of the scaphoid allows early return to normal function and should be regarded as an alternative to conservative treatment in those patients who cannot accept immobilisation in a cast for three months or more, for sport, social or work-related reasons."	Randomization and allocation methods unclear. Surgery may result in faster recovery times and less time off work. However, surgery resulted in higher risk of arthritis.
Dias 2008 RCT No COI. No mention of sponsorship.	4.5	N = 71 (62 males, 9 females) with fractured scaphoid. Mean (SEM) age fixation: 29.3 (16 to 50). Cast: 31.4 (16 to 61).	Herbert screw fixation (n = 35) vs. below elbow plaster cast immobilization (n = 36). Mean follow up was 93 months.	No statistical difference in symptoms and disability as assessed by mean Patient Evaluation Measure (p = 0.4), or mean Patient-Rated Wrist Evaluation (p = 0.9), mean range of movement of wrist (p = 0.4), mean grip strength (p = 0.8), or mean pinch strength (p = 0.4).	"No medium-term difference in function or radiological outcome was identified between the two treatment groups."	Data suggest comparable efficacy between group outcomes comparing use of casts vs. surgical treatment of acute scaphoid fractures at 93 months.
Standard Cast						
Buijze 2014 RCT No mention of sponsorship. No COI.	7.0	N = 62 (19 female, 43 male) with CT or magnetic resonance image-confirmed nondisplaced or minimally displaced fracture of scaphoid. Mean±SD age no thumb: 42±18 years. Thumb cast 33±14 years.	Below-elbow cast with inclusion of thumb (n = 31) vsbelow-elbow cast without inclusion of thumb (n = 31). Follow up at 10 weeks and 6 months.	Mean±SD extent of union (%) no thumb vs. thumb cast: 85±24 vs. 70±30, p = 0.048.	"Immobilization of the thumb appears unnecessary for CT or magnetic resonance image-confirmed nondisplaced or minimally displaced fractures of the waist of the scaphoid."	Data suggest immobilization of thumb via casting for non-displaced and minimally displaced scaphoid wrist fracture is not beneficial as more union occurred in those without thumb casting via CT. Functional measures between groups comparable.

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Cohen 2001 RCT No mention of sponsorship or COI.	4.0	N = 200 with arm and leg injuries requiring cast support. Age and gender not reported.	Standard cast consisting of synthetic or plaster of paris, vs. focused rigidity cast of synthetic material.	Focused rigidity casting superior to traditional techniques for ability score (p = 0.0001), satisfaction score (p = 0.0023), overall impairment of function (p = 0.019), limitation of movement following cast removal (p = 0.024)	"Compared with the standard technique, focused rigidity casting has been shown to be superior to traditional methods with regard to satisfaction and functional scores without any detriment to clinical results."	Data suggest increased patient satisfaction with FRC vs. conventional plaster of Paris cast with comparable efficacy.
Colles' Cast						
Gellman 1989 RCT No mention of sponsorship or COI.	4.0	N = 51 (46 males, 5 females) with fractures of scaphoid. Mean age: 30 years.	Long thumb spica cast (N=28) vs. short-thumb spica cast (N=23).	Fractures of proximal and middle thirds had shorter time to union when treated initially with long thumb-spica cast (9.5 weeks vs. 12.7 weeks), p <0.05. Fractures of distal third did less well regardless of immobilization method.	"[W]e recommend an initial period of immobilization of six weeks in a long thumb-spica cast, followed by application of a short thumb-spica cast for non-displaced fractures of the proximal or middle third of the scaphoid."	Pseudorandomization, allocation not hidden, no blinding.
Clay 1991 RCT No industry sponsorship. No mention of COI.	4.0	N = 392 (222 males, 170 females) with scaphoid injury. Mean age: 29.7 years.	Colles' cast (N=145) vs. scaphoid cast (N=140) with thumb enclosed to the interphalangeal joint for 8 weeks	No difference in non-unions (10% in both groups), cast tolerance or in functional outcomes.	"Both types of cast were equally well tolerated and rehabilitation did not appear to be adversely affected by immobilisation of the thumb."	Lack of details on randomization, allocation, no blinding. High withdrawal rate in one study center (college students).
Hambidge 1999 RCT No industry sponsorship. No mention of COI.	4.5	N = 121 with fractures of scaphoid. Gender not reported. Mean age 30 years (range 16-76).	Immobilized with Colles'-type plaster cast in either 20° flexion (n = 58) vs. 20° extension (n = 63). Follow-up for 6 months.	Nonunion was not influenced by the position of immobilization: flexion 91% vs. extension 87%, p = 0.46.	"[A]cute fractures of the scaphoid should be treated in a Colles'-type cast with the wrist in slight extension."	Data suggest position of wrist before casting is not important, rather, immobilization via casting is for scaphoid fracture union.

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Follow-up Visits

Duration of immobilization is typically 6 to 8 weeks to develop resolution of tenderness and for imaging evidence of healing.(402, 1131) After 6 to 8 weeks, the cast should be removed, imaging repeated, and casts reapplied for an additional 3 to 6 weeks, with a repeating process until evidence of fracture healing is documented. The average casting time for non-displaced fractures is 10 weeks,(402) with all expected to heal in 6 months.(401)

Medications

NSAIDS/ACETAMINOPHEN

Recommendation: NSAIDs or Acetaminophen for Scaphoid Fractures

NSAIDs or acetaminophen are recommended to control pain associated with scaphoid fractures.

Indications – Pain due to a scaphoid fracture.

Frequency/Duration – Scheduled dosage rather than as needed is generally preferable.

Indications for Discontinuation – Resolution of pain, lack of efficacy, development of adverse effects, particularly gastrointestinal.

Strength of Evidence – **Recommended, Insufficient Evidence (I)**

Level of Confidence – Moderate

Rationale for Recommendation

There is no quality evidence for or against the use of NSAIDs or acetaminophen for scaphoid fractures. These medications have been found useful in other musculoskeletal injuries and by inference may be efficacious for control of swelling and pain in the initial stages of injury, although some concerns about healing of bones have been raised. Other studies have suggested no delayed bone healing (see Distal Forearm Fractures section).

Evidence for the Use of NSAIDs/Acetaminophen

There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: NSAIDs, non-steroidal anti-inflammatory, acetaminophen, ibuprofen, scaphoid bone, scaphoid fractures; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 0 articles in PubMed, 4 in Scopus, 0 in CINAHL, 0 in Cochrane Library, 80 in Google Scholar, and 0 from other sources. We considered for inclusion 0 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 0 from Google Scholar, and 0 from other sources. Zero articles met the inclusion criteria.

Physical Methods/Rehabilitation

1. *Recommendation: Education after Cast Removal for Scaphoid Fractures*
   Referral of select patients needing education after cast removal for scaphoid fractures is recommended.

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**

   Level of Confidence – Low

2. *Recommendation: Physical or Occupational Therapy after Cast Removal for Scaphoid Fractures for Patients with Functional Debilities*
   Referral of patients with functional debilities or those unable to return to work for physical or occupational therapy after cast removal for scaphoid fractures is recommended.

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**

   Level of Confidence – Moderate

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3. *Recommendation: Physical or Occupational Therapy after Cast Removal for Scaphoid Fractures for All Other Patients*
   Routine referral for physical or occupational therapy after cast removal for scaphoid fractures of otherwise healthy patients who are able to return to work is not recommended.

   Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
   Level of Confidence – Low

Rationale for Recommendations
There are no quality studies evaluating education or occupational or physical therapy for scaphoid fracture. (However, there are several studies showing this for various MSD outcomes when comparing formal therapy with a self-administered home exercise program – see section on Post-Operative Rehabilitation and Rehabilitation of Patients with Functional Deficits: CTS and Other Disorders.) These therapies are generally unnecessary for most patients. However, some patients may need formal therapy with exercises if there are considerable impairments or a failure to progress after removal of the cast or splint. A few appointments for educational purposes for select patients are recommended. The number of appointments is dependent on the degree of debility, with one or two educational appointments appropriate for mildly affected patients. Patients with severe debility or those unable to return to work may necessitate 8 to 12 appointments that particularly include progressive strengthening exercises. Additionally, while routine use may be of limited benefit, those patients who have muscle weakness or other debilities may also derive benefit from therapy including self-training exercises, particularly if unable to return to work. Therefore, occupational or physical therapy is recommended for select patients.

Evidence for the Use of Physical Methods/Rehabilitation
There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Cast, Casts, Immobilization, Remove, Removal; scaphoid bone, scaphoid fractures, controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 105 articles in PubMed, 15 in Scopus, 23 in CINAHL, 1 in Cochrane Library, 112 in Google Scholar, and 0 from other sources. We considered for inclusion 1 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 0 from Google Scholar, and 0 from other sources. Of the 1 article considered for inclusion, 0 randomized trials and 1 systematic studies met the inclusion criteria.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Physical, Therapy, Rehabilitation, scaphoid bone, scaphoid fractures, controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 121 articles in PubMed, 65 in Scopus, 21 in CINAHL, 16 in Cochrane Library, 153 in Google Scholar, and 0 from other sources. Zero articles met the inclusion criteria.

Surgery
Displaced fractures are believed to require surgical treatment with fixation, but there are no quality studies of displaced fractures. Surgical treatment of non-displaced scaphoid fractures has been evaluated in quality studies and there is no quality evidence of improved long-term outcomes with surgery.(402, 1183, 1195-1200) These studies generally indicate earlier, short-term functional recovery is achieved by surgery compared with prolonged casting.(401, 1183, 1195, 1197, 1198) A Swedish study also found higher costs among manual workers treated with casts due to longer periods of lost time.(1200) However, two quality studies, one with 10-year follow-up, demonstrated an 11-fold increased risk of scaphotrapezial osteoarthritis in those surgically treated with internal fixation compared with those

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casted.(402, 1183) Another study noted a significant potential for overtreatment of these patients with surgery.(1198)

Indications to surgically fix a scaphoid fracture are not well defined, and there is a suggestion that some patients are better candidates than others (e.g., widely displaced fragments, or requirement for earlier recovery such as in professional athletes). Quality evidence indicates operative treatment of non-displaced or minimally displaced scaphoid fractures provide no long-term benefit in functional outcomes, and results in significantly higher incidence of scaphotrapezial joint osteoarthritis. Until better quality evidence becomes available, the decision to surgically treat a non-displaced scaphoid fracture is a decision between the orthopedist and patient with a discussion suggested to include the benefits of earlier functional recovery versus the longer term risks of osteoarthrosis.

1. *Recommendation: Surgical Fixation of Displaced Scaphoid Fractures*
   Surgical fixation of displaced scaphoid fractures is recommended.

   Strength of Evidence **– Recommended, Insufficient Evidence (I)**
   Level of Confidence – High

Rationale for Recommendation
See above.

2. *Recommendation: Surgical Intervention of Non-displaced or Minimally Displaced Scaphoid Fractures for Patients Requiring Early Recovery*
   Surgical intervention of treatment of non-displaced or minimally displaced scaphoid fractures is recommended for patients requiring earlier functional recovery.

Indications – Patients with non-displaced or minimally displaced scaphoid fractures who cannot or do not wish to be treated with an attempt at non-operative treatment. This includes athletes. It also may include patients who are unable to work until the fracture is healed, thus electing to forego attempted non-operative management and its attended lower risk of later osteoarthrosis but longer course of immobilization in exchange for earlier return to work. There is no significant evidence that one technique, including bone grafting is superior to another.(1201-1205)

Strength of Evidence **– Recommended, Evidence (C)**
Level of Confidence – Low

3. *Recommendation: Surgical Intervention of Non-displaced or Minimally Displaced Scaphoid Fractures for All Other Patients*
   Surgical intervention for treatment of non-displaced or minimally displaced scaphoid fractures is not recommended for all other patients.

   Strength of Evidence – **Not Recommended, Evidence (C)**
   Level of Confidence – Low

Rationale for Recommendation
See above.

Evidence for the Use of Surgery vs. Non-operative Treatment for Scaphoid Fractures
There are 13 moderate-quality RCTs incorporated into this analysis.(401, 402, 1217, 1236, 1248-1250, 1253-1258) (Drac 14) There is one low-quality trial included in the Appendix 2.(1259) (Jeon 09)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Surgical Fixation, Surgery, Scaphoid fracture, scaphoid bone, fracture; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 132 articles in PubMed, 343 in Scopus, 2 in CINAHL, 4 in Cochrane Library, 657 in Google Scholar, and 0 from other sources. We considered for inclusion 17 from PubMed, 5 from Scopus, 1 from CINAHL, 0 from Cochrane Library, 2 from Google Scholar, and 0 from other sources. Of the 25 articles considered for inclusion, 14 randomized trials and 2 systematic studies met the inclusion criteria.

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Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Surgical Fixation vs. cast						
McQueen 2008 RCT The Scottish Orthopaedic Research Trust into Trauma (SORTIT) assisted in performing the study. No mention of COI.	7.5	60 (50 males, 10 females) patients between the ages of 17 and 65 with a Herbert type B1 or B2 fracture of the scaphoid. Mean age was 29.4 years.	Percutaneous fixation of the scaphoid within 14 days of injury using a standard Acutrak screw (Group 1, N=30) Vs. Colles cast with the thumb free (Group 2, N=30). Immobilization continued for at least 8 weeks, no patient was treated in a last for longer than 12 weeks. Follow-up for 1 year.	Mean decrease grip strength (%) (8 weeks/12 weeks/26 weeks/52 weeks): operative (10/3/-1/-2) v. non-operative (42/25/11/5), (p<0.001) at week 8, 12, and 26, NS at 52. Mean decrease pinch strength (5): operative (9/4/0/-5) v. non-operative (29/15/3/1), (p<0.001) at week 8, (p=0.012) at week 12, NS at week 26 and 52. Mean decrease range of movement (%): operative (11/6/3/2) v. non-operative (52/32/11/6), (p<0.001) at weeks 8 and 12, (p=0.018) at week 26, NS at week 52. Mean Green/O'Brian score: week 8, operative (79) v. non-operative (39), p<0.001; week 12, operative (88) v. non-operative (56), (p<0.001); week 26 (92 v. 78), (p=0.006); week 52 NS. Percentage good and excellent results: week 8 (52 v. 0), (p<0.001); week 12 (68 v. 15), (p<0.001); week 26 (81 v. 56), (p=0.055); week 52 (100 v. 88), (p=0.025). Radiological outcome resportion: operative 0 v. non-operative 8, (p=0.02). Mean time to union (weeks): operative (9.2) v. non-operative (13.9), (p<0.001). Mean time to normal ADLs (weeks): full sports (6.4 v. 15.5), (p<0.001); full employment (3.8 v. 11.4), (p<0.001).	"[O]ur study confirms earlier time to union and quicker return to work and sport with percutaneous screw fixation of nondisplaced fractures of the waist of the scaphoid."	Effects of surgical intervention allowed earlier return to work or sport with faster mean time to union. There were no differences in function at 1 year.
Vinnars 2008	7.0	N = 75 (58 males, 17	Nonoperative treatment with a cast	All fractures united. A significant increase in	"This study showed that the primary benefit of operative	10-yr follow-up of non displaced scaphoid

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RCT In support of their research for or preparation of this work, one or more of the authors received, in any one year, outside funding or grants in excess of $10,000 from the Folksam research fund (Sweden) and the AFA research fund (Sweden). Neither they nor a member of their immediate families received payments or other benefits or a commitment or agreement to provide such benefits from a commercial entity. No commercial entity paid or directed, or agreed to pay or direct, any benefits to any research fund, foundation, division, center, clinical practice, or		females) with an acute nondisplaced or minimally displaced scaphoid fracture. Mean age was 30.5 years.	(N=35) vs. Internal fixation with a Herbert screw (N=40). Follow up over 10 years.	prevalence of osteoarthritis in scaphotrapezial joint found in operatively treated group. No differences in subjective symptoms, as measured with limb-specific outcome scores found between two groups. No significant differences in range of motion, grip strength, changed hand dominance after injury, or return to same work after injury. Scaphotrapezial arthritis occurred in 1 patient in nonoperatively treated group and in 11 in operatively treated group (p = 0.005).	treatment-(i.e., a short immobilization time and an early return to work) was transient. Our observation of an increased risk of osteo-arthritis in the operatively treated group points to the importance of careful selection of patients who may benefit from operative treatment.”	fracture suggests conservative management has equal long term functional outcomes and lower risk for scaphotrapezial arthritis.

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other charitable or nonprofit organization with which the authors, or a member of their immediate families, are affiliated or associated.						
Dias 2005 RCT No industry sponsorship or COI.	6.5	N = 88 (79 males, 9 females) patients with a bicortical fracture of the scaphoid. Mean age was 29.5 years.	Internal fixation with Herbert screw (no cast) (N=44) vs. Below elbow cast with thumb free (Colles'). (N=44) Follow up for 52 weeks.	Grip strength and range of motion better in operative group at 8 weeks, but differences disappeared by 12 weeks. No other significant differences in pain, patient evaluation, or return to work.	"Each fracture should be treated non-operatively in a functional cast. Surgical intervention should be offered only to the every few patients who cannot return to work in a cast, and such patients should be made fully aware of the risks and limited gains provided by acute fixation."	Allocation, randomization details unclear.
Saedén 2001 RCT No industry sponsorship or COI.	5.0	N = 62 (49 males, 13 females) acute fractures of the scaphoid. Mean age was not provided.	Short arm cast (N=30) vs. Herbert screws group (N=32) 12-year follow-up.	Patients treated by surgery who were working at time of injury were on sick leave an average of 6 + 3 weeks compared with 15 + 10 weeks in conservatively treated group (p = 0.002, t =-3.77). At 12 year follow-up, 90% surgical and 69% conservative groups reported no pain or wrist discomfort. Grip strength and ROM not different between groups. Radiographic evidence of osteoarthritis more common in surgical group (p = 0.049), although no difference in symptoms.	"In our study the fractures united whether they were treated operatively or conservatively. Internal fixation of an acute fracture of the scaphoid allows early return to normal function and should be regarded as an alternative to conservative treatment in those patients who cannot accept immobilisation in a cast for three months or more, for sport, social or work-related reasons."	Randomization and allocation methods are unclear. Surgery may result in faster recovery times and less time off work, although it may come at the expense of higher radiographic arthritic changes.
Bond 2001 RCT Sponsored by the Chief, Bureau of	5.0	N=25 (22 males, 3 females) full-time military personnel with acute nondisplaced fracture of the scaphoid waist.	Cast immobilization (N=14) vs. fixation with a percutaneous cannulated Acutrak screw (Acumed, Beaverton, Oregon) (N=11).	Average time to fracture union: seven weeks in screw fixation vs. 12 weeks in cast immobilization, p=0.0003. Return to work: 8 weeks fixation group vs. 15 weeks	"Percutaneous cannulated screw fixation of nondisplaced scaphoid fractures resulted in faster radiographic union and return to military duty compared with cast immobilization. The specific indications for and the risks and benefits of	Small sample size (n=25). Data suggest average time to fracture union in percutaneous screw fixation group was seven weeks compared to twelve weeks in cast group. Additionally, the

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Medicine and Surgery, Navy Department, Washington, DC, Clinical Investigation program. No mention of COI.		Mean age was 24 years.	Follow up for 2 years.	cast immobilization group, p=0.0001.	percutaneous screw fixation of such fractures must be determined in larger randomized, prospective studies."	time to return to work in surgical group was eight weeks compared to fifteen week in cast group. Both groups showed comparable results for grip strength, ROM and patients satisfaction at 2 years.
Adolfsson 2001 RCT No mention of COI or sponsorship.	4.0	N=53 (39 males, 14 females) with undisplaced fracture of the waist of the Scaphoid. Mean age of 31 (range, 15±75) years.	Immobilization in a below elbow plaster cast for 10 weeks. If no union cast immobilization was continued for another 6 Weeks (N=28) vs. Percutaneous Acutrak screw fixation (N=25). Follow up for up to 16 weeks if nonunion.	No statistically significant differences between the two treatment groups with regard to either the rate of union or the time to union.	"Acute percutaneous internal fixation of undisplaced scaphoid waist fractures using the Acutrak screw allows early mobilisation without adverse effects on fracture healing."	Data suggest comparable results between casting versus Acutrak screw insertion in terms of rate of or time to union. Patients with screw insertion had significantly better ROM at 16 weeks but no better grip strength.
Clementson 2015 RCT Supported by grants from the Swedish Research Council (Medicine) and Funds from Region Skåne. No COI.	4.0	N=38 with acute non- or minimally displaced scaphoid waist fracture. Mean age and gender were not provided.	Conservative treatment: below-elbow thumb spica cast, incorporating the thumb up to the interphalangeal joint (N=24) vs. arthroscopic screw fixation (N=14). Follow-up for 3 years.	ROM at 26 weeks: 88% fixation group vs. 97% conservative group; p=0.004.	"Non- and minimally displaced scaphoid waist fractures are best treated conservatively. Operative treatment may provide an improved functional outcome in the short term but at the price of a possible increased risk of arthritis in the long term."	Data suggest conservative treatment group (cast) had significantly better ROM at 26 weeks. No significant differences between grip and for pinch strength. Surgery group "may" provide improved short term functional outcomes but at 6 years radiography showed more signs of arthritis in surgically treated group.
Vinnars 2008 RCT In support of their research for or preparation of the article, one or more authors	7.0	75 (58 males, 17 females) patients with a scaphoid fracture that occurred less than 28 days before being seen and between the ages of 17 and	Non-operative treatment: immobilization in a below-the-elbow scaphoid cast with the thumb in palmar abduction, the interphalangeal joint free, and the wrist in neutral or slight extension; cast worn for 6 weeks with option of an additional cast worn for another 2-4 weeks (N=42)	There were no significant differences between groups for primary outcomes.	"This study did not demonstrate a true long-term benefit of internal fixation, compared with nonoperative treatment, for acute nondisplaced or minimally displaced scaphoid fractures."	10-yr follow-up of non displaced scaphoid fracture suggests conservative management has equal long term functional outcomes and lower risk for scaphotrapezial arthritis.

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received, in any one year, outside funding or grants in excess of $10,000 from the Folksam research fund (Sweden) and the AFA research fund (Sweden)		65. Mean age was 30.5 years.	vs. operative treatment: used volar approach centered over the tubercle of the scaphoid, with minimal incision exposing only the scaphotrapexial joint, dorsal approach, or combined volar and dorsal approach; after surgery, application of well-padded short arm noncircumferential dorsal plaster splint with the thumb left free for 2 weeks (N=43). Follow-up for a median of 10 years.			
Bone grafting						
Caporrino 2014 RCT No COI. No mention of sponsorship.	5.0	N=75 (71 males, 4 females) with scaphoid nonunion. Mean±SD age: VBG 26.1±7.1 years. NVBG 29.1±8.11 years.	Vascularized bone grafting (VBG) using the 1, 2 intercompartmental suprareticular artery vs. distal radius nonvascularized bone graft (NVBG). Follow-up every 2 weeks until bone healing for up to 29 months.	Mean±SD time to union: NVBG 69.7±15.1 days vs. VBG 58.0±10.3 days; (p=0.002). Ulnar deviation degrees: NVBG 29.4±5.8 vs. VBG 25.4±8.5; (p=0.033).	“Although the VBG group attained earlier union, this may not be clinically meaningful, nor justify the greater technical difficulty and use of resources associated with this intervention.’	Patient blinding unclear. Data suggest VBG group achieved an earlier union compared to distal radius nonvascularized bone graft group by 12 days, union rates for both groups were comparable. Also, there was significantly less ulnar deviation in VBG group.
Fixation vs. Bone graft						
Braga-Silva 2008 RCT No mention of COI or sponsorship.	6.5	N = 80 (56 males, 24 females) with symptomatic scaphoid non-union pseudoarthrosis of single wrist submitted for surgery. Dominant hand involved in 88% of cases. Mean age was 26 years.	Distal radius vascularised bone graft (n = 35) vs. Iliac crest non-vascularised bone graft (n = 45). Mean±SD follow up radial grafts: 3.1±1.2 years. Iliac grafts: 2.6±1.6 years.	No statistically significant difference between two groups with regards to ranges of extension, flexion and ulnar deviation movements.	“The use of bone graft in the treatment of scaphoid nonunion has improved the prognosis, allowing an increase in the likelihood of painless bone consolidation and restoration of wrist function”	Data suggest comparable results between techniques for grip strength and ROM post-op mean time 2.8 years. Union consolidation of fracture quickest in non-vascularized group.

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Garg 2013 RCT No mention of sponsorship. No COI.	6.0	N=100 with scaphoid nonunion. Mean age Group 1: 32.4 years (25 males, 17 females). Group 2: 36.8 years (30 males, 16 females).	Internal fixation plus distal radius bone graft (Group 1: N=50) vs. iliac crest bone graft was used instead (Group 2: N=50). Follow up for 3 years.	Bone fusion was achieved in 87.1 % of group 1 and 86.5 % of group 2 patients. No p-value given. Mean time for union was 4.2 months in group 1 and 4.5 months in group 2. No p-value given.	"There is no advantage of the iliac crest over the distal radius graft to justify its greater morbidity."	Data suggest comparable results between distal radius bone grafts vs. iliac crest bone graft for scaphoid nonunion.
Ribak 2010 RCT No mention of COI or sponsorship	5.0	N = 86 with scaphoid nonunion. No mention of age or gender.	Vascularised bone graft from dorsal and distal aspect of radius (n = 46) vs. Conventional non-vascularised bone graft from distal radius (n = 40). Mean follow up in group 1 25.3 months. Group 2 22.5 months.	Vascularized bone graft achieved 89.1% bone fusion compared to 72.5% bone fusion rate in non-vascularised bone graft. (p = 0.024)	"[V]ascularised bone grafting yields superior results and is more efficient when there is a sclerotic, poorly-vascularised proximal pole in patients in scaphoid nonunion. On the other hand, in patients with well vascularised fragments, either the vascularised or conventional technique can be used, depending upon the surgeon's experience and preference."	Data suggests vascularized bone grafting is superior to non-vascularized bone grafting. More patients receiving vascularized grafts achieved bone fusion (89.1%) vs. non-vascularized (72.5%). Functional results better in vascularized vs. non-vascularized.
Raju 2011 RCT No mention of COI or sponsorship.	4.0	N=33 (27 males, 6 females) with non-union of the scaphoid. Mean age: 28 years.	Herbert screw fixation (n=11) vs. Matti Russe bone grafting (n=9) vs. Kohlman modification of vascularised muscle pedicle graft procedure (n=13). Mean follow-up duration was 28 Months.	Herbert vs. Matti vs. Kohlman: 8, 6 and 11 patients achieved scaphoid union after mean intervals of 17, 16, and 15 weeks. No p-values given.	"The time to union was earliest in the Kohlman modification of vascularised muscle pedicle graft procedure, which is recommended for patients with old non-union (>1 year) or proximal pole fractures."	Small sample. Data suggest all 3 fixation techniques were of comparable efficacy with time to union of fracture occurring earlier in the Kohlman procedure which is recommended for patients with non-union fractures older than one year or proximal pole fractures.
Drac 2014 RCT Supported by grant project IGA MZCR NS 9623-4/2008. No COI.	4.0	N=76 (68 males, 8 females) Patients with acute nondisplaced or minimally displaced type B2 scaphoid fractures. Mean age was 30 years.	Group A- Palmar Percutaneous approach (N=36) Vs. Group B- Dorsal Limited Approach (N=36) Follow-up for 1 year after surgery.	There were no significant differences between Group A and Group B for flexion, extension, radial and ulnar deviation, grip strength, presence of persisting complaints, patient satisfaction or DASH score at any of the follow-up points (p>0.05).	"We found no advantage to the palmar percutaneous approach in the treatment of nondisplaced and minimally displaced scaphoid fractures type B2 compared to dorsal limited approach."	Data suggest comparable efficacy at one year.

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ULTRASOUND/OSTEOGENIC PROTEIN ADJUVANT

1. *Recommendation: Ultrasound with Bone Graft for Scaphoid Fractures*
   There is no recommendation for or against the use ultrasound to accelerate bone graft healing for scaphoid fractures.

   Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**
   Level of Confidence – Low

Rationale for Recommendation
Low intensity pulsed ultrasound has been evaluated for the treatment of fractures.(1260-1269) (Rubin 01, Riboh 12, Siska 08, Virk 12, Pounder 08, Barry 15, Nelson 03, Parvizi 05, Smoljanovic 07, Griffin 12) There is one moderate-quality RCT that reported earlier healing of muscle-pediculated bone graft after low intensity ultrasound treatment for 21 patients with scaphoid non-union with healing of a mean 38 days earlier.(1270) While the results are promising, they need replication with a larger sample size prior to recommendation.

Evidence for the Use of Ultrasound with Bone Graft for Scaphoid Fractures
There is 1 moderate-quality RCT incorporated into this analysis.(1270)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Ultrasound, Osteogenic Protein Adjuvant, Scaphoid Fractures, Ultrasonography, Ultrasonic, Scaphoid Bone, bone fractures, controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 18 articles in PubMed, 80 in Scopus, 0 in CINAHL, 4 in Cochrane Library, and 2,268 in Google Scholar. We considered for inclusion 1 from PubMed, 4 from Scopus, 0 from CINAHL, 1 from Cochrane Library, 5 from Google Scholar, and 0 from other sources. Of the 11 articles considered for inclusion, 1 randomized trials and 10 systematic studies met the inclusion criteria.

Author/Year Study Type Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Ricardo 2006 RCT	4.5	N = 21 with vascularized bone graft and internal fixation with k-wire	Ultrasound treatment vs. sham ultrasound	Daily 20 minute low intensity ultrasound treatment over scaphoid led to reduced time to overall (clinical and radiographic) healing by 38 days (average 56±3.2 days compared with 94±4.8 days; p <0.0001).	"All patients achieved fracture union (active and placebo groups), but compared with the placebo device (11 patients), the active device (ten patients) accelerated healing by 38 days (56±3.2) days compared with 94±4.8 days, p<0.0001, analysis of variance."	Study suggests low intensity ultrasound treatment beneficial in improving healing time in this subset of patients undergoing bone graft with internal fixation.

2. *Recommendation: Osteogenic Protein Adjuvant for Scaphoid Fractures*
   There is no recommendation for or against the use of osteogenic protein-1 for adjuvant treatment with bone grafting for scaphoid fractures.

   Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**
   Level of Confidence – Low

Rationale for Recommendation
There is a small trial of osteogenic protein-1 (BMP-7) for treatment of 17 patients with scaphoid non-union at the proximal pole included 3 arms comparing: 1) autologous iliac bone graft; 2) autologous iliac bone graft plus osteogenic protein-1; versus 3) allogenic iliac bone graft plus osteogenic protein-1.(1207) The study reported the following healing rates: sclerotic area at 3 months 138.3±15.1 versus 74.0±14.1

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versus 103.6±13.2mm^2 respectively. However, the results need repeating in a larger sample size prior to a recommendation.

Evidence for the Use of Osteogenic Protein Adjuvant with Bone Graft for Scaphoid Fractures
There is 1 moderate-quality RCT incorporated into this analysis.(1207)

Author/Year Study Type Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Bilic 2006 RCT	6.0	N = 17	Autologous iliac graft vs. Autologous iliac graft + osteogenic protein-1 (OP-1) vs. Allogenic iliac graft + OP-1	OP-1 improved performance of autologous graft healing (4 vs. 9 weeks in control). OP-1 improved functional performance of both groups vs. autologous graft alone. Sclerotic bone replaced by vascularized bone as assessed by CT 3 months after operation vs. 24 months after operation (sclerotic area mm2): Autograft only: 138.3± 15.1* vs. 111.5±8.6; Autograft + OP-1: 74.0*±14.1 vs. 31.7±6.8***; Allograft + OP-1: 103.6 ±13.2* vs. 55.6± 11.7*** *p <0.05 vs. before operation ***p <0.05 vs. autograft only	"Recombinant human OP-1 supports proximal pole scaphoid non-union healing via increased bone vascularization and replacement of preexisting proximal pole sclerotic bone as a consequence of avascular necrosis. The addition of OP-1 to allogenic bone implant equalised the clinical outcome with the autologous graft procedure. Consequently the harvesting of autologous graft can be avoided."	Small sample size; study suggests significant potential benefit from using OP-1 in healing time, functional improvement, and avoiding autologous grafting.

Distal Phalanx Fractures and Subungual Hematoma

Diagnostic Criteria

Diagnosis is evident from clinical suspicion, physical examination findings, and x-ray confirmation.

Special Studies and Diagnostic and Treatment Considerations

X-RAYS

Recommendation: X-rays for Diagnosing Tuft Fractures
X-rays are recommended to diagnose tuft fractures.

Indication – Clinical tuft fractures that do not involve the DIP joint do not require x-rays as they do not alter treatment. Still, the threshold for obtaining x-rays for those fractures is low in the event they may involve the joint.

Frequency/Duration – Obtaining x-rays once is generally sufficient. Follow-up x-rays are rarely indicated aside from complicated healing.

Strength of Evidence – **Recommended, Insufficient Evidence (I)**
Level of Confidence – Moderate

Rationale for Recommendation
There are no quality studies evaluating the use of x-rays for distal phalangeal/tuft fractures. X-rays may assist in identifying fractures and the magnitude of the involvement of the DIP joint surface, which if large enough may alter management in favor of surgery (see below). As this section of the digit is readily accessible for physical examination, patients may be treatable without x-rays as x-rays will not change

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the management of tuft fractures that do not involve the joint. X-rays are recommended for assessment of fractures thought to involve the DIP joint.

Evidence for the Use of X-rays
There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: X-Ray, radiography, radiograph, roentgenogram, Distal Phalanx Fractures, Tuft Fractures subungual hematoma, diagnostic, diagnosis, sensitivity, specificity, positive predictive value, negative predictive value, and predictive value of tests, efficacy, and efficiency. We found and reviewed 51 articles in PubMed, 46 in Scopus, 0 in CINAHL, 2 in Cochrane Library, and 382 from Google Scholar. We considered for inclusion Zero from PubMed, Zero from Scopus, Zero from CINAHL, Zero from Cochrane Library, Zero from Google Scholar, and Zero from other sources. Zero articles met the inclusion criteria.

MRI/CT/ULTRASOUND/BONE SCAN IMAGING
Recommendation: MRI, CT, Ultrasound, or Bone Scanning for Diagnosing Tuft Fractures
MRI, CT, ultrasound, or bone scanning is not recommended for diagnosing tuft fractures.

Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
Level of Confidence – High

Rationale for Recommendation
There are no quality studies regarding the use of MRIs, CTs, ultrasound, or bone scanning for diagnosing tuft fractures. As x-rays are sufficient for diagnostic purposes, neither MRI, CT, diagnostic ultrasound, nor bone scanning is recommended.

Evidence for the Use of MRI/CT/Ultrasound/Bone Scan Imaging
There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: MRI, CT, CAT, Ultrasound, Bone scan imaging, Distal Phalanx Fractures, Subungual Hematoma, Tuft Fractures, diagnostic, diagnosis, sensitivity, specificity, positive predictive value, negative predictive value, and predictive value of tests, efficacy, and efficiency. We found and reviewed 20 articles in PubMed, 10 in Scopus, 0 in CINAHL, 6 Cochrane Library, and 60 from Google Scholar. We considered for inclusion 0 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 0 from Google Scholar, and 0 from other sources. Zero articles met the inclusion criteria.

Initial Care

Tuft fractures are initially treated by caring for accompanying soft tissue injury and splinting of the finger to prevent further discomfort or injury. Reduction of the relatively uncommon significantly displaced fractures should be attempted with dorsal traction followed by immobilization in a volar splint. In the small percentage of patients, reduction cannot be achieved and referral to an orthopedic surgeon for consideration of pinning may be indicated.(77)

Management of subungual hematoma associated with a tuft fracture varies widely. There are no quality RCTs investigating the treatment ramifications of no treatment, trephination, nail plate removal, nail bed laceration repair, or conversion of closed fracture into open fracture.(75, 76, 1208-1218) As subungual hematoma is often associated with nail bed laceration, many practitioners promote removing the nail and repairing the nail bed to avoid future cosmetic defects.(76) The primary concern for this procedure is the potential to convert an underlying fracture into an open fracture.(75, 76, 1208-1218)

Tuft fractures associated with nail avulsion may require reduction of the nail plate under the eponychium, or removal if reduction cannot be performed. As with the removal of the nail for other conditions, the eponychial space should be preserved by packing with petroleum gauze cut in the shape of the nail to

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prevent scarring of the nail bed and stunted nail growth.(1218) The nail or gauze should remain in place for 2 to 3 weeks to allow initial formation of a new nail plate. Full growth of the new nail takes approximately 4 to 5 months. Open fractures other than from subungual hematoma trephination of the distal phalanx require cleansing, debridement, and inspection for foreign bodies. Orthopedic assistance is usually not required for uncomplicated closures. Open fractures with extensive soft tissue damage frequently are associated with chronic pain and disability and generally require assistance from an orthopedic or hand surgeon.

1. *Recommendation: Trephination for Management of Subungual Hematoma*
   Trephination is recommended for management of subungual hematoma.

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – Moderate

2. *Recommendation: Nail Removal or Laceration Repair for Management of Subungual Hematoma*
   Nail removal or laceration repair is not recommended for the management of subungual hematoma.

   Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
   Level of Confidence – Low

Rationale for Recommendations
There are no quality studies regarding trephination or nail removal/laceration repair to manage subungual hematoma. (75, 76, 1208-1218) In a prospective study of 47 patients with subungual hematoma involving 50% or more surface area of the nail, a nail bed laceration was associated with fracture in 80% of patients. Thus, tuft fractures with subungual hematoma have a high likelihood of an associated laceration.(76) However, another prospective study of 48 patients with subungual hematoma, 42% of which had an underlying tuft fracture, were treated exclusively with electrocautery trephination. At 10-months follow-up post-trephination, there were no infectious or cosmetic complications despite not repairing the laceration or by converting a closed fracture into an open fracture. Another prospective study conducted in children with subungual hematoma compared nail removal and laceration repair to trephination over a 2-year follow-up and concluded that there was no justification based on absence of adverse clinical outcomes from trephination to perform nail removal and exploration.(1216) Each participant had a short course of antibiotics. There were no case reports found of osteomyelitis from trephination over hand tuft fracture, nor any reports of adverse cosmetic outcomes (nail scarring, permanent depression) in patients with finger nail bed laceration that were managed without suturing. Thus, the practice of avoiding trephination over distal phalangeal fracture to avoid creating an open fracture, or the practice of exploring and repairing nail bed lacerations associated with subungual hematoma appears unsupported by the available literature.

Trephination is most commonly accomplished with a hot cautery unit. Successful trephining with 29-gauge needle inserted below the nail plate reported,(1219) as well as fine point scalpel blade, surgical drill and laser have also been reported.(1209) Trephining gives good cosmetic and functional results.(1208)

Evidence for the Use of Trephination and Nail Removal or Laceration Repair
There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Trephination; nail removal; laceration repair (subungual hematoma) / Distal Phalanx Fractures and Subungual Hematoma, Tuft Fractures ;controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 6 articles in PubMed, 1 in Scopus, 0 in CINAHL, 1 in Cochrane Library, 180 in Google Scholar, and 1 from other sources. We considered for inclusion 3 from PubMed, 1 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 1 from Google Scholar, and 1 from

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other sources. Of the 6 articles considered for inclusion, 0 randomized trials and 2 systematic studies met the inclusion criteria.

NSAIDs/ACETAMINOPHEN

Recommendation: NSAIDs or Acetaminophen for Tuft Fractures

NSAIDs or acetaminophen are recommended to control pain associated with tuft fractures.

Indications – Pain due to tuft fracture.

Frequency/Duration – Scheduled dosage rather than as needed is generally preferable.

Indications for Discontinuation – Resolution of pain, lack of efficacy, development of adverse effects, particularly gastrointestinal.

> *Strength of Evidence* – **Recommended, Insufficient Evidence (I)**
> *Level of Confidence* – Low

Rationale for Recommendation

There is no quality evidence regarding the use of NSAIDs or acetaminophen to control pain associated with tuft fractures. However, these medications are thought to be effective for control of swelling and pain in the initial stages of injury, are not invasive, have low adverse effects, are low cost, thus they are recommended.

Evidence for the Use of NSAIDs or Acetaminophen

There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: NSAIDS, Anti-Inflammatory Agents, Non-Steroidal, non-steroidal anti-inflammatory Agents, Non-Steroidal agents; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 0 articles in PubMed, 0 in Scopus, 0 in CINAHL, and 0 in Cochrane Library, 719 in Google Scholar. Zero articles met the inclusion criteria.

ANTIBIOTIC PROPHYLAXIS

Recommendation: Post-trephination Antibiotic Prophylaxis for Open Fractures

There is no recommendation for or against the use of post-trephination antibiotic prophylaxis for open fractures.

> *Strength of Evidence* – **No Recommendation, Insufficient Evidence (I)**
> *Level of Confidence* – Low

Rationale for Recommendation

Antibiotic prophylaxis for open fractures is widely used. However, they may not be necessary for open phalangeal fractures as a quality study did not show evidence of improvements upon infection rates compared with aggressive irrigation and debridement as there were equal numbers of soft tissue infections and no cases of osteomyelitis in either group.(1220) However, the study appears underpowered to detect these relatively infrequent events. Use of antibiotics may be more strongly indicated for those with risks for infection, such as patients with diabetes mellitus. Thus, there is no recommendation for or against use of antibiotics and the threshold for use of antibiotics for prophylaxis is suggested to be low.

Evidence for the Use of Antibiotic Prophylaxis

There is 1 high-quality RCT incorporated into this analysis.(1287) (Stevenson 03) There is 1 low-quality RCT in Appendix 2.(1288) (Sloan 87)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Antibiotic prophylaxis**,** Distal Phalanx Fractures and Subungual Hematoma, Tuft Fractures; controlled clinical trial, controlled trials, randomized

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controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 2 articles in PubMed, 12 in Scopus, zero in CINAHL, and 2 in Cochrane Library. We considered for inclusion 2 from PubMed, zero from Scopus, zero from CINAHL, zero from Cochrane Library and zero from other sources. Of the 2 articles considered for inclusion, 2 randomized trials and zero systematic studies met the inclusion criteria.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Stevenson 2003 RCT Sponsored by the Research Network, Ayrshire and Arran Health Board. No COI	8.5	N = 193 (159 males; 34 females) with an open fracture of the distal phalanx; Age range 16 – 88.	Antibiotic four times a day for five days (N = 98) vs Placebo four times a day for five days (N = 95). Follow-up 4 or 5 days, 14 days and 8 weeks following injury unless wound was healed and patient is asymptomatic.	Infection rate (antibiotic vs. placebo): 3% vs 4% (p>0.05).	"[T]he addition of prophylactic flucloxacillin to thorough would toilet and careful soft-tissue repair of open fracture of the distal phalanx confers no benefit."	Data suggest no benefit of addition of prophylactic flucloxacillin for treating distal phalanx fractures compared to placebo.

TETANUS IMMUNIZATION

Recommendation: Tetanus Immunization Status for Open Fractures

For open fractures, it is recommended that tetanus immunization status to be updated as necessary.

Indications – Wounds that are not clean or burns if more than 5 years have elapsed since last tetanus immunization.(1221)

Strength of Evidence – **Recommended, Insufficient Evidence (I)**
Level of Confidence – High

Rationale for Recommendation

There are no quality studies of tetanus immunization updating for open fractures. However, these immunizations are widely used and believed to have been successful on a population basis in reducing risk of tetanus over many decades. Tetanus immunizations are minimally invasive, have low adverse effects, and are low cost. As the adverse effects of not immunizing may be fatal, tetanus immunization updating for open wounds is recommended. Wounds that are not clean or burns should require immunization if over 5 years since last immunization, rather than 10 years.(1221) Patients without a completed immunization series of 3 injections should receive tetanus immune globulin along with immunization.

Evidence for the Use of Tetanus Immunization

There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Tetanus immunization, Distal Phalanx Fractures and Subungual Hematoma, Tuft Fractures; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found, reviewed and considered for inclusion 0 articles in PubMed, 10 in Scopus, 0 in CINAHL, 0 in Cochrane Library and 0 in other sources. Zero articles met the inclusion criteria.

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IMMOBILIZATION

1. *Recommendation: Protective Splinting of Distal Phalanx for Fractures*
   Protective splinting of the distal phalanx to the PIP is recommended for fractures.(77, 78, 1222)
   Duration – Approximately 3 weeks.

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – Moderate

2. *Recommendation: Tight Circumferential Taping for Tuft Fractures*
   Tight circumferential taping around the fingertip is not recommended for tuft fractures.

   Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
   Level of Confidence – Low

Rationale for Recommendations
There are no quality studies evaluating immobilization for fractures. In the closed crush fracture of the distal phalanx, the *L*-shaped Alumafoam splint placed on the volar aspect to protect the soft tissues has been considered the best treatment, although quality comparative trials are lacking. Splinting generally is maintained for approximately 3 weeks. Tight circumferential taping is not recommended due to potential to impair circulation. Volar splinting is not invasive, has few adverse effects, is low cost and is recommended.

Evidence for the Use of Immobilization
There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Immobilization, Splinting, Tight, circumferential, taping, Distal, Phalanx, Tuft, Fractures, fracture, Subungual, Hematoma; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 2 articles in PubMed, 0 in Scopus 0 in CINAHL, 1 in Google Scholar, and 1 in Cochrane Library. We considered for inclusion 15 from PubMed, 5 from Scopus, 11856 from CINAHL, 24 in Google Scholar, 91 from Cochrane Library, and 0 from other sources. Of the 11986 articles considered for inclusion, 0 randomized trials and 4 systematic studies met the inclusion criteria.

Follow-up Visits
Uncomplicated closed tuft fractures do not require follow-up, particularly if there is not a need for work and activity limitations. Two or three appointments may be required for gradual reduction in limitations. Patients should be advised that residual tenderness and hypersensitivity to cold temperatures may persist for 6 months in a more than half of all patients with this injury.(1223)

Prescription Medications
There are no quality studies of the use of other prescription medications in tuft fracture than already addressed in the Initial Care section. However, some patients may require pain medication, especially nocturnally, for the first few days.

Physical Methods/Rehabilitation
EXERCISE
Exercise is not indicated acutely. Few patients require exercise after recovery. For those with residual deficits, particularly post-operatively, see section on Post-Operative Rehabilitation and Rehabilitation of Patients with Functional Deficits: CTS and Other Disorders.

Recommendation: Routine Use of Physical or Occupational Therapy for Tuft Fractures
There is no recommendation for or against the routine use of physical or occupational therapy for treatment of tuft fractures.

Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**
Level of Confidence – Low

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Rationale for Recommendation
There are no quality studies of the use of physical or occupational therapy or other methods for tuft fractures, and these injuries rarely require therapy. Joint mobilization therapy may be useful for complicated injuries or post surgical fixation. A few appointments for purposes of teaching range of motion exercises for recovery of full motion may be rarely indicated, particularly for those with more severe injuries or those with a lack of improvement after removal of splints. However, the vast majority of patients with tuft fractures require no further treatment.

Evidence for the Use of Physical or Occupational Therpay
There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Exercise, Physical Therapy, Occupational Therapy, Distal Phalanx Fractures and Subungual Hematoma, Tuft Fractures; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found, reviewed and considered for inclusion 12 articles in PubMed, 3 in Scopus, 0 in CINAHL, 2 in Cochrane Library, 167 in Google Scholar, and 0 in other sources. Zero articles met the inclusion criteria.

Surgery
Distal phalangeal diaphyseal fractures rarely require operative fixation, except those that are extremely displaced, unable to be reduced or are unstable. Retrograde percutaneous Kirschner-wire fixation is the preferred internal fixation technique.(87)

Evidence for the Use of Surgery
There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Retrograde percutaneous Kirschner-wire fixation, Bone Wires, Distal Phalanx Fractures and Subungual Hematoma, Tuft Fractures; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 0 articles in PubMed, 6 in Scopus, 0 in CINAHL, and 12 in Cochrane Library, 136 in Google Scholar, and 0 from other sources. We considered for inclusion 0 from PubMed, 1 from Scopus, 0 from CINAHL, 0 from Cochrane Library and 0 from other sources. Of the 1 articles considered for inclusion, 0 randomized trials and 1 systematic studies met the inclusion criteria.

Middle and Proximal Phalangeal and Metacarpal Fractures

Diagnostic Criteria
Diagnosis is determined by clinical suspicion evident from history, physical examination findings and x-ray confirmation.

Special Studies and Diagnostic and Treatment Considerations
X-RAYS
Recommendation: X-rays for Diagnosing Phalangeal or Metacarpal Fractures
X-rays are recommended for diagnosing phalangeal or metacarpal fractures and should include three projections, including a posteroanterior, lateral, and oblique view. A true lateral projection isolating the involved digit is required.

Strength of Evidence – **Recommended, Insufficient Evidence (I)**
Level of Confidence – High

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Rationale for Recommendation
There are no quality studies evaluating the use of x-rays for phalangeal and metacarpal fractures. However, x-rays assist in identifying fractures, orientation of fracture plane(s), magnitude of the involvement of the interphalangeal and metacarpal phalangeal joints, which if large enough may alter management in favor of surgery (see below). X-rays are recommended for assessment of fractures of the phalanges and metacarpals.

Evidence for the Use of X-rays
There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL and Cochrane Library without date limits using the following terms: X-Ray, Metacarpal, Middle, Proximal, Phalangeal, boxer's, Fracture, Bone, Diagnostic, Diagnosis, Sensitivity, Specificity, positive, predictive, value, negative, predictive, Predictive, Value, of, Tests, efficacy, efficiency. We found, reviewed and considered for inclusion 251 articles in PubMed, 2 in Scopus, 7 in CINAHL, 0 in Cochrane Library, 1080 in Google Scholar and 0 in other sources. Zero articles met the inclusion criteria.

MRI/CT/ULTRASOUND/BONE SCAN IMAGING
Recommendation: MRI, CT, Ultrasound, or Bone Scanning for Diagnosing Phalangeal or Metacarpal Fractures
MRI, CT, ultrasound, or bone scanning is not recommended for diagnosing phalangeal or metacarpal fractures.

Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
Level of Confidence – Moderate

Rationale for Recommendation
There are no quality studies evaluating MRIs, CTs, ultrasound, or bone scanning for diagnosing phalangeal or metacarpal fractures. As fracture displacement and rotation are of primary concern, most fractures are readily diagnosed and treatment planned with radiographs. Discovering occult non-displaced fractures on CT would be unlikely to change the management except for delineation of articular impaction injuries.(78) Therefore, MRI, CT, diagnostic ultrasound, or bone scanning is not recommended for diagnosing phalangeal or metacarpal fractures.

Evidence for the Use of MRI/CT/Ultrasound/Bone Scan Imaging
There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: MRI, CT, Ultrasound, bone, scan, imaging; Metacarpal, Middle, Proximal, Phalangeal, boxer's, Fracture, Bone, Diagnostic, Diagnosis, Sensitivity, Specificity, positive, predictive, value, negative, predictive, Predictive, Value, of, Tests, efficacy, efficiency. We found and reviewed 90 articles in PubMed, 1 in Scopus, 5 in CINAHL, 647 in Google Scholar, and 1 in Cochrane Library. We considered for inclusion 2 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 0 from Google Scholar, and 0 from other sources. Of the 744 articles considered for inclusion, 0 randomized trials and 0 systematic studies met the inclusion criteria

Initial Care
Initial management should include treatment of soft tissue injuries(1224) and pain control following completion of physical examination. Regional anesthesia should be administered to complete diagnostic assessment (passive range of motion, rotational alignment) and to perform closed reduction of the fracture, although not until neurovascular examination is documented.

Regional anesthesia is typically performed through injection of local anesthetic as a digital block through one of many described techniques including digital ring block, palmar subcutaneous block, metacarpal block, and volar thecal block. The traditional digital block technique, also known as dorsal subcutaneous

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block, and occasionally referred to as metacarpal block, includes instilling local anesthetic from a dorsal approach into the webspace lateral to each side of the injured finger. A true metacarpal block is similar to ring block, but at the metacarpal head. A volar thecal block, also referred to as transthecal block, is the instillation of local anesthetic into the potential space of the tendon sheath at the distal palmar crease (A-1 pulley) proximal to the injured digit. The palmar subcutaneous block is performed at the same location as the thecal block, but subcutaneously. Other block techniques include ulnar or radial block injuries that are proximal to the phalanx, such as for metacarpal injuries, and hematoma block which is the direct injection of local anesthetic into the fracture hematoma.

DIGITAL BLOCK

Recommendation: Digital Block – Traditional (Ring) Block Technique, Palmar Subcutaneous Block

The ring block technique, followed by volar subcutaneous block, is moderately recommended for digital anesthesia, as it provides more effective coverage of dorsal phalangeal injuries than the other techniques.

Strength of Evidence – **Moderately Recommended, Evidence (B)**
Level of Confidence – Moderate

Rationale for Recommendation

For phalangeal fractures, there is clear evidence that the three most common digital blocks are similarly effective in onset and depth of anesthesia, although each has advantages and drawbacks particular to the specific technique. However, although it requires two punctures, the traditional digit or ring block has been found to be as effective or more effective than the other two block types as it provides better anesthetic results for the dorsal finger as compared to palmar (subcutaneous) block(1225-1227) and transthecal block.(1228-1230) There is no clear difference in the primary anesthesia outcomes between transthecal and palmar techniques(99, 1231, 1232) although patients preferred the subcutaneous technique and many reported residual pain at the block site 24 hours after injection in the transthecal block group. Subjects in the ring block were also satisfied with the technique compared to transthecal blocks, and were rated very similar to palmar block despite having two injections. Thus, the subcutaneous techniques of ring block palmar subcutaneous block are recommended over transthecal block mainly related to patient preference and residual pain, and ring block is recommended as the first line technique as it is less likely to have incomplete anesthesia of the dorsal finger. There are no quality studies for hematoma block in the hand, but they have been reported effective in distal radius, ulnar, and ankle injuries. Hematoma block may provide advantage for proximal metacarpal injuries over ulnar/radial blocks.

Evidence for the Use of Digital Block for Middle and Proximal Phalangeal or Metacarpal Fractures

There are 2 high-(99, 1227) and 7 moderate-quality(1225, 1226, 1228-1232) RCTs or crossover trials incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Digital block, digital anesthesia, ring block technique, palmar subcutaneous block, middle, proximal, phalangeal, metacarpal, fractures, bone fractures, boxers; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 0 articles in PubMed, 41 in Scopus, 1 in CINAHL, 0 in Cochrane Library, 60 in Google Scholar, and 0 from other sources. We considered for inclusion 0 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 0 from Google Scholar, and 0 from other sources. Nine articles met the inclusion criteria.

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Author/Year Study Type Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Digital Block						
Yin 2006 RCT No mention of sponsorship or COI.	8.5	N = 91 (23 female/68 male) with injuries to 1-2 figners distal to basal crease of finder. Age 14-60.	Traditional digital block (n = 50) vssingle subcutaneous palmar block (n = 41). Follow-up for 1 month.	No differences between 2 groups per time to onset of anesthesia and injection pain score with per protocol or ITT analyses.	"The palmar techniques, including single subcutaneous palmar block and transthecal block carry a risk of not anesthetizing the dorsum of the digit adequately, particularly the dorsum of the thumb and the proximal phalanx of the fingers."	Study included RCT as well as meta-analysis of other digital anesthesia RCTs.
Hung 2005 RCT Crossover Trial Sponsored by funds from American Foundation of Surgery of Hand, Raymond M. Curtis Research Foundation and MedStar Research Institute. No mention of COI.	8.0	N = 50 (gender not specified) healthy volunteers. Age not given.	Digital (metacarpal) block vs. single subcutaneous palmar block vs. transthecal block	Overall significant difference (p <0.001) between methods evaluated with digital metacarpal block taking significantly longer to abolish sensation (265 seconds vs. 187 seconds vs. 176 seconds) as compared with other 2 methods. No significant difference between average pain scores by patients; 43% chose subcutaneous block as their first choice vs. metacarpal block vs. transthecal block.	"Subcutaneous block is effective and preferred by healthy volunteers for digital anesthesia."	Study conducted in non-injured hands. Volume of anesthetic was limited to 2ml. All subject received all blocks in different fingers. Results are opposite those found by Knoop.
Hill 1995 RCT Crossover Trial No mention of sponsorship or COI.	7.0	N = 81 (gender not specified) healthy adutls. Age 18-45 years.	TT or transthecal block vsTD or traditional digital block or ring block.	Blocks completed with 2ml 1 % lidocaine at each site. All blocks successful without complications. Mean VAS pain scores favored traditional block (1.4 ± .13 vs. 1.7 ± .17, p = 0.02). Time to loss of pinprick sensation was faster for ring block (188 vs. 152 seconds).	Transthecal digital block is clinically equal to the traditional method in terms of time to anesthesia and associated pain.	Study included 162 blocks on 81 subjects. Patients were healthy without injury and served as their own control.

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Williams 2006 Crossover Trial No mention of sponsorship or COI.	7.0	N = 27 (16 female/11 male) volunteers. Mean age 31 years.	Digital block vs. single subcutaneous palmar block.	No difference in median pain scores with respect to volar and dorsal injection techniques (VAS 4.06 vs. 4.52). Volunteers preferred palmar block (22 of 27) if required to have another in the future.	"Our results demonstrated that there was more pain experienced with the use of the two-injection dorsal technique, but the difference in pain scores was not statistically significant."	Lack of blinding; study conducted on healthy volunteer population. Both techniques had incomplete anesthesia in some subjects (palmar – dorsum of phalanges, digit – hemidigit anesthesia).
Cummings 2004 Crossover Trial Sponsored by University of Illinois College of Medicine and Department of Emergency Medicine at OSF St. Francis Medical Center. No mention of COI.	6.5	N = 25 Paid volunteers Mean age of 31 years old. 13 Females, 12 Males	Transthecal (modified) (N=25) vs. Traditional digital block (N = 25) (All 25 volunteers received both treatments.) No mention of follow up.	No difference in pain rating from the block procedures (p = 0.579). Average time to complete block was faster in all measured dermal zones (average of 1.38 to 5.46 minutes faster) for traditional block vs. transthecal block (p <0.05).	"The effect of modified transthecal block is equal to that of traditional block in terms of pain perception. For the dorsal and radial proximal zones, the traditional block appears to have better distribution of anesthesia."	Subjects served as both comparison groups. Author states study was double-blind, but appears questionable as number and location of puncture was different for each method.
Low & Wong 1997 Crossover Trial No mention of Sponsorship or COI.	6.5	N = 142 Mean age of 33.5 years old. 14 Females, 128 Males	Transthecal (N = 71) vs. Single injection subcutaneous (superficial to A-1 pulley) digital block (N=71) No mention of follow up.	Blocks performed with 3cc 1% lignocaine/ bupivacaine mixture. No differences between 2 techniques with regards to effectiveness, distribution, onset, and duration of anesthesia.	"The subcutaneous block would appear to be a better choice as it is easier to administer and has no risk of intraarticular injection."	Study compared single injection techniques in subjects with actual injuries. Randomization and allocation is unclear.
Knoop 1994 Crossover Trial	5.5	N = 30 patients that required digital anesthesia.	Digital block (N = 30) vs. Single subcutaneous palmar block	Digital block not statistically less painful than metacarpal block (VAS 2.53±1.98cm vs. 3.35±2.77cm, p = 0.18). Digital block more efficacious as metacarpal block failed anesthesia to pinprick in 23% vs.	"Digital block and metacarpal block, as described in this study, are equally painful procedures. Digital block, however, is more efficacious and requires significantly less	Subjects served as both comparison groups with both procedures being completed on half of same finger, which is major weakness. Lack of methodology details.

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No mention of sponsorship or COI.		No mention of mean age. Range 19-64 years old. 9 Females, 21 Males	(N = 30) (All patients had both treatments.) No mention of follow up.	3% (p = 0.023). Time to anesthesia shorter for digital block 2.82 minutes ± 1.01 vs. 6.35 minutes ± 2.94 (p <0.001).	time to onset of anesthesia for the injured finger."	
Keramidas 2004 Crossover Trial No mention of sponsorship or COI.	5.5	N = 50 patients with a finger(s) injury. Mean age of 35 years old. 15 Females, 35 Males	Transthecal Digital Block (N = 50) vs. Traditional digital block (N = 50) No mention of follow up.	Subjects had 2 or more injured fingers. Blocks performed with 2cc 1% lidocaine transthecally. All blocks successful without complications. Mean time to pinprick sensation faster for traditional block (100± 6.2 s vs. 165±9.3 s, p <0.05). At 24 hours post block, 18 of 52 transthecal blocks had residual pain; none of subcutaneous blocks had pain. Patients preferred subcutaneous block 46 vs. 4.	"The transthecal digital block is comparable to the traditional subcutaneous infiltration technique with respect to the time and effectiveness of anesthesia but not with respect to the associated pain following anesthesia. Patients seem to prefer the subcutaneous infiltration technique because it is less painful."	Randomization and allocation unclear, although patients served as both intervention arms. States study double blinded but only described blinding of assessor.
Low & Vartany 1997 Crossover Trial No mention of sponsorship. No COI.	5.5	N = 20 healthy volunteers. No mention of age/sex.	Transthecal (N = 20) vs. Single injection subcutaneous (superficial to A-1 pulley) digital block (N = 20) Follow up 24 hrs after experiment.	Blocks performed with 2ml 1% lidocaine; 40% of transthecal group and 45% of subcutaneous group achieved entire finger anesthesia. No differences based on injection method. No differences in magnitude of sensory nerve action potentials. Injector subjectively rated subcutaneous injections as easier to perform than transthecal.	"Transthecal and subcutaneous techniques showed no differences in terms of distribution, onset, and duration of anesthesia. Although both techniques give similar levels of anesthesia, subcutaneous block is believed to be superior because the transthecal technique has more dis-advantages."	Lack of study details, including randomization and allocation methods. Subjects were own control, and had no injuries.

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Medications

NSAIDS/ACETAMINOPHEN

Recommendation: NSAIDs or Acetaminophen for Phalangeal or Metacarpal Fractures

NSAIDs or acetaminophen are recommended to control pain from phalangeal or metacarpal fractures.

Indications – Pain due to phalangeal or metacarpal fracture.

Frequency/Duration – Scheduled dosage rather than as needed is generally preferable.

Indications for Discontinuation – Resolution of pain, lack of efficacy, development of adverse effects particularly gastrointestinal.

> *Strength of Evidence* – **Recommended, Insufficient Evidence (I)**
> *Level of Confidence* – Moderate

Rationale for Recommendation

There is no quality evidence, however these medications are thought to be effective for control of swelling and pain in the initial stages of injury, are not invasive, have low adverse effects, are low cost, and thus are recommended. While there have been some concerns regarding delayed fracture healing, other studies have suggested no delayed bone healing (see Distal Forearm Fractures section). These concerns appear outweighed by pain management concerns.

Evidence for the Use of NSAIDs or Acetaminophen

There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: NSAID, aspirin, acetaminophen, Middle, Proximal, Phalangeal, Metacarpal, Fractures, bone Fractures, boxer's; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 0 articles in PubMed, 56 in Scopus, 0 in CINAHL, 4 in Cochrane Library, 60 in Google Scholar, and 0 from other sources. We considered for inclusion 0 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 0 from Google Scholar, and 0 from other sources. Zero articles met the inclusion criteria.

ANTIBIOTIC PROPHYLAXIS

Recommendation: Antibiotic Prophylaxis for Open Phalangeal Fractures

There is no recommendation for or against the use of antibiotic prophylaxis for open phalangeal fractures.

> *Strength of Evidence* – **No Recommendation, Insufficient Evidence (I)**
> *Level of Confidence* – Low

Rationale for Recommendation

Antibiotic prophylaxis for open phalangeal fractures are commonly used but may not be necessary based on the results of a prospective (non-randomized) trial of 91 open phalangeal fractures in fingers with intact digital arteries which compared aggressive irrigation and debridement with antibiotics. There were equal numbers of soft tissue infections and no cases of osteomyelitis in either group.(1220) However, the study may have been underpowered for these infrequent complications.

Evidence for the Use of Antibiotic Prophylaxis

There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, and Cochrane Library without date limits using the following terms: Anti-bacterial agents, antibiotics, antibiotic prophylaxis, and antibiotic;controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly;

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systematic, systematic review, retrospective, and prospective studies. We found and reviewed zero articles in PubMed, 1 in Scopus, zero in CINAHL, and 1 in Cochrane Library. We considered for inclusion 0 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library and 0 from other sources. Zero articles met the inclusion criteria.

TETANUS IMMUNIZATION

Recommendation: Tetanus Immunization Status for Open Fractures

For open fractures, it is recommended that tetanus immunization status to be updated as necessary.

Indication – Wounds that are not clean or burns if more than 5 years have elapsed since last tetanus immunization.(1221)

Strength of Evidence – **Recommended, Insufficient Evidence (I)**
Level of Confidence – High

Rationale for Recommendation

There are no quality studies of tetanus immunization updating for these fractures. However, these immunizations are widely used and believed to have been successful on a population basis in reducing risk of tetanus over many decades. Tetanus immunizations are minimally invasive, have low adverse effects and are low cost. As the adverse effects of not immunizing may be fatal, tetanus immunization updating for open wounds is recommended. Wounds that are not clean or burns should require immunization if over 5 years since last immunization, rather than 10 years.(1221) Patients without a completed immunization series of 3 injections should receive tetanus immune globulin along with immunization.

Evidence for the Use of Antibiotic Prophylaxis

There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, and Cochrane Library without date limits using the following terms: Anti-bacterial agents, antibiotics, antibiotic prophylaxis, and antibiotic;controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed zero articles in PubMed, 1 in Scopus, zero in CINAHL, and 1 in Cochrane Library. We considered for inclusion 0 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library and 0 from other sources. Zero articles met the inclusion criteria.

Physical Methods/Rehabilitation

EXERCISE

Exercise is not indicated acutely. Some patients have considerable, functional deficits after casting and require exercise. For patients with residual deficits, particularly after casting or post-operatively, see section on Post-Operative Rehabilitation and Rehabilitation of Patients with Functional Deficits: CTS and Other Disorders.

Middle and Proximal Phalanx Fractures

IMMOBILIZATION AND SURGERY

There are no quality studies comparing non-operative treatment, percutaneous fixation, bone screws, or plates for middle and proximal phalangeal fractures. There also are no quality studies defining acceptable limits of displacement for non-operative management, determining the ideal splint time or duration of internal or external fixation, making comparisons of fixation techniques or defining ideal post-operative rehabilitation impractical. Immobilization or fixation technique is therefore dictated by the physical and radiographic findings. More than 90% of phalangeal fractures can be managed non-operatively.(83, 1233) Non-operative management techniques include padded aluminum splints, buddy tape, functional splinting, and gutter casting.

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1. *Recommendation: Immobilization for Middle and Proximal Phalanx Fractures*
   Immobilization is recommended for treatment of middle and proximal phalanx fractures.(83, 1233)
   Frequency/Duration – When percutaneous fixation with wire is used, supplemental stabilization with splint or casting for 3 to 4 weeks should also be used as the wire does not provide sufficient rigidity.

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – Moderate

Rationale for Recommendation
For middle and proximal phalangeal fractures that do not fit the criteria addressed in the specific fracture types, splinting for 3 to 4 weeks is recommended.

2. *Recommendation: Immobilization for Non-displaced and Stable Transverse Diaphyseal Fractures of the Middle and Proximal Phalanges*
   Non-operative management (immobilization) of non-displaced and stable transverse diaphyseal fractures of the middle and proximal phalanges is recommended as these fractures do not require fixation and can be managed without surgery.
   Frequency/Duration – Immobilization of the affected digit with neighboring digit in 70 to 90° of MCP flexion for 1 to 3 weeks.

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – Moderate

Rationale for Recommendation
There are no quality studies that address non-operative management of acute non-displaced and stable transverse diaphyseal fractures of the middle and proximal phalanges. These fractures have good results with non-operative management. The affected digit is immobilized with neighboring digit in 70 to 90° of MCP flexion for 1 to 3 weeks. The tolerance limits for non-operative management after closed reduction are angulation of 10°, shortening less than 2mm, bone apposition of greater than 50%, and no malrotation. Displacement outside these limits should be evaluated for treatment with closed reduction and percutaneous fixation, or upon failure of closed reduction, open reduction and internal fixation.(68, 87)

3. *Recommendation: Non-operative Management of Non-displaced Oblique Fractures of the Middle and Proximal Phalanges*
   Non-operative management of non-displaced oblique fractures of the middle and proximal phalanges is recommended as these fractures are usually stable and require rigid immobilization alone.
   Frequency/Duration – Examinations weekly for the first 3 weeks.

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – Moderate

Rationale for Recommendation
There are no quality studies for management of oblique fractures. Buddy taping should not be used as rotational correction may not occur. The fracture must be examined weekly for the first 3 weeks. Displaced fractures can be stabilized with closed reduction and percutaneous Kirschner wires or through open reduction with interfragmentary screw or plate-and-screw devices. Long oblique fractures (length double the diameter of bone at fracture site) can be stabilized by closed reduction and percutaneous Kirschner wires(78, 87) or with intramedullary wires.(89)

4. *Recommendation: Closed Reduction with Splinting for Base Phalanx Fractures*
   Closed reduction with splinting is recommended for base phalanx fractures.(1224)

   Indications – Involvement of less than 40% of the middle phalanx base.

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – Low

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Rationale for Recommendation
There are no quality studies for management of base fractures. However, base fractures are commonly a fracture-dislocation of the PIP joint and consists of an avulsion fracture of the volar lip of the middle phalanx with dorsal subluxation of the remaining base of the middle phalanx. Closed reduction with splinting is recommended(1224) if the fracture involves less than 40% of the middle phalanx base. If this fails, treatment is by pin fixation. Dynamic traction is another effective described technique for base fractures and also for the treatment of comminuted intra-articular fractures (Pilon fractures) of the base of the middle phalanx. Unstable displaced articular fractures at the base of the proximal phalanx are treated with percutaneous wires crossing the MCP joint to hold the joint reduced, and a transverse wire holding the fracture alignment similar to Bennett's fracture of the thumb.(1224)

5. *Recommendation: Surgical Management of Condylar Fractures*
   Surgical management of condylar fractures is recommended as these fractures are unstable.

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – Moderate

Rationale for Recommendation
Displaced oblique fractures involving a single condyle are unstable, and are stabilized operatively with two transverse pins or screws. Bicondylar fractures are reconstructed with screws and connected to the shaft with a pin or through the use of a condylar plate.(78, 1224)

6. *Recommendation: Surgical Management for Malrotated Phalangeal Fractures*
   Surgical management for malrotated phalangeal fractures is recommended as deformity and impairment may result.

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – Moderate

Rationale for Recommendation
Surgical management for malrotated phalangeal and metacarpal fractures is recommended, to prevent or reduce rotational deformity that can result in fingers crossing over each other or interfering with hand function, if malrotation cannot be corrected and stabilized by closed reduction.

Metacarpal Fractures

Except for 5th metacarpal neck fractures, there are no quality studies comparing non-operative management, percutaneous fixation, bone screws, or plates. Further, there are no quality studies defining acceptable limits of displacement for non-operative management, determining the ideal splint time or duration of internal or external fixation, making comparisons of fixation techniques or defining ideal post-operative rehabilitation. Metacarpal head fracture in an uncommon fracture, usually intra-articular and frequently results in late traumatic arthrosis.

1. *Recommendation: Non-operative Treatment of Distal Metacarpal Head Fracture*
   Non-operative treatment of distal metacarpal head fractures using closed reduction and protective immobilization with radial or ulnar gutter splint is recommended for fractures with less than 20% of joint involvement.
   Indication – Fractures with less than 20% of joint involvement.

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – Moderate

Rationale for Recommendation
There are no quality studies that address non-operative treatment of acute distal metacarpal head fractures. Metacarpal neck fractures are common extra-articular fractures at the base of the head, usually the result of axial impaction, resulting in the neck being displaced dorsally and the metacarpal head being displaced volarly. Recommendations are based on prior clinical experience. Cases with greater than 20% joint involvement likely require open reduction and internal fixation followed by nearly immediate motion.(84)

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2. *Recommendation: Non-operative Treatment of Distal Metacarpal Head Fracture with Acceptable Angulation*
   Non-operative treatment of distal metacarpal head fracture using angulation is recommended.
   Indication – Degree of angulation 15° in the ring finger and 10° in the index and long fingers.
   Frequency/Duration – These fractures heal quickly in 3 to 4 weeks with a gutter or radial splint maintaining MCP joint flexion. Operative fixation is usually with percutaneous pinning.(84)

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – Moderate

Rationale for Recommendation
Treatment of Boxer's fracture, or 5th metacarpal neck fracture, varies widely, with proponents of casting, splinting, taping, and operative fixation. There are no quality studies comparing non-operative and operative techniques, although there are two prospective trials with long-term follow-up suggesting non-operative treatment with early mobilization provides comparable outcomes to operative intervention, and perhaps is superior as operative fixation may increase the risk for metacarpohamate joint osteoarthrosis,(1234) although it may result in slightly more cosmetic deformity.(1235)

3. *Recommendation: Non-operative Treatment of Fifth Metacarpal Neck Fractures (Boxer's Fracture)*
   Non-operative treatment is recommended before surgical treatment for most 5th metacarpal neck fractures as the outcomes are similar both functionally and anatomically.

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – Moderate

4. *Recommendation: Use of Functional Therapies Rather than Casting or Splinting for Fifth Metacarpal Neck Fractures*
   The use of functional therapies including taping, functional bracing, and strapping is moderately recommended over casting or ulnar splinting for 5th metacarpal neck fractures.

   Strength of Evidence – **Moderately Recommended, Evidence (B)**
   Level of Confidence – Moderate

Rationale for Recommendations
There are eleven moderate-quality studies available comparing the effectiveness of different non-operative measures and no clear evidence of superiority of one approach over another.(1236-1246) A Cochrane review also concluded that no single non-operative treatment regimen for fracture of the neck of the 5th metacarpal can be recommended as superior to another in results.(1247) However, there is moderate evidence supporting functional therapies in general, with two moderate-quality studies supporting functional therapies over casting or splinting. Functional taping provided better functional outcome with no increase in deformity over casting,(1236) and treatment by compression bandage without reduction or splinting with a mean angulation angle of 48° had equal functional outcomes with closed reduction and splinting.(1238) Another moderate-quality study supports the use of strategic metacarpal bracing (3-point brace), another type of functional therapy, which provided equivalent functional outcomes to neighbor strapping but with less pain.(1237)

Ulnar gutter cast was compared with functional mobilization (pressure bandage for 1 week) in patients with 70° angulation or less and no rotation of the 5th metacarpal. Although the study was limited by small sample size, there were no differences in subjective symptoms of pain, return to work and hobby, or the need for physiotherapy.(1239) Several non-randomized prospective and retrospective trials with long-term follow up (up to 4 years) of patients treated without immobilization support these findings.(1248-1250) Other methods described in the literature for non-operative management with reported efficacy include fracture brace,(1251) modified Thomine brace,(1252) and a glove cast.(1253) However, there is no recommendation for or against any of these interventions as there is insufficient evidence.

There is no consensus on the degree of acceptable volar angulation manageable with non-operative treatment. It is reported as 30° in a small prospective case series of 18 patients(1254) followed for a mean of 20 months, and 60° and 70° in early mobilization trials.(1238, 1239) Intra-articular fractures

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have also been reported to be successfully treated non-operatively, although comparison of non-operatively and operative management demonstrated high level of intermittent pain (38%), 49% decreased grip, and 65 radiographic signs of osteoarthritis in both groups.(1255)

Evidence for the Use of Functional Therapies vs. Casting or Splinting for Metacarpal Fractures
There are 11 moderate-quality RCTs incorporated into this analysis.(1236-1246) There are 3 low-quality RCTs in Appendix 2.(1256-1258)

Taping:
A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library and Google Scholar without date limits using the following terms: Taping, functional bracing, strapping vs. casting or splinting (fifth metacarpal neck fractures only), Middle and Proximal Phalangeal and Metacarpal Fractures (fifth metacarpal neck fractures, boxer's fracture, shaft metacarpal fractures - transverse, oblique, spiral, comminuted); controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 17 articles in PubMed, 4 in Scopus, zero in CINAHL, zero in Cochrane Library, 27 in Google Scholar, and zero from other sources. We considered for inclusion 11 from PubMed, zero from Scopus, zero from CINAHL, zero from Cochrane Library, zero from Google Scholar, and zero from other sources. Of the 11 articles considered for inclusion, 11 randomized trials and zero systematic studies met the inclusion criteria.

Fixation:
A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: percutaneous fixation, bone screws, plates, internal fixation, external fixation, closed reduction, middle, proximal, phalangeal, metacarpal, fractures, bone fractures, boxer's, condylar fractures; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 244 articles in PubMed, 301 in Scopus, 11 in CINAHL, 1 in Cochrane Library, 282 in Google Scholar, and 0 from other sources. We considered for inclusion 3 from PubMed, 2 from Scopus, 0 from CINAHL, Cochrane Library, and Google Scholar, and 1 from other sources. Of the 6 articles considered for inclusion, 5 randomized trials and 1 systematic studies met the inclusion criteria.

Immobilzation:
A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms Immobilization: padded aluminum splints, buddy tape, functional splinting, gutter casting, splinting (closed reduction), Middle, Proximal, Phalangeal, Metacarpal, Fractures, bone Fractures, boxer's; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 0 articles in PubMed, 2 in Scopus, 4 in CINAHL, 19 in Cochrane Library, 100 in Google Scholar, and 1 from other sources. We considered for inclusion 0 from PubMed, 0 from Scopus, 0 from CINAHL, 1 from Cochrane Library, 0 from Google Scholar, and 1 from other sources. Of the 2 articles considered for inclusion, 0 randomized trials and 2 systematic studies met the inclusion criteria

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Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Immobilization						
Hofmeister 2008 RCT No mention of sponsorship. NO COI.	6.0	N=81 with an acute (<7 days old) isolated fracture of the 5th metacarpal neck. Mean age 25 years. No mention of gender.	Casting with the MCP joint in flexion in a short-arm cast with volar outriggers with ring and small finger interphalangeal joints in extension, SAC-VOR (N=40) vs. casting with MCP joint in neutral extension and a cast with a 3-point mold about the fracture site, MCP-ext (N=41). All patients underwent a fracture reduction prior to cast placement. Cast was removed after 4 weeks. Assessments at 1 week, 4 weeks, and 3 months after the start of treatment.	Postreduction AP plane: SAC-VOR 5º vs. MCP-ext 14º ($p<0.05$).	"[W]e found that both methods of immobilization were equally effective in maintaining fracture reduction."	Data suggest comparable efficacy between (SAC VOR) and (MPC-ext) with a slight advantage to MCP-ext in terms of grip strength, patient tolerability and ROM.
Harding 2001 No mention of sponsorship or COI	5.5	N = 73 (3 females, 62 males) Patients with minimally angulated (<40°), closed fractures of the little finger metacarpal neck with no rotational deformity or associated injury. Mean age was 26.5 years	Molded metacarpal brace (N=37) vs. neighbor strapping for 5th metacarpal neck fracture (N=28) Follow up at 3 weeks.	Patients treated with brace complained of less pain ($p = 0.001$) and had slightly better range of finger movement ($p = 0.03$). More returned to work by 3 weeks ($p = 0.007$). None developed rotational or significant angular deformity.	"The results of our study... showed a clear benefit over neighbor strapping for mean range of active range of motion of MCP joint, mean pain score, and return to work by 3 weeks."	There was no mention of control for co-interventions. For working populations this study suggests earlier return to work.
Kuokkanen 1999 No mention of sponsorship or COI.	5.5	N = 29 (26 males, 3 females) Patients treated for subcapital fractures of the fifth metacarpal bone. Mean age: 29 years.	Compression bandage for 1 week vs. splint immobilization (MCP 60° of flexion)	Angulation of fracture remained practically at same level compared with primary angulation in both groups. ROM of MCP ($p = 0.02$) and PIP ($p = 0.01$) joints higher in functional group at 4 weeks, but no difference at 3 months. Grip force was better in functional group at 4 weeks ($p = 0.002$).	"We suggest that at least subcapital fractures of the fifth MC that are modestly and slightly angulated should be treated functionally, without reduction and splinting. Based on the present findings the correction achieved by closed reduction does not persist..."	Small sample size. Patients in functional group had higher degree of pre-treatment angulation but still had equal or better functional outcomes in this population.
Braakman 1998	5.0	N = 50 (43 males, 5 females)patients	Ulnar gutter plaster cast vs. functional tape of 5th metacarpal fracture.	In both groups, fracture reduction partially lost at 1	The patients in the tape group showed a quicker and superior	Lack of randomization and allocation details.

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No mention of sponsorship or COI.		with a fracture of the 5th metacarpal Mean age was 26 years.	Follow up period was 6 month.	week follow-up for all patients who had reduction. No relation between functional recovery and existence of residual symptoms based on initial fracture angulation. Normal mobility restored in all patients in table group, whereas mobility limited in 44% of cast group at 4 weeks and 8% at 3 months.	functional recovery than those in the cast group. After 6 months, there were no significant differences between the groups with regard to functional and anatomical results or the number of patients with residual symptoms.	No blinding of assessor.
Statius Muller 2003 RCT No mention of sponsorship or COI.	5.0	N= 40 (38 males, 2 females) with a fracture of the subcapital MC-V ≤ 3 days old and angulated ≤70º. Mean age 29 years.	Ulnar gutter plaster cast for 3 weeks followed by mobilization within pain limits (N=20) vs. 1 week of pressure bandage (N=20). Follow-up 6 and 12 weeks after fracture.	There were no significant differences between groups at 6 and 12 weeks follow-up.	"[A] pressure bandage for 1 week and immediate mobilization is a sufficient alternative treatment of a boxer's fracture, if this is not angulated greater than 70° and not rotated."	Small sample size. Data suggest comparable efficacy between groups.
McMahon 1994 RCT No mention of sponsorship or COI.	4.5	N=42 with unilateral fresh closed stable fractures (displaced <50% of width of shaft, angulated less than 40º and showed an angle of over 60º between plane of fracture and axis of shaft) of the shaft of single finger metacarpal Mean age plaster 27 years, compression glove 35 years. No mention of gender.	Compression glove worn on injured hand and early mobilization (N=21) vs. immobilization in plaster splint (N=21). Treatment lasted between 6-14 days after entry. All patients received hand exercises between 6-13 days after injury. Follow-up began at week 2, weekly intervals for 3 weeks.	Mean loss of total active motion (degrees): week 2 glove 56±26 vs. splint 84±33 (p=0.0036); week 3 glove 23±17 vs. splint 46±23 (p=0.0010); week 4 NS (p=0.15). Mean increase in circumference of PIP joint (mm): week 2 glove 2.2±2.8 vs. splint 4.5±3.2 (p=0.019); week 3 glove 0.5±2.5 vs. splint 2.1±2.8 (p=0.059); week 4 NS (p=0.27). Mean	"Use of a compression glove avoided the loss of function imposed by splintage and was associated with a greater range of movement during the second and third weeks."	Small sample size (N=42). Data suggest glove group experienced less pain and prevented loss of function and better range of motion during second and third weeks.

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				increase in hand volume (cm3): week 2 glove 19±31 vs. splint 42±36 (p=0.029); week 3 NS (p=0.13); week 4 NS (p=0.69).		
Randall 1992 RCT No mention of sponsorship or COI.	4.5	N=18 (13 males, 5 females) undergoing treatment of metacarpal fracture and hand has been immobilized for ≥2 weeks. Mean age 28.7 years.	Joint mobilization using traction and palmar/dorsal glide techniques (N=9) vs. control, no mobilization (N=9). Both groups received home exercises. Three appointments on alternate days over a 1 week period.	Mean torque range of motion (TROM): treatment 73.6 vs. control 58.7 (no p-value reported).	"The joint mobilization treatment given to the subjects in this study resulted in a significant gain in AROM and decrease in joint stiffness within a treatment session when compared to the control group."	Small sample (18). Data suggest significant increase in metacarpal phalangeal joint motion after joint mobilization when compared to controls.
Konradsen 1990 RCT No mention of sponsorship or COI.	4.0	N=100 with shaft or neck fracture of the 2nd-5th metacarpal bone. Median age plaster cast 22 years, functional cast 22.5 years. No mention of gender.	Immobilization by plaster cast as ulnar gutter cast for 5th metacarpal or as dorsal cast for 2nd-4th metacarpals (N=) vs. immobilization by functional cast, Delta-Lite® allowing free ROM of wrist and digit joints (N=). Reduction was performed in all patients. Casts removed after 3 weeks. Assessments at 1 week, 3 weeks, and 3 months after injury.	Fracture angulation after cast removal (median degrees): subcapital – plaster cast 25 vs. functional cast 16 (p<0.05); diaphyseal – plaster cast 14 vs. functional cast 5 (p<0.01). Return to work in occupations where use of hands could be avoided (time in days): plaster cast 7 vs. functional cast 1 (p<0.05).	"Functionally treated patients returned to work faster than did patients in studies of nonimmobilization (Hunter and Cowen 1970, Arafa et al. 1986, Ford et al. 1989), perhaps because the short, but solid, bandage gave a feeling of security and provided pain relief."	Data suggest functional cast group returned to work in 1/3 the time compared to plantar cast group. Functional casting reduced volar angulation by 2/3 in metacarpal shaft fractures and 1/3 in metacarpal neck fractures as compared to plantar cast group.
Fixation						
Kim 2015 RCT No mention of sponsorship. NO COI.	7.0	N = 46 (46 males, zero females) with displaced fifth metacarpal neck fractures with apex dorsal angulation >30º. Mean age 29 years.	Antegrade intramedullary K-wire pinning (N =23) vs percutaneous retrograde intramedullary K-wire pinning (N =23). All patients received an ulnar gutter short-arm splint post-surgery to be worn for 5 weeks.	Postoperative outcomes at 3 months: ROM antegrade 80 vs. retrograde 69 (p<0.001); VAS points antegrade 2 vs. retrograde 4 (p<0.001); grip strength % antegrade	"[T]reatment of a displaced fifth metacarpal neck fracture by antegrade intramedullary pinning produces better clinical outcomes at 3 months	Data suggest antegrade intramedullary pinning had some clinical benefit to retrograde intramedullary pinning during recovery phase but these benefits are not present at 6 months.

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			Follow-up at 3 and 6 months postoperatively.	81 vs. retrograde 71 (p<0.001); DASH score, points, antegrade 4.3 vs. retrograde 10.3 (p<0.001). Postoperative outcomes at 6 months: ROM (p=0.35); VAS (p=0.67); grip strength (p=0.41); DASH score (p=0.48).	postoperatively in terms of ROM, VAS, grip strength, and DASH score of the fifth metacarpophalangeal joint than percutaneous retrograde intramedullary pinning, but that the differences in clinical parameters are not sustained at 6 months postoperatively."	
Winter 2007 RCT No mention of sponsorship or COI.	5.5	N = 36 male with fracture of neck of 5th metacarpal, recent and closed fracture. Mean age 31.4 years.	Transverse pinning with 2 K-wires 1.5mm diameter (N = 18) vs intramedullary pinning with 3 K-wires 1mm diameter (N = 18). Both groups wore palmar splint for 1 week after procedure then physiotherapy 3x a week for 30 days. K-wires removed 6 weeks after surgery. Follow-up at days 8, 15, 30, 45, 60, and 90 after surgery.	Total active motion (TAM) at final follow-up: intramedullary 279±11.9º vs. transverse 261±36.5º (p=0.02). Active ROM MCPj at final follow-up: intramedullary 94±5.9º vs. transverse 81.5±19.4º (p=0.0037). Percentage of contralateral grip strength: intramedullary 92% vs. transverse 83% (p=0.06).	"This study suggests that intramedullary pinning is a particularly efficient procedure for treatment of the boxer's fracture.."	Small sample. Data suggest better functional outcomes with intramedullary pinning group unclear if patients were informed of surgical treatment.
Krukhaug 2009 RCT No mention of sponsorship. No COI.	5.0	N = 75 (6 male and 64 female) with unstable distal radius fractures (AO-type A3) suitable for non-bridging external fixation; >10º of dorsal angulation and/or radial shortening of >2mm vs. uninjured wrist. Mean age 62 years.	H group: Hoffman compact II fixator (N = 37) vs D group: Dynawrist fixator (N = 38). All patients treated with closed reduction. Follow-up post-op, 6, 12, 24, and 52 weeks.	Median radial tilt (degrees): post-op Hoffman 8 volar vs. Dynawrist 2 volar (p = 0.002); at removal of fixators Hoffman 9 volar vs. Dynawrist 4 (p = 0.04). Mean loss of flexion (degrees): 6 weeks Hoffman 34 vs. Dynawrist 24 (p = 0.001).	"The Dynawrist bridging but dynamic fixator gives radiographic and functional outcome similar to that of the Hoffman II compact non-bridging fixator."	Data suggest comparable efficacy in both groups for radial tilt, inclination and radial length.

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Horton 2003 RCT Sponsored by a grant from the AO foundation. No mention of COI.	5.0	N = 32 (14 male and 14 female) with an isolated and displaced spiral or long oblique fracture of the shaft of the proximal phalanx. Mean age 26 years.	Treated by closed reduction and Kirschner wire fixation (N = 17) vs Treated by open reduction and lag screw fixation (N = 15). Follow-up for a median of 40 (range 15-76) months.	18/28 achieved a full recovery and 9/10 complained only of niggling or minor problems. No significant difference between the functional recoveries of the two groups, (p = 0.3). The median pain VAS for the whole study group was 0 (range 0–7).	"There was no significant difference in the functional recovery rates or in the pain scores for the two groups."	Small sample size. Data suggest comparable results.
Sletten 2015 RCT Sponsored by a grant from Sofies Mindes Ortopedi AS, Oslo, Norway. No COI.	5.5	N = 85 (61 male and 24 female) with little finger metacarpal neck fractures with ≥30° palmar angulation in the lateral view. At least 18 years.	Conservative treatment without reduction of the fracture (N = 43) vs Closed reduction and bouquet pinning (N = 42). Follow-up at 1 week, 6 weeks, 3 months, and 1 year.	Median operative time 30 minute. The palmar angulation was a median of 41° (range 30–58) in the conservative group at inclusion. In the operative group, palmar angulation was reduced from a median of 40° (range 30–59) – 17° (range –9–31). At 1 year, The QuickDASH score was median 0 in both groups. No statistically significant or clinical relevant differences in QuickDASH scores at any time, but a worse QuickDASH Work score in the operative group at 6 weeks before pin removal, (25 versus 6 points, p = 0.07).	"There was a trend versus better satisfaction with hand appearance (p = 0.06), but longer sick leave (p < 0.001) and more complications (p = 0.02) in the operative group."	Data suggest comparable efficacy between conservative treatment vs. bouquet pinning of little finger metacarpal neck fractures for pain, finger ROM, grip strength, and quality of life. However, there was better patient satisfaction with hand appearance but longer sick leave in the surgical group.

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5. *Recommendation: Routine X-rays in Follow-up of Fifth Metacarpal Neck Fractures*
   Routine x-ray for follow-up of non-operative treatment of 5th metacarpal fractures is not recommended as it has little clinical impact on fracture management.

   Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
   Level of Confidence – Low

Rationale for Recommendation
Routine radiographs in follow-up of non-operative treatment for 5th metacarpal neck fracture were not found to be of clinical utility(1259) except in only one case from two retrospective studies of 307 patients and 288 patients. Follow-up radiographs are indicated if physical examination suggests loss of reduction or instability within one week of the fracture.

Shaft Metacarpal Fractures

Shaft metacarpal fractures are usually transverse, oblique, spiral or comminuted. Determination of whether or not a fracture can be managed non-operatively is unclear.

1. *Recommendation: Non-operative Management of Metacarpal Shaft Fractures*
   There is no recommendation for or against non-operative management of metacarpal shaft fractures.

   Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**
   Level of Confidence – Low

Rational for Recommendation
There are no quality studies and there are conflicting opinions regarding whether any angulation of the middle and index finger is acceptable,(84) versus whether up to 15° of dorsal angulation of the middle and index finger(89) can be tolerated. The ring finger is thought to tolerate 20°.(84) There is general agreement that rotational deformity is poorly tolerated. Thumb shaft fractures are rare, and those with less than 30° angulation can be managed with forearm-hand-based opponens splint for 3 to 4 weeks. Parameters of fifth digit fractures are discussed separately (see Boxer's Fracture). Ultimately, decisions for non-operative versus surgical intervention balance acceptance of metacarpal shortening with risks accompanying surgical intervention.

Oblique fractures likely benefit from fixation (intra-medullary wires)(89) to prevent shortening. If adequate closed reduction is achieved and the fracture is stable, a 3-point brace (pressure points over the fracture apex and two counter-pressure points proximal and distal on the opposite side) can be used. Metacarpal shaft fractures that cannot be reduced, are unstable, or have multiple neighboring shaft fractures require fixation (pinning, wire, plate, lag screws).

2. *Recommendation: Surgical Management for Base Fractures of the Proximal Metacarpal*
   Surgical management of base fractures of the proximal metacarpal is recommended as these fractures are rarely stable and require percutaneous pins or screws to maintain reduction.

   Indications – Extra-articular fractures with up to 15° of deformity in the 4th and 5th metacarpals, and only 5° in the 2nd and 3rd metacarpals can be managed with immobilization using a gutter splint holding the MCP in 70° flexion, wrist in neutral position, and allowing movement of the PIP and DIP joints.(84)

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – Moderate

3. *Recommendation: Operative Fixation for Bennett's Fracture and Rolando's Fracture*
   Operative fixation is recommended for Bennett's and Roland's fractures as these fracture types are unstable.

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – Moderate

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4. *Recommendation: Surgical Management for Malrotated Phalangeal Fractures*
   Surgical management for malrotated phalangeal fractures is recommended as deformity and impairment may result.

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – Moderate

Rationale for Recommendations
There are no quality studies for Bennett's or Rolando's fractures of the thumb. Bennett's fracture of the thumb is a common metacarpal base fracture associated with dislocation, and requires operative fixation with one or two wires to maintain alignment of the shaft and joint surface, as does the base of the 5th metacarpal.(68) Rolando's fracture is a comminuted intra-articular burst fracture at the thumb base requiring internal and external fixation to preserve metacarpal length and reapproximate articular fragments.(84)

Evidence for the Use of Surgery
There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: operative fixation, middle, proximal phalangeal, metacarpal fractures, metacarpal, neck fractures, boxer's fracture, shaft metacarpal fractures, transverse, oblique, spiral, comminuted; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 69 articles in PubMed, 90 in Scopus, 0 in CINAHL, 18 in Cochrane Library, 175 in Google Scholar, and 0 from other sources. We considered for inclusion 0 from PubMed, 1 from Scopus, 0 from CINAHL, Cochrane Library, Google Scholar, and from other sources. Zero articles were included.

Follow-up Visits
There are no quality studies on frequency or timing of return visits. X-rays for follow-up of all metacarpal fractures are reasonable; however, fractures at risk for displacement after reduction are particularly recommended to have repeat radiographic studies 7 to 10 days after injury to ensure no further displacement or malrotation has occurred – **Recommended, Insufficient Evidence (I),** *Level of Confidence - Moderate*. Motion and other hand exercises should be started at the earliest date the fracture becomes stable**.**

Physical Methods/Rehabilitation
1. *Recommendation: Ice, Compression, and Elevation for Acute Metacarpal Fractures*
   Ice, compression, and elevation are recommended for controlling edema related to acute metacarpal fractures.

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – Low

2. *Recommendation: Early Mobilization for Acute Metacarpal Fractures*
   Early mobilization of acute metacarpal fracture (before 21 days) is recommended.

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – Low

Rationale for Recommendations
There are no quality studies for physical methods of metacarpal fracture management. However, it is believed that controlling edema and early mobilization result in a more favorable outcome. Inflammation associated with traumatic injury, fracture hematoma and any resultant soft tissue damage from fracture displacement including adjacent tendons and ligaments results in edema and routine tissue repair processes. Immobilization in the presence of these inflammatory processes can result in adhesions to tendons, ligaments, capsules, or skin and subsequent stiffness and loss of function.(1260) Phalangeal fractures respond less favorably to immobilization than metacarpal fractures, with a predicted 84% return

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of motion, compared to 96% return in metacarpal fractures. Immobilization continued longer than 4 weeks is reported to further reduce the return to motion to 66%.(1222)

There are no quality studies defining the efficacy or advantages of specific physical methods in reducing the effect of inflammation and immobilization. Control of edema after injury has been thought to be important in restoring function.(1261) Ice, compression, and elevation should be emphasized, with particular emphasis on hand elevation overnight.(1262)

Early mobilization to promote venous return via muscle contraction and thus reduce swelling and propensity towards complex regional pain syndrome (CRPS) is advocated for stable fractures. Early motion of simple metacarpal fractures initiated within 21 days of injury is likely to result in earlier recovery of motion and strength, and earlier return to work without adversely impacting fracture alignment.(1263) Tendon gliding range of motion exercises should be initiated as soon as possible based on the fracture immobilization method.

Evidence for the Use of Joint Mobilization
There are 3 moderate-quality RCTs incorporated into this analysis.(1308, 1309, 1327) (Kuokkanen 99; Statius Muller 03; Sletten 15)

Ice:
A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library and Google Scholar without date limits using the following terms: Ice, Compression, Elevation, Metacarpal, Middle, Proximal, Phalangeal, boxer's, Fractures, Bone; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found, reviewed and considered for inclusion 0 articles in PubMed, 0 in Scopus, 0 in CINAHL, 0 in Cochrane Library, 0 in Google Scholar and 0 in other sources. Zero articles met the inclusion criteria.

Joint mobilization:
A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Joint mobilization, early ambulation, Middle and Proximal Phalangeal and Metacarpal Fractures (fifth metacarpal neck fractures, boxer's fracture, shaft metacarpal fractures - transverse, oblique, spiral, comminuted) ;controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 4 articles in PubMed, 56 in Scopus, 380 in CINAHL, 3 in Cochrane Library, and 3 in Google Scholar. We considered for inclusion 1 from PubMed, 0 from Scopus, 0 from CINAHL, 1 from Cochrane Library and 1 from Google Scholar. Of the 4 articles considered for inclusion, 3 randomized trials and 1 systematic studies met the inclusion criteria.

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Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Kuokkanen 1999 No mention of sponsorship or COI.	5.5	N = 29 (26 males, 3 females) Patients treated for subcapital fractures of the fifth metacarpal bone. Mean age: 29 years.	Compression bandage for 1 week vs. splint immobilization (MCP 60° of flexion)	Angulation of fracture remained practically at same level compared with primary angulation in both groups. ROM of MCP (p = 0.02) and PIP (p = 0.01) joints higher in functional group at 4 weeks, but no difference at 3 months. Grip force was better in functional group at 4 weeks (p = 0.002).	"We suggest that at least subcapital fractures of the fifth MC that are modestly and slightly angulated should be treated functionally, without reduction and splinting. Based on the present findings the correction achieved by closed reduction does not persist..."	Small sample size. Patients in functional group had higher degree of pre-treatment angulation but still had equal or better functional outcomes in this population.
Statius Muller 2003 RCT No mention of sponsorship or COI.	5.0	N= 40 (38 males, 2 females)with a fracture of the subcapital MC-V ≤ 3 days old and angulated ≤70º. Mean age 29 years.	Ulnar gutter plaster cast for 3 weeks followed by mobilization within pain limits (N=20) vs. 1 week of pressure bandage (N=20). Follow-up 6 and 12 weeks after fracture.	There were no significant differences between groups at 6 and 12 weeks follow-up.	"[A] pressure bandage for 1 week and immediate mobilization is a sufficient alternative treatment of a boxer's fracture, if this is not angulated greater than 70° and not rotated."	Small sample size. Data suggest comparable efficacy between groups.
Sletten 2015 RCT This work was supported by a grant from Sofies Mindes Ortopedi AS, Oslo, Norway. NO COI.	5.5	N = 85 patients with little finger metacarpal neck fractures with ≥ 30 º palmar angulation in the lateral view. Mean age Conservative Group 29 (18–67) and Operative group 25 (18–68) Gender (M:F) Conservative group (39:4) Operative (39:3)	Conservative group received an initial plaster-of-Paris applied for pain for one week, then buddy strapping was applied over the proximal 0phalanges of the little and ring fingers, and the patients started active exercises. N = 43 Operative group underwent closed reduction and internal fixation by antegrade, intramedullary bouquet pinning then The postoperative regime was identical to the conservative regime. N = 42 Follow up at at 1 week, 6 weeks, 3 months, and 1 year	For conservative vs. operative; QuickDASH (0 vs. 0 (p=0.54)), VAS overall Satisfaction (97 vs 100 (p=0.17)), TAM (º) (261 vs 260 (p=0.68)), Grip strength (kg) (49 vs 49 (p=0.78)),	"After 1 year, there were no statistical differences between the groups in QuickDASH score, pain, satisfaction, finger range of motion, grip strength, or quality of life. There was a trend versus better satisfaction with hand appearance (p = 0.06), but longer sick leave (p < 0.001) and more complications (p = 0.02) in the operative group."	Data suggest comparable efficacy between conservative treatment vs. bouquet pinning of little finger metacarpal neck fractures for pain, finger ROM, grip strength, and quality of life. However, there was better patient satisfaction with hand appearance but longer sick leave in the surgical group.

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Distal Forearm Fractures

Special Studies and Diagnostic and Treatment Considerations

X-RAYS

Recommendation: X-ray for Suspected Distal Forearm Fractures

X-rays in the posterior-anterior and lateral views are recommended as a first-line study for suspected distal forearm fractures.

Strength of Evidence – **Recommended, Insufficient Evidence (I)**
Level of Confidence – High

Rationale for Recommendation

There is no quality evidence for evaluation of x-ray studies for evaluation of suspected distal radial fractures. However, x-ray studies are standard of practice for suspected fracture. Therefore, as a first-line study, PA, lateral and if available oblique x-ray image views are recommended. Radiographic evaluation should provide the provider necessary information on location, configuration, displacement, subluxation, likelihood of stability, and concomitant potential of soft tissue injury. Contralateral wrist x-ray images should be considered as a comparison that may improve reliability of some radiographic measurements, particularly for a more accurate determination of stability and provide greater guidance on indication for treatment.

Evidence for the Use of X-rays

There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Distal Forearm Fracture, xray, diagnostic, diagnosis, sensitivity, specificity, positive predictive value, negative predictive value, and predictive value of tests, efficacy, and efficiency. We found and reviewed 22 articles in PubMed, 3 in Scopus, 24 in CINAHL, 0 Cochrane Library, and 11,100 from Google Scholar. We considered for inclusion 1 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 0 from Google Scholar, and 0 from other sources. Zero articles were included.

MRI

Recommendation: MRI for Diagnosing Distal Forearm Fractures

MRI is recommended to diagnose suspected soft-tissue trauma after x-ray images confirm a complex displaced, unstable, or comminuted distal forearm fractures.

Indication – X-ray confirmation of complex displaced, unstable, or comminuted distal forearm fracture.

Strength of Evidence – **Recommended, Insufficient Evidence (I)**
Level of Confidence – Low

Rationale for Recommendation

There is no quality evidence that MRI is superior to radiographs for the initial detection of distal radial fractures and should not be generally used as a first line test. Upon confirmation of displaced, comminuted or unstable fracture, MRI may be an important diagnostic technique for the evaluation of suspected injuries of soft tissues related to distal radius fractures, such as to the flexor and extensor tendons or the median nerve. Other potential indications include identification of triangular fibrocartilage complex perforations, ruptures of carpal ligaments, and demonstration of contents of the carpal tunnel.(1264-1266)

Evidence for the Use of MRI

There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: magnetic resonance imaging, MRI,

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distal forearm fracture, distal forearm fractures, colles' fracture, colles fracture, colles fractures, dinner fork deformity, diagnostic, diagnosis, sensitivity, specificity, positive predictive value, negative predictive value, and predictive value of tests, efficacy, and efficiency. We found and reviewed 19 articles in PubMed, 117 in Scopus, 1 in CINAHL, 4 in Cochrane Library, and 640 from Google Scholar. Zero articles met the inclusion criteria.

CT

Recommendation: CT for Diagnosis and Classification of Occult and Complex Distal Forearm Fractures
CT is recommended for investigation of occult and complex distal forearm fractures to gain greater clarity of fracture displacement, articular involvement, and subluxation of the distal radioulnar joint.(1267)

Indication – Negative x-rays with occult fracture strongly suspected.

Strength of Evidence – **Recommended, Insufficient Evidence (I)**
Level of Confidence – Moderate

Rationale for Recommendation
In contrast to MRI, CT should be considered when x-ray images are negative but on the basis of physical findings an occult fracture is strongly suspected. CT may also be useful for evaluation of complex comminuted fractures, providing superior depiction of distal radial articular surface involvement, fragment positioning, and diagnosis of subluxations of the distal radioulnar joint.(1267, 1268) The value of CT has been demonstrated by Katz et al, who showed the use of CT scanning for evaluation of articular step off and gaping, comminution, and treatment influenced observers to change treatment plans developed from radiographs and resulted in increased interobserver reliability in the proposed management of these injuries.(1269)

Evidence for the Use of CT
There are 3 quality studies incorporated into this analysis.(1339, 1342, 1343) (Johnston 92; Harness 06; Avery 14)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: CT, CAT, computed tomography, distal, Forearm, radial, Radius fractures, bone Fractures, Colles' Fracture, diagnostic, diagnosis, sensitivity, specificity, positive predictive value, negative predictive value, and predictive value of tests, efficacy, and efficiency. We found and reviewed 302 articles in PubMed, 20 in Scopus, 3 in CINAHL, 16 Cochrane Library, and 20 from Google Scholar. We considered for inclusion 1 from PubMed, 1 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 0 from Google Scholar, and 1 from other sources. Of the 3 articles considered for inclusion 3 diagnostic studies met the inclusion criteria.

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Author/Year Study Type	Score	Number	Area of Body	Diagnoses	Type of CT	X-ray used	MRI Used	More than on rater	Blinding of rater	Myelography	Surgery Performed	Clinical outcomes assessed	Long term follow-up (mean when noted)	Results	Conclusion	Comments
Avery III 2014 Retrospective Study	5.5	17 sets of images No mention of how many patients, mean age, or gender.	Wrist	Distal Radial Fracture	GE LightSpeed VCT	+	-	+	+	-	-	-	-	CT and traction radiographs had the about the same ability to identify fracture fragments, except for the volar rim fragment. The volar rim was correctly identified 72% of the time on traction radiography compared to CT's 60% (p<0.01). CT correctly identified the radial column more often than traction radiographs (71.8% vs 65.8%, p=0.04)	"The information obtained from the traction radiographs compared with CT imaging showed little significant difference with regard to fracture fragment characterization and led surgeons to consistent treatment recommendations with both imaging modalities"	Small sample. Data suggest use of traction radiographs may be an alternative to CT imaging for diagnosing and assessing distal radial fractures.

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Harness 2006 Retrospective	7.5	30 No mention of mean age, or gender	Wrist	Wrist Fracture	GE Advantage 3.1 Workstation	+	-	+	+	-	-	+	-	Pertaining to a coronal fracture line, 3D CT imaging resulted in a sensitivity of 0.82, a specificity of 0.50, and accuracy of 0.77. 2D CT imaging resulted in values of 0.81, 0.56, and 0.77, respectively. When combined, the two images had slightly better results: a sensitivity of 0.87, a specificity of 0.56, and an accuracy of 0.82.	"Three-dimensional computed tomography improves both the reliability and the accuracy of radiographic characterization of articular fractures of the distal part of the radius and influences treatment decisions"	Dats suggest use of 3-D CT for analyzing complex intra-articular distal radius fractures.

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Johnston 1992	5.5	22 Mean age = 31.5 13 men 9 women	Wrist/Hand	Acute distal radial and/or carpal injury	GE 9800 scanner	+	-	+	- (No mention)	-	-	-	-	Only 19 of the 22 patients had a radial distal fracture. 3 sets of plain film were interpreted as normal. However, a CT scan revealed that all three were fractures. CT scan enhanced the details of the fractures. In one case, a “innocent lip fracture” on plain film turned into an intra-articular compress of the scaphoid fossa on the CT.	“CT has an advantage over conventional tomography in lending itself to potential three-dimensional reconstruction.”	Data suggest CT visualizes more detail in evaluating acute distal radial fractures compared to plain radiographs.

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Follow-up Visits

No quality evidence exists for specific follow-up care of distal radial injuries outside of identified recommendations listed in this section. Routine follow-up as with other fractures should be followed, with consideration of forearm girth changes with reduced swelling after the immediate injury period that may necessitate re-casting or immobilization device adjustments, and monitoring the potential for reduction failure with subsequent radiographic studies.

Medications

NSAIDS

Recommendation: NSAIDs for Acute Colles' Fracture (Distal Forearm Fracture) Analgesia
The use of NSAIDs to control bone pain associated with Colles' fracture is recommended as there does not appear to be any negative effect on bone fracture union or functional recovery.

Indications – Bone pain associated with Colles' fracture.
Frequency/Duration – Scheduled dosage rather than as needed is generally preferable.
Indications for Discontinuation – Resolution of pain, lack of efficacy, development of adverse effects particularly gastrointestinal.

Strength of Evidence – **Recommended, Evidence (C)**
Level of Confidence – Moderate

Rationale for Recommendation
There are three moderate-quality studies that show NSAIDs are effective for pain relief of distal forearm fracture.(1270-1272) Flurbiprofen was more effective than placebo in conjunction with bier block manipulation and for post manipulation pain.(1272) Piroxicam was more effective than paracetamol,(1270) and diflunisal was equally effective as mefenamic acid. No changes in Gartland and Werley functional assessment scores(1272) or functional recovery in post menopausal women(1270) were found, indicating there is no significant benefit other than pain relief from the use of NSAIDS.

Evidence for the Use of NSAIDs for Distal Forearm Fractures
There are 4 moderate-quality RCTs or prospective studies incorporated into this analysis.(1344-1347) (Thomas 86)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: anti-inflammatory agents, non-steroidal, NSAIDS, non-steroidal anti-inflammatory, ibuprofen, acetaminophen, distal, forearm, radial, radius, fractures, bone fractures, Colles' fracture; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 13 articles in PubMed, 25 in Scopus, 0 in CINAHL, 18 in Cochrane Library, 5,993 in Google Scholar, and 3 from other sources. We considered for inclusion 4 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 0 from Google Scholar, and 0 from other sources. Of the 4 articles considered for inclusion, 4 randomized trials and 0 systematic studies met the inclusion criteria.

Author/Year Study Type Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Davis 1988 Prospective study	7.0	N = 100 (gender not specified) with Colles' fractures.	Group 1, 50mg flurbiprofen (f) (n = 53) vs. Group 2 or placebo (p) randomized after dividing into group 1 (displaced fracture	Mean grip strength (mmHg) Group1 f/p: Week 2: 59/53, Week 6: 92/93, 1 year: 192/189. Mean grip strength (mmHg) Group 2 f/p: Week 2: 88/82, Week 6: 112/149, 1 year: 195/207. One-year	"[F]lurbiprofen provides significant pain relief and does not significantly delay union of Colles' fractures."	Data suggest efficacy without delaying union.

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		Average age for groups I and II; 55.7 and 64.1.	requiring Bier's block and manipulative reduction) or group 2, no reduction (n = 45).	assessment results (percentages) Group 1 f/p: patients who needed physiotherapy 11(45)/7(35), patients with residual pain 10(40/9(45), patients with restricted activities 10(40)/7(35). 1-year assessment results (percentages) Group 2 f/p: who needed physiotherapy 5(27)/2(12), patients with residual pain 9(50)/3(19), patients with restricted activities 6(33)/2(12). Garland and Werley's functional assessment, 1 year, Group 1 excellent or good/total: f 19/24, p 18/20. Group 2 f 17/18, p 16/16.		
Adolphson 1993 RCT Sponsored by a grant from Pfizer AB. No mention of COI.	6.0	N = 42 (42 female). Mean age and range 63 (52-79).	20mg a day per os piroxicam (Feldene®) for 8 weeks after initial 48 hours vs. 500mg paracetamol as rescue drug.	7% mean decrease in bone mineral content in radius after 8 weeks for piroxicam; 10% decrease in control (p = NS). Pain piroxicam/ placebo 10 days: 2.1/3.1, 4 weeks 1.0/2.5, 8 weeks 1.0/0.9 (p <0.05). Grip Strength piroxicam/ placebo 10 days/4 weeks 10/6, 8 weeks 32/26 (p = NS).	"The patients who received piroxicam had significantly less pain during plaster treatment, but there was no difference in the rate of functional recovery between the groups."	Study population limited to post-menopausal women affecting generalizability of results.
Thomas 1986 RCT No mention of sponsorship or COI.	5.0	N = 55 (21 males, 34 females) with fracture of distal end of radius, parallel to the wrist join and with a tendency to dorsal displacement, treated in the normal way with no external skeletal fixation, fracture splinted in below-elbow plaster cast for between 4 to 6 weeks; mean age of both	Normal treatment of fracture plus receiving three 50 mg tablets of diclofenac, a prostaglandin inhibitor, a day for seven days (N = 29, Men = 10, Women = 19) vs Normal treatment of fracture plus receiving three 50 mg placebo tablets a day for seven days (N = 26, Men = 11, Women = 15). Follow-up at two weeks after removel of cast	Comparison of loss of total range of movement between diclofenac vs. placebo groups – Student's t test (0.05 < P < 0.1), Patients' perception of pain between diclofenac vs. placebo groups – ratings from none (11 vs 6), improved (15 vs 17), no change (2 vs 2), worse (1 vs 1) – Chi squared (X2 = 1.44, 0.05 < P < 0.1), Patients' perception of stiffness between diclofenac vs. placebo groups – none (12 vs 3), improved (13 vs 20), no change (4 vs 3), worse (0 vs 0) – Chi squared (X2 = 6.88, 0.05 < P < 0.1) Comparison between diclofenac vs placebo groups on percentage loss of grip strength (Mann – Whitney U test, 0.02 < P < 0.05)	"Both subjective and objective tests of recovery at 2 weeks after removal of splintage following fractures of the distal end of the radius showed that those patients treated with a prostaglandin inhibitor recovered better than those who received placebo. This form of treatment may prove most valuable in patients who might otherwise be slow to recover or in whom a rapid recovery is especially desirable."	Data suggest prostaglandin groups had improved ROM, a more rapid recovery stronger grip and less pain.

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		groups = 55 [no mean average listed for entire study population].				
Barrington 1980 RCT Trials drugs were provided by the Pharmacy at the Royal Infirmary. No mention of COI.	4.5	N = 52 (47 female, 5 male) with pain due to Colles' fracture Mean age of 62.7 years.	5 days of either 500mg diflunisal (Dolobid®) BID or 500mg mefenamic acid (Ponstel®) TID.	"Both treatments were effective in relieving pain, night pain, and limitation of movement by pain, and there was no significant difference between the response in the two groups."	"No statistical significant differences in the effectiveness or tolerability between the two drugs." Authors suggest twice daily dosage may be regarded as an advantage for diflunisal treatment helping to ensure patient compliance.	Blinding mode unclear. Data suggest comparable efficacy.

Initial Care

Non-Displaced Distal Radial Fracture

1. *Recommendation: Immobilization Period of Three or Less Weeks (Early Mobilization) for Non-displaced or Minimally Displaced Distal Radius Fractures*
   Immobilization of non-displaced or minimally displaced distal forearm fractures limited to 3 weeks is moderately recommended and has equivalent or superior functional outcomes than periods greater than 3 weeks for non-displaced or minimally displaced distal radius fracture.

   Strength of Evidence – **Moderately Recommended, Evidence (B)**
   Level of Confidence – Moderate

Rationale for Recommendation
Six moderate-quality studies(1273-1278) support limiting immobilization of non-displaced or minimally displaced non-articular fractures of the distal radius to a period of 3 weeks or less. The clinical definition of minimally displaced fractures, however, is not established by quality evidence, as the available literature lacks a consistent standardized fracture classification, such as Frykman's or the AO classification systems. In general, the inclusion and exclusion criteria for entry into interventional studies reviewed in this Guideline may act as a defacto guideline, defining minimally displaced as fractures with less than 10° of dorsal angulation, less than 10° of radial angulation, and less than 2 to 3mm of radial shortening.(106, 1274, 1279-1281)

In each study comparing immobilization of 3 or 5 weeks, patients demonstrated either improved functional measures such as pain scores(1274) wrist swelling, wrist and grip strength, and better subjective patient assessments with shorter immobilization periods, or no measurable differences between the groups indicating there is no advantage to longer immobilization periods. There were no differences in radiographic findings in any of the studies associated with duration of immobilization.(1273, 1275) There is no quality evidence supporting immobilization for periods greater than 3 weeks in these cases. Although there is one low-quality study that suggests equivalent functional results are achieved with fewer cases of complex regional pain syndrome (1 vs. 5),(106) there is insufficient evidence to support 1-week immobilization.

2. *Recommendation: Use of Functional Brace or Splint over Traditional Casting for Non-displaced or Minimally Displaced Distal Radius Fractures*

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The use of functional bracing or splinting that will allow mobilization of the radial-carpal joint while maintaining stabilization of the fracture is moderately recommended over traditional casting to immobilize the forearm and wrist for non-displaced or minimally displaced Colles' fractures.

Strength of Evidence – **Moderately Recommended, Evidence (B)**
Level of Confidence – Moderate

Rationale for Recommendation
There are multiple moderate-quality studies providing moderate evidence in support of functional bracing or splinting over traditional casting for non-displaced or minimally displaced fractures of the distal radius.(1274, 1275, 1282-1285) Functional bracing or splinting techniques described allow for mobilization at the radiocarpal joint. Various splinting techniques have been described, including the use of the lightweight removable splints,(1285) posterior splint with tubigrip,(1274) crépe bandage,(1275) elastic bandage,(1282) triple point loading brace with adjustable Velcro straps,(1284) and 3-point loading functional plaster brace.(1283)

As there are no direct comparisons between types of functional bracing, no specific recommendation can be made as to which if any technique is superior. The importance of early radiocarpal joint mobilization appears to be most important factor. Improved functional outcome through early mobilization may be a surrogate or confounder to the recommendation for shorter durations (3-week period) of immobilization, which essentially achieves the same objective of reducing immobilization of the radiocarpal joint. The literature is unclear if there might be an additive effect for functional bracing combined with immobilization of the fracture for 3 weeks or less, as functional bracing was compared to traditional casting of 4 to 6 weeks duration.

3. *Recommendation: Casting/Bracing Non-displaced or Minimally Displaced Colles' Fractures in Pronation or Supination*
   There is no recommendation for or against casting/bracing the forearm and wrist in pronation or supination for non-displaced or minimally displaced Colles' fractures.

   Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**
   Level of Confidence – Low

Rationale for Recommendation
There are two moderate-quality studies on cast positioning of the forearm and hand, either supination or pronation, and functional outcomes. One study found no advantage to supination over conventional Colles' casting;(1286) the other found forearm casting in pronation superior to above-elbow supination.(1287) As both techniques were last reported on more than 20 years ago, and with more recent evidence indicating that functional splinting is more effective casting, no recommendation is made regarding casting in pronation or supination in patients with non-displaced Colles' fractures, although pronation is likely superior to supination if casting is attempted. Casting the forearm and wrist in pronation may provide benefit over casting in supination, although neither is recommended if functional bracing or splinting is an available treatment option.

Evidence for Immobilization/Fixation for Non-displaced Colles' Fracture
There are 26 moderate-quality RCTs and 1 prospective study incorporated into this analysis.(106, 1239, 1348-1352, 1357-1361, 1363-1377) (Tumia 03; Bunger 84; Arora 11; Wik 09; Bong 06; Sarmiemto 80; Gupta 91; Rosetzsky 82; Wahlstrom 82; Uzzaman 08; Ismatullah 12) There are2 low-quality RCT in Appendix 1.(1375, 1378) (Gupta 11)

Early Immobilization:
A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Early Immobilization & Mobilization & Colles' Fracture Or Distal Radial Fracture; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 76 articles

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in PubMed, 30 in Scopus, 8 in CINAHL, 12,970 in Google Scholar, 18 in Cochrane Library, and 0 from other sources. We considered for inclusion 5 from PubMed, 5 from Scopus, 3 from CINAHL, 1 from Cochrane Library, 3 from Google Scholar, and 0 from other sources. Of the 17 articles considered for inclusion, 9 randomized trials and 8 systematic studies met the inclusion criteria.

Functional Bracing:
A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Functional Bracing & Casting, Distal Radial Fractures or Colles' Fracture; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed ? articles in PubMed, 4 in Scopus, 1 in CINAHL, 5 in Cochrane Library, 11,230 in Google Scholar, and 0 from other sources. We considered for inclusion 4 from PubMed, 1 from Scopus, 1 from CINAHL, 0 from Cochrane Library, 1 from Google Scholar, and 0 from other sources. Of the 7 articles considered for inclusion, 6 randomized trials and 1 systematic studies met the inclusion criteria.

Casting:
A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Casting and Bracing and Colles' Fractures Or distal Radial Fractures; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed ? articles in PubMed, 35 in Scopus, 7 in CINAHL, 14 in Cochrane Library, 8830 in Google Scholar, and 0 from other sources. We considered for inclusion ? from PubMed, 17 from Scopus, 1 from CINAHL, 0 from Cochrane Library, 4 from Google Scholar, and 0 from other sources. Of the 22 articles considered for inclusion, 18 randomized trials and 4 systematic studies met the inclusion criteria.

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Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Functional Bracing						
Moir 1995 RCT No mention of sponsorship or COI.	6.5	N = 85 (70 females/9 males) individuals with distal Colles' fracture; Median age. Group 1: 55 (22-86) Group 2: 60 (21-84)	Functional brace vs. control (dorsal plaster splint for 2 weeks followed by casting). Follow up at 10-14 days, 5-6 weeks, and 8, 13, and 26 weeks.	Functional score results; brace vs. control (lower score is better): 8 weeks 10 vs. 14 (p = 0.02); 13 weeks 4 vs. 11 (p = 0.003); 26 weeks 2 vs. 5 (p = 0.02). Grip strength as % of uninjured side: 8 weeks 50 vs. 35 (p = 0.0006); 26 weeks, 73 vs. 71 (p = 0.6). Analogue pain score (0-10); median: Splint removal 1 vs. 2 (p = 0.02); 8 weeks 1 vs. 2 (p = 0.048)	"The brace gave better functional results than conventional plaster treatment. The improved function was apparent up to 6 months after injury. Finger function and pinch strength were also better in the brace-treated patients. Anatomical results were similar in the two groups."	The brace-treated fractures were initially less severely displaced than control fractures. "The improved functional results, particularly in terms of pinch and grip strength, are particularly important in the group of elderly patients who live alone."
Stewart 1984 RCT No mention of sponsorship and COI.	5.0	N = 243 (No mention of Gender) patients with fractures of the distal radius; No mention of Mean age.	Conventional Colles' plaster vs. (Sarmiento) supinated cast-brace vs. below elbow cast-brace. Follow-Up at 6 weeks, and 3, 6 months.	Anatomical assessment excellent or good/total: plaster 45/93; supinated brace 43/70; short brace 43/72. Functional results mean score at 3 months/6 months: plaster 10.0/6.3; supinated brace 9.5/6.7; short brace 10.7/6.9. Incidence of carpal tunnel compression symptoms was 17% at 3 months and 12% at 6 months. No statistical significance between groups for incidence of symptoms.	"Early hand function and the supinated position advocated by Sarmiento were found to confer no anatomical or functional advantage; we could see no reason to change from the use of conventional plaster casts in the treatment of uncomplicated Colles' fractures."	Author suggests 4 indications for use of below-elbow cast brace: request by patient for complete freedom of movement of fingers and thumb; pre-existing finger stiffness or painful arthritis of carpometacarpal joint of thumb; the possibility that patient may develop Sudeck's osteodystrophy; and to all direct access to the hand for dressings in patients with soft-tissue injuries.
Tumia 2003 RCT No mention of sponsorship. One or more of the authors will received or have received benefits for	5.0	N = 339 (31 male and 139 female) categorized into minimally displaced and displaced requiring manipulation groups. Mean age of 58.4 years.	Conventional Colles' plaster cast (N = 163) vs Prefabricated functional brace or the Aberdeen Colles' fracture brace (N = 166). Follow-up for 14 weeks.	Functional scores cast/brace non-manipulated group Week 8: 6.7/5.5; Week 24: 2.6/2.7 manipulated group Week 8: 11.4/10.6; Week 24: 5.4/5.8. Mean pain score cast/brace non-manipulated group 10 d: 2.2/2.4 p = 0.27; Week 24: 1.0/1.0 p = 0.96; manipulated group 10 d: 1.8/2.1 p = 0.19; Week 24: 0.5/0.5 p = 0.043.	"There was no significant difference in the functional outcome between the two treatment groups."	Author comment on younger patients having better functional results not presented in body of study results. There appears to be no advantage to flexible brace over cast.

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personal or profession use from commercial party related directly or indirectly to the subject of this article.						
Bünger 1984 RCT Sponsored by the Danish Medical Research Council grant, and the Medical Research Council for the countries of Sonderjylland, Ribe and Ringkbing grant. No mention of COI.	4.5	N = 145 (20 male and 125 female) with Colles' fracture. Age not given.	Functional bracing in supination or FUSU (N = 68) vs Dorsal Plaster Immobilization orDPI (N = 77). Follow-up after 7 weeks and 3 months.	Primary treatment; DPI vs. FUSU: Anatomic end results (excellent/good)/total 65/72 vs. 59/64 (p <0.05). Functional results at 6 months (excellent/good)/total 62/72 vs. 59/62 (p <0.5)	"Functional bracing in supination provided superior results in the treatment of particularly displaced intra-articular Colles' fracture."	Suggests the functional benefit from FUSU is primarily secondary to decreased fracture redislocation.
Abbaszadegan 1989 RCT No mention of sponsorship or COI.	4.0	N = 80 (No mention of gender)"un-displaced or min-imally displaced Colles' fractures"; No mention of mean age.	4 weeks in dorsal plaster cast vs. an elastic bandage. Follow up at 10-12 days. 1, 2, 3, and 6 months.	Follow up time: pain plaster cast/elastic bandage 11 d 4.7/4.0 (p = 0.09), 8 wk 3.2/1.8 (p ≤0.001), 1 year 1.9/1.3 (p = 0.06). Strength plaster/elastic 1 year 78/94 (p = 0.045). Lidstrom grading 1 year: plaster/total, elastic/total, Excellent 23/34, 31/34; Good 9/34, 3/34; Fair 2/34, 0/34. P <0.05	"Elastic bandage treatment resulted in less pain, improved grip strength and better subjective satisfaction at one year. It did not result in increased fracture displacement when compared to conventional plaster splints. Functional treatment of the minimally displaced	Applicable to non or minimally displaced fractures in mostly female population with mean age of 62 (19-81)

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					Colles' fracture is recommended."	
Early Immobilization						
Christensen 1995 RCT No mention of sponsorship or COI.	5.5	N = 33 patients with undisplaced fractures of the distal radius; Mean Age 3 wk group : 61 (29-78). 5 wk group: 64 (40-84).	Immobilizing plaster splints at either 3 or 5 weeks for undisplaced fractures. Follow Up for 3 months and 9 months.	Differences in modified median Gartland and Werley scores at 3, 9 months insignificant (3 weeks/5 weeks): Score-3 months 2.0/3-0; Score: 9 months 1.0/1.0.	No difference in "radiological healing at 3 months or in the functional scores after 3 and 9 months."	Early mobilization at 3 weeks appears to have no negative or positive impact on nondisplaced fractures.
Davis 1987 RCT No mention of sponsorship or COI.	5.0	N = 55 (11 males/44 females) patients with slightly displaced fractures of the distal radius; Mean age, Group 1: 56.6 Group 2: 55.6	After 2-week period of posterior splinting, patients randomized to tubigrip vs. below elbow cast for 3 additional weeks. Follow-up at 2, 5, and 7 weeks.	No significant difference of pain between groups. Gartland and Werley's functional assessment (excellent or good) total: Week 5 cast 11/25; Week 5 tubigrip (tg) 23/27 p <0.05; Wk 7 cast 22/25 p <0.01, p <0.05; Week 7 tg 25/27 p <0.01. Complications of treatment cast/tg: Fracture displaced 3/2; Physiotherapy needed 3/1.	"Unnecessary to splint slightly displaced fracture of the distal radial metaphysis for 4 weeks… a faster functional recovery will be obtained [if fractures are in an unrestrained tubigrip support] in a manner that had been shown to be acceptable to most patients."	No blinding in this study.
Dias 1987 RCT No mention of sponsorship or COI.	5.0	N = 187 (no mention of gender) patients with unilateral Colles' fractures that were older than 55; No mean age.	Undisplaced fractures treated either with conventional 5 weeks cast (Group 1) or crêpe bandage (Group 2) and early mobilization. Displaced fractures were treated either with conventional 5 week cast (Group 3) or modified 5 week cast (Group 4). Follow-Up at weeks 1, 5, 9, and 13.	Early mobilization more resolution of wrist swelling first 5 weeks. At 9 and 13 weeks, wrist girth was similar. Deterioration rate of radiological deformity was similar in conventionally treated groups as with mobilization groups. Grip strength recovery expressed as a percentage of strength of contralateral hand much better in early mobilization groups. Undisplaced fractures Group 1/Group 2: Week 5 36.1/45.7 p <0.001; Week 9 51.7/63.5 p <0.005; Week 13 58.3/76.2 p <0.001.	"Early wrist movement hastened functional recovery and led to earlier resolution of wrist swelling. Discomfort was no greater than in patients who were treated conventionally. The bony deformity, which recurred irrespective of the method of treatment, was not adversely affected by early mobilization."	This study includes weaknesses in randomization and baseline comparability.

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				Displaced fractures Group 3/Group 4: Week 5 25.0/33.4 p = 0.016; Week 9 44.0/48.8 p = 0.215; Week 13 60.1/62.7 p = 0.540.		
Arora 2011 RCT No sponsorship or COI.	4.5	N = 73 (18 male and 55 female) with distal radial fracture; mean age 76.7 (65-89).	Group 1, operative group that underwent Open reduction and internal fixation (ORIF) 12 weeks after injury (N = 36) vs Group 2, immobilized in short arm cast for 5 weeks (N = 37). Follow-up at baseline, 6, 12 weeks, 6 and 12 months.	Disabilities of the Arm, Shoulder and Hand Score (DASH) at 6 weeks group 1 vs 2; 18.8±17.9 vs 34.4±22.5 (p = 0.00). At 12 weeks; 13.3±14.8 vs 23.2±19.3 (p = 0.02). Patient-Rated Wrist Evaluation (PRWE) group 1 vs 2, at 6 weeks; 36.4±28.7 vs 64.9±29.0 (p = 0.00), at 12 weeks; 33.7±32.0 vs 54.4±31.8 (p = 0.01). Grip Strength (kg) group 1 vs 2, 6 weeks; 14.1±10.7±5.6 (p = 0.01). At 12 weeks; 15.7±6.2 vs 2.5±4.4 (p = 0.02). At 6 months; 19.8±7.4 vs. 16.1±5.6 (p=0.02). At 12 months; 22.2±6.3 vs 18.8±5.8 (p = 0.02). Significantly more complications in operative group, 13 vs 5 (p<0.05).	"[H]owever, at twelve months after surgery, the active range of motion, the pain level, and the PRWE and the DASH scores were not different between the operative and nonoperative treatment groups."	Data suggest at 12 months, ROM, pain level and PRWE and DASH scores equivalent. Patients in surgical group reported better grip strength throughout trial.
McAuliffe 1987 Prospective RCT No mention of sponsorship or COI.	4.5	N = 108 (All Women) who had a Colles' fractures.	Plaster immobilization for 3 (Group A) or 5 (Group B) weeks. Follow Up baseline, 3 months, and 1 year.	72% of Group A reported good or excellent results relating to pain, disability, and range of movement at 3 months while 66% of Group B did; after 1 year 85% of Group A had a good or excellent result and 77 % did in Group B. Group A showed statistical significance for pronation after 1 year, less pain at time of plaster removal, 3 months and 1-year follow up as well as stronger grip strength after 1 year.	"Early mobilization produced less pain and a stronger grip. It did not lead to any greater loss of reduction of the fracture. However, there was no significant improvement in the final range of movement of the wrist."	In this elderly population, mobilization after 3 weeks may lead to less short-term disability.
Millet 1995	4.0	N = 90 female with unilateral Colles' fracture;	5 week below elbow plaster cast (N = 45)	All patients in early mobilization reported greater comfort after switching from	"Early mobilization is a satisfactory treatment option for Colles' fracture	No significant clinical differences found between the treatment groups.

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Prospective Study No mention of sponsorship or COI.		Mean age of 61 years.	vs 3 week plaster cast with 2 week flexible cast. Displaced fractures in both groups were manipulated. (N = 45). Patients followed for 3 years.	plaster to flexible casting. Mean grip scores and joint mobilities higher at all time points with early mobilization, reaching levels of statistical significance at 6, ($p < 0.01$) months for grip score and 3 months for joint mobility, ($p = 0.04$).	and may, in fact, hasten functional recovery."	
Stoffelen 1998 RCT No mention of sponsorship or COI.	4.0	N = 52	Plaster immobilization for 1 week vs. plaster immobilization for 3 weeks in minimally displaced fractures.	Functional Cooney score; 1 week (SD) vs. 3 weeks (SD): 6 weeks 61.6 (12.1) vs. 56.8 (19.7) 3 months 77.4 (13.8) vs. 71.5 (19.2); 1 year 86.8 (10.9) vs. 82.2 (18.6). One-week group Cooney score generally higher at every re-evaluation period than 3-week plaster group. Differences, however, not statistically significant.	"No dislocations occurred. All patients experienced eventful healing with good or excellent results in 92% of cases. We believe, therefore, that only minimal immobilization is required in these fractures and that they should be mobilized as soon as comfort allows."	Higher number of complex regional pain syndrome (CRPS) cases in 3-week group than 1-week group (5 vs.1).
Casting/Bracing						
Wong 2010 Prospective RCT No mention of sponsorship or COI.	6.5	N=60 (Predominately female) elderly Chinese people with dorsal angulated fracture of the distal radius; Mean Age Group 1 71 (65-76) Group 2 70 (66-76)	Group 1 (N=30) Patients given plaster of Paris cast preceded by closed reduction. Vs Group 2 (N=30) Patients were treated with K-Wire Follow up at 2 weeks prior to injury and then 1, 2, 4, 6 weeks, 3, 6 months and 1 year after assessment of radiographs.	No statistically significant differences between the K-Wire treatment and the plaster of Paris group.	"Although our study showed that the 'tripod technique' [K-Wire] is safe without significant complications, there is an Cochrane review of wiring for distal radial fractures… We do not provide a biomechanical rationale to explain our 'tripod technique' but we feel that it is a better construct to prevent collapse of the fracture/"	Data suggest casting alone not better than pinning for extra-articular fractures of the distal radius in elderly Chinese (predominantly female) patients.
O'Connor 2003 RCT	6.5	N = 66 (22 males/44 females) adult patients with minimally displaced radial fractures;	(N=32) Below-the-elbow plaster of Paris cast vs. (N=34) lightweight removable "Futuro" splint for minimally displaced Colles' fractures;	No significant differences in pain scores. Cast satisfaction higher in splint group at weeks 1, 2, and 6. No difference in anatomical outcome. Functional scores and wrist range of motion	"A lightweight splint provides an acceptable, comfortable and economic alternative to plaster of Paris and allows faster restoration of function without an	Patients in splint group were educated on rationale for splint use as authors found cultural bias toward the traditional cast.

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No mention of sponsorship or COI.		Mean Age, Group 1: 56.6 (16-81). Group 2: 57 (18-79)	Follow-up at 1, 2, 6, and 12 weeks.	were better at 6 weeks, but the differences disappeared at 12 weeks.	increased risk of malunion."	
Ledingham 1991 RCT No Mention of sponsorship or COI.	5.5	N = 60 (50 females/10 males); Mean Age-Group 1: 60.2. Group 2: 61.3.	(N=30) Plaster-of-Paris functional brace (brace) vs. (N=30) Standard below-elbow cast (control). Follow-Up at baseline, 24 hrs, 7-14 days, and 35-42 days.	Final radiological result; Brace vs. Control: Overall, brace group had better radiological results than control (lower score better) mean score 2.5 vs. 4.3 (p <0.05). No significant differences between <60-years-old brace and control or between brace under and over 60 years old. Significant difference in controls vs. under 60 years (12.7 vs. 4.4, p <0.005). Functional grading results (Excellent + Good) using modified Gartland and Werley significant difference of brace vs. control at 12 weeks, but not at 26 weeks.	"With the Plaster-of-Paris brace described in this paper, we have shown improved final radiological and early functional results compared to the standard below-elbow cast."	Authors demonstrated in radiographic and functional grading that patients over 60 years old may benefit the most, although sample sizes were small.
Grafstein 2010 RCT Sponsored through an unrestricted grant in aid from Smith & Nephew, manufacturers of both the splint and cast material used in this study. No COIs.	4.5	N = 101 (78 females/23 Males) with a displaced fracture of the distal radius requiring closed reduction.	Circumferential casting or CC (N = 40) vs Volar–dorsal splinting or VDS (N = 31) vs Modified sugar-tong splinting or MST (N = 30). Follow-up at 8 weeks and 6 months.	Median pain scores were not statistically different between the groups. 22 patients (22%, 95% CI: 13.9%–30.1%) had radiographic loss of reduction: VDS= 5 patients (16%, 95% CI 3.1%-28.9%), CC= 8 patients (20%, 95% CI: 7.6%–32.4%), and MST= 9 patients (30%, 95% CI: 13.6%–46.4%) (p = 0.17).	"Rates of loss in anatomic position were not statistically significant among the 3 types of dressings used. However, there was a clinically important trend of increased loss of reduction with the use of MST splinting."	Sparse methods. Data suggest all three immobilization methods comparable as there was no statistically significant difference between groups.

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Moroni 2004 RCT No mention of sponsorship or COI.	4.0	N=40 (All female) Osteoporotic patients who are 65 years of age or older; Mean Age >65 years old	Group 1 (N=??) Patients who received plaster cast eith closed reduction. Vs Group 2 (N=??) Received external fixation Follow up at 2 weeks, 6 weeks, and 3 months.	Redisplacements Group 1 vs Group 2; 4 vs 0. Volar Angle at post opgroup 1 vs group 2; 8.6±5.8 vs 3.4±1.8. At 6 weeks; -1.9±9.4 vs 1.9 ±3.4 (p<0.0005). Radials Angle at post op, group 1 vs 2; 20.6±4.9 vs 23.5±3.5. At 6 weeks, 17.1±6.3 vs 23.3±3.5 (p=0.008). Horesh Demerit Point Score at 3 months, Group 1 vs Group 1; 7.7±3.3 vs 6.6±3.4 (p<0.006).	"In conclusion, our study supports the use of external fixation in the treatment of osteoporotic wrist fractures. Both radiographic and clinical results were better in the external fixation group than in the plaster cast group."	Study of elderly females with osteoporotic wrist fractures. Data suggest that external fixation is superior to casting as both the volar angle deformities and radial angle deformities were lowered.
Cohen 1997 Prospective RCT No mention of sponsorship or COI.	4.0	N=30 (22 females/8 female) who had varying degrees of Radial distal fractures; Mean Age Group 1 56 (33-89) Group 2 58 (19-86)	Group 1 (N=10) Non displaced fractures, 5 fiberglass tape, 5 QuickCast tape. Vs Group 2 (N=10) (Displaced but stable after reduction fractures) 5 in QuickCast, 5 with fiberglass tape. Vs Group 3 (N=10) (Displaced fractures requiring Pin fixation) 5 with quick cast, 5 with fiberglass. Follow up at cast removal 5.5 weeks to 6.5 weeks	Number of cast Applications, Group 1, 2, and 3, Fiberglass vs QuickCast: Group 1; 2.2 vs 1.2, Group 2; 2.2 vs 1.0, Group 3; 3.0 vs 2.0. (p<0.001). Problems with cast answer (1-10) Fiberglass vs Quickcast: 1.0±0.8 vs 0.5±0.4 (p<0.001). Some cast complications within both groups, not significant.	"In sum, a short-arm cast constructed of the Quick-Cast does save approximately on cast change in the treatment of distal radius fractures with no apparent effect on fracture healing. The QuickCast does, however, cost more in materials alone. This financial differential must be weighed against the labor saved of a single cast application with additional savings of time for he applier and patient."	Small sample size, sparse methods. Data suggest Quick Cast eliminates approximately one cast change without compromise of fracture healing but Quick Cast is more costly.
Cohen 2001 RCT No mention of sponsorship or COI.	4.0	N=200 (No mention of gender) patients who sustained arm or leg injuries required cast support (N=29 individuals with Radial Distal fracture);	Group 1 (N=14) patients with Forced Rigidity Casting (FRC) Vs Group 2 (N=15) patients treated with Complete Plaster of Paris synthetic cast (Standard)	Increase in Ability FRC vs Standard: favored group 1 (p=0.0002). Satisfaction better in FRC group (p=0.00009).	"The technique of focused rigidity casting can be recommended in the treatment of fractures of the fifth metatarsal and distal radius in preference to standard casts. Focused rigidity casting provides greater ability in the cast and patient satisfaction	Data suggest increased patient satisfaction with FRC vs. conventional plaster of Paris cast with comparable efficacy.

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		Mean Age (no Mention?)	Follow-Up while in the cast and after cast removal. No specific time frame stated.		during treatment without loss of clinical effectiveness."	
Wik 2009 RCT No mention of industry sponsorship. The authors declare no COI.	4.0	(N=72) (all women) over the age of 50 who sustained low-energy trauma and a displaced Colles' fractures initially considered suitable for closed reduction and immobilization in a plaster cast.	Reduction and a complete plaster cast (N=34) v. reduction and a dorsal plaster splint (N=38). Immobilization for 5 weeks with follow-up at 1 and 10 days and 5 weeks after reduction.	Mean dorsal angulation 10 days after reduction: slightly better in the dorsal plaster splint group, p=0.04. Radial length at 5 weeks was better in the complete plaster group, p=0.02.	"[S]urgeons caring for such cases may choose the immobilization method for the first 10 days following reduction according to their individual preferences and those of the injured person."	Data suggest dorsal splinting 10 days after Colles' fracture reductions resulted in a mean difference of n3.4 degrees of dorsal angulation but at 5 weeks, casting was better for a difference of 1.6 mm of radial length. Pain ratings between the two methods were comparable.
Bong 2006 Prospective RCT No sponsorship or COI.	4.0	N = 85 (85 fractures, 26 male and 59 female) who were used had acquired a displaced distal radial fracture; mean age 64 (27-91).	Group 1 immobilized using short-arm radial gutter splint (N = 38) vs Group 2 immobilized with sugar tong splint. Follow-up 7-10 days after initial injury (N = 47). Radiographs taken in respective splint.	No significant difference between loss of fracture reduction, volar tilt, radial height, radial inclination. Disabilities of the ARM, Shoulder, and Hand (DASH) scores, Group 1 vs group 1 at 1 week; 62±19 vs 70±15 (p=0.044).	"Based on our study we recommend that surgeons consider using a short-arm radial gutter splint for the initial immobilization of displaced distal radius fractures."	Sparse baseline comparability details. Data suggest both long and short arm splints are effective in maintaining the reduction of distal radius fractures but the short arm splint was preferred by patients.
Sarmiemto 1980 RCT No mention of sponsorship or COI.	4.0	N = 156 (50 male and 106 female) with Colles' fractures. A median age of 49 years.	Bracing in either pronation, fractures were immobilized in a long-arm cast with the wrist at 20" of volar flexion and ulnar deviation; the elbow at 90" of flexion and the forearm in either pronation (N = 78) vs Supination the elbow at 90" of flexion and the forearm in supination	In the Type II category, in the supinated fractures, there were 9 excellent, 4 good and no fair or poor results; in the pronated group, 9 excellent, 8 good and 1 fair result. In combining the results for all types of braced Colles' fractures, (I-IV) 93% of the supination group and 87% of the pronation group achieved excellent or good functional results.	"Treatment with functional bracing in supination position yielded 90% excellent or good functional results."	This paper is quoted in most subsequent research pertaining to bracing.

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			(N = 78). Follow-up for 15 weeks.			
Gupta 1991 RCT No sponsorship. No mention of COI.	4.0	N = 204 (82 male and 122 female) with displaced Colles' fractures. Mean age 46 years.	Plaster immobilization with either: Palmar flexion or PF (N = 60 vs Neutral or NP (N = 75) vs Dorsiflexion or DF wrist position (N = 69). Follow-up for 15 months.	Functional results excellent or good/total: Type III PF 20/28; NP 26/34; DF 28/32 Type IV PF 10/17; NP 8/19; DF 15/17; Type V PF 9/15; NP 13/22; DF 16/20	"After manipulation of a Colles' fracture, immobilization of the wrist in dorsiflexion would appear to provide better maintenance of reduction."	Immobilization of wrist in palmar flexion had detrimental effect on hand function.
Rosetzsky 1982 RCT No mention of sponsorship or COI.	4.0	N = 46 (15 male and 35 female) with Colles' fractures of the forearm. Mean age was 45 years.	Polyurethane casts (N = unknown) vs Traditional plaster-of-Paris braces (N = unknown). Follow-up at 6 weeks.	No significant difference for secondary adjustment of casts between groups, (p > 0.90). No significant differences for failure of retaining fracture reduction, (p > 0.50).	"Polyurethane braces are a good supplement to plaster-of-Paris bandage in such fractures and recommended in selected cases."	Alternative to plaster of Paris in 1980s.
Wahlström 1982 RCT No mention of sponsorship or COI.	4.0	N = 42 (all women) with extra articular fractures. Mean age 65 years.	Immobilization in pronation (N = 14) vs Supination (N = 12) vs Midway position (N = 16). Follow-up at 10 days and 1-4 months after reduction.	Five fractures had to be re-reduced, one from pronation, one from midway and three from supination group. Patients with redislocation ≥10° number pronation 2/14, midway 6/12, and supination 8/16.	"The position of the forearm during immobilization is of importance for the degree of redislocation."	Applicable to cast application rather than long-term functional results.
Uzzaman 2008 RCT No mention of industry sponsorship or COI.	4.0	(N=40) (19 females/11 males) patients with displaced Colles fracture at the emergency of outpatient department	Closed reduction and two crossed percutaneous Kirschner wire fixation combined with plaster cast support (Arm A, N=20) v. conventional method-reduction by closed manipulation and maintained by plaster cast immobilization (Arm B,	Anatomic end result of Arm A was better than Arm B, p<0.05. There was a significant Satisfactory result in Arm A compared Arm B, p<0.05.	"Closed reduction and Percutaneous kirschner wire fixation combined with plaster cast immobilization is better method than the conventional plaster cast immobilization – in restoration of preinjury anatomical alignment	Data suggest percutaneous fixation group superior to cast alone group for maintaining radial length and angulation resulting in better function and also had less reported complications.

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		within 7 days of injury.	N=20). Plaster was removed at week 6. K-wires were removed at 6-8 weeks. Rehabilitation was recommended until near or full functional recovery. Follow period was 6-14 months.		and there by the functional outcome – in the management of colles' fracture."	
Ismatullah 2012 Prospective RCT No mention of sponsorship or COI.	4.0	(N=30, 13 males/17 females) adult patients with a comminuted distal radius fracture; Mean Age 49.8 ±16.05	Group 1 (N=15) Treated with plaster casting. Vs. Group 2 (N=15) Treated with external fixation. Follow-Up at baseline and 12 weeks.	Green & O'Brien Criteria rankings, Group 1 v 2, 12 weeks; Group 1: 4 were excellent, 3 were good, 4 were fair, 4 were poor. Group 2: 5 were excellent, 6 good, 2 fair, and 2 poor.	"We recommend external fixation in comminuted fractures of the distal radius, which are potentially unstable fractures. It decreases the complications of re-displacement and shortening which may occur when these fractures are managed with closed reduction and casting."	Data suggest external fixation in comminuted dstal radius fractures better than casting.

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Displaced Distal Radial Fracture

Distal radial fractures with radiographic measurements of 10° or more of dorsal angulation, more than 2 mm of radial shortening or with any degree of radial shift require reduction to reduce the risk for deformity and disability. Closed reduction should result in no more than 5° of dorsal angulation and no more than 2mm of radial shortening. Unstable fractures are defined as fractures with bone loss or bone involvement that will not allow for structural integrity without the use of internal or external fixation of the bone. Examples include fractures with dorsal comminution or radial lateral shift of more than 2mm, have been proposed as limits for consideration of surgical intervention.(107, 108)

CLOSED REDUCTION TECHNIQUE

Recommendation: Closed Reduction Technique for Displaced Distal Radial Fractures

Manipulation and dynamic traction devices are recommended for closed reduction technique for displaced distal radial fractures as they have demonstrated equivalent ability to achieve initial reduction of injury.

Strength of Evidence – **Recommended, Evidence (C)**
Level of Confidence – Moderate

Rationale for Recommendation

For closed reduction, there is one high-quality and two moderate-quality studies comparing the effectiveness of manipulation and traction techniques for displaced Colles' fracture. There was no difference in immediate reduction results using Chinese finger dynamic traction devices compared to manipulation under anesthesia.(1279, 1293, 1294) Long-term outcomes also showed no differences in post reduction failures, as both methods have 25 to 29% loss of reduction with casting. It is likely the loss of reduction is unrelated to reduction technique, and rather more related to immobilization technique. In a group of elderly patients, there were no differences in functional outcomes or deformity between those that underwent manipulation and casting versus those that were non-reduced and casted if the degree of displacement had less than 30° of dorsal angulation and 5mm of radial shortening.(1295)

Despite non-superiority of reduction outcomes for manipulation or dynamic traction, one author in two papers reports lower rates of severe reduction pain and reduced long-term neurological deficits with dynamic traction (paresthesia, reduced 2-point discrimination) compared with manipulation under hematoma block.(1293, 1294) This author suggests the difference may have been related to the anesthetic technique rather than the reduction technique.

As noted earlier, the lack of a standard fracture classification system across each of these studies inhibits prognostic or treatment indications to be generalized. For these studies, Earnshaw used criteria of >10° of dorsal angulation, > 5 mm radial shortening, no marked comminution or displacement of articular surfaces. Kongsholm included mostly Frykman II, VI, VII, VIII fractures in the study, which may have included comminuted fractures, and those enrolled by Kelly included up to 5 mm of radial shortening and 30° of dorsal angulation.

Evidence for the Use of Closed Reduction Technique for Distal Radial Fractures

There are 4 moderate-quality RCTs incorporated into this analysis.(1279, 1293-1295)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: closed reduction technique, distal, forearm, radial, radius fractures, bone fractures, colles' fracture, displaced; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 14 articles in PubMed, 24 in Scopus, 13 in CINAHL, 0 in Cochrane Library, 19930 in Google Scholar, and 0 from other sources. We considered for inclusion 4 from PubMed, 0 from Scopus, CINAHL, Cochrane Library, Google Scholar, and from other sources. Of the 4 articles considered for inclusion, 4 randomized trials and 0 systematic studies met the inclusion criteria.

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Author/Year Study Type Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Earnshaw 2002 RCT No sponsorship or COI.	7.5	N = 225 (172 female/53 male) displaced Colles-type fractures.	Closed reduction with either finger-trap (n = 112) vs. Manual manipulation (n = 111).	87% of fractures were successfully reduced. "By five weeks, fifty-six (25%) of the 225 fractures had been treated with surgical intervention because of failed closed treatment and only sixty-five (29%) remained in a satisfactory position."	"The two methods of fracture reduction did not differ with regard to the eventual position of the fracture or the rate of failure."	All reductions performed post Bier's block. Loss of reduction during the period of cast immobilization is common in this study.
Kongsholm J Orthop Trauma 1987 RCT	5.5	N = 116 with acute displaced Colles' fracture	(Group A) dynamic reduction device with no anesthesia vs. (Group B) 8-10ml of 1% lidocaine with plaster cast.	2/62 patients in Group A displayed symptoms and signs of neurological impairment at 5 weeks compared to 11/54 patients in Group B, p <0.01. 1 year follow up resulted in figures of 4/62 and 8/54 with p <0.05.	"The dynamic reduction technique without local anesthesia results in a significantly lower frequency of neurological complication than manual reduction after injection of local anesthetic into the fracture hematoma."	The neurologic complications included subjective paresthesia, positive Tinel's sign or 2 point discrimination >4mm. Authors note "nerve damage" was mild and in no case in either group did it lead to surgical neurolysis.
Kelly 1997 RCT	5.0	N = 30	Reduction of the fracture under Bier's block then immobilized in dorsoradial plaster of Paris slab compared to plaster immobilization only in elderly population.	11/15 in Bier's block group and 9/15 in immobilization only group considered that their wrist was of normal appearance or had only slight deformity visible. Functional outcome Bier's block/ immobilization: Gartland and Werley score 5.8/6.6. Grip strength % predicted 48.8±17%/55.8±19%.	"There was no detectable difference between the groups in any of the outcome measures."	Study suggests reduction does not provide any benefit over risk of Bier's block to the elderly population within the parameters of 30° of dorsal angulation and 5mm of radial shortening.
Kongsholm Injury 1987 RCT	4.0	N = 116	(Group A) dynamic bone alignment device compared without anesthesia to (Group B) traditional manual reduction using local infiltration anesthesia	No differences between the groups in "no pain" or "slight pain." However, for severe pain Group B had 19 vs. 5 patients, p <0.001.	"Dynamic reduction without anesthesia seems to be a less painful method for the patients than traditional manual reduction under local anesthesia."	Study did not follow longitudinal results of reduction.

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CASTING OR FUNCTIONAL BRACING

Unlike casting for non-displaced and minimally displaced distal radial fractures, there are few studies comparing casting technique and functional bracing for displaced distal radial fractures and most of the available work was conducted more than 20 years ago. There is no defined standard for casting technique and forearm positioning that provides significant advantage over any other technique for displaced distal forearm fractures.

Recommendation: Use of Functional Brace or Splint over Traditional Casting for Displaced Distal Radial Fracture

There is no recommendation for or against the use of a functional brace or splint that will allow mobilization of the hand while maintaining stabilization of the reduced displaced distal radial fracture.

Strength of Evidence **– No Recommendation, Insufficient Evidence (I)**
Level of Confidence – Low

Rationale for Recommendation

There are few studies that compare specific casting or immobilization techniques. Rather, bracing and casting has been studied in the greater context of allowing hand functionality (functional brace) compared with traditional Colles' casting (elbow flexion, forearm pronation with ulnar deviation) as well as position of the wrist (palmar flexion, neutral, dorsiflexion) and forearm position (pronation, supination).(1277, 1296-1301) One moderate-quality study of 339 patients with non-specific displaced fractures showed no difference in casting versus functional bracing.(1300) Two moderate quality studies found bracing in the supine position may have advantages for intra-articular fractures,(1296, 1299) whereas bracing in pronation may provide advantage for extra-articular fracture.(1297) However, another moderate-quality study with 250 participants found no differences between hand and ulnar positioning.(1302) In several of these studies, the authors concluded results were related to displacement of original fracture and degree of successful reduction more than immobilization technique. Thus, there are insufficient data to recommend specific casting or immobilization techniques for displaced Colles' fractures.

Evidence for the Use of Casting/Functional Bracing for Displaced Forearm Fractures

There are 10 moderate-quality RCTs or prospective studies incorporated into this analysis.(1277, 1292, 1296-1301, 1303, 1304) There is 1 low-quality RCT in Appendix 2.(1302)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: casting or functional bracing, displaced distal radial fracture, distal, forearm, radial, radius fractures, bone fractures, colles' fracture; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 30 articles in PubMed, 13 in Scopus, 1 in CINAHL, 41 in Cochrane Library, 3174 in Google Scholar, and 7 from other sources. We considered for inclusion 4 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 0 from Google Scholar, and 7 from other sources. Of the 11 articles considered for inclusion, 11 randomized trials and 1 systematic studies met the inclusion criteria.

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Author/ Year Study Type (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Casting or Functional Bracing						
Tumia 2003 RCT No mention of sponsorship. One or more of the authors will received or have received benefits for personal or profession use from commercial party related directly or indirectly to the subject of this article.	5.0	N = 339 (31 male and 139 female) categorized into minimally displaced and displaced requiring manipulation groups. Mean age of 58.4 years.	Conventional Colles' plaster cast (N = 163) vs Prefabricated functional brace or the Aberdeen Colles' fracture brace (N = 166). Follow-up for 14 weeks.	Functional scores cast/brace non-manipulated group Week 8: 6.7/5.5; Week 24: 2.6/2.7 manipulated group Week 8: 11.4/10.6; Week 24: 5.4/5.8. Mean pain score cast/brace non-manipulated group 10 d: 2.2/2.4 p = 0.27; Week 24: 1.0/1.0 p = 0.96; manipulated group 10 d: 1.8/2.1 p = 0.19; Week 24: 0.5/0.5 p = 0.043.	"There was no significant difference in the functional outcome between the two treatment groups."	Author comment on younger patients having better functional results not presented in body of study results. There appears to be no advantage to flexible brace over cast.
Arora 2011 RCT No sponsorship or COI.	4.5	N = 73 (18 male and 55 female) with distal radial fracture; mean age 76.7 (65-89).	Group 1, operative group that underwent Open reduction and internal fixation (ORIF) 12 weeks after injury (N = 36) vs Group 2, immobilized in short arm cast for 5 weeks (N = 37). Follow-up at baseline, 6, 12 weeks, 6 and 12 months.	Disabilities of the Arm, Shoulder and Hand Score (DASH) at 6 weeks group 1 vs 2; 18.8±17.9 vs 34.4±22.5 (p = 0.00). At 12 weeks; 13.3±14.8 vs 23.2±19.3 (p = 0.02). Patient-Rated Wrist Evaluation (PRWE) group 1 vs 2, at 6 weeks; 36.4±28.7 vs 64.9±29.0 (p = 0.00), at 12 weeks; 33.7±32.0 vs 54.4±31.8 (p = 0.01). Grip Strength (kg) group 1 vs 2, 6 weeks; 14.1±10.7±5.6 (p = 0.01). At 12 weeks; 15.7±6.2 vs 2.5±4.4 (p = 0.02). At 6 months; 19.8±7.4 vs. 16.1±5.6 (p=0.02). At 12 months; 22.2±6.3 vs 18.8±5.8 (p = 0.02). Significantly more complications in operative group, 13 vs 5 (p<0.05).	"[H]owever, at twelve months after surgery, the active range of motion, the pain level, and the PRWE and the DASH scores were not different between the operative and nonoperative treatment groups."	Data suggest at 12 months, ROM, pain level and PRWE and DASH scores equivalent. Patients in surgical group reported better grip strength throughout trial.
Bünger 1984 RCT Sponsored by the Danish Medical Research Council	4.5	N = 145 (20 male and 125 female) with Colles' fracture. Age not given.	Functional bracing in supination or FUSU (N = 68) vs Dorsal Plaster Immobilization orDPI (N = 77).	Primary treatment; DPI vs. FUSU: Anatomic end results (excellent/good)/total 65/72 vs. 59/64 (p <0.05). Functional results at 6 months (excellent/good)/total 62/72 vs. 59/62 (p <0.5)	"Functional bracing in supination provided superior results in the treatment of particularly displaced intra-articular Colles' fracture."	Suggests the functional benefit from FUSU is primarily secondary to decreased fracture redislocation.

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grant, and the Medical Research Council for the countries of Sonderjylland, Ribe and Ringkbing grant. No mention of COI.			Follow-up after 7 weeks and 3 months.			
Wik 2009 RCT No mention of sponsorship. No COI.	4.0	N = 72 females who sustained low-energy trauma and displaced Colles' fractures initially suitable for closed reduction and immobilization in plaster cast. Age >50.	Reduction and a complete plaster cast (N = 34) vs Reduction and dorsal plaster splint (N = 38). Immobilization for 5 weeks with follow-up at 1 and 10 days and 5 weeks after reduction.	Mean dorsal angulation 10 days after reduction: slightly better in the dorsal plaster splint group, (p = 0.04). Radial length at 5 weeks was better in the complete plaster group, (p = 0.02).	"[S]urgeons caring for such cases may choose the immobilization method for the first 10 days following reduction according to their individual preferences and those of the injured person."	Data suggest dorsal splinting 10 days after Colles' fracture reductions resulted in a mean difference of n3.4 degrees of dorsal angulation but at 5 weeks, casting was better for a difference of 1.6 mm of radial length. Pain ratings between the two methods were comparable.
Bong 2006 Prospective RCT No sponsorship or COI.	4.0	N = 85 (85 fractures, 26 male and 59 female) who were used had acquired a displaced distal radial fracture; mean age 64 (27-91).	Group 1 immobilized using short-arm radial gutter splint (N = 38) vs Group 2 immobilized with sugar tong splint. Follow-up 7-10 days after initial injury (N = 47). Radiographs taken in respective splint.	No significant difference between loss of fracture reduction, volar tilt, radial height, radial inclination. Disabilities of the ARM, Shoulder, and Hand (DASH) scores, Group 1 vs group 1 at 1 week; 62±19 vs 70±15 (p=0.044).	"Based on our study we recommend that surgeons consider using a short-arm radial gutter splint for the initial immobilization of displaced distal radius fractures."	Sparse baseline comparability details. Data suggest both long and short arm splints are effective in maintaining the reduction of distal radius fractures but the short arm splint was preferred by patients.
Millet 1995 Prospective Study No mention of sponsorship or COI.	4.0	N = 90 female with unilateral Colles' fracture. Mean age of 61 years.	5 week below elbow plaster cast (N = 45) vs 3 week plaster cast with 2 week flexible cast. Displaced fractures in both groups were manipulated. (N = 45). Patients followed for 3 years.	All patients in early mobilization reported greater comfort after switching from plaster to flexible casting. Mean grip scores and joint mobilities higher at all time points with early mobilization, reaching levels of statistical significance at 6, (p < 0.01) months for grip score and 3 months for joint mobility, (p = 0.04).	"Early mobilization is a satisfactory treatment option for Colles' fracture and may, in fact, hasten functional recovery."	No significant clinical differences found between the treatment groups.
Rosetzsky 1982 RCT	4.0	N = 46 (15 male and 35 female) with Colles' fractures of the forearm.	Polyurethane casts (N = unknown) vs	No significant difference for secondary adjustment of casts between groups, (p > 0.90). No significant differences for failure of	"Polyurethane braces are a good supplement to plaster-of-Paris bandage in such	Alternative to plaster of Paris in 1980s.

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No mention of sponsorship or COI.		Mean age was 45 years.	Traditional plaster-of-Paris braces (N = unknown). Follow-up at 6 weeks.	retaining fracture reduction, (p > 0.50).	fractures and recommended in selected cases."	
Sarmiemto 1980 RCT No mention of sponsorship or COI.	4.0	N = 156 (50 male and 106 female) with Colles' fractures. A median age of 49 years.	Bracing in either pronation, fractures were immobilized in a long-arm cast with the wrist at 20" of volar flexion and ulnar deviation; the elbow at 90" of flexion and the forearm in either pronation (N = 78) vs Supination the elbow at 90" of flexion and the forearm in supination (N = 78). Follow-up for 15 weeks.	In the Type II category, in the supinated fractures, there were 9 excellent, 4 good and no fair or poor results; in the pronated group, 9 excellent, 8 good and 1 fair result. In combining the results for all types of braced Colles' fractures, (I-IV) 93% of the supination group and 87% of the pronation group achieved excellent or good functional results.	"Treatment with functional bracing in supination position yielded 90% excellent or good functional results."	This paper is quoted in most subsequent research pertaining to bracing.
Gupta 1991 RCT No sponsorship. No mention of COI.	4.0	N = 204 (82 male and 122 female) with displaced Colles' fractures. Mean age 46 years.	Plaster immobilization with either: Palmar flexion or PF (N = 60 vs Neutral or NP (N = 75) vs Dorsiflexion or DF wrist position (N = 69). Follow-up for 15 months.	Functional results excellent or good/total: Type III PF 20/28; NP 26/34; DF 28/32 Type IV PF 10/17; NP 8/19; DF 15/17; Type V PF 9/15; NP 13/22; DF 16/20	"After manipulation of a Colles' fracture, immobilization of the wrist in dorsiflexion would appear to provide better maintenance of reduction."	Immobilization of wrist in palmar flexion had detrimental effect on hand function.
Wahlström 1982 RCT No mention of sponsorship or COI.	4.0	N = 42 with extra articular fractures. Mean age 65 years.	Immobilization in pronation (N = 14) vs Supination (N = 12) vs Midway position (N = 16). Follow-up at 10 days and 1-4 months after reduction.	Five fractures had to be re-reduced, one from pronation, one from midway and three from supination group. Patients with redislocation ≥10° number pronation 2/14, midway 6/12, and supination 8/16.	"The position of the forearm during immobilization is of importance for the degree of redislocation."	Applicable to cast application rather than long-term functional results.

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REDUCTION ANALGESIA

1. *Recommendation: Bier Block Analgesia for Manipulation of Acute Displaced Distal Forearm Fractures*
   Bier block analgesia is moderately recommended as a first-line technique for manipulation of acute displaced distal forearm fractures.

   Strength of Evidence – **Moderately Recommended, Evidence (B)**
   Level of Confidence – Moderate

2. *Recommendation: Hematoma Block Analgesia for Manipulation of Acute Displaced Distal Forearm Fractures*
   Hematoma block analgesia is recommended for manipulation of acute displaced distal forearm fractures.

   Strength of Evidence – **Recommended, Evidence (C)**
   Level of Confidence – Low

3. *Recommendation: Dynamic Reduction for Acute Distal Forearm Fractures*
   Dynamic reduction is recommended as an alternative technique for distal forearm fractures as it may result in less reduction pain than hematoma block, and may have a lower neurologic complication rate than a hematoma block.

   Strength of Evidence – **Recommended, Evidence (C)**
   Level of Confidence – Low

Rationale for Recommendations
There are three moderate-quality studies that support the use of Bier block (intravenous local anesthetic) over hematoma (local infiltration) block for pain control during manipulation and reduction of displaced Colles' fracture.(1305-1307) In addition, those manipulated under Bier block were found to have better anatomic outcomes,(1306, 1307) lower remanipulation rates,(1306) and better grip strength at 6 months.(1307) Interestingly, medical staff may prefer hematoma infiltration over bier block based on perception of ease of technique, analgesia quality, and risk avoidance despite patient satisfaction and preference for Bier block.(1305) There are no quality studies comparing Bier block with any of the other techniques. Thus, Bier block is recommended as a first-line technique for achieving adequate analgesia and for potentially improving chance for better anatomic and functional outcome.

Dynamic reduction which does not require anesthesia block may hold slight advantage over hematoma block from the patient's perspective, although there is one study of moderate quality available on the topic, wherein less severe pain was reported during dynamic reduction than those receiving local infiltration.(1293) There was no difference in reduction quality, and no longitudinal results were reported. The same author reported in a different paper, likely of the same study group, that hematoma infiltration resulted in higher subjective paresthesia or mild deficit in 2-point discrimination at 5 weeks and 1 year compared with the dynamic traction group.(1294) Hematoma infiltration provided lower pain scores during reduction and quicker onset of analgesia than patients receiving IV pentazocine (Talwin®) and diazepam (Valium®).(1308) Finally, in one moderate-quality study, hematoma block showed no difference with cubital block, and both were judged to be substandard.(1309)

Evidence for Reduction Analgesia for Displaced Distal Forearm Fractures
There is 1 high-(1308) and 6 moderate-quality(1293, 1294, 1305-1307, 1309) RCTs incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: reduction analgesia, bier block, analgesia, hematoma block analgesia, dynamic reduction, distal, forearm, radial, radius fractures, bone fractures, Colles' fracture; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 5 articles

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in PubMed, 11 in Scopus, 0 in CINAHL, 1 in Cochrane Library, 100 in Google Scholar, and 3 from other sources. We considered for inclusion 3 from PubMed, 1 from Scopus, 0 from CINAHL, Cochrane Library, and from Google Scholar, and 4 from other sources. Of the 8 articles considered for inclusion, 8 randomized trials and 0 systematic studies met the inclusion criteria.

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Author/Year Study Type (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Singh 1992 RCT No mention of sponsorship or COI.	9.0	N = 66 (46 male and 20 female) with Colles' fracture. Mean age groups A and B; 36±16 and 39±15.	Group A, received 30mg pentazocine with 5mg diazepam (N = 33) vs 20cc or 20cc of 1.5% Xylocaine (N = 33). Follow-up for 15 hours.	"The pain scores during reduction in the local anesthetic group were markedly lower (mean 2.7, median 1.8) than the scores in the sedation group (mean 8.2, median 8.7), p < 0.001."	"Hematoma block by local anesthetic is a safe and effective alternative to sedation in reduction of Colles fracture."	Patients receiving local anesthesia had lower pain and quicker reductions than those receiving sedation.
Kendall 1997 RCT No mention of sponsorship or COI.	5.5	N = 142 (17 male and 125 female) with Colles' fracture. Mean age for Bier's block and Haematoma groups: 65 and 6 years.	Bier's block (N = 72) vs Haematoma block with either alkalinized non-alkalinized local anesthetic (N = 70). Follow-up not specified.	Mean pain scores Bier's block/hematoma: administration of anesthetic 2.8/5.3 p <0.001; manipulation of fracture 1.5/3.0 p <0.01. Alkalinized vs. non-alkalinized hematoma block alkalinized/non-alkalinized: median pain score on administration 4.4/5.9 p = 0.08; median pain score on manipulation 3.5/3.0 p = NS. More remanipulations in hematoma block (17/ 70) than Bier's block (4/72) (p = 0.003).	"Bier's block is superior to hematoma block in terms of efficacy, radiological result, and remanipulation rate."	Trend to decreased pain with alkalinized v non-alkalinized group but did not reach significance.
Kongsholm J Orthop Trauma 1987 RCT No mention of sponsorship or COI.	5.5	N = 116 (6 male and 56 female) with acute displaced Colles' fracture. Mean age 61.6 years.	Group A, dynamic reduction device with no anesthesia (N = 62) vs Group B, 8 to 10ml of 1% lidocaine with plaster cast (N = 54). Follow-up for 1 year.	2/62 in Group A displayed symptoms and signs of neurological impairment at 5 weeks vs. 11/54 in Group B, p </0.01. 1 year follow up resulted in figures of 4/62 and 8/54 with p <0.05.	"The dynamic reduction technique without local anesthesia results in a significantly lower frequency of neurological complication than manual reduction after injection of local anesthetic into the fracture hematoma." authors speculate "that the mechanism for such nerve damage is scarring and fibrosis in the vicinity of the nerves, which is secondary to elevated pressure in the tissues probably caused by the increased volume load due to the injection."	Neurologic complications included subjective paresthesia, positive Tinel's sign or 2 point discrimination > 4mm. Authors note that "nerve damage was mild and in no case in either group did it lead to surgical neurolysis."
Fathi 2015 RCT	5.0	N = 143 (76 male and 67 female) with distal radial fracture. Mean	Procedural sedation and analgesia or PSA group, received 0.05 mg/kg	Pain numeric rating scale before / 5 / 10 / and 15 minutes after treatment:	"Ultrasound guided haematoma block may be a safe and effective	Data suggest comparable efficacy in both groups but

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No mention of sponsorship. No COI.		age for PSA and US-HB groups: 41.1(15.3) / 38.9 (14.7).	midazolam, plus 2 mcg/kg fentanyl (N = 72) vs Ultrasound-guided haematoma block or US-HB group, sterile injection of 10-15 cc 1% lidocaine (N = 7). Follow-up for 1 week after manipulation.	p = 0.98 / 0.84 / 0.19 / 0.01 / and 0.07. Overall mean time of reduction-to-discharge 131.85 (±46.45) minutes with a minimum of 60 and a maximum of 300 minutes. Time-to-discharge in the PSA and US-HB groups: 142.15 (±34.05) and 121.39 (±54.60) minutes, respectively. Time-to-discharge was significantly lower in the US-HB group, (p = 0.007).	method in distal radial fracture reduction pain control, especially during overcrowded shifts when close patient monitoring during intravenous PSA is not optimally possible."	time to discharge was lower in US group.
Haasio 1990 RCT No mention of sponsorship or COI.	4.5	N = 35 (gender not specified) with fresh Colles' fractures. Mean age 62 ± 3 years.	Group 1, or conduction block cubital nerve, 15 ml of 10 mg/ml prilocaine used (N = 16) vs Group 2, hematoma block, 15 ml of 10 mg/ml prilocaine (N = 19). Follow-up at 5, 10, and 20 minutes after the injection.	44% (7/16) in Conduction group and 68% (13/19) in hematoma block were painless. Difference between study groups with respect to pain not statistically significant.	"Neither of the block techniques for the manipulation of Colles' fracture can be regarded as ideal because of the considerable number of patients feeling pain during the maneuver."	Lack of blinding. Prilocaine used in both interventions.
Abbasza-degan Acta Orthop Scand 1990;61:348-9 RCT No mention of sponsorship or COI.	4.0	N = 99 (11 male and 88 female) with displaced Colles' fractures. Mean age of 64 years.	Fractures reduced with local anesthesia (L) of 15 to 20ml prilocaine (N = 49) vs Compared to 3mg prilocaine/kg regional intravenous block (N = 50). Follow-up after 6 months.	Pain and strength as percentage of the uninjured wrist R/L: Pain initially 1/2.5 p = 0.002; 8 weeks 3/3/ p = 0.7; 24 weeks 0/2 p = 0.005. Strength initially not measured; 8 weeks 25/18 p = 0.2; 24 weeks 65/53 p = 0.01.	"Patients treated with regional intravenous block had less pain during the manipulation of the fracture and better grip strength at the 6-month follow-up. The anatomic end result (dorsal angulation) was better after regional anesthesia."	Authors noted study did not support findings of neurologic complications from local anesthesia as reported by Kongsholm.
Kongsholm Injury 1987 RCT No mention of sponsorship or COI.	4.0	N = 116 (11 male and 110 female) with an acute displaced Colles' fracture. Mean age 61.6 years.	Group A dynamic bone alignment device compared without anesthesia (N = 62) vs Group B traditional manual reduction using local infiltration anesthesia (N = 54). Follow-up at 5 weeks and 1 year.	No differences between the groups in "no pain" or "slight pain." However, for severe pain, Group B had 19 vs. 5 patients, (p < 0.001).	"Dynamic reduction without anesthesia seems to be a less painful method for the patients than traditional manual reduction under local anesthesia. The reduction with the dynamic and manual methods is similar."	Study did not follow longitudinal results of reduction.

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Cobb 1985 RCT No mention of sponsorship or COI.	4.0	N = 100 with Colles' fractures. Aged over 15 years.	Bier's block, fracture was manipulated 10 minutes after injection (N = 44) vs Local infiltration, facture was manipulated 10 minutes after injection (N = 56). Follow-up for 20 minutes.	"Pain scores during manipulation were higher for patients receiving local infiltration vs. bier block (mean 5.53/10 vs. 3.67/10, P, 0.003). No difference was noticed in the period of postoperative painlessness between the groups: Bier's block 3-7 (3-0) hours; local infiltration 4-0 (3-0) hours."	Despite findings, author states "For patients with fresh Colles' fracture local anesthetic infiltration was more popular among accident service staff (table), giving satisfactory anesthesia, being simpler and quicker to perform, and avoiding risks of a large intravenous does of local anesthetic agent reaching the general circulation."	Paper highlights difference in staff perception (thought local was better) vs. patients own perception (preferred Bier's).

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Physical Methods/Rehabilitation

ELECTROMAGNETIC FIELDS

Recommendation: Use of Low Frequency Electromagnetic Fields to Stimulate Bone Healing of Distal Radial Fractures

The use of extremely low frequency (1-1000 Hz) electromagnetic field therapy to stimulate bone healing in patients with non-displaced fractures is not recommended.

Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
Level of Confidence – Low

Rationale for Recommendation
There is one moderate-quality study of extremely low frequency (ELF) electromagnetic field (EMF) therapy, which is hypothesized to stimulate bone healing as measured by scintigraphy. The study found early increased bone activity in the first two weeks vs. control, but the differences disappeared after Week 2. In a subset of patients with displaced fractures that were re-displaced during the study, EMF of ELF resulted in higher scintimetric scores; however, the clinical significance of this finding is unknown.(1310)

Evidence for the Use of Electromagnetic Fields for Distal Radial Fractures
There are 3 moderate-quality RCTs incorporated with this analysis.(1389-1391) (Cheing 05; Lazovic 12)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Electromagnetic field therapy, electromagnetic therapy, PEMFT, Pulsed electromagnetic field theapy, magnetic therapy, magnet therapy, distal, Forearm, radial, Radius Fractures, bone Fractures, Colles' Fracture; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 0 articles in PubMed, 60 in Scopus, 0 in CINAHL, 14 in Cochrane Library, 100 in Google Scholar, and 0 from other sources. We considered for inclusion 0 from PubMed, 2 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 0 from Google Scholar, and 1 from other sources. Of the 3 articles considered for inclusion, 3 randomized trials and 0 systematic studies met the inclusion criteria.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Wahlström 1984 RCT No mention of sponsorship or COI.	5.5	N = 30 Mean age of 60.9 years old. 30 Females, 0 Males	Electromagnetic fields of extremely low frequency (N = 15) – Received treatment vs. Control (N = 15) – Did not receive treatment	Scintimetric exam treated group/ control group: Week 1: 23.9±6.4/ 18.5±6.5 p <0.05; Week 4: 44.6±13.6/ 41.6±15.0.	"The clinical relevance of the results is not known, but one interpretation of the data is that the stimulation with EMF of ELF improves (accelerates) the early phase of fracture healing. The data warrant further investigation of fresh fracture treatment with this method."	Magnitude of differences disappeared at 4 weeks, thus importance of results unclear.

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Cheing 2005 RTC No mention of sponsorship of COI.	5.0	N = 83 patients diagnosed with stable distal radius fracture(s). Mean age = 63.1 55 Women 28 Men	Group A (N=23) Ice plus PEMF 30 min of ice plus PEMF vs Group B (N=22) Ice plus sham PEMF 30 min of ice plus sham PEMF Vs Group C (N=22) PEMF. No ice. PEMF alone Vs Group D, Control (N=16) Sham PEMF. No Ice. Sham PEMF alone. All treatment were done for 5 consecutive days Visual analogue scale pain scores, volumetric measurements and ROM were measured on days 1, 3, and 5.	VAS: The VAS score on day 1 was ranging from low to medium. On day 3, there was no significant drops between the groups. But the sham PEMF with no ice had the least amount of reduction. On day 5, the score for Ice plus PEMF was significantly higher than the other three groups. Volumetric Measurement: Day one, baseline, measurements were comparable between the groups. On day 3, the sham PEMF and no ice group decreased less than the others. Day 5 revealed that Ice plus PEMF was better than the PEMF/no ice and sham PEMF/ no ice group. Also the ice/sham PEMF group was better than the shame PEFM/no ice group. ROM: Flexion improved significantly in the two PEMF (ice/no ice) group compared to the sham PEMF on day 3. Day 5 yielded similar results, but the differences was not significant. Pronation was the exact opposite. The difference between day 1 and 3 were not significant. But the difference between day 3 and 5 were.	"The addition of pulsed electromagnetic field to ice therapy produces better overall treatment outcomes than ice alone, or pulsed electromagnetic field alone in pain reduction and range of joint motion in ulnar deviation and flexion for a distal radius fracture after an immobilization period of 6 weeks"	Data suggest pain was significantly reduced via VAS as well as ulnar ROM deviation with the additition of PEMF to ice or PEMF alone compared to sham groups.
Lazovic 2012 RTC No mention of sponsorship or COI	4.0	N = 60 women who sustained unilateral extra-articular displaced stable DRF Mean age PEMF = 67.90 ± 5.56	PEMF Group (N=30) PEMF therapy 5 days a week for 2 weeks Vs. Control Group (N=30) No therapy. Follow up at 2-3 days after removal of cast.	PEMF yielded better mean results for edema, pain, and function scores compared to the control. However, only the edema score was significant (p=0.000). PEMF resulted in significant values, when comparing ROM to	"During immobilization PEMF therapy in DRF patients gave better results immediately after cast removal in terms of edema and wrist range of motion (ROM)."	Some baseline differences between groups which could cause PEMF group to show worse outcomes. PEMF group was older. Data suggest PEMF for

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		Mean age Control = 64.50 ± 6.02 60 women 0 men		the control, for flexion (p=0.003), extension (p-009) and supination (0.004). Other ROM values were high in the PEMF group except for radial deviation.		distal radius fracture beneficial for increased ROM and decreased edema post cast removal.

EXERCISE

Exercise is not generally indicated acutely. Some patients have deficits after casting or surgery and require exercises and rehabilitation.

1. *Recommendation: Education after Cast Removal for Acute Colles' Fracture*
   Referral of select patients needing education after cast removal for acute Colles' fracture is recommended.

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – Low

2. *Recommendation: Use of Physical or Occupational Therapy after Cast Removal for Acute Colles' Fracture for Patients with Functional Deficits Unable to Return to Work*
   Referral of patients with functional deficits or those unable to return to work for physical or occupational therapy after cast removal for acute Colles' fracture is recommended.

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – Moderate

3. *Recommendation: Routine Referral for Physical or Occupational Therapy after Cast Removal for Colles' Fracture for Patients Able to Return to Work*
   Routine referral for physical or occupational therapy after cast removal for Colles' fracture of otherwise healthy patients who are able to return to work is not recommended.

   Strength of Evidence – **Not Recommended, Evidence (C)**
   Level of Confidence – Moderate

Rationale for Recommendations

There are two moderate-quality studies on the effects of physical or occupational therapy to hasten functional recovery once the cast is removed in non-surgical patients. One study, despite lack of blinding in the control group and small sample size, showed no added benefit to the addition of occupational therapy to home exercise instructions by the provider. This finding was consistent regardless of fracture angulation and functional scores.(1311) Conversely, in another study also weakened by small sample size and lack of blinding, physical therapy (passive joint mobilization) was found more effective than no therapy in increasing wrist extension and grip strength in the immediate cast removal period. However, there were no long-term measures to determine the duration of benefit in the intervention group.(1312) One low-quality study(1313) and one case series(1314) also found no functional benefit for physical therapy.

A few appointments for educational purposes for select patients are recommended. The numbers of appointments are dependent on the degree of debility, with one or 2 educational appointments appropriate for mildly affected patients. Patients with severe debility or those unable to return to work may necessitate 8 to 12 appointments that particularly emphasize progressive strengthening exercises. Additionally, while routine use may be of limited benefit, those patients who have muscle weakness or other debilities may also derive benefit from therapy including self-training exercises, particularly if unable to return to work. Therefore, occupational or physical therapy is recommended for select patients.

Evidence for the Use of Physical or Occupational Therapy for Colles' Fracture

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There are 8 moderate-quality RCTs incorporated into this analysis.(1392, 1393, 1396-1401) (Wakefield 00; Kay 00; Filipova 15; Valdes 05; Magnus 13; Kay 08) There are 2 low-quality RCTs and one other study (1355, 1394, 1395) in Appendix 2.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Education, Cast removal, Colles' Fracture; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 0 articles in PubMed, 0 in Scopus, 0 in CINAHL, 0 in Cochrane Library, 64 in Google Scholar, and 0 from other sources. We considered for inclusion 0 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 0 from Google Scholar, and 0 from other sources. Zero articles met the inclusion criteria.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: physical therapy, occupational therapy distal, Forearm, radial, Radius Fractures, bone Fractures, Colles' Fracture; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 4 articles in PubMed, 5 in Scopus, 2 in CINAHL, 1 in Cochrane Library, 79 in Google Scholar, and 1 from other sources. We considered for inclusion 4 from PubMed, 2 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 0 from Google Scholar, and 0 from other sources. Of the 6 articles considered for inclusion, 4 randomized trials and 2 systematic studies met the inclusion criteria.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Exercise; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 3 articles in PubMed, 21 in Scopus, 0 in CINAHL, 1 in Cochrane Library, 146 in Google Scholar, and 0 from other sources. We considered for inclusion 1 from PubMed, 1 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 0 from Google Scholar, and 0 from other sources. Of the 2 articles considered for inclusion, 2 randomized trials and 0 systematic studies met the inclusion criteria.

Author/Year Study Type Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Wakefield 2000 RCT No COI or Sponsorship	6.5	N = 96 patients over the age of 55 with a distal radius fracture treated with immobilization in plaster; mean age 72 (55-90). Gender (M:F); 9:87	Group 1 which was taught and given home exercises by a physiotherapist in a fracture clinic and referred to a course of physiotherapy (N = 49) vs Group 2 which was instructed in home exercises only (N=47). Follow-up at plaster cast removal, three	Mean difference (95% CI) for group 1 vs. group 2 at 6 months. Flexion/Extension: 12.2 (5.4 to 19.2), (p =0.001). All data (collected at 3months and 6months) comparing JAMAR grip strength, Pronation/Supination, Radial/Ulnar Deviation, and Functional Scores were not statistically significant.	"Home exercises are adequate rehabilation after uncomplicated fracture of the distal radius, and routine referral for a course of physiotherapy should be discouraged."	Data suggest home exercises for uncomplicated fractures are beneficial.

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			months, and six months.			
Christensen 2001 RCT No mention of COI or Sponsorship	5.0	N = 30 with distal radius colles' type fracture; mean age 66 years; Gender (M:F) 3:27	Home exercise instructions for shoulder, elbow, wrist and fingers with and without occupational therapy.	No statistical significance between groups in dorsal angulation, radial angulation, axial radial length, or functional scores.	"For non-surgically treated patients with a distal radius fracture only instructions are necessary."	No blinding or control of compliance.
Kay 2000 RCT No mention of sponsorship or COI	4.5	N = 39 patients with fractures involving the distal radius, and after removal of pins and/or cast. ; mean age for non-mobilisation group 51.6, mobilization group 54.7. Gender (M:F); 12:27	Non-mobilisation group received advice and home exercises from a physiotherapist. (N = 20) vs Mobilisation group received advice, home exercises, and a six week course of passive mobilisation. (N = 19) Follow-up at initial appointment, three weeks, and six weeks.	Mean difference (95% CI) for non-mobilisation group vs mobilisation group at initial, three weeks, six weeks: Flexion : (-0.6 , -5.0, -1.3), (p = 0.02). All data collected comparing extension, flexion, radial deviation, ulnar deviation, pronation, supination, web space, thumb motion scale, and grip strength were not statistically significant.	" This study found that passive mobilisation did not add to the effectiveness of a regimen of advice and exercise for patients following fractures involving the distal radius managed with pins and/or plaster casts. "	Data suggest comparable efficacy.
Valdes 2015 RCT No sponsorship or COI	4.5	N = 50 patients with DRF and underwent volar plate fixation; Mean age Therapy group (28-81) Non therapy (23-92); Gender (M:F) 8:42	Therapy group received instruction from a standard pictorial home exercise program (HEP) and therapy with certified hand therapists. 2visits/wk for 16 visits N = 26 Non therapy group received standard pictorial HEP N = 24 Follow-up at 2,4,6,8, 12 for secondary outcomes and 6 months for primary outcomes	No statistically significant differences between scores of PRWHE, wrist/forearm motion, pain or grip strength between groups.	"Supervised clinic-based therapy is equally beneficial for patients without complications. Clinic-based therapy may be preferable for patients with noteworthy complications after a distal radius fracture with volar plate fixation."	Data suggest no difference between groups.
Filipova 2015 RCT No COI or sponsorship	4.0	N = 61 patients who were treated conservatively for distal radius fracture; mean age 60 ; Gender (M:F) 14:47	Group A received 9 PT sessions consisting of 20min galvanic baths, and 30 min individual kinesiotherapy. (N = 31) vs	Rehabilitation outcomes p values for a two-way (Time and Therapy) mixed ANOVA Time was statistically significant (p < 0.001) for all outcomes; wrist flexion, forearm rotation,	"The combined therapy resulted in a statistically significant increase of grip strength in comparison with isolated physical therapy in the period of 12–16 weeks after the fracture. This	Data suggest significant increased grip strength with combination therapy in conservatively treated distal radial fracture patients.

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			Group B received 9 combined therapy sessions. 30 minutes FOT combined with the same PT program as group A. (N = 30) Follow-up at first week of cast removal (T1) , immediately after the end of rehabilitation (T2, 8-12 weeks after fracture) and 1 month after completion of rehabilitation (T3, 12-16 weeks after fracture)	hand grip strength, DASH. Therapy was statically significant for grip strength (p = 0.038) Interaction effect was significant for rotation (p = 0.034), grip strength (p = 0.021) Grip strength was statistically different among group B vs Group A comparing time periods T3:T1 (67% vs 53% (CI 95%)), (p = 0.024)	effectiveness was not confirmed with DASH score results."	
Watt 2000 RCT No mention of COI or sponsorship	4.0	N = 18 patients with Colles' Fractures; mean age physiotherapy group 74.4, Non physiotherapy group 77.3; Gender (M:F) 1:17	Physiotherapy vs. non-physiotherapy following cast removal. Follow up at six weeks after cast removal	Clinical significant increase in wrist extension and grip strength after 6 weeks physiotherapy (passive joint mobilization).	"Routine referral of Colles' fracture patients to physiotherapy following cast removal is beneficial."	Small sample size, no blinding, no long term outcomes measures.
Exercise						
Kay 2008 RCT Sponsored by RAH Allied Health Research Grant No mention of COI	6.5	N = 56 patients with DRF managed with pins and/or a cast; Mean age Experimental group 55 control group 55.8 Gender (M:F) 17:39	Experimental group received a physiotherapist directed program of advice and exercise. (N = 28) vs. Control group who did not receive any physiotherapy intervention. Follow-up at three and six weeks	No significant difference found between groups comparing wrist extension, ROM or strength.	"An advice and exercise program provided some benefits over no intervention for adults following distal radius fracture."	Data suggests that passive mobilization does not seem to add any benefit for distal radial fractures as both groups showed comparable efficacy.
Magnus 2013 RCT Sponsored by Royal University Hospital Grant NO COI	4.0	N = 51 women with unilateral DRF; Mean Age Training group 63.3 ± 10 Control group 62.7 ± 10.2	Training group received strength training in non-fractured arm during casting and through follow up and standard clinical rehabiliation (N = 27) vs Control group, received standard	Fracture hand strength Training vs control at 12wks (17.3± 7.4 kg vs 11.8 ± 5.8kg (p < 0.017)) No significant differences in strength at 9, 12 or 26 wks. Fractured hand ROM training vs control group at 12 weeks (100.5° ±	"Strength training for the nonfractured limb after a distal radius fracture was associated with improved strength and ROM in the fractured limb at 12 weeks postfracture. These results have important implications for rehabilitation	All subjects were female. Data suggest at 12 weeks, strength training for non-fractured extremity after distal radius fracture was associated with improved strength and ROM.

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		Gender (M:F) 0:51	clinical rehabilitation (N = 24). Follow-up at week 1, 3, 6, 9, 12, 26	19.2° vs 80.2° ± 18.7° (p < 0.017)) Not significant differences in ROM at 9 , 12, 26 weeks No significant differences in patient rated wrist questionnaires at week 9 or 26.	strategies after unilateral injuries."	

Surgery

1. *Recommendation: Closed Reduction or External Fixation for Severely Displaced Extra-articular Fractures, Comminuted, or Displaced Intraarticular Fractures of the Distal Forearm*
   Closed reduction or external fixation is moderately recommended for treatment of severely displaced extra-articular fractures, and for comminuted, displaced intra-articular fractures of the distal forearm.

   Strength of Evidence – **Moderately Recommended, Evidence (B)**
   Level of Confidence – High

2. *Recommendation: Cast Immobilization or External Fixation for Moderately Displaced Extra-articular Fractures, Non-comminuted or Non-displaced Intra-articular Fractures of the Distal Forearm*
   Cast immobilization is moderately recommended for treatment of extra-articular fractures or distal forearm fractures that include moderately displaced extra-articular fractures, non-comminuted or non-displaced intra-articular fractures. External fixation is moderately recommended as a second option for fractures that fail reduction while immobilized.

   Strength of Evidence – **Moderately Recommended, Evidence (B)**
   Level of Confidence – Moderate

3. *Recommendation: Medullary Pinning As an Alternative to External Fixation*
   Medullary pinning (k-wire or intramedullary fixation techniques) is recommended as an alternative to external fixation.

   Strength of Evidence – **Recommended, Evidence (C)**
   Level of Confidence – Low

4. *Recommendation: Bone Cement As an Alternative to External Fixation*
   Remodellable bone cement (injected or open reduction) is recommended as an effective alternative to external fixation and casting.

   Strength of Evidence – **Recommended, Evidence (C)**
   Level of Confidence – Low

5. *Recommendation: Open Reduction and Internal Fixation Via Dorsal or Volar Plating*
   Open reduction and internal fixation by either dorsal or volar plating is recommended if fracture remains unstable by other treatment methods. There is no clear evidence of a preferential approach.

   Strength of Evidence **– Recommended, Insufficient Evidence (I)**
   Level of Confidence **- Low**

6. *Recommendation: Triangular Fibrocartilage Complex (TFCC) Repair for Distal Radial Fractures*
   There is no recommendation for or against TFCC repair associated with distal radial fractures.

   Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**
   Level of Confidence – Low

Rationale for Recommendations

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Most comparative studies for surgical intervention of distal radial fractures includes external fixation using various named external fixators. In consideration of the topic, all studies using external fixators are considered as one particular treatment group, as few comparisons are made between individual types or brands of fixators. There are several moderate-quality studies available for this treatment. Overall, the available data is weakened by studies with small sample sizes, a lack of consistency in fracture types included in each study, and inconsistency in reported final outcomes measures (i.e., functional, radiographic) and duration of follow-up. Extra-articular fractures or distal forearm fractures that include non-displaced intra-articular fractures can be treated initially with external immobilization, using external fixation as a second option for fractures that fail reduction while immobilized. External fixation likely does not provide improved functional results in the elderly.

In consideration of support for external fixation, 5 moderate-quality studies that included either mixed fracture types or were limited to extra-articular, non comminuted and non-displaced intra-articular fracture types, generally showed equivocal or non-statistically significant positive trends in radiographic or functional outcomes when compared with casting.(1315-1319) Another moderate-quality study compared plaster cast to external fixation and found that patients with plaster casts showed significantly higher Maximum Voluntary Contraction than patients with primary external fixation on day immobilization device was removed until between 18 weeks and 1 year when the groups equalized.(1281) Therefore, there is evidence supporting non-operative treatment for these fractures using non-invasive immobilization techniques. However, for the more severe fractures, including comminuted extra-articular and displaced comminuted intra-articular types, there are 6 moderate-quality studies that support improved clinical outcomes from external fixation over casting.(1320-1325) Thus, there is strong evidence to support more invasive immobilization techniques for these more severe injuries. One exception to this may be for those over age 65, as there is one moderate-quality study that showed no difference in functional outcomes despite worse anatomical outcomes, suggesting the final anatomical outcome is less important in this age group.(1326) As there is only one study supporting this, there is insufficient evidence to make recommendation for or against greater emphasis on non-operative treatment in older populations.

Two moderate-quality comparison studies of external fixation with medullary pinning (percutaneous) resulted in mostly equivocal studies for radiographic and clinical outcomes measures,(1327, 1328) although both authors felt there were financial and post-operative care advantages with pinning over external fixation. One moderate-quality study, weakened by co-intervention differences, demonstrated improved outcomes with combined external fixation and additional k-wire fixation for displaced intra-articular fractures.(1323) If pinning is selected, there does not seem to be any difference in technique comparing Kapandji and Willinegger procedures,(1329) nor in the length of post-operative cast immobilization comparing 1 vs. 6 weeks.(1330) An alternative method for the treatment of distal radial fracture includes the use of bone cement. There are five moderate-quality studies found, although one author reported on the same study population in two different papers. The injection of remodellable bone cement, or the open reduction and use of remodellable bone cement, was shown to provide improved anatomic and functional outcomes compared to casting(1331, 1332) and external fixation(1333, 1334) and reducing immobilization time.(1335) There is only one moderate-quality study on the repair of triangular fibrocartilage complex (TFCC) with distal radial fractures.(1336) In a small sample size study limited to Frykman II and VI, closed reduction and casting had equivocal results to surgical repair. However, this study was published in 1989, prior to more recent anatomic studies and case series reports on TFCC. Therefore, no recommendation is made for TFCC repair based on insufficient evidence.

There is no quality evidence for specific internal fixation techniques in comparison to external fixation or other immobilization techniques. However, there is one moderate-quality study of two internal fixation techniques, which recommends against the use of pi-plates, which were more difficult to match properly to distal radius, and resulted in worse wrist flexion and extension outcomes than from ¼ tube plates.(1337) Thus, with insufficient evidence for comparison, there are no recommendations for internal fixation techniques.

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Evidence for Surgery for Displaced Distal Forearm Fractures
There are 39 moderate-quality RCTs or prospective studies incorporated into this analysis.(1356, 1367, 1402-1437) (Rozental 09; Foldhazy 10; Grewal 05; Grewal 11; Karantana 13; Kreder 05; Cassidy 03; Jeyam 02; Krishnan 03; Leung 08; Wei 09; Atroshi 06; Arora 11; Abramo 09; Egol 08)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: **Bone Cement** / Distal Forearm Fractures & Colles' Fractures ;controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 5 articles in PubMed, 12 in Scopus, 2 in CINAHL, 0 in Cochrane Library, and 6037 from Google Scholar. We considered for inclusion 0 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 3 from Google Scholar, and 0 from other sources. Of the 3 articles considered for inclusion, 2 randomized trials and 1 systematic studies met the inclusion criteria.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: **Cast Immobilization / Distal Forearm Fractures & Colles' Fractures** ;controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 2 articles in PubMed, 5 in Scopus, 1 in CINAHL, and 2 in Cochrane Library, 6558 from Google Scholar, and 2 from other sources. We considered for inclusion 0 from PubMed, 1 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 2 from Google Scholar, and 2 from other sources. Of the 5 articles considered for inclusion, 5 randomized trials and 0 systematic studies met the inclusion criteria.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: **Closed Reduction / Distal Forearm Fractures & Colles' Fractures** ;controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 0 articles in PubMed, 10 in Scopus, 2 in CINAHL, and 4 in Cochrane Library, 15380 from Google Scholar. We considered for inclusion 0 from PubMed, 3 from Scopus, 0 from CINAHL, 2 from Cochrane Library, 8 from Google Scholar, and 0 from other sources. Of the 13 articles considered for inclusion, 6 randomized trials and 1 systematic studies met the inclusion criteria.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: **Medullary Pinning / Distal Forearm Fractures & Colles' Fractures**; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 0 articles in PubMed, 0 in Scopus, 0 in CINAHL, and 0 in Cochrane Library, 2175 from Google Scholar, and 5 from other sources. We considered for inclusion 0 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 0 from Google Scholar, and 2 from other sources. Of the 2 articles considered for inclusion, 1 randomized trials and 0 systematic studies met the inclusion criteria.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: **Open Reduction / Distal Forearm Fractures, Colles' Fracture** ;controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 5 articles in PubMed, 6 in Scopus, 2 in CINAHL, and 2 in Cochrane Library, 5425 from Google Scholar, and 10 from other sources. We considered for inclusion 0 from PubMed, 1 from Scopus, 1 from CINAHL, 1 from Cochrane Library, 3 from Google Scholar, and 3 from other sources. Of the 9 articles considered for inclusion, 7 randomized trials and 2 systematic studies met the inclusion criteria.

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A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: **Triangular Fibrocartilage Complex Repair (TFCC) / Distal Forearm Fractures & Colles' Fractures**; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found, reviewed and considered for inclusion 0 articles in PubMed, 0 in Scopus, 0 in CINAHL, 0 in Cochrane Library, 968 from Google Scholar, and 0 in other sources. Zero articles met the inclusion criteria.

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Author/ Year Study Type (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
External Fixation vs. Casting						
Kreder 2006 RCT Sponsored by a grant from the Orthopeadic Research and Education Fundation. No mention of COI.	7.5	N = 113 (74 female/39 male) skeletally mature with distal radius fracrues. Age 16-75 years.	Closed reduction casting (n = 59) vs. Closed reduction and external fixation (n = 54). Follow-up for 2 years.	No statistically significant differences in functional, clinical, or radiographic outcomes found; 19 patients in external fixator group had additional percutaneous pin fixation; 5 patients initially randomized to cast group actually received external fixations within 3 weeks of surgery (within 2 weeks of initiating cast treatment) because their fractures displaced or acceptable closed reduction could not be achieved (n = 5; 8.5%).	"For distal radius fractures with metaphysical displacement but with a congruous joint, there exists a trend for better functional, clinical, and radiographic outcomes when treated by immediate external fixation and optional K-wire fixation."	Author notes to achieve statistically significant results, a sample of n = 600 would be necessary. "…simply not enough patients or resources to definitively answer this functional question."
McQueen 1996 RCT No sponsorship or COI.	6.0	N = 120 (13 males/107 females) patients with unstable fractures of distal radius; Mean age 63 (16-86).	Closed re-reduction with forearm cast (Group 1) vs. Open reduction and bone grafting (Group 2) vs. Closed re-reduction and application of Pennig external fixator (Group 3) vs. Closed re-reduction and application of Pennig external fixator, but at three weeks the ball joint was released to allow wrist movement (Group 4). Follow up at 6 weeks and one year.	Mean dorsal angulation correction better in open reduction and grafting group (Group 2) vs. control and external fixation groups at 6 weeks and 1 year. Groups 3 and 4 better than control, but no statistical difference between fixation and fixation with early mobilization. Mean mass grip strength as a percentage of normal side showed sequential improvement, but no statistical analyses done. Carpal malalignment had a significant association with diminished recovery of strength of mass grip (p = 0.02), chuck grip (p = 0.02) and key grip (p = 0.05) after 1 year. Similar association with recovery of range of rotation at 3 months (p = 0.005), 6 months (p = 0.002) and 1 year (p = 0.01). After 1 year radial shortening had a significant negative association with recovery of chuck (p 0.005), key (p = 0.01) and pinch (p = 0.001) grip strengths.	"Functional results at 6 weeks, 3 and 6 months, and at one year showed no difference between any of the four groups despite anatomical disparity. The main influence on final outcome was carpal malalignment which had statistically significant negative effect on function."	Despite differences in the final anatomical appearance of the distal radius, the incidence of carpal malalignment was similar in all groups. Authors state correction of palmar tilt is most important to reduce carpal malalignment. The four techniques in the study are equivocal in this study for improving palmar tilt.

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Jenkins 1987 RCT No mention of sponsorship or COI.	6.0	N = 58 (no mention of gender) patients with a displaced Colles' fracture; no mention of mean age.	Forearm plaster vs. external fixator in patients with displaced Colles' fractures. Follow-up at 4, 8, and 16 weeks.	Mean loss of position significantly worse for plaster vs. fixator in dorsal angle 10.5° v 0.1° (p <0.01), radial angle 6.5° vs. 0.7° (p <0.01), radial length 3.7 vs. 0.3° (p <0.01). Using a positional grading scale to rate changes between post-manipulation and union, 22 of 24 in plaster group had good or excellent post-manipulation, falling to 12 of 24 at union. In fixator group, no decrease, as all 30/32 with good or excellent post-manipulation patients remained at 30 of 32.	"The external fixator proved more effective at holding the manipulated position, and the radiological loss of position during fracture union was minimal compared with that seen in patients treated in plaster."	External fixation is more effective than plaster in radiological scoring. There were no measurements of function in this study.
Abbasza-degan Acta Orthop Scand 1990;61:528-30 RCT No mention of sponsorship or COI.	5.0	N = 47 (11 males/36 females) with severely displaced Colles' fractures types 3 and 4; Mean age 63 (22-75)	Prospective 1-year study of plaster cast or primary external fixation. Follow up at 4, 8, 12, 24 weeks, and 1 year.	Follow-up according to pain and subjective function: Pain cast/fixation (VAS 0-10); 8 weeks 3/2 (p = 0.04); 12 weeks 2/1 (p = 0.1); 24 weeks 2/0.5 (p = 0.009); 1 year 1/0 (p = 0.0002. Function cast/fixation (VAS 0-10); 8 weeks 5/7 (p = 0.1); 12 weeks 7/7 (p = 0.7); 24 weeks 8/9 (p = 0.1); 1 year 9/10 (p = 0.02). Functional outcome excellent or good/total: Plaster 12/19; Fixation 19/22.	"Primary external fixation for severely malpositioned Colles' fractures might lead to a better radiographic and functional end result than conventional plaster-cast treatment."	5 fractures in plaster cast group redislocated after 11 days, and re-reduction and external fixation were required, with 3/5 reporting good or excellent results.
Merchan 1992 RCT	5.0	N = 70 with comminuted intra-articular fractures of the distal radius of types III to VIII;	Closed reduction and forearm plaster vs. application of a Clyburn dynamic external fixator.	"Significant loss of position occurred in 27 (77%) of the plaster group at the 7-day examination… Patients stabilized with an external fixator had maintained their reduced position." In fixator group, 54.3% had excellent reduction, 34.3% good reduction, 8.7% fair reduction and 2.7 poor reduction compared to plaster group where 37.2% had excellent reduction, 17.2% had good reduction, 34.2% had fair reduction, and 11.4% had poor reduction. 4 occurrences of pin tract infection were found, however they were superficial and responded to treatment by cleansing and antibiotics. 3 encounters of pin loosening occurred. Reflex	"It does appear that a good anatomic position combined with early rehabilitation of wrist function produces very favorable functional results in patients under 45 years of age."	Study labeled as double blind; however, only an independent assessor could be blinded which was not well described.

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				sympathetic dystrophy did not develop with Clyburn fixator however, severe Sudeck's atrophy developed in 2 plaster-treated patients.		
Stein 1990 RCT No mention of sponsorship or COI.	5.0	N = 126 with distal radius fracture; Mean age Group 1: 56 (20-89). Group 2: 54 (22-79).	Fixation with above-the-elbow cast immobilization vs. external fixation; Follow up at 1, 2, 4, and 6 weeks, then again at 6 months and 4 years.	Patients categorized on 4 grade severity scale based on deformity, dorsal angulation, and shortening. Garland and Werley objective and subjective results showed 71 of 88 Grade I, II cast group had excellent or good results. In types II, IV fracture, external fixation had better scores 36 of 40 vs. 15 of 22 (p <0.001).	"Extraarticular fractures of the distal radius should be treated with cast immobilization. Comminuted intraarticular fractures of the distal radius should be treated with external fixation, which maintains accurate anatomic position until solid fracture healing is achieved."	Study randomizes by day of admission and apparently resulted in a 72:1 ratio of allocations to casting and a randomization failure.
Pring 1988 RCT No mention of sponsorship or COI.	4.5	N = 75 (14 males/61 females) patietns with Colles' fractures; Mean age Group 1: 59.3. Group 2: 64.	Forearm cast alone vs. bipolar fixation of displaced fracture.	Mean percentage grip cast/Bipolar: 7 weeks 28.5/21.6, 12 weeks 46.2/48.5, 6 months 63.8/67.6. "Nine fractures treated with plaster alone redisplaced and required manipulation. No patient initially treated with bipolar fixation required remanipulation. Functional results at 6 months did not reach statistical significance."	"A good final position (functional position) is desirable, even in the elderly; that bipolar fixation provides a method of achieving this, and that it is applicable to all but open fractures of the distal radius."	Conclusions are based on trend and not statistical significance.
Lagerström Scand J Rehabil Med 1999;31(1):55-62 RCT	4.5	N = 33	Plaster cast (P-group) vs. external fixation using AO External Fixator® (E-group) vs. secondary fixator group (PE Group).	Differences between uninjured and injured sides; P-group vs. E-group in Maximum Voluntary Contraction (MVC) (Newtons) (Higher difference is weaker); 6 weeks: 190.7*** SD = 49.0 vs. 206.7 *** SD = 77.5; 10 weeks: 126.4** SD = 48.8 vs. 155.6** SD = 59.6; 52 weeks: 32.6 SD = 38.1 vs. 34.2* SD = 35.0. *p<0.05; **p<0.01; ***p<0.001	For injured side patients with plaster casts showed significantly higher MVC (stronger) than patients with primary external fixation on day immobilization device removed until between 18 weeks and 1 year when groups equalized. Patients that failed casting and had external fixation had slower recovery trends.	Author suggests slower rates for MCV recovery as basis for early intervention with physiotherapy, particularly in the external fixation and secondary external fixation groups.
Jenkins 1988 RCT No mention of sponsorship or COI.	4.0	N = 106 (males/ females) who had sustained a Colles' fracture sufficiently displaced to require	Forearm plaster vs. external fixator in patients (AO/ASIF minifixator) under age 60. Follow up at baseline, 1 week, 4 weeks, 3	Comparison of excellent and good outcomes/total: Subjective: external fixator 44/59, plaster 32/41. Objective external fixator 57/59, objective 40/41. Fixator group had much greater proportion of excellent than the plaster group. At 12 months, the plaster group had	"The wrist's immobilization does nothing to retard its early recovery. External fixation of these fractures is indicated solely for the purpose of improving long-term function by virtue of the improved anatomy that the treatment affords, and	Study accounted for grip strength in dominant vs. non-dominant contralateral comparisons.

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		manipulative reduction; Mean Age Group 1: 40.1. Group 2: 34.5.	months, and 12 months.	significantly reduced grip strength than externally fixated group (93.9% SD±9.4% vs. 84.1% ± 19.6 (p = 0.05).	for this reason methods of treatment that permit early wrist mobilization at the possible expense of the anatomical position are not justified."	
Howard 1989 RCT No sponsorship or COI.	4.0	N = 50 (No mention of Gender) patients with severely displaced comminuted Colles' Fractures; No mention of Mean Age.	Plaster with fracture manipulated under Bier's block and supported by molded below-elbow plaster backslab vs. external fixation with 2 pairs self tapping 2.0mm Hoffman pins inserted into radius, proximal to line of crossing of radial nerve.	For overall anatomical result, 14/25 fixator cases graded excellent compared with 2/25 plaster treated cases (p <0.001). No significant differences in functional results when combining excellent or good outcome/total: 3 months Plaster 12/25, External fixation 14/25 6 months plaster 18/25, External fixation 19/25. However, a significant difference in excellent only at 6 months. 16/25 vs. 9/25 (p <0.05).	"External fixation produces significantly better anatomical results than plaster in severely displaced comminuted Colles' fractures and a significant improvement in function."	Most other studies reviewed reported functional results as excellent and good combined (considered satisfactory).
Young 2003 Prospective Study No mention of sponsorship or COI.	4.0	N = 125 (28 males/97 females) with dorsally angulated fractures of the distal radius; Median Age Group 1: 54 (21-73). Group 2: 60 (24-75).	Group 1: primary bridging external fixation vs. Group 2: manipulation of the fracture with dorsal plaster slab converted to below-elbow plaster cast at 1 week	At 7-year follow-up, 17 died, 22 lost to follow-up, leaving 86. "There were no difference between groups for ranges of flexion, extension, pronation, supination and ulnar and radial deviation or grip strength." Gartland and Werley scores similar with 34/36 of external fixation group and 47/49 of casting group reporting excellent or good scores. Residual wrist pain low with no differences between groups. Patients showing arthritic changes ext. fix n = 11/36, cast n = 9/49 not significant. Incidence of 14% reported for occurrence of radiological post-traumatic arthritis following intra-articular fractures.	"Radiographic result after distal radial fracture is significantly better if patients are treated by external fixation rather than by plaster immobilization. However, after 7 years, the outcome measures that the patient notices, such as range of movement and function, are no different between the two treatment methods."	High dropout rate at long-term follow-up.
Roumen 1991 RCT	4.0	N = 101 (8 males/93 females) with displaced Colles' fracture; Mean Age 70.1	External fixator or conventional cast treatment (control) in patients that failed manipulation and	Elderly patients with displaced Colles' fractures treated with initial reduction and plaster backslab. At Week 1 and 2, patients with dorsal angulation >10° or radial shortening >5mm re-manipulated	"External fixation is not indicated for the treatment of redisplacement of a Colles' fracture in an elderly patient. Even severe secondary displacement can be accepted."	No correlation between anatomic and functional outcomes in elderly patients.

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No sponsorship or COI.			splinting after 2 weeks vs. primary group that did not fail initial treatment (p).	and held by external fixator or conventional cast treatment. Anatomical results excellent or good outcome/total: primary 44/58, external fixator 16/21, control 0/22. Functional end-result excellent or good outcome/total: Primary 41/58, External fixator 12/21, control 19/22. No clear correlation between final anatomical result and functional result (Spearman coefficient 0.18, p >0.05).		
K-Wire						
Allain 1999 RCT No mention of sponsorship or COI.	7.0	N = 60 (45 female/15 male) with dorsally displaced extra-articular or non-comminuted intra-articular fractures of distal radius after trans-styloid K-wire fixation. Mean age 75 (21-83).	Postoperative immobilization for 1 (Group 1) or 6 (Group 2) weeks.	Patients followed at 1-year post-op. One reflex sympathetic dystrophy in Group 1, none in Group 2. Ulnar deviation statistically significant (p = 0.03) after early mobilization (mean difference between normal and impaired wrist). No significant differences in grip strength, (25 kg in Group 1 and 21 kg in Group 20, sick leave, functional discomfort, or outcome satisfaction.	"Addition of plaster cast immobilization of wrist after trans-styloid fixation with two K-wires, in Colles' fractures may not be necessary if styloid fragment large enough to allow good K-wire fixation, as well as if fracture does not consist of more than 2 articular fragments."	No differences found in radiographic outcomes between groups.
Strohm 2004 RCT No sponsorship or COI.	4.0	N = 100 (15 males/85 females) patients with Colles-type fracture of distal radius; Mean Age 65 (29-92)	Kirschner wire osteosynthesis via Kapandji procedure vs. Willenegger procedure.	Martini scores; Kapandji vs. Willenegger. Average 4 (range, 16-38 points) vs. 28 (range, 11-36 points) (p <0.005). Difference in the modified Martini score between the treatment group was found for type-A2 (p = 1.004) and A3 (p = 0.007) fractures but not for type-C1 fractures (p = 0.6).	Conventional Kirschner wire fixation remains good method of osteosynthesis for treating displaced fractures of distal part of radius. "We found both the functional and radiographic outcomes of the Kapandji method to be significantly better than those of the Willenegger technique."	Study intervention included both different fixation and different length of casting. Follow-up times differ among patients.
Kapoor 2000 RCT No mention of sponsorship or COI.	4.0	N = 90 (No mention of Gender) adult cases of acute displaced intra-articular fractures of the distal end of the	Closed reduction and plaster immobilization vs. external fixation (Roger and Anderson type) vs. Open reduction and external fixation	Follow-up for 4 years. Final functional assessment (%); Plaster vs. Fixator vs. Open reduction: Good and excellent 43 vs. 80 vs. 63. Fair and poor 57 vs. 20 vs. 37. Average loss of arc with plaster 37° in comparison with 19° by external fixator. Average grip strength (in comparison with normal side) in	"Displaced severely comminuted intra-articular fractures should be treated with an external fixator."	Study intervention is different for fixation vs. internal fixation related to mobilization and physiotherapy. Follow-up times differ not clearly

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		radius; Mean age 39.	(Kirschner wires, small T plates or both) in patients with displaced intra-articular fractures.	groups was fixator 70%, open reduction and internal fixation 68% and plaster 63%.		stated for each patient group.
External Fixation vs. Pinning						
Ludvigsen 1997 RCT Study supported by a grant from the Norweigan Orthopaedic Society.	6.0	N = 60 (7 males/53 females) with Colles' Fracture type Older 3; Mean Age Group 1: 61 (31-80). Group 2: 58 (31-89).	External fixation vs. percutaneous pinning.	Patients immobilized for 6 weeks; outcome assessed after 6 months. Groups showed similar results with respect to radiographic parameters and function. All fractures healed and no difference in complication rate was observed.	Most unstable distal radial fractures, classified as Older's type 3 and 4, can be treated with percutaneous pinning and a plaster cast, which is simpler and cheaper than external fixation.	With equivocal results, author justification for conclusion is based on other studies that loss of reduction may occur if external fixator is removed before 8 weeks, as radial shortening occurring during this time may result in loss of reduction.
Pritchett 1995 RCT No sponsorship or COI.	4.5	N = 100 (45 males/55 females) with distal radial fractures; Median Age Group 1: 65.3 (34-79). Group 2: 66.7 (37-83).	External fixation vs. medullary pinning.	Excellent or good outcome/total: external fixation 42/50, medullary pinning 48/50. Loss of ROM and grip strength slight and not significantly different between groups. Treatment outcomes of mean operating time, office visit numbers, use of more than 1 prescription drug, device removal, bathing and dressing problems, and other operation all favored medullary pinning.	"The two most important measures of outcome, patients complaints and cost, were significantly lower with pinning than with external fixation and we now believe that medullary fixation is the treatment of choice for these fractures."	Non-clinical outcomes favor medullary pinning.
Internal Fixation						
Hahnloser 1999 RCT No mention of sponsorship or COI.	6.0	N = 46 (11 males/35 females) with unstable commin-uted fracture of distal radius; Mean Age Group 1: 53.8 (17-77). Group 2: 58.2 (23-77).	Internal fixation via two 1/4 tube plates vs. [pi]-plate.	43% of [pi]-plates were too large and 19% could not be matched properly to distal radius. Range of wrist motion of the operative wrist expressed in percentage of the normal contralateral side: [pi]-plaster/tube plates Flexion 68 (±26 SD)/ 85 (±15); Extension 67 (±23)/ 86 (±12).	"With open reduction, cancellous bone grafting, and internal plate fixation in comminuted distal radial fractures, excellent results can be achieved. In our experience, we cannot recommend the [pi]-plate in its current shape and prefer to stabilize distal radius fractures and dorsal fragment dislocations with two 1/4 tube plates."	Recommendation against pi-plate for internal fixation.

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Ekenstam 1989 RCT Financial support given by the Disabilities Committee of the Swedish insurance companies.	5.0	N = 41 (10 males/31 feamles) with Lidström Group Iia+c or Frykman Groups II and VI; Mean Age Group 1: 49 (16-68). Group 2: 53 (18-69).	Triangular ligament was repaired after closed reduction (Group A) vs. closed manipulation and above-elbow cast (Group B).	Clinical examination results controls/group B/group A mean (SD): Strength 60(22)/58 (18)/59(25); Flexion 68(11)/58(11)/57(15). No difference for any part of clinical exam for 2 treatment methods.	"Repair of the ruptured triangular ligament in extraarticular fractures of the distal radius is not better than conventional treatment."	Dropout rate unclear. Randomization and baseline comparability not clear.
External Fixation vs. Bone Cement						
Schmalholz 1989 RCT No mention of Sponsorship or COI.	6.0	N = 47 (o males/47 feamles) with Frykman Types 1 and 2 that redislo-cated after two reduct-ions; Median Age Group 1: 66 (47-80). Group 2: 70 (55-81).	Bone cement (methylmethacryla te) (Group 1) vs. plaster cast (Group 2).	21/24 patients in Group 1 and 10/23 in Group 2 recovered full dorsiflexion; 8 in Group 1 and 1 in Group 2 regained full strength. Wrist appearance satisfactory for all in Group 1/none in Group 2 at 8 weeks. Group 1 function excellent in 6, good in 17, and fair in 1; Group 2 saw good in 2, fair in 12, and poor in 9. (p <0.001).	"The operated on group were better with regard to all objectively measurable characteristics; all operated on fractures had healed radiographically, and the cement was surrounded by cortical bone."	Description of 2nd study sounds similar. Unclear if these 2 reports represent one trial with 3 arms split into 2 reports.
Schmalholz 1990 RCT No mention of Sponsorship or COI.	6.0	N = 48 (2 males/46 females) with redislocated Colles Fractures; Median Age Group 1: 67 (50-75). Group 2: 66 (50-81)	Dorsal bone deficiency filled with bone cement (methylmethacrylat e) (Group I) vs. external fixation (Group II).	Surgery on day 16 (median 16, range 14-18) in both groups. Group 1 (cement) had significant improvement in volar flexion, supination, pronation, and grip strength first 2-4 months post treatment. At 6 months all differences equalized. Group II, 24% had complications; none in Group I.	Final results equal in the 2 groups, but Group I improved earlier and had no complications.	Open reduction and bone cement appears more effective than external fixation.
Sanchez-Sotelo 2000 RCT No sponsorship or COI.	5.0	N = 110 (13 males/97 females) with distal radius fractures; Mean Age, Norian SRS: 65.18 ± 6.10, control	Remodellable bone cement (Norian SRS) and cast for 2 weeks vs. closed reduction and cast for 6 weeks.	Mean ranges of movement and mass grip strength as percentages of normal side. Norian SRS/Control: Extension 6 weeks 65.09±8.26/40.67±6.06 (p <0.001); 1 year 95.7±3.2/ 90.1±3.4 (p <0.01). Flexion 6 weeks 53.84±5.51/43.60±5.93 (p <0.001); 1 year 86.2±3.41/77.8±4.2 (p	"The injection of a remodellable bone cement into the trabecular defect of fractures of the distal radius provides a better clinical and radiological result than conventional treatment."	Positive study for the use of remodellable bone cement over immobilization.

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		group 66.87 ± 6.56.		<0.01). Grip Strength 6 weeks 38±4.43/21.42±4.87 (p <0.001); 1 year 92.3±4.32/80.3±7.3 (p <0.001). Radio-ulnar pain Norian SRS/ Control: 3 months 45 (81.8 %)/ 30(54.5%); 12 months none 49 (89.1%)/ 38 (69.1%). Complication Norian SRS/ Control: Malunion 10 (18.2%)/23(41.8%); Reflex sympathetic dystrophy 3(5.4%)/4 (7.3%).		
Kopylov 2001 RCT Study supported by Norian Corp., Greta and Johan Kocks Stifelse, the Medical Faculty of Lund University and the Swedish Medical Research Council.	4.0	N = 23 (No mention of Gender) osteo-porotic patients with distal radial fracture; Mean Age 68 in SRS group, 65 in external fixation.	External fixation vs. Norian SRS	Clinical findings reported in 1999 study. Stereometric findings are reported here. In all fractures there was a good correlation (r2 = o.93, p = 0.0001) between longitudinal radiostereometric analysis displacement from the first to last investigation.	"Stereometric analysis showed that 5 weeks of immobilization is sufficient for healing with external fixation in this age group. Treatment of the fracture with Norian SRS might reduce the immobilization time to 2 weeks but additional hardware may have to be used to ensure stability of the fracture system."	Second report on population.
Kopylov 1999 RCT Study Supported by Norian Corp. and the Swedish Medical Research Council	4.0	N = 40 (36 men/4 women) with distal radial fractures; Mean age 67.5.	Stabilized with SRS injection and immobilized with cast for 2 weeks vs. externally fixed with Hoffman's bar for 5 weeks	"SRS can be used in the treatment of unstable distal radial fractures. The more rapid recovery of grip strength and wrist mobility in the SRS group appears to be due to the shorter immobilization time."	"The shorter immobilization time with SRS permitted earlier return of hand function. The question remains whether early mobilization by itself is enough to reach a good final result, even in the absence of fixation with SRS. That question is addressed in an ongoing study."	No differences were found at 2 years in grip strength or mobility.
Beginning of New RCTS						
Atroshi 2006	7.5	N=38 (7 males/31 females)	Group 1 (N=19) patients treated	No significantly different results in the mean DASH scores between both groups. No difference in	"The lack of a clear clinically relevant advantage	Data suggest similar efficacy between groups but non-

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RCT Research supported by grants from Region Skane, Sweden. No COI.		dorsally displaced distal radius fracture; Mean Age, Group 1: 71 (57-84). Group 2: 70 (55-86).	with wrist-bridging fixation. Vs Group 2 (N=19) patients treated with non-bridging external fixation. Follow Up at 10, 26, and 52 weeks after surgery.	patient satisfaction, or pain between groups. No difference in range of motion between groups, No significant different between grip strength.	does not support non-bridging fixation instead of bridging fixation for older patients with distal Radius fracture."	bridging external fixation group better for maintaining radial length in several displaced radial fractures in the elderly.
Wei 2009 Prospective Randomized trial In support of their research for or preparation of this work, one or more of the authors received, in any one year, outside funding or grants in excess of $10,000 from the Doris Duke Clinical Research Fellowship. Received benefits from BiometEBI.	7.0	N=46 (13 males/33 females) patients with an unstable distal radial fracture; Mean Age Group 1: 58 ± 17.	Group 1 (N=22) patients treated with external fixation Vs Group 2 (N=12) patients treated with a radial column plate. Vs Group 3 (N=12) patients treated with a volar plate. Follow up at 10-14 days, 6 weeks, and 3, 6, and 12 months post-op.	Disabilities of the Arm, Shoulder and Hand (DASH) results, 6 weeks, group 3 vs group 1; 41 ± 23 vs 56 ± 19 (p=0.037). DASH 3 months group3 vs group 2 and vs group 1; 7 ± 5 vs 28 ± 17 (p=0.027), and 29 ± 18 (p=0.028). DASH at 1 year, group 3 vs 1 and 2; 4 ± 5 vs 18 ± 14 (p=0.025) and 18 ± 12 (p=0.056). Grip Strength (percentage value compared to uninjured side, at 6 months, group 1 vs 2; 75 ± 21 vs 53 ± 9 (p=0.042). Lateral pinch (% vs uninjured side); group 2 vs 3, at 3 months and 12 months. 66±14 vs 86±13 (p<0.042), 73±8 vs 94±5 (p<0.036). Range of motion; Extension, group 1 vs group 3 and 2 (degrees), 6 weeks; 10 vs 38 & 32 (1 v 3 p=0.023), (1 v 2 p=0.032), respectively. Supination (degrees), group 1 vs 2 and 3, 6 weeks; 34 vs 57 and 55 (1 v 2 p=0.041), (1 vs 3 p=0.049) respectively. Radiographic Measurements; Radial inclination (deg), group 2 v 3, 6 weeks; 25.0±5.2 vs 21.1±7.0 (p=0.003). Radial Length (mm), group 1 vs 2,	"In conclusion, this study provides new evidence supporting the trend toward fixation of distal radial fractures with locked volar plates."	Data suggest the use of a locked volar plate resulted in better patient reported outcomes at 3 months but at 6 months and 12 months, all 3 groups had good outcomes in terms of ROM, strength and radiographic alignment but the radial column plate group had significantly better radial inclination and length compared to other 2 groups.

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				6 weeks; 11.4±2.1 vs 13.0±3.5 (p=0.038). Radial Inclination (deg), group 2 vs 1, at 12 months; 29.5±5.2 vs 20.9±3.4 (p=0.007). Group 2 vs 3; 29.5±5.2 vs 17.6±2.1 (p=0.003). Radial Length (mm), group 2 vs 1, 12 months; 16.5±3.5 vs 10.8±2.1 (p=0.002). Group 2 vs 3; 16.5±3.5 vs 9.5±2.7 (p=0.027).		
Egol 2008 Prospective Randomized Trial No sponsorship or COI.	7.0	N=88 (41 males/47 females) patients with a distal radius fracture that needed operative repair; Mean Age Group 1 49.9 (18-78). Group 2 52.2 (19-87).	Group 1 (N=38) patients that received external fixation and supplementary K-Wire fixation. Vs Group 2 (N=39) who were treated with volar plating.) Follow up at 2, 6 weeks, then at 3, 6, 12 months.	The mean DASH score in any of the intervals. For all parameters, as a percentage of the injured side, the range of movement was better in internally-fixed group; pronation (p<0.001), supination (p=0.05), extension (p=0.05), radial deviation (p=0.002), reached statistical difference at 3 months. Similar complications.	"None of the improvements was associated with a better outcome. Furthermore, while the number of complications between the two methods was similar, there was a greater incidence for re-operation in the plating group. Despite this finding, our study showed no evidence for the superiority of one treatment over the other."	Data suggest similar efficacy between groups but less re-operations were required in the external fixation group.
Rozental 2009 Prospective Raqndomized Trial No sponsorship or COI.	6.5	N=45 () patients with an unstable fracture of the distal radius; Mean Age Group 1: 51 (19-77). Group 2: 52 (24-79).	Group 1 (N=23) patients treated with open reduction and internal fixation Vs Group 2 (N=22) patients treated with Closed reduction and percutaneous pinning. Follow up at 6, 9, 12 weeks, and 1 year.	Range of Motion Parameters (deg), group 1 vs 2, 6 weeks; Extension: 45±20 vs 16±13 (p<0.01). Flexion: 50±12 vs 26±16 p<0.01). Supination: 79±21 vs 40±29 (p<0.01). Pronation: 77±17 vs 63±26 (p=0.04). Ulnar Deviation: 27±10 vs 15±11 (p<0.01). Radial Deviation: 15± vs 7±6 (p<0.01). Grip Strength (% vs uninjured arm), group 1 vs 2, 6 weeks; 49.3±20.9 vs 25.6±30.1 (p<0.01). Pinch Strength (% vs uninjured arm), group 1 vs 2, 6 weeks; 59.1±25.8 vs 38.8±27.0 (p=0.01). DASH Score, group 1 vs 2, 6 weeks; 27±17 vs 53±28 (p<0.01). 9 weeks; 17±17 vs 39±25 (p<0.01). 12 weeks: 11±13 vs 26±23 (p=0.01). No significant difference between radiological outcome,return to	"The present study confirms the hypothesis that volar plate fixation results in less functional disability in the first few months after treatment than does percutaneous pin fixation. At one year after the injury, we did not identify a difference between the treatment groups with regard to functional or radiographic outcomes."	Data suggest similar efficacy between groups but better early outcome results in the open reduction external fixation group with fewer overall numbness of complications.

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				work/life activities, or complications.		
Grewal 2011 RCT No sponsorship or COI.	5.5	N=50 (12 males/38 females) Patients with fractures of the distal radius; Mean age Group 1: 58.0 ± 9.9. Group 2: 53.8 ± 11.7.	Group 1 (N=26) patients treated with open reduction and internal fixation. Vs Group 2 (N=24) patients with external fixation procedures. Follow up at baseline, 6 weeks, and 3, 6, 12 months.	Group 1 scored 11 points lower on Patient-Rated Wrist Evaluation (PRWE) throughout whole study, except at 12 months (p=0.03). Group 1 vs 2 (specifically Volar locking plates) had significantly lower PRWE scores at baseline (p=0.03) and 6 weeks (p=0.06). No difference in radiological parameters, range of motion, grip strength, and complications.	"[O]ur trial suggests that ORIF (Group 1) provides a short-term advantage over external fixation, but these differences do not persist over time. Our results are viewed with caution, given that the ORIF group also reported lower pain and disability at the initial preoperative assessment and because the trial had a small sample size."	Data suggest ORIF group better than external fixation in short term but at 1 year, the results equalize among groups.
Krishnan 2003 Prospective RCT No mention of sponsorship or COI.	5.5	N=60 (19 males/ 41 females) patients with intra-articular fractures of the distal radius; Mean age Group 1: 58 (18-82) vs Group 2: 55 (19-83).	Group 1 (N=30) pinned with a "Delta" frame and instructed to do wrist exercises Vs Group 2 (N=30) pinned in the "Hoffman" style and were not able to move wrist. Follow Up at 1, 6, 12, 26, 52 weeks.	No statistical difference between groups in extension, ulnar deviation, pronation and supination, grip strength, comparable complications in both groups except for rupture of extensor pollicis brevis tendon.. Flexion, Group 1 vs Group 2 at 6, 26, and 52 weeks median (range) in deg; 28 (10-60) vs 35 (10-90) (p,0.02), 45 (30-95) vs 55 (40-95) (p=0.008), 50 (25-100) vs 60 (45-100) (p=0.02). Radial deviation, group 1 vs Group 2, at 6 weeks; favored group 1 (p=0.002). Completing daily activities was better in group 2 than group 1 (p=0.034) at week 2.	"In conclusion, this study demonstrated that the outcomes of patients with complex unstable intraarticular fractures of the distal radius are similar, regardless of whether they are treated with a static bridging external fixator or a dynamic non-bridging external fixator."	Data suggest comparable efficacy between groups.
Abramo 2009 RCT Supported by Region Skane, Lund University	5.5	N=50 (14 males/36 females) patients with unstable of comminute distal radius fractures; Mean Age 48 (20-65).	Group 1 (N=25) who were treated with Open reduction and internal fixation Vs Group 2 (N=25) who were treated with closed	Grip strength (% vs uninjured arm), group 1 vs 2, 7 weeks; 47% vs 34% (p=0.01). Forearm rotation (deg), group 1 vs 2, 7 weeks; 129 vs 104 (p=0.006). Grip strength (% vs uninjured arm), group 1 vs 2, 1 year; 90 vs 78 (p=0.03). Forearm rotation (deg), group 1 vs 2, 7 weeks; 149 vs 136 (p=0.03). No	"[T]he two methods we compared will both give a good result with good DASH values, good grip strength, and good range of motion after a year. Overall, considering the subjective and objective results	At 1 year, data suggest internal fixation group had better ROM, grip strength and fewer malunions than external fixation group.

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Hosptial, the Swedish Medical Research Council, Alfred Osterlund foundation, the Great and Johan Kock Foundation, Maggie Stephens Foundation, Thure Carlsson Foundation, faculty of Medicine at Lund University.			reduction and external fixation. Follow up at 2, 5, 7 weeks, and 3, 6, 12 months.	significant differences found between groups in regards to DASH scores. Patients with moderate-heavy manual work had more days at home in group 2 vs group 1, (p=0.04).	as well as the rate of major complications and the sick-leave, we believe that internal fixation gives a superior result and in our opinion it would be the method of choice;"	
Cassidy 2003 Randomized Prospective Trial One of more of the authors received grants or outside funding from the Norian Corporation. Three authors were employees of Norian.	5.0	N=323 (51 males/272 females) patients who had sustained a displaced and/or unstable distal radial fracture; Mean Age Group 1: 63.5 ± 11. Group 2: 63.7 ± 12.	N=161 patients treated with Norian SRS cement and a closed reduction. (Group 1) Vs N=162 patients treated only with closed reduction and either external fixation or cast immobilization (Group 2). Follow up evaluations were specified at 1, 2, 4, and 6-6 weeks, also at 3, 6, and 12 months.	Group 1 v Group 2 subjective pain rating difference; Group 1 lower at 2 and 4 weeks, (p=0.02, p=0.02, respectively). Group 1 required less pain medicine at 2 weeks (p=0.004). Group 1 vs Group 2 grip hand strength at 6-8 weeks, 18 lb vs 10 lb (p<0.0001). Group 1 at 6-8 weeks had better digital range of motion (p<0.01). Group 1 had significantly less swelling of forearm at 2 weeks, (p=0.0146), and various digits at 6-8 weeks. Jebsen dexterity test, Group 1 dominant hand fracture at 6-8 weeks took lees time to pick up small objects (p=0.0023). Group 1 vs group 2, ulnar variance at 12 months. 2.0 vs 1.4 (p=0.02). Complications largely due to loss of reduction, no significant difference in complications between groups.	"Our data suggest that Norian SRS cement provides adequate fixation for the majority of distal radial fractures to permit early wrist mobilization."	Data suggest Norian SRS cement is beneficial for most distal radial fractures and may allow faster recovery due to accelerated rehabilitation. The control group experienced a significantly higher number of post procedure infections.

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Földhazy 2010 RCT No mention of sponsorship or COI.	5.0	N=59 (6 males/53 females) with displaced fractures of the distal radius; Mean Age Group 1: 70 (62-81) Group 2: 73 (60-85).	Group 1 N=29 patients treated with open reduction and internal fixation with plaster casting. Vs Group 2 (N=22) Patients treated with closed reduction and external fixation. Follow up at 2, and 5 weeks, 2, 6, and 12 months.	No significant difference in Clinical outcomes, and complications. Slightly better dorsal extension and radial deviation in group 1 at final follow up (p=0.036 and p=0.043, respectively). Final dorsal angulation, group 2 vs 1, 1 year; 11±9 vs 20±14 (p=0.001).	"[W]e believe that the results of this prospective, randomized and comparative study are that in 60--85 year old patients, with a displaced distal radial fracture after low energy trauma, no obvious clinical benefit could be demonstrated using closed reduction and external fixation as compared with closed reduction and plaster treatment."	Data suggest comparable efficacy between groups although primary external fixation group showed a positive radiographical effect. However, one third of the external fixation group had a complication.
Kreder 2005 RCT Supported by a Grant from the Orthopaedic Research and Education Foundation, Orthopaedic Trauma Association and Sunnybrook Trust Fund.	5.0	N=179 (109 males/70 females) skeletally mature patients with displaced intra-articular fractures of the distal radius; Mean Age Group 1: 40 (20-78). Group 2: 39 (20-81)	Group 1 (N=88) patients treated with Closed reduction and K-Wore Fixation. Vs Group 2 (N=91) Patients treated with open reduction and internal fixation. Follow up at 6 weeks, 12 and 24 months.	Patients in group 1 had better function overall, scoring a mean of 6 points (95% CI: 4.1-33.0) in Musculoskeletal Functional Assessment (MFA). Pain scores were better overall for group 1 (p=0.052) NS. MFA, group 1 vs 2, 6 months; 15.1 vs 37.9 Difference: -12.8 (95% CI: -23.7 - -1.9). Grip Strength, group 1 vs 2, improved throughout study by 10.1 lb (p=0.05).	"[W]e recommend that open reduction be preceded by an attempt at minimally invasive percutaneous reduction. If an acceptable reduction is achieved then open reduction is unnecessary and function will be superior."	Significant loss to follow up. Data suggest that at 2 years of the intra-articular step and gap were minimized, the indirect reduction and percutaneous fixation group had a quicker return of function with better functional outcomes.
Arora 2011 Prospective Randomized Trial No sponsorship or COI.	4.5	N=73 (18 males/55 females) with distal radial fracture that were unstable; Mean Age 76.7 (65-89).	Group 1 (N=36) individuals who were treated with open surgery and fixed with K-Wire, volar locking plate, or DVR. Vs	No significant differences in clinical parameters. Significantly more complications in the operative treatment group (p<0.05). DASH scores, 6 weeks group 1 vs 2; 18.8±17.9 vs 34.4±22.5 (p<0.001). Patient-Rated Wrist Evaluation (PRWE) scores at 6 weeks; group 1 vs 2; 36.4±28.7 vs 64.9±29.0 (p<0.001). DASH	"Volar fixed-angle plate systems have made plate osteosynthesis popular for elderly individuals with osteoporotic bones. However, at twelve months after surgery, the active range of motion, the pain level, and the PRWE and the DASH	Data suggest at 12 months, ROM, pain level and PRWE and DASH scores equivalent. Patients in surgical group reported better grip strength throughout trial.

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			Group 2 (N=37) individuals casted for 5 weeks. Follow up at 6 and 12 weeks, as well as 6 and 12 months.	Scores at 12 weeks, group 1 vs 2; 13.3±14.8 vs 23.2±19.3 (p=0.02). PRWE score at 12 weeks, group 1 vs 2; 33.7±32.0 vs 54.4±31.8 (p=0.01). Last follow up, dorsal tilt, radial inclination, radial shortening, and intra-articular step-off were significantly better, and loss of reduction was significantly lower in group 1 (p<0.05).	scores were not different between the operative and nonoperative treatment groups."	
Karantana 2013 RCT No sponsorship or COI.	4.5	N=130 (no mention of gender) patients with a distal radial fracture; Mean Age not listed (18-73)	Group 1 (N=64) patients treated with open reduction and volar plating. Vs Group 2 (N=66) patients treated with closed reduction and external fixation. Follow-Up at 6, and 12 weeks, also at 1 year.	Patient evaluation measure (PEM), group 1 vs 2, 6 weeks; 34±13 vs 45±12 (p<0.001). Quick Dash, group 1 vs 2, 6 weeks; 41±21 vs 52±20 (p=0.002). Grip Strength (% vs uninjured arm), group 1 vs 2, 6 weeks; 40±23 vs 10±12 (p<0.001). 12 weeks; 65±26 vs 45±22 (p=0.002). 1 year; 95±22 vs 84±19 (p=0.005). Range of Motion, group 1 vs 2, 6 weeks; Extension (deg): 57±22 vs 17±30 (p<0.001). Felxion (deg): 59±18 vs 47±22 (p=0.001). Pronation (deg): 80±17 vs 65±28 (p=0.001). Supination (deg): 73±23 vs 37±26 (p<0.001). More complications within group 2; (p=0.047).	"In conclusion, use of a volar locking plate resulted in a faster early postoperative recovery of function compared with that following closed reduction and percutaneous wire fixation. However, there was no significant difference at or after twelve weeks."	Data suggest comparable efficacy at 3 months and 1 year post procedure. The volar locking plate group did demonstrate some increased grip strength as well as anatomical improvement but these results were not significant.
Leung 2008 RCT In support of their research for or preparation of this work, one or more of the authors received, in any one year, outside funding or	4.0	N= 137 (85 males/52 females) with an acute intra-articular of distal radial fracture; Mean Age 44.	Group 1 (N=74) fractures that were treated using external fixation and percutaneous pinning. Vs Group 2 (N=70) fractures that were stabilized with plates. Follow-Up 6, 12, and 24 months.	Gartland and Werley point system results, group 1 vs group 2 at 24 months; 39% excellent, 55% good, 6% fair, 0% poor, vs 67% excellent, 30% good, 3% fair, 0% poor (p=0.04). Arthritis grade, group 1 vs group 2, at 24 months; 24% grade-0, 65% grade-1, 15% grade-2. Vs 44% grade-0, 52% grade-1, 4% grade-2 arthritis (p=0.001).	"[W]e have demonstrated that open reduction and plate fixation is a better way to treat intra-articular distal radial Fractures than is external fixation and percutaneous fixation."	Data suggest plate fixation at 2 years was better than external fiaxation plus percutaneous pin fixation for the treatment of intraarticular distal radial fractures.

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grants in excess of $10,000 from the AO Research Institute.						
Grewal 2005 Prospective Randomized Trail No sponsorship or COI.	4.0	N=62 (33 males/29 females) with AO type C intra-articular distal radius fractures; Mean age Group 1: 45 ± 2.7. Group 2: 46 ± 2.7.	Group 1 (N=29) were treated with Open reduction and internal fixation. Vs Group 2 (N=33) were treated by mini open reduction with percutaneous K-Wire fixation. Follow up at 2, 4, 6, 10-12 weeks, 6 months, and 1, 2 years.	Complication Rate, Group 1 vs 2; 72.4% vs 24.2% (p=0.004). Grip Strength (% vs uninjured arm), group 1 vs 2, 86% vs 97% (p=0.019). Range of motion not significantly different. Radiographic outcomes not statistically different. Pain scores (DASH), group 1 vs 2, at 1 year; 22.1 vs 10.0 (p=0.02). after hardware taken out in some of the group 1 patients pain scores equalized at 2 years.	"Although dorsal Pi plates still may have a role in treating intra-articular distal radius fractures we have shown that mini open reduction with percutaneous K-wire and external fixation is a technique that provides a safe and effective alternative to open reduction and dorsal Pi plating when treating comminuted intra-articular distal radius fractures."	Data suggest comparable efficacy between groups with the dorsal plate groups having greater numbers of complications.
Jeyam 2002 RCT One of the authors was supported by funding from Orthofix PLC.	4.0	N=21 (0 males/21 females) with distal radial Melone fractures type 1 and 2; Mean age Group 1: 74. Group 2: 71.	(N=9) fracture was stabilized by K-wire using intrafocal technique, then castred for 4 weeks. (Group 1) vs (N=9) fracture site was cleaned and injected with Orthofix Bone source bone cement (Group 2). Follow-Up at 1 day, and 1, 23, 6, 12, and 26 weeks.	Group 2, 1 week all three radiological parameters had deteriorated. Group 1 Vs 2, dorsal angle at 1 week, -7 (-19-6) and 6 (-5-15) (p<0.05) remained significant throughout the entire study. Radial angle worse in group 2, not significant. Group 1 vs Group 2, Grip strength at 6 months: 11 (6-17) vs 8 (4-10) (p<0.03).	"The results of this small study clearly indicate that hydroxyapatite cement (Bonesource) does not provide adequate fracture stability when used alone."	Data suggest that at 12 and 26 weeks, the hydroxyapatite group performed worse on grip strength, palmar flexion and dorsal flexion. There were no outcome measures where this group performed better.

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Ganglion Cyst

Special Studies and Diagnostic and Treatment Considerations

There are no quality randomized trials for diagnostic testing in the evaluation of ganglia of the upper extremity. Generally, diagnosis is based on physical examination findings. Diagnosis is usually confirmed upon aspiration of mucinous fluid from the mass.

X-RAYS

1. *Recommendation: Routine X-rays for Diagnosis of Wrist Ganglia*
   X-ray to diagnose dorsal or volar wrist ganglia in select patients is recommended.

   Indications – Ganglia, especially occurring in the context of trauma where fracture may be present.
   Frequency/Duration – Obtaining x-rays once is generally sufficient.

   Strength of Evidence **– Recommended, Insufficient Evidence (I)**
   Level of Confidence – Low

2. *Recommendation: Routine Use of X-rays for Evaluation of Dorsal or Volar Wrist Ganglia*
   The routine use of x-ray to evaluate dorsal or volar wrist ganglia is not recommended.

   Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
   Level of Confidence – Moderate

Rationale for Recommendations
Patients develop ganglia for numerous reasons, ranging from trauma to arthritis to idiopathic. The threshold for obtaining x-rays should be low. Patients incurring ganglia due to trauma or other inciting events that may result in other traumatic sequelae such as fractures, dislocations, and sprains, should have x-rays. Patients incurring ganglia through non-traumatic means are candidates for initial management without x-rays. Some practitioners advocate the use of x-rays for routine evaluation of all patients with dorsal or volar wrist ganglia. However, there is no supporting evidence for this practice. In a prospective case series of 103 patients with volar and dorsal ganglia, three view wrist radiographs were obtained and a retrospective review of medical records completed. Findings on x-ray altered the course of management in 1 case (1%).(1338)

Evidence for the Use of X-rays
There is 1 low-quality study included in Appendix 2.(1439) (Sakamoto 13)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Ganglion, Cyst, Cysts, Xray, X-ray, diagnostic, diagnosis, sensitivity, specificity, positive predictive value, negative predictive value, and predictive value of tests, efficacy, and efficiency. We found and reviewed 371 articles in PubMed, 298 in Scopus, 2 in CINAHL, 0 Cochrane Library, and 3240 from Google Scholar. We considered for inclusion 1 from PubMed, 1 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 0 from Google Scholar, and 0 from other sources. Of the 3911 articles considered for inclusion, 1 met the inclusion criteria.

MRI

Recommendation: MRI for Evaluation of Wrist Pain with Suspected Occult Dorsal or Volar Wrist Ganglia
There is no recommendation for or against the use of MRI for the evaluation of wrist pain with suspected occult dorsal or volar wrist ganglia as it may be of limited benefit in deciding on the course of treatment.

Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**
Level of Confidence – Low

Rationale for Recommendation
In a small study of 20 patients with suspected occult ganglia, an MRI was obtained prior to surgical exploration and excision of the cyst. Comparison of MRI diagnosis with intra-operative findings and histological evaluation of the excised specimen resulted in MRI scanning sensitivity of 83%, specificity of

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50%, and a positive predictive value of 94%.(292) The findings suggest in the absence of palpable mass, with no history of trauma or other conditions such as arthritis, an MRI may be beneficial for the diagnosis of occult symptomatic ganglia. However, in light of the results reported by Lowden,(114) which found nearly half of the asymptomatic population have an occult ganglia, the accuracy of these findings for screening purposes are questionable and the utility of a positive result may be of less clinical consequence. MRI may be useful in distinguishing synovitis from ganglion, which may be useful in determining the course of treatment.(1339) MRI is reasonable for patients who have had persistence of pain consistent with a ganglion lasting at least 3 weeks without trending towards improvement.

Evidence for the Use of MRI

There are 4 moderate-quality studies incorporated into this analysis.(1440-1443) (Anderson 06; Goldsmith 08; Vo 95; Cardinal 94)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: MRI, Magnetic resonance imaging, Ganglion Cyst, Wrist, hand, Ganglion, ganglia, dorsal, volar, diagnostic, diagnosis, sensitivity, specificity, positive predictive value, negative predictive value, and predictive value of tests, efficacy, and efficiency. We found and reviewed 19 articles in PubMed, 2037 in Scopus, 1 in CINAHL, 8 Cochrane Library, and 40 from Google Scholar. We considered for inclusion 0 from PubMed, 3 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 0 from Google Scholar, and 1 from other sources. Of the 4 articles considered for inclusion 4 diagnostic studies met the inclusion criteria.

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Author/Year Study Type	Score	Number	Area of Body	Diagnoses	Type of MRI used	Type of CT used	T1 weighted	T2 weighted	X-ray	Myelography	More than one	Surgery	Clinical outcomes assessed	Long term follow-up	Results	Conclusion	Comments
Anderson 2006 Retrospective	6.0	34 patients 23 women 11 men Mean age = 29.5	Wrist	Dorsal occult ganglion cyst	1.5-T superconducting magnet	-	+	+	+	-	+	+	-	-	35 abnormalities were diagnosed with MRI: 25 ganglia, 16 dorsal occult ganglia and 6 synovitis. Surgery confirmed MRI diagnosis with an overall agreemtn of 71% (95% CI, 0.38-0.76) Sensitivity to ganglia was 89% (95% CI 56%-99%) to dorsal occult ganglia cysts was 94% (95% CI 70%-100%)	"MRI is accurate in preoperatively distinguishing between ganglion and synovitis in the setting of chronic dorsal wrist pain"	Data suggest MRI is useful preoperatively in distinguishing between synovitis and occult ganglia particularly in cases of chronic wrist pain and edema.
Goldsmith 2008 Retrospective	5.5	20 patients 20 wrists	Wrist	Occult dorsal wrist ganglion cyst	Siemens' 1.5 T imager	-	+	+	+	-	-	+	-	-	MRI found 16 of 20 wrist had an occult ganglion. Surgery was performed	"MRI scans provide relatively good reliability in establishing the	Data suggest MRI is a good technique for visualizing occult

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		11 women 9 men Mean age = 36													on all 20 patients, identifying 18 occult ganglions. 16 of the 20 wrists had histological features of a ganglion cyst. The 4 negative MRI were positive and 3 of the 18 positive in surgery were negative. MRI at the time of surgery provided a sensitivity of 83%, a specificity of 50% and a PPV of 94%. However, when evaluated with histological findings, the sensitivity was 80%, specificity was 20%, the PPV	diagnosis of an occult dorsal wrist ganglion"	dorsal wrist ganglia.

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															was 75% and the accuracy was 65%.		
Vo 1995 Retrospective	4.0	14 patients with chronic dorsal pain No mention of age or gender	Wrist	Chronic Dorsal Wrist pain of unknown etiology	1.5-Tesla General Electric Signa	-	+	+	-	-	-	+	+	-	10 of 14 were positive for occult dorsal wrist ganglion on the MRI. 7 of the 10 MRI positive patients underwent surgery after nonoperative treatment failed and was confirmed as positive though histological examination. One of the positive patient developed a palpable ganglion. The two other positives were not confirmed.	"The use of a properly formatted high-resolution MRI in this patient population was diagnostic for occult dorsal wrist ganglion."	Small sample. Data suggest in the presence of a negative clinical workup, MRI is useful in detecting occult dorsal wrist ganglia.

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															The PPV is 100%		
Cardinal 1994 Prospective	4.0	14 wrists in 13 patients Mean age = 30 9 women 4 men	Wrist	Occult dorsal carpal ganglion	1.5-T Imager, Signa Advantage	-	+	+	-	-	-	+	-	-	US identified 11 dorsal carpal ganglion cyst while MRI identified 9. One patient that was positive on US denied a MRI. The other US positive had an inconclusive diagnosis of a ganglion. Five of the cases were confirmed by surgery. One ganglion was missed by both imaging techniques.	"MR imaging and US are equally effective in the detection of occult dorsal carpal ganglia."	Small sample. Data suggest comparable efficacy between MRI and US for detecting occult dorsal carpal ganglia.

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ULTRASOUND

Recommendation: Ultrasound for Evaluation of Chronic Wrist Pain with Suspected Occult Dorsal or Volar Wrist Ganglia

There is no recommendation for or against the use of ultrasound for the evaluation of chronic wrist pain with suspected occult dorsal or volar wrist ganglia. It may be beneficial in select cases in deciding on the course of treatment.

Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**
Level of Confidence – Low

Rationale for Recommendation

In a small study of 57 patients with non-traumatic wrist pain and no palpable mass, ultrasound was used to determine the presence of ganglia at the wrist – 33 patients (58%) were found to have a ganglia of which 20 were treated with excision or aspiration and improvement of symptoms after the intervention. As MRI has demonstrated the prevalence of ganglia in asymptomatic study volunteers to be nearly 50%,(114) there is likely a high probability of finding ganglia on ultrasound as well. Thus, a positive finding of ganglion by ultrasound is of unknown clinical significance, particularly in that the study did not provide long-term follow-up for all of the patients that were found to have a ganglion cyst. If ultrasound is utilized, it would appear to be reasonable among patients who have had persistence of pain lasting at least 3 weeks without trending towards improvement.

Evidence for the Use of Ultrasound

There is 1 moderate-quality study incorporated into this analysis.(1444) (Osterwalder 97)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: ultrasonography, ultrasound, sonography, ganglion cysts, ganglion, ganglia, dorsal, volar, hand, wrist, diagnostic, diagnosis, sensitivity, specificity, positive predictive value, negative predictive value, and predictive value of tests, efficacy, and efficiency. We found and reviewed 43 articles in PubMed, 94 in Scopus, 0 in CINAHL, 7 in Cochrane Library, and 2,190 from Google Scholar. We considered for inclusion 1 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 0 from Google Scholar, and 0 from other sources. Of the 1 article considered for inclusion 1 diagnostic study met the inclusion criteria.

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Author/Year Study Type	Score	Number	Area of Bdoy	Diagnoses	Type of Ultrasound	CT used	MRI Used	More than on rater	Blinding of rater	Myelography	Surgery Performed	Clinical outcomes	Long term follow-up (mean when noted)	Results	Conclusion	Comments
Osterwalder 1997 Diagnostic	6.0	N = 168; mean age = 27 (52 male, 116 female)	Wrist	suspected occult wrist ganglion who complained of wrist pain and palpation findings were inconclusive	For first three years - Aloka model SSD-6202S, for last two years - Hitachi model EUB-55S, both models used 7.5-MHz linear transducer and spacer	-	+	-	-	-	+	-	-	Out of the 168 patients examined by ultrasound 68 were diagnosed with a cyst and 85 were diagnosed with absence of a cyst. In 15 patients the diagnosis was not clear enough to get a definitive answer. Ultrasound sensitivity, specificity, accuracy, positive predictive value and negative predictive values plus the 95% confidence intervals were the following: 88% (73-96%), 85% (64-95%), 87% (76-94%), 90% (75-97%), 83% (62-94%)	"It was concluded that ultrasound of the wrist can be used as a first-line imaging procedure in clinically inconclusive situations and that ultrasound evidence of an occult dorsal ganglion is a reliable indicator for surgery." "Only Cardinal et al. 8 specifically discussed MRI and ultrasound diagnoses of occult wrist ganglions. They reported that ultrasound allowed correct diagnosis in 5 positive ganglions and 1 false negative (2-mm) ganglion that MRI had indicated to be 4 positive, 1 false positive, and 1 false negative cases. It is therefore still uncertain whether the reliability of MRI for the diagnosis of occult wrist ganglions can approach that of ultrasound."	Data suggest US of wrist is useful for imaging inconclusive persistence wrist pain patients who are suspected of having an occult ganglion.

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Initial Care

1. *Recommendation: Non-operative Management (No Treatment) for Acute Asymptomatic Wrist and Hand Ganglia*
   The use of non-operative management (no treatment) for acute asymptomatic wrist and hand ganglia is recommended as first-line management as the natural history for spontaneous resolution is more than 50%, and in recognition of the high recurrence rate of most other treatment strategies.

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – Low

Rationale for Recommendation
There are many observational studies describing the natural history for ganglia to resolve without any treatment over time. More than 50% are likely to resolve within months to years. A recently published 6-year follow-up, reported a 58% spontaneous resolution rate in patients that received no intervention.(1340) Thus, in the asymptomatic patient, it is reasonable to provide patients reassurance that the mass is benign, and that the natural course is for most to resolve without treatment, making waiting a reasonable trial. However, patients may wish to have an intervention for cosmetic relief, and have reported higher satisfaction despite the higher risk of surgical or interventional complications.(1340)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: non operative management, no treatment, ganglion cyst, wrist, hand, ganglion, ganglia, dorsal, volar; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 56 articles in PubMed, 30 in Scopus, 0 in CINAHL, 3 in Cochrane Library, 12596 in Google Scholar, and 0 from other sources. We considered for inclusion 0 from PubMed, Scopus, CINAHL, Cochrane Library, Google Scholar, and 0 articles from other sources. Zero articles met the inclusion criteria.

2. *Recommendation: Aspiration (without Other Intervention) for Acute Cosmetic and Ganglia Related Pain*
   Aspiration (without other intervention) of the cystic fluid is recommended as it may result in immediate relief of acute cosmetic and ganglia related pain.

   Duration – One aspiration is recommended.(1341) However, a long-term course of aspiration is usually of no benefit in terms of resolution. There is no recommendation on how many times aspiration should be attempted before advancing to other intervention. Variants of simple aspiration include steroid injection, splinting, multiple punctures, hyaluronidase, and sclerosing agents, reviewed below.

   Strength of Evidence – **Recommended, Evidence (C)**
   Level of Confidence – Low

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: aspiration; ganglion cyst, wrist, hand, ganglion, ganglia, dorsal, volar; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 11 articles in PubMed, 29 in Scopus, 0 in CINAHL, 5 in Cochrane Library, 8,180 in Google Scholar, and 0 from other sources. We considered for inclusion 1 from PubMed, 0 from Scopus, 0 from CINAHL, 1 from Cochrane Library, 0 Google Scholar, and 1 from other sources. Of the 3 articles considered for inclusion, 2 randomized trial and 1 systematic studies met the inclusion criteria.

3. *Recommendation: Aspiration with Steroids*

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There is no recommendation for or against the addition of steroids with aspiration.

Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**
Level of Confidence – Low

Rationale for Recommendations
Aspiration with instillation of steroids is the most common treatment for upper extremity ganglia. Recurrence rates range from 14 to 83%. There are no quality studies that compare simple aspiration with the addition of steroids; thus, no quality evidence to address whether this results in potential benefits. However, a review of cohorts has shown an average recurrence rate of 51% for aspiration alone, and a recurrence rate of 52% with aspiration and steroids.(118) As the cystic structure has been shown histologically and with electron microscopy to have no synovial lining, but rather a network of collagenous fiber layers, there is little theoretical reason to believe that steroid agents would result in reducing inflammation, as there is theoretically no tissue in the cyst to be inflamed. There is no recommendation for or against steroids when aspiration is used for immediate relief.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Ganglion Cyst (wrist ganglia, dorsal or volar wrist ganglia), Aspiration with steroids; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 4 articles in PubMed, 15 in Scopus, zero in CINAHL, zero in Cochrane Library, 498 in Google Scholar, and zero from other sources. We considered for inclusion 3 from PubMed, zero from Scopus, zero from CINAHL, zero from Cochrane Library, zero from Google Scholar, and zero from other sources. Of the 3 articles considered for inclusion, 3 randomized trials and zero systematic studies met the inclusion criteria.

4. *Recommendation: Aspiration and Multiple Punctures of Cyst Wall*
   The technique of multiple punctures of the cyst wall is not recommended as it does not provide improved benefit over simple aspiration.

   Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
   Level of Confidence – Low

Rationale for Recommendation
There is one quality study comparing simple aspiration with multiple wall punctures,(1342) which did not show any significant difference in efficacy. A review of non-RCT studies comparing aspiration with multiple punctures showed an average of 64% recurrence rate, which is worse than aspiration alone.(118) Thus, there is no added benefit to making multiple punctures in the cystic wall, and may result in additional skin trauma and higher risk of infection, making this intervention not recommended.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Aspiration and multiple punctures of cyst wall, Ganglion Cyst (wrist ganglia, dorsal or volar wrist ganglia); controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed zero articles in PubMed, 2 in Scopus, zero in CINAHL, zero in Cochrane Library, 155 in Google Scholar, and zero from other sources. Zero articles met the inclusion criteria.

5. *Recommendation: Splinting after Aspiration for Acute or Subacute Dorsal or Volar Wrist Ganglia*
   There is no recommendation for or against the use of splinting after aspiration for the treatment of acute or subacute dorsal or volar wrist ganglia as splinting may have uncertain efficacy and may lead to prolonged joint stiffness.

   Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**
   Level of Confidence – Low

Rationale for Recommendation

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There are no quality studies comparing immobilization as an adjunct treatment. In a prospective series, immobilization after aspiration was not found to be of any significant benefit compared those without immobilization in a 1-year prospective study of volar, dorsal and digital ganglia.(1343) However, in an earlier study including multiple punctures, immobilization had a positive effect for successful outcomes.(1344) These conflicting results, in the absence of quality experimental data, preclude making recommendation for or against this intervention.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: aspiration, splint, splints, splinting, ganglion cyst, wrist, hand, ganglion, ganglia, dorsal, volar; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 0 articles in PubMed, 2 in Scopus, 0 in CINAHL, 0 in Cochrane Library, 1,294 in Google Scholar, and 0 from other sources. Zero articles met the inclusion criteria.

6. *Recommendation: Hyaluronidase Instillation after Aspiration*
   There is no recommendation for or against the instillation of hyaluronidase into the cystic structure after aspiration.

   Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**
   Level of Confidence – Low

Rationale for Recommendation
One moderate-quality study compared the standard therapy of aspiration and steroids with the addition of hyaluronidase to the mixture.(1345) Although the study showed a positive effect on the patient reporting for excellent results, it was not statistically significant for good and excellent combined between the two groups. Thus, there is insufficient evidence for recommendation for or against this intervention.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: aspiration, hyaluronoglucosaminidase, hyaluronidase, Ganglion Cyst, Wrist, hand, Ganglion, ganglia, dorsal, volar; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 0 articles in PubMed, 2 in Scopus, 0 in CINAHL, 1 in Cochrane Library, 376 in Google Scholar, and 0 from other sources. We considered for inclusion 0 from PubMed, 1 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 0 Google Scholar, and 0 from other sources. Of the 1 article considered for inclusion, 1 randomized trials and 0 systematic studies met the inclusion criteria.

7. *Recommendation: Aspiration and Sclerosing Agents*
   Sclerosing agents such as phenol and hypertonic saline, which when instilled are intended to result in scarring and closure of the cystic potential space, are not recommended.

   Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
   Level of Confidence – Low

Rationale for Recommendation
As the cystic structure as described histologically and with electron microscopy have determined there is no synovial lining, rather a network of collagenous layers, there is little theoretical reason to believe that sclerosing agents would result in inciting an inflammatory reaction. In one small prospective study of 29 patients in Africa, 2cc of hypertonic saline injected into the cyst structure after aspiration was reported to result in only one recurrence after a 2-year follow-up.(1346) A small study of 10 patients treated with phenol injection was reported with good results.(1347) From anatomic studies, it has been shown that the cystic structure is connected to the synovial space in some cysts, so that there is some theoretical risk that instilling sclerosing agents will directly enter into a joint with resultant poor consequences. Thus, these therapies are only reported in small studies with higher risk of causing harm, and are not recommended.

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A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: aspiration and sclerosing agents, phenol and hypertonic saline, ganglion cyst, wrist, hand, ganglion, ganglia, dorsal, volar; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 0 articles in PubMed, Scopus, CINAHL, Cochrane Library, 346 in Google Scholar, and 0 from other sources. We considered for inclusion 0 from PubMed, Scopus, CINAHL, Cochrane Library, Google Scholar, and 0 articles from other sources. Zero articles met the inclusion criteria.

8. *Recommendation: Surgical Excision for Subacute or Chronic Upper Extremity Ganglia*
   Surgical intervention is recommended for treatment of subacute or chronic upper extremity ganglia after a trial of non-operative management.

   Strength of Evidence – **Recommended, Evidence (C)**
   Level of Confidence – Moderate

Rationale for Recommendation
Surgical intervention is the most effective treatment method for upper extremity ganglia despite the significant recurrence rates and higher risk of complications.(115, 1341, 1348) As most upper extremity ganglia are asymptomatic, consideration of surgical risks and a trial of non-operative management are prudent before performing a surgical procedure for cosmetic reasons. One moderate-quality study exists comparing the recurrence rates of surgery to aspiration with steroids.(115) With a sample size of 28 dorsal ganglia, the success rate at 6 months was significantly higher with surgery (82% vs. 38%, $p < 0.05$). The generalizability of the study is limited because of the small sample and the exclusion of other ganglia types. The success of surgery reported in non-randomized prospective case series suggest an overall recurrence rate between 5% and 40%. More recent surgical techniques that include comprehensive dissection and excision of the cyst, pedicle, and a cuff of the adjacent joint capsule are believed to have better results.(118)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Surgical Excision, Ganglion Cysts, Ganglion, Ganglia, Dorsal, Volar, Hand, Wrist; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 0 articles in PubMed, 11 in Scopus, 1 in CINAHL, 5 in Cochrane Library, 20 in Google Scholar, and 0 from other sources. We considered for inclusion 0 from PubMed, 1 from Scopus, 0 from CINAHL, 1 from Cochrane Library, 0 Google Scholar, and 0 from other sources. Of the 2 articles considered for inclusion, 2 randomized trials and 0 systematic studies met the inclusion criteria.

9. *Recommendation: Arthroscopic versus Open Excision*
   There is no general indication for one surgical technique (arthroscopic or open excision) over another for all cases and both are recommended. There may be advantages of arthroscopic procedures for ganglia originating in the radiocarpal joints, whereas open excision may have advantages in ganglia originating in midcarpal joints, although both have the same success rate.

   Strength of Evidence – **Recommended, Evidence (C)**
   Level of Confidence – Low

Rationale for Recommendation
There are two moderate-quality studies comparing open excision to arthroscopic resection of wrist ganglia. In both studies, rates of recurrence were low and not significantly different,(1349, 1350) thus showing no clear advantage for either technique. However, when comparing outcomes results for lost time, complications and functionality, arthroscopic excision of radiocarpal ganglia had faster recovery

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time and fewer complications than open excision, whereas open excision had better recovery and fewer complications than arthroscopic excision for midcarpal ganglia.(1350) However, these conclusions are weakened by small sample size and lack of statistical analyses to make recommendation for or against difficult. In a non-randomized trial,(116) the effectiveness of arthroscopic excision of dorsal ganglia in a 2-year follow-up study demonstrated 5% recurrence, although failure with arthroscopy was treated with open excision.

Evidence for Aspiration and Surgery for Ganglion Cysts
There are 6 7 moderate-quality RCTs incorporated into this analysis.(115, 1446, 1447, 1450, 1456-1459) (; Jagers Op Akkerhuis 02) There are 2 low-quality RCTs in Appendix 2.(1453, 1460) (Balazs 15, Varley 97)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Arthroscopy, Arthroscopic, Open Excision, Surgery, Ganglion Cysts, Ganglion, Ganglia, Dorsal, Volar, Hand, Wrist; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 0 articles in PubMed, 2 in Scopus, 1 in CINAHL, 1 in Cochrane Library, 20 in Google Scholar, and 2 from other sources. We considered for inclusion 0 from PubMed, 1 from Scopus, 1 from CINAHL, 0 from Cochrane Library, 0 Google Scholar, and 2 from other sources. Of the 2 articles considered for inclusion, 0 randomized trials and 1 systematic studies met the inclusion criteria.

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Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Aspirations and Multiple Puncture group						
Stephen 1999 RCT No mention of sponsorship or COI.	4.0	N = 119 (male to female ratio 1:3.1) with ganglia. Age not given.	Simple aspiration (N = 65) vs Aspiration and multiple wall punctures (N = 54) Follow-up for 1 year.	"16 of 51 ganglia (31%) treated by aspiration alone resolved and did not recur in contrast to 9 of 41 ganglia (22%) in the multiple puncture group."	"The study has demonstrated that multiple puncture of the ganglion wall does not improve the results of simple ganglion aspiration."	Lack of study details. No randomization or allocation details. Drop-out 23% at 1-year follow-up.
Aspiration and Steroid Alone (prior use of Hyaluronidase)						
Paul 1997 RCT No mention of sponsorship or COI.	4.0	N = 70 (29 male and 41 female) with ganglia of the wrist or hand. Mean age given.	Group 1, local anesthetic of 0.5% lignocaine plus 0.5 mls of ganglion contents were aspirated v via a 16 gauge needle (N = 35) vs Group 2, treated by conventional technique of aspiration under local anesthetic and immediate injection of 40 mg of Depomedrone (N = 35). 2 year follow-up.	Patients reporting excellent results significantly higher in hyaluronidase group (49% vs. 20%, p = 0.0051). However, good and excellent ratings combined showed trend for hyaluronidase (89% vs. 57%) but not significant, (p = 0.072).	"The cure rate with the combined use of hyaluronidase and methylprednisolone was 89% compared to 57% when treated by aspiration and instillation of methylprednisolone alone."	Lack of study details. 100% follow-up achieved at 2 years. Treatment may be beneficial for viscous cystic fluid that is too viscous for aspiration.
Aspiration and Surgical Excision and Steroid Injection						
Limpaphayom 2004 RCT No mention of sponsorship or COI.	6.5	N = 28 (24 female and 4 male). Age surgery/ aspiration: 29.9±9.79/32.0±13 .08.	Surgery, 5 cc of 1% Xylocaine (N = 11) vs Aspiration, steroids, and immobilization (N = 13). Follow-up for 6 months.	At 6 month follow-up, the success rate was 81.8% by surgical excision and 38.5% by aspiration,(p = 0.047).	"Result of treatment can be varied but by this RCT, surgery was shown to obtain a superior result in terms of success rate than aspiration, methylprednisolone acetate injection plus wrist immobilization."	Single trial of aspiration. Lack of blinding. Only included dorsal wrist ganglia.

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Latif 2014 RCT No mention of sponsorship or COI.	4.0	N = 173 (36 male and 147 female) with ganglia within wrist, ankle and knee. Mean age 26 years.	Group 1 who opted for aspiration and injection treatment (N = 143) vs Group 2 who opted for surgical treatment (N = 44). Follow-up baseline and 6 months.	Group 1 vs group 2 success at third week of injection: 82 (57%) vs 41 (93%). Success rate at 6 months (116 (81%) vs 0 (0%). Failure rate within group 1 vs group 2: 27 (19%) vs 3 (7%) (p <0.028).	"In symptomatic ganglia, surgical excision is a better treatment option as the failure rate is less compared to triamcinole acetonide injection after aspiration.."	Data suggest surgical excision best treatment for symptomatic ganglia vs. injection-aspiration. At 6 months, injection-aspiration success rate 81.0% vs. surgical excision 93.0%. Failure rates significant at 19.0% for injection-aspiration group and 7.0% for surgical excision group.
Jagers Op Akkerhuis 2002 Prospective Randomized Trial No mention of sponsorship or COI.	4.5	N = 89 (27 males, 62 females). Mean age is 39.5 years.	Hyaluronidase + Aspiration (N = 43) vs Surgical Excision (N = 46) Follow-up 1 year.	Hyaluronidase treatment resulted in recurrence in 33 of the 43 patients (77%). Recurrences after surgery were found in 11 of the 46 (24%) patients: six within 3 months and five between 3 months and 1 year.	Surgical excision is preferable to aspiration after hyaluronidase, assuming that the aim of treatment is resolution of the ganglion. However hyaluronidase and aspiration has a 23% success rate and can be used for those patients who prefer not to undergo surgery.	Data suggest HA groups had a recurrence rate at 1 year of 77% vs. the surgery group 24% (p<0.01) when treating ganglia showeing lack of efficacy.
Arthroscopic Resection vs Open Excision Technique						
Rocchi 2008 RCT No mention of sponsorship. No COI.	4.5	N = 51 (17 male and 24 female) with dorsal wrist ganglions. Mean age 29.8 years.	Arthroscopic resection (N = 41) vs Open excision of volar ganglion cyst (N = 10). Follow-up for 47.8 months.	Comparisons by radiocarpal ganglia (RCG) and midcarpal ganglia (MCG) locations. For open resection of RCG, mean functional recovery time 13 days with mean time lost from work 21 days, 15/20 reporting good results at 24 months and 3 bad results. Arthroscopic RCG 18/20 good results with 9 days recovery time and 9 days lost time. MCG subgroup, 5/5 good results with open excision with functional recovery time 10 days, lost time 17 days; 1/5 in arthroscopic group treated successfully.	"Comparing our two groups, we noted rather better results with arthroscopy in the treatment of radiocarpal ganglia, and better results for open operation in the treatment of midcarpal ganglia."	No statistical analyses presented.
Kang 2008 RCT	4.0	N = 72 with ganglion recurrence or wrist pain. Mean age for the open	Arthroscopic technique consisted of 2 stab incisions at the standard 3-4 and 4-5 portal sites (N = 41)	At 4-8 weeks, 1/41 in arthroscopic group vs. 0/31 in open excision group had recurrence (p = 0.381). 17% in arthroscopic group reported	"The results of our study suggest that the technique of arthroscopic surgery does not achieve superior rates of ganglion recurrence."	Lack of study details. High attrition rate at 12 month follow-up. No blinding.

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No sponsorship. No mention of COI.		group was 36 years and for the arthroscopic group 34 years.	vs Open excision of dorsal ganglion cyst (N = 31). Follow-up of 12 months.	residual pain vs. 10% (p = 0.369). At 1 year, no significant difference in pain or recurrence.		

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Follow-up Visits

Because of the natural course of spontaneous resolution and recurrence, follow-up should be dictated by the course of treatment selected by the patient and physician.

Prescription Medications

No prescription medications are shown to be effective for treatment of upper extremity ganglia. By inference from other musculoskeletal conditions, NSAIDs may be of benefit as an analgesic for ganglia associated wrist pain, although there is no evidence of their efficacy.

Evidence for the Use of Medications
There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: anti-inflammatory agents, non-steroidal, NSAIDS, non-steroidal anti-inflammatory, ibuprofen, acetaminophen; ganglion cyst, wrist, hand, ganglion, ganglia, dorsal, volar; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 0 articles in PubMed, 3 in Scopus, 0 in CINAHL, 8 in Cochrane Library, 7,710 in Google Scholar, and 0 from other sources. Zero articles met the inclusion criteria.

Physical Methods/Rehabilitation

EXERCISE

Exercise is not generally indicated acutely. For those with residual deficits, particularly post-operatively, see section on Post-Operative Rehabilitation and Rehabilitation of Patients with Functional Deficits: CTS and Other Disorders.

Evidence for the Use of Exercise
There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: exercise, exercising, physical activity; ganglion cyst, wrist, hand, ganglion, ganglia, dorsal, volar; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 1 articles in PubMed, 5 in Scopus, 0 in CINAHL, 9 in Cochrane Library, 15,300 in Google Scholar, and 0 from other sources. Zero articles met the inclusion criteria.

Hand Arm Vibration Syndrome (HAVS)

Special Studies and Diagnostic and Treatment Considerations

Currently there is no “gold standard” for the diagnosis and staging of hand-arm vibration syndrome (HAVS). Most authorities have adopted the Stockholm workshop scale(1351, 1352) which is subjective and relies on patient recall.(1353) This subjective system presents problems with reliability, particularly from patients pursuing compensation claims, which has been demonstrated in at least one study of persons reporting HAVS-related Raynaud’s phenomenon and submitting photographs of their hands during an active episode for review. Approximately 50% of the study population that reported to have captured their episode did not have supporting photographic evidence for what they were reporting.(1354)

In the pursuit of objective testing, there are a number of reported physical methods that attempt to provide measurable physiologic changes to support the diagnosis of HAVS. For measurement of vascular changes, the cold provocation test (CPT) has long been a cited maneuver. CPT is conducted by

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immersing the hands in water at 10° C-15° C for 10 minutes, and comparing skin temperature recovery at 5 and 10 minutes with baseline prior to the cold water bath. The observer also looks for signs of blanching or white finger. There are several variations of this technique, which include adding more sophisticated temperature measurement instruments for measurement of finger skin temperature (FST) changes, or thermographic studies such as with infrared and dynamic infrared imaging. Finger systolic blood pressure (FSBP) measurement has also been described. Each of these tests attempts to reproduce or measure vascular changes associated with cooling.(1355-1359) Neurological testing has also been described through various methods. Most include measurement of sensory and motor functions, rather than nerve conduction or EMG studies. These tests include vibrotactile threshold tests, thermal aesthesiometry, grip strength, and dexterity testing.

Recommendation: Cold Provocation Test, Cold Stress Thermography (Finger Skin Temperature, Infrared, Dynamic Infrared, Laser Doppler Imaging), Finger Systolic Blood Pressure, Vibrotactile Threshold Testing, Thermal Aesthesiometry, or Nerve Conduction Velocity Studies to Diagnose Hand Arm Vibration Syndrome

There is no recommendation for or against the use of a cold provocation test, cold stress thermograpy (finger skin temperature, infrared, dynamic infrared, laser Doppler imaging), finger systolic blood pressure, vibrotactile threshold testing, thermal aesthesiometry, or nerve conduction velocity studies to diagnose hand arm vibration syndrome (HAVS).

Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**
Level of Confidence – Low

Rationale for Recommendations

Despite the widespread acceptance of physiologic testing, there are no quality RCTs comparing the utility of diagnostic methods for HAVS. Furthermore, there is poor correlation of these various physiological tests with the Stockholm workshop scales,(1360) and a general inability of these tests to reliably differentiate HAVS from controls.(1361, 1362)

A recent review of the literature concluded that there does not appear to be any single test with satisfactory diagnostic capability in diagnosing HAVS (white finger), but supports the use of cold provocation testing (CPT) as reasonable.(1363) However, a large scale review of cold provocation testing in over 40,000 UK miners being evaluated for compensation claims found only slight correlation of self-reported clinical severity and CPT results, concluding that CPT should not be used for evaluating the vascular component of HAVS.(1364) There remains no established standard for CPT methodology, which makes interpretation and comparisons difficult. While the test is relatively benign and inexpensive, the results are of unknown diagnostic utility.

There is little information available supporting the utility of thermographic imaging. Most of the reports are of small populations. The most recent study (21 patients) concluded that none of the available methods is sufficient for arterial constriction testing, but may be useful in follow-up testing of individuals.(1365) A similar story exists for finger systolic blood pressure monitoring as a diagnostic test. A recent prospective study measuring the changes in finger systolic blood pressure (FSBP) after segmental local cooling for vibration-induced white finger in vibration exposed vs. non-exposed populations showed a significant decrease in FSBP in the exposed group with reported HAVS vs. non-exposed as well as the exposed with no history of HAVS. The sensitivity and specificity of the FSBP test with a cut-off value of 75% of normal at 23 +/- 1 degrees C, were 65.2 and 87.5%, respectively, and at 21 +/- 1 degrees C, they were 73.9 and 82.5%, respectively.(1366) However, the study used self-report of HAVS and included retired (no longer exposed) persons in the exposed with HAVS group.

Testing for neurological deficits may be slightly more beneficial than vascular testing for confirming the severity of nerve damage associated with HAVS, although they are not definitive in objectively identifying HAVS. In a follow-up report of UK miners being evaluated for HAVS claims, 57,000 persons evaluated with vibrotactile threshold testing and thermal aesthesiometry showed some evidence that these tests are reliable indicators of underlying neurological damage.(1367)

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Thus, there is insufficient evidence for making evidence based recommendations on the utility of each of the various tests currently available for the vascular and neurological components of HAVS. Administering a combination of these tests may improve the diagnostic utility when considered in context of the medical history and occupational exposures. Nerve conduction studies may also be indicated to rule out other associated or concomitant upper extremity disorders, although are not likely of useful benefit for diagnosis of HAVS. In addition to neurovascular physiologic testing, there are limited reports of serologic testing for HAVS.

Evidence for the Use of Diagnostic Testing

There are 3 moderate-quality studies incorporated into this analysis.(1471, 1478, 1479) (Coughlin 01a; Coughlin 01b; Poole 04) There are 4 low-quality studies in Appendix 2.(1480-1483) (Lindsell 99; Kurozawa 91; Bogadi-Sare 94; Lawson 97)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Hand-Arm Vibration Syndrome, Vibration white finger, dead finger, white fingers, hand-transmitted vibration, hand-arm vibration, traumatic vasospastic disease, Cold provocation, cold stress thermography, finger systolic blood pressure, vibrotactile threshold testing, thermal aesthesiomtry, never conduction velocity, diagnostic, diagnosis, sensitivity, specificity, positive predictive value, negative predictive value, and predictive value of tests, efficacy, and efficiency. We found and reviewed 0 articles in PubMed, 2 in Scopus, 0 in CINAHL, 16 Cochrane Library, and 120 from Google Scholar. We considered for inclusion 0 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 4 from Google Scholar, and 5 from other sources. Of the 9 articles considered for inclusion 7 diagnostic studies met the inclusion criteria.

Author/Year Study Type	Score	N	Area of Body	Diagnoses	Type of Thermography	CT used	MRI Used	More than on rater	Blinding of rater	Myelography	Surgery Performed	Clinical outcomes	Long term follow-up (mean when noted)	Results	Conclusion	Comments
Coughlin 2001 Same as OCC MED Case Control	5.5	31 subjects in two groups. Group A: 10 healthy volunteers. 5 men, 5 women. Median age of 35. Group B: 21 patients. 20 men, 1 woman. Median age of 45	Hand	HAVS with RP	Cold Provocation	-	-	-	-	-	-	-	-	After cold provocation, the finger temperature and time for the finger temperature to return to pre-cooling levels were able to distinguish the HAVS group and the normal group. The sensitivity of CPT was low after cooling, but	"CPT has a good sensitivity, specificity, positive predictive value and negative predictive value; it strongly suppo	Data suggest CPT test has good sensitivity and specificity and supports a diagnosis of digital vascospasm.

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														reach up to 95% 3 min after rewarming. The accuracy of the test was also the greatest towards the last stages of rewarming. The specificity and PPV were high during precooling stages and remained relatively high during the rewarming stages. NPV was low during the precooling stage and became high (>90) during the rewarming stages.	rts the clinical diagnosis of digital vasospasm. ”	

Author/ Year	Score	Study Design	Population/ Case Definition	Investigative Test	Gold Standard / Comparative Test	Results	Conclusion	Comments
Poole 2004	6.0	Case Control	N = 46 24 Males with HAVS VS 22 Males without HAVS (Control) Mean age = 46	Measuring FSBP after cold provocation at 30, 15 and 10°C	FST measurement following immersion of hands in 15°C water for 5 min	FSBP on the middle finger yielded a sensitivity of 60%, specificity of 84.1%, PPV of 71.5%, and a NPV of 75.9%. Compared to FSBP, FST had results of 68%, 71%, 61%, and 77%, respectively.	“Based on our data, the FSBP may also have limited use in confirming a positive diagnosis of vibration-induced vascular problems.”	Data suggest FSBP is of limited value as a diagnostic test for HAVS although it may have value in ruling out and/or confirm the vascular component of HAVS.
Coughlin 2001	5.5	Case Control	N = 50 participants	Two-Point discrimination	Depth sense perception	When testing using DSP, there was no significant	“The increased sensitivity of the TPD	Data suggests the 2 point disc providers increased

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OCC MED			20 with HAVS VS 15 Sedentary worker VS 15 manual workers No mention of mean age.			difference in the right hand of all three groups. The left hand was significantly poorer in the HAVS group than the two others. DSP has a sensitivity of 41, specificity of 94, PPV of 82 and NPV of 70. When testing with TPD, both hands were significantly poorer in the HAVS group than the two other groups. TPD has a sensitivity of 46, specificity of 94, PPV of 84, and NPV of 72.	disc would suggest that it should be used in preference to the DSP disc for the assessment of sensorineural dysfunction in patients with HAVS."	sensitivity for the assessment of HAVS vs. the depth sense disc.

1. *Recommendation: Serologic Tests (Thrombomodulin, Soluble Intracellular Adhesion Molecule 1 [s1-CAM 1]) to Diagnose Hand Arm Vibration Syndrome*
   Serologic tests – thrombomodulin, soluble intracellular adhesion molecule 1 (s1-CAM 1) – are not recommended to diagnose HAVS.

   Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
   Level of Confidence – Low

2. *Recommendation: Testing for Connective Tissue Disorders to Diagnose Hand Arm Vibration Syndrome*
   There is no recommendation for or against the use of testing for connective tissue disorders to diagnose HAVS.

   Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**
   Level of Confidence – Low

Rationale for Recommendations
There are no quality randomized studies on the utility of serologic testing or connective tissue disorders testing for HAVS. There does not appear to be any serologic tests that currently provide objective evidence or staging of HAVS. Objective serum tests, such as levels of soluble thrombomodulin (sTM) and soluble intercellular adhesion molecule-1 (sICAM-1), may provide some utility in the future as they have been shown to be statistically different in exposed groups with HAVS symptoms, but the usefulness is hampered currently by the lack of clear reference ranges,(1353) as each of the measurements for both comparison groups were still in the range considered normal. Testing for other causes of Raynaud's phenomenon, particularly connective tissue disorders such as scleroderma and systemic lupus erythematosus may be beneficial when occupational exposure histories are not consistent with clinical presentation and the threshold for such testing should be low.

Evidence for the Use of Serologic Testing or Connective Tissue Disorders Testing

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There is 1 moderate-quality study incorporated into this analysis.(1484) (Kanazuka 96) There is 1 low quality study in Appendix 2.(1485) (Kennedy 99)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Hand-Arm Vibration Syndrome, Vibration white finger, dead finger, white fingers, hand-transmitted vibration, hand-arm vibration, traumatic vasospastic disease, Cold provocation, cold stress thermography, finger systolic blood pressure, vibrotactile threshold testing, thermal aesthesiomtry, never conduction velocity, diagnostic, diagnosis, sensitivity, specificity, positive predictive value, negative predictive value, and predictive value of tests, efficacy, and efficiency. We found and reviewed 0 articles in PubMed, 0 in Scopus, 4 in CINAHL, 9 Cochrane Library, and 150 from Google Scholar. We considered for inclusion 0 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 1 from Google Scholar, and 2 from other sources. Of the 3 articles considered for inclusion 3 diagnostic studies met the inclusion criteria.

Author/ Year	Score	Study Design	Population/ Case Definition	Investigative Test	Gold Standard / Comparative Test	Results	Conclusion	Comments
Kanazuka 1996 No mention of sponsorship or COI.	4.0	Case Control	N=175 Males 100 Patients with HAVS (Mean age = 63.0±6.3) Vs 25 Patients with collagen disease (Mean age = 43.5±16.8) Vs 50 Healthy patients (Mean age = 56.8±7.8)	TM one-step sandwich enzyme immunoassay	Not mentioned	Patients with HAVS had a significantly higher level of plasma TM (3.32±1.11 ng/mL) than the normal control (2.49±1.05 ng/mL, p<0.0001). There was no significant difference between the HAVS group and the collagen disease group (3.65±2.02 ng/mL, p<0.01).	"[W]e suggest that endothelial injury is present in vibration syndrome, the degree of endothelial injury in vibration syndrome equals that in collagen disease, and the endothelial injury in chain-saw operators is greater than that in rock-drill operators."	Data suggest endothelial injury exists in patients with VWF as well as collagen disease.

Initial Care

There are no quality randomized clinical studies for the treatment of physiologic manifestations associated with HAVS. The most prudent form of treatment is to first remove or reduce the exposure to vibration, particularly in the earlier stages of symptom presentation. Smoking has been identified as a risk factor for HAVS.(1368) By inference, smoking cessation is a frequent recommendation to patients with HAVS. The effects of smoking on HAVS, if any, are thought to be a result of chronic platelet function inhibition,(1369) effects on the microvasculature and that of nicotine on smooth muscle function. However, there is no quality evidence that smoking cessation will affect the course. **As a risk factor, smoking cessation is recommended**.

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Other common advice based on the proposed pathophysiology of vasospasm includes avoidance of beta-blockers, sympathetic stimulants including caffeine, decongestants, amphetamines and even cocaine as they may act as potential triggers. Further, maintenance of hand and body temperature in cold environments may help avoid or reduce the risk of symptoms.

Follow-up Visits

There are no recommendations in the literature for the frequency or duration of follow-up visits. A few follow-up appointments to evaluate results of non-invasive measures, exposure avoidance, and serologic testing are indicated.

Prescription Medications

There are no quality studies of medications that prevent or improve symptoms related to HAVS. As the vascular component of HAVS mimics other causes of Raynaud's phenomenon, calcium channel antagonists, which have positive benefit for many with non-vibration related cases, are often prescribed for HAVS.

CALCIUM CHANNEL BLOCKERS

Recommendation: Calcium Channel Blockers for Advanced Subacute or Chronic Hand Arm Vibration Syndrome

Use of calcium channel blockers (nifedipine) for treatment of vascular symptoms similar to Raynaud's phenomenon is recommended for advanced subacute or chronic HAVS.

Indications – Patients with HAVS. Generally used in patients with sufficient symptoms such that removal from exposure is insufficient for management.

Frequency/Dose – Per manufacturer's recommendations; generally initiated with low dose. Blood pressure should be monitored and may require lower doses, especially among those without higher blood pressures or among those with adverse effects.

Discontinuation – Resolution, intolerance, adverse effects.

Strength of Evidence – **Recommended, Insufficient Evidence (I)**
Level of Confidence – Low

Rationale for Recommendation

There is no quality evidence for the use of calcium channel blockers in HAVS population. It is a commonly accepted treatment for Raynaud's phenomenon associated with connective tissue diseases with moderate benefit. A review of all calcium channel antagonist trials for non-HAVS Raynaud's is beyond the scope of this text. Rather, as this medication is already frequently used for advanced HAVS, and with the lack of other treatments available, it may be considered a treatment for symptomatic patients once exposure sources are reduced or eliminated and other personal health measures have started.

Evidence for the Use of Calcium Channel Blockers

There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: calcium channel blockers, hand arm vibration syndrome, vibration white finger, dead finger, white fingers, hand-transmitted vibration, hand-arm vibration, traumatic vasospastic disease; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 19 articles in PubMed, 0 in Scopus, CINAHL, and Cochrane Library, 152 from Google Scholar, and 0 from other sources. We considered for inclusion 1 from PubMed, 0 from Scopus, CINAHL, Cochrane Library, Google Scholar, and from other sources. Of the 1 articles considered for inclusion, 0 randomized trials and 1 systematic studies/background met the inclusion criteria.

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Physical Methods/Rehabilitation

EXERCISE

Exercise is not generally indicated.

Evidence for the Use of Exercise

There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: exercise, exercising, physical activity, Hand-Arm Vibration Syndrome, vibration white finger, dead finger, white fingers, hand-transmitted vibration, hand-arm vibration, traumatic vasospastic disease; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 5 articles in PubMed, 2 in Scopus, 0 in CINAHL, 14 in Cochrane Library, 1,158 in Google Scholar, and 0 from other sources. Zero articles met the inclusion criteria.

Laceration Management

Special Studies and Diagnostic and Treatment Considerations

There are no quality studies on diagnostic testing for the evaluation of wounds with lacerations. However, among the minority of wounds of sufficient severity, the use of imaging to rule out traumatic injury to bone or other structures is generally considered effective and well established. Yet, detection of retained soft tissue foreign bodies remains a clinical dilemma, with one study reporting up to 38% of foreign bodies in hand wounds going undetected by the initial provider, resulting in the second-leading cause of lawsuits in emergency medicine.(1370) Furthermore, if nerve injury is detected or suspected, then EDS may be indicated 2 to 3 weeks post-injury. An immediate EDS is not recommended as Walerian degeneration will not have been completed until at least 2 weeks post-injury, making earlier studies falsely normal.

X-RAYS

Recommendation: X-rays for Evaluation of Lacerations with Suspected Fracture or Foreign Body

X-rays are recommended for the evaluation of traumatic injury resulting in skin lacerations to rule out fracture or if a radiopaque foreign body is suspected.

Strength of Evidence **– Recommended, Insufficient Evidence (I)**
Level of Confidence – Moderate

Evidence for the Use of X-ray

There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Laceration management, x-ray, xray, radiography, lacerations with suspected fracture, foreign bodies, diagnostic, diagnosis, sensitivity, specificity, positive predictive value, negative predictive value, and predictive value of tests, efficacy, and efficiency. We found and reviewed 24 articles in PubMed, 20 in Scopus, 0 in CINAHL, 0 in Cochrane Library, and 1880 from Google Scholar. We considered for inclusion 0 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 0 from Google Scholar, and 0 from other sources. Zero articles met the inclusion criteria.

ULTRASOUND

Recommendation: Ultrasound for Evaluation of Suspected Superficial Foreign Bodies

Ultrasound is recommended for evaluating suspected radiolucent materials or as an alternative test when radiopaque foreign body is suspected but not detected on x-ray images.

Strength of Evidence **– Recommended, Insufficient Evidence (I)**

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Level of Confidence – Low

Evidence for the Use of Ultrasound
There are 4 quality studies incorporated into this analysis.(1489-1492) (Soubeyrand 08; Tahmasebi 14; Wu 12; Fornage 86)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Ultrasound, Laceration Management, Suspected superficial foreign bodies, ultrasonography, diagnostic, diagnosis, sensitivity, specificity, positive predictive value, negative predictive value, and predictive value of tests, efficacy, and efficiency. We found and reviewed 122 articles in PubMed, 62 in Scopus, 0 in CINAHL, 0 in Cochrane Library, and 8,560 from Google Scholar. We considered for inclusion 0 from PubMed, 2 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 2 from Google Scholar, and 0 from other sources. Of the 5 articles considered for inclusion 4 diagnostic studies met the inclusion criteria.

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Author/ Year Study Type	Score	N	Area of Body	Diagnoses	Type of Ultrasound	CT used	MRI Used	More than on rater	Blinding of rater	Myelography	Surgery Performed	Clinical outcomes assessed	Long term follow-up (mean when noted)	Results	Conclusion	Comments

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Soubeyrand 2008 Diagnostic No mention of sponsorship or COI.	7.5	N=30 injuries in 26 patients (19 males, 7 females) Mean age: 34 years	Hand and Wrist	Laceration Management/ Lesion	Doppler Ultrasound	-	-	+	-	-	+	+	72 hours	There were 20 injuries of the finger and 10 of the palm The right side was involved in 17 of 30 injuries (57%) and the dominant hand was involved in 11 of 30 injuries (37%). Injury at home occurred in 18 cases and at work in 10 cases. Two patients were injured on the street. Penetrating object was glass in 17 injuries, knife in 7 injuries, metallic object in 2, human teeth in 2, machinery in 1, and a stone in 1. A complete US examination was performed in all 30 cases, despite moderate pain in two cases. Of 98 examined tendons, 81 appeared intact and 17 were damaged. Of 81 examined nerves, 63 appeared intact and 18 were damaged. Of 75 examined arteries, 61 appeared intact and 14 were damaged. The lesion path was visualized in 22 of the 30 injuries. In five injuries, the path did not extend beyond the fascial layer (superficial injury), and in two injuries, the path ended in the muscle. Foreign bodies were visualized in five injuries.	"In conclusion, US proved highly effective in detecting tendon and arterial lesions. The results were less reliable regarding nerve damage. US may be effective in identifying hand lesions that require surgical repair and in selecting patients who can be treated without surgical exploration, provided they undergo a second physical examination 72 hours after the injury. Further studies in larger numbers of patients are needed to evaluate this possibility."	Data suggest US is effective in the detection of volar injuries without tendon or arterial leslions but not as good for detection of nerve leslions.

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Tahmasebi 2014 Diagnostic Sponsored by Nil and no COI.	5.5	N=51 patients (41 males, 10 females) Mean age: 24.95 ±13.4 years	HWF	Laceration Management	USG	-	-	-	-	-	+	-	-	Predominant chief complaints of the patients were: foreign body sensation in 24, discharging wound in 15, and pain in 12 cases. Ten cases had a history of surgical exploration without the use of USG examination, which had no foreign body detected. On USG scan, 100% of the foreign bodies were echogenic. USG revealed a foreign body in 50 patients. All patients underwent surgical exploration or USG-guided removal. Forty-six patients had a foreign body removed. One patient had a negative USG exam and surgical exploring revealed a 7-mm thorn. USG was falsely positive in three cases with failed surgical manipulation due to the presence of air bubbles and scar tissue, as well in as one case with calcified granuloma. Foreign bodies were thorn, wood, glass, and plastic. The sites of the foreign bodies were foot, hand, leg, arm, forearm, ankle, wrist, knee, and thigh. Sizes of foreign body varied from 4-51 mm and in 50% of cases, the size of the foreign body was greater than 13 mm.	"Real-time high-frequency USG is a highly sensitive and accurate tool for detecting and removing the radiolucent foreign bodies, which are difficult to be visualized by routine radiography."	Data suggest US can detect radiolucent-soft-tissue foreign bodies that radiographs can not.

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Wu 2012 Diagnostic	4.5	N=34 patients	H W F	Laceration Management	Bedside Tendon Ultrasonography	-	+	-	-	-	-	+	-	"Thirty-four patients were enrolled in this study. There were 6 finger injuries, 11 hand injuries, 6 forearm injuries, 6 arm injuries, and 5 lower extremity injuries. Based on MRI or direct wound exploration, 4 patients had partial tendon injuries, 9 patients had complete tendon injury, and 21 patients had no evidence of tendon injury noted. Bedside ultrasound was able to accurately diagnose the extent of tendon injury in 33 of the 34 total cases. In comparison, physical examination accurately diagnosed 29 of the 34 total cases. On average, time to diagnosis and disposition based on bedside ultrasound findings was 46.3 minutes. In contrast, overall time to wound exploration, MRI, or consultation was 138.6 minutes.	"Bedside ultrasound is more sensitive and specific than physical examination alone for detecting tendon lacerations and takes less time to perform than traditional wound exploration techniques or MRI. Data obtained from bedside ultrasonography can be used to improve diagnostic accuracy and enhance and expedite patient care."	No mention of gender or mean age. Data suggest bedside US increases the sensitivity/specificity in detection of tendon inuuries when comared to physical exam alone.

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Fornage 1986 Diagnostic No mention of sponsorship or COI.	4.0	N=10 patients suspected of having a foreign body in either hand or foot.	Hand and Foot	Laceration Management	High-resolution linear array real-time scanner sonography	-	-	-	-	-	+	-	-	“Eight foreign bodies were found at surgery; glass in 4 cases, metal in 3 cases, and vegetable material in 1 case. All foreign bodies were visualized as hyperechoic on sonograms. An acoustic shadow was present in 2 cases only (glass fragments). A hyperechoic comet-tail artifact secondary to reverberations inside the dense echogenic foreign body was visualized in 3 cases. In 7 cases a surrounding hypoechoic mass ranged from 1.2-3 cm in diameter correlated well with inflammatory changes found at surgery. Seven of the eight foreign bodies were glass or metallic fragments and were radiopaque with sizes of 0.1-1 cm. In 1 case a vegetable fragment responsible for a cyst could not be seen on the radiograph, but was demonstrated on sonograms.	“Evaluation of foreign bodies should begin with radiographs. If these are negative or inconclusive, sonography may be helpful in detecting nonopaque foreign bodies or foreign bodies in areas that are not easily evaluated by radiographic projections. When a foreign body is visualize, sonography allows its 3D localization.	No mention of gender or mean age. Data suggest after initial radiographic evaluation for foreign bodies are negative, sonography may be useful in locating foreign bodies.

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CT

Recommendation: CT for Evaluation of Suspected Superficial Foreign Bodies

There is no recommendation for or against the use of CT for suspected superficial foreign bodies. CT is not routinely recommended, but may be indicated for the evaluation of suspected radiolucent materials and as an alternative test when radiopaque foreign body is suspected but is not detected on x-ray images or ultrasound.

Strength of Evidence **– No Recommendation, Insufficient Evidence (I)**
Level of Confidence – Low

Rationale for Recommendations

Most work-related lacerations presenting to clinics are too superficial to involve the bone or joints. However, if the injury mechanism or location of injury suggests a possibility of fracture, x-rays are indicated (see specific fracture sections for further recommendations). There are no quality studies of imaging techniques for the evaluation of suspected foreign bodies. If a foreign body is suspected, additional diagnostic testing should be considered dependent on the suspected foreign body type. For suspected radiopaque substances such as metals or glass, traditional x-ray reliably detects the foreign body 80 to 95% of the time.(1370) However, x-ray images do not reliably detect radiolucent foreign bodies such as wood, plastic, or vegetative material.

Ultrasound is increasingly being utilized for the evaluation of suspected radiolucent foreign bodies,(1370) although there are no quality studies available. There are several case series and cadaver studies(1371-1375) providing reports of high sensitivity, although there are also a small number of false positives related to tendons or other artifacts. CT has reported high sensitivity for radiopaque substances, and moderate sensitivity for radiolucent materials. Because of increased costs, higher radiation exposure, with intermediate sensitivity, CT may be best used when a foreign body is suspected but not detected by x-rays or ultrasound. MRI is not indicated for evaluation of metallic foreign bodies in particular.

Evidence for the Use of CT

There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Laceration, Foreign, CT, CAT, Computerized Tomography, diagnostic, diagnosis, sensitivity, specificity, positive predictive value, negative predictive value, and predictive value of tests, efficacy, and efficiency. We found and reviewed 60 articles in PubMed, 12 in Scopus, 0 in CINAHL, 63 Cochrane Library, and 4680 from Google Scholar. Zero articles met the inclusion criteria.

Treatment

As previously stated, optimal results are accomplished by preventing infection through thorough wound cleansing, approximating wound edges with appropriate closure techniques, and providing a clean, moist environment to accelerate wound healing. If nerve injury is detected or suspected then appropriate surgical consultation should be considered.

WOUND PREPARATION

Infection is one of the primary factors that interfere with wound healing. Contamination of the wound from inoculation of skin flora or environmental bacteria, foreign bodies such as gravel, vegetation, dirt, and other industrial related compounds can act as a nidus for wound infection. Adequate wound anesthesia may be required for wound preparation. Anesthetic technique is reviewed later in this section.

1. *Recommendation: Wound Cleansing, Irrigation, and Debridement*
   Meticulous wound preparation after appropriate anesthesia using saline irrigation or copious amounts of running tap water, scrubbing, and debridement of devitalized tissue is recommended.

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**

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Level of Confidence – High

2. *Recommendation: Wound Irrigation with Sterile Saline or Tap Water*
   The use of either sterile saline or tap water is recommended for an irrigating solution.

   Strength of Evidence – **Recommended, Evidence (C)**
   Level of Confidence – High

3. *Recommendation: Sterile or Clean Glove Use During Wound Cleaning*
   The use of either sterile or clean gloves during wound cleaning is recommended.

   Strength of Evidence – **Recommended, Evidence (C)**
   Level of Confidence – High

Rationale for Recommendations
Wounds become infected when they contain more than 10^5 bacteria per gram of tissue.(1376) As there is no test to determine the immediate bacterial load of a particular laceration, it seems prudent that all wounds should undergo some form of cleansing to decrease the amount of soil or presence of small foreign bodies to reduce the inoculation of bacteria and prevent infection. There are no quality studies comparing infection rates in wounds that are irrigated vs. non-irrigated or cleansed. However, it is widely accepted that irrigation and cleansing are best practice. Therefore, although there is a lack of quality evidence, wound cleansing, irrigation, and debridement are recommended. Optimal irrigating solutions and techniques are more controversial.

There is moderate evidence that irrigation solution does not make a significant difference in infection rates of routine laceration management. A high-quality study comparing tap water to sterile saline in a pediatric population showed no difference in infection rates at 48 hours.(1377) Another moderate-quality study of 715 lacerations randomized to irrigation under regular tap water vs. sterile saline using pressure syringe irrigation also found no significant difference in infection rates.(1376) Patients enrolled in tap water irrigation were instructed to wash their wound under regular tap water (U.S. location) for a minimum of 2 minutes. However, the power of these studies to detect differences in infection rates may be too low to conclude inferiority. On balance, there appears to be no difference in infection rates between the common practice of using sterile saline for routine laceration repair or using regular tap water for uncomplicated extremity lacerations and either wound irrigation with sterile saline or tap water is recommended. There is no quality evidence supporting the use of concentrated povidine-iodine solution instillation into the wound, although a low-quality study suggests some benefit in reduced infection rates,(1378) another low-quality study found no difference in infection rates between normal saline, povidine, and Shur Clens®.(1379) There is some concern that concentrated povidine-iodine, hydrogen peroxide, and detergents may cause tissue toxicity.(195)

There are no quality studies on irrigation pressures. High-pressure irrigation may result in increased trauma.(195) Optimal pressures of 5 to 8 psi generated by large syringe and 16- to 19-gauge needle have been recommended.(195) One moderate-quality study compared a commercial pressurized canister irrigation system with a standard syringe and 20-gauge catheter at maximal plunger force using saline and benzalkonium chloride.(1380) The study had weaknesses but found no difference in infection rates or soft tissue trauma between the groups. The only advantage was that irrigation times were shorter (3.9 versus 7.3 minutes) using the canister.

For lacerations that involve skin areas where significant hair may hamper closure efforts, removal by clipping rather than shaving is commonly suggested to reduce potential sources of contamination resultant from disturbing bacteria on hair shafts, although there is no evidence to support this method in routine laceration repair. Debridement of devitalized tissue through surgical excision and scrubbing may also reduce the risk of infection. Generally, sterile technique has been recommended. However, there is one large moderate-quality study of 816 lacerations that showed no difference in infection rates in repair using sterile gloves versus non-sterile clean gloves,(1381) thus either is recommended.

Evidence for Wound Preparation
There is 1 high-(1377) and 3 moderate-quality(1376, 1380, 1381) RCTs incorporated into this analysis.

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A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: wound preparation, wound cleansing, irrigation, debridement, wound healing, laceration, wound, cuts, management, repair, care, upper extremity; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 4 articles in PubMed, 0 in Scopus, 15 in CINAHL, 5 in Cochrane Library, 8321 in Google Scholar, and 0 from other sources. We considered for inclusion 0 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 5 from Google Scholar, and 0 from other sources. Of the 4 articles considered for inclusion, 4 randomized trials and 0 systematic studies met the inclusion criteria.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Wound Irrigation Tap Water vs Normal/Sterile Saline						
Bansal 2002 RCT Sponsored by funds from Sarah M. and Charles E. Seay Distinguished Chair in Pediatric Medicine, University of Texas. No mention of COI.	9.0	N = 46 (17 female and 28 male) with simple lacerations. Age range 2-15.	Wound irrigation by high pressure (25-40 PSI) syringe using tap water (N = 21) vs Normal sterile saline (N = 24). Follow-up for 48 hours.	Post irrigation culture positive in 11/21 (52%) for tap water, 7/24 for sterile saline (29%) p = 0.20. No difference in infection rates at 48 hours.	"Our study suggests that tap water may serve as a cost-saving alternative to normal saline for irrigating simple lacerations before repair."	Hand lacerations were excluded. Pediatric population.
Moscati 2007 RCT Sponsored in part by a grant from the Federal Highway Administration and he Calspan University at Buffalo Research Center. No mention of COI.	7.5	N = 715 with acute simple lacerations require ing sutures or staples. Age and gender not specified.	Tap water irrigation at sink (N = 300) vs High pressure sterile saline (N = 334). Follow-up for 48 hours.	11/374 in saline group developed infection (3.3%) vs. 12/339 (4.0%) with no significant difference between the groups.	"Compared with sterile saline, tap water for wound irrigation is more cost-effective and appears to be equally safe and efficacious."	Sixty percent of enrolled lacerations were of upper extremity. Baseline comparability of common variables not presented. Author estimates total US savings $65.6 million by using tap water irrigation vs. current practice.
Wound irrigation: Syringe Irrigation vs Pressurized Canister						

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Chisholm 1992 RCT Sponsored in part by a grant from Dey Laboratories, Inc.	5.0	N = 542 (male to female ratio 1.8:1 and 2.7:1 in Canister group) with lacerations requiring closure. Mean age for Syringe and Canister groups; 24.9 and 23.8 years.	220mL canister of sterile NS with 0.006% benzalkonium chloride (N = unknown) vs NS irrigation using 30-mL syringe, 20-gauge IV catheter tip 1 in. above skin edge, depress syringe plunger with maximal force (N = unknown). Follow-up	Face and hands most frequently lacerated. Mean irrigation time for pressurized canister group (281) 3.9 vs. 7.3 minutes for syringe irrigation group (254) (p <0.0001). Wound complications occurred in 8/221 (3.6%) in syringe irrigation group and 12/ 245 (5.0%) in pressurized canister group, (p = 0.50).	"There was no significant difference in infection rates between the two groups. The pressurized canister group's wounds were cleansed in almost half the time of those in the syringe group."	Lack of control for dressing type, use of topical antibiotics. Final wound observations made by multiple observers including patient self-report office based practitioners, and ED practitioners.
Sterile vs Nonsterile Gloves for Uncomplicated Lacerations						
Perelman 2004 RCT Sponsored by research grants from Canadian Association of Emergency Physicians and Bales Research Foundation of North York General Hospital. No COI.	7.5	N = 816 (221 female and 595 male) any type of uncomplicated soft tissue lacerations. Age for Standard and Clean nonsterile groups: 30.2± 18.2 and 30.5±19.1.	Standard intervention, sterile (N = 408) vs Clean non-sterile gloves for uncomplicated lacerations in immunocompetent patients (N = 408). Follow-up for 1 year.	Infection rates: sterile gloves (n = 24) 6.1% (95% CI 3.8-8.4%) vs. clean gloves (n = 17) 4.4% (2.4-6.4%) (NS). No difference in infection rates (relative risk 1.37; 95% CI 0.75 to 2.52; p = 0.295).	"[S]tudy provides evidence that clean, nonsterile, boxed gloves can be safely used for repairing uncomplicated traumatic lacerations without increasing the risk of wound infections."	All wounds injected with pressure. Unclear if blinding possible for proportion of follow-ups completed at study sight vs. those going elsewhere. Laceration sites: extremities in 61.8% of patients, head or neck in 36.6%, and trunk or buttocks in 1.6%.

WOUND ANESTHESIA

Wound anesthesia is commonly obtained after completing a sensory examination through local infiltration, digital nerve block or topical application of anesthetic preparations. Anesthetic technique is most commonly performed based on wound location and the preference of the treating health care professional.

1. *Recommendation: Local Infiltration plus Topical Anesthetic or Digital Block for Finger Laceration Repair*
   Adequate anesthesia by either topical anesthetic plus local infiltration or digital block is moderately recommended for finger laceration repair. There is no recommendation of one technique over the other. For distal finger lacerations, digital block may be substantially less painful than local infiltration performed without topical anesthetic. If the operator and patient preference is digital block, the various techniques are described and evaluated in the management of phalangeal fracture section in this guideline.

   Strength of Evidence – **Moderately Recommended, Evidence (B)**
   Level of Confidence – Moderate

2. *Recommendation: Local Infiltration for Extremity Wound Repair*
   Instillation of local anesthetic for extremity wounds after sensory testing is recommended as the first-line technique for most laceration repairs unless the size or complexity would require

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potentially toxic doses of local anesthetic. Local anesthetic with epinephrine (except digits) is recommended.

Strength of Evidence – **Recommended, Insufficient Evidence (I)**
Level of Confidence – Low

3. *Recommendation: Topical Anesthetics for Lacerations*
The use of topical anesthetics, Tetracaine-Adrenaline-Cocaine (TAC) and EMLA, are recommended as an alternative to local infiltration for lacerations of the extremities (excluding digits) or as pre-treatment to reduce pain related to needle infiltration. However, these anesthetics have longer times to onset of effective anesthesia.

Strength of Evidence – **Recommended, Evidence (C)**
Level of Confidence – Low

Rationale for Recommendations
There are numerous quality studies of different anesthetic techniques for management of laceration repairs of the finger. There is one high-quality and one moderate-quality study comparing local infiltration to digital block for finger lacerations. However, in the high-quality study, both received topical anesthesia which may have otherwise confounded the results. The authors found no difference in pain of providing anesthesia or quality of anesthesia between the two techniques.(1382) Digital anesthesia was preferred by providers and patients for both the application and quality of anesthesia in a moderate quality study,(1383) although it was uncertain if the comparison groups had similar baseline pain. Although there may be a modest advantage to digital anesthesia, there is not enough evidence to support one technique over the other, and both are recommended based on operator and patient preference.

There is one quality study that compared topical anesthetics with placebo,(1384) and that trial demonstrated efficacy, although it is a remote study utilizing Tetracaine-Adrenaline-Cocaine (TAC) and topical lidocaine. However, there are many trials comparing different topical agents. Topical anesthetics are applied to provide analgesia for subsequent local infiltration, or to provide anesthesia for wound repair. Topical anesthetics used for laceration repair without local infiltration are best used in highly vascularized regions, although they have also been used successfully in the extremity. In the past, TAC has been used effectively,(1384-1386) but concerns of toxicity have resulted in the development and use of non-cocaine containing products. Lidocaine-Adrenaline-Tetracaine (LAT, LET) and EMLA are now the primary topical anesthetics used in the United States. LAT has been shown to be more effective than TAC in one high-quality study(1387) for topical anesthesia and as effective in another high-quality study(1388) for topical pre-treatment for infiltration. EMLA was also shown to be more effective for topical anesthesia than TAC in a moderate quality study.(1389) There is one high-quality study comparing EMLA and LAT for topical anesthesia that demonstrated equal efficacy, with a slight advantage to LET in the time to achieving anesthesia.(1390) Thus, there is sufficient evidence to support the use of LAT and EMLA for pretreatment and for primary anesthesia in select wounds in adult populations.

Although local infiltration is the most common technique, there are no quality studies of local anesthetic infiltration versus placebo. Nor are there any quality studies comparing topical anesthetics to local infiltration or nerve blocks. As local infiltration is the gold standard for most wound repair, and the failure of topical anesthetics is treated by local infiltration or nerve block in complicated wounds, there is no recommendation for the use of topical anesthetics over local infiltration.

There is one high-quality study comparing lidocaine solutions with buffering, the addition of epinephrine, and the use of diphenhydramine as an alternative(1391) for upper extremity wounds. Lidocaine with epinephrine with or without buffering was preferred by patients over diphenhydramine or buffered solutions without epinephrine. This result contradicts with common anecdote of using buffered solutions to reduce injection pain.

Evidence for Wound Anesthesia
There are 5 high-(1382, 1387, 1388, 1390, 1391) and 5 moderate-quality(1383-1386, 1389) RCTs incorporated into this analysis.

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A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: anesthesia, wound healing, laceration, wound, cuts, management, repair, care, upper extremity, local infiltration plus topical anesthetic; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 76 articles in PubMed, 39 in Scopus, 3 in CINAHL, 3 in Cochrane Library, 4524 in Google Scholar, and 5 from other sources. We considered for inclusion 0 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 5 Google Scholar, and 5 from other sources. Of the 10 articles considered for inclusion, 10 randomized trials and 0 systematic studies met the inclusion criteria.

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Author/Year Study Type Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Digital vs. Local Infiltration						
Chale 2006 RCT No mention of sponsorship or COI.	9.0	N = 55 (16 female and 39 male) with traumatic lacerations of 1 finger. Age 40.1 (19.3) digital group; 36.3 (14.0) topical group.	Digital block 1 to 2 mL of lidocaine 1% was injected on both sides of the finger (N = 28) vs Local anesthesia 1 to 2 mL of lidocaine 1% was injected (N = 27). Both had topical anesthetics as co-intervention. 15 minute topical application	Wound outcomes; digital vs. local anesthesia: Time until onset of anesthesia in minutes: 7.7 vs. 1.9 p = 0.001. Mean pain of needle insertion in mm: 29.4 vs. 28.1 p = 0.87. Mean pain of anesthetic infiltration in mm 24.9 vs. 22.6, (p = 0.72).	"Digital and local anesthesia of finger lacerations with prior application of LET to all wounds results in similar pain of needle insertion, anesthetic infiltration, and pain of suturing."	Application of LET to all wounds makes comparison of digital to local needle injection pain difficult in the absence of LET, which is most cases in the U.S.
Robson 1990 RCT No mention of sponsorship or COI.	5.0	N = 60 (gender not specified) with lacerations of the digits. Age over 16 years.	Digital block 1 ml of anesthetic was applied (N = 28) vs Local anesthesia 2% plain lignocaine (N = 32). Follow-up unclear.	Assessment by patient and operator for pain related to application of anesthesia and suturing significantly better for digital block compared with local infiltration, (p < 0.01).	"[D]idigital block should be considered as the method of choice in all cases of digital lacerations requiring local anesthesia for their repair."	No baseline comparison data was presented.
Injectable Agents						
Ernst 1996 RCT No mention of sponsorship or COI.	10.0	N = 200 (50 female and 130 male) with simple lacerations not involving vascular compromise infection. 18 years of age.	Group A, buffered 1% lidocaine (N = 45) vs Group B, buffered 1% lidocaine with epinephrine (N = 46) vs Group C, 1% lidocaine with epinephrine (N = 47)	"Buffered lidocaine (A) and buffered lidocaine with epinephrine (B) were significantly less painful to inject than was diphenhydramine with epinephrine (D) (p < 0.01 for both the physicians and the patients). Lidocaine with epinephrine (C) was not statistically different from A, B, or D (p < 0.05). For suturing (anesthesia effectiveness), the patients and the physicians	"Although we found buffered lidocaine solutions less painful to inject in this four-agent comparison study, we were unable to detect a statistically significant difference."	Author confirms findings of related study on diphenhydramine causing more pain on injections with solutions at room temperature in this study.

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			vs Group D, 0.5% diphenhydramine for suturing of minor lacerations (N = 42). Follow-up unclear.	found that lidocaine with epinephrine with or without buffering (B or C) worked better than A or D, (p < 0.01)."		
Topical Agents						
Ernst 1995 RCT Sponsored by grant from Louisiana State University Emergency Medicine Residency Grant Fund. No mention of COI.	9.5	N = 95 (23 female and 76 male) with linear lacerations of face or scalp. Mean age LAT/TAC group: 33±11 / 34±13.	LAT or lidocaine – adrenaline-tetracaine (N = 48) vs TAC or tetracaine – adrenaline – cocaine (N = 47). Follow-up for unclear.	LAT found to have fewer painful sutures than TAC (p = 0.036). For physician ratings, difference between LAT vs. TAC groups showing that LAT more effective than TAC during suturing, (p = 0.093). Patient ratings however showed no significant difference in pain scores.	"We found that patients had smaller percentages of sutures causing pain in the LAT group than in the TAC group."	This study of topical anesthetics was in an adult population. Study limited to small lacerations (< 5 cm). Anesthetic solutions were refrigerated which may have affected results (painful injections).
Singer 2001 RCT No mention of sponsorship or COI.	9.5	N = 60 (14 female and 44 male) with pretreating lacerations prior to lidocaine injection. Mean age 8.5 years.	EMLA cream (N = 31) vs LET or cream for pretreating lacerations prior to lidocaine injection (N = 29). Anesthetic application times range from 15 to 135 minutes, not other follow up specified.	"51/54 wounds received supplemental injection of lidocaine and were similar in the both groups (92% for LET vs 97% for EMLA, p = 0.47). Wounds treated with LET were more frequently anesthetic to a stick with a 27-gauge needle than wounds treated with EMLA (73% vs 40%, respectively, p = 0.01)... no difference in the median pain of supplemental lidocaine injection between the two groups."	"[P]retreatment of uncomplicated lacerations ... with LET or EMLA cream results in a similar reduction in the pain of subsequent injection of lidocaine."	Lack of placebo group.
Schilling 1995 RCT Sponsored by FA Bean Education and	8.5	N = 171 (51 female and100 male) with uncomplicated laceration on face or scalp. Mean age TAC/LET	Lidocaine, epinephrine, tetracaine (LET) solution (N = 57) vs Tetracaine, adrenaline, cocaine (TAC) solution	"In the TAC and LET groups combined, 116 of the 151 patients (76.8%) received adequate anesthesia before suturing. There was no difference between TAC (79.5%) and LET (74.4%) (p = 0.46). There was no difference between TAC and LET in	"LET is an effective alternative to TAC for topical anesthesia during suturing of uncomplicated lacerations on the face and scalp in children."	Applicability uncertain as population was pediatric with scalp/facial lacerations. May have had adult parents with needle phobia.

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Research Fund, Minneapolis Children's Medical Center. No mention of COI.		group: 5.9 ±3.3/6.4±3.4	(N = 58). Serum lidocaine obtained 10, 20, and 40 minutes after LET and TAC application.	adequacy of anesthesia before suturing or duration of anesthesia during suturing of lesions located on the forehead/eyebrow or scalp area."		
Pryor 1980 RCT No mention of sponsorship or COI.	7.5	N = 151 (gender not specified) with lacerations. Age range 1 to >17, mean age 9 years.	Topical TAC (N = unknown) vs topical lidocaine (N = unknown) vs placebo for lacerations <5cm (N = unknown). Wound complications assessed at 48 to 72 hours.	"These was no significant difference between patients anesthetized with TAC (18%) and lidocaine (23%) in their need for additional lidocaFine following initial anesthetic application and/or during wound repair; 83% of the patients in the placebo group required supplemental lidocaine.Successful initial anesthesia did not differ significantlyin any of the anesthetic groups. TAC produced initial anesthesia more often in extremity locations vs lidocaine or placebo."	"These results suggest that TAC, when applied correctly, may be the preferred anesthetic for laceration repair in children."	Blinding only in TAC vs placebo group. Remarkably, 17% of topical placebo group did not require anesthesia. Study was pediatric population.
Zempsky 1997 RCT Sponsored by by grant from the General Clinical Research Center, Children's Hospital of Pittsburgh. No mention of COI.	7.5	N = 32 (gender not specified) with lacerations. Ages 5 to 18 years.	EMLA without supplemental anesthesia (N = 16) vs TAC for suturing uncomplicated extremity wounds (N = 16). Mean time of anesthetic application in the EMLA-treated group was 55 minutes cs 29 minutes in TAC-treated group, (p < 0.01).	"85% of EMLA group had complete wound repair without supplemental anesthesia, compared with 7 of 16 patients (45%) in the TAC-treated group (p-0.03)…The mean time of anesthetic application in the EMLA-treated group was 55 minutes, compared with 29 minutes in the TAC-treated group (p<0.01). The EMLA-and TAC-treated groups were not significantly different with regard to the VAS scores."	"Our data show that extremity wounds treated with EMLA for 60 minutes require supplemental anesthesia less often than those wounds treated with TAC for 30 minutes."	No mention of control of other analgesics. May not be applicable to adults. Although inclusion criteria was up to 18 years old.
Kuhn 1996 RCT	7.5	N = 181 (gender not specified) with lacerations.	MAC (N = 95/114) vs	"There was no significant difference in the overall efficacy of the two solutions… MAC was significantly more effective in anaesthetizing wounds of the	"MAC can be substituted for the less readily available TAC whenever expedient."	Purpose of study was to determine if acceptable alternative to tetracaine, which is not readily available in Australia. Allocation method and baseline comparability unclear.

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Sponsored by grant from Development Fund of Society of Hospial Pharmacists of Austraila. No mention of COI.		Age >12 years.	TAC topical anesthesia for wound suturing (N = 37/66). Follow-up unclear.	head than of the extremities (p<0.001), while TAC did not differ significantly in effectiveness between the two sites…Patients' preference for topical anesthesia in the future did not differ markedly between the two treatment groups: 70/86."		
Vinci 1996 RCT No mention of sponsorship or COI.	7.0	N = 156 with lacerations. Age range 3-18 years.	Group I, TAC 11.8% cocaine (N = 49) vs Group II, TAC 4% cocaine (N = 49) vs Group III, tetracaine plus cocaine 4% for lacerations anesthesia (N = 58). First assessment after 15 minutes and 15 after second application.	"Solutions containing 11.8% cocaine (TAC 1) and 4% cocaine with adrenaline (TAC 2) were significantly more likely (p < 0.001) to produce complete anesthesia then the solution with 4% cocaine without adrenaline…A A second dose of TAC 3 was more often required to produce complete or partial anesthesia, (p< 0.003).	"The application of a TAC solution containing 4% cocaine is as effective as a TAC solution containing 11.8% cocaine; use of this 4% solution decreases the cost of the agent."	No placebo group. Allocation unclear. Population 3-18 year olds.

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WOUND REPAIR

Wound repair is most commonly performed through primary closure (immediate approximation of the wound edges) to reduce discomfort and speed healing. Closure of most low-risk wounds can occur 12 to 24 hours after the injury. Contaminated wounds or those at high risk of infection should be closed within 6 hours.(151) Wounds outside of these parameters can be treated by delayed primary intention after 2-3 days of antibiotics reducing risk for subsequent infection. Sutures are the most common method, followed by staples, adhesives, and tapes.

1. *Recommendation: Non-surgical Management of Non-complicated Hand Lacerations Less than 2cm in Linear Length*
   It is recommended that non-complicated linear lacerations of the hand less than 2cm be managed without suturing by healing via secondary intention for some workers. Wounds should be carefully selected, not have tension, including not overlying or near joints and not have tension applied due to manual labor.

   Strength of Evidence **– Recommended, Evidence (C)**
   Level of Confidence – Low

2. *Recommendation: Surgical Referral for Hand Lacerations with Evidence of Nerve Injury*
   Immediate referral to a surgeon is recommended if the laceration shows evidence of a nerve injury.

   Strength of Evidence **– Recommended, Insufficient Evidence (I)**
   Level of Confidence – High

3. *Recommendation: Suture Repair for Hand or Forearm Lacerations*
   Suture repair is moderately recommended for lacerations of the hand or forearm as these lacerations respond well to common suture techniques and suture materials. There are no recommendations for one technique over another or for one suture material type over another.

   Strength of Evidence **– Moderately Recommended, Evidence (B)**
   Level of Confidence – Moderate

4. *Recommendation: Use of Tissue Adhesive, Staples, and Surgical Tape (Steri-Strips) for Uncomplicated Laceration Repair*
   Tissue adhesives, staples and surgical tape are moderately recommended for routine skin repair of non-complicated extremity lacerations within the limitations of repair strength equivalent to 5-0 suture material or higher.

   Strength of Evidence – **Moderately Recommended, Evidence (B)**
   Level of Confidence – Moderate

Rationale for Recommendations

There is one moderate-quality study comparing suture repair with non-surgical treatment (secondary intention) for hand lacerations less than 2 cm in length and uncomplicated by underlying joint, tendon, fracture, or nerve injury or medical conditions that would affect healing.(1392) There were no differences between the groups in cosmetic appearance, return to activity, or infection. As many hand lacerations are small and uncomplicated, this study suggests non-surgical management for non-gaping uncomplicated lacerations of the hand may be appropriate. Although, a comprehensive recommendation for working populations is not made as the provider should consider tensile forces on the wound and other environmental exposures resultant from occupational duties that likely reduce the ability to use non-surgical management for some patients in making a treatment decision.

There are no quality RCTs of upper extremity wound lacerations comparing suture repair with healing by secondary intent for gaping lacerations exceeding 2cm in linear length. However, wound closure most commonly by suture techniques has been long performed making suture repair the basis for other comparison studies. Therefore, although there is a lack of supporting studies, suturing is considered first line for laceration repair, with the strength of other repair recommendations made against using secondary intent in non-infected wounds.

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Various suture techniques have been described to provide the approximation of skin margins. However, there is a relative lack of quality studies that are methodologically sound while also having sufficient follow-up time of greater than one year to derive robust conclusions regarding the relative merit of different suturing techniques. Optimal results are thought to be dependent on skin edge eversion to eliminate depressed scarring, elimination of dead space and minimization of tension of individual sutures to avoid tissue necrosis. Common techniques include simple interrupted, vertical mattress, and running sutures. There are two moderate-quality studies of suture techniques, although there were no direct comparisons between the common techniques. Two versions of vertical mattress were compared with no difference in outcomes in a low quality study.(1393) Simple running cutaneous suture was compared with running subcutaneous sutures (removed at 14 days and not removed non-absorbable suture) and subcutaneous polygalactin (absorbable) running suture for treatment of post-elliptical excisions, rather than traumatic lacerations.(1394) There were short and intermediate advantages of polygalactin vs. polypropylene subcutaneous sutures, which disappeared at 9 months. This study, however, may not be generalizable to laceration repairs. Comparison of single layer vs. bi-layer repair for minor lacerations showed no difference in cosmetic results, although this was a study of facial lacerations, and may not be applicable even though the face is considered cosmetically more sensitive than the extremity.(1395) Therefore, there is no quality evidence to recommend one technique over another, and there are multiple scenarios that one technique might offer technical advantage over another, so that the operator focus may best be on principles for assuring optimal results.

There is also a lack of quality data comparing suture types for extremity laceration repair. The available cosmetic studies are both methodologically weak and have inadequate follow-up times to derive clinically meaningful differences on cosmesis.(1396) One moderate-quality study showed comparability of absorbable catgut to nylon sutures for simple repair.(1397) A low-quality study showed no difference between absorbable suture with nylon suture.(1398) A systematic review in pediatric and adult populations of absorbable vs. non-absorbable sutures did not find superiority of one over the other.(1399) Another moderate-quality study compared Teno Fix® repair, which uses a multifilament stainless steel suture, to a simple repair with cruciate suture for flexor tendon lacerations and found that repairs with the Teno Fix® had lower rupture rates and similar functional outcomes when compared with conventional repair.(1400) Thus, there is insufficient quality evidence to make a recommendation for or against the use of absorbable or non-absorbable suture material for superficial closure of extremity lacerations.

In addition to evaluating different types of sutures, one moderate-quality study compared suturing to stapling and concluded that stapling is more cost-effective than sutures. However, no outcomes measures for cosmetic results or complications were presented.(1401)

There are 17 moderate-quality studies comparing tissue adhesives with standard suture repair of routine extremity lacerations that have shown at least equivalent or superior cosmetic results with no statistically significant increase in infections, dehiscence rates, or other complications.(151, 1402-1419) Advantages to using tissue adhesives also include elimination of the need for local anesthesia, significant reduction of repair time, and ease of performing the procedure saving on visit time over suture repair. Disadvantages of wound characteristics (especially depth and length) and occupational tasks requiring considerable tension are considerable in working populations and are discussed below.

The most commonly used tissue adhesive is octylcyanoacrylate also known as Dermabond®. The other major glue is N-butyl 2-cyanoacrylate, also known as Histoacryl® and Histoacryl Blue® which has a blue tint for reported easier application.(1420) are only two direct comparisons of the compounds, which showed no difference in outcomes measures.(1421, 1422)

In each of the studies which included traumatic and surgical wounds of the hands, upper extremities, trunk and face in both pediatric (1-18 years of age) and adult populations, wound characteristics were usually limited to non-crush injuries, less than 4 cm in length, less than 5mm deep, and without other complicating factors including history of keloid or other scarring disorders, diabetes mellitus,

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corticosteroid or other immunosuppressant use, or debilitating illnesses. Thus, the results of equivalency in treatment may not be applicable to many with work-related upper extremity lacerations.

Tissue adhesive was also compared to the use of Steri-Strips in 7 moderate-quality studies as either a primary comparison(1418, 1419) or as part of the “standard care” treatment arm. (1403, 1407, 1410, 1413, 1414) In each trial, Steri-Strips were found to be equivalent in efficacy to tissue adhesive with the same inclusion and exclusion criteria. Tissue adhesive was also compared with the use of skin stapling in 5 moderate quality studies(151, 1404, 1407, 1413, 1414) as part of the non-surgical treatment arms. In each of these studies, the results were equivalent in all outcomes measures.

Therefore, there is strong evidence that tissue adhesives, skin stapling, and adhesive tapes are effective in the repair of routine lacerations of the upper extremity provided they are used on skin areas that are not subject to significant tension (i.e., joints, creases in hand, etc.). In appropriate cases, these have the added advantage of reduced operator or procedural time and material costs compared with suture repair.

Evidence for Wound Repair
There are 29 moderate-quality RCTs incorporated into this analysis.(151, 1392-1395, 1397, 1400, 1401, 1403-1406, 1408-1421, 1423-1425) There are 4 low-quality RCTs(1398, 1426-1428) in Appendix 2.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: wound repair, wound healing, laceration, wound, cuts, management, repair, care, upper extremity; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 454 articles in PubMed, 95 in Scopus, 17 in CINAHL, 2 in Cochrane Library, 15062 in Google Scholar, and 0 from other sources. We considered for inclusion 20 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 9 Google Scholar, and 4 from other sources. Of the 34 articles considered for inclusion, 34 randomized trials and 0 systematic studies met the inclusion criteria.

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Author/Year Study Type Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Suturing vs. Healing by Secondary Intention						
Quinn 2002 RCT Sponsored by US National Institutes of Health. JQ was paid by Ethicon, for speaking and educational sympsiums.	7.5	N = 91(40 female and 51 male) with lacerations. Age in Suture and Conservative groups: 40 (16) and 38 (15).	Suturing method of securely closing wounds (N = 47) vs Conservative treatment of uncomplicated lacerations <2cm (N = 48). Follow-up at 8 and 10 days.	Mean scores for cosmetic appearance; suturing vs. conservative treatment: Doctor scores 83mm vs. 80mm; patient scores 83mm vs. 82mm. One sutured wound treated with antibiotics for infection. No infections in conservatively treated wounds.	"Similar cosmetic and functional outcomes result from either conservative treatment or suturing of small uncomplicated lacerations of the hand, but conservative treatment is faster and less painful."	Results are specific to hand lacerations < 2 cm in linear length. The authors caution against generalization to cosmetically sensitive areas.
Suturing Techniques						
Singer 2005 RCT No mention of sponsorship. No COI.	7.0	N = 65 (9 female and 56 male) with lacerations; mean age 18.5±20.0.	Single-layersutures (N = 32) vs Double-layer closure of facial lacerations (N = 33).	Mean number of deep sutures used in patients assigned to a 2-layer closure was 2.8 ± 1.4. Wound outcomes; Single vs. double-layer. No infections in either group.	"Single-layer closure of non-gaping, minor facial lacerations is faster than double-layer closure."	Results may not be applicable to other body areas.
Alam 2006 RCT Sponsored by by research funds from Department of Dermatology, Northwestern University.	7.0	N = 36 (21 female and 15 male) with lacerations. Age 18-65 years.	Simple running polypropylene sutures 14 days (N = unknown) vs Subcuticular running polypropylene sutures 14 days (N = unknown) vs Subcuticular running polypropylene sutures not removed (N = unknown) vs Subcuticular polyglactin 910 sutures left in place (N = unknown). Follow-up at 3 and 9 months.	No difference in suture at either 3 months or 9 months. Greater scar width at 3 and 9 months, with back wounds being wider, (p < 0.001). No technique was superior.	"While scar width does not appear to vary significantly based on choice of epidermal closure, bilayered closures of the trunk and extremity have better overall appearance and less associated erythema at 3 and 9 months."	Patient was both control and experimental arm with 2 lesions per person.

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Jones 1993 RCT No mention of sponsorship or COI. No COI.	7.0	N = 30 (gender not specified) with lacerations. Age for traditional and shorthand group: 27.9 ± 6.3 and 25.3 ± 5.5.	Shorthand vertical mattress sutures (N = 15) vs Classic mattress sutures for lacerations ranging from 2 to 9cm (N = 15). Follow-up 7 to 10 days for wound assessment.	"Suture repair times were significantly shorter using the shorthand vertical mattress stitch compared with the traditional method (88.4 vs. 45.6 sec/suture; p <0.05). No incidents of significant scar widening, cross-hatching, or prolonged inflammation were noted with the shorthand vertical mattress technique."	"The shorthand vertical mattress stitch is an efficient, alternative method for laceration repair that does not compromise wound eversion."	Allocations unclear. No blinding.
Karounis 2004 RCT Sponsored by the Montreal Children's Research Institute and the Canadian Association of Emergency Physicians. No mention of COI.	5.0	N = 95 (58 male and 37 female) with lacerations < 12 hours old requiring suture repair. Mean age for groups A and B: 8.1 and 9.5 years.	Group A, absorbable catgut sutures (N = 50) vs Group B,non-absorbable nylon sutures (N = 45). Follow-up at 4 months.	No differences were found in proportion of optimal WES (6/6) between Group A and NA (62% vs. 49%; relative risk = 0.73%; 95% CI = 0.45 to 1.17). No differences found between Group A and NA for rates of dehiscence (2% vs. 11%; p = 0.07).	"Long-term cosmetic outcomes in wounds repaired with simple plain gut sutures seem to be at least as good as in wounds repaired with non-absorbable nylon sutures."	Randomization, allocation unclear. High drop-out rate.
Kundra 2010 RCT No mention of sponsorship or COI.	4.5	N = 100 (21 male and 49 female) elective day case hand and wrist surgery. Mean age Absorbable/ non-absorbable group: 54.0 / 57.3.	Absorbable 3/0 Vicryl rapide™ (N = 37) vs Non-absorbable (3/0 nylon) for the wound closure (N = 33). Follow-up 6 weeks post-surgery.	Mean VAS score for wound satisfaction were 82.5 for non-absorbable group vs 80.4 for the absorbable group. Mean DASH scores were 21.7 vs 21.1 absorbable group.	"Either suture material can be used confidently with respect to overall aesthetic appearance in such patients."	Data suggest both suture types were comparable, but data based upon questionnaire responses.
Suture vs. Staples						
Orlinsky 1995 RCT No mention of sponsorship or COI.	7.0	N = 141 with suturable linear lacerations of the extremities. Average age was 28 years and 29 for suture group.	Stapling (N = 78) vs Suturing for skin closure (N = 83). Follow-up until wound closure, average speed for stapling was 8.3 seconds per centimeter and suturing was 63.2 seconds.	"The average speed for stapling was 8.3 seconds per centimeter and for suturing was 63.2 seconds,(p = 0.0001) . Cost of labor was calculated to be 1.23 per minute…The relative labor cost of stapling versus suturing was 0.14 (76 cents v $ 5.31, p = 0.001). The speed of repair	"We conclude that, with respect to emergency department repair of linear nonfacial lacerations, stapling is a less expensive means of skin closure than suturing."	Results are based on hourly wage rather than payment by procedure codes. No outcomes measures for cosmetic results or complications were presented.

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				increased with increasing length of lacerations."		
Tissue Adhesives vs. Suturing						
Singer 1998 RCT Sponsored in part by a grant from Closure Medical, Inc., Raleigh, NC. No mention of COI.	7.0	N = 124 (48 female and 76 male) with standard closure of traumatic lacerations. Range age 1-17 years.	Tissue adhesive Octylcyanoacrylate (N = 63) vs Standard wound closure techniques for lacerations (N = 61). Follow-up for 3 months.	Patients treated with octylcyanoacrylate less frequently received local anesthesia (21% vs. 89%, p < 0.001). Groups similar with respect to decontamination with normal saline (81% vs. 75%, p = 0.36), irrigation (50% vs. 65%, p = 0.13), and use of a scrub (48% vs 31%, p = 0.08).	"Wounds treated with Octylcyanoacrylate and standard wound closure techniques have similar appearances 3 months later."	Comparison group included sutures and staples. Not clear how these were selected once randomized to control group.
Quinn 1993 RCT Sponsored by the Children's Hospital of Eastern Ontario Research Nstitute. No mention of COI.	6.5	N = 81 (34 male and 47 female) children with clean facial lacerations less than 4 cm in length and 0.5 cm in width. Age range, 0.7 to 16 years and 0.5 to 15 years.	Tissue adhesive Histoacryl Blue® (N = 37) vs Suturing with local anesthetic (N = 38). Follow-up for 5 days.	Cosmetic outcomes; Histoacryl vs. suture: Mean visual analog scale score (mm) 60.6 vs. 57.2 p = 0.45	"Histoacryl Blue® is a faster and less painful method of facial laceration repair that has cosmetic results similar to the use of sutures."	Pediatric population (newborn to 18). Randomization and allocation not well defined.
Holger 2004 RCT Sponsored by HealthPartners Research Foundation. No mention of COI.	6.5	N = 150 (108 male and 42 female) with facial lacerations. Mean age for those completing follow-up and did not: 70.2 and 28.6 (N = 84 and 66).	OC or octylcyano-acrylate tissue adhesive (N = 49 vs NL or 6-0 monofilament suture (N = 49) vs RG or Rapid 6-0 gut absorbable suture (N = 47). Follow-up at 9 and 12 months.	No clinically significant differences in cosmetic outcome among the three groups at 9-12 months.	"The use of either octylcyanoacrylate or rapid absorbing gut suture could be preferred in this setting (ED), eliminating the need for follow-up visits for suture removal."	All repairs made by physician assistants. High lost to follow-up rate at 9-12 months.
Sinha 2001 RCT	6.5	N = 50 (9 male and 35 female) with variety of hand operations. Mean age for adhesive and suture groups: 49 (9) and 51 (17).	N-butyl 2-cyanoacrylate tissue adhesive (Indermil) (N = 20) vs Sutures (5-0 nylon) at 2 and 6 weeks	No significant difference in cosmetic outcome assessment, but 5 minor wound dehiscences (3 in tissue adhesive group, 2 in suture group).	"Evaluation of patients in the two groups of our study showed similar wound outcomes."	Post-operative hand surgery wounds. Study limited to 6 week follow-up. Small sample size limits study power.

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No sponsorship. No mention of COI.			(N = 24). Follow-up at 2 and 6 weeks.			
Shamiyeh 2001 RCT No mention of sponsorship. No COI.	6.5	N = 79 (24 male and 55 female) requiring varicose vein surgery. Are range for group S / T/ and TA: 26 – 70 / 16 – 72 / and 20 – 73.	S group or Suture 5-0 monofilament (N = 26) vs Group T or adhesive tape (N = 28) vsTA or octylcyanoacrylate tissue adhesive (N = 25).	There were no differences between the groups for dehiscence or infections. The scars were judged slightly better for cosmetic result in the suturing group, but scores were not statistically significant.	"Comparing 5-0 monofilament sutures, tapes, and tissue adhesive for skin closure after phlebotomy, there was no difference in cosmesis, but closure with tape was by far the cheapest method."	Cost argument is relative, as all treatment material costs were $11 or less.
Singer 2002 RCT Sponsored by a research grant from Closure Medical Corporation, Raleigh, NC, which developed TraumaSeal. Two of the authors (AJS, JEH) are on the speaker's bureau of Ethicon Inc. No mention of other COI.	6.0	N = 924 wounds of traumatic lacerations, excisions of skin lesions or scar revisions, minimally invasive surgeries, and general surgical procerus. Mean age 31.9 and 30.7 for standard group.	OCA or octylcyanoacrylate tissue adhesive (N = 406) vs Standard wound closure methods,sutures, adhesive tapes, or staples (N = 408). Follow-up 5 to 10 days.	Wounds widely distributed over body. Many required subcutaneous sutures (55%). At 5-10 day follow-up, wound dehiscence and infection rates not significantly different between groups. At 3 months, no differencefs in wounds considered optimal (82% OCA vs. 83% other).	"Repair of traumatic lacerations and surgical incisions with OCA is faster than with standard wound closure techniques, and cosmetic outcome is similar at 3 months."	Allocation unclear although baseline comparability was non-significant. Study included large number of wounds (surgical and traumatic) which may improve applicability.
Quinn 1997 RCT Sponsored by Closure Medical Corp,	6.0	N = 136 (101 male and 35 female) with lacerations requiring suture. Mean age 35.3 ± 14.1 and 36.9 ± 17.2 for suture group.	Skin closure with octylcyanoacrylate adhesive (N = 68) vs Monofilament suture (N = 68). Follow-up for 3 months.	Octylcyanoacrylate vs. sutures: Mean VAS cosmesis scores, mm: 67 vs. 68 p = 0.65. Mean VAS pain scores, mm: 7.2 vs. 18.0 p <0.01; Infection, No.: 0 vs. 1; Dehiscence, No.: 3 vs. 1	"Octylcyanoacrylate tissue adhesive effectively closes selected lacerations. This relatively painless and fast method of wound repair can replace the need for	High dropout rate at 3 month follow-up.

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Raleigh, NC. No mention of COI.					suturing several million lacerations each year."	
Quinn 1998 RCT Sponsored by a research gift from Closure Medical Corp. No mention of COI.	6.0	N = 136 (63 male and 13 female) with traumatic wounds. Mean age for OCT and Sutures groups: 37.4 ± 12.4 and 39.6 ± 18.3 years.	Octylcyano-acrylate tissue adhesive (N = 68) vs 5-0 or smaller monofilament suture (N = 68). Follow-up at 3 months and 1 year.	No differences found in demographic or clinical characteristics between groups. At 1 year, no difference found in optimal wound scores (73% vs. 68%, p = 0.60) or in visual analog scale cosmesis scores (69 vs. 69mm, p = 0.95) for octylcyanoacrylate.	"One year after wound repair, no difference is noted in the cosmetic outcomes of traumatic lacerations treated with octylcyanoacrylate tissue adhesive and sutures. The assessment of wounds 3 months after injury and wound repair provides a good measure of long-term cosmetic outcome."	One year follow-up to 1997 study.
Bruns 1996 RCT No mention of sponsorship or COI.	6.0	N = 61 (49 male and 12 female) with lacerations less than 12 hours old. Between 1 and 18 years of age.	Histoacryl Blue (HAB) tissue adhesive (N = 30) vs Suture (N = 31) Follow-up at 1 week and 2 months.	Two plastic surgeons blinded to treatment. One rated no difference between groups, other favored HAB for better scar appearance.	"The use of HAB is an acceptable alternative to conventional suturing."	Pediatric population (<18 years old). Allocation not well defined.
Simon 1998 RCT No mention of sponsorship or COI.	6.0	N = 61 (49 male and 12 female) with lacerations. Median age for with follow-up and without: 4.0 and 3.0.	Histoacryl Blue (HAB) tissue adhesive (N = 30) vs Sutures in facial lacerations (N = 31). Follow-up at 2 months and 1 year.	Overall ratings of cosmetic outcomes were comparable or better in appearance for HAB group by blinded plastic surgeons. When reviewed by Langer line orientation, cosmetic appearance of sutured lacerations worse against Langer lines vs. sutured with Langer line orientation. No difference in Langer orientation with HAB group.	"The cosmetic appearance of facial lacerations repaired with HAB was comparable to conventional suturing, and appears to be less affected by the initial orientation of the wound with Langers lines than with conventional suturing."	Second report of similar study group. Allocation unclear.
Toriumi 1998 RCT Sponsored partially by Closure Medical	5.5	N = 111 (gender not specified) underwent surgical procedure for skin closure. Mean age was 41.2 years.	Octyl-2-cyanoacrylate (N = 57) vs 5-0 sutures (N = 54). Follow-up at 5, 7, and 90 days and 1 year.	Difference in time for skin closure between octyl-2-cyanoacrylate and sutures significant (p < 0.0001). No significant difference on modified Hollander scale at 90 days (p = 0.51). However, at 1 year, mean VAS scale for cosmetic outcome showed improved cosmetic results for	"The lower visual analog scale score represented a superior cosmetic outcome at 1 year with the octyl-2-cyanoacrylate as compared with sutures."	Study population was post-operative plastic surgery for facial and neck lesions.

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Corporation, Raleigh, N.C. No mention of COI.				incisions treated with octyl-2-cyanoacrylate (p = 0.03).		
Simon 1997 RCT No mention of sponsorship or COI.	5.0	N = 61 (49 male and 12 female) with lacerations. Median age for with follow-up and without: 4.0 and 3.0.	Skin sutures (N = 30) vs Histoacryl blue (HAB) tissue adhesive (N = 31). Follow-up at 1 year.	Wounds evaluated at 2 months and 1 year. Wounds comparable in cosmetic appearance at 2 months by one rater and significantly better for HAB by second rater. At 1 year, wounds comparable by both raters.	"The use of HAB in an ideal alternative to conventional suturing for cutaneous closer of low-tension lacerations in children with a long term cosmetic outcome comparable to conventional suturing."	Allocation, baseline comparability not described.
Handschel 2006 RCT No mention of sponsorship or COI.	5.0	N = 45 with an orbital floor fracture or facial wounds. The mean Age in the adhesive group was 47 years and 42 years in suture group.	Dermabond (octyl-2-cyanocrylate) (N = unknown) vs Ethilon 6-0 sutures (N = unknown). Follow-up at 3 months after surgery.	Patients rated skin adhesive higher on VAS, whereas surgeons rated sutured wounds as best cosmetically based on photographs. The scar wound depth was statically significantly greater in skin adhesive group than suture group.	"The adjustment of the edges of the wounds as measured by the depth of the scar is significantly worse with (Dermabond) than with thin sutures. The sutured wounds give better cosmetic results in younger patients in particular."	Authors used standardized incision (periorbital) to control wound type. Lack of study details for randomization. Small sample size. Results may be more applicable to cosmetically sensitive areas (face).
Karcioglu 2002 RCT No mention of sponsorship or COI.	4.0	N = 92 (male to female ratio 1.26) with lacerations equal to or shorter than 5 cm. Mean age 34 ± 11.04.	Histoacryl Blue (HAB) tissue adhesive (N = 24) vs Suture repairs (N = 28). Follow-up at 10 days and 3 months.	"There were no statistically significant scores of cosmetic outcomes at the tenth day and third month. The ratio of patients who reported satisfaction from the method was significantly higher in the HAB group than the sutured group (p = 0.007). Costs of treatment were significantly lower than sutures (p = 0.000)."	"HAB is a cheaper method of laceration repair and results in greater satisfaction of both the patient and the physician. The cosmetic outcomes are the comparable."	Lack of study details. No baseline data presented. High dropout at follow-up visits at 10 days and 3 months.
Tissue Adhesive vs. Adhesive Strips, Staples						
Singer 1998 RCT	7.0	N = 124 (48 female and 76 male) with standard closure of traumatic lacerations; age 1-17 years.	Tissue adhesive (Octylcyano-acrylate) (N = 63) vs Standard wound closure techniques for lacerations	Patients treated with octylcyanoacrylate less frequently received local anesthesia (21% vs. 89%, p <0.001). Groups similar with respect to decontamination with	"Wounds treated with Octylcyanoacrylate and standard wound closure techniques have similar appearances 3 months later."	Comparison group included sutures and staples. Not clear how these were selected once

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Sponsored in part by a grant from Closure Medical, Inc., Raleigh, NC. The authors also acknowledge the ED academic associates. nurses, and physicians for assistance in data collection. No mention of other COI.			(N = 61). Follow-up assessment at a median of 93.5 days.	normal saline (81% vs. 75%, p = 0.36), irrigation (50% vs. 65%, p = 0.13), and use of a scrub (48% vs 31%, p = 0.08).		randomized to control group.
Bruns 1998 RCT Sponsored in part by a grant from Closure Medical Corporation. No COI.	6.0	N = 83 (55 male and 28 female) with lacerations. Mean and median age for 2-OCA and Sutures / Staples: 3.5 (2.0, 5.0) and 4.0 (3.0, 6.0)	2-OCA or 2-Octylcyano-acrylate (N = 42) vs staples, steri-strips or monofilament sutures (N = 41). Follow-up at 3 months.	Length of time for cutaneous closure was decreased (median, 2-OCA 2.9 minutes vs. suture/staple 5.8 minutes; p <0.001). Assessment of pain not significantly different between groups. 95% receiving 2-OCA would choose 2-OCA over standard wound closure at next visit for laceration repair. No significant differences in clinical characteristics between groups at 3 months.	“2-OCA is an acceptable alternative to conventional methods of wound repair with comparable cosmetic outcome.”	Similar study design as previous study by same author (Bruns 1996). Funded by manufacturer of ethilon and Dermabond.
Mattick 2002 RCT No sponsorship. Ethicon supplied the Dermabond tissue adhesive and the camera. The Steristrips were from	5.5	N = 60 (28 male and 16 female) children with suitable lacerations. Between 1-14 years of age.	2-Octylcyano-acrylate or tissue adhesive (N = 30) vs Adhesive strips (N = 30). Follow-up at 3 and 12 months.	Evaluation at 3 and 12 months. “Cosmetic outcome for both treatments was high, with no significance when viewed from the critical eye of both the parent and the plastic surgeon.”	“In conclusion, both tissue adhesives and adhesive strips are excellent "no needle" alternatives for the closure of suitable pediatric lacerations.”	Small sample size with high percentage lost to follow-up.

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departmental stock.						
Zempsky 2001 RCT No mention of sponsorship or COI.	5.5	N = 97 (60 male 37 female) and with simple facial lacerations in children. Mean age for Steri-step group and Dermabond: 5.2 (2.7) and 5.3 (4.1) years.	3M Steri-Strip Closure, 2-Octylcyano-acrylate (N = 48) vs Dermabond orAdhesive strips (N = 49). Follow-up at 2 months.	Wound dehiscence occurred in 1 steri-stirps and 5 dermabond patients. No difference in total complication rates between groups (p = 0.11). Wound scores for rating surgeons not significantly different.	"Steri-strips and Dermabond provide similar cosmetic outcomes for closure of simple facial lacerations.."	Lack of study details. No allocation and minimal baseline compatibility data provided.
Singer Plast Reconstr Surg 2002 RCT Sponsored by a research grant from Closure Medical Corporation, Raleigh, NC, which developed TraumaSeal. Two of the authors (AJS, JEH) are on the speaker's bureau of Ethicon Inc. No mention of COI.	5.0	N = 924 and 814 patients (542 male and 382 female) wounds. Mean age 31.3 (21.1) years.	Octylcyanoacrylate tissue adhesive (N = 455 wounds) vs Standard wound closure methods sutures, adhesive tapes, or staples (N = 469). Follow-up for 3 months.	Characteristics associated with suboptimal cosmetic appearance on multivariate analysis were presence of associated tissue trauma 3.9 (95 C.I. 1.4-10.7), use of electrocautery (OR 2.9, 95% CI 1.8-6.5), extremity location (OR 2.9, 95% CI 1.2-3.7), wound width (OR 1.08, 95% CI 1.01-1.14). Wound infection associated with tissue trauma (8.7% vs. 1.7, p = 0.04) and incomplete wound apposition (6.6 % vs. 0.5 %.	"Suboptimal wound appearance is increased with extremity wounds, wide wounds, incompletely apposed wounds, associated tissue trauma, use of electrocautery, and infection.".	This is the second report of same population. Some methodology details lacking in this report.
Tissue Adhesive vs. Tissue Adhesive						
Osmond 1999 RCT Sponsored by Closure Medical Corp., Raleigh, NC. No mention of COI.	7.0	N = 94 (37 female and 57 male) with facial lacerations. Age at least 18 years.	Octylcyano-acrylate (N = 47) vs butylcyano-acrylate for superficial linear facial lacerations (N = 47). Follow up at 3 months.	No difference between butylcyanoacrylate and octylcyanoacrylate in time of wound repair (4.2 vs. 4.0 min, p = 0.88), pain induced by the procedure (VAS score 24 vs. 15, p = 0.37), and ease of procedure as rated by study physician (12 vs. 15).	"Although octylcyanoacrylate may have some superior physical properties compared with butylcyanoacrylates, based on this trial we recommend that children with selected facial lacerations (superficial, linear, < 4cm) may have	Study population limited to pediatrics (<18 years old) with facial lacerations.

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					their lacerations closed by either method."	
Flexor Tendon Laceration Repair with Device vs. Simple Tendon Repair						
Su 2005 RCT No mention of sponsorship or COI.	5.0	N = 67 (67 male and 20 male) with 85 flexor tendon injuries digits 2-5. Zone II laceration of flexor digitor-um profun-dus tendon with or without superficialis laceration. At least 18 years of age.	Teno Fix® repair (N = 29) vs Simple repair with cruciate suture (3-0/4-0 polypropylene) plus circumferential (6-0 monofilament nylon). Tendon had to be wide enough for use of the device. Rehabilitation with passive ROM first POD. Kleinert method for 1st 3 weeks (N = 38). Active flexion protocol at 4 weeks. Follow-up at 12 weeks.	Excellent/good and fair/poor results in: Teno Fix vs. 67% and 33% vs. traditional suture 70% excellent/good and 30% fair/poor. Ruptures developed in 0% Teno Fix vs. 9/51 (18%) traditional suture (p = 0.01). No differences in pain, grip/pinch strength or DASH scores, (p > 0.05).	"Tendon repairs with the Teno Fix® have lower rupture rates and similar functional outcomes when compared with conventional repair, particularly in patients who are noncompliant with the rehabilitation protocol."	Some baseline differences may be due to 7 crossovers to control group for technical reasons. High dropouts in control group at 6 months. More smokers in control group combined with more ruptures in controls raise concern for potential confounding.
Other						
Sener 2015 RCT No mention of sponsorship or COI.	5.5	N = 54 (39 male and 15 female) with hand lacerations. Age range 18-65 years.	Local infiltration anesthesia or LIA; hydrochloride 2% and 27 gauge needles used (N = 23) vs Peripheral nerve block or PNB (N = 31). Follow-up not given.	Response to injection pain and suture pain, (p = 0.220 and p = 0.316). Patient satisfaction and need for additional local anesthetics, (p = 0.785 and p = 0.628). Difference statistically significant for time to loss of pinprick sensation in the local infiltration group 1.3 min vs 2.2 minutes in block group, (p < 0.001). Significant difference regarding pain response to suturing; 8.8 vs 14.50, (p = 0.045).	"In conclusion, LIA or PNB for hand laceration surgery is convenient and predictable."	Data suggest both groups with comparable efficacy except for time required to administer (nerve block 2.2 min and local anesthesia 1.3min)
Moazzam 2003 RCT No mention of sponsorship or COI.	5.0	N = 20 (17 male and 3 female) undergoing free radial forearm flap surgery. Average age 58 years (range 28–84).	Cross-suturing, using a 4/0 gauge suture of Polyglyconate (N = 10) vs Control, the graft was applied without cross-suturing of the wound (N = 10). Follow-up at 3 and 7 months.	Cross-suturing group had immediate reduction in size of 30-68%, the mean reduction of 53%. Reduction of area of the cross-sutured forearm scars made after 3-7 months from 40 to 77%, with a mean reduction of 65%. At 3-7 months after surgery in the control cases had a reduction in scar area ranging from 17 to 68%, the mean of 38%.	"A cross-suturing technique is presented to reduce the deformity of the radial forearm flap donor defect."	Small sample size. Data suggest cross-suturing technique decreased size of forearm deformity when compared to controls (65% vs. 38%) as well as decreasing the area of the split skin donor site.

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Follow-up Wound Care

1. *Recommendation: Semi-occlusive or Occlusive Dressing of Wounds*
   There is no recommendation for or against the use of semi-occlusive or occlusive dressing for wounds. The use of semi-occlusive dressings is commonly used although there is little evidence that this practice improves infection rate or cosmetic outcomes. Dressings may be more indicated based on potential contamination at work or other workplace exposures.

   Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**
   Level of Confidence – Low

2. *Recommendation: Routine Wound Recheck by Health Professional*
   It is recommended that complicated wounds repaired with sutures or staples and heavily contaminated or infected at initial presentation be closely followed-up within 24 to 72 hours and at suture removal.

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – Moderate

Rationale for Recommendations
There is no quality evidence on proper wound dressing of upper extremity lacerations, the timing and necessity of wound recheck by a health professional, and the timing of suture removal. Upon completion of wound repair, common practice remotely was to cover the wound with semi-occlusive non-adherent dressing for 24 to 48 hours with topical antimicrobial product.(1429) Based on two reports from the 1960s, it was common practice is to keep the wound moist, which was thought to promote re-epithelialization, and reduce risk of infection. However, there are no quality trials supporting this practice and some question the concept.(1430-1432) Current practice is to minimize the use of these dressings for most lacerations to promote movement and use of injured body part(s) and frequently involves the use of bacitracin or poly-antibiotic ointment.

There is one related moderate-quality study comparing infection rates after dermatological excision and repair of wounds that were either left uncovered after 12 hours and allowing normal bathing vs. those that were kept dry under bandage for 48 hours. In this post-surgical population of 857 patients, there was no statistical difference in the infection rate, demonstrating that wounds can be uncovered and allowed to get wet in the first 48 hours without significant risk.(1433) However, it is unclear if traumatic lacerations would react different from surgically controlled wounds so no recommendation is made for or against use of occlusive or semi-occlusive dressings. Physician discretion is indicated dependent on the wound and characteristics of workplace exposures of the wound.

Wound care instructions are usually provided verbally or in written format including information on monitoring for signs of infection. There are no studies on post-repair infection rates comparing persons who have received verbal or written instructions with those that return in 24 to 48 hours for a wound check. However, there is one case series of 433 patients that on follow-up evaluation were asked to rate their wound based on wound care instructions provided for signs of infection. On physician examination, 21 were deemed to have a wound infection. Of these 21, 10 patients did not rate their wound as infected giving a false negative rate of 48% (10/21), although the false positive rate was low at 8%. It is, however, uncertain if these would have resolved or resulted in serious infection, as the follow-up visit occurred at different times, including suture removal. Thus, providing wound care instructions is likely useful, costs little except additional provider time, and may prevent serious infections from going undetected. Routine wound check at 24 to 72 hours is also a common practice and is recommended for complicated wound repair, those that are contaminated or with suspicion of retained foreign bodies, already infected at initial presentation, or if patient is working in unclean environments.(403)

Suture removal for optimal results in upper extremity lacerations is not well defined by quality studies. Common practice is removal of sutures or staples in cosmetically sensitive areas with low tension in 3 to 5 days, 1 week in lower tension areas on the upper extremities, and 10 to 14 days in high-tension areas.(151, 403, 1434) Wounds closed with cyanoacrylates or surgical tape are less likely to have

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concerns and follow-up may not be needed except for documentation of healing for patients in workers compensation systems.

Evidence for Follow-up Wound Care
There is 1 moderate-quality RCT incorporated into this analysis.(1433)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: follow-up wound care, semi occlusive dressing, routine wound check, wound healing, laceration, wound, cuts, management, repair, care, upper extremity; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 67 articles in PubMed, 84 in Scopus, 176 in CINAHL, 10 in Cochrane Library, 25 in Google Scholar, and 0 from other sources. We considered for inclusion 1 from PubMed, 0 from Scopus, CINAHL, Cochrane Library, Google Scholar, and 0 articles from other sources. Of the 1 article considered for inclusion, 1 randomized trials and 0 systematic studies met the inclusion criteria.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Wounds of Minor Skin Excision and Wound Management						
Heal 2006 RCT No mention of sponsorship or COI.	6.0	N = 857 (600 male and 257 female) with wounds or minor skin excision. Mean age 44 years.	Intervention group, or wound kept dry and covered 48 hours (N = 450) vs Control group, dressing removal and bathing within 12 hours of repair (N = 420). Follow-up within 12 and 24 hours.	Infection rates: dry group 8.9% vs. no dressing and wet 8.4%, intervention rate ratio not inferior to control p <0.05.	"Wounds can be uncovered and allowed to get wet in the first 48 hours after minor skin excision without increasing the incidence of infection."	Wounds were post-surgical excision repairs, which may be different characteristically from traumatic laceration. No blinding.

Prescription and Other Medications

ANTIBIOTIC PROPHYLAXIS

Recommendation: Antibiotic Prophylaxis in Uncomplicated Hand and Forearm Lacerations
Routine antibiotic prophylaxis is not recommended for uncomplicated hand and forearm lacerations.

Strength of Evidence – **Not Recommended, Evidence (C)**
Level of Confidence – Moderate

TOPICAL ANTIMICROBIALS

Recommendation: Use of Topical Antimicrobials for Wound Care
There is no recommendation for or against the use of topical antimicrobials for wound care as there is little evidence that this practice improves clinical infection rate or cosmetic outcomes.

Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**
Level of Confidence – Low

Rationale for Recommendations
There are two moderate-quality studies conducted over 25 years ago that demonstrated no difference in infection rates between no treatment or placebo and prophylactic oral doses of clindamycin, flucloxacillin, trilopen, and aerosolized povidine – iodine applied directly into the wound.(1435, 1436) However, one moderate-quality study did find that wound irrigation with penicillin provided reduced rates of wound infection.(1437) Each of these studies had significant weaknesses, and strong conclusions cannot be drawn. Two low-quality studies of cephalexin and clindamycin demonstrated no improvement in infection

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rates but are excluded from the analysis because of lack of study details.(1438, 1439) There are no quality data or recent data on newer broad-spectrum antibiotics for prophylaxis. Adequate irrigation, cleansing, and debridement of non-complicated wounds is therefore recommended as first line treatment to prevent infection, whereas antibiotic prophylaxis is not recommended unless other complicating factors warrant.

The use of topical antimicrobials is also common, but it is controversial. A high-quality study(1440) demonstrated a lower infection rate in wounds treated with topical antibiotics vs. petroleum ointment, although the control group's treatment may preclude strong conclusions. Although there was lower incidence of infection in the active antimicrobial arms vs. petrolatum, the infection rates were similar to other reported incidences that did not use any ointment. It is not possible to determine if the use of antimicrobial is efficacious, or if the use of non-antimicrobial ointment may increase infection risk. Thus, there is insufficient evidence to recommend for or against the use of topical antimicrobials, although they are generally inexpensive, easy to apply, and have relatively low risks for adverse effects. Wounds closed with tissue adhesives should remain uncovered, and application of ointments or antimicrobials should be avoided to reduce risk of dehiscence.(403) An additional concern is that neomycin is considerably allergenic, thus neomycin-containing compounds may have a relative disadvantage.

Evidence for the Use of Antibiotic Prophylaxis
There is 1 high-quality RCT on topical antimicrobials(1440) and 3 moderate-quality RCTs on antibiotic prophylaxis that are incorporated into this analysis.(1435-1437)

Antibiotic Prophylaxis
A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library and Google Scholar without date limits using the following terms: Antibiotic, Prophylaxis, Wound, Healing, Laceration, Cuts, Management, Repair, care, Upper, Extremity; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 5 articles in PubMed, 4 in Scopus, 8 in CINAHL, 8590 in Google Scholar, and 1 in Cochrane Library. We considered for inclusion 2 from PubMed, 0 from Scopus, 1 from CINAHL, 2 from Google Scholar, 1 from Cochrane Library and 0 from other sources. Of the 8608 articles considered for inclusion, 4 randomized trials and 6 systematic studies met the inclusion criteria.

Topical, Antimicrobials
A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library and Google Scholar without date limits using the following terms: Topical, Antimicrobials, Wound, Healing, Laceration, Cuts, Management, Repair, care, Upper, Extremity; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 58 articles in PubMed, 0 in Scopus, 8 in CINAHL, 5960 in Google Scholar, and 1 in Cochrane Library. We considered for inclusion 2 from PubMed, 0 from Scopus, 3 from CINAHL, 5960 from Google Scholar, 3 from Cochrane Library and 0 from other sources. Of the 6026 articles considered for inclusion, 0 randomized trials and 1 systematic studies met the inclusion criteria.

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Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Dire 1995 RCT No mention of sponsorship or COI.	8.5	N = 426 (gender not specified) with hand lacerations. Age BAC/ NEO/SIL/PTR group: 19.9 (15.1)/18.3 (13.7)/19.7 (14.1)/17.1 (13.1).	BAC or topical antimicrobials Neomycin (n = 109) vs. NEO group or bacitracin (n = 110) vs. SIL or silvadene group (n = 99) vs. PTR or petroleum ointment group (n = 108). Follow-up for 15 months.	Wounds were primarily head/neck followed by hand, lower extremity, and arm. Overall 42/426 infections (9.9%). Infection rates with 95% CI. Bacitracin 5.5% (2.0-11.6), Neomycin 4.5% (1.5-10.3). Silvadene 12.1% (6.4-20.2). Petrolatum 17.6% (10.9-26.1). Petrolatum was significantly higher (p = 0.0034) than others. No differences between other arms.	"The use of topical antibiotics resulted in significantly lower infection rates than did the use of a petrolatum control."	Study unable to address question of anti-microbial vs. no topical preparation. Infection rates in antimicrobial arms similar to previous studies using same techniques without antimicrobial treatment. Possible conclusion is that use of ointments without antimicrobial therapy increase risk of infection.
Lindsey 1982 RCT No mention of sponsorship or COI.	6.0	N = 260 Gender and age were not disclosed.	0.9% NaCl vs. 5% sodium benzyl penicillin for lacerations Follow-up history not disclosed.	"The study was terminated ...after the inclusion of 260 lacerations, when the upper sloping boundary was crossed for late infections… [A]nalysis of the distribution of preferences in the data at the time of stopping the study indicated high levels of statistical significance in the early purulent infections as well."	"It appears that two out of three or three out of four infections can be averted merely by flooding the wound with penicillin immediately before suture."	Methodology details sparse. Analyses and results also sparse.
Roberts 1985 RCT No mention of sponsorship or COI.	4.5	N = 418 Povidone Iodine average age 33.0 with 74.3% male and No treatment average age 28.1 with 71.2% males.	Povidine-iodine powder aerosol treatment of wound vs. none prior to suture repair Follow-up history not disclosed.	"There was no significant difference in the infection and imperfect healing rates between the povidine iodine and control groups. Significant factors (P<0.01) in the infected wounds were the condition of the dressing and part of the injured hand (palmar injuries). Neither the patients age, the time from injury to suturing or the number of sutures made a significant difference to the incidence of perfect healing."	"This trial does not show a significant difference in infection rate with povidine iodine therapy. The number of infected cases which were statistically analyzed was small."	No blinding of observer. Lack of study details. High dropout rate.
Roberts 1977 RCT No mention of sponsorship or COI.	4.0	N = 368 patients with hand lacerations. Triplopen group mean age is 30.4, Flucloxacillin group mean age is 29.8, and No antibiotics group mean age is 33.8. No gender disclosed.	Trilopen IM vs. Flucloxacillin PO vs. Control (no antibiotics) Follow-up 7 days after suturing.	"Chi-square analysis showed no significant difference in infection rate between the three groups (P > 0.3), but the Trilopen-treated group healed better (P < 0.05) than either of the other groups. Severe contamination of the original wound and a change of dressing carried out at home were also found to be significant compared to controls."	"Overall infection rate was 9.8 %, lower than other published work. Our results show that a course of flucloxacillin gave no improvement in wound healing over a policy of using no antibiotics. The other surprising fact…58% of patients said they had experienced no pain at all when the anesthetic had worn off."	Lack of study details. No allocation or baseline compatibility data provided.

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NSAIDs/ACETAMINOPHEN

Recommendation: NSAIDs or Acetaminophen for Upper Extremity Post-laceration Repair

NSAIDs or acetaminophen are recommended to control pain associated with upper extremity post-laceration repair.

Indications – Pain due to upper extremity post-laceration repair.

Frequency/Duration – Scheduled dosage rather than as needed is generally preferable.

Indications for Discontinuation – Resolution of pain, lack of efficacy, development of adverse effects, particularly gastrointestinal.

> *Strength of Evidence* – **Recommended, Insufficient Evidence (I)**
> *Level of Confidence* – Moderate

Evidence for the Use of NSAIDs/Acetaminophen

There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: NSAIDS, Wound Healing, Laceration, Lacerations, Wound, Cuts, Management, Repair, care, upper extremity; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 3 articles in PubMed, 10 in Scopus, 0 in CINAHL, 1 in Cochrane Library, 2900 in Google Scholar, and 0 from other sources. Zero articles met the inclusion criteria.

OPIOIDS

See Opioids recommendations in Carpal Tunnel Syndrome section.

Physical Methods/Rehabilitation

EXERCISE

Exercise is not indicated acutely. For a few patients with major trauma, or complex wounds, exercise in the recovery period is necessary. For patients with residual deficits, particularly post-operatively, see section on Post-Operative Rehabilitation and Rehabilitation of Patients with Functional Deficits: CTS and Other Disorders.

Evidence for the Use of NSAIDs/Acetaminophen

There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: exercise, exercising, physical activity, wound healing, laceration, wound, cuts, management, repair, care, upper extremity, hand, arm, forearm; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 72 articles in PubMed, 39 in Scopus, 17 in CINAHL, 195 in Cochrane Library, 72,700 in Google Scholar, and 0 from other sources. Zero articles met the inclusion criteria.

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WOUND CULTURE

Recommendation: Routine Wound Culture and Sensitivity of Animal and Human Bites

Routine culture and sensitivity of animal and human bite wounds is moderately not recommended as it has not been shown to be an effective predictor for infection or subsequent treatment of infected wounds.

Strength of Evidence **– Moderately Not Recommended, Evidence (B)**
Level of Confidence – Moderate

Rationale for Recommendation

There is 1 high-quality study and one moderate quality study of primarily animal, but also included some human bites where uncomplicated bite wounds were routinely cultured prior to treatment assignment.(162, 163) In both studies, there was no correlation between the pathogens that were cultured and any subsequent cultures from infected wounds.(162, 163) Another study also provided culture data, which confirmed expected flora, but no association was drawn in the analyses with subsequent infections.(1441) These analyses only apply to wounds that have no joint, tendon or tendon sheath involvement.

Evidence for the Use of Bite Wound Cultures and Sensitivity of Animal and Human Bites

There is 1 high-(163) and 2 moderate-quality(162, 1441) RCTs incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: wound culture, human, animal, dog, cat, bite, bites, diagnostic, diagnosis, sensitivity, specificity, positive predictive value, negative predictive value, and predictive value of tests, efficacy, and efficiency. We found and reviewed 1 articles in PubMed, 12 in Scopus, 0 in CINAHL, 17 in Cochrane Library, and 29,100 from Google Scholar. We considered for inclusion 0 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 0 from Google Scholar, and 3 from other sources. Of the 3 articles considered for inclusion 3 diagnostic studies met the inclusion criteria.

Author/Year Study Type Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Skurka 1986 RCT No mention of sponsorship. All three authors worked in the Division of Infectious Diseases at the hospital where study was held.	8.5	N = 39 (gender not specified) with obviously infected wounds, allergy to penicillin, antibiotics administere within 3 days prior to bite. Age 1-16.	Penicillin V-K (100,000 U/Kg/day q6hours x 2 days (n = 19) vs. Placebo (n = 20).	Overall infection rate 7.7%. Infection rate of antibiotic group = 5% vs. placebo = 10.5%, (p = NS).	"Prophylactic penicillin failed to prevent infection in dog bite wounds. Cultures showed various organisms but were of no predictive value for development of infection. It seems failure is better correlated to the quality of the local wound care than to prophylactic antibiotic."	Small sample size. No control for co-interventions. Culture samples of infected wounds not resistant to penicillin. Sample size for wounds sutured too small for comparison (N = 2), although neither became infected.
Brakenbury 1989	5.0	N = 122 (42 female, 80	Amoxicillin/ clavulanate for 5 days vs. placebo	Non-significant trend toward faster healing with	Amoxicillin/clavulanate significantly reduced the wound infection rate in	Study included a mixture of dog, human, and cat

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RCT Beecham Research Laboratories sponsored the research and helped with the analysis.		male). Mean ages of antibiotic and placebo groups for general bites is 30 and 34. Mean ages for same groups for hand bites are 30 and 37.	in full thickness animal bite wounds.	amoxicillin/clavulanate. No difference in age subgroups in rate healing. In adults, 33% of wounds in antibiotic treatment group became infected vs. 60% receiving placebo (p = 0.009). In children, difference non significant (24% antibiotic vs. 20% placebo). Wound infection significantly reduced by antibiotics in wounds older than 9 hours, but not in fresher wounds.	patients with bites where the skin is broken and where the patient presented 9 to 24 hours after injury.	bites, although a majority was dog bites. Study included primarily bites to the hand.
Boenning 1983 RCT Douglas A. Boenning is the Microbiology Laboratory director for The Children's Hospital of Philadelphia. Coauthor Gary R. Fleisher is the assistant director of The Children's Hospital of Philadelphia Emergency Department. No mention of sponsorship.	4.0	N = 55 (gender not specified) with mean age for penicillin group and control group being 10.5 and 9.5 respectively.	Penicillin V 250mg PO QID for 5 days vs. no antibiotics	Overall infection rate 3.6%, with no significant difference between control and penicillin groups. No difference in types of organisms isolated prior to treatment.	Penicillin prophylaxis of superficial non-facial dog bites in children appears no better than local wound care alone when lesions are cleansed soon after occurring. Initial cultures of dog bite wounds have no value in predicting subsequent wound infection.	Quasi-randomization by odd-even day of admission. No blinding, non-placebo control group.

Initial Care

1. *Recommendation: Blood Borne Pathogen Protocol for Human Bites*
   For human bites, it is recommended that exposures that could be considered high risk for viral blood borne pathogen transmission be evaluated and treated according to blood borne pathogen protocols.

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – Moderate

Rationale for Recommendation
There is no quality evidence for or against implementing blood borne pathogens protocols for human bites. However, exposures that could be considered high risk for transmitting viral blood borne pathogens (HIV, HBV, HCV), such as a traumatic bite lacerations where the offender may have concurrent oral trauma (fight, accident, seizure) should be considered for testing and prophylaxis according to standard protocols

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particularly as needlestick injuries with HIV contaminated blood carry substantially reduced risk of transmission if prophylactic anti-virals are administered in a timely manner. Institutions where employees are at higher risk for human bites may consider implementing policies for this particular class of injuries. A recent study of police officer bite exposures reported an estimated exposure rate to possible viral transmission of 68/10,000/year. Of these measured exposures for this group, 89 (79%) sources were tested, finding 4% HBV-positive, 4% HIV-positive, and 18% HCV-positive.(161)

2. *Recommendation: Prophylactic Antibiotics for Dog Bite Wounds*
   Prophylactic antibiotics are recommended for treatment of dog bite wounds.

   Indication – All dog bites. It may be reasonable to omit antibiotics for minor wounds.
   Dose/Frequency – Different antibiotics have been used in the quality studies, including penicillin VK, cloxacillin, dicloxacillin, erythromycin, co-trimoxazole, cephalexin, and amoxicillin/clavulnate. Strong Gram positive coverage is required. Tailoring the antibiotic selection to anticipated local antibiotic resistance profiles is advisable.

   Strength of Evidence – **Recommended, Evidence (C)**
   Level of Confidence – Low

Rationale for Recommendations
A pooled study of wound infection rates from dog bites was performed for this guideline that utilized the published data from all high- and moderate-quality studies antibiotics and showed a 37% reduction in wound infections compared with placebo (Odds Ratio 0.63, 95% CI 0.40, 0.97). These studies analyzed penicillin,(162, 163) penicillinase resistant penicillins,(1442-1444) sulfa compounds,(1445) erythromycin, (1442, 1444) or amoxicillin/ clavulanate.(1441) Thus, there is no clear preferential antibiotic to recommend. The individual studies all failed to show statistically significant reductions in infections, but were likely underpowered as infections are relatively infrequent and the studies had modest sample sizes. Prophylactic antibiotics are not invasive, have low adverse effects and are low cost particularly for generic compounds and thus are recommended for treatment of dog bites.

Evidence for the Treatment of Dog Bites
There is 1 high-(163) and 5 moderate-quality(162, 1563, 1564, 1566, 1567) (Rosen 85) RCTs incorporated into this analysis. There is 1 low-quality RCT in Appendix 2.(1565)

Blood Borne Pathogen Protocol
A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Blood borne pathogen protocol, Human bites, animal, dog, cat, bites, bite, Torso, Upper Extremity; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 0 articles in PubMed, 0 in Scopus, 0 in CINAHL, 1 in Cochrane Library, 618 in Google Scholar, and 7 from other sources. We considered for inclusion 0 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 0 from Google Scholar, and 7 from other sources. Seven articles met the inclusion criteria.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library and Google Scholar without date limits using the following terms: Prophylactic Antibiotics/ Cat bites, lacerations, upper extremity, bites, hand, arm, forearm;controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 1 article in PubMed, 6 in Scopus, 2 in CINAHL, 9 in Cochrane Library, and 1542 in Google Scholar. We considered for inclusion 1 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 1 in Google Scholar, and 0 from other sources. Of the 2 articles considered for inclusion, 0 randomized trials and 1 systematic study met the inclusion criteria.

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Author/Year Study Type Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Skurka 1986 RCT No mention of sponsorship or COI.	8.5	N = 39 (gender not specified) with obviously infected wounds, allergy to penicillin, antibiotics administer within 3 days prior to bite. (aged one to 19)	Penicillin V -K (100,000 U/Kg a day 6 hours for 2 days (n = 19) vs. Placebo (n = 20).	Overall infection rate 7.7%. Infection rate of antibiotic group = 5% vs. placebo = 10.5%, (p = NS).	"Prophylactic penicillin failed to prevent infection in dog bite wounds."	Small sample size. No control for co-interventions. Culture samples of infected wounds were not resistant to penicillin. Sample size for wounds sutured too small for comparison (n = 2), although neither became infected.
Brakenbury 1989 RCT No mention of sponsorship or COI.	5.0	N = 125 (42 females, 80 males for adults & 20 females, 43 males for kids) with dog, human and cat bites. Mean age for adults: 33.5 years, and 9 for kids.	Augmentin (n=88) for 5 days vs. Placebo (n=97) in full thickness animal bite wounds.	Non-significant trend toward faster healing with amoxicillin/ clavulanate. No difference in age subgroups in healing rates. In adults, 33% of wounds in antibiotic treatment became infected vs. 60% receiving placebo (p = 0.009). In children, difference non-significant (24% antibiotic vs. 20% placebo). Wound infection significantly reduced by antibiotics in wounds older than 9 hours, but not in fresher wounds.	"Amoxicillin/clavulanate significantly reduced the wound infection rate in patients with bites where the skin is broken and where the patient presented 9-24 hours after injury."	Study included a mixture of dog, human, and cat bites, although a majority was dog bites. Study included primarily bites to the hand.
Jones 1985 RCT No mention of sponsorship or COI.	4.5	N = 113 patients for dog bite wounds. Mean age, gender not specified.	5 day course of Co-trimoxazole 960 mg twice daily (n=58 wounds) vs. placebo (n=55 wounds)	Incidence of wound infection 13.8% in placebo vs. 5.5% in antibiotic group (p = 0.135). Hand wounds, infection rate 16.7% in placebo vs. 0% antibiotic (p = 0.0595).	"In conclusion, we feel that the routine treatment of dog bite wounds with antibiotics is not justified, but that hand wounds should be considered for such treatment."	Thirty-five subjects who failed to return for follow-up were classified as non-infected. Study had low power (required 370 patients in each group for sufficient power).
Rosen 1985 RCT No mention of sponsorship or COI.	4.5	N = 33 (66 wounds) (73 females, 77 males) with dog-bite wounds who were admitted within	Prophylactic antibiotics (either cloxacillin, dicloxacillin or erythromycin) group receiving 250mg 4x times daily for 5 days (n	Overall infection rate was 7.6% with 2/35 infections in antibiotics group, 3/31 in placebo group (p = NS). All infected wounds were of the hand/wrist vs. elsewhere p <0.01).	"Antibiotic administration does not reduce the likelihood of subsequent infection in the management of recent dog-bite wounds, or the incidence of infection when only hand wounds were considered."	Authors found higher risk for infection in hand/wrist wounds than other body parts. No information provided on compliance or other co-interventions.

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		8 hours of the incident. Mean age 27.8 for antibiotics group and 31.8 for placebo group.	= 35 wounds) vs. Placebo control group (n = 31 wounds). Both groups received standardized wound cleaning based on protocol. Follow-up at 2 or 3 days.			
Boenning 1983 RCT No mention of sponsorship or COI.	4.0	N = 55 children with non-facial dog bites (gender: not specified) Mean age for penicillin group: 10.5; control group: 9.5 years	Penicillin V 250mg PO QID for 5 days (n=25) vs. no antibiotics only local wound care (n=30)	Overall infection rate 3.6%, with no significant difference between control and penicillin groups. There was no difference in types of organisms isolated prior to treatment.	Penicillin prophylaxis of superficial non-facial dog bites in children appears to be no better than local wound care alone when lesions are cleansed soon after they occur. Initial cultures of dog bite wounds have no value in predicting subsequent wound infection.	Quasi-randomization by odd-even day of admission. No blinding, non-placebo control group.
Dire 1992 RCT Authors Dire and Hogan were part of the Emergency Medicine Rersidence Program for the Darnall Army Community Hospital where the study was held. No mention of sponsorship.	4.0	N = 185 (75 female/110 male). Mean age 9.0 for antibiotic group and 9.2 for placebo group.	Oral antibiotics (cephalexin, dicloxacillin or erythromycin) (n= 89) vs. no antibiotic treatment. (n=96)	One wound (1.1%) in antibiotic group and 5 (5.1%) in control group became infected (p = 0.212). No partial-thickness wounds became infected. No difference in wound infection rates for sutured wounds in the two groups (p = 0.562).	"Our results do not show a significant difference in wound infection rates among all low-risk dog bite wounds with or without oral antibiotic use. Routine prophylactic antibiotics would not seem cost-effective in the low-risk dog bite population."	Sparse study details. No blinding or placebo. Wounds were irrigated with povidone-iodine.

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3. *Recommendation: Prophylactic Antibiotics for Uncomplicated Human Bite Wounds*
Prophylactic antibiotics are recommended for treatment of uncomplicated human bite wounds.

Strength of Evidence – **Recommended, Evidence (C)**
Level of Confidence – Low

Rationale for Recommendation
There is one moderate-quality study of human bites,(164) and another moderate-quality study that included human bites along with other animals(1441) comparing the utility of prophylactic antibiotics in preventing wound infections. However, despite a relatively modest sample size in the sole study addressing risk of infection from human bites, a broad-spectrum oral antibiotic or IV antibiotics was found to be effective in preventing infection.(164) The study, which included dogs, cats, humans, and other animals, did not find any significant differences using Augmentin®.(1441) Given the reported higher incidence of wound infections related to human bites and the sole quality study addressing this question documenting success, the balance of evidence suggests prophylactic treatment is appropriate. Pathogens are usually gram-positive bacteria; prophylactic coverage from a broad-spectrum oral antibiotic is suggested to cover most typical staphylococcal and streptococcal species.

Evidence for the Treatment of Human Bites
There is 1 moderate-quality RCT incorporated into this analysis.(164)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library and Google Scholar without date limits using the following terms: Prophylactic Antibiotics / Human bites, torso, Upper extremity, lacerations, antibiotics, Animal bites ;controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 0 articles in PubMed, 8 in Scopus, 1 in CINAHL, 5 in Cochrane Library, and 3161 in Google Scholar. We considered for inclusion 0 from PubMed, 1 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 3 from Google Scholar, and 1 from other sources. Of the 5 articles considered for inclusion, 1 randomized trial and 3 systematic studies met the inclusion criteria.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Zubowicz 1991 No mention of COI or sponsorship.	5.0	N = 48 patients (23 males, 25 females). Mean age:26 years	Ceclor 250mg po tid vs Kefzol 1gm IV q8 and penicillin G 1.2 million U IV q 6 h vs. placebo	Infection rate in placebo group was 47% (7/15) with no infections in oral or IV antibiotics groups (p <0.05).	In uncomplicated human hand bite, wound toilet coupled with daily dressing changes and an oral prophylactic broad-spectrum antibiotic is satisfactory treatment in compliant patient.	Adult population. Sparse study details including lack of randomization and allocation methods. Patients admitted to hospital for control of co-interventions and compliance.

4. *Recommendation: Prophylactic Antibiotics for Uncomplicated Cat Bite Wounds*
Prophylactic antibiotics are recommended for treatment of uncomplicated cat bite wounds.

Strength of Evidence – **Recommended, Insufficient Evidence (I)**
Level of Confidence – Low

Rationale for Recommendation
There are no quality studies of antibiotic prophylaxis for cat bites. Only one study was found, but was relatively unhelpful due to limited sample size.(1446) However, the study showed a high incidence of wound infection in the placebo group (4 of 6) compared to none in the oxacillin prophylaxis group. Reported incidence rates of infections from cat bites is 20 to 40%,(153) and complications related to cat bites may be more significant. Therefore, broad spectrum antibiotics that include coverage for

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Pasteurella multocida, which is the most common pathogen contracted from cat bites,(1447) may be indicated.

Evidence for the Use of Prophlactic Antibiotics
There are no quality studies incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library and Google Scholar without date limits using the following terms: Prophylactic Antibiotics/ Cat bites, lacerations, upper extremity, bites, hand, arm, forearm; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 1 article in PubMed, 6 in Scopus, 2 in CINAHL, 9 in Cochrane Library, and 1542 in Google Scholar. We considered for inclusion 1 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 1 in Google Scholar, and 0 from other sources. Of the 2 articles considered for inclusion, 0 randomized trials and 1 systematic study met the inclusion criteria

5. *Recommendation: Laceration Repair for Dog-Bite Wounds*
   Suturing of non-complicated dog bite wounds after adequate wound care is recommended as it may lead to a better cosmetic result and is not likely to result in increased wound infections over wounds allowed to heal by secondary intent.

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – Moderate

Rationale for Recommendation
There is one moderate-quality study of laceration repair for dog bite wounds.(1442) There are no quality studies for human or cat bite lacerations. A low-quality study compared infection rates and cosmetic outcomes of dog bite wounds repaired with monofilament suture versus allowing to heal by secondary intent.(1448) There was no difference found in infection rates. Patients were less satisfied with the cosmetic outcome in the non-sutured group. No statistically significant difference was found in infection rates in sutured wounds.(1442) These and several other studies considered in the antibiotic prophylaxis recommendation section have concluded that wound care (irrigation, debridement, cleansing) is the primary factor for preventing infection.

Evidence for the Treatment of Bite Laceration Repair
There is 1 moderate-quality RCT incorporated into this analysis.(1442) There is 1 low-quality RCT in Appendix 2.(1448)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library and Google Scholar without date limits using the following terms: Suture, Bites, Human, Animal, Dog, Cat, Bite, Torso, Upper Extremity, controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 0 articles in PubMed, 2 in Scopus, 3 in CINAHL, 5 in Cochrane Library, and 50 in Google Scholar. We considered for inclusion 0 from PubMed, 1 from Scopus, 0 from CINAHL, 1 from Cochrane Library, 2 from Google Scholar, and 2 from other sources. Of the 6 articles considered for inclusion, 4 randomized trials and 2 systematic studies met the inclusion criteria.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Dire 1992 RCT Authors Dire and Hogan were part of	4.0	N = 185 (75 female/ 110 male).	Oral antibiotics (cephalexin, dicloxacillin or erythromycin) vs. no	One wound (1.1%) in antibiotic group and 5 (5.1%) in control group became infected (p = 0.212). No partial thickness wounds became infected. No difference in	"Our results do not show a significant difference in wound infection rates among all low-risk dog bite wounds with or without oral antibiotic use. Routine prophylactic antibiotics would not seem	Sparse study details. No blinding or placebo. Wounds irrigated with

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the Emergency Medicine Rersidence Program for the Darnall Army Community Hospital where the study was held. No mention of sponsorship.		Mean age 9.0 for antibiotic group and 9.2 for placebo group.	antibiotic treatment.	infection rate for sutured wounds in groups (p = 0.562).	cost-effective in the low-risk dog bite population."	povidone-iodine.

Follow-up Visits

There are no quality studies on the frequency and timing of follow-up visits for animal or human bites, or the effectiveness of wound care instruction and education. As the incidence of infection related to human and cat bites is much higher than for dog bites, there may be a stronger argument for having these patients present for wound check in 48-72 hours post injury. Follow-up for non-routine wounds should be dictated by the clinical presentation, or by other indications such as blood borne pathogens protocols and concurrent injury management.

Prescription Medications

There are no recommendations for the use of prescription medications except as noted for antibiotics and blood borne pathogens elsewhere.

Hand/Finger Osteoarthrosis

Diagnostic Criteria

For most purposes, a history and physical examination is sufficient but sometimes x-rays are used. X-rays are sometimes used in medicolegal situations to document the degree and extent of involvement. However, x-rays can be negative in those with osteoarthrosis as well as show evidence of disease among those asymptomatic.

Special Studies and Diagnostic and Treatment Considerations

X-RAYS

Recommendation: X-rays to Evaluate Hand Osteoarthrosis

X-rays are recommended to define objective evidence of the extent of hand osteoarthrosis.

Strength of Evidence – **Recommended, Insufficient Evidence (I)**
Level of Confidence – High

Rationale for Recommendation

There are no quality studies evaluating x-rays for hand osteoarthrosis. Most patients do not require x-rays for diagnosis and can be managed clinically. However, in some cases, x-rays are helpful and may assist in some patients in diagnosing and treating the condition. Thus, x-rays are recommended for hand osteoarthrosis.

Evidence for the Use of X-rays

There are no quality studies incorporated into this analysis.

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A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms:X-ray, radiography, x-rays, hand and finger osteoarthrosis, joint disease, osteoarthritis, diagnostic, diagnosis, sensitivity, specificity, positive predictive value, negative predictive value, and predictive value of tests, efficacy, and efficiency. We found and reviewed 0 articles in PubMed, 36 in Scopus, 0 in CINAHL, 1 in Cochrane Library, and 378 from Google Scholar. We considered for inclusion 0 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 0 from Google Scholar, and 0 from other sources. Zero articles met the inclusion criteria.

Initial Care

Relative rest, splints, ice, and heat have been utilized for treatment of hand osteoarthrosis.(1449-1451) Uncontrolled trials have reported splinting reduced the need for hand surgery.(910, 1452) Exercises have been recommended as well.(1451, 1453-1458)

1. *Recommendation: Relative Rest and Self-application of Ice for Chronic Hand Osteoarthrosis*
   Relative rest and self-application of ice are not recommended for chronic hand osteoarthrosis.

   Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
   Level of Confidence – Low

2. *Recommendation: Splinting for Acute Flares or Chronic Hand Osteoarthrosis*
   Splinting is recommended for acute flares or chronic hand osteoarthrosis.

   Indications – Hand osteoarthrosis symptoms insufficiently treated with NSAIDs, acetaminophen, and/or topical medications. Prefabricated or custom-made orthoses may be utilized.

   Strength of Evidence **– Recommended, Evidence (C)**
   Level of Confidence – Low

3. *Recommendation: Exercise for Acute Flares or Chronic Hand Osteoarthrosis*
   Exercise is recommended for treatment of acute flares or chronic hand osteoarthrosis.

   Indications – Hand osteoarthrosis symptoms insufficiently treated with NSAIDs, acetaminophen, and/or topical medications.

   Frequency/Dose – One or 2 appointments for teaching home exercises. An additional subsequent appointment or two a few weeks later may be helpful to reinforce exercises and techniques.

   Strength of Evidence **– Recommended, Evidence (C)**
   Level of Confidence – Low

4. *Recommendation: Self-application of Heat for Acute Flares or Chronic Hand Osteoarthrosis*
   Self-application of heat is recommended for acute flares or chronic hand osteoarthrosis.

   Indications – Hand osteoarthrosis symptoms insufficiently treated with NSAIDs, acetaminophen, and/or topical medications.

   Frequency/Dose – Self-applications of heat, most commonly 15 to 20 minutes, 3 to 5 times a day.

   Strength of Evidence **– Recommended, Insufficient Evidence (I)**
   Level of Confidence – Low

Rationale for Recommendations
There are no quality studies of these treatments other than splinting and exercise. Relative rest does not appear to improve the disease in any other joint in the body (see Hip and Groin Disorders Guideline), and instead may promote debility. Thus, while not invasive, potential adverse effects may occur. Although it is generally low cost provided the patient is able to continue to work, it is not recommended.

All quality studies of splinting addressed thumb CMC/trapeziometacarpal OA. There is one quality study evaluating splinting versus no splinting that suggested modest benefits,(1459) although that trial may have been biased by a non-interventional control. Two crossover trials of different splints suggest a

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flexible splint or support across the thumb CMC joint is superior to other, more rigid splint options.(1449, 1460) A fourth study compared two different exercise and splint regimens and found no differences,(1461) thus whether splints are beneficial compared with no splint is unclear. Splinting, particularly with a soft elastic support, is not invasive, has few adverse effects, is generally low cost and thus is recommended.

Most patients find heat superior to cryotherapies; however, there are no quality studies of either for treatment of hand OA. Heat may help with symptomatic relief, is not invasive, has no adverse effects, is not costly when self-applied and thus is recommended.

Exercise has not been widely investigated for treatment of hand OA, but has not been found to be harmful for hip or knee osteoarthritis patients (see Hip and Groin Disorders Guideline) and those patients obtain superior benefits with active exercise, and by inference may suggest rest is not appropriate for hand osteoarthrosis patients. One quality study found a home exercise program performed daily after a single 30-minute training session superior to educational controls for treatment of hand osteoarthrosis.(1458) An uncontrolled trial found strength training increased grip strength and reduced pain;(1456) however, a subsequent moderate-quality crossover trial by the same researcher did not find an exercise regimen of range of motion and strengthening exercises superior to another.(1457) As well, a study of combined exercises and splints failed to find one program superior.(1461) However, it is possible the trial by Rogers et al that evaluated exercises placed emphasis on flexibility exercises, thus biasing towards the null when additional trials may demonstrate clinically meaningful results. Exercises are not invasive, have low adverse effects and are low cost after an appointment or two for teaching purposes and are recommended.

Evidence for Splinting and Exercise for Hand Osteoarthrosis
There are 10 moderate-quality RCTs and randomized crossover trials incorporated into this analysis.(1571, 1579-1587) (Bani 13; Becker 13; Carreira 10; Villafane 13) There are 4 low-quality RCTs and 1 low-quality controlled clinical trial(1572, 1574, 1588-1590) (Boustedt 09; Adams 14; Weiss 00) in Appendix 2.

Rest:
A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Rest, Hand, Fingers, Thumb, Metacarpus, Osteoarthritis, Osteoarthrosis; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 26 articles in PubMed, 20 in Scopus, 169 in CINAHL, 1 in Cochrane Library, 100 in Google Scholar, and 0 from other sources. Zero articles met the inclusion criteria.

Ice:
A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Ice, Cryotherapy, Cold Therapy, Ice Pack, Self-Applied Ice, Cold Pack, Hand, Fingers, Thumb, Metacarpus, Osteoarthritis, Osteoarthrosis, controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 12 articles in PubMed, 22 in Scopus, 0 in CINAHL, 0 in Cochrane Library, 47,970 in Google Scholar, and 0 from other sources. We considered for inclusion 1 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 0 Google Scholar, and 0 from other sources. Of the 1 articles considered for inclusion, 0 randomized trials and 1 systematic studies met the inclusion criteria.

Splinting:
A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: splints, splint, splinting; hand, fingers, thumb, metacarpus, osteoarthritis, osteoarthrosis, degenerative arthritis; controlled clinical trial,

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controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 63 articles in PubMed, 73 in Scopus, 18 in CINAHL, 57 in Cochrane Library, 15,710 in Google Scholar, and 0 from other sources. We considered for inclusion 8 from PubMed, 2 from Scopus, 1 from CINAHL, 2 from Cochrane Library, 4 from Google Scholar, and 0 from other sources. Of the 17 articles considered for inclusion, 10 randomized trials and 10 systematic studies met the inclusion criteria.

Exercise:
A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Exercise, Hand, Fingers, Thumb, Metacarpus, Osteoarthritis, Osteoarthrosis; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 10 articles in PubMed, 182 in Scopus, 5 in CINAHL, 184 in Cochrane Library, 150 in Google Scholar, and 2 from other sources. We considered for inclusion 0 from PubMed, 1 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 2 Google Scholar, and 2 from other sources. Of the 5 articles considered for inclusion, 4 randomized trials and 1 systematic studies met the inclusion criteria.

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Author/Year Study Type Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Splint vs. No Splint						
Rannou 2009 RCT No conflict of interest disclosed. Funded by the Programme Hospitalier de Recherche Clinique National.	7.0	N = 112 (56 females/56 males) base of thumb OA (trapeziometa-carpal) Age = Mean of 63 for custom-made group, Mean of 63.5 for control group	Custom-made splint vs. no splint. Nocturnal use only prescribed for 12 months.	Pain VAS (baseline/ change at 1 mo/change at 12 months): splint (45.5±19.9/-10.1±3.0/-22.2±3.2) vs. control (47.7±19.8/-10.7±3.3/-7.9±3.5), p = 0.89 at 1 month and p = 0.002 at 12 months. Similar results for Cochin Hand Function Scale, patient-perceived disability. Pinch strength at 12 months splint: -5.4±7.1 vs. -14.4±7.7 (p = 0.38).	"For patients with base-of-thumb osteoarthritis, wearing a splint had no effect on pain at 1 month but improved pain and disability at 12 months.."	Subjects had severe disease. Baseline duration of disease worse in controls. More co-interventions in controls may have lessened differences. Post-traumatic disease excluded. No differences at 1 month vs. positive differences at 3 months difficult to resolve, particularly with nocturnal splint use.
Bani 2013 RCT crossover No COI. Financial support provided by the University of Social Welfare and Rehabilitation Science.	5.0	N = 35 (25 female/10 male) with grade 1 or 2 thumb carpometacarpal joint osteoarthritis, clinical and radiological diagnosis, pain in the base of the thumb Age = Mean average of 53.42 for prefabricated group, 54.91 for custom made group, and 58.64 for control group	Prefabricated thumb splints (N=12) vs Custom made thumb splint (N=12) vs Control group (N=11) Follow up Weeks 4, 6, and 10	The control group reported no significant differences in pain, function, or grip and pinch strength at week 4. At week 6 pinch strength significantly improved (p=0.000). At week 10 pinch strength (p=0.000) and pain (p=0.05) were the only parameters to improve. At week four both splints produced significant differences in pain (p=0.000 for prefabricated, p=0.000 for custom) and pinch strength (p=0.000, p=0.001). Functionality scores were significant for prefabricated splints (p=0.018) but not for custom splints (p=0.232). All were compared to the control group.	"Both splints increased pain, pinch strength and function compared to baseline and control group. We found no evidence that splints improved grip strength as compared to control group. There were no significant differences in function and pinch in comparing the splints. Pain was the only significant difference. The custom made splint demonstrated better results in pain reduction. It appears that these splints are helpful in the short-term in early CMC OA, particularly for pain."	Data suggest comparable efficacy with respect to functional outcomes but custom made splints were reported to be more comfortable. Small sample size. Crossover design.

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				At week 6 pain was significantly different for the custom splint (p=0.049). Grip strength was not improved. Pinch strength was improved in both prefabricated (p=0.000) and custom (p=0.000) groups. Functionality also improved in custom group (p=0.026). At week 10 both splints reduced pain (p=0.000 for prefabricated, p=0.000 for custom). Pinch strength and functionality were significant (p=0.000) for both). There were no significant differences between the two types of splints for functionality (p=0.136), grip strength (p=0.528), or pinch strength (p=0.651). At week 10 pain levels significantly differed (p=0.024).		
Becker 2013 RCT No COI or sponsorship.	4.5	N = 62 (48 female/14 male) with diagnosis of trapeziometa carpal arthrosis Age = mean of 63	Pre-fabricated neoprene Comfort Cool_ Thumb CMC Restriction Splint (N=32) vs Customized 3.2 mm thick thermoplast hand-based thumb spica splint (N=30) Follow up 9 weeks (average)	Comfort was the only statistically significant variable between the two splints (p=0.048) with participants preferring the neoprene splint. There were no detectable differences between the splints for areas of functionality, pain, pinch strength, satisfaction, and grip strength.	"When compared to custom-made thermoplast splints, pre-fabricated neoprene hand-based thumb spica splints are, on average, more comfortable, less expensive, and as effective in treating trapeziometacarpal arthrosis."	High dropout rate for final analysis. Data suggest comparable efficacy but neoprene splints tend to be reported as being more comfortable.
Carreira 2010 RCT	5.0	N = 40 (38 female/2 male) with	Splint group, thermoplastic splint, used splint from day 1 for daily activities	Between day 0 and day 90 there was a statistically difference in pain level	"Splint use during activities of daily living for patients	Data suggest that functional splints used for OA of the

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No mention of COI. Study was supported by the Fundacao de Amparo a Pesquisa do Estado de Sao Paulo.		osteoarthritis in trapeziometa carpal joint in dominant hand, clinical and radiological diagnosis, pain in base of thumb of dominant hand of between 3 and 7 on visual analog scale for pain (0 – 10 cm) Age =	(N = 20) vs Control group, thermoplastic splint, used only during evaluations and between days 90 and 180 Follow up Day 45, 90, and 180	between the groups (p=0.003). This was also observed at day 45 (p=0.013) and day 90 (p=0.002). In the splint group the pain was significantly reduced when comparing levels from day 0 to 45 (p < 0.001) and 0 and 90 (p < 0.001). No significant difference between the groups in scores of the first (p=0.524) and second (p=0.893) question of the DASH scores. Scores differed significantly for question three (p=0.382). No significant difference was observed between groups for dexterity, grip strength, and pinch strength. Comparing score differences from day 0 and day 180 the only significant difference was for pain without a splint (p=0.009).	with trapeziometacarpal osteoarthritis reduces pain, but does not alter function, grip strength, pinch strength or dexterity."	trapeziometacarpal joint "may" reduce pain but do not alter function (grip strength, pinch strength or dexterity).
Splint vs. Another Splint						
Weiss 2004 Randomized Crossover Trial No mention of COI. Funded by grant from the AAHS.	4.0	N = 25 (21 females/4 males); all with first CMC joint OA No mention of ages.	Prefabricated neoprene splint vs. custom thermoplastic short opponens splint for 1 week each	Pain at rest baseline 5.42 (SEM 0.48). Pain after CMT: 3.59 (0.44) vs. PFN: 2.29 (0.33), p <0.05. Pain with pinching favored PFN splint (p <0.05). "Long-term" patient preference 72% PFN vs. 24% CMT.	"[S]ubjects with stage I and II first CMCJ-OA will have pain relief with thumb splinting. In addition, the PFN splint will provide greater relief when compared with the CMT splint."	Suggests prefabricated neoprene splint over MCP and MCM superior to custom made orthosis for very short term treatment of 1 week.
Buurke 1999 Randomized Crossover Trial No mention of COI or sponsorship.	4.0	N = 10 (10 females/0 males) with OA of 1st CMC joint Age = Mean of 67.2	3 thenar eminence orthoses [supple elastic (Uriel 25), elastic with semi-rigid thumb busk (Gibortho ref. 6302) vs. semi-rigid polyethylene (Sporlastic 07051)]; 4 weeks each splint	Wearing comfort: Uriel 62.5 vs. Sporlastic 28.6 vs. Gibortho 23.3 (p <0.05). Order of preference Uriel then Gibortho/Sporlastic. Pain ratings: Uriel 47±34 vs. Sporlastic 55±37 vs. Gibortho 48±31. No preference for pain ratings.	"Eight out of 10 patients prefer the permanent use of a TE orthosis. Six patients chose the supple elastic orthosis and two chose the semi-rigid orthosis."	Small sample size. Half were splinting at the start of study. Crossover trial and 4 weeks duration are relative strengths.

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Exercise vs. Sham						
Villafñne 2013 RCT No sponsorship or COI.	7.0	N = 60 diagnosed with CMC joint OA Mean Age of 82 years 51 Females, 9 Males	Control (N = 30) – Placebo group, received detuned ultrasound therapy. vs Experimental (N = 30) – Received multimodal treatment protocol for CMC joint OA-related pain. Follow-up 1 and 2 months after intervention.	The experimental group (3.7, CI 95% 2.4, 3.8) had a significant greater reduction in pain than the control group (0.3, CI 95% 0). An ANOVA revealed no significant differences in pressure pain threshold between both groups (F=0.44, P=.72). There was no significant difference between the two groups in regards to grip strength (F=1.2, P = .31) and tip pinch strength (F = 0.4, P = .75)	"This study provides evidence that a multimodal intervention consisting of joint mobilization, neural mobilization, and exercise is beneficial to reduce pain in patients with CMC joint OA."	Data suggest combination therapy (ie. Joint mobilization, neural mobilization and exercise) is better than sham for pain treatment in patients with CMC joint OA.
Stamm 2002 RCT Sponsored by an unrestricted grant from Merck, Sharp, and Dohme. No mention of COI.	4.5	N = 40 with hand osteoarthritis Mean Age of 60.5 years 35 Females, 5 Males	Control (N = 20) Vs Joint protection and exercise (JPE) group (N = 20) No mention of Follow up	At baseline, grip strength was slightly, but not significantly, higher in the control group (0.43 ± 0.21 in JPE group and 5.4 ± 0.16 in the control group in the right hand and he left hand yielded 0.44 ± 0.19 and 0.53 ± 0.19, respectively. After 3 months, grip strength significantly improved in the JPE for both hands (P <0.0001 for the right hand and P = 0.0005 for the left hand, when compared to baseline). There was no significant improvement for the control group (P = 0.2335 for the right hand and P = 0.1612 for the left hand).	"Joint protection and hand home exercises, easily administered and readily acceptable interventions, were found to increase grip strength and global hand function."	Program involves minimal 1 visit. Baseline controls' grip stronger than exercise group may bias in favor of exercises. Improvements in strength not related to exercise time raises some questions.
Rogers 2009 Randomized Clinical Trial Sponsored by the Hygenic Corporation. No COI.	4.0	N = 46 subjects at least 50 years or older with radiographic OA.	Exercise Group – 16 weeks of daily hand exercise intervention. Vs Sham Group – 16 weeks with OTC nonmedicated hand moisturizing lotion.	Changes in AUSCAN sub-scales did not differ between the two treatment groups. Grip and pinch measures improved after exercise but not sham.	"The results of this investigation found that while a home-based daily 16-week regimen of hand strength and range of motion exercises modestly improved grip and pinch strength, this benefit was not sufficient to see	No placebo control. Exercise regimen emphasized range-of-motion, which may have biased towards null.

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		Mean age of 75 years old. 40 Females, 6 Males	No mention of group distribution. Time of follow up not mentioned.		an improvement in self-reported hand physical function or pain”	
Exercise and Splint vs. Other Exercise and Splint						
Wajon 2005 RCT No mention of COI or sponsorship.	4.0	N = 40 (31 females/9 males) All with Stage I-III trapezio-meta-carpal OA Age = 59.7 for thumb strap group, 61.2 for short opponens splint	Thumb strap splint plus abduction exercises vs. short opponens splint plus pinch exercises. Splints custom thermoplast. Exercises (5-10 reps, 3 sessions a day) added after 2 weeks of splinting. Total 6 weeks treatment.	VAS pain scores (weeks 0/2/6): thumb strap plus abduction exercises (3.0±1.9/2.1±1.8/1.3±2.2) vs. opponens splint plus pinch exercises (2.9±2.2/1.8±1.8/0.9±1.2).	“While both groups improved, neither regimen is superior to the other in patients with trapeziometacarpal osteoarthritis.”	Data suggest comparable efficacy. Splint worn full time, which may reduce ability to work or perform other activities.

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Follow-up Visits

Many patients require no follow-up appointments as the main thrust of the initial treatment generally focuses on securing the diagnosis and initiating treatment. Patients may require a few follow-up appointments, depending on severity and need for workplace limitations.

Medications

NSAIDS/ACETAMINOPHEN

NSAIDs and acetaminophen are widely used to treat pain associated with osteoarthrosis (OA), and are considered highly efficacious, although most studies evaluating their use lasted not longer than 6 weeks.(1463-1466) Most quality studies evaluated NSAIDs and acetaminophen in hip and/or knee OA patients and some evaluated low back pain patients (see Hip and Groin, and Low Back Disorders Guidelines). Few have evaluated hand osteoarthrosis patients.(1467-1469)

1. *Recommendation: NSAIDs for Acute Flares, Subacute, or Chronic Hand Osteoarthrosis*
   NSAIDs are moderately recommended to control pain associated with acute flares, subacute, or chronic hand osteoarthrosis. [Evidence is robust and strongly recommended for the treatment of osteoarthrosis in other body regions – Strongly Recommended, Evidence (A) (see Hip and Groin Disorders Guideline). Evidence is also present for efficacy of these agents for treating symptoms from OA flares (see Hip and Groin Disorders guideline).]
   Strength of Evidence **– Moderately Recommended, Evidence (B)**
   Level of Confidence – High

2. *Recommendation: NSAIDs for Acute Flares, Subacute, or Chronic Hand Osteoarthrosis*
   There is no recommendation for or against one NSAID over another as there is no consistent quality evidence that one NSAID is superior to another.
   Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**
   Level of Confidence – High

3. *Recommendation: NSAIDs for Acute Flares, Subacute, or Chronic Hand Osteoarthrosis*
   There is no recommendation for or against enteric-coated vs. sustained release preparations as there is no consistent quality evidence demonstrating superiority of one or the other (see Hip and Groin Disorders guideline).
   Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**
   Level of Confidence – High

4. *Recommendation: Acetaminophen for Acute Flares, Subacute, or Chronic Hand Osteoarthrosis*
   Acetaminophen (or the analog paracetamol) may be a reasonable alternative for treatment of osteoarthrosis pain – Recommended, Evidence (C),(1470, 1471) **although quality evidence is available that documents these are consistently less efficacious in comparison with NSAIDs [Evidence (A)]**(1472-1479) and at least two quality trials with placebo comparisons have been negative including one with a large sample size of 779 patients.(1474, 1480) Yet, acetaminophen may be preferable for initial treatment of elderly patients and others with risks for gastrointestinal bleeding.
   Level of Confidence – High

   Risk of adverse events from chronic NSAID use should be incorporated, especially including risk of gastrointestinal bleeding. Risk assessment should particularly include: prior history of gastrointestinal bleeding and source, length of treatment, age, smoking, diabetes mellitus and other medical factors. **It is strongly recommended that patients with greater risk should be considered for treatment with either acetaminophen, NSAID plus misoprostol, proton pump inhibitors or a COX-2 selective agent – Strongly Recommended, Evidence (A)** (see Hip and Groin Disorders Guideline).(1463, 1464, 1481-1484) While COX-2 selective agents have generally been

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recommended as either third- or fourth-line medications for routine use in osteoarthrosis patients, when there is a risk of gastrointestinal complications, they are often preferred. Proton pump inhibitors and misoprostol are also gastro-protective and have quality evidence of efficacy and are recommended (see Hip and Groin Disorders Guideline),(1481, 1482, 1484-1493) while there is substantially less evidence in support of sucralfate.(1492) COX-2 selective agents may still be used for those with contraindications to other medications, especially those with a history of gastrointestinal bleeding or past history of peptic ulcer disease. For patients at high risk of gastrointestinal bleeding, there is evidence that a combination of proton pump inhibitor plus COX-2 selective agent is efficacious.(1487) Should rofecoxib become available, it is suggested that it be considered as a fourth- or fifth-line medication for treatment of osteoarthrosis, likely paired with low-dose aspirin, and be positioned as a second-line medication for those with contraindications for the first- and second-line medication and in whom acetaminophen and celecoxib appear ineffective.

Indications – For hand osteoarthrosis patients, NSAIDs and acetaminophen are recommended for treatment. Over-the-counter agents may suffice and may be tried first.

Frequency/Duration – As-needed use may be reasonable for many patients. However, nearly all trials used scheduled doses. While not evaluated in hand OA patients, there is evidence that nocturnal dosing is superior for treatment of hip OA if the patient primarily has morning or nocturnal pain,(1494) although the study was of indomethacin and may only apply to shorter half-life agents as reproducibility of these findings and generalizability to other NSAIDs such as celecoxib with a longer half-life has not been shown.(1495)

Indications for Discontinuation – Resolution of hand pain, lack of efficacy, or development of adverse effects that necessitate discontinuation.

Strength of Evidence – **Recommended, Evidence (C)**
Level of Confidence – High

5. *Recommendation: NSAIDs for Patients at Risk for GI Adverse Effects*
Concomitant prescriptions of cytoprotective medications are strongly recommended for patients at substantially increased risk for gastrointestinal bleeding. There are four commonly used cytoprotective classes of drugs: misoprostol, sucralfate, double-dose histamine Type 2 receptor blockers (famotidine, ranitindine, cimetadine, etc.), and proton pump inhibitors (esomeprazole, lansoprazole, omeprazole, pantoprazole, rabeprazole). There is not generally believed to be substantial differences in efficacy for prevention of gastrointestinal bleeding,(1496) although evidence for sucralfate is limited. There also are combination products of NSAIDs/misoprostol that have documented reductions in risk of endoscopic lesions (see Hip and Groin Disorders Guideline).

Indications – For patients with a high-risk factor profile who also have indications for NSAIDs, cytoprotective medications should be considered, particularly if longer term treatment is contemplated. At-risk patients include those with a history of prior gastro-intestinal bleeding, the elderly, diabetics, and cigarette smokers.

Frequency/Duration – As recommended.

Indications for Discontinuation – Intolerance, development of adverse effects, or discontinuation of NSAID.

Strength of Evidence – **Strongly Recommended, Evidence (A)**
Level of Confidence – High

6. *Recommendation: Discussion Regarding NSAIDs for Patients at Risk for Cardiovascular Adverse Effects*
Patients with known cardiovascular disease or multiple risk factors for cardiovascular disease should have the risks and benefits of NSAID therapy for pain discussed.

Frequency/Dose **–** If needed, NSAIDs that are non-selective are preferred over COX-2 specific drugs. In patients receiving low-dose aspirin for primary or secondary cardiovascular disease prevention, to minimize the potential for the NSAID to counteract the beneficial effects of aspirin, the NSAID should be taken at least 30 minutes after or 8 hours before the daily aspirin.(1497)

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Strength of Evidence – **Recommended, Insufficient Evidence (I)**
Level of Confidence – Moderate

7. *Recommendation: Acetaminophen or Aspirin for Patients at Risk for Cardiovascular Adverse Effects*
   Acetaminophen or aspirin is strongly recommended as the first-line therapy for patients with known or multiple risk factors for cardiovascular disease.

   Frequency/Dose **–** See above.

   Strength of Evidence – **Strongly Recommended, Evidence (A)**
   Level of Confidence – High

8. *Recommendation: Acetaminophen for Acute Flares, Subacute, or Chronic Hand Osteoarthrosis*
   Acetaminophen is recommended to control pain associated with acute flares, subacute, or chronic hand osteoarthrosis pain, particularly for patients with contraindications for NSAIDs.

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – High

Rationale for Recommendations
There is abundant quality evidence that COX-1 and COX-2 NSAIDs improve pain and produce higher functional status among chronic osteoarthrosis patients (see Hip and Groin Disorders Guideline), and two quality studies included hand OA patients. There are a few studies of osteoarthrosis flares that also consistently document benefits, although not involving hand OA patients. There are many quality trials comparing the various NSAIDs, however, there is no consistent quality evidence of superiority of one over another or of one class over another class. There is one quality study suggesting that evening dosing of indomethacin results in better pain control, but the study has not been replicated(1494) and there is no similar result with the longer half life agent celecoxib.(1495) There is quality evidence that NSAIDs are less impairing than opioids, yet with comparable efficacy (see Chronic Pain and Low Back Disorders guidelines).

Quality evidence documents NSAIDs as superior to acetaminophen for symptomatic relief of OA (see Chronic Pain, Hip and Groin Disorders, and Low Back Disorders Guidelines).(1472-1478, 1498) However, quality evidence also indicates higher rates of gastrointestinal adverse effects among NSAID users and generally lower overall adverse effects profiles for acetaminophen, providing rational for utilization of acetaminophen to treat some patients, particularly the elderly and others prone to GI complications.

NSAIDs are not invasive, have low side effect profiles in a healthy working age patient population, and when generic medications are used are low cost. The potential for NSAIDs to increase the risk of cardiovascular events needs to be carefully considered in patients and will likely require additional quality studies to fully address. Acetaminophen is a recommended alternative, particularly for first line treatment or for patients at increased risk for GI complications. These medications are recommended.

Evidence for the Use of NSAIDs and Acetaminophen for Hand Osteoarthrosis
There is 1 high-quality crossover trial(1499) and 5 moderate-quality RCTs(1467, 1500-1503) incorporated into this analysis. There is 1 low-quality RCT in Appendix 2.(1468)

Acetaminophen:
A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: antiinflammatory agents, non-steroidal, Hand, Fingers, Thumb, Metacarpus, Osteoarthritis, Osteoarthrosis, NSAIDS, Acetaminophen; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 42 articles in PubMed, 58 in Scopus, 11 in CINAHL, 3 in Cochrane Library, 24081 in Google Scholar, and 0 from other sources. We considered for inclusion 4 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 0 Google Scholar, and 4 from other sources. Of the 8 articles considered for inclusion, 7 randomized trials and 0 systematic studies met the inclusion criteria.

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Gastrointestinal tolerability:
A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: antiinflammatory agents, non-steroidal, Hand, Fingers, Thumb, Metacarpus, Osteoarthritis, Osteoarthrosis NSAIDS, gastrointestinal tolerability; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 1 articles in PubMed, 8 in Scopus, 1 in CINAHL, 13 in Cochrane Library, 5496 in Google Scholar, and 0 from other sources. We considered for inclusion 0 from PubMed, 1 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 0 Google Scholar, and 0 from other sources. Of the 1 article considered for inclusion, 1 randomized trials and 0 systematic studies met the inclusion criteria.
Cardiovascular tolerability:
A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: antiinflammatory agents, non-steroidal, Hand, Fingers, Thumb, Metacarpus, Osteoarthritis, Osteoarthrosis, NSAIDS, cardiovascular tolerability; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 1 article in PubMed, 6 in Scopus, 3 in CINAHL, 10 in Cochrane Library, 5425 in Google Scholar, and 0 from other sources. We considered for inclusion 0 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 0 Google Scholar, and 0 from other sources. Zero articles met the inclusion criteria.

Acetaminophen, Aspirin, cardiovascular tolerability:
A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: antiinflammatory agents, non-steroidal, Hand, Fingers, Thumb, Metacarpus, Osteoarthritis, Osteoarthrosis, Acetaminophen, Aspirin, cardiovascular tolerability; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 0 articles in PubMed, 6 in Scopus, 0 in CINAHL, 0 in Cochrane Library, 5199 in Google Scholar, and 0 from other sources. We considered for inclusion 0 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 0 Google Scholar, and 0 from other sources. Zero articles met the inclusion criteria.

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Author/Year Study Type Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Pope 2004 RCT Sponsored by by Physicians Services Incorporated Foundation, Toronto, Ontario. No mention of COI.	8.5	N = 51 (gender not specified) with hip, knee or hand OA. Mean age 54 ± 2.4 years in N of 1 group, and 59 ± 2.3 years in conventional therapy	N of 1 group or of diclofenac 50mg plus misoprostol 200µg (n = 24) vs. Conventional therapy or placebo for 2 week durations for 6 months (n = 27).	In one group 11 patients preferred diclofenac, none preferred placebo, and 11 had no preference. NSAID appeared to be effective in 81% of patients.	"N of 1 trials were time-consuming in these patients and are more expensive, but with slightly better outcomes. In addition, NSAID seem to be effective in a majority of subjects with OA who have been uncertain of their benefit."	Subjects at enrollment "uncertain the nonsteroidal anti-inflammatory drugs were helpful." Results suggest NSAIDs are efficacious for majority of patients who were uncertain if they were effective.
Barthel 2010 RCT Sponsored by Novartis Consumer Health, Inc. and Endo Pharmaceuticals Inc. COI: MBC is fulltime employee of Endo Pharmaceuticals Inc. MSG is full-time employee of Novartis Consumer Health, Inc. RDA has received research grants from Novartis Consumer Health, Inc. and Ferring Pharmaceuticals , Inc. and consulting fees from Novartis Consumer Health, Inc., Ferring Pharmaceuticals	7.5	N = 783 (80.2% female and 19.8% male) with radiographically confirmed hand osteoarthritis. Mean age was 63.9 years.	Diclofenac Group- Diclofenac sodium 1% gel (4 g total, 2 g to each hand) (n = 400) vs. Placebo Group- Vehicle consisted of isopropyl alcohol, propylene glycol, cocoyl caprylocaprate, mineral oil, ammonia solution, perfume cream 45/3, carbomer homopolymer type C, polyoxyl 20 cetostearylether, and purified water (n = 383). Follow-up for 8 weeks.	There was no significant difference between groups for VAS pain intensity at 8 weeks, ($p > 0.05$). There were also no significant differences between groups for changes in AUSCAN scores, ($p > 0.05$) and global rating of disease, ($p > 0.05$).	"Pain relief correlated with improvements in physical function, stiffness, and global rating of disease in patients with hand OA, irrespective of treatment."	Combined analyses of 2 prospective RCTs suggesting that pain from hand OA is directly related to function, stiffness, disease status, and improvements in any of above is not dependent upon active vs. placebo treatment. Anticipation of pain is what limits function.

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, Inc., and Rottapharm and has participated in speakers' bureaus for Ferring Pharmaceuticals , Inc. and Forest Laboratories, Inc.						
Grifka 2004 RCT Sponsored by grant from Novartis Pharma AG, Basel, Switzerland. No mention of COI.	7.5	N = 594 (490 female and 401 male) with symptomatic osteoarthritis. Mean age 61.9 years.	200 mg Group-Lumiracoxib 200mg od (n = 205) vs. 400mg Group-Lumiracoxib 400mg od (n = 193) vs. Placebo (n = 196). Follow-up at 4 weeks.	At week 2, 200mg had pain intensity decrease of 21.3 points, 400mg group had decrease of 21.1 and placebo was 12.5. Both Lumiracoxib groups showed significant difference for pain intensity vs. placebo (p <0.001). But differences not significant between lumiracoxib groups. At week 4, respective decreases 28, 30 and 19.3. Global assessment of disease activity also decreased at week 4; 16.3, 20.9 and 9.4 in 200, 400 and placebo groups.	"Lumiracoxib 200 and 400 mg od were effective and well tolerated treatments for OA of the hand. Lumiracoxib significantly improved overall OA pain intensity in the target hand versus placebo, with a tolerability profile similar to placebo."	Data suggest both lumiracoxib 200mg and 400mg superior to placebo for treating hand OA pain at 4 weeks and overall tolerability comparable between all 3 groups.
Widrig 2007 RCT No mention of sponsorship or COI.	7.5	N = 204 (147 female and 57 male) with hand osteoarthritis. Mean age was 64 years.	Ibuprofen Group- 4cm strip of gel, applied 4x a day for 3 weeks. (n = 99) vs. Arnica gel 4cm strip of gel applied 4x a day for 3 weeks (n = 105). Follow-up for 3 weeks.	Pain intensity and hand function very similar in both groups, (p >0.05). No significant differences between groups for secondary outcomes of number of painful joints, intensity and duration of morning stiffness, (p >0.05).	"Our results show that short-term use, up to three weeks, of arnica gel improves pain and function in hand OA, indistinguishably from ibuprofen gel."	A non-inferiority study. Data suggest comparable efficacy between NSAID and arnica for topical treatment of hand OA.
Gabay 2011 RCT Supported by the Institut Biochimique SA (IBSA), PambioNoranco, Switzerland. Cem Gabay, MD, Carole Medinger-Sadowski, MD, Danielle Gascon,	7.5	N=162 patients (42 males, 120 females) with hand OA. Mean age 63.9±8.5 years for CS group and 63.0±7.2 years for placebo group.	CS group: (n=80) 800 mg tablet of chondroitin sulfate with glass of water taken for 6 consecutive months. Vs. Placebo Group: Placebo same size tablet as CS group. (n=82)	Improvement in patient hand pain was significantly better for the CS group than the placebo group (p=0.016). The decrease in FIHOA score showed a similar pattern (p=0.008). Presence of erosive OA was significantly associated with higher FIHOA score (p=0.005), but not with global pain intensity (p=.75). Hand function improved significantly more in the CS groups than in the placebo group (p=0.008). There was a statistically significant difference	"This study demonstrates that CS improves hand pain and function in patients with symptomatic OA of the hand and shows a good safety profile."	Data suggest CS efficacy vs. placeboin hand OA patients with improved function and reduced pain.

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RN, Frank Kolo, MD, Axel Finckh, MD: University Hospitals of Geneva and University of Geneva School of Medicine, Geneva, Switzerland. Dr. Gabay has received consulting fees, speaking fees, and/or honoraria from IBSA, Roche, MSD, Pfizer, and Bristol-Myers Squibb (less than $10,000 each)				between groups in favor of CS for duration of morning stiffness and for investigator's global impression of treatment efficacy. No statistical significance for grip strength, acetaminophen consumption, and safety end points.		
Smith 2010 RCT Sponsored by past Peacock Trust. No COI.	7.0	N = 40 (35 female/5 male) with osteoarthritis in first carpometacarpal joint. Mean age 66.9 years.	Treatment group up to 20ml 0.5% sodium salicylate injected on any 1 occasion, given all in 1 large patch or divided between 2-4 smaller patches (n = 20) vs. Control Group: blunt 23-gauge probe pressed on skin over each patch as if patch injected (n = 20). Assessments at weeks 3, 7, and 13 years.	Patients assessed for pain, tenderness and disability using the VAS scale. The difference was 1.9 cm between the groups for VAS pain at the final follow-up in favor of the active group, (p = 0.007). The difference for VAS tenderness score was also significant in favor of the active group, 1.4 cm, (p = 0.02).	"The data show that subcutaneous sodium salicylate injections are an effective symptomatic treatment for OA of the thumb."	Small sample size. Data suggest injection of subcutaneous sodium salicylate effective in thumb OA vs. sham.
Gastrointestinal Complications						
Lisse 2003 RCT Sponsored by Merck & Co., Inc. No COI.	7.0	N = 5,557 (3948 female/1609 male) with knee, hip, hand or spine OA. Mean age 63 years.	Rofecoxib 25mg a day (n = 2785) vs. Naproxen 500mg twice daily for 3 months. Double dummy (n = 2772).	Discontinuation due to adverse GI events lower in rofecoxib group (5.9% vs. 8.1%), RR = 0.74 (95% CI 0.60-0.92, p = 0.005). Similar findings in low-dose ASA takers. Less use of GI meds in rofecoxib group (9.1% vs. 11.2%, p = 0.014). Two perforations, ulcers or bleeding episodes in rofecoxib vs. 9 in naproxen (RR = 0.22, p = 0.038).	"[R]ofecoxib, 25 mg once daily, was as efficacious as naproxen, 500 mg twice daily, in controlling symptoms over a 3-month period and was associated with significantly better GI tolerability."	Very large sample size; no placebo. Participants allowed to take H-2 blockers. Results suggest equivalent efficacy for pain, but higher adverse GI symptoms and bleeds for naproxen vs. rofecoxib.

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TOPICAL NSAIDS
Topical NSAIDs are used for treatment of hand osteoarthrosis(1504-1506) that include over-the-counter products.

Recommendation: Topical NSAIDs for Hand Osteoarthrosis
Topical NSAIDs are recommended to control pain associated with hand osteoarthrosis.

Indications – Mild, moderate, or severe hand osteoarthrosis.

Frequency/Duration – See manufacturer's recommendation.

Indications for Discontinuation – Resolution, intolerance, adverse effects, or lack of benefits.

Strength of Evidence – **Recommended, Insufficient Evidence (I)**
Level of Confidence – Low

Rationale for Recommendation
Topical NSAIDs have been widely used. There are two quality studies are single-application studies precluding an evaluation is a regular treatment regimen, although they do suggest weak efficacy.(1504, 1505) Thus, there are not quality studies, and they appear to have quality evidence of efficacy for conditions with target tissue that is close to the skin, such as lateral epicondylitis (see Elbow Disorders Guideline) which is analogous to the skin in the dorsal hands. These medications are generally well tolerated, have few adverse effects, and are not costly when generic prescriptions are used, although they can be costly with name-brand prescription use over time. These medications are recommended.

Evidence for the Use of Topical NSAIDs for Hand Osteoarthrosis
There are 4 moderate-quality RCTs or crossover trials (1629, 1633, 1634, 1636) (Rothacker 94; Altman 09; Barthel 10) incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Topical NSAIDs, Topical non steroidal anti-inflammatory drug, Hand, Fingers, Thumb, Metacarpus, Osteoarthritis, Osteoarthrosis; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 0 articles in PubMed, 32 in Scopus, 9 in CINAHL, 67 in Cochrane Library, 150 in Google Scholar, and 2 from other sources. We considered for inclusion 0 from PubMed, 0 from Scopus, 1 from CINAHL, 0 from Cochrane Library, 3 Google Scholar, and 2 from other sources. Of the 6 articles considered for inclusion, 4 randomized trials and 2 systematic studies met the inclusion criteria.

Author/Year Study Type Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Topical NSAIDs vs. Placebo						
Rothacker 1994 RCT Crossover Trial Sponsored in part by Thompson Medical Company, West Palm Beach, Florida. No mention of COI.	7.5	N = 50 (41 female/8 male) with hand OA. Mean age 66 years.	Trolamine salicylate 10% cream single application (n = 24) vs. Placebo single application (n = 25).	Changes in right hand pain severity (0/45/120 minutes): Trolamine salicylate (-0.2/-1.3/-1.4) vs. placebo (-0.2/-0.9/-1.1), p = 0.60, p = 0.08, p = 0.32. Mean change in pain relief scores at 45 minutes p = 0.047, with other times not significant.	"Trolamine salicylate has been shown to be both safe and effective in this single-application study of patients suffering from morning pain and stiffness associated with osteoarthritis in the hands."	Ultra-short term study, single application. Suggests weak efficacy that is not long lasting.

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Altman 2009 RCT No mention of sponsorship and COI.	7.5	N = 385 diagnosed with OA in their primary hand. Mean age of 64.1 years old. 296 Females, 89 Males	Diclofenac Sodium Gel Group (N = 198) – Patients were given a topical 1% diclofenac sodium gel. vs Vehicle Group (N = 187) – Patients were given a placebo gel. Follow up 1, 2, 4, 6, 8 weeks after gel given.	At week 8, the diclofenac sodium gel group stayed significantly superior to the vehicle group on the AUSCAN stiffness and functional indices (P<0.048 and P<0.017, respectively). Diclofenac sodium gel decreased pain intensity by 42.3%, total AUSCAN score by 35% and global rating of disease by 36.1%.	"Topical diclofenac sodium gel was generally well tolerated and effective in primary hand OA."	Data suggest topical diclofenac gel was superior to placebo suggesting efficacy.
Barthel 2010 Prospective Sponsored by Novartis Consumer Health, Inc. and Endo Pharmaceuticals Inc. No COI.	7.5	N = 783 diagnosed with primary hand OA by American College of Rheumatology criteria Mean age of 63.9 years old 628 Females, 155 Males	Diclofenac Sodium Gel Group (N = 400) – Received 4g of 1% diclofenac sodium gel. Vs Vehicle Group (N = 383) – Received 4g of vehicle gel. Follow up 1, 2, 4, 6, 8 weeks after gel given.	Patients with at least 70% improvement from baseline score in VAS pain intensity had large mean improvements in AUSCAN pain, function, stiffness, and global rating of disease. Those that worsened also experienced a decrease in AUSCAN pain, function, stiffness, and global rating of disease. Change in VAS is correlated with AUSCAN pain, function, stiffness, and global rating of disease (P<0.001).	"Diclofenac sodium 1% gel is indicated for relief of OA pain in joints amenable to topical treatment, such as the hands and knees."	Data suggest pain relief correlates with improved hand function in OA patients irrespective of treatment.
Rothacker 1998 RCT	6.5	N = 86 with hand OA.	Trolamine salicylate 10% cream vs. placebo. Single applications of each.	Sum of pain intensity differences scores: Trolamine salicylate - 3.44 vs. -2.45, p = 0.072. Combined hands analysis p = 0.049.	"10% trolamine salicylate cream was shown to be safe and effective for the temporary relief of minor pain and stiffness associated with osteoarthritis in the hands."	Data suggest efficacy over very short-term from single application.

OPIOIDS – Oral, Transdermal, and Parenteral (Includes Tramadol)

See Opioids recommendations in Carpal Tunnel Syndrome.

COMPLEMENTARY/ALTERNATIVE THERAPIES

Glucosamine, chondroitin sulfate, methyl-sulfonyl methane, diacerein (diacerhein, diacetylrhein), harpagophytum, avocado soybean unsaponifiables, ginger, oral enzymes, and rose hips are often classified as complementary and alternative therapies that are sometimes used by patients for treatment of osteoarthrosis. (These are reviewed in detail in the Hip and Groin Disorders guideline.)

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1. *Recommendation: Capsaicin for Chronic Hand Osteoarthrosis or Acute Flares of Osteoarthrosis*
   Capsaicin is recommended for treatment of chronic hand osteoarthrosis or acute flares of osteoarthrosis.

   Indications – Hand osteoarthrosis pain or acute flares (study has also included rheumatoid arthritis patients).(1507, 1508)

   Frequency/Duration – Up to 4 times a day.

   Dose – Fixed dose per manufacturer.

   Indications for Discontinuation – Excessive burning of the skin or other intolerance. Not recommended for continual use, rather periods without use have been recommended.

   Strength of Evidence – **Recommended, Evidence (C)**
   Level of Confidence – Low

2. *Recommendation: Yoga for Chronic Hand Osteoarthrosis or Acute Flares of Osteoarthrosis*
   Yoga is recommended for treatment of chronic hand osteoarthrosis or acute flares of osteoarthrosis.

   Indications –Hand osteoarthrosis pain in motivated patients.
   Frequency/Duration – Self-directed program after up to 8 supervised sessions.(1509)

   Indications for Discontinuation – Intolerance, non-compliance.

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – Low

3. *Recommendation: Glucosamine, Chondroitin Sulfate, Methyl-sulfonyl Methane, Diacerein (Diacerhein, Diacetylrhein), Harpagophytum, Avocado Soybean Unsaponifiables, Ginger, Oral Enzymes, Nettle Leaf, or Rose Hips for Chronic Hand Osteoarthrosis or Acute OA Flares*
   There is no recommendation for or against use of glucosamine, chondroitin sulfate, methyl-sulfonyl methane, diacerein (diacerhein, diacetylrhein), harpagophytum, avocado soybean unsaponifiables, ginger, oral enzymes, nettle leaf, or rose hips for treatment of chronic hand osteoarthrosis or acute flares.

   Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**
   Level of Confidence – Low

Rationale for Recommendations
There is one quality study of capsaicin for treatment of these patients and it suggests benefits over a 4-week trial, thus it is recommended.(1507) There is one low-quality study of yoga,(1509) that suggested benefits. As yoga is not invasive, has few adverse effects, and is low cost, it is recommended for select, motivated patients.

There are more than 30 quality studies reviewed in the Hip and Groin Disorders Guideline. The largest volume of studies addresses glucosamine and chondroitin sulfate. This quality literature mostly addresses hip or knee osteoarthrosis or low back pain. Of the 5 quality, double-blinded studies that used x-rays for evaluation of glucosamine/chondroitin, three have documented delayed progression of joint space narrowing. There are 3 low-quality studies of chondroitin sulfate for treatment of hand arthrosis with one suggesting delay of hand x-ray changes.(1510) Yet, there are quality studies of knee and hip OA that have been both sizable and negative. However, glucosamine and chondroitin have problems with lack of standardization of doses. Nettle leaf(1511) has an additional problem of relative unavailability. This problem affects the other, less studied agents in this group of treatments. Consequently, although these agents are not invasive, have low adverse effects profiles, and may be costly over time, there is no recommendation for or against these agents.

Evidence for the Use of Complementary and Alternative Therapies for Hand Osteoarthrosis

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There is 1 high-(1642) (Reeves 00) are 4moderate-quality RCTs and crossover trials incorporated into this analysis.(1637, 1638, 1641, 1643) (Shin 13) There are 4 low-quality RCTs(1639, 1640, 1644, 1645) in Appendix 2.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Complementary therapy, alternative therapy, Hand, Fingers, Thumb, Metacarpus, Osteoarthritis, Osteoarthrosis; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 0 articles in PubMed, 55 in Scopus, 6 in CINAHL, 70 in Cochrane Library, 150 in Google Scholar, and 0 from other sources. We considered for inclusion 0 from PubMed, 1 from Scopus, 1 from CINAHL, 0 from Cochrane Library, 0 Google Scholar, and 7 from other sources. Of the 9 articles considered for inclusion, 9 randomized trials and 0 systematic studies met the inclusion criteria.

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Author/Year Study Type Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Capsaicin vs. Placebo						
McCarthy 1992 RCT	5.0	N = 21 OA (14) and RA (7)	Capsaicin 0.075% vs. placebo QID for 4 weeks	VAS pain scores were (baseline vs. weeks 1/2/4): Capsaicin -10% vs. placebo -11%/-35% vs. -10%/ -55% vs. -18% (p <0.02) (graphic interpretations).	"[T]opical capsaicin is a safe and potentially useful drug for the treatment of painful OA of the hands."	Blinding questionable. Suggests capsaicin reduces pain.
Schnitzer 1994 RCT	4.0	N = 59 Hand OA	Study began with all on capsaicin 0.025% vs. placebo and all QID dosing for 3 weeks, then BID for 6 weeks.	Capsaicin superior to placebo at Weeks 1 and 3 for pain responses (p = 0.046 and p = 0.018). Articular tenderness also favored capsaicin at all times except 6 weeks.	"[I]t may be prudent to taper the regimen gradually to avoid the decrease in pain relief seen with an abrupt decrease in dosage."	Data suggest capsaicin effective, however study both decreased treatment frequency and randomized to placebo vs. treatment, thus somewhat limiting conclusions.
Stinging Nettle vs. Non-Stinging Nettle						
Randall 2000 Crossover Trial No mention of sponsorship or COI.	7.0	N = 27 (23 female/4 male) with OA base of thumb or index finger. 2RA, 1 AS. Age range 45-82 years.	Stinging Urtica dioica (n = 13) vs. non-stinging nettle leaf Lamium album (n = 14).	VAS pain scores (baseline/post): stinging nettle (38.3/23.67) vs. non-stinging nettle (36.59/37.04), p = 0.026. Daily NSAID use: nettle (1.04/0.70) vs. non-stinging nettle (0.93/0.93), p >0.05. Health assessment scores improved more with stinging nettle (p = 0.003).	"After one week's treatment with nettle sting, score reductions on both visual analogue scale (pain) and health assessment questionnaire (disability) were significantly greater than with placebo."	Success of blinding questionable. Patients applied the plant leaf themselves.
Dextrose vs. Placebo						
Reeves 2000 Prospective RCT No mention of sponsorship or COI.	8.0	N = 27 patients with osteoarthritis in the hands. Mean age of 64.2 years old. 16 Females, 11 Males	Dextrose Group (N = 13) – Received 0.5 mL of 10% dextrose or 0.075% xylocaine in bacteriostatic water. vs Control Group (N = 14) – Received 0.075% xylocaine in bacteriostatic water.	Flexion range improved significantly (P = 0.003) in dextrose treated joints compared to placebo-treated joints. After 6 months, the control group received dextrose injections and improved pain reduction from 18% to 54% in the average joints and 9.7% to 38% in total joint collection.	"Dextrose prolotherapy was clinically effective and safe in the treatment of pain with joint movement and range limitation in osteoarthritic joints."	Data suggest at 12 months, ROM, pain level and PRWE and DASH scores equivalent. Patients in surgical group reported better grip strength throughout trial.

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			Follow up 6 months and 12 months after first injection.			
Diacerein vs. placebo						
Shin 2013 RCT Sponsored by Myungmoon Pharmaceutical Co, Ltd. COI, Dr. Shin is a consultant to Pfizer Inc.	7.0	N = 86 patients fulfilled the American College Board of Rheumatology criteria for hand OA. Mean age of 57.8 years old. 83 Females, 3 Males	Diacerein Group (N=42) – Received Diacerein 50 mg BID or 12 weeks vs Placebo Group (N=44) – Received placebo BID for 12 weeks Follow up 4 and 12 weeks after initial enrollment.	There are no significant difference in change in AUSCAN pain score at 4 weeks (Diacerein vs placebo, P = 0.507). Diacerein was significantly improved (P = 0.004) for the physician global assessment. Adverse events occurred 38 (90%) times in the diacerein group and 29 (67%) in the placebo group.	"The results of this trial indicate that the safety profile of diacerein 50 mg BID is acceptable, although the regimen may be unsuccessful in controlling the symptoms of hand OA."	Data suggest comparable efficacy between groups.

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LOW-LEVEL LASER THERAPY
Low-level laser therapy has been used for treatment of hand osteoarthrosis patients, although the evidence has been noted to conflict.(1514-1516)

Recommendation: Low-Level Laser Therapy for Hand Osteoarthrosis
Low-level laser therapy is moderately not recommended for treatment of hand osteoarthrosis.

Strength of Evidence – **Moderately Not Recommended, Evidence (B)**
Level of Confidence – Moderate

Rationale for Recommendation
There is one high-quality study that suggests low-level laser therapy is ineffective for treatment of hand osteoarthrosis.(1517) Low-level laser therapy is not invasive and has low adverse effects, but it is costly and in the absence of efficacy is therefore not recommended.

Evidence for the Use of Low-Level Laser Therapy for Hand Osteoarthrosis
There is 1 high-quality RCT incorporated in this analysis.(1517)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Low Level Light Therapy, LLLT, Hand, Fingers, Thumb, Metacarpus, Osteoarthritis, Osteoarthrosis; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 9 articles in PubMed, 18 in Scopus, 1 in CINAHL, 0 in Cochrane Library, 150 in Google Scholar, and 0 from other sources. We considered for inclusion 1 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 0 Google Scholar, and 0 from other sources. Of the 1 articles considered for inclusion, 1 randomized trials and 0 systematic studies met the inclusion criteria.

Author/Year Study Type Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
LLLT vs. Sham						
Brosseau 2005 RCT Sponsored by Ontario Arthritis Society, Ontario Ministry of Health and Long-Term Care, University Research Chair, and inistry of Human Resources. No menstion of COI.	9.0	N = 88 patients diagnose d with OA. Mean age of 65.7 years old. 69 Females, 19 Males	Low Level Laser Therapy Group (N = 42) – Received inactive LLLT vs Sham Low Level Laser Therapy Group (N = 46) – Received Gallium Aluminum Arsenide LLLT Follow-up 6 and 18 weeks after last treatment of LLLT.	There was no significant difference in VAS sores and morning stiffness. Grip strength significantly improved for participants in the active LLLT group (P = 0.041) and a significant reduction in finger distance between thumb and the base of the fifth metacarpal (P = 0.011). No significant differences were found in other outcomes.	"LLLT is no better than placebo at reducing pain, morning stiffness, or improving functional status for OA-hand patients."	Suggests LLLT not effective.

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Injections

INTRAARTICULAR INJECTIONS

Intraarticular glucocorticosteroid and hyaluronidate injections are sometimes performed to attempt to deliver medication with minimal systemic effects to the arthritic joint,(1518-1526) particularly when acetaminophen and NSAIDs have failed. These injections are generally performed without fluoroscopic or ultrasound guidance in the distal upper extremity.

1. *Recommendation: Intraarticular Glucocorticosteroid Injection for Subacute or Chronic Hand Osteoarthrosis*
   Intraarticular glucocorticosteroid injections are recommended for the treatment of subacute or chronic hand osteoarthrosis.

   Indications – Moderately severe or severe hand osteoarthrosis pain with insufficient control with NSAID(s), acetaminophen, and potentially splinting and/or exercise. Its usual purpose is to gain sufficient relief to either resume medical management or to delay operative intervention.

   Frequency/Duration – One (1) injection should be scheduled, rather than a series of 3. Various medications have been used, as well as adjuvant anesthetic agents. There are no head-to-head comparisons in quality studies of different medications to ascertain optimum medication(s).

   Dose – Various doses have been utilized without evidence to identify an ideal dose for hand or phalangeal joints.

   Indications for Discontinuation – A second glucocorticosteroid injection is not recommended if the first has resulted in significant reduction or resolution of symptoms. If there has not been a response to a first injection, there is generally less indication for a second. If the physician believes the medication was not well placed and/or if the underlying condition is so severe that one steroid bolus could not be expected to adequately treat the condition, a second injection may be indicated. If placement is thought to be difficult, ultrasound or fluoroscopic guidance may be particularly indicated for a second injection. In patients who respond with a pharmacologically appropriate several weeks of temporary partial relief of pain, but who then have worsening pain and function and who are not (yet) interested in surgical intervention, a repeat injection is an option. There are not believed to be benefits beyond approximately 3 injections in a year. Patients requesting a 4th injection should have reassessment of non-operative management measures and be counseled for possible surgical intervention.

   Strength of Evidence – **Recommended, Evidence (C)**
   Level of Confidence – Low

2. *Recommendation: Intraarticular Hyaluronate Injection for Subacute or Chronic Hand Osteoarthrosis*
   Intraarticular hyaluronate injections are recommended for the treatment of subacute or chronic hand osteoarthrosis.

   Indications –Hand osteoarthrosis pain with insufficient control with NSAID(s), acetaminophen, and potentially splinting and/or exercise. Its usual purpose is to gain sufficient relief either to resume medical management or to delay operative intervention.

   Frequency/Duration – Number and frequency of injections are unclear (one trial found no differences between 1, 2, or 3 injections).(1523) Most physicians perform 3 injections.(1519)

   Dose – See manufacturer's recommendations.

   Indications for Discontinuation – Sufficient relief to not require additional injection(s), failure to improve, or allergic reactions.

   Strength of Evidence – **Recommended, Evidence (C)**
   Level of Confidence – Low

Rationale for Recommendations

There are several quality studies for treatment of hand osteoarthrosis with glucocorticosteroids. However, the studies conflict regarding the length of benefits. However, nearly all studies have suggested benefits.(1519, 1520, 1524, 1526) No studies have suggest prolonged benefits with more than approximately 3 months benefits, thus this intervention is a short to intermediate term intervention.

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Optimal glucocorticoid doses and preferable adjuvant anesthetic agents are unclear. These injections are invasive, have low adverse effects, and are moderately costly. They are recommended as an option for treatment of hand OA patients particularly after inadequate results from NSAID trials or other non-operative interventions.

There are a few quality studies of hyaluronate injections for treatment of hand osteoarthrosis. These suggest benefits. Duration of improvement is uncertain, although one trial suggested pain relief as far as 26 weeks.(1520) These injections are invasive, have moderate adverse effects and are costly. In select cases where other treatments have failed, these injections are recommended.

Evidence for the Use of Intraarticular Injections
There is 1 high-(1527) and 3 moderate-quality RCTs(1528-1530) incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Intraarticular Injections, glucocorticosteroid, hyaluronate injection; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 22 articles in PubMed, 9 in Scopus, 3 in CINAHL, 0 in Cochrane Library, 9928 in Google Scholar, and 0 from other sources. We considered for inclusion 7 from PubMed, 1 from Scopus, 1 from CINAHL, 0 from Cochrane Library, 0 Google Scholar, and 0 from other sources. Of the 9 articles considered for inclusion, 6 randomized trials and 1 systematic studies met the inclusion criteria.

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Author/Year Study Type Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Wenham 2012 RCT Sponsored by Arthritis Research UK. E.H. is part-funded by Arthritis Research UK. COI, A.J.G. has received payment from GE ultrasound division for lecturing. All other authors have declared no COI.	8.5	N = 70 (57 female/13 male) with symptoms of OA hand pain. Mean age for placebo group was 61.1 years and for PNL group 61.9 years.	Prednisolone (PNL) 5mg (n = 35) vs. placebo capsules (n = 35). Follow-up at 4 and 12 weeks.	At 4 weeks the adjusted mean reduction in pain VAS was 19.9mm (PNL group) and 16.8mm (placebo group) (p = 0.54). There were no statistically significant differences in VAS, Australian/Canadian Hand Osteoarthritis Index or joint counts between placebo and PNL groups at 4 or 12 weeks.	"This is the first randomized controlled trial of low-dose corticosteroid alone for painful hand OA, which demonstrated that short-term low-dose oral PNL is not an effective analgesic treatment for hand OA."	Data suggest PNL compared to placebo is not effective for hand OA pain.
Spolidoro Paschoal Nde 2015 RCT No mention of sponsorship or COI.	6.0	N=60 patients (2 males, 58 females) with diagnosis of OA involving PIP or DIP joints. Mean age: 60.7 years(±8.2)	TH/LD Group: One injection 20 mg/ml TH and 2% lidocaine w/o epinephrine. IAI administered in 0.3 ml dose of TH for PIP and 0.2 ml of TH for DIP both with 0.1 ml of 2% LD. Vs. LD Group: One injection of lidocaine. IAI administered with only 0.1 ml 2% LD w/o epinephrine in IP joint.	Significant difference was observed for VASm and physician VASs variables. The TH/LD group showed better performance than LD group for VASm and physician VASs (p=0.014 and 0.022 respectively) from first week to end of study. No statistical significance between groups or adverse effects.	"The IAI with TH/LD has been shown to be more effective than the IAI with LD for pain on movement and joint swelling in patients with OA of the IP joints. Regarding pain at rest, there was no difference between groups."	Data suggest IAI with TH/LD better than IAI with LD foredema reduction and increased movement.
Figen-Ayhan, 2009 RCT No mention of industry sponsorship. No COI.	6.0	N= 33 patients (0 males, 33 females)(66 hands) with thumb base osteoarthritis (OA). Mean age was 62.6 years.	Hylan Group- 1mL of Hylan G-F 20 solution (N = 33 Hands) vs Saline Group- Injection of saline (N = 33 Hands). Follow-up at 6 and 24 weeks.	Both groups significantly improved from baseline to 6 weeks in pulp to pulp pinch, tripod pinch and key pinch strength (p≤ 0.04). Both groups also showed a significant improvement in VAS pain scores between baseline and the 6th week (p≤ 0.02). The Hylan group also showed significant improvement with regards to VAS pain score at the 24th week (p= 0.01). This difference was not	"Although short-term placebo analgesic effect could not be ignored, intra-articular hylan was effective on pain, pinch strength, and function at the 24th week."	Each patient received both treatments (one on each hand). The hands were randomized. Data suggest HA may be an alternative method to improve thumb OA as there was improvement of function and grip strength at 24 weeks when compared to placebo.

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				significant in the saline group at 24 weeks (p=0.2).		
Monfort, 2015 RCT No mention of sponsorship. No COI.	6.0	N= 88 patients (11 males, 77 females) with osteoarthritis of the thumb. Mean age was 62.8 years.	Hyaluronic acid Group- Ultrasound-guided intra-articular treatment with hyaluronic acid. Total of 3 injections (5 mg) (N=48) Vs. Betamethasone Group-ultrasound-guided intra-articular treatment with betamethasone. 1.5 mg of betamethasone disodium phosphate and 1.5 mg of betamethasone acetate. (N=40) Follow-up at 7, 14, 30, 90 and 180 days.	There was a significantly larger change from the baseline FIHOA score in the HA group vs. the Betamethasone group at Day 14; 3 vs. 1 (p<0.05), Day 90; 5.5 vs. 1 (p<0.005) and Day 180; 7 vs. 2 (p<0.005). There was also a significantly larger change from the baseline VAS pain score in the HA group vs. the Betamethasone group at Day 180; 3.12 vs. 1.60 (p<0.05).	"Both hyaluronic acid and betamethasone were effective and well-tolerated for the management of rhizarthrosis. Hyaluronic acid was more effective over time and more efficiently improved functionality and pain in patients with more severe symptoms."	Data suggest both HA and steroid injections were beneficial and well tolerated for OA of the first carpometacarpal joint but HA appeared to be better for more severe symptoms and worked better over time.
Bahadir, 2009 RCT No mention of sponsorship. No COI.	5.0	N= 40 patients (0 males, 40 females) with stage II or III trapeziometacarpal joint osteoarthritis. Mean age was 62.9 years.	Steroid group- One injection of 20 mg triamcinolone acetonide (N=20) Vs. Hyaluronate group- 3 injections of 5 mg sodium hyluronate at 1-week intervals. (N=20) Follow-up for 12 months.	The VAS pain score decreased significantly for both groups after treatment throughout the 12 months. The VAS pain score was significantly lower in the Steroid group compared to the hyaluronate group at 1 month after treatment; 3.1 vs. 4.7 (p=0.033), and at 6 months; 3.5 vs. 5.7 (p=0.002). The difference was not significant at 12 months; 4.9 vs. 6.0 (p=0.128).	"Our findings showed that both intra-articular injection of steroid and sodium hyalurunate are effective in trapeziometacarpal joint osteoarthritis. However the steroid injection was found to be superior to sodium hyaluronate injection in reducing pain and improving hand function."	Open label trial. Data suggest similar efficacy but steroid better than HA for pain reduction and improved hand function for treatment of TMJO.
Stahl 2005 RCT	4.5	N=52 patients (6 males, 46 females) with trapeziometacarpal	MA Group: 40 mg Methylprednisolone intraarticular injection Vs.	Significant improvement in pain for both groups (p<0.001). No significant difference in improvement of VAS values between 2	"Steroids and hyaluronate injections were found effective in reducing pain. Hyaluronate was more	Data suggest comparable efficacy with some improved function in HA group.

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No mention of sponsorship or COI.		joint grade II arthritis. Mean age: 62 years.	SH Group: 15 mg Sodium hyaluronate intraarticular injection	groups. Grip strength improved significantly for steroid group. SH group showed improvement in grip after 6 months and pinch and PPT after 3 months.	effective in the improvement of some aspects of fine hand function."	

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PROLOTHERAPY INJECTIONS

Recommendation: Prolotherapy Injections for Subacute or Chronic Hand Osteoarthrosis

There is no recommendation for or against the use of prolotherapy injections for treatment of subacute or chronic hand osteoarthrosis.

Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**
Level of Confidence – Low

Rationale for Recommendation

Prolotherapy injections are invasive as they require numerous, repeated injections in phalangeal joints. The magnitude of the purported benefits is modest. The results of Reeves' 2000 study suggesting some benefits compared with placebo injections(1531) needs to be replicated, including with a larger sample size, evaluation of functional outcomes and with sufficient follow-up duration to allow for adequate assessment of risks and benefits of these procedures prior to a recommendation in favor of this treatment.

Evidence for the Use of Injections for Hand Osteoarthrosis

There are 2 high-(1642, 1654) quality and 5 moderate-quality RCTs and crossover trials incorporated into this analysis.(1651-1653, 1655, 1664) (Jahangiri 14) There is 1 low-quality RCT in Appendix 2.(1656)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Prolotherapy Injections OR Proliferative Therapy AND Hand, Fingers, Thumb, Metacarpus, Osteoarthritis, Osteoarthrosis; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 2 articles in PubMed, 2 in Scopus, 1 in CINAHL, 2 in Cochrane Library, 997 in Google Scholar, and 0 from other sources. We considered for inclusion 1 from PubMed, 1 from Scopus, 1 from CINAHL, 0 from Cochrane Library, 1 Google Scholar, and 4 from other sources. Of the 8 articles considered for inclusion, 8 randomized trials and 2 systematic studies met the inclusion criteria.

Author/Year Study Type Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Glucocorticosteroid vs. Placebo Injections						
Meenagh 2004 RCT No mention of sponsorship or COI.	8.5	N = 40 (36 female/4 male) with CMC joint OA. Age range 41-71.	Triamcinolone hexacetonide 0.25mL, 5mg (n = 20) vs. sterile saline. Fluoroscopically guided injections (n = 20).	VAS pain changes (4/12/24 weeks): placebo (18.5/23.3/ 14.0) vs. steroid (10.5/3.5/0.0), NS. Patient and physician global assessments improved in both groups at 4-12 weeks.	"No clinical benefit was gained from intra-articular steroid injection to the CMCJ in moderate to severe osteoarthritis compared with placebo injection."	VAS pain ratings suggest trend towards modest pain reductions especially at 4 weeks, but none at 24 weeks. Suggests steroid injection relatively ineffective.
Different Types of Glucocorticosteroid Injections (No Placebo)						
Jalava 1983 Crossover Trial No mention of sponsorships.	5.0	N = 24 (12 females, 12 males); 120 injected DIP, PIP joints, yet study describes RA patients; Mean Age 48.6 (24-73)	Triamcinolone hexacetonide vs. methyl-prednisolone 0.2-0.3mL/joint Follow-Up at baseline, week 1, 4, 12, and 24.	Effect at 6 months: TH: 21.0% Unchanged; 3.5% Worse, p<005. MP: 32.0 % unchanged; 10.0 % worse	"All injections produced clinically significant effects. There were no significant differences between the two treatment groups at the start of the treatment, but	Crossover trial. States RA patients, but DIP/PIP joint injections. Multiple injections in multiple digits of same patient. No placebo group, thus conclusion on benefit for all not clearly

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					after 6 months the results in the TH group were significantly better. However, there were also more joints with skin and soft tissue atrophy in this group than in the MP group."	supportable. Data suggest triamcinolone may be superior.
Glucocorticosteroid vs. Viscosupplementation Injections						
Fuchs 2006 RCT Sponsored by TRB Chemedica AG, Richard-Reitzner-Allee. No COI.	6.0	N = 56 (11 males/45 females) thumb CMC joint OA; Median Age, Group 1: 59.5 Group 2: 61.0	Three intraarticular injections of: Group 1 (N=28) Sodium hyaluronic acid (SH) 10mg vs. Group 2 (N=28) triamcinolone acetonide TA 10mg injections. Imaging not used; Follow Up at baseline, 3, 14, and 26 weeks.	VAS pain assessment (visits 1/3/5/6/7): SH (65.5/54.0/34.0/35.0/30.0) vs. TA (63.5/46.0/20.0/22.0/45.5).	"A single course of three SH injections is effective in relieving pain and improving joint function in patients with OA of the CMC joint of the thumb. Although in comparison with triamcinolone its effects are achieved more slowly, the results indicate a superior long-lasting effect of hyaluronan at 6 months after end of treatment period."	No placebo group. Data suggest effect of steroid largely gone at 6 months, but not for visco-supplementation.
Viscosupplementation vs. Glucocorticosteroid vs. Placebo						
Heyworth 2008 RCT Sponsored by by a grant from Wyeth-Ayerst Pharmaceuticals and Genzyme Corporation. No mention of COI.	7.5	N = 60 (52 female/2 male) with basal joint OA. Mean age 63 ± 1.	(2) 1-mL injections of hylan G-F 20 1 week apart (n = 20) vs. Steroid1mL betamethasone (n = 22) vs. 2 placebo saline injections (n = 18). All received 2 injections, 1 week apart.	Data graphically presented; suggest grip strengths worse for saline than other 2 groups. However, not statistically significant between groups. Within groups, steroid superior at Weeks 2 and 4 to baseline and Hylan better at Weeks 2, 4, 12, 26 compared with baseline. No between-group VAS differences, but lower VAS pain compared with baseline for controls and steroid at Weeks 2 and 4, however for hylan, reductions were at Weeks 2, 12, 26 compared with baseline.	"There were no statistically significant differences among hylan, steroid, and placebo injections for most of the outcome measures at any of the follow-up time points. However, based on the durable relief of pain, improved grip strength, and the long-term improvement in symptoms compared with preinjection values, hylan injections should be considered in the management of	Trend towards Hylan relief lasting longer than gluco-corticosteroid injection. States no baseline difference but stats for age are dissimilar. Dropout rate unclear.

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					basal joint arthritis of the thumb."	
Single vs. Multiple Viscosupplementation Injections						
Roux 2007 RCT No mention of sponsorship or COI.	4.0	N = 42 (4 males/38 females) ; Mean Age 64.8 ± 8.0	1ml sodium hyaluronidate (Sinovial) 1 injection vs. 2 injections vs. 3 weekly injections using image intensifier Follow-Up at baseline, 1 month, and 3 months.	1 injection VAS (1 month, 3 months): 58.4±16.2, 43.1±22.8; 2 injections: 54.6±18.9, 39.5±28.6; 3 injections: 60.1±17.0, 29.8±21.9	"No significant differences were found between each group over the study period for pain relief and function. But the intra groups analysis results show that intra-articular sodium hyaluronidate injections into the carpometacarpal joint of the thumb in osteoarthritis can be efficacious on pain and functionality."	No placebo. Unequal treatment control biases towards more treatment. Trend towards lower grade disease across the categories (x-ray grades 3.1/2.7/2.4) may bias towards more injections suggests randomization failure and may be fatal flaw.
Prolotherapy Injections						
Reeves 2000 RCT No mention of sponsorship or COI.	8.0	N = 27 (16 female/11 male) with 150 joints DIP, PIP and thumb CMC joint OA. Age for dextrose and control group: 64.5 (9.2) and 63.9 (9.4).	0.5ML of 10% dextrose plus 0.075% xylocaine vs. 0.075% xylocaine injections into medial and lateral aspects of each joint. Injections at 0, 2, 4 months	VAS after 3 injections improved 37% in active treatment vs. 18% controls (NS). Pain with rest and grip non-significant trend towards dextrose. Pain with movement improved with dextrose (59 to 67 vs. 57 to 48 in controls) (p = 0.027)	"Dextrose prolotherapy was clinically effective and safe in the treatment of pain with joint movement and range limitation in osteoarthritic finger joints."	Small sample sizes and high dropout rates.
Jahangiri 2014 RCT No sponsorship or COI.	7.0	N=60 (44 female/16 males) patients with osteoarthritis in the first carpometacarpal joint (CMC); Mean Age 63.6 ± 9.7.	Local corticosteroid (LC) group, had placebo injections of 1 ml 0.9 % saline were administered (for masking) followed by a single dose of 40 mg methylprednisolone acetate (0.5 ml) mixed with 0.5 ml of 2 % lidocaine in the 3rd month Vs. Group 2: Dextrose Prolotherapy (DX) group, had 0.5 ml of 20 % DX mixed with 0.5 ml of 2 % lidocaine was injected; Follow-Up at baseline 1, 2, and 6 months.	LC - DX difference, Hand Assessment Questionnaire Disability Index (HAQ-DI) scores (Mean Difference (95% CI)), two months: 1.0 (0.2-1.9) (p=0.01). 6 months: 1.0 (0.2 – 1.8) (p=0.01). Pain, Visual Analogue Scale (VAS), 2 months: 1.0 (0.1-2.0) (p=0.01). 6 months: 1.1 (0.2-2.0) (p=0.02). Pinching, 1 month: 2.9 (0.9-4.9) (p=0.005). Both groups improved significantly within themselves and was significant in all three categories listed above.	"Both LC and DX can relieve pain and suppress Inflammatory processes. Furthermore, DX has been suggested To strengthen soft tissue too. There are some reports Indicating improvement in ligament laxity after DX prolotherapy."	Data suggest steroid better at 1 month but at 2 months, both groups had comparable results but at 6 months there was a better outcome in the DX group. After 6 months, both groups showed improved function but DX group had an overall better function score.

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Surgery

Various surgical procedures are utilized to treat patients with hand osteoarthrosis.(1532-1545) Among these are arthrodesis, arthroplasty and various other reconstructive procedures, although many have been developed and utilized to primarily treat patients with rheumatoid arthritis.(1546-1548)

1. *Recommendation: Reconstructive Surgery for Select Patients with Trapeziometacarpal Arthrosis*
   Reconstructive surgery is recommended for treatment of select patients with trapeziometacarpal arthrosis.

   Strength of Evidence – **Recommended, Evidence (C)**
   Level of Confidence – Low

2. *Recommendation: Trapeziectomy with Ligament Reconstruction and Tendon Interposition for Thumb CMC Joint Osteoarthritis*
   Trapeziectomy with ligament reconstruction and tendon interposition (LRTI) is not recommended for treatment of thumb CMC joint osteoarthritis.

   Strength of Evidence – **Not Recommended, Evidence (C)**
   Level of Confidence – Low

3. *Recommendation: Fusion for Select Patients with Hand Osteoarthrosis*
   Fusion is recommended for treatment of select patients with hand osteoarthrosis.

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – Low

Rationale for Recommendation

There are several moderate-quality studies evaluating surgery for hand osteoarthrosis, all of which concern the basal thumb joint (trapeziometacarpal joint). (1532-1534, 1536, 1537, 1540, 1543-1545, 1549, 1550) There are a few quality studies of surgery for rheumatoid arthritic joints, such as MCP joint replacement.(1551-1554) However, these are beyond the scope of this document. Most of the OA studies address a comparison between trapeziectomy and trapeziectomy with ligament reconstruction or arthroplasty versus tendon interposition arthroplasty. Regardless, ligament reconstruction and tendon interposition procedures do not appear to be superior to the simpler trapeziectomy,(1534, 1535, 1541, 1549, 1550, 1555, 1556) and some studies suggest longer recovery and higher complication rates with the more extensive procedures. Thus, the ligament reconstruction with tendon interposition procedure is generally not recommended. One moderate-quality study has concluded that earlier mobilization is superior to delayed mobilization after surgery.(1537)

Surgery is often career ending for patients who perform manual labor or requires cessation of manual tasks. Thus patients should be appropriately counseled as they may decide that the fulfillment from performing physical labor outweighs the discomfort. There are no quality studies of joint fusion. However, joint fusion is generally helpful for patients with significantly symptomatic osteoarthrosis who fail to achieve sufficient relief from other treatments.

Evidence for the Use of Surgery for Hand Osteoarthrosis

There are 6 moderate-quality RCTs incorporated into this analysis.(1534, 1537, 1549, 1550, 1555, 1557)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Reconstructive surgery , Hand, Fingers, Thumb, Metacarpus, Osteoarthritis, Osteoarthrosis, trapeziometacarpal arthrosis, trapeziectomy with ligament reconstruction and tendon interposition, thumb CMC joint osteoarthritis, fusion, hand osteoarthrosis; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 136 articles in PubMed, 22 in Scopus, 6 in CINAHL, 1 in Cochrane Library, 20105 in Google Scholar, and 0 from other sources. We considered for inclusion 1 from PubMed, 3 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 0 Google Scholar, and 1 from other sources. Of the 5 articles considered for inclusion, 5 randomized trials and 2 systematic studies met the inclusion criteria.

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Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Trapeziectomy vs. Trapeziectomy plus Palmaris Longus Tendon Interposition						
Prosser 2014 RCT No mention of COI or sponsorship.	6.5	N = 56 (11 males, 45 females) with osteoarthritis of TMC joint underwent TMC arthroplasty allocated to either rigid orthotic or Semi-rigid orthotic groups. Mean age: 66.9±8.5 years.	Allocated to rigid orthosis (n = 28) vs. Allocated to semi-rigid orthosis (n = 28). Following surgery, a dorsal plaster backslab was applied to Immobilize the wrist and thumb of all participants. Immediately following surgery the surgeon advised the patient to move the fingers (composite extension and flexion) and thumb interphalangeal joint (extension and flexion) within the confines of the backslab. Follow-up after 6weeks, 3 months and 1 year.	Both groups performed equally well. There was no significant between-group difference for PRWHE scores (0.47, CI -11.5 to 12.4), including subscales for pain and function, or for any of the secondary outcomes at one year follow-up	"The rigid orthosis and semi-rigid orthosis (allowing more wrist and thumb motion) used from 2 to 6 weeks following TMC arthroplasty performed equally well in this study. There was no significant difference between the two groups at one year for the primary outcome of PRWHE scores or for any secondary outcome. Clinically, either orthosis could be recommended. Patient comfort, cost and availability may determine choice between orthoses in clinical practice."	Data suggest comparable efficacy between rigid vs semi-rigid orthotics post TMC arthroplasty.
Davis 2004 RCT No COI. No mention of sponsorship.	6.5	N = 162 patients (0 males, 162 females) with painful trapeziometa-carpal osteo-arthritis; 183 thumbs; 183 surgeries	Simple trapeziectomy vs. trapeziectomy with Palmaris longus interposition vs. trapeziectomy with ligament reconstruction and tendon interposition using 50% of flexor carpi radialis tendon. All thumbs splinted for 6 weeks.	82% good pain relief and 68% regained sufficient strength for normal activities of daily living at 1-year follow-up. No differences in pain levels at 3 months (p = 0.58) or 1 year (p = 0.4). Pain levels at 3 months (No pain or restriction): T = 12, T+PL = 9, T+LRTI = 10. Discomfort with use but no restriction: T = 24, T+PL = 20, T+LRTI = 19.	"The outcomes of these 3 variations of trapeziectomy were very similar at 1-year follow-up evaluation. In the short term at least there appears to be no benefit to tendon interposition or ligament reconstruction."	Includes patients in other report below; 21 bilateral cases – did not always crossover. Results suggest no differences in outcomes.
Davis 2009 RCT No mention of COI or sponsorship.	6.5	N = 113 patients (5 males, 103 females) (133 thumbs; 20 bilat-eral)	Trapeziectomy with Flexor carpi radialis ligament reconstruction, tendon interposition and Kirschner wire insertion followed by splintage for 6 weeks vs. excision of trapezium with no Kirschner wire and immobilization of thumb in soft bandage for 3 weeks.	At 1 year, 81% of trapeziectomy had no pain or only discomfort after use with no activity restrictions vs. 67% of trapeziectomy with LRTI (p = 0.1). DASH scores [baseline (95% CI)/3 months/1 year]: Trapeziectomy [65(58-72)/52(44-59)/34 (26-42)] vs. Trapeziectomy and LRTI [65(59-72)/42 (35-	"[T]his study found that the results of simple excision of the trapezium, as described by Gervis (1949), are similar to those produced by excision of the trapezium with ligament reconstruction and tendon interposition	Suggests no short or intermediate term (1 year) benefits demonstrable of more extensive procedures and trend of benefit for trapeziectomy alone.

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				50)/37(28-45). Key pinch: trapeziectomy (4.1/3.5/4.4) vs. trapeziectomy plus LRTI (4.0/3.7/4.7).	using the technique described by Burton and Pellegrini (1986)…[A]nd, until further larger studies are performed, the value of such additions to trapeziectomy remain unproven."	
Davis 1997 RCT Sponsored by Wishbone Trust. No mention of COI.	4.5	N = 76 patients (0 males, 76 females)	Trapeziectomy vs. trapeziectomy with soft tissue interposition vs. trapeziectomy with ligament re-construction and tendon interposition	RSD complications: T = 0, T+STI = 0, T+LRTI = 2. Thumb key pinch strengths (baseline/3 months/1 year): T (3.7/3.4/4.8) vs. T+STI (4.0/3.1/4.6) vs. T+LRTI (3.4/3.1/4.4). Hand grip strengths [mean (range in kg)]: T [14.8 (4-46)/14.7(2-40)/19.2) vs. T+STI [12.4 (4-25)/10.8 (2-27)/16.9) vs. T+LRTI [11.3 (1-22)/14.0 (2-25)/19.1).	"In the short term at least, tendon interposition and ligament reconstruction do not improve the results of trapeziectomy."	Some baseline differences. Results suggests trapeziectomy equivalent to combined ligament reconstruction procedure or soft tissue interposition.
Kriegs-Au 2004 RCT No COI and no sponsorship.	4.0	N = 43 patients (6 males, 25 females) (52 thumbs)	Trapezial excision with ligament re-construction vs. trapezial excision with tendon interposition	Long-term outcome (Buck-Gramcko Score): 51.3 vs. 44.6 points. Strength measures Group I (ligament reconstruction) vs. (pre-op and final follow-up) vs. Group II (ligament reconstruction and tendon interposition): Mean tip-pinch strength (bar[Pa]): 0.21, 0.32; 0.23, 0.25; Mean grip strength bar [Pa]): 0.52, 0.46; 0.52, 0.44; Mean palmar abduction (degree): 10.7, 3.6:2.4; 11.9, 4.1:2.9.	"Tendon interposition does not affect the outcome after the ligament reconstruction for the treatment of osteoarthritis of the thumb carpometacarpal joint. Furthermore, proximal migration of the thumb metacarpal does not appear to influence the functional outcome."	High dropout rate. Original demographic data not reported. Data suggest tendon interposition not superior to ligament reconstruction.

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Post-operative Rehabilitation and Rehabilitation of Patients with Functional Deficits: CTS and Other Disorders

Post-operative rehabilitation and rehabilitation for patients with distal upper extremity musculoskeletal disorders has long been prescribed. Post-operative splinting was previously widely used as evidenced in the older quality literature.(911, 915, 937, 1558, 1559) But, plaster casts have been replaced by splints which were later replaced by soft bandages and dressings(907, 918, 922-924, 928, 932, 935, 953, 958) which has also coincided with, or been facilitated by, less invasive and smaller incisions.

SOFT BANDAGES AND SPLINTS

1. *Recommendation: Soft Bandages During Post-operative Rehabilitation*
   Soft bandages are recommended during post-operative rehabilitation.

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – Low

2. *Recommendation: Splints During Post-operative Rehabilitation*
   Splints are recommended during post-operative rehabilitation for select patients.

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – Low

Rationale for Recommendations
As surgery has become less invasive, the degree or whether to splint, has become questionable as splints encourage lack of mobility which likely impairs or delays recovery with potentially increasing risk of complex regional pain syndrome, debility and delayed recovery. Three low-quality studies all suggest that splints are not effective;(784, 1559, 1560) however, there is no quality data and some splints appear indicated for select patients. Thus, there are limited indications for splints in patients with select diagnoses generally involving more extensive surgical procedures or other needs to utilized splints for protective purposes.

Evidence for the Use of Post-operative Soft Bandages and Splints
There are 7 moderate-quality RCTs(1459, 1561-1566) incorporated into this analysis. There are 4 low-quality RCTs in Appendix 2.(963, 1559, 1560, 1567)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Soft bandage, splint, splinting, immobilization, Postoperative Period, post-operative, rehabilitation, upper, extremity; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 120 articles in PubMed, 12 in Scopus, 35 in CINAHL, 1 in Cochrane Library and 18800 in Google Scholar. We considered for inclusion 7 from PubMed, 1 from Scopus, 0 from CINAHL, 0 from Cochrane Library 0 from Google Scholar, and 1 from other sources. Of the 18968 articles considered for inclusion, 11 randomized trials and 1 systematic studies met the inclusion criteria.

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Author/Year Study Type Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Immobilization vs. Early Mobilization						
Crowley 2013 RCT No sponsorship or COI.	4.0	N = 12 with ulnar collateral ligament (UCL) injuries of the thumb who underwent UCL repair with Mitek bone anchor. Median age 42 years.	SR: standard rehabilitation for 4 weeks of immobilization in POP thumb spica then 2 weeks of flexion, extension, opposition, abduction, and adduction of thumb and ultrasound, scar massage, light function for ADLs, and splint at night and out of home; therapy continued for 2-4 more weeks (N = 6) vs. (EAM) early controlled active mobilization 3-5 days postop; given custom-made thermoplastic splint; first 4 weeks exercises emphasized flexion, extension, opposition, abduction and adduction of thumb ; next 2 weeks same are SR group (N = 6). Study duration, 8-12 weeks or until participants could resume full ADLs.	There were no significant differences between groups.	"Our results suggest that there may be a benefit in early active mobilization over standard rehabilitation but that a larger randomized control trial is needed to assess this more accurately."	Pilot study of 12 patients. Data suggest early active mobilization lead to earlier restoration of hand function as well as an earlier return to work but no difference between groups in final ROM. A larger study would support preliminary findings.
Germann 2001 RCT No mention of sponsorship or COI.	4.0	N = 20 with extensor indicis proprius transfer for extensor pollicis longer (EPL) tendon rupture. Mean age dynamic motion 52 years, immobilization 42 years.	Dynamic motion protocol (DG group): 2 days after surgery wore forearm splint with limited but progressive increase in active flexion of interphalangeal (IP) joint plus passive extension through wire-rubber band system for 3 weeks (N = 10) vs. immobilization protocol (IG group): forearm cast with 20º wrist extension	Active ROM of IP joint after 4 weeks: DG 74º vs. IG 50º ($p<0.05$). Grip strength (DG vs. IG): 3 weeks 49% vs. 27% ($p<0.05$); 4 weeks 45% vs. 60% ($p<0.05$); 6 weeks 44% vs. 65% ($p<0.05$). Pinch grip (DG vs. IG): 3 weeks 36% vs. 20% ($p<0.05$).	"The dynamic protocol can therefore be considered as an important factor for a considerable reduction of overall treatment cost. Although all parameters plateaued after 6 and 8 weeks, the early dynamic motion protocol is the superior concept and has become standard procedure for these patients."	Small sample. Data suggest early dynamic motion group had better ROM of the interphalangeal joint grip and pinch strength at 3 weeks compared to immobilization group. Hand function was comparable between groups at 6 and 8 weeks but the shortened total rehab

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			and thumb in full extension and abduction for 3 weeks (N = 10). Follow-up at 3, 4, 6, and 8 weeks after surgery			time in dynamic motion group appears cost effective as there was approximately 10 days of treatment and time off work saved.
Splint vs. Splint						
Sillem 2011 RCT/Crossover Sponsored by British Columbia Medical Services Vancouver Foundation	6.0	N = 59 with carpometacarpal (CMC) OA of the thumb. Mean age 64 years.	Comfort Cool™ prefabricated neoprene splint (n = 59) vs. Hybrid custom-made splint (N = 59). Participants wore splint when symptomatic, during heavier manual tasks, and at night. Two 4 week treatment periods were separated by a 1 week washout period. Total duration of study was 9 weeks. Follow-up at 4, 5, and 9 weeks and 3 months.	Mean±SD mean difference Australian Canadian Hand Osteoarthritis Hand Index (AUSCAN): 3.7±11.13 in favor of Hybrid splint (p=0.02).	"The Hybrid and Comfort Cool™ splints had an equivalent therapeutic effect on hand function, grip strength, and lateral pinch strength."	Crossover equivalence trial. Data showed comparable results for hand function, grip strength and lateral pinch strength but the Hybrid splint was better at decreasing pain compared to Comfort Cool™.
Splint vs. Control						
Rannou 2009 RCT Sponsored by the Programme Hospitalier de Recherche Clinique National. No COI.	7.5	N = 112 (101 female/11 male) with base-of-thumb osteoarthritis. Mean age splint group 63.0±7.9 years, control 63.5±7.6 years.	Intervention group: custom-made neoprene splint (n = 57) vs. Control group: usual care (n = 55). Follow-up: 1, 6, and 12 months.	Intervention group had reduction in VAS pain score/ reduction in disability by Cochin Hand Function Scale score/patient-perceived disability at 12 months: -22.2 vs. -7.9, -14.3 [CI: -23.4 to -5.2]; p = 0.002/ -1.9 vs. 4.3; - 6.3 [CI: -10.9 to -1.7]; p = 0.008/ -11.6 vs. 1.5; -13.1 [CI: -21.8 to -4.4]; (p = 0.003). Intervention group experienced statistically significant improvements (61% vs. 38%, >10-mm [p = 0.014]; 56% vs.31% >15-mm [p = 0.007]; and 54% vs. 25% >20-mm [p = 0.002]).	"For patients with base-of-thumb osteoarthritis, wearing a splint had no effect on pain at 1 month but improved pain and disability at 12 months."	Data suggest wearing a splint for base of thumb OA had no effect on pain reduction at one month but at 12 months there was pain and function improvement.
Hermann 2014 RCT Sponsored by Norwegian Occupational	7.5	N = 59 (58 female/1 male) with hand osteoarthritis (HOA). Mean age 70.5±6.7 years.	Orthosis group: soft thumb base orthosis and hand exercises focused on increasing joint mobility, grip strength, and stability of CMC joint 2 sessions per day (n = 30) vs.	There were no significant differences between groups.	"[A] soft orthosis seems to have an immediate pain-relieving effect when worn, but no general effect in terms of reduced pain, or improved hand strength	Data suggest a soft orthosis has immediate pain relieving benefits when worn but no benefit in terms of pain reduction,

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Therapy Association, Norwegian Rheumatism Association, and the Norwegian Women's Public Health Association. No COI.			Control group: hand exercises only (n = 29). Study duration 2 months. Follow-up at 2 months.		or activity performance in participants with CMC-OA when not worn."	improved hand strength or activity when not worn.
Jerosch-Herold 2011 RCT Sponsored by Action Medical Research Charity and National Institute for Health Research (NIHR). No COI.	5.5	N = 154 undergoing fasciectomy of dermofasciectomy for Dupuytren's disease. Mean age hand therapy only 67.5±9.2 years, splint 67.2+10.0 years.	Hand therapy only (n = 77) vs. hand therapy with night splinting worn for 6 months (n = 77). Follow-up for 12 months after surgery.	There were no significant differences between groups.	"Contrary to the widespread belief in the value of postop night splinting for up to 6 months after fasciectomy or dermofasciectomy we found no evidence of its short or long-term effect."	Data suggest comparable results from self-reported outcomes.
Cook 1995 RCT No mention of sponsorship of COI.	4.0	N = 50 patients having undergone CTR. Patient's age and gender are not disclosed.	Volar splint vs. soft bulky dressing removed 1st post-op day. 1 month follow-up.	Excellent results (14 days/1 month): unsplinted 9/25 (36%)/12/25 (48%) vs. splinted 1/25 (4%)/2/25 (8%). More rapid RTW in unsplinted (15 days vs. 24 days, p = 0.01). Return to full work in 17v27days, p = 0.005.	"We conclude that splinting the wrist following open release of the flexor retinaculum is largely detrimental, although it may have a role in preventing the rare but significant complications of bowstringing of the tendons or entrapment of the median nerve in scar tissue. We recommend a home physiotherapy programme in which the wrist and fingers are exercised separately to avoid simultaneous finger and wrist flexion, which is the position most prone to cause bowstringing."	Sparse details. Full open incision suggests splints not appropriate post-operatively.

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NSAIDS/ACETAMINOPHEN

1. *Recommendation: NSAIDs During Post-operative Rehabilitation*
   NSAIDs are moderately recommended to control pain during post-operative rehabilitation.

   Indications – All hand, wrist, forearm post-operative patients may be candidates other than those with contraindications for use.

   Frequency/Duration – Scheduled dosage rather than as needed is generally preferable initially.

   Indications for Discontinuation – Resolution of pain, lack of efficacy, development of adverse effects, particularly gastrointestinal.

   Strength of Evidence – **Moderately Recommended, Evidence (B)**
   Level of Confidence – High

2. *Recommendation: Acetaminophen During Post-operative Rehabilitation*
   Acetaminophen is recommended to control pain during post-operative rehabilitation.

   Indications – All hand, wrist, forearm post-operative patients may be candidates other than those with contraindications for use.

   Frequency/Duration – Scheduled dosage rather than as needed is generally preferable initially.

   Indications for Discontinuation – Resolution of pain, lack of efficacy, development of adverse effects, particularly gastrointestinal.

   Strength of Evidence **– Recommended, Insufficient Evidence (I)**
   Level of Confidence – Moderate

Rationale for Recommendations
Acetaminophen has been shown to be less efficacious than naproxen, but is recommended due to its lower adverse effects.(639)

Evidence for the Use of NSAIDs Post-operatively
There are 1 high-(639) and 9 moderate-quality(972, 1568-1575) RCTs incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: NSAIDs, Anti-Inflammatory Agents, Non-Steroidal, acetaminophen, Agents, Non-Steroidal, Postoperative, Period, post-operative, rehabilitation, upper, extremity;controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 40 articles in PubMed, 0 in Scopus, 0 in CINAHL, 0 in Cochrane Library and 13502 in Google Scholar. We considered for inclusion 10 from PubMed, 0 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 0 from Google Scholar, and 0 from other sources. Of the 13542 articles considered for inclusion, 10 randomized trials and 0 systematic studies met the inclusion criteria.

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Author/Year Study Type Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Husby 2001 RCT No mention of sponsorship or COI.	8.0	N = 42 (9 female/33 male) due to be operated on for DC or CTS. Mean age 61 years.	Post-op naproxen (500mg BID) vs. Paracetamol (1000mg QID) vs. Placebo for 3 days immediate post-op CT release surgery. Second trial 35 with Dupuytren's contracture.	Post-op CTS swelling as percentage of pre-op volume 3.5±3.3 vs. 4.6±3.2 vs. 3.8±2.6. For Dupuytren's contracture releases 5.6±3.8 vs. 6.9±3.7 vs. 8.2±5.1. Additional analgesics used 0, 2, and 8 in naproxen, paracetamol and placebo groups.	"Naproxen might have a clinical relevant effect on swelling when used on minor surgery in the hand, unlike paracetamol. Naproxen might be a useful analgesic during the immediate postoperative phase."	Results suggest a beneficial effect that the studies were not powered to detect.
Sen 2006 RCT No mention of sponsorship or COI.	7.5	N = 45 (24 female/21 male) ASA I-II undergoing hand or forearm surgery. Mean age control 45 years, L-IVRA 42 years, L-IV 39 years.	Control group: IV saline 0.9% 2 ml + intravenous regional anesthesia (IVRA) with lidocaine 0.5% and saline (n = 15) vs. L-IVRA group: IV saline + IVRA lidocaine 0.5% with lornoxicam 8mg (n = 15) vs. L-IV group: intravenous lornoxicam 8mg + IVRA lidocaine 0.5% and saline (n = 15). Follow-up for 24 hours post-op.	Mean±SD intraoperative fentanyl (control vs. L-IVRA vs. L-IV): amount (µg) 23.3±25.8 vs. 3.3±12.9 vs. 19.4±18.6 (p = 0.014); requirement time (min): 15.8±6 vs. 28±9 vs. 13.6±8 (p = 0.042). Mean VAS (control vs. L-IVRA vs. L-IV): tourniquet release 3.33 vs. 1.73 vs. 3.13 (p = 0.003); tourniquet release after 2 hour 2.6 vs. 2.0 vs. 2.93 (p = 0.031). Mean±SD time to first postoperative analgesic request, minutes (control vs. L-IVRA vs. L-IV): 28±20 vs. 229±85 vs. 95±24 (p = 0.0038). Mean±SD diclofenac mg (control vs. L-IVRA vs. L-IV): 85±26 vs. 15±31 vs. 67±36 (p <0.001). Mean±SD paracetamol consumption mg (control vs. L-IVRA vs. L-IV): 1400±207 vs. 200±253 vs. 1100±320 (p <0.0001).	"[A]ddition of lornoxicam to lidocaine in IVRA shortens sensory and motor block onset times, prolongs sensory and motor block recovery times, and improves tourniquet pain while it prolongs first analgesic requirement time, and decreases total amount of analgesic."	Pilot study. Data suggest adding lornoxicam to lidocaine for intravenous regional anesthesia shortens the onset of sensory and motor block, decreases tourniquet pain and improves post-op analgesia. However, data suggest recovery times were prolonged in lornoxicam plus lidocaine group.
Ashworth 2002 RCT No mention of sponsorship or COI.	7.0	N = 47 (20 female/29 male) scheduled for inpatient elective hand surgery. Mean age systemic presurgery 57 years, regional presurgery 54.7 years, systemic	Systemic presurgery group: ketorolac 20mg intravenously in non-operative arm before surgery (n = 15) vs. regional presurgery group: ketorolac 20mg intravenously to operative arm after tourniquet inflation (n = 15) vs. systemic postsurgery group: ketorolac 20mg intravenously in non-	VAS score 24 hours after surgery: 12.2 mm higher in systemic postsurgery group vs. systemic presurgery group (p=0.037).	"[T]here seems no benefit to be gained by giving ketorolac as intravenous regional anaesthesia compared with the usual method of giving it intravenously into the general circulation before the operation."	Data suggest no benefit in the administration of ketorolac post surgery.

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		postsurgery 53.4 years.	operative arm after surgery (n = 15). Follow-up 1, 2, 4, 6, and 24 hours after surgery.			
Rivera 2008 RCT Sponsored by Bureau of Medicine and Survey at the Navy Department in Washington, DC, Clinical Investigation Program. No mention of COI.	7.0	N = 60 (20 female/35 male) undergoing hand surgery. Mean age ketorolac 39.5±13.6 years, placebo 37.58±12.2 years.	Bier block of 50mL of 0.5% lidocaine + 20mg ketorolac (n = 30) vs. Bier block of 50mL of 0.5% lidocaine + normal saline (n = 30). Follow-up 48 hours after discharge.	VAS post anesthesia care unit (PACU) ketorolac vs. control: 30 min 0.48 vs. 2.20 (p<0.05); 45 min 0.38 vs. 2.23 (p<0.05); 60 min 0.45 vs. 2.50 (p<0.05). Median time (minutes) to second request of postop analgesic (ketorolac vs. placebo): 1102 vs. 505 (p=0.048).	"Based on the results of this study we recommend that 20 mg ketorolac be considered in intravenous regional anesthesia."	Blinding is poorly described. Compared to placebo data suggests addition of ketorolac (20 mg) to lidocaine for controlling postoperative pain after non-traumatic hand and wrist surgery may be beneficial for reducing subsequent pain medication requests.
Sai 2001 RCT No mention of sponsorship or COI.	6.5	N = 120 (gender not specified) undergoing hand surgery with brachial plexus block. Mean age 43 years.	Ampiroxicam 27mg orally vs. alegioxa 100mg, orally vs. placebo 3 hours before surgery. Follow-up when each patient requested an analgesic suppository.	Median pain scores at time of first analgesic request (analgesic vs placebo): 1.0 vs. 4.0 (p <0.0001). Median pain scores at 24 hours after operation (analgesic vs. placebo): 0 vs. 2.0 (p <0.0001). Number of patients requiring analgesic suppositories (analgesic vs placebo): 6 vs 44 (p<0.0001).	"We suggest that preoperative administration of ampiroxicam improves pain control during the early post-operative phase."	Sparse methods. Data suggest administration of ampiroxicam significantly reduced the post-operative pain and need for increased pain medication.
Cornesse 2010 RCT No mention of sponsorship or COI.	6.0	N = 60 undergoing minor hand surgery (carpal tunnel release or synovial cyst resection) under intravenous regional anesthesia. Mean age 1 g 51±15 years, 2 g 55±18 years.	1 g intravenous paracetamol before surgery (n = 30) vs. 2 g intravenous paracetamol before surgery (n = 30). Discharged after 4 hours. Once at home, patients instructed to take 1 g of paracetamol orally every 6 hours. Follow-up for 24 hours after surgery.	Pain scores: lower in 2 g paracetamol intravenous group vs. 1 g paracetamol intravenous (p=0.04).	"[A]n intravenous loading dose of 2 g paracetamol provides better analgesia than 1 g in adult patients undergoing minor hand surgery."	Unclear if loading doses were blinded to treater. Data suggest increasing the loading dose of paracetamol from 1g to 2 g improves post-op analgesia after minor hand surgery.
Rawal 2001 RCT No mention of sponsorship or COI.	6.0	N = 120 ASA I-II undergoing ambulatory hand surgery with IV regional anesthesia.	Group T: tramadol 100 mg orally every 6 hours (n = 40) vs. Group M: metamizol 1 g every 6 hours (n = 40) vs. Group P: paracetamol 1 g every 6 hours (n = 40)	Mean ±SD number of study tablets (tramadol vs. metamizol vs. paracetamol) day 1/ day 2: 5.5±1.1/ 5.0±2.6 vs. 4.9±1.1/ 6.0±2.9 vs. 2.8±1.2/ 3.1±0.6 (p<0.05 metamizol vs. tramadol on day of surgery;	"None of the study drugs provided adequate analgesia for all patients, as about 40% required rescue analgesia."	Data suggest tramadol most effective in pain relief of ambulatory hand surgery patients. It was associated with the greatest number

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		Mean age tramadol 42.1±14.1 years, metamizol 44.5±13.8 years, paracetamol 46.0±14.2 years.	from discharge. Follow-up after 2 days.	p<0.001 paracetamol vs. tramadol and metamizol on both days).		and highest severity of adverse events, thus highest patient dissatisfaction largely related to severity of nausea and dizziness.
Spagnoli 2011 RCT No mention of sponsorship or COI.	6.0	N = 114 with postoperative pain following hand and foot surgery under brachial plexus block. Mean age 56 years.	Group TP: tramadol/paracetamol 37.5/325mg (n = 57) vs. Group P: paracetamol monotherapy 1000 mg (n = 57) 2 tablets a day for 3 days. Follow-up 7 days after discharge.	Mean VAS (paracetamol vs. tramadol/paracetamol): post-op 0-6 hours 1.92 vs. 0.40 (p <0.005). Number requiring extra dose analgesic post-op (paracetamol vs. tramadol/paracetamol): 0-6 h 32 vs. 4 (p<0.005); 6-12 h 11 vs. 0 (p <0.005); 12-24 h 7 vs. 0 (p <0.01).	"The association of tramadol and paracetamol appears to have more efficacy when compared with paracetamol monotherapy for acute postoperative pain after hand and foot surgery."	Data suggest some benefit in use of tramadol and paracetamol combination compared to paracetamol therapy alone for the management of acute postoperative pain post hand and foot surgery.
Jankovic 2008 RCT No mention of sponsorship or COI.	5.5	N = 45 ASA physical status I-II undergoing ambulatory hand surgery. Mean age Group L 34±12 years, Group LK 33±12 years, Group LDK 35±13 years.	Group L: 3mg/kg 2% lidocaine for intravenous regional anesthesia (IVRA) (n = 15) vs. Group LK: 3mg/kg 2% lidocaine + 30 mg ketorolac for IVRA (n = 15) vs. Group LDK: 3 mg/kg 2% lidocaine + 8 mg dexamethasone + 30 mg ketorolac for IVRA (n =15). All groups received 0.9% NaCl added for total volume of 40mL. All patients allowed 10mg ketorolac every 6 hours as needed at home. Follow-up 24 hours after surgery.	Median postoperative VAS scores post anesthesia care unit admittance (PACU ad.) 120 min (Group L vs. Group KL vs. Group LDK): 3 vs. 3 vs. 2 (p<0.05, Group LDK vs. Group L). Mean±SD 24 hour total ketorolac tablet consumption (Group L vs. Group LK vs. Group LDK): 3.8±1.3 vs. 2.2±1.6 vs. 1.3±0.6 (p<0.05 Group LDK vs. Group L; p<0.05 Group LDK vs. Group LK).	"The addition of both ketorolac and dexamethasone to lidocaine IVRA provided improved tourniquet tolerance, prolonged analgesia in the postanesthesia care unit during the first 2 h after the medical pro c e d u re, and diminished the need for analgesic supplements during the first day after ambulatory hand surgery."	Sparse methodology. Data suggest IVRA of lidocaine, ketorolac, and dexamethasone provides effective perioperative analgesia for ambulatory hand surgery patients.
Reuben 1995 RCT	5.0	N = 60 undergoing hand surgery (carpal tunnel release,	Control group: 0.9% intravenous (IV) saline 2mL and intravenous regional anesthesia (IVRA) with saline	Median postoperative pain scores (control vs. IV-K vs. IVRA-K): VAS 30: 1.1 vs. 0.9 vs. 0.3 (p <0.0001 IVRA-K vs. other groups); VAS 60: 1.0±1.6±0.7 (p = 0.0131 IVRA-K vs.	"[T]he addition of K to 0.5% lidocaine for IVRA provided better control of intraoperative tourniquet pain, improved analgesia in	Sparse methods. Data suggests addition of ketorolac to 0.5% lidocaine provided better

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No mention of sponsorship or COI.		excision of a ganglion cyst, or tenolysis). Mean age control 49±17 years, IV-K 46±21 years, IVRA-K 50±19 years.	added to it (n = 20) vs. Group IV-K: ketorolac 60 mg IV and saline added to IVRA solution (n = 20) vs. Group IVRA-K: saline IV and ketorolac 60 mg added to IVRA solution (n = 20). All patients allowed Tylenol No. 3 tablets every 4 hours as needed for pain at home. Follow-up 24 hours.	other groups). Mean±SD 24 hour total medicine (control vs. IV-K vs. IVRA-K): 4.6±1.3 vs. 3.0±1.1 vs. 1.9±1.4 (p=0.0003 IVRA-K vs. other groups). Mean±SD time to first medicine (control vs. IV-K vs. IVRA-K): 281±2.44 vs. 356±255 vs. 653±501 (p=0.0241 IVRA-K vs. other groups).	the PACU during the first postoperative hour, and diminished the heed for analgesic supplements during the first postoperative day."	control of intraoperative tourniquet pain, improved PACU pain relief during the first hour post-op and up to 24h post-op compared to either lidocaine alone or placebo.

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ARNICA

Recommendation: Arnica During Post-operative Rehabilitation

Arnica is not recommended during post-operative rehabilitation.

Strength of Evidence – **Not Recommended, Evidence (C)**
Level of Confidence – Low

Rationale for Recommendation

Arnica has been utilized for post-operative recovery in CTS patients,(772, 1576) with the two quality studies conflicting. However the higher quality study suggests a lack of efficacy, thus there is overall weak evidence that arnica is ineffective, and thus it is not recommended.

Evidence for the Use of Arnica Post-Operatively

There is 1 high-(772) and 1 moderate-quality(1576) RCT incorporated into this analysis.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Arnica, Montana, Postoperative Period, post-operative, rehabilitation, upper, extremity; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 2 articles in PubMed, 9 in Scopus, 19 in CINAHL, 6 in Cochrane Library and 144 in Google Scholar. We considered for inclusion 1 from PubMed, 0 from Scopus, 0 from CINAHL, 2 from Cochrane Library 0 from Google Scholar, and 0 from other sources. Of the 180 articles considered for inclusion, 2 randomized trials and 2 systematic studies met the inclusion criteria.

Author/Year Study Type Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Stevinson 2003 RCT Sponsored by Dr Susil Kumar and Jamila Mitra Charitable Trust (UK); homeopathic and placebo tablets supplied by A Nelson & Co Ltd. No mention of COI.	8.5	N = 62 (49 female and 13 male) CTR patients. Ages of 18 and 70 years.	Arnica 30C (n = 21) vs. Arnica 6C (n = 21) vs. Placebo TID for 7 days pre-op and 14 days post-op (n = 22).	No pain differences (p = 0.79) and bruising (p = 0.45) at Day 4. Swelling and analgesic use did not differ. Adverse events reported by 2 patients in arnica 6C group, 3 in placebo, 4 in arnica 30C. Results do not suggest homeopathic arnica has an advantage over placebo in reducing post-op pain, bruising and swelling in patients undergoing elective hand surgery.	"Since the experiences of patients who receive no benefit from Arnica are less likely to be reported, the myth becomes reinforced."	One surgeon operated. Data suggest no efficacy.
Jeffrey 2002 RCT Ian Wiggle and Weleda Ltd provided arnica and placebo preparations. No mention of COI.	6.0	N = 32 Endo-scopic CTR patients Arnica group had 12 men:8wo men, and Placebo group had	Arnica D6 3 tablets TID plus Arnica 5% ointment TID vs. double placebo Follow-up was 2 weeks after surgery	Wrist circumferences and grip strengths both non-significant. Pain reduced in Arnica compared with placebo at 2 weeks (p <0.03).	"The role of homeopathic and herbal agents for recovery after surgery merits further investigation."	Baseline data not given and 1 week data suggest trend. Possible inadequate randomization. Objective measures showed no differences.

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		6 men: 11 women. Average male age 51, and female age is 55.				

CRYOTHERAPY/COOLING BLANKET

1. *Recommendation: Cryotherapy During Post-operative Rehabilitation*
   Cryotherapy is recommended for post-operative rehabilitation for carpal tunnel release patients.

   Strength of Evidence – **Recommended, Evidence (C)**
   Level of Confidence – Low

2. *Recommendation: Cooling Blanket During Post-operative Rehabilitation*
   A cooling blanket is recommended during post-operative rehabilitation.

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – Low

Rationale for Recommendations
Cryotherapy has been shown to be effective for post-carpal tunnel release patients and is therefore recommended during post-operative rehabilitation. The evidence is in favor of a cooling blanket versus ice therapy and therefore, a cooling blanket is recommended during post-operative rehabilitation.(1577)

Evidence for the Use of Cryotherapy/Cooling Blanket During Post-operative Rehabilitation
There is 1 moderate-quality RCT incorporated into this analysis.(1577)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: Cryotherapy OR Cooling Blanket / Post-operative rehabilitation and rehabilitation of patients with functional deficits: CTS and other disorders; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found, reviewed and considered for inclusion 17 articles in PubMed, 0 in Scopus, 2 in CINAHL, 0 in Cochrane Library, 3883 in Google Scholar, and 0 in other sources. One RCT met the inclusion criteria.

Author/Year Study Type Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Hochberg 2001 RCT No sponsorship or COI.	4.0	N = 72 (46 males/26 females) adults presenting Carpal Tunnel Syndrome who were legible for single open surgical procedures; No specification on mean age of study sample.	Temperature –controlled cooling blanket vs. standard ice pack for 3 days. Follow-Up immediate following post-op and after three days.	Pain ratings (baseline/day 3): cooling blanket (8.3±1.8/4.5±2.3) vs. ice (8.3±1.3/7.3±2.5), p <0.001.	Use of a "(temperature-controlled cooling blanket) compared with traditional ice therapy, provides patients with greater comfort and lessens the need for narcotics."	Incisional length of 6cm large compared with most recent trials which may have affected results and limits study generalizability to treatment of larger open CTR incisions.

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ACTIVITY/EXERCISE/PHYSICAL OR OCCUPATIONAL THERAPY

1. *Recommendation: Activity During Post-operative Rehabilitation for Patients with Functional Deficits*
   It is recommended that post-operative patients or those with functional deficits stay as active as possible and use the hand as much as possible post-operatively or post-injury.

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – High

2. *Recommendation: Exercise During Post-operative Rehabilitation for Patients with Functional Deficits*
   It is recommended that post-operative patients or those with functional deficits perform graded, increased exercises post-operatively or post-injury. A home exercise program may accomplish this for many patients.

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – High

3. *Recommendation: Formal Physical or Occupational Therapy During Post-operative Rehabilitation for Patients with Functional Deficits*
   Post-operative patients should be observed particularly for failure to progress as expected, as well as for complex regional pain syndrome (see Chronic Pain guideline) or other complications, and it is recommended that there should be a low threshold for institution of formal physical or occupational therapy for rehabilitation. Patients with functional deficits should have a home exercise program with low threshold to refer to therapy for formal treatment if deficits are considerable or there is a failure to progress as expected with a home exercise program.
   Indications – Failure to progress, or moderate to severe functional deficits.
   Frequency – Five to 6 appointments with objective measures followed. Patients demonstrating continued improvements in objective measures may require additional 5 to 6 appointments.
   Discontinuation – Achievement of goals, failure to progress, adverse effects, non-compliance.

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – Moderate

Rationale for Recommendations
Most of the quality studies that have described post-operative rehabilitation components have not prescribed formal physical or occupational therapy for rehabilitation.(907, 918, 923, 1558) Instead, most instructed patients to “keep fingers moving” or perform finger exercises,(922, 928) perform mobility exercises,(946) use the hand daily as tolerated,(922) use “as comfort allowed,”(917) or “use as much as possible” or “as soon as possible.”(778, 940, 953) Unfortunately, there is little quality evidence comparing approaches and there is likely a significant difference between using the hand “as tolerated” and “as much as possible.” There also are no quality studies comparing specific exercises for rehabilitation of patients with deficits compared with no treatment or home exercise programs. Quality studies are needed to address these issues, particularly as they may impact the sizable lost-time problems. In the absence of quality evidence, but inferring from numerous other MSD diagnoses that suggest activity is helpful, it is recommended that patients stay as active as possible and use the hand as much as possible post-operatively, as well as for those with functional deficits, and that there should be a low threshold for institution of formal physical or occupational therapy for rehabilitation.

Evidence for Mobilization During Post-operative Rehabilitation
There are 12 moderate-quality RCTs(958, 1578-1588) incorporated into this analysis. There are 4 low-quality RCTs(1589-1592) in Appendix 2.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: exercise, physical therapy, occupational therapy, upper extremity, postoperative period, postoperative, post-operative, rehabilitation, upper extremity; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic,

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systematic review, retrospective, and prospective studies. We found and reviewed 1,005 articles in PubMed, 6,515 in Scopus, 53 in CINAHL, 499 in Cochrane Library, 50,100 in Google Scholar, and 0 from other sources. We considered for inclusion 5 from PubMed, 1 from Scopus, 0 from CINAHL, 0 from Cochrane Library, 0 from Google Scholar, and 13 from other sources. Of the 119 articles considered for inclusion, 17 randomized trials and 2 systematic studies met the inclusion criteria.

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Author/Year Study Type Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Mobilization vs Immobilization Post-op						
Rath 2009 RCT Sponsored by the LEPRA Society. No COI.	5.0	N = 50 (11 female/39 male) with supple claw hand deformities, ulnar nerve paralysis for >1 year and completion of multi-drug therapy for Hansen's disease undergoing tendon transfer. Mean age IAMP 31±10 years, immobilization group 28±10	Immediate active motion protocol (IAMP) 2 days after tendon transfer for 3 weeks (n = 25) vs. immobilization after tendon transfer for 3 weeks with therapy beginning 22 days after surgery (n = 25). Follow-up monthly for 3 months after discharge and then at 3 month intervals for 1 year, then once a year.	Mean±SD PIP joint angles in open hand position: total digits at discharge IAMP 1±9º vs. immobilization 5±9º (p = 0.005). Mean±SD PIP joint angles in the intrinsic plus position: total digits at discharge IAMP 10±10º vs. immobilization 16±10º (p = 0.00). Mean±SD zero pain level (VAS scores) achieved, week: IAMP 3±1 vs. immobilization 6±1 (p <0.001).	"The current study demonstrates that an early motion protocol results in quicker restoration of function."	Data suggest IAMP group yields earlier pain relief and quicker restoration of function.
Giessler 2008 RCT No mention of sponsorship. No COI.	4.0	N = 21 (10 female/11 male) with a closed extensor pollicis longus (EPL) tendon rupture in zones T4 and T5 treated with tendon transfer. Mean age DY 51 years, AC 59 years.	Dynamic extension splinting (DY) starting 2 days postoperative with limited ROM of IP joints vs. early active (AC) protocol starting 2 days postoperative: early active thumb extension with limited flexion in a splint. Both groups wore a dynamic extension splint between exercises and saw hand therapist at least 3 times a week. Splints completely removed after 3 weeks. Follow-up 3, 4, 6, 8 weeks post-op.	Total ROM in IP joint at 3 weeks (splint removal): higher in DY group vs. AC group (p=0.027). Relative ROM of CMP and IP joints vs. contralateral thumb week 3: active ROM of IP joints DY group 72% of contralateral side vs. AC group 49% of contralateral side (p=0.005).	"Considering the small group sizes, both regimens (dynamic vs early active) achieved comparable clinical results. The early active protocol does not have a notably higher complication rate but fails to accelerate rehabilitation."	Small sample (N = 21). Data suggest comparable efficacy between groups although the early active protocol reported a higher complication rate without rehabilitation rate acceleration.
Physiotherapy Post-op						
Souer 2011	5.0	N = 94 with unstable distal	Surgeon-directed independent exercises: wrist splint until full	3 month outcomes (independent exercise vs.	"[T]his clinical trial supports the concept	Data suggest formal, prescribed PT is not as

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RCT No sponsorship. COI, one more of the authors received payments or services, either directly or indirectly (i.e., via his or her institution), from a third party in support of an aspect of this work.		radial fracture treated with open reduction and volar locking plate fixation and screws alone within 4 weeks of injury. No mention of gender distribution. Mean age occupational therapy 50.7 years, independent exercise 48.6 years.	finger and forearm motion and then wean out wearing splint to regain wrist motion; performed exercises for finger flexion, forearm supination and pronation 3-4 times a day for at least 30 minutes (n = 48) vs. occupational therapy: supervised exercises to regain digit, wrist, and forearm motion and strengthen hand (n = 46). Follow-up at 6 weeks, 3 months and 6 months after surgery.	occupational therapy): grip strength (lb) 55±22.6 vs. 45± 17.4 (p <0.05); grip strength (% of value on uninjured side) 81± 18.9 vs. 66± 16.0 (p<0.05); pinch strength (% of value on uninjured side) 90± 23.7 vs. 80± 22.7 (p<0.05); Gartland and Werley score (points) 2±1.3 vs. 2±2.2 (p <0.05). 6 month outcomes (independent exercise vs. occupational therapy): wrist flexion-extension arc (deg) 129±22.6 vs. 118±17.7 (p<0.05); Wrist flexion-extension arc (% of value on uninjured side) 88±11.7 vs. 84±7.3 (p <0.05); Wrist extension (deg) 62±13.7 vs. 55±10.2 (p <0.05); Ulnar deviation (deg) 40±9.2 vs. 32±12.1 (p <0.05); Ulnar deviation (% of value on uninjured side) 93±19.4 vs. 82±29.2 (p <0.05); Supination (deg) 90±0.9 vs. 84±13.1(p <0.05); Grip strength (% of value on uninjured side) 92±19.8 vs. 81±16.4 (p<0.05); Mayo wrist score (points) 83.4±12.7 vs. 79.0±9.9 (p <0.05).	that patient education and independent exercises are, on the average, adequate for optimal recovery from a distal radial fracture treated with open reduction and volar plate fixation.”	good as independent exercises for improving ROM and/or disability post volar plate fixation surgery for distal radial fractures.
Krischak 2009 RCT No mention of sponsorship. No COI.	4.5	N = 46 (30 female/16 male) with distal radius fractures undergoing internal fixation with locking plates after open reduction.	Physical therapy, 12 sessions lasting 20-30 minutes each, 6 weeks (n = 23) vs. unassisted home exercise program for 6 weeks, detailed instructions and demonstrations given after surgery (n = 23). All put in splint after surgery for 2 weeks. Splint removed for therapy and then back on afterward. Follow-up 1 week after surgery and after 6 weeks of treatment.	Mean±SD Patient Rated Wrist Evaluation (PRWE) score at 6 weeks: home exercise 18.5±15.9 vs. physical therapy 36.1±13.9 (p <0.001). Mean grip strength relative to opposing healthy side 6 weeks: home exercise 54% of starting base value vs. physical therapy 32% of starting base value (p=0.003). ROM of extension and flexion after 6	“[I]nstructions in a home exercise program using a booklet with guidance is a valid alternative to prescribed physical therapy.”	Data suggest PT after volar plating of wrist fractures is effective for post-op rehab although data in study is self-reported in a training diary.

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		Mean age home exercise 53.7±17.9 years, physical therapy 56.0±11.1 years.		weeks of treatment: home exercise 79% of uninjured side vs. physical therapy 52% of uninjured side (p <0.001). Ulnar and radial abduction compared to uninjured side at 6 weeks: home exercise 70% vs. physical therapy 59% (p = 0.013).		
Physical Therapy/ Occupational Therapy						
Pomerance 2007 RCT No sponsorship. No mention of COI.	7.0	N = 150 (110 female/40 male) with NCS confirmed CTS underwent CTR. Average age 46 years.	Therapy (2 week course, 6 sessions, nerve gliding, ROM, strengthening) (n = 73) vs. No therapy. No restrictions to motion and no splints either group. RTW allowed at first post-op visit (N = 77).	RTW at first post-op visit in 80/93 (86.0%) commercial insurance vs. 15/40 (37.5%) WC vs. 12/17 (70.6%) Medicare patients. Between group's post-op grip and pinch strengths not different. DASH scores (19±17/18±17) not different.	"The current randomized study failed to show benefit in a 2-week course of hand therapy after carpal tunnel release using a short incision. The cost of supervised therapy for an uncomplicated carpal tunnel release seems unjustified."	Small incision. Higher costs and no demonstrable benefits from supervised therapy. Data suggest much lower prompt RTW in WC patients. Costs higher for therapy ($600 Medicare and $900 WC).
Provinciali 2000 RCT No mention of sponsorship or COI.	5.5	N = 100 (82 female/18 male) EDS confirmed Average age of 54.69 years.	Multimodal rehabilitative treatment vs. progressive home exercise program	"No difference in symptom occurrence between the two groups was detected after 1 and 3 months. One month after surgery, only patients in the first group showed motor dexterity improvement according to NHPT and JTT scores. At the 3-month follow-up, the two groups did not differ but the group undergoing rehabilitation showed a shorter return-to-work interval."	"A rehabilitation approach after hand surgery is clinically relevant to accelerate recovery but neither modifies functional recovery nor reduces symptom occurrence."	Study suggests no differences in outcomes.
Mitsukane 2015 RCT No mention of sponsorship or COI.	4.5	N = 28 (19 female/9 male) with unilateral distal radial fracture. Mean age 63±13.0 years.	Experimental group: 30 repetitive wrist extensions of injured wrist with maximal isometric contraction for 3 seconds followed by 3 seconds of rest repeated 10 times for 1 minute with a minute rest, sequence repeated 3 times during a 6 minute period (n = 14) vs. control group: no exercises, 6 minutes of rest (n = 14). Follow-up after	Mean±SD change in grip strength (kg) post intervention (experiment vs. control): 16.4±9.9 (p=0.01) vs. 15.3±8.2 (p=0.26). Mean±SD change in VAS (mm) post intervention (experiment vs. control): 2.3±5.1 (p=0.03) vs. 13.3±23.0 (p=0.13).	"This study suggests that repetitive maximal wrist extension is useful in physical examinations to reveal the maximal grip force of patients with DRF, and it is effective as a warm-up training procedure in preparation for	Small sample, sparse methods. Data suggest grip strength increased in experimental group immediately after repetitive wrist extension but not in control group. Pain decreased in experimental group vs. control group.

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			intervention and 10 minutes after that.		conventional grip strength exercises."	
Rostami 2013 RCT Sponsored by the Medical Research Council in Ahvaz Jundishapur University of Medical Sciences. No COI.	4.5	N = 23 (17 female/6 male) with active ROM impairment of hand after orthopaedic injuries. Mean age 38 years.	Mirror therapy (MT): concentrating on ROM exercises on unaffected hand in mirror while performing ROM exercises with impaired hand not in mirror 30 minutes a day, 5 days a week for 3 weeks plus half hour of conventional rehab (tendon gliding exercises, blocking exercises, place-and-hold exercise, PNF techniques, dynamic splinting, functional activities, and ADLs) after each MT session (n = 15) vs. control group: conventional rehabilitation for 30 minutes plus 30 minutes direct observation of affected hand performing movements 5 days a week for 3 weeks (n = 15). Both groups performed a 15 minute home program, MT for MT group and active range of motion (AROM) for control group, twice daily. During 3 week follow-up, both groups attended a scheduled rehab program (hand therapy) 30 minutes a day, 3 days a week. Assessments at baseline and day after 3 week intervention ended. Follow-up 3 weeks after intervention ended.	Mean±SD change total active motion (TAM) pre to post/post to follow-up (MT vs. control): 154±32 vs 61±24 (p=0.001)/ NS. Mean±SD change DASH score pre to post/post to follow-up (MT vs. control): -34±7 vs. -15±11 (p = 0.001)/ -5±4 vs. -10±6 (p = 0.02).	"Findings suggest that adding a regular and scheduled programme of MT to classic rehabilitation techniques is effective for early and maximum improvement of motor recovery and functional abilities in the patients with orthopaedic injuries."	Data suggest MT plus conventional rehab was than control group.
Guzelkucuk 2007 RCT No sponsorship. No mention of COI.	4.0	N = 36 with functional loss due to hand injury. Bone, tendon, peripheral nerve injuries, with impaired hand function.	Controls: rehab program (physical therapy, passive, active assist, active ROM, strengthening, BID) vs. therapy plus therapeutic exercises (same exercises plus 1 session of therapeutic activities). Sessions 30 minutes, 5 days a week for 3 weeks. HEP after 3 weeks; 2 month follow-up.	Grip strength (baseline/post/follow-up): Control (10±9/10±9/11±10) vs. therapeutic exercises (7±5/13±6/23±14), p <0.001. Pinch strength, Jebsen tests also all p <0.001.	"Because of the complex anatomy, determination of the most appropriate treatment may not be easy in an injured hand. Our results showed that the therapeutic activities that mimick the ADL improve the functions of the hand more effectively."	Some sparse details. Heterogeneous disorders. Seen 1.5-6 months after injuries. More contact time in exp. group. Trend to longer time since injury in controls. Also suggests benefits of therapy with emphasis on functional exercise.

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		No mention of gender distribution. Average age of 23±3 years.				
Cross-Education						
Magnus 2013 RCT Sponsored by Royal University Hospital Foundation Grant, doctoral funding from Natural Sciences and Engineering Research Council of Canada, the Dean's Scholarship from the University of Saskatchewan, and a Graduate Scholarship from the University of Saskatchewan. No COI.	4.0	N = 51 females with unilateral distal radius fracture <2 weeks old. All >50 years of age. Mean age 63.0±10.0 years.	Standard rehabilitation: forearm casting; 6 visits to clinic at weeks 1, 3, 6, 9, 12, and 26 post-fracture; and adoption of 3 exercise protocols targeting the fractured side; active ROM of neck, shoulder, elbow, fingers, and thumb while in cast; cast removed – exercises focused on improving active and passive ROM of fractured wrist and hand; stretching and strengthening with encouragement to continue at home after 12 weeks, control (n = 24) vs. standard rehabilitation + strength training of nonfractured limb for 26 weeks, train (n = 27). Follow-up for 26 weeks.	Mean±SD handgrip strength of fractured arm 12 weeks postfracture (training vs. control): 17.3±7.4 kg vs. 11.8±5.8 kg (p = 0.017). Mean handgrip strength of nonfractured arm at 12 weeks postfracture (training vs. control): 30.7±6.5 vs. 24.9±4.4 (p = 0.017). Mean±SD ROM data (degrees) 12 weeks postfracture (training vs. control): flexion/extension 100.5±19.2 vs. 80.2±28.7 (p = 0.017).	"This intervention study found that strength training the nonfractured limb was associated with significantly improved strength and ROM in the fractured limb via cross-education in the early stages of rehabilitation."	All subjects were female. Data suggest at 12 weeks, strength training for non-fractured extremity after distal radius fracture was associated with improved strength and ROM.
Paraffin Bath Therapy						
Dilek 2013 RCT No sponsorship or COI.	6.0	N = 46 (40 female/6 male) with bilateral hand osteoarthritis. Mean age paraffin 58.87±9.47 years, control 59.95±8.71 years.	Group 1: dip-wrap paraffin bath therapy at 50ºC 10 dips followed by 15 minutes in a plastic bag until paraffin cooled 5 times a week for 3 weeks for both hands (n = 29) vs. Group 2: control (n = 27). All patients received education about disease and joint protection techniques and allowed paracetamol. Follow-up at 3 and 12 weeks.	Median pain at rest: 3 weeks paraffin group 2.00 vs. control 4.00 (p = 0.01); 12 weeks 0.00 vs. 5.00 (p <0.001). Median grip strength: right hand 12 weeks paraffin group 20.00 vs. control 13.33 (p = 0.004); left hand 12 weeks 18.00 vs. 12.00 (p = 0.010). Median pinch strength: right hand chuck pinch 12 weeks 5.33	"Paraffin bath therapy seems to be effective both in reducing pain and tenderness and maintaining muscle strength in hand osteoarthritis."	Data suggest paraffin bath therapy had significant benefit in hand OA both for pain reduction and muscle strength retention suggesting paraffin may be a short term therapy option.

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				vs. 3.66 (p = 0.03; right hand lateral pinch 12 weeks 6.00 vs. 4.33 (p = 0.01); left hand chuck pinch 4.83 vs. 3.66 (p=0.01); left hand lateral pinch 12 weeks 5.15 vs. 4.33 (p=0.05). Median painful joint: 12 weeks 3.00 vs. 10.00 (p = 0.04).		
Massage Therapy						
Field 2011 RCT Sponsored by Johnson & Johnson Pediatric Institute and Massage Envy. No mention of COI.	4.0	N = 46 with hand pain. No mention of gender distribution. Mean age 50 years.	Massage therapy once a week for 15 minutes for 4 weeks and taught self-massage to be done once daily vs. standard treatment control. Assessments on the first and last days of the 4 week study	First day post: mean pain massage 2.4 vs. control 2.6 (p <0.05); mean grip strength 7.7 vs. 6.3 (p <0.05); mean anxiety 27.19 vs. 30.2 (p <0.001); mean depression 1.9 vs. 3.9 (p <0.01). Last day post: mean pain 1.3 vs. 2.8 (p <0.01); mean grip strength 8.5 vs. 6.7 (p <0.005); mean anxiety 28.4 vs. 29.7 (p <0.01); mean depression 1.4 vs. 3.9 (p = <0.05).	"The current study suggests that the combination of therapist and self-massage as a more intensive therapy is effective and would likely be more cost-effective for reducing pain and enhancing grip strength."	Data suggest massage therapy group experience less pain, greater grip strength and a more positive mood vs. control group causing less anxiety and better sleep.
Physical Therapy/Mobilization						
Wakefield 2000 RCT No sponsorship OR COI.	6.5	N = 96 (72 female/9 male) with fracture of distal radius, previously treated by plaster immobilization Mean age of 72 years (55 – 90).	Taught and given standard sheet of home exercises by physiotherapist, referred for course of physiotherapy (n=49) vs Taught and given standard sheet of home exercises only Follow up Week 6, Month 3, Month 6	Only flexion/extension at 26 weeks was significantly different (p=0.001) in the two group comparison via ANOVA. No significant differences were observed in parameters between groups. The physiotherapy group displayed significantly higher flexion/extension improvement at six months (p=0.044). There were no significant differences between each group at six months.	"Our study has shown that home exercises are adequate rehabilitation after uncomplicated fracture of the distal radius, and routine referral for a course of physiotherapy should be discouraged. The role of physiotherapy in patients at high risk of a poor outcome requires further investigation.	Data suggest home exercises for uncomplicated fractures are beneficial.

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Appendix 1. Dupuytren's Disease

Dupuytren's disease is a disorder of the hand involving the formation of fibrosis (scar tissue) in the palm and digits with subsequent contractures.(1593) It has strong age and inheritance patterns;(1594-1598) thus, it is generally thought to be non-occupationally related.(1599, 1600) Purported risks include the use of alcohol, smoking, diabetes mellitus, and epilepsy.(1594) However, although there are no quality studies involving occupational factors, there are some reported associations with both heavy(1601) and manual work.(1602) Therefore, to help provide improved care for patients, this disorder is included as an appendix to the Hand, Wrist, and Forearm Disorders Guideline.

Many treatments have been used for patients with Dupuytren's disease, including radiotherapy, dimethylsulfoxide injections, topical applications of vitamins A and E, physical therapy, ultrasound, corticosteroid injections, 5-Fluorouracil, and gamma interferon injections. Almost all of these treatments have been found ineffective.(1603) While surgery is currently the most effective treatment for Dupuytren's disease, the contracture often reoccurs with time.

RADIOTHERAPY

Radiotherapy has been used to attempt to slow or prevent the progression of Dupuytren's disease.(1604) Treatment involves irradiating the nodules and cords associated with Dupuytren's with x-rays or electrons.

Recommendation: Radiotherapy for Prevention of Progression of Dupuytren's Disease
There is no recommendation for or against the use of radiotherapy to prevent the progression of Dupuytren's disease.

Strength of Evidence **– No Recommendation, Insufficient Evidence (I)**
Level of Confidence – Low

Rationale for Recommendation
One moderate-quality trial of radiotherapy found no differences between two types of radiotherapy treatment regimens.(1604) However, the trial had no placebo group and there was no comparison between treatments. In addition, results suggested regression over 1 year. Radiotherapy is non-invasive and has moderate adverse effects, but it is moderately costly and there is no quality evidence of its efficacy. Therefore, there is no recommendation for or against the use of radiotherapy to prevent the progression of Dupuytren's disease.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: radiotherapy, dupuytren contracture, dupuytrend disease, hand; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 4 articles in PubMed, 32 in Scopus, 1 in CINAHL, 0 in Cochrane Library, 2784 in Google Scholar, and 0 from other sources. We considered for inclusion 1 from PubMed, 0 from Scopus, CINAHL, Cochrane Library, Google Scholar, and 0 from other sources. Of the 1 article considered for inclusion, 1 randomized trial and 0 systematic studies met the inclusion criteria.

COLLAGENASE INJECTIONS

Collagenase injections have been utilized for treatment of Dupuytren's disease to lyse and rupture the finger cords that are causing the joint contracture.(1605-1607) (

Recommendation: Collagenase Injections for Treatment of Dupuytren's Disease
Collagenase injections are moderately recommended for treatment of Dupuytren's disease.

Indications – Dupuytren's contractures sufficient to result in impairment, nearing impairment, or sufficient to result in significant cosmetic deformity.

Frequency/Dose – Clostridial collagenase 10,000 U injection; repeat injection(s) at 4 to 6 week intervals.

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Discontinuation – Resolution of contracture, sufficient reduction for patient to decline additional injection, adverse effects, or failure to respond to 3 injections.

Strength of Evidence **– Moderately Recommended, Evidence (B)**
Level of Confidence – Moderate

Rationale for Recommendation
Quality studies evaluating the efficacy of clostridial collagenase show considerable benefits.(1605, 1606, 1608, 1609) These injections are minimally invasive, have relatively few reported adverse effects (skin tears if prolonged contracture), but are costly. Therefore, collagenase injections are moderately recommended for treatment of Dupuytren's disease. One trial recommended post-operative manipulation but had no placebo or sham group.(1610)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: collagenase injections, dupuytren contracture, dupuytren disease, hand; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 5 articles in PubMed, 68 in Scopus, 0 in CINAHL, 2 in Cochrane Library, 1126 in Google Scholar, and 0 from other sources. We considered for inclusion 2 from PubMed, 9 from Scopus, 0 from CINAHL, Cochrane Library, Google Scholar, and 0 from other sources. Of the 11 articles considered for inclusion, 7 randomized trials and 3 systematic studies met the inclusion criteria.

INTRA-OPERATIVE 5-FLUOROURACIL
5-Flourouracil (5-FU) is a chemotherapy drug that has been used for many years to treat cancer, principally as a thymidylate synthase inhibitor. It is administered intravenously or as a topical cream. 5-FU is also used in ophthalmic surgery as an anti-scarring agent, and topically to treat actinic (solar) keratoses and some types of basal cell skin carcinomas. 5-FU has also been used topically to attempt to slow or prevent recurrence of Dupuytren's disease after surgery by reducing proliferation rates of fibroblasts.(1601)

Recommendation: 5-Fluorouracil for Recurrence of Dupuytren's Disease in Surgical Patients
5-Fluorouracil is not recommended to prevent the recurrence of Dupuytren's disease in surgical patients.

Strength of Evidence **– Not Recommended, Evidence (C)**
Level of Confidence – Low

Rationale for Recommendation
There is one moderate-quality trial of 5-fluorouracil administered intraoperatively which showed no difference when compared with placebo.(1601) 5-Fluorouracil is not invasive, but has adverse effects and is moderately costly. Therefore, 5-Fluorouracil is not recommended to prevent recurrence of Dupuytren's disease.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: fluorouracil, 5 fluorouracil, dupuytren contracture, dupuytren disease, hand; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 0 articles in PubMed, 7 in Scopus, 0 in CINAHL, 0 in Cochrane Library, 1522 in Google Scholar, and 0 from other sources. We considered for inclusion 0 from PubMed, Scopus, CINAHL, Cochrane Library, 1 from Google Scholar, and 0 from other sources. Of the 1 article considered for inclusion, 1 randomized trials and 0 systematic studies met the inclusion criteria.

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POST-OPERATIVE USE OF NSAIDS AND ACETAMINOPHEN

NSAIDs have been used to treat post-operative swelling from surgery for Dupuytren's disease and appear to be superior to acetaminophen (paracetamol).(639) Naproxen may also be useful as an analgesic during the immediate post-operative phase.(639)

1. *Recommendation: NSAIDs to Treat Post-operative Swelling from Surgery for Dupuytren's Disease*
   NSAIDs are moderately recommended to treat post-operative swelling from surgery for Dupuytren's disease.

   Indications – Dupuytren's disease surgical patients.

   Frequency/Dose – Naproxen 500mg BID.(639)

   Duration – Trial utilized 3 days of treatment.

   Strength of Evidence **– Moderately Recommended, Evidence (B)**
   Level of Confidence – High

2. *Recommendation: Acetaminophen for Dupuytren's Surgery*
   Acetaminophen is recommended for Dupuytren's surgery.

   Frequency/Dose – Paracetamol 1g QID trialed for 3 days. (Note: an FDA advisory committee recommended a maximum dose of 650mg and there is a suggestion of toxicity at 1g QID especially over a few days and particularly in patients consuming excess alcohol or who have liver disease.)(1611)

   Strength of Evidence **– Recommended, Evidence (C)**
   Level of Confidence – Moderate

Rationale for Recommendations

There is one high-quality study evaluating the effect of drugs on acute post-operative swelling after surgery for Dupuytren's; it documents the efficacy and superiority of naproxen to paracetamol, which in turn was superior to placebo.(639) However, there is no quality evidence that other NSAIDs are inferior to naproxen. NSAIDs and acetaminophen are non-invasive, have low adverse effects (particularly over 3 days), and are low cost. Therefore, they are recommended to treat post-operative swelling and pain resulting from surgery for Dupuytren's disease.

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: anti-inflammatory agents, non-steroidal, dupuytren contracture, dupuytren disease, hand; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 1 articles in PubMed, 2 in Scopus, 0 in CINAHL, 1 in Cochrane Library, 440 in Google Scholar, and 0 from other sources. We considered for inclusion 1 from PubMed, 0 from Scopus, CINAHL, Cochrane Library, Google Scholar, and 0 from other sources. Of the 1 article considered for inclusion, 1 randomized trials and 0 systematic studies met the inclusion criteria.

SURGERY

Surgical procedures have long been used to attempt to improve range of motion in patients with contracture from Dupuytren's disease.(1600) The goal of surgical care is to excise or incise the diseased fascia. This treatment does not cure the disease, but is meant to improve severe debilitating joint contractures. Several types of surgery have been used to treat Dupuytren's disease, depending on the contracture. **Extensive fasciectomy** involves removing as much fascia as possible, including that which is grossly normal. Today, this procedure is not commonly performed because of increased morbidity which often included hematoma, edema, and prolonged post-operative stiffness. **Dermofasciectomy** removes the diseased fascia and the overlying skin. This requires resurfacing (covering) the wound with a full-thickness skin graft. Recurrence rates are quite low with this approach. Because of the radical nature of this procedure, it is usually reserved for patients with recurrent or severe disease. **Regional or selective fasciectomy** involves excising only grossly involved fascia. Although the disease process

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clearly extends into clinically normal palmar fascia, this approach has proven successful in correcting MCP joint contractures and some PIP joint contractures; this procedure carries an acceptably low morbidity rate. Some surgeons prefer to leave the skin wound open to heal by secondary intention as a means of decreasing hematoma risk. This approach is commonly used today.

1. *Recommendation: Surgery for Treatment of Dupuytren's Contracture*
   Surgery using the technique of regional or selective fasciectomy is recommended for contracture due to Dupuytren's disease.

   Strength of Evidence **– Recommended, Insufficient Evidence (I)**
   Level of Confidence – Low

2. *Recommendation: Percutaneous Needle Fasciotomy (aka Needle Aponeurotomy) for Treatment of Dupuytren's Contracture*
   Percutaneous needle fasciotomy (aka needle aponeurotomy) is not recommended for patients with contractures due to Dupuytren's disease due to the high recurrence rates common with this technique.

   Strength of Evidence **– Not Recommended, Insufficient Evidence (I)**
   Level of Confidence – Low

3. *Recommendation: "Firebreak" Full-thickness Skin Graft for Dupuytren's Contracture, Extensive Fasciectomy, or Dermofasciectomy for Treatment of Dupuytren's Contracture*
   "Firebreak" full-thickness skin graft, extensive fasciectomy, or dermofasciectomy for Dupuytren's contracture is not recommended for routine Dupuytren's contracture surgery.

   Strength of Evidence **– Not Recommended, Evidence (C)**
   Level of Confidence – Low

Rationale for Recommendations
There are no quality studies comparing surgical results with non-surgical treatments or with no treatment.(1599, 1600, 1612) Considering the high propensity for Dupuytren's contracture to progress or reoccur (estimated at 27 to 80% after surgery(1600, 1613-1615)), surgical studies with sufficient follow-up to determine long-term benefits are needed. However, as some patients with functional limitations appear to improve at least in the short to intermediate term lasting many months to years, regional or selective fasciectomy is recommended. Surgery is invasive, has known adverse consequences including recurrences, and is costly. However, it also appears effective for at least a limited period of time and for some patients it may be the only treatment option available; thus, surgery is recommended particularly for patients with functional limitations. Full-thickness skin graft has been found to be ineffective and thus is not recommended.(1599)

Evidence for Dupuytren's Disease
There are 2 high-(639, 1738) and 15 moderate-quality(1698, 1731-1733, 1736, 1737, 1740-1742, 1744, 1748-1752) (McGrouther 14; Kemler 12; van Rijssen 12; Kan 16) RCTs incorporated in this analysis. There is also one other study included.(1739)

A comprehensive literature search was conducted using PubMed, Scopus, CINAHL, Cochrane Library, and Google Scholar without date limits using the following terms: splints, dupuytren contracture, dupuytren disease, hand; controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random*, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 70 articles in PubMed, 285 in Scopus, 17 in CINAHL, 1 in Cochrane Library, 633 in Google Scholar, and 1 from other sources. We considered for inclusion 6 from PubMed, 1 from Scopus, 0 from CINAHL, Cochrane Library, Google Scholar, and 1 from other sources. Of the 8 articles considered for inclusion, 6 randomized trials and 2 systematic studies met the inclusion criteria.

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Table 1a. Quality Studies for the Treatment of Dupuytren's Disease

Author/Year Study Type Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Radiotherapy						
Seegenschmiedt 2001 RCT No mention of sponsorship or COI.	6.0	N = 129 (67 male and 62 female) with clinically evident and progressive early-stage DC. Mean age for Group A and B: 65 ± 11 / 61 ± 14 years.	Group A, radiotherapy 10 x 3 Gy (total dose, 30 Gy) in 2 series (5 x 3 Gy) separated by 8 weeks (N = 63) vs Group B, 7 x 3 Gy (total dose, 21 Gy) in 1 series within 2 weeks (N = 66). Follow-up 3 and 12 months.	At 12 months, reduction of symptoms, nodules and cord observed in both treatment groups (p < 0.01). For subjective responses, 76 (59%) patients (Group A, 41; Group B, 35) stated "regression of DC symptoms" in 120 (61%) sites (A, 60; B, 60); range of regression equal for both groups: <25% regression for 74 of 120 (62%) sites (A, 35; B, 39), 25-50% regression for 37 (31%) sites (A, 35; B, 19), 51-75% regression in 7 (6%) sites (A, 5; B, 2), and >75% regression in 2 (2%) sites (all in group A); 46 (36%) patients (A, 19; B, 27) had "stable condition" in 65 (33%) sites (A, 30; B, 35), whereas 7 (5%) patients (A, 3; B, 4) suffered "progression of DC symptoms" in 13 (7%) sites (A, 5; B, 8)."	"Both tested RT regimens have been well accepted and tolerated by patients. Acute toxicity was slightly more enhanced in the low-dose group (21 Gy) than in the mediumdose group (30 Gy), probably due to the dose-time factor.."	No placebo group. RT therapy individualized. Data suggest RT may be effective due to reported regression, but that cannot be proved.
Collagenase Injections vs. Placebo						
Badalamente 2002 2 RCTs Supported by grants from the U.S. Food and Drug Administration, the National Institutes of Health (General Clinical	8.0	First trial or IIA: N = 36 (31 male and 5 female) with MP joint constractures. Mean age 65 years. Second trial or IIB:	IIA trial: Single dose of Collagenase injection of 10,000 U (N = 18) vs Placebo consisted of sterile normal saline containing	1 month after injection, 14/18 (77.8%) collagenase group had contracture correction to 0-5º vs. 2/18 (11.1%) placebo. Retreatment of 16 placebo patients who did not respond to 1st blinded injection had flexion contracture correction to 0-5º in 10 after a 1st open-label	"(C)ollagenase injection into the cord causing MP and/or PIP joint contractures in Dupuytren's disease is a safe and effective method in the majority of patients in restoring normal finger extension and thus improving range of finger motion."	Phase 2 trials. Suggests collagenase effective.

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Research Center Grant, and the Advance Biofactures Corporation, Lynbrook, NY. No COI.		N = 80 (64 male and 16 female) with MP joint contractures. Mean age 63.9 years.	2 mmol/L calcium chloride (N = 18). IIB trial: Collagenase injection of10,000 U, (N = 23) vs Collagenase injection of 5,000 U (N = 22) vs Collagenase injection of 2,500 U (N = 18) vs Placebo included sterile normal saline containing 2 mmol/L calcium chloride (N = 17). Follow-up occured on days 7 and 14 and at months 1, 2, 3, 6, 9 and 12.	10,000-U injection; in 2 after 2nd injection; in 1 after 3rd. 2nd trial data suggests 10,000 U dose superior.		
Hurst 2009 RCT Double-blind Sponsored by Auxilium Pharmaceuticals and grant support from BioSpecifics Technologies. COI, Dr. Hurst received consulting and advisory-board fees from Auxilium Pharm.; Dr.	7.5	N = 308 (245 male and 63 female) with joint contractures of 20 degrees or more; mean age 62.7±9.5 years.	Treatment Group 0.58mg collagenase clostridium Was injected into affected cords via 0.25ml of sterile diluent (MCP joints) or 0.20ml sterile diluent (PIP joints). Maximum of 3 injections every 30 days. Treatment cycle included injection, finger extension, and 30 day follow-up (N = 204) vs	Collagenase injected cords compared to placebo injections meeting primary endpoint (64.0% vs. 6.8%, P<0.001). Collagenase joint ROM compared to placebo, 43.9 to 80.7 degrees vs. 45.3 to 49.5 degrees, (p <0.001).	“Collagenase clostridium histolyticum significantly reduced contractures and improved the range of motion in joints affected by advanced Dupuytren’s disease.”	Cord I study. Data suggest that compared to placebo collagenase clostridium histolyticum significantly reduced contractures and increased ROM of joints in patients with Dupuytren’s disease. Adverse effects (treatment related outcomes) significantly higher in collagenase group.

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Badalamente, receiving consulting and advisory-board fees from Auxilium Pharm.; Dr. Kaplan, receiving consulting and advisory-board fees from Auxilium Pharm.ls; Drs. Rodzvilla and Smith, are employees of and holding stock options with Auxilium Pharmaceuticals; Drs. Meals, Hentz, and Hotchkiss, receiving consulting fees from Auxilium.			Placebo Group 10 mM TRIS per 60 mM sucrose in diluent administered similarly to treatment group (N = 104). Follow-up at 1, 7, and 30 days post-injection.			
Badalamente 2007 RCT Supported by BioSpecifics Technologies Corp. Plus grants from the US Food and Drug Administration and the National Institutes of Health. Editorial support was provided by Auxilium Pharmaceuticals, Inc.	7.5	N = 35 (28 male and 7 female) with fixed flexion deformity of 20° or greater of the MCP or PIP joints in at least 1 finger. Age ≥ 18 years.	Collagenase injection (10,000 U) maximum of 3 injections in the primary joint were (N = 23) vs Placebo 10,000 U of collagenase was established as the minimum safe and effective dose (N = 12). Follow-up at 1, 7, 14, and 30 days.	21/23 (91%) collagenase vs. 0/12 (0%) achieved clinical success (p <0.001) with up to 3 injections in the primary joint for MCP and PIP contractures. Average number of injections 1.4.	"The collagenase injections safely and effectively corrected MCP and PIP contractures in patients with 1 or more DC-affected joints. Recurrence rates after treatment appear to be low.."	Some details sparse. Data suggest efficacy.
Gilpin 2007 RCT Double-blind Sponsored by Auxilium Pharmaceuticals. COI, D.G. and S.C. own shares in	7.0	N = 66 (56 male and 10 female) with contractures affecting metacarpophalangeal (MCP) or proximal interphalangeal (PIP) joints; mean±SD age	Treatment group: 0.58mg collagenase clostridium histolyticum per injection. Injected directly into Dupuytren's affected cords. Maximum of 3 injections every 30 days. Treatment cycle included	Significantly more primary joints in the treatment group had reduced contracture from 0° to 5° (44.4% vs. 4.8%; p < .001). Treatment MCP joint vs placebo MCP joint contracture reductions (13/20 vs. 1/11; p = 0.003)	"Collagenase clostridium histolyticum is a highly tolerated and effective non-surgical treatment for Dupuytren's disease. In addition to collagenase injections, regular finger extension exercises and night splinting may have additional benefits."	A randomized placebo controlled trial with 9 month open label phase (CORDII). Data suggest collagenase clostridium histolyticum when compared to placebo has benefit for treating Dupuytren's contractures and is well tolerated.

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Auxilium. J.K. is on advisory board of Auxilium. N.J. is an employee of and owns stock options in Auxilium Pharmaceuticals.		63.8 ± 9.0 years.	injection, finger extension, and 30 day follow-up (N = 45) vs Placebo group received Lyophilized Tris and sucrose in sterile diluent (N = 21). Follow-up at 1, 7, and 30 days post-injection.			
Mickelson 2014 RCT No sponsorship or COI.	4.0	N = 43 or 46 digits (35 male and 8 female) with MCP or PIP joint contracture, or both of at least 20º; age range 43-85 years.	All received 0.58mg CCH a few millimeters apart at 3 contiguous locations along Dupuytren cord on day 1. Day 1 group MCP and PIP joint contractures measured and pain scores recorded (N = 22). vs Day 7 group MCP and PIP joint contractures measured and pain scores recorded (N = 24). Follow-up day 1 or 7 and 30.	No significant difference in MCP flexion between day 1 and 7 groups in follow-ups. Contracture was significantly lower in the 7 day group (23º vs. 40º). PIP joints showed no significant differences between 1 and 7 day groups during follow-ups.	CCH correction of Dupuytren contractures was shown when manipulation was performed on day 7 with no differences in correction, pain or skin tears. This suggests that manipulation can be scheduled anytime within 7 days of injection.	Baseline comparability has significant differences. Patients may have had different digits randomized differently. No placebo or sham arm.
Witthaut 2011 Post Hoc RCT Sponsored by Pfizer Inc. Cord study	N/A	N = 308 (245 male and 63 female) with Dupuytren's disease and joint contractures	Maximum of 3 collagenase 0.58mg (N = 204) vs Placebo injections into cord of affected	Mean increase in ROM 36.7° in the collagenase-treated joints (p<0.001) and 4.0° in the placebo-treated joints (not significant).	"Injectable collagenase significantly improves ROM and treatment satisfaction versus placebo. ROM improvements are clinically relevant as well as statistically significant."	Post Hoc analyses of Cord I Study. Injectable collagenase clostridium histolyticum compared to placebo significantly improves ROM which are both clinically and statistically significant.

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sponsored by Auxillium Pharmaceuticals, Inc. Jorg Witthaut is an investigator for the collagenase Clostridium histolyticum clinical trial programme. The remaining authors are employees of Pfizer Inc. Groton, CT, USA.		≥20°. Mean ± SD age for collagenase 62±10 and placebo 63±9 years.	hand at 30-day intervals (N = 104). Follow-up on day 1 or 7 and 30.			
NEW McGrouther 2014 RCT Sponsored by Auxilium Pharmaceuticals Inc. Medical writing and editorial was funded by Pfizer Ltd. D.A.M. has acted as a professional advisor to Pfizer, A.J., S.B., R.A.G., and P.S. are employees of and own stock in Pfizer. B.C. is an employee of and owns stock in Auxilium Pharmaceuticals.	4.0	N = 58 with Dupuytren's contracture or DC. Mean age 61.4 (8.89), 40 male and 18 female.	Collagenase clostridium histolyticum or CCH injection treatment, one joint (N = 49) vs CCH Treatment Primary 2 Joints (N = 9). Follow-up for 90 days.	Mean number of injections per patient for up to 2 affected joints was 1.84, mean injections per joint was 1.62. Of the 56, 66% reported that they were 'very satisfied' and 27% 'quiet satisfied', 4% 'neither', and 0% 'very dissatisfied'. Commonly reported adverse events; edema peripheral reported by 79%, contusion by 55%, pain in extremity by 41%, injection site hemorrhage by 29% and injection site pain by 29% of patients.	"Collagenase clostridium histolyticum injection is a minimally invasive procedure that can be performed on an outpatient basis."	Data from open label trial. Data suggest CDH has some efficacy for management of DC.
5-Fluorouracil vs. Placebo Intraoperative						
Bulstrode 2004 RCT Sponsored by the RAFT Institute of Plastic Surgery, Mount Vernon	5.0	N = 15 male with two-digit disease. Mean age 61 years.	Treatment rays, 5-Fluorourasil a 1 cm section of the Dupuytren's tissue was marked and excised, plus excision either 0.5 ml of 5-fluorouracil (25 mg/ml) or 0.5 ml vs	Metacarpophalangeal joint movement improved from 68º (range, 20-109º) to 85º (range, 32-133º) for control rays and 69º (range, 29-100º) to 79º (range, 64-113º) for 5-fuorouracil treated rays at 3 months. MCP joint range of motion did not differ at 18 months.	"The follow-up data have not demonstrated a significant difference between the control 5-fuorourasil treated rays for either total active motion, or metacarpophalangeal or proximal interphalangeal joint movement or loss of extension."	Small sample size. Data suggest 5-FU ineffective.

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Hospital, Northwood, Middlesex. No mention of COI.			Control rays, Normal saline instilled in the excision. Follow-up for 18 months.			
Splints						
Jerosch-Herold 2011 RCT Sponsored by Action Medical Research Charity and the National Institute for Health Research (NIHR). No COI.	5.5	N = 154 (120 male and 34 female) undergoing fasciectomy of dermofasciectomy for Dupuytren's disease. Mean age hand therapy only 67.5±9.2 years, splint 67.2+10.0 years.	Hand therapy only within 2 weeks after surgery plus removal of sutures (N = 77) vs Hand therapy with night splinting worn for 6 months (N = 77). Follow-up for 12 months after surgery.	There were no statistically significant differences at 12 months between the two groups in DASH score (0.66, -2.79 to 4.11, p = 0.703), degrees of total active flexion of operated digits (-2.02, -7.89 to 3.85, p = 0.493), degrees of total active extension deficit of operated digits (5.11, 2.33 to -12.55, p = 0.172. The mean number of therapy sessions was 5.1 in the splint group and 5.6 in no-splint group.	"No differences were observed in self-reported upper limb disability or active range of motion between a group of patients who were all routinely splinted after surgery and a group of patients receiving hand therapy and only splinted if and when contractures occurred.."	Data suggest comparable results from self-reported outcomes.
NEW Kemler 2012 RCT No sponsorship or COI.	4.5	N = 54 with proximal interphalangeal (PIP) joint flexion contractures of at least 30º. Mean age 63 (9) and 64 (11) for hand therapy alone group, 8 female and 46 male.	Splint plus hand therapy (N = 28) vs Hand therapy alone (N = 26). Follow-up for 3 months.	After 1 year, the splint-plus-hand therapy had mean reduction of 21º in flexion contracture vs 29º in the group receiving hand therapy alone, (p = 0.1). 18 or 64% reported not less than "much improve" vs 19 or 73% of the 26 hand therapy alone, (p = 0.5). At 6 months pain did not differ significantly between group, VAS score 1.9 (2.0) vs 2.1 (2.4), (p = 0.7).	"After operative release of a Dupuytren's contracture, a postoperative protocol using a splint and hand therapy was no better than hand therapy alone in minimizing postoperative flexion contractures."	Data suggest lack of benefit of adding a splint to hand therapy vs. hand therapy alone for treating Dupuytren's contracture.
Post-Operative NSAIDs and Paracetamol vs. Placebo						
Husby 2001 RCT	8.0	N = 35 (33 male and 2 female) Dupuytren's contracture	Paracetamol1000mg 4 dimes daily (N = 12) vs	Postoperative Dupuytren's swelling as a percentage of preoperative volume: 5.6±3.8 vs. 6.9±3.7 vs. 8.2±5.1.	"[N]aproxen might have a clinical relevant effect on swelling when used on minor surgery in the hand, unlike paracetamol.	Results suggest a beneficial effect of naproxen over paracetamol, which is superior to placebo, which the

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No mention of sponsorship or COI.		(plus 42 CTS). Mean age (range): 61 (29-81).	Post-op naproxen 500mg BID twice daily (N = 12) vs vs Matching placebo for three days (N = 11) Follow-up at 72 hours after surgery.	Additional analgesics used were 0, 2 and 8 in naproxen, paracetamol, and placebo groups.	Naproxen might be a useful analgesic during the immediate postoperative phase."	studies were not powered to detect.
Surgical Procedures						
van Rijssen 2006 RCT No sponsorship and no mention of COI.	6.0	N = 121 (94 male and 19 female) or 125 hands, with Dupuytren's disease. Mean age 63 years.	Percutaneous needle fasciotomy or PNF (N = 57) vs Limited fasciotomy under either regional anesthesia or general anesthetist using tourniquet in all cases (N = 56). Follow-up for at 1 and 6 weeks for the primary outcome perimeters.	PNF: Largest mean TPED per ray contractures 1 week after PNF 30º (58% reduction), p = 0.001. Follow-up at 6 weeks, results better. Limited fasciotomy: mean TPED at 1 week 15º (73% reduction), p = 0.001. Largest reduction for PNF at MCP, but DIP for LF.	"In the short term and in cases with a TPED of 90° or less PNF is a good treatment alternative to LF for treatment of Dupuytren's disease.."	No non-operative or placebo intervention. Suggests equal (in) efficacy.
NEW van Rijssen 2012 RCT No mention of sponsorship and no COI.	5.5	N = 111 (17 female and 76 male) with affected hands and minimal passive extension deficit of 30 degrees. Mean age for LF and PNF groups; 63.1 and 62.8.	Limited fasciotomy or LF (N = 41) vs Percutaneous needle fasciotomy or PNF (N = 52). Follow-up at 1 and 6 weeks, 6 months, and 1,2, 3,4 and 5 years.	At 5-years, 33 hand in 31 patients treated with limited fasciectomy didn't develop recurrence or 76.8% vs 20.9%. Recurrence rate in the limited fasciectomy group was significantly smaller, (p < 0.001; 95% CI, 1.597 - 2.628), and recurrence occurred significantly later after limited fasciectomy than after percutaneous needle fasciotomy, (p = 0.001). At	"Percutaneous needle fasciotomy is the preferred treatment for elderly patients with Dupuytren's disease and for those willing to accept a possible early recurrence in the context of the advantages, such as fast recovery, a low complication rate, and minimal invasiveness."	Data suggest that at 5 years, the recurrence rate in the needle fasciotomy group was (84.9%) compared to the limited fasciotomy group (20.9%) and recurrence occurred ealier the needle fasciotomoy group.

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				the time of treatment, older age decreased the recurrence rate, (p = 0.005).		
NEW Kan 2016 RCT Sponsored by Fonds NutsOhra and Stichting Coolsingel. No mention of COI.	6.0	N = 80 (62 male and 14 female) with primary Dupuytren's contracture. Mean age 63 ± 9 for PALF and 63 ± 8 for LF group.	Procedure consisting of extensive percutaneous aponeurotomy and lipofilling or PALF (N = 40) vs Limited fasciectomy (N = 40). Follow-up at 2 weeks, 3 weeks, 6 months and 1 year.	At 1 year, 15/85 PALF treated joints or 18%, had some recurrence vs 5/58 limited fasciectomy treated joints or 9%, (p = 0.107). The overall complication rate not significantly different between the groups, (p = 0.402).	"PALF demonstrates a significantly shorter convalescence, similar operative contracture correction, lower incidence of long-term complications, and no significant difference regarding 1-year postoperative results compared with limited fasciectomy."	Data suggest PALF showed shorter recovery times, fewer complications, comparable results to standard fasciotomy group. However, at one year post procedure the PALF group had more recurrence (18% vs.9%).
Ullah 2009 RCT No sponsorship. No mention of COI.	6.0	N = 79 (65 male and 14 female) with Dupuytren's contracture of the proximal interphalangeal joint. Mean age of 62.9 years.	Dermofasciectomy or "Firebreak" skin graft performed on one finger (N = 39) vs Fasciectomy was performed on second finger (N = 40). Follow up at 12, 24 and 36 months.	Mean range of movement of PIP 34.6º (1-80º) preoperatively, improved to 65º (2-98º) at 3 years. Progressive recurrence of PIP contracture over 3years in 11 (12.2%); 5 had fasciotomy with Z-plasty; contracture recurred in 5.4 months vs. 8months for full-thickness skin graft (p = 0.6).	"[N]o difference in recurrence rates between the two methods of treatment at three years and were surprised at the low recurrence rate after fasciectomy and Z-lasty alone."	Suggests full thickness graft not more effective.
Citron 2005 RCT No mention of sponsorship or COI.	5.0	N = 100 63 male and 16 female) with Dupuytren's disease in one ray only and any degree of resultant	Modified Brunner incision closed with multiple Y-V plasties (N = 62) vs Z-plasty group had longitudinal incision,	Mean post-op deformity on final review or at recurrence 25º in modified Bruner group vs. 24º in Z-plasty group (NS). Recurrence rate 33% modified Bruner vs. 18% Z-plasty group (NS).	"There is no evidence to suggest that the type of incision influences the time distribution of recurrent disease but this possibility cannot be discounted."	Data suggest no differences between the 2 procedures.

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		contracture. Age mean for both groups 65 (10) years.	closed with Z-plasties (N = 38) vs Follow-up for 2 years.			
Bhatia 2002 Prospective RCT No mention of sponsorship or COI.	4.5	N = 31 (28 male and 3 female) undergoing surgery for Dupuytren's disease; age range 38-79 years.	Staple group: staples via an automatic stapling device. Time spent closing recorded. Pain levels recorded during staple removal at 1 week follow-up (N = 13) vs Suture group: received 4-0 monofilament polybuster sutures. Time spent closing recorded. Pain levels recorded during suture removal at 1 week follow-up (N = 18). Follow-up at weeks 1 and 2 following surgery.	Mean skin closure time with sutures 51 seconds per cm and 25 seconds per cm with staples (p <0.001). The mean pain score for removal 2.4 for suture removal and 5.2 for staple removal, (p = 0.008).	"As staples can be inserted in half the time of conventional sutures we recommend their use for closure of extensive palmar wounds following long operative procedures."	Data suggest patient pain was higher for staple removal over suture removal but staples took less time to insert and no significant differences in wounds once staples or sutures removed.

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Appendix 2: Excluded Studies

(Low-quality Randomized Controlled Trials and Non-randomized Studies)

The following low-quality randomized controlled studies (RCTs) and other studies were reviewed by the Evidence-based Practice Hand, Wrist, and Forearm Panel to be all inclusive, but were not relied upon for purposes of the development of this document's guidance on treatments because they were not of high quality due to one or more errors (e.g., lack of defined methodology, incomplete database searches, selective use of the studies and inadequate or incorrect interpretation of the studies' results, etc.), which may render the conclusions invalid. ACOEM's Methodology requires that only moderate- to high-quality literature be used in making recommendations.(1617)

ERGONOMIC INTERVENTIONS

Author/Year Study Type Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Ripat 2006 RCT Sponsored by Manitoba Hydro. No mention of COI.	3.0	N = 68 with two or more symptoms of WRUED (Work Related Upper Extremity Disorders). Mean age 42.2 years.	Adapted Group- Microsoft Natural MultiMedia Keyboard adapted to reduce activation force required to depress keys (light touch) (n = 43) vs. Unadapted Group- Standard keyboard with no adaptations made (n = 25). Follow-up for 6 months.	No significant differences between two groups for Symptom Severity (SSS) and Functional Status Scales (FSS) between groups (p <0.05). When data from groups combined, SSS and FSS-typing measures significant at both 12 and 24 week (p <0.0001) at both time points.	"Positive results in reduction of symptom severity and improvement in functional status were identified for participants in both keyboard study groups, providing further evidence to support the use of ergonomic keyboards for individuals with WRUED. The vast majority of participants were satisfied with their study keyboard."	Both keyboard groups improved over time, however, there were no differences between groups. Some randomized to experimental group were "forced" to use the LT keyboard.
Hedge 1999 RCT Sponsored by Honeywell, Inc., Proformix, Inc., Global, Global Contrac and Teknion. No mention of COI.	2.5	N = 38 professionals who used a computer work average of 5.4 hours per day. Mean age 37.4.	DT Group- DT keyboard tray. User measurements taken to put keyboard at comfortable height. (n = 23) Vs. Control Group- conventional adjustable keyboard with or without a padded wrist rest (n = 15). Measurements taken immediately following intervention.	No significant differences between pre- and post-test measurements in the control group for wrist extension and ulnar deviation (p >0.05). Significant difference between pre and post wrist extension in DT group; 17.6 vs. 12.1 (p <0.05). No significant difference for ulnar deviation. (p>0.05). In post-test upper posture index (UPI) there was a significant difference in favor of the DT group vs. control for number of subjects reporting a UPI < 4; 60% vs. 90% (p = 0.044).	"Overall, the wrist movement data, the RULA data and the self-reported musculoskeletal discomfort data all point to improvements within a short time after using the DT system."	Methodological details sparse.

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Lincoln 2002 RCT Supported by grant from Robert Wood Johnson Foundation and Workers' Compensation Health Initiative grant 034366 and cosponsored by US Department of Labor. No mention of COI.	2.5	N = 101	Nurse case manager training in ICN vs. no ICM training.	"Trained nurses were more likely to recommend accommodations addressing workstation layout, computer-related improvements, furnishings, accessories, and lifting/carrying aids, whereas the untrained nurses were more likely to suggest light duty and lifting restrictions. This study indicates that the training was associated with a change in the practice behavior of case managers regarding the workplace accommodation process."	"More research is needed to identify barriers to implementation and develop more effective approaches to facilitate worksite accommodations in disabled workers with carpal tunnel syndrome and other persistent upper extremity disorders."	
Galinsky 2007 RCT No mention of sponsorship or COI	1.5	N = 51	All workers spent 4 weeks with conventional breaks (2 15-minute breaks a day) and 4 weeks with supplementary breaks (2 15-min breaks plus 4 5-minute breaks per day). One group performed brief stretching exercises during breaks; control group did no stretching during breaks.	Mean rate of data entry under supplementary rest break schedule significantly faster than rate under conventional rest break schedule (p <0.0002). No significant effects of stretching on discomfort or performance observed. Discomfort and eyestrain significantly lower with supplementary breaks; supplementary breaks attenuated accumulation of discomfort and eyestrain during work sessions.	"These results provide further converging evidence that supplementary breaks reliably minimize discomfort and eyestrain without impairing productivity."	Short-term study in temporary workers who may be unaccustomed to work. Compliance rates were low – 25 to 39%.

WORK RESTRICTIONS

Author/Year Study Type Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Ripat 2006 RCT Sponsored by Manitoba Hydro. No mention of COI.	3.0	N = 68 with two or more symptoms of WRUED (Work Related Upper Extremity Disorders). Mean age 42.2 years.	Adapted Group-Microsoft Natural MultiMedia Keyboard adapted to reduce activation force required to depress keys (light touch) (n = 43) vs. Unadapted Group-Standard	No significant differences between two groups for Symptom Severity (SSS) and Functional Status Scales (FSS) between groups (p <0.05). When data from groups combined SSS and FSS-typing measures were significant at both 12 and 24 week (p <0.0001) at both time points.	"Positive results in reduction of symptom severity and improvement in functional status were identified for participants in both keyboard study groups, providing further evidence to support the use of ergonomic keyboards for individuals with WRUED. The vast majority of	Both keyboard groups improved over time, however, there were no differences between groups. Some randomized to experimental group were "forced" to use the LT keyboard.

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			keyboard with no adaptations made. (n = 25) Follow-up for 6 months.		participants were satisfied with their study keyboard."	
Hedge 1999 RCT Sponsored by Honeywell, Inc., Proformix, Inc., Global, Global Contrac and Teknion. No mention of COI.	2.5	N = 38 professional workers who used a computer at work for an average of 5.4 hours per day. Mean age 37.4.	DT Group- DT keyboard tray. User measurements taken to put keyboard at comfortable height (n = 23) vs. Control Group conventional adjustable keyboard with/without padded wrist rest. (n = 15). Measurements immediately following intervention.	No significant differences between pre- and post-test measurements in control group for wrist extension and ulnar deviation (p >0.05). Significant difference between pre- and post-wrist extension in DT group; 17.6 vs. 12.1 (p <0.05). No significant difference for ulnar deviation. (p >0.05). In post-test upper posture index (UPI) there was a significant difference in favor of DT group vs. control for number of subjects reporting UPI <4; 60% vs. 90% (p = 0.044)	"Overall, the wrist movement data, the RULA data and the self-reported musculoskeletal discomfort data all point to improvements within a short time after using the DT system."	Methodological details sparse.

RETURN-TO-WORK PROGRAMS

Author/Year Study Type Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Feuerstein 1993 Non-randomized comparative study	N/A	N = 49	Eligible for multi-component rehab program (n = 34) vs. not eligible (n = 15)	Findings indicated "74% of the treatment group returned to work or were involved in state-supported vocational training in contrast to 40% of the control group (p <0.05)."	"These findings suggest the need to modify treatment components to facilitate an increased return-to-work rate. Areas that may prove useful include a greater emphasis ergonomic modifications at the workplace to reduce the risks of repetitiveness, force, awkward posture, and insufficient work/rest cycles, as well as efforts to modify work	

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					style directly in order to reduce the impact of ergonomic stressors on the ability to perform essential job tasks.	

CARPAL TUNNEL SYNDROME – DIAGNOSTICS
Electrodiagnostic Studies

Author/Year Study Type Conflict of Interest (COI)	Score	Study Design	Population/ Case Definition	Investigative Test	Gold Standard / Comparative Test	Results	Conclusion	Comments
Jackson 1989	3.5	Diagnostic	N =162 divided into groups: Group 1 (n = 38) healthy volunteers. Group 2 (n = 40) with positive clinical testing but negative Electromyography (EMG) and Nerve Conduction Studies. Group 3 (n = 53) clinical confirmed CTS, positive NCS, Negative EMG. Group 4 (n = 30) clinically confirmed CTS, positive NCS and EMG.	Electrodiagnostic studies including Palm median nerve latency (Palm (m). Distal Sensory latency difference between median and radial nerve (DSL (m-r)). Palmar latency difference between median and ulnar nerve (Palm (m-u)). Distal Sensory latency difference (DSL (m-u)). Amplitude of sensory action potential ratios and the 2nd and 5th digit. (Amp).	Screening history as well as physical diagnostic testing was used to ensure the existence of Carpal Tunnel Syndrome, as well as eliminate patients with peripheral neuropathy.	Abnormality percentages of different tests Group 1, 2, 3, 4: Palm (m): 2.6%, 16%, 96%, 94%. DSL (m-r): 0%, 44%, 89%, 100%. DSL (m-u): 5.3%, 44%, 100%, 100%. Palm (m-u) 5.3%, 30%, 98%, 94%. Amp: 0%, 2.3%, 33%, 61%. Group 2 abnormalities using a combination of tests: DSL (m-u) and DSL (m-r): 51%. DSL (m-u) DSL (m-r) and Palm (m-u) 51%.	"Certainly supplemental studies can serve as a discriminating instrument, distinguishing between individuals on a dimension of interest (NCS) when no gold standard is available for validating these measures."	Study suggests use of comparing median and radial distal sensory latencies in digit 1 and coparing median and ulnar distal sensory latencies in digit 4 when CTS referrals have normal nerve conduction studies.

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Zaher 2012	3.0	Diagnostic	N=52 with CTS. Follow-up at 12 weeks.	Electrodiagnostic Studies (n = 20)	MRI (n = 10) vs. Ultrasound (n = 22).	17/20 (85%) had electrodiagnostic findings of prolonged motor and sensory latencies of the median nerve, reduced sensory and motor conduction velocities, and median-ulnar sensory latency difference. 10/10 (100%) underwent MRI showed swelling of media nerve, increased signal intensity, and palmar bowing of transverse carpal ligament. 19/22 (86.3%) with ultrasounds showed enlargement of median nerve at proximal carpal tunnel with increased cross-sectional area over 12 mm2, and palmar bowing and thickening of flexor reticulum.	"Ultrasound is superior to other investigation tools as it provides accurate and rapid diagnosis of CTS with the least cost."	Study enrolled only subjects with mild CTS. Study suggests ultrasound is superior to other diagnostic techniques for mild CTS due to its relatively low cost and raped results MRI and electrodiagnostic studies did have better diagnostic outcomes.

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Homann 1999	3.0	Diagnostic	N = 824 workers recruited from 6 different companies, with a mean job tenure 8.9±9.1	Electrodiagnostic testing of median-Ulnar sensory peak latency difference >0.5 ms, more severe was a difference of >0.8 ms.	Self-administered surveys and hand diagrams. Questionnaire asked about symptom severity, and persistence. Workers indicated pain, numbness, and areas of tingling on hand diagram.	Electrodiagnostic (EDX) positive results (n = 139, 16.9%), Physical Examination (PE) positive (n = 165, 20.1%), Wrist, Hand, and Finger Symptoms (WHF Sx) positive (n = 305, 37.0%). Correlation between PE and EDX (n = 36), between WHF Sx and PE (n = 90), EDX and WHF Sx (n = 55). Between all 3 tests (n = 23).	"The combination of results from electro-diagnostic testing and symptom survey procedures appears to provide the best criterion for defining CTS for epidemiologic investigations in which the intent is to evaluate either the impact of intervention or the exposure-response relationship."	Study reports poor correlation between electrodiagnostic findings, symptom surveys and symptom presentation from physical exams in diagnosing CTS.

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Uncini 1989	2.5	Diagnostic	43 with symptoms and signs of CTS and 33 controls. Group 1: (26 hands) mild abnormalities DPSNL >2.9 msec onset, 3.5 msec peak; group 2: (16 hands) normal or borderline median nerve results D2SNL <2.9 msec, onset or 3.5 msec peak.	Electrodiagnostic studies: median DML, wrist to abductor pollicis brevis (APB); ulnar DML, wrist to abductor dititi minimi (ADM); median sensory nerve latency (SNL) D2 to wrist and D2 to palm; ulnar SNL D5 to wrist; median and ulnar SNL D4 to wrist.	N/A	Both groups had longer median latencies from digit 4 to wrist than digit 2 to wrist. D4 latencies more significant in group 1 (D4 latency onset: 3.7±0.5 and D2: 3.3±0.2) and group 2 (3.0±0.4 and 2.6±0.2) than D2 latencies, suggesting D4 more sensitive than D2-Wr. Significant differences in paired nerves (adjusted for controls) of median D4 SNL - ulnar IV DSL vs. median DML - ulnar DML (group 1: p <0.05 and group 2: p <0.05), and median D4 SNL - ulnar D4 SNL vs. median D2 SNL - ulnar DV SNL (group 1: p <0.05 and group 2: p <0.05). Meant D4 technique most sensitive for disease detection.	"In conclusion, stimulating digit 4 and comparing latencies to median and ulnar nerves is a simple method that is more sensitive than other techniques in detecting CTS. Detection of the double peak potential recorded over the median nerve allows immediate diagnosis of CTS. Even when the double peak is not recognized, a median and ulnar D4 latency difference greater than 0.5 msec suggests CTS."	Study suggests stimulation of digit 4 is useful in identification of CTS. D4 latency is longer in CTS patients compared to other digits.

Ultrasound

Author/Year Study Type Conflict of Interest (COI)	Score	N	Area of Upper Extremity	Diagnoses	Type of Ultrasound	CT used	MRI Used	More than on rater	Blinding of rater	Myelography	Surgery Performed	Clinical outcomes assessed	Long term follow-up (mean when noted)	Results	Conclusion	Comments

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Wiesler 2006 Diagnostic	3.0	N=44 wrists (26 patients), N=86 wrists (43 controls).	Wrist	Patients with symptoms, clinical exam findings, and nerve conduction study findings for CTS. Mean duration of symptoms 12 months (range 1.5-72 months). Mean age 56 years CTS, 36 years controls.	Philips HDI 5000 with 12/5-MHz linear-array transducer	-	-	-	-	-	-	-	-	Pearson correlation coefficient ultrasound vs. nerve conduction study (NCS): 0.37 (p = 0.013). Sensitivity and specificity: cutoff point of 11+ mm^2 = sensitivity 91%, specificity 84%; PPV 74%; NPV 95%.	"[H]igh-resolution ultrasound is informative in the evaluation of CTS and shows enlargement of the median nerve at the distal wrist crease in symptomatic patients."	A 1:2 (CTS vs. normal). Suggests HRUS may be used to diagnose CTS and enlargement of the median nerve at the wrist crease in symptomatic patients is usually predictive for CTS.
Yesildag 2004 Diagnostic	3.0	N=86 (148 wrists), N=45 (76 wrists) controls	Wrist	CTS symptoms. Mean age CTS 49.8±8.7 years, controls 42.7±11.3 years.	12 MHz linear array transducer (ATL 1500 HDI)	-	-	-	-	-	-	-	-	Mean±SD cross-sectional area by tracing method: CTS 14.9±4.7 vs. control 7.8±1.6 (p <0.001). Mean±SD cross-sectional area by ellipsoid formula: CTS 14.2±4.5 vs. control 7.5±1.8 (p <0.001). Cutoff for sensitivity and specificity: 10.5mm^2 for mean cross-sectional area; using tracing method – sensitivity (95% CI) 89.9 (85-94.8), specificity 94.7 (89.7-99.7), PPV 97 (94.3-99.9), NPV 82.7 (74.8-90.6); using indirect method – sensitivity 86.5 (81-92), specificity 93.4 (97.88-99), PPV 96.2 (92.9-99.4), NPV 78.1 (69.5-86.6).	"The ultrasonographic measurement of the median nerve cross-sectional area is a sensitive, specific and useful non-invasive method for the diagnosis of carpal tunnel syndrome."	2:1 matched study suggesting ultrasonographic of median nerve may be useful in CTS initial diagnosis of CTS made via EMG.

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Zaher 2012 Diagnostic	3.0	52	W	CTS	Not described	-	+	-	-	-	+	-	12 weeks	17/20 (85%) had electrodiagnostic findings of prolonged motor and sensory latencies of median nerve, reduced sensory and motor conduction velocities, and median-ulnar sensory latency difference. 10/10 (100%) underwent MRI showed swelling of media nerve, increased signal intensity, and palmar bowing of transverse carpal ligament. 19/22 (86.3%) with ultrasounds showed an enlargement of median nerve at proximal carpal tunnel with increased cross-sectional area over 12 mm2, and palmar bowing and thickening of flexor reticulum.	"Ultrasound is superior to other investigation tools as it provides accurate and rapid diagnosis of CTS with the least cost."	Study enrolled only subjects with mild CTS. Study suggests ultrasound superior to other diagnostic techniques for mild CTS due to its relatively low cost and raped results MRI and electrodiagnostic studies did have better diagnostic outcomes.

Magnetic Resonance Imaging and Diffusion Tensor Imaging

Author/Year Study Type Conflict of Interest (COI)	Score	Number	Area of Upper Extremity	Diagnoses	Type of MRI used	Type of CT used	T1 weighted images	T2 weighted images	X-ray	Myelography	More than one rater	Surgery Performed	Clinical outcomes assessed	Long term follow-up (mean when noted)	Results	Conclusion	Comments

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Guggenberger 2012 Diagnostic	3.5	N = 15 patients and 45 healthy individuals	W	CTS	3.0 T MR imager	-	+	-	-	-	+	-	-	+	Factorial anisotropy or FA decreased and apparent diffusion coefficient or ADC increased when moving from proximal to distal locations, (p <0.001). Significant difference between healthy volunteers and those with CTS, (p <0.001 for both FA and ADC). FA threshold of 0.47 and ADC threshold of 1.054 X 1023 mm^2/sec might be used in diagnosis of CTS.	"Normative diffusion values for MR neurography of the median nerve with DTI depend on the anatomic location and age but not on sex."	1:3 matching of cases to controls suggests significant difference between controls compared to CTS groups for both FA and ADC that may be useful in diagnosing CTS. FA decreased and, AC increased when moving from proximal to distal and with age.
Horng 2012 Diagnostic	3.5	N = 50 with CTS and 45 healthy volunteers.	W	CTS	GE 1.5 T Signa Excite MRI system	-	+	-	-	-	-	-	-	-	4 subjects had abnormal NCS results. Pain scale (VAS) / and DASH questionnaire; CTS Patients and Healthy Volunteers: 59±20 and 7±15, and 26±19/4±5. Grasp strength (kg)/Palmar pinch strength (kg)/Lateral pinch strength (kg)/Monofilament sensory test: 15.7±1.2 vs. 14.8 ±1.1/17.1±7.5 vs 22.9±7.8/ 2.7 ± 1.6 vs 3.8±1.4/4.1±2.3 vs. 5.3 ±1.7/and 29.7±3.5 vs 32.3±3.1.	"The accuracies of MRI and ultrasonography for diagnosing CTS were improved by measuring the bowing of the flexor retinaculum in the grasp position."	Study suggests ultrasonography comparable to MRI in diagnosing CTS only if both rest and grasp position are combined. Sample size small.
Bak 1997 Diagnostic	3.5	20 with suspected CTS	W	CTS	1.5 T Philips ACS-NT superconductive MR unit.	-	+	-	-	-	-	-	-	-	Electrophysiological examination suggested median nerve entrapment in 18 wrists. These then compared to remaining 22 electrophysiologically normal wrists. No significant differences between groups for swelling, flattening, bowing ratio and carpal tunnel index (p >0.05).	"Neither symptoms nor electrophysiological findings in CTS were relat- I ed to specific MR parameters."	Small sample size. Study did not demonstrate a correlation between MR images to electrophysiological changes in CTS. No difference found between CTS group to normal group with respect to swelling ratio, flattening ratio, bowing ratio or carpus tunnel index.

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Deryani 2003 Diagnostic	3.0	N = 55 wrist, of those N = 30 with CTS and N = 25 healthy subjects. The mean age for CTS / healthy subjects: 48.69 ±2.12 / 50.20 ± 8.21.	W	CTS	MRI	-	+	+	-	-	-	-	+	-	Statistically significant differences between median nerve diameters (at psiform bone level: 8.47±1.41 mm; and distal radio ulnar joint level: 4.04 ± 1.06 mm and 2.42 ± 0.95 mm), the diameter rations and flexor retinaculum bulging rations (26.21 ± 5.98% and 7.27 ± 4.53%), ($p < 0.001$). Hyperintensity was fond in 4 of 25 controls and isointensity in 21, ($p < 0.001$).	"[M]RI examination of structural changes that occur in the carpal tunnel, neighboring structures and the median nerve would be useful in the diagnosis of CTS, especially in case with suspected clinical and electrophysiological diagnosis."	Small sample size. Study suggests MRI in tandem with electrophysiological evaluation to make CTS diagnosis.

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Zaher 2012 Diagnostic	3.0	52	W	CTS	MRI (n = 10) vs. ultrasound (n = 22) vs. Electrodiagnostic Studies (n = 20)	-	-	+	-	-	-	+	-	12 weeks	17/20 (85%) had electrodiagnostic findings of prolonged motor and sensory latencies of median nerve, reduced sensory and motor conduction velocities and median-ulnar sensory latency difference. 10/10 (100%) underwent MRI showed swelling of media nerve, increased signal intensity, and palmar bowing of transverse carpal ligament. 19/22 (86.3%) with ultrasounds showed an enlargement of the median nerve at proximal carpal tunnel with an increased cross-sectional area over 12 mm^2, and palmar bowing and thickening of flexor reticulum.	"Ultrasound is superior to other investigation tools as it provides accurate and rapid diagnosis of CTS with the least cost."	Study enrolled only subjects with mild CTS. Study suggests ultrasound superior to other diagnostic techniques for mild CTS due to its relatively low cost and rapid results MRI and electrodiagnostic studies did have better diagnostic outcomes.

CARPAL TUNNEL SYNDROME – TREATMENT

Author/Year Study Type Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Exercise						
Horng 2011 RCT No mention of sponsorship. No COI.	3.5	N = 60 with CTS. Mean age 50.5+9.4 years.	Group 1 received paraffin therapy, a splint, and instructions for tendon gliding exercise (n = 20) vs. Group 2 received paraffin therapy, a splint, and instructions for nerve gliding exercise (n = 20) vs. Group 3 received only paraffin therapy and a splint (n = 20). Follow-up at 2-months.	Difference between before and after treatment: Symptom severity – Group 1: -0.7+0.8; Group 2: -0.3+0.6; Group 3: -0.6+0.6; p = 0.56; Functional status – Group 1: -0.4+0.5; Group 2: 0.1+0.5; Group 3: -0.2+0.7 p = 0.04; Pain scale – Group 1: -19.7+24.6; Group 2: -10.5+18.0; Group 3: -17.2+26.2; p = 0.44	"To improve the functional status and quality-of-life of CTS patients, the combination of tendon gliding exercises, paraffin therapy, and splinting might be more effective than the combination of nerve gliding exercises, paraffin therapy, and splinting."	Baseline comparability differences in functional status scores of the three groups.
Heebner 2008 RCT	2.0	N = 60 diagnosed with CTS by physician. Mean age 52	Group 1 received standard care including education, splinting, and tendon-gliding exercises (n = 28) vs. Group 2	No statistical difference reported between groups. P-values not provided. Compared to baseline, follow-up scores for median nerve	"The results of this study suggest that persons with CTS in a community hospital do not benefit from a one-time nonsurgical	Methodological details sparse.

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No mention of sponsorship or COI.		years. Age range 32-75 years.	received the same standard care along with active neurodynamic mobilization exercises (N = 32). Follow-up at 6 months.	provocation test, DASH, and CTSQ not significantly different (p-vales ranged from 0.308 to .966) in both groups. Values not provided.	intervention that includes splinting instruction and standard tendon-gliding exercises alone or splinting and tendon gliding along with neural mobilization exercises."	
Tal-Akabi 2000 RCT No mention of sponsorship or COI.	2.0	N = 21 with CTS mean duration of 2.3+2.5 years from surgery waiting list. Mean age: 47.1+14.8 years.	Neurodynamic mobilization (ULTT2a) (n = 7) vs. Carpal bone mobilization (n = 7) vs. No treatment (n = 7). Follow-up and intervention length are unclear.	Only the post-intervention Pain Relief Scale (PRS) demonstrated significant difference between the three groups (p<0.01). Mean PRS – Neurodynamic: 3.14; Carpal Bone: 3.71; Control: 0.	"The study has failed to show significant differences in the effectiveness between mobilization of the median nerve and carpal bone mobilization in the treatment of patients presenting with carpal tunnel syndrome."	Small sample size (N=21). Inclusion criteria of ULTT2a was also a treatment arm, potentially providing a fatal study flaw. Methodological details sparse.
Bardak 2009 RCT Sponsored by Sanofi Aventis. No mention of COI.	1.5	N = 111 (111 hands) with CTS. Mean age 49.14+9.6 years.	Group 1 standard conservative treatment (SCT) (n = 41) vs. Group 2 SCT plus tendon and median nerve gliding exercises (n = 35) vs. Group 3 tendon and median nerve gliding exercises (n = 35). Follow-up 2 and 11 months.	Symptom total point change – Group1: -7.4; Group 2: -10.5; Group 3: -2.9. Significant difference between Groups 1 and 3 and Groups 2 and 3 (p<0.001). Functional status scale change – Group 1: -6.7; Group 2: -6.7; Group 3: -3.8. Significant difference between Groups 1 and 3 and Groups 2 and 3 (p <0.001).	"In conclusion, in cases of idiopathic CTS, conservative treatment is clinically effective. Adding tendon and nerve gliding exercises is also beneficial to the management of long-term CTS. Tendon and nerve gliding exercises alone are inferior to other modalities."	Methodological details sparse. Largely female population.
NSAIDs						
Gurcay 2009 RCT No mention of sponsorship or COI.	3.5	N =32 female, housewife patients with clinically and EDS confirmed mild or moderate CTS. Mean age 40.8±11.2 years.	Group A: local injection of 6mg betamethasone through 25-guage needle near distal wrist-flexion crease (n = 18) vs. Group B: meloxicam 15 mg/day, PO, for 3 weeks (n = 14). Both groups advised to wear wrist splints in neutral position at night for 3 weeks. Follow-up at 3 months.	No significant difference found between the groups for Functional Status Scale (FSS) scores, Jebsen Taylor Test (JTT) scores, or electrophysiological findings at 3 months (p>0.05).	"[T]he two treatment methods resulted in some functional gains in hand dexterity and improvement in electrophysiological data, but with neither of the methods demonstrating superiority."	Small sample size in each group. Neither treatment was superior to the other.
Vitamins						
Stransky 1989 RCT	3.5	N = 15 EDS confirmed	200mg of Vitamin B_6 vs. placebo	"Significant changes in nerve conductions and EMGs did not occur when initial and follow-up data were compared. Clinical findings	"Vitamin B_6 seems to have no advantage over conservative therapy for carpal tunnel syndrome."	

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No mention of sponsorship or COI.				did not correlate with electrodiagnostic findings."		
Lidocaine Patches						
Moghtaderi 2009 RCT No mention of sponsorship or COI.	2.5	N = 65 with clinical and electrodiagnostic evidence of CTS. Aged 18-75 years.	Group 1 received ELMA cream (n = 30) vs. Group 2 received one injection of methylprednisolone acetate 40 mg at wrist (n = 35). Follow-up for 4 weeks.	Significant changes reported in pain in both groups, (p <0.001). Treatment-related adverse events (AEs) reported in 2 patients in group 1 (5.7%) and 10 patients in group 2 (28.5%).	"ELMA cream was effective in reducing pain associated with CTS and well tolerated and it may offer patients with CTS an effective, noninvasive symptomatic treatment."	Methodological details sparse.
Jensen 2006 RCT/Parallel-group/Open label Sponsored by grant from Endo Pharmaceuticals, Inc (M.P.J.). M.P.J. and S.R.N. received research support and/or consulting fees. A.R.G., N.O. and B.S.G. hold stock options in Endo Phar.	1.5	N = 40 with CTS. Age 18-75.	Lidocaine patch 5% daily (n = 20) vs. Lidocaine 1% single injection of 0.5mL plus methylprednisolone acetate 40mg at start of study (n = 20). Follow-up for 4 weeks.	Statistically significant decreases in 10 of 20 PQAS pain descriptor ratings occurred with both treatments, (p <0.0025); 8 ratings showed no significant trends for decreasing before treatment to after treatment. No significant differences found between treatment conditions on any of the PQAS items.	"The results support the validity of the PQAS items for assessing the effects of pain treatment on pain qualities of carpal tunnel syndrome."	Methodological details sparse.
Magnets						
Combination Magnetic Field Therapy						
Weintraub 2008 RCT Sponsored by Nikken, Inc. No COI.	3.5	N = 36 at least 18 years of age with CTS. Mean age: 62.3 years.	Combination of simultaneous static and time-varying dynamic magnetic field stimulation (Biaxial Super Mini [Mx^2R]) 4-hours/day (N = 17) vs. Sham device (N = 19). Follow-up at 2 months.	Magnet vs Sham – NPS Total Composite reduction: 42% vs 24% (p = 0.04). VAS reduction: 39% vs 27% (not significantly different). NPS 8 Total Descriptor reduction: 43% vs 24% (p = 0.04). No difference between groups for Nerve Conduction.	"In conclusion, there is little doubt that time-varying PEMF produce neuro-biological effects, and our novel data suggest that this unique physics-based device generating AC and DC magnetic fields simultaneously directed to the carpal tunnel is an attractive nonsurgical approach this is safe, and can achieve statistically significant short-, intermediate-, and long-term pain relief and mild changes in neuromodulation."	Limited study enrollment and small sample size. Dropouts led to uneven participation between groups.
Pulsed Magnetic Field Therapy						

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Arikan 2011 RCT No mention of sponsorship or COI.	3.5	N = 57 hands from 38 patients with idiopathic CTS. Mean age: 48.8 years.	Pulsed Magnetic Field Therapy 30 minutes/day for 3 weeks using BTL-09 device (n = 28 hands/19 patients) vs. Sham therapy same procedure without running device (n = 29 hands/19 patients). Assessment at baseline and end of treatment. Follow-up 1 month post-treatment.	When compared, no significant change was observed between groups for either clinical parameters or electrophysiologic studies (p> 0.05).	"(W)e conclude that magnetic field and placebo magnetic field treatments in the patients with idiopathic carpal tunnel syndrome are effective to both clinical and electrophysiological endpoints in short term, but not superior to each other."	Baseline comparability data suggest randomization failure and possible quasi randomization "every other".
Dakowicz 2011 RCT No mention of sponsorship or COI.	2.5	N = 38 with diagnosed idiopathic CTS confirmed by ENG. Mean age 50.8±10.3 years.	Low-level laser therapy (LLLT) using Ga-As Physioter D-50 for 5 minutes and 33 seconds (N = 18) vs. Pulsed magnetic therapy (PMF) with Magnetronic MF-10 for 15 minutes (N = 20). Two series of 10 sessions, with 2 week break between. Assessment after each series and at 6 months post-treatment.	No between-groups comparisons were made. In both groups, VAS improved after each series and at 6-months post-treatment (p <0.05).	"The presented study demonstrated that a clinical improvement in CTS patients was observed after LLL as well as PMF."	Sparse baseline comparability data. At 6 months, both groups showed comparable (in)efficacy
Splinting						
Bhatia 2000 RCT	3.5	N = 102	Plaster splint vs wool and crepe bandage.	"There were no reported problems with wound breakdown or other symptoms at the 2 week follow-up. Using the Mann-Whitney U test, there were no significant statistical differences in the [pain scores or number of tablets ingested up top 3 days postoperatively between the two groups."	"This prospective randomized study has not supported the use of plaster. We believe that patients undergoing carpal tunnel release should be treated postoperatively with a bulky wool and crepe bandage."	States single blinded, but unclear how blinding was done.
Horng 2011 RCT No mention of sponsorship. No COI.	3.5	N=60 patients with symptoms (pain, numbness within median nerve distribution, nocturnal pain), positive Phalen	Group 1: paraffin therapy (in hospital 2x a week, administered by none-dip method at 55ºC) plus splint (custom made neutral volar wrist splint to be worn at night for at least 8 weeks) plus tendon gliding exercise	Functional status difference before/after treatment (mean±SD): Group 1; -0.4±0.5 vs. Group 2; 0.1±0.5 vs. Group 3; -0.2±0.7 (p = 0.04). NS between groups for symptom severity score (p = 0.56), pain scale (p = 0.44), Disability of the Arm	"To improve the functional status and quality-of-life in CTS patients, the combination of tendon gliding exercises, paraffin therapy, and splinting might be more effective than the combination of nerve	Baseline comparability differences in functional status scores among the 3 groups.

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		sign or positive Tinel sign, and electrophysiology evidence of CTS. Mean age 50.5±9.4 years.	three times daily holding each position for 7 seconds and then repeating the exercises 5 times per session (N=20) vs. Group 2: paraffin therapy plus splint plus nerve gliding exercise (N=20) vs. Group 3: paraffin therapy plus splint (N=20). Follow up 2 months after treatment.	Shoulder, and Hand (DASH) questionnaire (p = 0.29), World Health Organization Quality of Life Questionnaire Brief Version (WHOQOL-BREF) physical domain (p = 0.31), WHOQOL-BREF psychologic domain (p = 0.53), WHOQOL-BREF social domain (p = 0.88), and WHOQOL-BREF environmental domain (p = 0.45).	gliding exercises, paraffin therapy, and splinting."	
Koca 2014 RCT No mention of sponsorship or COI.	3.5	N=75 patients with idiopathic CTS; presence of paresthesia, pain, and/or vasomotor symptoms of hand through distribution of median nerve for longer than 6 weeks; positive Phalen's maneuver and/or Tinel's sign and/or carpal compression test. Mean age Group I – 35.4±4.2 years, Group II – 34.2±5.2, Group III 34.9±4.8 years.	Group I: splint therapy, neutral position wrist splint with aluminum bar at night for 3 weeks (n = 25) vs. Group II: transcutaneous electrical stimulation, TENS on the carpal ligament and palmar area of hand at pulse rate of 100 Hz frequency and stimulation period of 80 ms, 20 minute sessions for 15 total sessions (n = 25) vs. interferential current, IFC therapy at base frequency of 4,000 Hz with a modulation frequency range of 20 Hz, electrodes placed on 1/3 mid portion of volar area of forearm, palmar area of hand, and thenar area of hand, 20 minute sessions for 15 sessions (n = 25). Assessments at baseline and 3 weeks after completion of treatment.	NS between TENS and splint therapy for improvement in clinical scores (p >0.05). VAS (mean±SD) at 6 weeks: IFC 4.80±1.18 vs. splint 6.37±1.18 (p = 0.001); IFC vs. TENS 6.68±1.42 (p <0.001). Median nerve motor distal latency (mMDL) mean±SD at 6 weeks: IFC 3.89±0.88 vs. splint 4.06±0.61 (p = 0.001); IFC vs. TENS 4.06±0.88 (p = 0.003). Median sensory nerve conduction velocity (mSNCV) mean±SD at 6 weeks: IFC 41.80±1.76 vs. splint 40.75±1.48 (p = 0.010); IFC vs. TENS 41.38±1.78 (p = 0.021). Symptom severity (mean±SD) at 6 weeks: IFC 2.70±1.03 vs. TENS 3.37±1.21 (p = 0.015). Functional capacity (mean±SD) at 6 weeks: IFC 1.90±1.21 vs. TENS 2.50±0.78 (p = 0.039).	"[O]ur results indicate the potential for the use of IFC as a new and safe therapeutic option for the management of CTS."	Small group sizes and short follow-up time.
Gurcay 2012 RCT No mention of sponsorship or COI.	3.5	N= 54 female housewives with mild-to-moderate CTS diagnosed with clinical and	Group I: phonophoresis with 0.1% betamethasone applied over carpal tunnel at frequency 1 MHz and intensity 1W/cm^2 for 10	Boston Symptom Severity Scale (BSSS): significant at 3 months, phonophoresis vs. control in favor of phonophoresis (p = 0.012). NS between groups for grip	"[W]e observed no added benefit or increased motor skills or hand dexterity in the groups after treatments."	Sparse baseline data and comparable efficacy.

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		electrophysiological evidence. Mean age 43.7±8.4 years.	minute sessions, 3 days a week for 3 weeks (n = 18) vs. Group II: iontophoresis with 0.1% betamethasone, 2 mA for 10 minutes a day, 3 days a week for 3 weeks (n = 16) vs. Group III: wrist splint only, custom-made volar thermoplastic splint in neutral position worn at night only for 3 weeks (n = 18). Assessments at baseline, 3 months after treatment.	strength (p = 0.280) and 9-hole peg test, NHPT (p = 0.811).		
Sevim 2004 Prospective, randomized, blinded trial	3.0	N = 120 EDX confirmed	Betamethasone injections 4cm proximal to the carpal tunnel vs. injections distal to carpal tunnel vs. just splinting vs. control	"Splinting provided symptomatic relief and improved sensory and motor nerve conduction velocities at the long-term follow-up when the splints were worn almost every night. Proximal and distal injections of steroids were ineffective on the basis of both clinical symptoms and electrophysiologic findings."	Steroid injections may be beneficial short-term in mild and moderate CTS. However, splinting provided long term symptomatic relief and improved sensory and motor nerve conduction.	
Stralka 1998 RCT	3.0	N = 120	Splint vs. Splint with energized high voltage pulse unit	"In the energized group, post-treatment evaluation showed statistically significant decreases in the amount of stimulation required to stimulate the median nerve and the amount of hand edema and pain. The energized group also had improved repetitive task times. None of these improvements occurred in the non-energized group."	"HVPC appears to be an effective method for minimizing the severity of repetitive stress injuries of the wrist."	Methods details sparse. Diagnoses not clear. Study would seem to be blinded; however, that is not described.
Madjdinasab 2008 RCT No mention of sponsorship or COI.	3.0	N = 48 idiopathic CTS patients. Mean age 42.19 years.	Splint group: neutral position splint at night and during the day if possible for 6 weeks (n = 24) vs. steroid group: oral prednisolone 20mg/day for 2 weeks (n = 24). Assessments at	No significant differences between groups for median nerve sensory, motor distal latency, and conduction velocity (p >0.05).	"Both treatment methods (splint and oral steroids) are effective but they don't have any significant difference between two methods after six weeks follow up."	Sparse baseline data, short follow-up. At 6 weeks, comparable efficacy, but duration of treatment is different.

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			baseline and 6 week follow-up.			
Dincer 2009 RCT No mention of sponsorship. No COI.	2.5	N = 60 females with bilateral mild to moderate CTS diagnosis made by electromyography and clinical examination. Mean age: 34 years for Sp, 30 years for SpUS, 36 years for SpLLL group.	Splinting only (Sp), (N= 40) Vs. Splinting + Ultrasound therapy, A total of 10 US treatment sessions were performed once a day, 5x a week for 2 weeks (SpUS), (N= 40) vs. Splinting plus low level laser therapy (SpLLL), (N= 40). Follow up visits: in first month, and third month, after treatment. Patients were instructed to wear the splints at night for 3 mo. Ultasound therapy was administered to each other for 3 min per session, on the area over carpal tunnel at a frequency of 3 MHz and an intensity of 1.0W/ cm2 in continuous mode with a transducer 5 cm2 in size with gel.	After profile analysis (MANOVA), results showed that improvements in SpUS and SpLLL groups statistically significantly better than those seen in Sp group (p = 0.0429 and p = 0.0001). Also, difference between SpUS and SpLLL groups significant (p =0.03). Both SpUS and SpLLL groups had statistically significantly better improvement than Sp group at 3 months (*p* <0.0001 for both groups) On the other hand, no significant differences between SpUS and SpLLL group profiles. VAS pain scores improved in all groups at 1 and 3 month vs. baseline. Both SpUS and SpLLL groups improvements significantly better than Sp group improvement over time (p = 0.0001 for both). SpLLL group showed significantly better improvement than SpUS group.	"In conclusion, the results of this study demonstrate the effectiveness of conservative treatments for mild to moderate CTS. Combining US or LLL therapy with splinting appeared to be more effective than splinting alone in our study. However, the combination of LLL therapy with splinting appeared to be superior to splinting plus US, especially for improvements in symptom severity, pain alleviation, and patient satisfaction. Further research with larger patient samples and longer follow-up periods are required to independently confirm our findings, and to determine the most effective doses and protocols for LLL and US therapies."	Methodological details sparse
Burke 1994 RCT	1.5	N = 59	Splints vs. optimal angle	"The results indicate that the neutral angle provided superior symptom relief, and that the relief did not often improve between 2 weeks and 2 months of wear."	"All splints were custom made volar cock-up style splints constructed of thermoplastic splinting material."	Randomization unclear, study states blinded but that seems unlikely.
Pinar 2005 RCT No mention of sponsorship or COI.	1.5	N = 26 females with NCS positive CTS	Tendon gliding exercises (n = 6) vs. thermoplastic volar splint plus instructions to reduce physical activities for 10 weeks	Grip strength TGE vs. splint plus reduced use (pre/post): 17.8±6.1/22.0±6.8 vs. 20.4±4.7/21.7±4.3 (p <0.05) between groups. Most results negative.	"Significant progress was detected in both control and experimental groups during the posttreatment phase compared with the initial phase (P<0.05). However, when the 2 groups were compared, the experimental group in which nerve gliding exercises were added to conservative therapy	Low sample size. Blinding unclear. Diagnostic criteria unclear, including NCS and 9 other criteria that seem unlikely fulfilled for all. No non-treatment comparison. No between group differences. Conclusion for ultrasound not clearly supported. If bilateral

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					approaches demonstrated more rapid pain reduction; these patients also showed greater functional improvement, especially in grip strength (P<0.05)."	CTS (12/30), both treated the same and double-counted in results, weakening conclusions.
Acupuncture						
Khosrawi 2012 RCT Study funded by research chancellor of Isfahan University of Medical Sciences. No COI.	1.5	N = 72 with mild to moderate CTS confirmed using Tinel's and Phalen's tests and electrophysiological testing; mean age: Acupuncture Group 41.7±9.3; Control Group 41.1±9.6	Acupuncture Group underwent treatment in eight sessions of 60 minute duration over 4 weeks and also night splinting (n = 32) vs. Control group was given vitamins B1, B6 and sham acupuncture. Also had night splinting (n = 32). Follow-Up at baseline 2 weeks and 4 weeks.	Global Symptom Score (GSS) acupuncture group vs. control group at Week 4: 14.6±5.4 (p <0.001) vs 22.5±8.9 (p = 0.17). Nerve Conduction Velocity at 4 weeks, Acupuncture vs control: 37.6±8.3 vs 33.2±5.9 (p <0.02)	"Our findings indicated that the acupuncture can improve the overall subjective symptoms of carpal tunnel syndrome and could be adopted in comprehensive care programs of these patients."	Methodological details sparse.
Ho 2014 RCT Study supported by the grant of the National Science Council, Chine Medical University Hospital, and Taiwan Department of Health Clinical Trial and Research Center of Excellence.	1.5	N = 26 confirmed CTS via electrodiagnostic testing; mean age Acu Group: 49.5±9.7; Electro-Acu Group: 50.1±10.1	Acupuncture Group Given 24 sessions of 15 minute duration over 6 weeks (n = 15) vs. Electro-Acupuncture Group given same acupuncture points and sessions along with duration however stainless steel needle negative charged inserted in middle of wrist while positive was inserted in forearm. Follow-up at baseline, 2 weeks after treatment session and electrodiagnostic testing done 4 weeks after treatment.	Symptom severity scores baseline vs. 2 week follow-up. Electroacupuncture decreased significantly (p <0.02). Distal Motor Amplitude acupuncture group, baseline to 4 weeks after treatment. 6.49±2.70 to 7.62±2.87 (p = 0.02), Electro-Acu no significant increase. Shortened median sensory latency, baseline-4 week follow-up. Acu 3.70±1.15 to 3.22±1.02 (p = 0.04) vs electro-Acu not statistically significant. Median Nerve F wave mean latency, baseline to 4 weeks. Acu group 29.11±3.38 to 28.27±3.76 (p = 0.002) vs. electro-Acu no significant difference. Grip strength baseline to 4 weeks post treatment, Acu 23.3±9.85 to 27.88±12.44 (p = 0.01) vs alectro-Acu no significant difference.	"Despite the limitations in this study, we found that safety depth acupuncture and electroacupuncture could exert different positive therapeutic effects for patients with CTS. As evidenced by the improvement of Symptomology using electroacupuncture and improvements of grip strength, electrophysiological findings, and physical provocation sign of using acupuncture, the findings of this study provide references in clinical decision making when selecting proper treatment programs for symptomatic CTS patients."	Methodological details sparse.

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Cai 2009 RCT No Mention of COI or sponsorship.	0.5	N = 98 cases of CTS all history of strain or traumatic injury of wrist joint. Mean age: Warm Needling Group Range 32-67 years; Control Group 35-71 Years old	Acupuncture group: warm needling tachniques and Tuina relaxing manipulations. 10 30 minute sessions (n = 60) vs. Control Group Given block therapy with 10mg Triamcinolone A and lidocaine once every 3-5 days, Dibazol and Vitamin B1 were taken orally 3 times daily until trial over. (n = 38). Follow-up only mentioned only after 1 course of treatment. (no specific time frame)	Clinically cured (clinical symptoms disappeared, movement restored, negative in Carpal canal irritating test. Acu group 49 (81.67%) vs control 18 (47.37% (p<0.01).	"Acupuncture plus Tuina manipulation is a simple therapy for carpal tunnel syndrome, but with remarkable therapeutic effects."	Methodological details sparse.
Low-level Laser Therapy						
Stasinopoulos 2005 RCT No mention of sponsorship or COI.	3.0	N = 25 with unilateral idiopathic carpal tunnel syndrome, mild to moderate nocturnal pain, and paraesthesia lasting >3 months. The mean age was 47.4 years.	Polarized polychromatic noncoherent light or Bioptron light administered perpendicular to carpal tunnel area for 6 minutes at operating distance 5-10cm from carpal tunnel area, 3x weekly for 4 and 6 weeks (n = 25). Outcome measures used were participants' global assessments of nocturnal pain and paraesthesia, respectively, at 4 weeks and 6 months. Follow-up at 4 weeks, and 6 months.	At 4 weeks, 2 (8%) had no change in nocturnal pain, 6 (24%) were in slightly less nocturnal pain, 12 (48%) were much better in regard to nocturnal pain and 5 (20%) were pain-free. At 6 months, 3 patients (12%) were slightly better in regard to nocturnal pain, 13 (52%) were much better regarding nocturnal pain, and 9 patients (36%) were pain-free.	"Nocturnal pain and paraesthesia associated with idiopathic carpal tunnel syndrome improved during polarized polychromatic noncoherent light (Bioptron light) treatment."	Open trial with sparse methodological details. Small sample size and no placebo group.
Manipulation and Mobilization						
Pratelli 2015 RCT No mention of sponsorship or COI.	2.5	N = 70 symptomatic hands clinically diagnosed and electromyographically proven CTS. Mean age 54.2 (38-74)	Group 1 (n = 35) treated with Fascial manipulation (FM) 45 minute session 3x a week for 3 weeks vs. Group 2 (n = 35) Low Level Laser Therapy 5x a day for 10 minute sessions. Follow-up 10 days before treatment,	BTCQ symptomatic and functional and Visual Analogue Scale scores baseline – first follow up, group 1: 3.027, 3.097, and 6.00 vs 1.362, 1.40, 0.80 (p <0.0001). Baseline vs second follow up 3.027, 3.097, and 6.00 vs 1.27, 1.31, 0.714 (p <0.0001). Group 2 BTCQ	"FM appears to be an appropriate treatment not only for musculoskeletal dysfunction but also for common nerve entrapments as in carpal tunnel syndrome. The method is effective and non-invasive. It gives excellent results for the	Methodological details sparse.

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			and 1 week and 3 months after treatment.	symptomatic and functional as well as Visual Analogue Scale baseline vs follow up 1: 3.52, 2.90, 5.51 vs 2.66, 2.58, 5.00 (p <0.001). Worsening of symptoms in group 2 from follow up 1 to 2.	relief of local symptoms and for restoring functionality with benefits that remain at three month follow up.	
Heebner 2008 RCT No mention of sponsorship or COI.	2.0	N = 61 with CTS confirmed using Nerve Conduction Velocity testing; mean age 52 (32-75)	Group 1 (n = 28) standard care provided by hospital (night splinting, tendon gliding exercises) vs. Group 2 (n = 32) same as group 1 but addition of neurodynamic mobilization exercise median nerve bias. Follow-up baseline, 1 and 6 months after initial treatment.	No statistical significance between the Disabilities of the Arm Shoulder and Hand scores and CTSW symptom severity scale (SSS). CTSQ functional scale (FSS) group 1 vs group 2, 2.2 vs 2.9 (p=0.016).	"The results of this study suggest that persons with CTS in a community hospital do not benefit from a one-time nonsurgical intervention that includes splinting instruction and standard tendon-gliding exercises alone or splinting and tendon gliding along with neural mobilization exercises."	Methodological details sparse. High dropout rate.
Bialosky 2011 RCT Study supported by grant from National Institutes of Health National Center for Complementary and Alternative Medicine.	1.5	N = 40 females; mean age for individuals with CTS: 40.75±10.38, 38.25 ± 12.32 for healthy individuals.	Group 1(n = 20) with clinically diagnosed CTS (Tinnel's, Phalen's, Carpal Compression Tests) vs. Group 2 (n = 20) age matched and no sign of CTS. Follow-up 2x a week for 3 weeks.	No statistically significant change in outcome measures associated with Neurodynamic Intervention. Baseline relationship between clinical pain and pain sensitivity w/ signs and symptoms of CTS: MP flexor retinaculum after sensation 0.88 (p <0.01). Change in usual pain over 3 weeks in MP flexor retinaculum after temporal summation -0.57 (p = 0.05) and after sensation -0.55 (p = 0.01).	"Participants with signs and symptoms of CTS differed from healthy age- and sex-matched controls in suprathreshold measures of pain sensitivity suggesting a central mechanism of pain. Immediate change in mechanical pain sensitivity and after sensation and 3-week change in temporal summation were associated with improvements in clinical pain intensity suggesting prognostic factors and a potential mechanism for improvement respectively"	Included both healthy subjects and those with CTS. Methods poorly described. Few meaningful results.
Massage						
Moraska 2008 RCT Sponsored by Massage Therapy Foundation	3.5	N = 27 with CTS for at least 6 months.	General massage (GM, n = 13) focused on reducing muscular tension and enhancing circulation to back, neck, and both upper extremities v. targeted massage (TM, n = 14)	Grip strength: TM showed significantly greater strength increase compared to GM, p=0.04.; improvement for TM first seen after 7th massage and maintained following 11th massage and for at least4	"The results from this study suggest that massage therapy may be a useful part of a conservative care treatment regimen, although additional research support is needed."	No meaningful differences between treatment groups. Small sample size (N=27).

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(Evanston, IL) No mention of COI.			aimed at probable sites of nerve entrapment along afflicted upper extremity. 12 30 minute structured massage treatments over 6 weeks.	weeks after last treatment, p<0.01 for all time points.		
Moraska 2010 RCT	3.5	Same as Moraska 2008	Same as above (Moraska 2008)	Same as above (Moraska 2008)	Same as above (Moraska 2008)	Same population as pilot report of Moraska 2008.
Therapeutic Touch						
Blankfield 2001 RCT Sponsored by grant from Ohio Academy of Family Physicians and General Clinical Research Center grant from NIH. No mention of COI.	1.5	N = 21 with electro diagnostically confirmed CTS. Mean age 57.4 for therapeutic touch treatment group, 55.2 for sham treatment.	Therapeutic touch (TT) group (n = 11) vs. sham (n = 10), 1x a week for 6 weeks. Follow-up period not mentioned.	Mean motor distal latencies (baseline/follow-up): TT (5.4±0.9/5.2±1.1ms) vs. sham (6.1±1.8/5.9±1.0msec), p >0.15. Pain/ relaxation scores NS.	"[T]T was no better than placebo in influencing median motor nerve distal latencies, pain scores, and relaxation scores."	Suggests lack of benefit. Small sample size. Methodological details sparse. Data concerning for possible randomization failure.
Ultrasound						
Ultrasound vs. Placebo						
Armagan 2014 RCT No mention of sponsorship. No COI.	3.5	N = 46 with CTS. Mean age: group 1: 45.20 years, group 2: 43.31 years; group 3: 44.53 years.	First group received 0 W/cm2 ultrasound treatment (placebo) (n = 15) Vs. second received 1.0W/cm2 continuous ultrasound treatment (n = 16) Vs. third received 1.0 W/cm2 1:4 pulsed ultrasound treatment (n = 15). Administered for 5 days a week for a total of 15 sessions. All patients also wore night splints during treatment period. Follow up: not mentioned.	Significant improvements in all groups as per post-treatment Functional Status Scale score (p <0.05 all groups), Symptom Severity Scale score (first group: p <0.05, second group: p <0.01, third group: p <0.001) and Visual Analogue Scale score (first and third groups: P<0.01, second group: p <0.001). Sensory conduction velocities improved in 2nd and 3rd groups (p <0.01). Distal latency in 2nd finger showed improvement only in 3rd group (p <0.01) and action potential latency in palm improved only in 2nd group (p <0.05)	"The results of this study suggest that splinting therapy combined with placebo and pulsed or continuous ultrasound have similar effects on clinical improvement. Patients treated with continuous and pulsed ultrasound showed electrophysiological improvement; however, the results were not superior to those of the placebo."	Methodological details sparse. No differences seen between groups.
Oztas 1998 RCT No mention of sponsorship. No COI.	2.5	N = 18 females with CTS in 30 hands. Mean age: Group A: 53.2 years; Group B: 51.3	Group A: continuous ultrasound therapy with intensity of 1.5 W/cm2 (n = 10) Vs. Group B: US therapy with intensity of 0.8 w/cm2 (n = 10) Vs. Group C: US therapy	Night pain/paresthesia before treatment/after treatment: Group A: 2.30±.68/1.40±.52; Group B: 260±.70/ 1.70±.82; Group C: 2.60±.69/1.40±.97. Mean distal latency: Group A: 5.85±1.87/6.00± 1.95; Group B:	"Ultrasound therapy in CTS was comparable to placebo ultrasound in providing symptomatic relief, and the probability of a negative effect on motor	Single blind (patient). Suggests ultrasound not effective. Small sample size of 18 women. Methodological details sparse.

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		years; Group C: 49.0 years.	with intensity of 0.0 W/cm2 (n = 10). 5 minutes, 5 days a week for 2 weeks.	5.90±1.29/ 6.10±1.46; Group C: 5.60±1.61/5.36±1.48.	nerve conduction needs to be considered."	
Ultrasound vs. Other Treatments or in Combination(s)						
Duymaz 2012 RCT No sponsorship or COI.	3.5	N = 58 unemployed with CTS confirmed by provocation tests and EMG and symptoms of numbness, tingling, weakness, and pain in hands for at least 3 months but not more than 1 year. Mean age 51.85±7.29 years.	Group I: iontophoresis with dexamethasone 0.4% at a current 2 mA for 20 minutes (n = 20) vs. Group S: iontophoresis sham using water at current 2 mA for 20 minutes (n = 18) vs. Group U: underwater ultrasound 5 minutes per session using direct current at an intensity of 0.8 W/cm^2, 3 applications once a day 5x a week for 3 weeks (n = 20). All received: training on performing tendon and nerve gliding exercises to be completed for 3 sets of 10 everyday; ergonomic training for daily living activities; and neutral wrist splinting at night. Follow-up after 3 months.	Mean±SD VAS on movement difference between pre and post treatment values Group I vs. Group S vs. Group U: 2.75±1.71 vs. 0.66±1.13 vs. 1.30±1.83 (p<0.001). Mean±SD VAS at rest difference between pre and post treatment values Group I vs. Group S vs. Group U: 2.55±1.76 vs. 0.50±0.78 vs. 1.20±1.73 (p <0.001).	"Our study results suggest that dexamethasone iontophoresis administration combined with tendon gliding exercises, splint and activity modification is reliable and effective in the treatment of patients with mild CTS."	Only differences observed are for VAS 2 point discrimination test and monofilament test.
Dincer 2009 RCT No mention of sponsorship. No COI.	2.5	N = 60 females with bilateral mild to moderate CTS diagnosis made by electromyography and clinical examination. Mean age 34 years for Sp, 30 years for SpUS, 36 years for SpLLL group.	Splinting only (Sp), (n = 40) vs. splinting + Ultrasound therapy, Total 10 US treatment sessions performed once a day, 5x a week, for 2 weeks (SpUS), (n = 40) vs. Splinting plus low level laser therapy (SpLLL), (n = 40) Follow up: 1st and 3rd month after treatment. Patients to wear splints at night for 3 months. Ultasound therapy administered to each other for 3 minutes per session on area over	After profile analysis (MANOVA), results showed improvements in SpUS and SpLLL groups were statistically significantly better than those in Sp group (p = 0.0429 and p = 0.0001, respectively). Also, difference between SpUS and SpLLL groups significant (p = 0.03). Both SpUS and SpLLL groups had statistically significantly better improvement than Sp group at 3 months (p = <0.0001 for both groups) On other hand, no significant differences between SpUS	"In conclusion, the results of this study demonstrate the effectiveness of conservative treatments for mild to moderate CTS. Combining US or LLL therapy with splinting appeared to be more effective than splinting alone in our study. However, the combination of LLL therapy with splinting appeared to be superior to splinting plus US, especially for improvements in symptom severity, pain alleviation,	Methodological details sparse.

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			carpal tunnel at 3 MHz and intensity of 1.0W/ cm2 in continuous mode with transducer 5 cm2 in size with gel.	and SpLLL group profiles. VAS pain scores improved in all groups at 1 and 3 month compared to baseline. Both SpUS and SpLLL groups' improvements significantly better than Sp group's improvement over time (p = 0.0001 for both). Also, SpLLL group showed significantly better improvement than did SpUS group.	and patient satisfaction. Further research with larger patient samples and longer follow-up periods are required to independently confirm our findings, and to determine the most effective doses and protocols for LLL and US therapies."	
Iontophoresis/Phonophoresis						
Aygul 2005 RCT	3.5	N = 31 (56 hands)	Local steroid injection 1ml dexamethasone sodium phosphate vs. iontophoresis treatment with 1-4mA galvanic current and mixture of 0.1% dexamethasone sodium phosphate vs. phonophoresis frequency of 3 MHz and intensity of 1.0 W/cm2, with transducer of 5cm2, including mixture of 0.1% dexamethasone sodium phosphate	Injection group had a steady significant improvement for all parameters except SNAPa, mTLI, and mMNCV at the first follow-up visit. Iontophoresis had significant improvements in the D4M-D4U and mTLI. Phonophoresis group had significant improvement of D4D-D4U and mMDL found 2 months after treatment.	"Steroid injection in CTS is more effective than iontophoresis and phonophoresis treatment in the short- to medium-term in patients with mild to moderate idiopathic CTS, and that the most sensitive neurophysiologic parameters at follow-up were D4D-D4U and D2M-D5U, which are objective parameters indicating the outcome of CTS treatment."	Random in abstract, but nowhere in methods.
Gurcay 2012 RCT No mention of sponsorship or COI.	3.5	N = 52 with CTS analyzed based on clinical and electrophysiological criteria. Mean age 43.7±8.4 (range 24-57) years.	Group I, phonophoresis, 0.1% betamethasone applied over area of CT at frequency of 1 MHz and an intensity of 1 W/cm2, plus wrist splint (n = 18) vs. Group II, 0.1% betamethasone iontophoresis from positive electrode at dosage of 2 mA for 10 minutes/day, plus wrist splint (n = 18) vs. Group III or control, instructed to use wrist splint alone (n = 18). Follow-up at 3 months.	At 3 months (T1), Boston Symptom Severity Scale (BSSS) improved in group I (p < 0.001), group II (p = 0.001), and group III (p < 0.001) compared to baseline (T0). Grip strength, and nine-hole peg test (NHPT) in all groups; I, II and III at 3 month vs baseline improved, (p > 0.05). A significant difference between groups for BSSS, F = 4.599, (p = 0.015). No statistical difference between groups for grip strength at T0 and T1, X2 = 2.546, (p = 0.280).	"Symptom severity improved in all groups after treatment, but no superiority was determined among the treatment groups with respect to motor skills and hand dexterity."	Sparse baseline data and comparable efficacy.
Carpal Tunnel Injections						
Aygul 2005	3.5	N = 31 (56 hands)	Local steroid injection 1ml dexamethasone	Injection group had a steady significant improvement for all	"Steroid injection in CTS is more effective than	Random in abstract, but nowhere in methods.

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RCT			sodium phosphate vs iontophoresis treatment with 1-4 mA galvanic current and mixture 0.1% dexamethasone sodium phosphate vs Phonophoresis frequency 3 MHz and an intensity 1.0 W/cm2, with transducer of 5 cm2, including mixture of 0.1% dexamethasone sodium phosphate	parameters except SNAPa, mTLI, and mMNCV at the first follow-up visit. Iontophoresis had significant improvements in the D4M-D4U and mTLI. Phonophoresis group had significant improvement of D4D-D4U and mMDL found 2 months after treatment.	iontophoresis and phonophoresis treatment in the short- to medium-term in patients with mild to moderate idiopathic CTS, and that the most sensitive neurophysiologic parameters at follow-up were D4D-D4U and D2M-D5U, which are objective parameters indicating the outcome of CTS treatment."	
Gurcay 2012 RCT No mention of sponsorship or COI.	3.5	N = 52 with CTS analyzed based on clinical and electrophysiological criteria. Mean age 43.7 ± 8.4 (range 24–57) years.	Group I, phonophoresis, 0.1% betamethasone applied over CT at frequency 1 MHz and intensity 1 W/cm2, plus wrist splint (n = 18) vs. Group II, 0.1% betamethasone iontophoresis from positive electrode at 2 mA for 10 minutes/day, plus wrist splint (n = 18) vs. Group III or control, instructed to use wrist splint alone (n = 18). Follow-up at 3 months.	At 3 months (T1), Boston Symptom Severity Scale (BSSS) improved in group I (p <0.001), group II (p = 0.001), group III (p <0.001) vs. baseline (T0). Grip strength, and 9-hole peg test (NHPT) in groups; I, II and III at 3 month vs. baseline improved (p >0.05). Significant difference between groups for BSSS, F = 4.599, (p = 0.015). No statistical difference between groups for grip strength at T0 and T1, X2 = 2.546, (p = 0.280).	"Symptom severity improved in all groups after treatment, but no superiority was determined among the treatment groups with respect to motor skills and hand dexterity."	Sparse baseline data and comparable efficacy.
Seok 2013 RCT No mention of sponsorship. No COI.	3.5	N = 36 with CTS with positive Tinel sign or Phalen test, and numbness and tingling at least two of first, second and third digit. At least 19 years of age.	Extracorporeal shock wave therapy or ESWT group one session with 1000 shocks at a frequency of 360 shocks per minute (n = 15) vs. Local corticosteroid or CS injection group received 1 milliliter of triamcinolone acetonide 40mg (n = 16). Follow-up at 3 months.	VAS score of 7.06±1.89 in ESWT group vs 6.87±1.26 in CS injection group. VAS score improvement at 1 month/3 months; 4.56±0.81 in ESWT vs 4.13±1.50 CS group/4.18±1.05 vs 3.31±1.82. Symptom severity score at 1 month; 20.13±6.24, (p <0.05) and at 3 months; 19.73± 4.48 vs 18.25±3.71 CS group, (p <0.05). Significant difference between ESWT and CS groups found only at median sensory distal latency 1 months after treatment.	"ESWT can be as useful as CS injection for relieving symptoms of carpal tunnel syndrome."	Methodological details sparse. Subjective improvements in both treatments but no differences between groups.

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Sevim 2004 Prospective randomized and blinded trials	3.0	N = 120 EDX confirmed	Betamethasone injections 4cm proximal to carpal tunnel vs. injections distal to carpal tunnel vs. just splinting vs control	"Splinting provided symptomatic relief and improved sensory and motor nerve conduction velocities at the long-term follow-up when the splints were worn almost every night. Proximal and distal injections of steroids were ineffective on the basis of both clinical symptoms and electrophysiologic findings."	Steroid injections may be beneficial short-term in mild and moderate CTS. However, splinting provided long term symptomatic relief and improved sensory and motor nerve conduction.	
Kamanli 2011 RCT No mention of sponsorship or COI.	2.5	N = 19 with bilateral CTS. Mean age for groups PIG and DIG: 42±10 and 52±13.	Proximal approach steroid injection group (PIG), with triamcinolone aestonide 20 mg (n = 10) vs. Distal approach steroid injection group (DIG), with triamcinolone aestonide 20mg (n = 9). Follow-up for 3 months.	BCTS / VAS-pain (0-10) / and HAQ at baseline and 3 months: 66.7 ± 12 and 31.6 ± 8.2 at 3 months vs 51.7 ± 14.7 and 34.9 ± 16 in DIG group/8.5 ±1.1 and 3.3 ± 2 vs 8.3 ± 1.7 and 3.9 ± 22 / and 0.97 ± 0.38 and 0.43 ± 0.22 vs 0.63 ± 0.53 and 0.29 ± 0.14.	"[S]teroid injection from distal approach (palmar) into the carpal tunnel on patients with CTS is very comfortable, easy, effective and alterative."	Small sample size, all bilateral CTS patients. Conflicting information on splinting: "All patients used hand-wrist splint during 3 weeks after injection" and "Co-interventions such as splinting were withheld for the duration of the study"
Stepić 2008 RCT No mention of sponsorship or COI.	1.5	N = 40 with CTS. The mean age of 51.6 years.	Group 1: surgical decompression of median nerve by open release of carpal tunnel (n = 20) vs. Group 1: perineural injection 1ml betamethason immediately after surgical decompression (n = 20). Follow-up 7, 30, and 90 days.	90 days after surgical procedure, both groups showed statistically significant better results in second group (t = -2.116; p = 0.043). Final measurements did not show statistically important difference between treatment methods applied, SCS1 = 45.347 msec in first group vs SCS2 = 47.673 msec in second group.	"Intraoperative application of the corticosteroid injection during the surgical decompression results in faster regaining of conduction speed of the median nerve."	Methodological details sparse.
Surgery						
Worseg 1996 Two consecutive case series	4.0	N = 126 EDS confirmed	64 surgeries treated endoscopically vs. 62 surgeries by open release of carpal ligament.	"No significant differences between the groups were obtained regarding postoperative symptom severity."	"The new device provides a reliable tool for single portal carpal tunnel release, although the risk of inadvertent damage to the neurovascular structures always remains a possibility with the endoscopic carpal tunnel technique."	Labeled as prospective clinical study. Not an RCT. Two consecutive case series compared.

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Demirci 2002 RCT	4.0	N = 90 EDS confirmed	Intracarpal betamethasone 6.4mg injections at Weeks 0 and 2 vs. open CTR	Boston questionnaire symptoms scale (0/3/6 months): open (3.4±0.7/1.3±0.3/1.3±0.3) vs. steroid (3.3±0.7/ 1.5±0.5/1.7±0.8), NS months 0-3 and p = 0.003 at 6 months.	Conservative steroid treatment provides short term improvement compared to surgery. It is relatively easy to apply, has a lower cost and comparable results short term and may be considered before surgery is done.	Study does not describe a randomization process. Thus, although scored low-moderate quality, study is classed as low quality. Data suggest symptoms reduced with both treatments at 6 months, but modestly favor CTR at that point.
Nitz 1989 RCT	3.5	N = 60	Open surgery vs. surgery with tourniquet	"Three weeks after the operation 77% of the patients in the tourniquet group had denervation in other than thenar muscles. Only one patient in the control (no tourniquet) group had similar electromyographic abnormalities after surgery. Tourniquet time and pressure did not vary significantly between those patients with or without postoperative forearm denervation. Mean operative time for the tourniquet and control groups was nearly identical."	"These findings indicate that upper extremity tourniquet application results in subclinical, temporary changes in the muscles of the forearm, probably on the basis of nerve changes and denervation."	
Brüser 1999 RCT	3.5	N = 80 with CTS	Short (2.5cm) vs. long (4.5cm) incision	Baseline differences including longer symptoms in short incision group (48.1 vs. 33.8 months).	"The long incision resulted in a significant 10% loss of strength only at week three, otherwise no significant difference was found between the results of the two groups."	Some patients apparently had neurolysis and some epineurolysis, which was unstructured.
Mackenzie 2000 RCT	3.5	N = 26	Open surgery vs. endoscopic methods	Grip strengths (baseline/weeks 1/2/4): endoscopic (43/29/42/44) vs. open (39/21/29/30) (p <0.01 at 2 and 4 weeks).	"Endoscopic carpal tunnel release provides faster recovery of strength than short-incision open carpal tunnel release and improves early postoperative comfort and function to a small degree."	
Borisch 2003 RCT	3.5	N = 273 EDS confirmed	Open CTR with vs. without epineurotomy.	Paraesthesias present in 93% of epineurotomy group at baseline; declined to 17% at 3 months vs. controls' 89% which declined to 8%. EDX changes not significant.	"Study showed no significant difference in the recovery of sensory conduction velocity and distal motor latency after open decompression of the	Dropout rates were high.

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					median nerve or open decompression combined with epineurotomy. Thus epineurotomy does not appear to have any effect on neurophysiological median nerve recovery after open carpal tunnel decompression."	
Finsen 1999 RCT No mention of sponsorship or COI.	3.5	N = 74 (82 wrists) on whom open carpal tunnel release performed. Mean age 48 in mobilized group; 51 in immobilized group.	Mobilized Group: light dressing and told to move wrist and fingers as comfort allowed. (n = 45) vs. Immobilized Group: well-padded plaster of Paris splint with wrist in slight dorsiflexion. (n = 37). Follow-up at 2 and 6 weeks, and 6 months.	Post-op VAS pain scores indicated patients in both groups benefited from post-op treatments. But no significant differences in mean VAS pain score at any time point for mobilized vs. immobilized; Pre-op 56mm vs. 51mm; 2 weeks 6mm vs. 5mm; 6 weeks 6mm vs. 2mm; 6 months 3mm vs. 2mm.	"Thus immobilization confers no advantage with regard to regress of the original complaints postoperatively. Nor did immobilization reduce the frequency of common complications, such as scar or pillar pain."	No advantage to splinting after carpal tunnel release surgery.
Hansen 2009 RCT No mention of sponsorship or COI.	3.5	N= 47 (54 hands) diagnosed with idiopathic CTS who required release of carpal tunnel. Mean age 48 years.	Novafil Group-Interrupted non-absorbable sutures. 5/0 monofilament polybutester (n = 26 hands) vs. Caprosyn Group-Continuous absorbable subcuticular 4/0 monofilament polyglytone sutures. (n = 28 hands). Follow-up assessed daily in patient's journal until sutures removed 10-14 days after surgery. Pain monitored through this period. Cosmetic appearance measured at 3 months.	VAS pain score significantly lower in Caprosyn group vs. Novafil group at post-op day 1 (p = 0.04) and post-op day 2 (p = 0.02). However, difference in VAS pain score not significant at any other time point. Caprosyn group showed better cosmetic result with 25/28 hands showing nice appearance when being evaluated by surgeon vs. 18/26 in Novafil group. However, this difference not significant (p = 0.14).	"There was a significant reduction in pain scores on days 1 and 2 in the patients treated with an absorbable continuous subcuticular suture, and no difference in inflammation or infection. There was no difference in the cosmetic appearance between the two groups after three months."	Sparse methodological details. At 3 months, comparable results.
Cellocco 2005 RCT No sponsorship or COI.	3.5	N = 185 affected by mild to moderate median nerve compression. 222 carpal tunnel release procedures	Group A: Mini-open blind technique using Knifelight (n = 82, 99 procedures) Vs. Group B- limited open technique (n = 103, 123 procedures). Follow-up at 19 and 30 months following surgery.	Group A returned to work significantly quicker in mean days than group B; 16.6 days vs. 25.4 days (p <0.001). Mean score for first section of Boston Carpal Tunnel Questionnaire (BCTi) significant at 19 months for group A vs. B; 1.46 vs. 2.04	"Our study suggests that the mini-open blind CT release can be a safe procedure, even when performed using a small transverse wrist incision."	Short follow up period (19 months) favored transverse procedure, but at 30 months the differences between groups decreased. Group A experienced shorter recovery rate and less pain & numbness.

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		performed on 185. Mean age 59 years.		(p <0.001). Second section scores BCTi also significant at 19 months; 2.02 vs. 2.53 (p <0.001). No significant differences between groups at 30 month follow-up.		
Heidarian 2013 RCT No sponsorship or COI.	3.5	N = 59 with indication for carpal tunnel release. Mean age 47.6 years.	Open Group: Open carpal tunnel release surgery (n = 30) vs. Knifelight Group: (n = 29). Follow-up immediately after surgery and 3 weeks and 6 months.	Knifelight group vs. open group showed significantly shorter operation time; 8.5 min vs. 21 min (p <0.001), significantly shorter mean scar length (mm); 14.8mm vs. 40.7mm (p <0.001). Knifelight also significantly quicker return to daily activity vs. Open; 34.4 days vs. 51.9 days (p = 0.015). VAS pain score at 3 weeks not significant between groups (p = 0.24).	"In conclusion according to the results of this study, compared to the open release method, Knifelight technique could significantly decrease the mean duration of surgery, incision length and time to return to work."	Sparse methodological details. Short follow-up time (3 weeks). Knifelight "appears" to decrease surgical time, scar length and time to resume normal activities, but pain ratings for both groups were comparable.
Ucar 2012 RCT No mention of sponsorship or COI.	3.0	N = 90 with CTS syndrome. Mean age 46.75 years.	G1 Group- Distal approach. A 2 cm vertical incision on the ulnar side of the thenar crease beginning at the distal wrist crease. (n = 45) Vs. G2 Group- Proximal approach. A 2 cm vertical incision made on the ulnar side of the palmaris longus tendon, beginning proximal to wrist crease. (n = 45) Follow-up at one month. Final follow up mean 30.4 months in G1 and 31.0 months in G2.	Boston Carpal Tunnel questionnaire scores used for assessment. Both groups increased significantly in Symptom and Functional scales from baseline from pre-op to 1 month follow up (p <0.001) and from 1 month follow-up to final follow-up (p <0.001). Functional and Symptom scores not significant between groups at any follow-up period (p >0.05). G2 showed significantly shorter mean operation time vs. G1; 10.7 min vs. 18.6 min (p <0.001). G2 also significantly less scar tissue pain vs. G1; 6.7% vs. 24.4% (p = 0.02).	"Finally, the absence of relapse and good clinical results make both surgical techniques used in this study suitable. For this reason, we consider that the selection of the mini-surgical technique used should depend on the experience and skill of the surgeon."	Sparse methodology and short follow-up time (1 month). Mean surgical time and scar tissue pain were less in group 2 (the 2 cm proximal incision group).
Kang 2008 RCT No sponsorship or COI.	3.0	N = 72 with diagnosed CTS. Mean age 34.8 years.	Arthroscopic Excision Group- 2 stab incisions at standard 3-4 and 4-5 portal sites (n = 41) vs. Open Excision Group- Transverse skin incision 2 to 3cm in length (n = 31). First follow-up 5-7	Main outcome ganglion recurrence. At 2nd follow-up, arthroscopic group 1 ganglion recurrence vs. 0 in open group (p = 0.381). Not significant at final follow up. One post-op complication in arthroscopic group vs. open	"Although other patient-preferred benefits such as improved earlier return of motion may still exist, the results of our study suggest that the technique of arthroscopic surgery does	High drop out rate. At 12 months, recurrence rates between these two procedures are comparable and arthroscopy is not superior to open procedure.

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			days. Second 4-8 weeks, final follow-up at 12 months.	group, but not significant (p = 0.381).	not achieve superior rates of ganglion recurrence."	
Tian 2007 RCT No mention of sponsorship or COI.	2.5	N = 62 (70 hands) with CTS. Mean age 52 years.	Endoscopic Group- One-portal endoscopic release (n = 32, 34 hands) Vs. Open Group- Open carpal tunnel release. (n = 30, 36 hands). Follow-up assessments taken at 3 months and final follow-up ranged from 18 to 48 months.	No significant difference between endoscopic and open groups for 2-point discrimination score at 3 months; 5.3 vs. 5.9 (p >0.05). Rate of scar tenderness significantly lower in Endoscopic group vs. Open Group; 36.0% vs. 65.0% (p <0.05). Mean operation time significantly lower in Endoscopic Group vs. Open Group; 12 vs. 38 minutes (p <0.01).	"The endoscopic carpal tunnel release is a reliable method in the treatment of idiopathic carpal tunnel syndrome. It has the advantages of slight scar tenderness, less operation time, less in-hospital stay, early functional recovery, safety and high satisfaction compared with open methods."	Sparse methodology.
Anesthesia during Surgery						
Sorensen 2013 RCT No sponsorship or COI.	3.5	N = 38 requiring endoscopic carpal tunnel release verified using neurophysiological testing; Mean (range) age 49 (31-76) for LA group and 52 (36-69) for IVRA group.	Local anesthesia group receiving 10ml (4mL given in proximal direction under subcutaneous fascia, 4mL subcutaneously in palm and 2mL subcutaneously in the distal wrist crease) Ropivacaine (n = 19) vs. Intravenous regional anesthesia group receiving 1% Mepivacaine (n = 19). Assess at baseline, during surgery, immediately after surgery, 2 hours and 24 hours post-op.	Immediately after surgery and 2 hours post-op, significant differences in mean (SD) VAS hand pain reported between LA and IVRA group: End of surgery: 0.2 (0.6) vs. 1.4 (1.8), (p <0.05), 2 hours post-op: 0.2 (0.5) vs. 1.4 (1.8), (p <0.05). During drug administration and immediately after surgery, significant differences in mean (SD) VAS arm pain reported between LA and IVRA groups: During administration: 2.1 (2.6) vs. 4.3 (1.7), (p <0.05), End of surgery: 0.6 (0.9) vs. 2.4 (2.3), (p <0.05).	"[L]A is generally a safe and effective method for ECTR after installing the LA in the subcutaneous tissue and under the subcutaneous fascia (in a proximal direction) alone, without installation of LA into the carpal tunnel…LA was more effective than IVRA at reducing patient-experienced overall pain at the end of the operation and pain in the hand 2 hours later. Furthermore, patients required less additional analgesia after surgery with LA than those treated under IVRA."	Follow up time of 24 hours Methodological details sparse
Lee 2013 RCT Double-blind Sponsored by the Seoul National University Hospital	2.5	N = 25 (50 hands) with bilateral carpal tunnel syndrome; Mean (±SD) age 57 (±10) for all participants.	Right handed injection (n = 25 hands) vs. Left handed injection (n = 25 hands). All participants received allocated hand treatment upon randomization, followed by treatment on opposite hand 6-12 weeks later.	In comparison of mean (±SD) unadjusted VAS scores and adjusted VAS scores for buffered and non-buffered lidocaine, there were significant differences: Buffered lidocaine unadjusted- 4.60 (±1.50), adjusted- 4.63 (±1.32), vs.	"[T]he results proved the buffered lidocaine could reduce the pain experienced during local anesthetic injection before carpal tunnel release."	Methodological details sparse. Small sample size (N=25)

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research fund. No COI.			Assessment at baseline and after each injection.	Nonbuffered lidocaine unadjusted- 6.48 (±1.53), adjusted- 6.61 (±1.68), (p <0.001) and (p <0.001).		
Braithwaite 1993 Randomized trial (?) No mention of sponsorship or COI.	2.5	N = 23 requiring carpal tunnel release; Participant ages not reported.	0.5% Bupivacaine injection alongside 1:200,000 adrenaline without tourniquet (n = 23 arms) vs. 0.5% Bupivacaine alone and pneumatic tourniquet (n = 23 arms). All received both treatments, but on randomized arms. Assessments at baseline, post-op and 14 days.	During procedure, participants demonstrated higher mean (SD) VAS pain scores with tourniquet compared to adrenaline limb: 4.7 (2.8) vs. 2.3 (1.7), (p <0.01). Participants' symptom diaries had no difference in paresthesia, post-op pain or bruising when comparing adrenaline and tourniquet limbs 14 days post-op.	"The use of adrenaline-containing local anaesthetic provides a satisfactory operative field, avoids the discomfort of a tourniquet and allows bilateral simultaneous carpal tunnel release to be accomplished without the need for general anaesthesia."	There was no control group. Participant arms were only randomized. Methodological details sparse
Ozer 2005 RCT No mention of sponsorship or COI.	2.5	N = 40 requiring surgical decompression of carpal tunnel. Mean age 48.2 (30-64) alkalinised group; 52.8 (42-67) non-alkalinised group.	Alkalinised group received 10ml prilocaine hydrochloride 2% buffered with 1ml sodium bicarbonate 8.4% (n = 20) vs. non-alkalinised group receiving 10ml prilocaine hydrochloride 2% (n = 20). Assessment baseline, hourly for 6 hours post-op and 12 hours.	At 1, 3, 6, 12 hours post-op, alkalinised group exhibited significantly lower mean (SD) VAS scores vs. non-alkalinised: 1 hour- 0 vs 0.5 (0.52), (p = 0.02), 3 hours- 0.12 (0.35) vs. 1.75 (1.05), (p = 0.001), 6 hours- 1.12 (0.35) vs. 2.16 (1.33), (p = 0.036), and 12 hours- 2.12 (0.83) vs. 2.75 (0.75), (p = 0.06).	"Buffered prilocaine provides a longer pain-free period for patients following surgical decompression of the median nerve. It is easy, safe, and cost-effective and it appears that the routine use of alkalinised prilocaine solution in patients undergoing carpal tunnel surgery may improve the comfort and prolong the duration of analgesia."	Follow up of 12 hours. Methodological details sparse.
Watts 2004 RCT No mention of sponsorship or COI.	1.5	N = 64 undergoing local anesthesia for open carpal tunnel decompression ; Mean (range) age 57 (28-89) years for both groups.	Buffered lidocaine group receiving 5ml of 2% plain lidocaine plus 0.5ml sodium bicarbonate 8.6% (n = 32) Vs. Plain lidocaine group receiving 5ml of 2% plain lidocaine plus 0.5 ml of sodium chloride 0.9% (n = 32). Assessments at baseline and post-op.	Although both groups reported pain improvement, here were no statistically significant results reported between groups for mean VAS pain scores, verbal pain scores or anxiety scores.	"[T]he pain of injection is not actually a major problem for most patients undergoing carpal tunnel decompression and there is no benefit in injecting buffered lidocaine. The pain scores for both groups were low and most patients reported that they were ''not at all'' anxious about having a similar injection again in the future. We did however note a correlation between increased pain score and increased	Methodological details sparse.

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					anxiety about future injections."	
Watts 2005 RCT No mention of sponsorship or COI.	1.5	N = 86 undergoing local anesthesia for open carpal tunnel decompression ; Mean (range) age 56 (30-83) for both groups.	27-gauge dental needle group (n = 46) vs. 23-gauge needle group (n = 40). Both groups received 4.4ml of 2% xylocaine with adrenaline 1:80,000 with pre-filled 2.2ml vials. Assessments at baseline and post-op.	Participants receiving injection via 27-gauge dental needle had significantly lower mean (SEM) VAS pain scores vs. standard 23-gauge needle: 22 (2.4) vs 33 (3.8), (p <0.02). Not significant when analyzing verbal response scale. Participants also self-reported less mean (SEM) anxiety with 27-gauge needle vs. 23-gauge: 7 (1.4) vs. 15 (3.4), (p <0.05).	"[P]atients reported less anxiety about future injections when the pain of the injection was reduced."	Methodological details sparse.
Yiannakopoulos 2004 RCT No sponsorship or COI.	1.5	N = 64 requiring carpal tunnel decompression verified by electrodiagnostic and clinical evidence alongside local anesthesia; Mean (SD) age 61 (8) years for all participants.	Group A; Lidocaine 1% mixed with normal saline group (n = 20) Vs. Group B; 10ml alkalinized lidocaine 1% at room temperature (22ºC) (n = 22) Vs. Group C; 10 ml alkalinized lidocaine warmed in 40ºC water bath for 30 minutes (n = 22) All groups received allocated treatment into palmar skin. Assessments at baseline and post-op.	Mean (SD) infiltration pain scores were significantly lower in Groups B& C compared to Group A: A- 21(11) & 42 (12), B- 25 (12) & 19 (7) vs. C- 21 (4) & 10 (4), (p<0.001). Group C also had significantly lower values compared to Group B, (p<0.001).	"We have found that buffering lidocaine with bicarbonate and warming the anesthetic solution helps to reduce pain on infiltration in patients undergoing carpal tunnel decompression."	Methodological details sparse.

MALLET FINGER

Author/Year Study Type Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Splinting						
Gruber 2014 RCT No mention of sponsorship. No COI.	3.5	N = 51 with fractured or unfractured mallet finger. Mean (±SD) age 49 (±14) for splint group and 51	Full-time custom-made thermoplastic splint group (n = 25) vs. No splint control group (n = 26). Follow up at 4 weeks.	No significant differences reported between splint and control groups for average final extensor lag, disability or treatment satisfaction.	"[T]here is not much benefit to additional night splinting after completing the standard splinting protocol for mallet finger. The extra cost and time associated with obtaining a custom-made removable splint should be balanced with the patient's preferences. It is possible that a subset of	Data suggests night splinting did not improve mallet finger outcomes in terms of extensor lag, disability or treatment satisfaction.

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		(±14) for control group.			patients might benefit from night splinting, although we did not find any such trends in our data. Patients should be aware that effective treatment of a mallet finger results in a slight extensor lag in most patients and a substantial probability of a lag of 20 degrees or greater."	
Garberman 1994 RCT	2.5	N = 75 excluded large fractures	Stack splint vs. Dorsally placed aluminum-foam splint. Splinted continuously for 6-10 weeks, then nightly for 4 weeks.	Splint treatment success (with no more than 10° extensor lag) in 17 of 21 (81.0%) in early group and 15 of 19 (78.9%) in delayed splint group. Fractures and type of splint immaterial.	"Splinting was as effective in the delayed treatment population as it was in the early treatment population."	Study design unclear as described as both retrospective and randomized. Dropout rate also unclear.
Kinninmonth 1986 RCT	2.5	N = 44	Perforated vs. stack splint. Splinted at least 6 weeks.	Successes were 79% Stack vs. 84% perforated splint.	"The perforated mallet finger splint can produce consistently good results even in those patients who would not tolerate a conventional splint. The fact that it is unnecessary to remove it for hygiene purposes is to its advantage."	High success rates, but methods sparse.

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EXTENSOR COMPARTMENT TENOSYNOVITIS

MRI

Author/Year Study Type Conflict of Interest (COI)	Score	Number	Area	Diagnoses	Type of MRI used	Type of CT used	T1 weighted	T2 weighted	X-ray	Myelography	More than one rater	Surgery Performed	Clinical outcomes	Long term follow-	Results	Conclusion	Comments
Hadidy 2009 Diagnostic No mention of Sponsorship of COI	2.5	N=29 patients (21 Females, and 8 males) clinically diagnosed with De Quervain's Tenosynovitis; Mean Age 49.4 ± 17.5.	Wrist	De Quervain's Tenosynovitis	1.5 T	N/A	+	+	-	-	+	-	+	-	Ultra-Sonography positive findings frequency (percentage) based upon following parameters; Tendon Thickening, Peritendinous edema, septation, subcutaneous edema, synovial thickening: 100%, 97.5%, 70%, 35%, 50%. MRI positive findings (Percentage) based upon the same parameters, respectively: 95%, 85%, 60%, 55%, 45%.	"Our statistical results indicate that ultrasound is, in general a more useful technique than MRI in identifying abnormalities in patients with De Quervain disease."	Data suggests US is of value to validate clinical diagnosis of DeQuervain's tenosynovitis but MRI may be beneficial in confirming cases not confirmed by US and detects other soft tissue changes but is more costly than US.

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Author/Year Study Type Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Glucocorticosteroid Injections						
Sawaizumi 2007 RCT	3.0	N = 36	Intra-sheath triamcinolone injection (1ml TC and 1ml of 1% lidocaine hydrochloride)	The 1-point injection excellent in 9 hands (50%), and 2-point injection excellent in 15 hands (75%); p <0.001).	Accurate injection of triamcinolone into sheath of both extensor pollicis brevis and abductor pollicis longus tendon considered very effective for deQuervain's disease.	Selection for treatment based on consecutive cases rather than randomization.
Avci 2002 RCT with pseudo-randomization	3.0	N = 19 wrists (18 females) with de Quervain's positive Finkel-stein's. All pregnant or lactating.	Glucocortico-steroid injection (methylpredni-solone 10mg plus 0.5mL 0.5% bupivacaine vs. thumb spica splint. Follow-up until asymptomatic and had stopped nursing (mean 12 months).	Complete relief in 100% of injection group vs. 0% splint group, though pain reportedly relieved while wearing splint. Recurrences in one injected patient.	"Splinting does not provide satisfactory pain relief."	Population was pregnant or lactating. Small sample size. Sparse details. Randomization was every other. Data suggest injection superior to splinting.
Kosuwon 1996 RCT	2.0	N = 140 with de Quervain's. Duration of symptoms unstated.	Steroid injection (dose and medication not specified) with vs. without wrist immobilization	Satisfactory results in 74% splinted vs. 75% unsplinted (NS). Lost days in splinted group mean 28 vs. 11, p<0.05.	"There is no difference in the results of treatment in this condition whether the patients were immobilized in a splint or not. However, the days lost from work in the group of non immobilization is less than the group of immobilization."	Abstract only. Sparse details. Results suggest no difference in outcomes whether wrist immobilized after injection or not.
Witt 1991 Prospective Cohort/Case Series	1.5	N = 95 (99 wrists) with de Quervain's. Symptom duration unstated	One mL injection of 1% lidocaine plus methylpredni-solone acetate 40mg. Minimum 12 months follow-up.	54% satisfactory. 30 wrists required surgical release. 22/30 (73%) of operated wrists had separate EPB compartment.	"Injection of one milliliter of a 1 per cent lidocaine solution and one milliliter of a suspension containing forty milligrams of methylprednisolone acetate. Twelve patients (twelve wrists) were lost to follow-up. Of the remaining eighty-seven wrists, fifty-four (62 per- cent) had a satisfactory outcome at a mean of eighteen months (minimum follow-up, twelve months). The duration of symptoms before treatment did not affect the outcome."	Not randomized trial. Primary purpose was to assess steroid flare. 73% of treatment failures had separate compartment for extensor pollicis brevis. Baseline symptom duration not predictive.

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NON-SPECIFIC HAND, WRIST, AND FOREARM PAIN
Electrodiagnostic Studies

Author/Year Study Type Conflict of Interest (COI)	Score	Study Design	Population/ Case Definition	Investigative Test	Gold Standard / Comparative Test	Results	Conclusion	Comments
Calder 2009 Diagnostic	3.5	Diagnostic	N = 46 (22 asymptomatic control subjects, 8 at-risk subjects, and 16 subjects with non-specific arm pain. Mean age 38.1 years.	Surface electromyographic (SEMG) activity	Comparing controls with patients and patients at risk.	Age significantly different among groups; control subjects significantly younger (p <0.05). Mean spike amplitude (MSA) significantly increased by 039 mV across all levels of % maximum contraction in patients with NSAP, showing 325% increase (p <0.05). At-risk group showed significant increase of 0.43 mV (430%) from 10% to 70% of MVC (p <0.05). In healthy controls MSA increased 1.1 mV (550%) from 10 to 70% of MVC (p <0.05).	"The NSAP group presented with differences in how the spike shape measures change with increasing contraction level that may be indicative of myogenic changes, a result that is consistent with previous quantitative EMG findings."	Controls significantly younger than study group which may influence results. Spike shape differences in EMG testing may provide valuable information in evaluating neuromuscular disorders.

RADIAL NERVE ENTRAPMENT
Electrodiagnostic Studies

Author/Year	Score	Study Design	Population/ Case Definition	Investigative Test	Gold Standard / Comparative Test	Results	Conclusion	Comments
Verhaar 1991 No sponsorship or COI.	3.5	Diagnostic	N = 16 (11 males, 5 females) with chronic pain of the lateral elbow who	Force measurements, nerve conduction studies and concentric-needle	Werner criteria	No statistically significant differences reported in the motor latencies	"Our data do not support the hypothesis that the signs and symptoms in most patients who have radial	Data suggest patients with radial tunnel syndrome do not have evidence of compression in the posterior interosseous nerve.

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			failed conventional therapy and 36 (24 males, 12 females) healthy controls; Mean age 44 for radial tunnel syndrome participants and 25 for healthy control participants.	electromyography		between pain-free and painful arms or between pain participants and controls for nerve conduction studies. No significant differences in fibrillation potentials for the radially innervated muscles of the forearm. No significant differences in force measurements between groups.	tunnel syndrome are caused by compression of the posterior interosseous nerve."	
Spindler 1990 No mention of sponsorship or COI.	3.0	Diagnostic	N = 3 (0 males, 3 females) with no evidence of neurological disease from superficial branch of radial nerve (SBRN) and lateral antebrachial cutaneous nerve (LACN) in the forearm. Mean age 39 years.	Conduction study of SBRN and LACN	Not stated	LACN: stimulation of radial nerve at elbow evoked response over LACN in forearm. Normal radial sensory conduction in forearm: 61.4±3.1 m/sec. Difference between LACN and SBRN conduction in same arm: 1.9+1.6 m/sec.	We therefore recommend that during all examinations for possible entrapment of the radial nerve in the forearm, the musculocutaneous nerve at the elbow also be stimulated. If the response is recordable from the radial sensory pickup electrodes while stimulating the musculocutaneous nerve, radial sensory conduction studies should be	Small sample size (N=30) Data suggest value in stimulating the musclulocutaneuous nerve at the elbow when evaluating RNE.

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							interpreted with great caution."	

SCAPHOID FRACTURES

Bone Scans

Author/Year Study Type Conflict of Interest (COI)	Score	N	Area of Body	Diagnoses	Type of Bone Scans	CT used	MRI Used	More than on rater	Blinding of rater	Myelography	Surgery	Clinical outcomes assessed	Long term follow-up (mean when noted)	Results	Conclusion	Comments
O'Carroll 1982 Diagnostic	3.5	30	Wrist	Scaphoid fracture. Mean age 32 years.	99m Tc Methylene Diphosphonate and large field of view Gamma camera.	-	-	-	-	-	-	-	6 weeks	6 of 30 patients had scaphoid fractures. All 6 with scaphoid fractures gave positive bone scan but 5 additional patients without fractures gave positive bone scans.	"Bone scanning, however, detected all scaphoid fractures but had a relatively high false positive rate."	Data suggest scintigraphy accurately diagnosed all true fractures and accurately detected those without fracture.

MRI

Author/Year Study Type Conflict of Interest (COI)	Score	Number	Area of Body	Diagnoses	Type of MRI used	Type of CT used	T1 weighted images	T2 weighted images	X-ray	Myelography	More than one rater	Surgery Performed	Clinical outcomes assessed	Long term follow-up (mean when noted)	Results	Conclusion	Comments
Kumar 2005 Diagnostic	3.5	N=22 patients (17 male, 5 females) with suspected scaphoid fractures from an	HWF	Scaphoid fractures	1.5 T MRI (Siemens Vision)	N/A	+	-	+	-	-	-	-	-	Scaphoid fractures detected in 6 of 22 participants based on low signal intensity on T1W. Using MRI within 24 hours of trauma had 100% sensitivity (CI: 72.3-100) and	Our study demonstrates that MRI can be used for early assessment of occult scaphoid fractures within 24 hours of injury. In a tertiary level hospital containing a MRI facility	Small sample size. Data suggest MRI may be effective to detect occult scaphoid fractures.

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		initial x-ray, presented within 24 hours of trauma													100% specificity (CI: 75.8-100).	operating at least 5 days a week, it is possible to accommodate an MRI of the wrist with a modified shortened protocol. This would lead to early initiation of treatment at the time of presentation and decrease the number lost to follow-up. The proposed clinical pathway would also reduce the over treatment of patients allowing scaphoid fracture to be ruled out at presentation—thus enabling early return to work instead of the usual 10 days in a plaster cast.”	
Imaeda 1992 Diagnostic No mention of sponsorship or COI.	3.5	N=28 patients(25 males, 3 females) Mean Age:26	WRIST	Scaphoid Fracture	General electirc signa system operated at 1.5 tesla with a 3 inch circular surfaces coil twodimensional Fourier transform multisection using an 8-10 cm. field of view, and	-	+	+	+	-	-	-	-	-	A fresh fracture was identified by decreased or iso signal intensity on the Tl-weighted image and increased signal intensity on the TZ-weighted image. This increase continued until bony union was apparent on radiographs. On the TZ-weighted image, high signal intensity was characteristic of fresh fractures and suggested	“Signal intensity on Tl- and T2-weighted images can be used to indicate the prognosis of each scaphoid fracture. A low signal intensity on a Tl-weighted image combined with a high signal intensity on a T2-weighted image would serve as a basis for a diagnosis of scaphoid fracture and provide some indication as to the likelihood of	Data suggest MRI depicts increased visualization of wrist anatomy which is useful for diagnosing and assessing the extent of union of scaphoid fracture.

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					sections 3 mm. thick taken with a 1.5 mm. interspace gap. Spin-echo pulse sequences and Tl-weighted (T.R. = 500-600 msec., T.E. = 20-30 msec.), Proton Density weighted (T.R. = 2000 msec., T.E. = 20-30 msec.) and T2-weighted (T.R. = 2000 msec., T.E. = 80 msec.) images										that bony union was possible. When bony union was complete, the intensity of the signal for the scaphoid on both Tl- and TZ-weighted images returned to normal.	healing. When bony union is complete, the signal intensity for both proximal and distal fragments on the Tl- and T2-weighted images resumes the iso level."	
Sharifi 2015	3.5	N=175 patients with suspected scaphoid fracture. 163	Wrist	Scaphoid Fracture	Type not mentioned	n/a	-	-	-	-	-	-	-	+	Negative MRI exam was found in 159 patients (90.9%) and positive in 16 patients (9.1%). T-test in both groups mean pain score	"It seems that although this method, beside other criteria in the diagnosis of fractures, can be useful in future	Data suggest pain measurement in combination with MRI for suspected bone fractures is not useful in

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		males, 12 females. Mean age 28.06±5.952 years.													in negative and positive MRI groups was 7.3±1.75 and 8.75±1.52 respectively that was p<.002 (95% CI). Sensitivity and specificity will be 94% and only 8% for scores 4.5 and higher, 94% and 18% for score of 5.5 and higher, and 94% and 38 for scores of 6.5 and higher respectively. While the sensitivity decreases down to 87% and the specificity increases up to 57% for score 7.5 and the sensitivity and specificity will be 75% and 72% for scores 8.5 and higher, respectively and finally, the sensitivity and specificity will be 31% and 87% for scores 9.5 and higher, respectively.	studies, it would not be helpful in fracture detection."	patients with normal radiographs.
Gaebler 1996	2.5	N=32 patients with clinically suspected scaphoid fracture.	Wrist	Scaphoid Fracture	1.5 Tesla	-	+	+	+	-	-	-	+	+	Fracture of the scaphoid was not confirmed in 26 cases. The MRI scans showed no indication of fracture, but in 11 cases, lesions of	"In cases where an occult scaphoid fracture is suspected, MRI should be performed to diagnose occult fracture	Small sample. Data suggest MRI is useful in diagnosing scaphoid fracture.

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		21 males, 11 females. Mean age: 29.5 years.													the carpus, carpal ligaments, and the radius were found. Scaphoid fracture was found in 6 patients by conventional radiographs after an average time of 16.3 days and for these 6 cases in 3.5 days. Specificity of MRI exams for occult scaphoid fractures was 100% (95% CI 89.12-100) and sensitivity of 100% (95% CI 60.7-100). In 11 cases scaphoid fracture could not be confirmed. In 2 cases an occult fracture of capitatum was diagnosed by MRI. In 3 cases, injuries of the radius were found.	immediately to prevent patients with simple wrist sprains from being immobilized for weeks and thus save money in our health system. The advantages of our method to diagnose occult scaphoid fracture with MRI are several: no radioactive diagnostic means are required, sensitivity and specificity are 100%, the method is readily available at our clinic, and $7200 per 100,000 inhabitants could be saved by routine use of this conventional method."	
Senevirathna 2013	2.5	N=110 patients with suspected scaphoid fracture. 72 males, 38 females. Mean age: 35.14 years.	Wrist	Scaphoid Fracture	1.5 Tesla	-	-	-	-	-	-	-	-	-	Twenty-four scans showed occult bone fractures. Three of these patients had scaphoid fractures diagnosed by MRI. Seventy-two patients had other incidental findings with MRI.	"The MRI scan is a useful tool to obtain a definite diagnosis in acute wrist injuries. If, however, the MRI scans are done after two weeks from the wrist injury, the probability of finding a definitive diagnosis of occult scaphoid fracture was only 2.7% in our study. We conclude that in the	Data suggest performing MRI 2 weeks after an acute wrist injury is useful in visualization of multiple wrist injuries including soft tissue and many other non-scaphoid wrist fractures.

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																majority of patients with persisting symptoms four to six weeks following a wrist trauma, the pathology will most often affect other carpal bones or in other structures including soft tissues."	
Schmitt 2011	2.5	N=10 patients with radial-sided wrist pain. 4 males, 6 females. Mean age 36.9 years.	Wrist	Scaphoid Fracture	1.5 Tesla	16-row scanner	+	+	-	-	+	+	+	+	Two cases with congenital thumb hypoplasia, the entire scaphoid was affected by extensive volume loss and osteosclerosis. Six patients presented with altered scaphoid shapes. In remaining 2 patients, shapes of scaphoid were unremarkable. In all patients, increased density of bone substance was evident. A gradient of osteosclerosis was evident in other 8 cases with bone density being most intense at the proximal and decreasing to distal pole. The sclerotic and cystic changes of scaphoid bone structure were better assessed in	"Pathoanatomy of Preiser's disease and the differentiation into three zones of bone marrow viability can be explained with the retrograde blood supply of the scaphoid. In its natural course, three different stages can be depicted with the initial stage seen only in MRI."	Very small sample. Data suggest MRI beneficial in visualization of anatomy of the three bone marrow zones in Preiser's disease when compared to radiographs.

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															9 patients assessed with CT imaging.		

Surgery

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Surgical Fixation vs. Cast						
Jeon2009 RCT No industry sponsorship or COI.	3.5	41 (39 males, 2 females) patients with an acute scaphoid fracture. Mean age was 28.5 years.	Volar Approach Group- A transverse stab incision was made at about 1 cm distal to the scaphotrapezial joint (N=19) Vs. Dorsal Approach Group- After stab incision over the center of the circle (usually over the scapholunate joint), the guide wire was driven dorsal to volar so that it exited at the radial base of the thumb. (N=22) Follow-up at 4, 8 and 12 weeks.	There were no significant differences between Dorsal and Volar approach for Pain (p=0.91), Flexion (p=0.989), Extension (p=0.300), Radial Deviation (p=0.380), Ulnar Deviation (p=0.414), and Modified Mayo wrist score (p=0.446).	"This study suggests that screws are placed more parallel to the long axis of the scaphoid and perpendicular to the fracture line via the dorsal approach; however, there was no significant difference with regard to functional outcome and bone union."	Data suggest comparable efficacy.

METACARPAL FRACTURES

Functional Therapies vs. Casting or Splinting

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments

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Conflict of Interest (COI)						
Immobilization						
Hansen 1998 RCT No mention of sponsorship or COI.	3.5	N = 105 with fracture of neck of ring or little metacarpal bone	Dorso-ulnar plaster-of-Paris from proximal interphalangeal joint to elbow (n = 35) vs. functional brace around wrist (n = 35) vs. elastic bandage (n = 35). Study duration 4 weeks. Follow-up at 3 months.	VAS during 4 weeks treatment: plaster-of-Paris 1.5 vs. functional brace 1.8 vs. elastic bandage 2.7 ($p < 0.05$). Median restriction of MCPJ movement at 4 weeks: plaster-of-Paris 20º vs. functional brace 0º vs. elastic bandage 10º ($p < 0.05$). Median restriction of MCPJ movement at 3 months: plaster-of-Paris 0º vs. functional brace 0º vs. elastic bandage 10º ($p < 0.05$).	"Patients treated with a functional brace mobilized as fast as patients treated with elastic bandage and faster than patients treated with plaster-of-Paris."	Data suggest comparable efficacy between use of functional brace vs. elastic bandage vs. plaster-of-Paris for fractures of ring and little metacarpal neck with slightly faster mobilization with functional brace. Patient satisfaction was similar in all groups. Fracture severity was not specified.
Strub 2010 Pseudo-RCT No mention of sponsorship. No COI.	3.0	N = 40 with 30º-70º palmar displacement of little finger metacarpal neck fracture. Mean age Group A 28 years, Group B 32 years.	Group A: closed reduction with K-wires and intramedullary splinting, palmar 2 finger splint for 5 days followed by functional mobilization in metacarpal brace for 5 weeks, wires removed after 3 months vs. Group B: conservative treatment without reduction and immobilized in a palmar 2 finger splint for 5 days followed by 5 weeks of functional mobilization and no hand therapy. Follow-up at 2 and 6 weeks, and 3, 6, and 12 months.	NS between groups at 1 year follow-up for flexion at metacarpophalangeal joint ($p = 0.69$), extension at metacarpophalangeal joint ($p = 0.08$) and grip strength ($p = 0.22$).	"[We] could not demonstrate any statistically significant differences in the conservative and surgical treatment of displaced boxer's fractures in terms of range of motion at the MCP joint or grip strength."	Small sample quasi randomization. Data suggest surgically treated group were more satisfied and had better aesthetic outcomes than non-surgically treated groups but no significant differences found between ROM or grip strength in 2 groups suggesting intramedullary splinting offers an aesthetic advantage without functional improvements.
Sørensen 1993 RCT No mention of sponsorship or COI.	3.0	N = 133 with fractures (140) of 2nd-5th metacarpal bones. Age range 10+.	Galveston metacarpal functional brace (n = 65) vs. dorsal/ulnar plaster cast (n = 68) for 4 weeks. Assessment at 1 week, 4 weeks, and 3 months after injury.	Percent reduced mobility 4 weeks after injury after cast removal: metacarpal brace 4% vs. cast 31% ($p < 0.01$).	"We found that the benefits did not outweigh the risks of the functional fracture bracing, and we cannot recommend the test version of the Galveston metacarpal brace."	High drop out in carpal-brace group (58%) compared to plaster-of-Paris (19%). Therefore, comparisons of the two treatment groups not possible. At 3 months the patients completing study reported equal mobility.

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Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Physical Therapy Or Occupational Therapy						
Lagerström Scand J Rehabil Med 1999;31:49-54 Clinical trial	3.5	N = 33	Functional reliability measures of injured vs. uninjured arms post immobilization.	Findings include 3 or more trials per session required to measure MVC. Intersession reliability lowest first 2 months; equal at 2 years. Healthy uninjured side can be reliable reference for injured side.	"Measurement methods and the present findings may serve as guidance in physiotherapy for these patients, especially if the uninjured side is used as reference."	Thrust of study is reliability of grip strengths.
Pasila 1974 RCT	3.0	N = 135	No physiotherapy with written and oral instructions to perform movements from doctor vs. physiotherapy with written instructions by physiotherapist	No statistically significant differences were found between two groups regarding subjective well-being and time lapse between injury and return to work. Patients in PT arm attended physiotherapy on average 4 times.	"A surgeon can effectively supervise the physical therapy of radial fracture patients by using additional printed instructions. Transferring the patient immediately to a physiotherapist's care did not affect the final result, but created extra administrative work and increased the number of visits made by the patient by approximately four."	Heterogeneous methodology problems weaken study conclusions.
Oskarsson 1997 Case series	N/A	N = 110	Written and oral physician instructions vs. same plus physiotherapy upon patient's request.	No significant differences in matched pairs for wrist function (maximal grip score, wrist movement score); 93% of patients attending physiotherapy believed it effective.	"Following the typical distal radius fracture, only patients with severe stiffness and those who for any reason cannot execute their self-training program should be referred to a physiotherapist."	Authors suggest PT acts as a placebo, and other less expensive placebos may be effective.
Casting/Functional Bracing						
Van Der Linden 1981 RCT	3.5	N = 250 (39 male/211 female)	Group 1: circular plaster cast, palmer flexion combined with pronation and ulnar deviation. Group 2: dorsal splint, neutral hand position, ulnar deviation preserved. Group 3: Circular plaster cast, neutral hand position, ulnar deviation preserved. Group 4: Dorsal splint, neutral hand position, without ulnar deviation. Group 5: Circular plaster cast,	Mean values for restriction of range of movement (in degrees) compared with uninjured side: Dorsiflexion Group 1 12.7; Group 2 17.4; Group 3 15.4; Group 4 12.4; Group 5 14.3.	"The technique of immobilization was found to be of subordinate importance for the final results, which are determined by the original displacement and the success of reduction."	Study suggests anatomic results are dependent on success of reduction.

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			neutral hand position, without ulnar deviation.			
Immobilization/Fixation						
Wik 2009 RCT No mention of industry sponsorship. No COI.	3.5	N = 72 females with low-energy trauma, displaced Colles' fractures initially considered for closed reduction and immobilization in plaster cast. Age >50.	Reduction and a complete plaster cast (n = 34) vs. Reduction and a dorsal plaster splint (n = 38). Immobilization for 5 weeks with follow-up at 1 and 10 days and 5 weeks after reduction.	Mean dorsal angulation 10 days after reduction: slightly better in the dorsal plaster splint group, (p = 0.04). Radial length at 5 weeks was better in the complete plaster group, (p = 0.02).	"[S]urgeons caring for such cases may choose the immobilization method for the first 10 days following reduction according to their individual preferences and those of the injured person."	Data suggest comparable efficacy between 2 groups suggesting personal preference for type of immobilization method.
Gupta 2011 RCT No mention of industry sponsorship or COI.	3.5	(N=40) (9 females/31 males) patients younger than 50 years of age with a fracture distal radius with dorsal angulation more than 20 degrees, severe dorsal communution, radial shortening more than 10 mm, and wrist joint fracture.	Closed reduction and long arm cast applied under brachial plexus block (Group A, N=20), followed after one week to check radiograph for any displacement; plaster removed at 6 weeks and then physiotherapy was started; reassessed at 3 months v. closed reduction and external fixation with poly axial clamp and distractor rod under brachial plexus block (Group B, N=20); plaster removed at 6 weeks and then physiotherapy was started; reassessed at 3 months.	Expenditure incurred (Rs) (mean±SD): Group A (1894.30±251.11) v. Group B (8156.84±377.33), p=0.00.	"[B]oth the methods of treatment produced no significant difference in outcome, functionally and anatomically, but the extra cost of anesthetic drugs, operation theatre charge, hazards of anesthesia, cost of implant can be avoided in cases of closed reduction and immobilization in plaster cast."	Data suggest comparable efficiacy between groups (unstable distal radius fractures treated either with closed reduction plus cast vs. closed reduction and external fixation lead to same functional and anatomical outcomes.

DISTAL PHALANX FRACTURES

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Antibiotic Prophylaxis						
Sloan 1987	3.5	N = 85 (81 males; 4 females) adult	No antibiotics (N = 10) vs.	Infection rate (no antibiotic vs	"Three different antibiotics regimes were	Data showed similar efficacy with all 3

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RCT No mention of industry sponsorship or conflict of interest (COI)		patients with open fracture of the distal phalanges of less than 6 hours; mean age 36.9 ± 15.9	Cephradine 500mg 4 times for 5 days (N=24) vs. Cephradine 1gm injection pre-operatively and Cephradine 500mg 4 times for 5 days (N = 24) vs. Cephradine 1gm injection pre-operatively and 1gm orally post-operatively. (N = 25) Follow up 2 and 5 days and thereafter as appropriate	antibiotic): 30% vs 2.7% (p=0.02)	compared, with no difference in the infection rate: therefore the simplest and surest method, a single pre-operative dose and a single post-operative dose, is recommended.”	antibiotic groups but the non-antibiotic group had a 30% infection rate. Data suggest a single pre-op and a single post-op dose of antibiotics is effective.

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GANGLION CYSTS
X-rays

Author/Year Study Type	Score	Number	Area of Spine	Diagnoses	Type of X-rays	CT used	MRI Used	More than on rater	Blinding of rater	Myelography	Surgery Performed	Clinical outcomes assessed	Long term follow-up (mean when noted)	Results	Conclusion	Comments
Sakamoto 2013 Clinical Study No mention of sponsorship. No COI.	3.5	N=17 (7 males, 10 females). Mean age is 48.9 years.	Wrist/Knee area.	Ganglion Cyst	Radiograph	-	-	-	-	-	+	+		Interosseous ganglion appears as a well-defined osteolytic lesion located near a joint.	Radiographs as well as clinical information are important for the accurate diagnosis of intraosseous ganglion.	Data suggest plain radiographs and clinical information are important in making an accurate diagnosis of intraosseous ganglia.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments

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Conflict of Interest (COI)						
Aspirations						
Khan 2011 Randomized Control Trial No sponsorship or COI.	3.5	N = 36 with dorsal wrist ganglion; mean Age 31 (17-45)	Group 1 (N=18) Patients treated with an open surgical excision. Vs. Group 2 (N=18) Patients treated using aspiration with 18G needle, followed by injection of triamcinolone acetonide. Follow-up at baseline, 1, 2, 6 weeks, and 6 months.	Success Rate, group 1 vs group 2: 17 (94.4%) vs 11 (61.1%) (p = 0.041). Rate of Recurrence, Group 1 vs Group 2: 1 (5.6%) vs 7 (39.9%) (p = 0.041). No complications in any of study groups during study period.	"Although the aspirations, triamcinolone acetonide injection plus wrist immobilization is one of the alternative methods, surgery was the most successful form of treatment when considering the cure rate of dorsal wrist ganglion, though we analyzed only a small group; our results can only be an indicator."	Small sample size. Data suggest surgical excision superior to aspiration plus triamcinolone plus wrist immobilization for treatment of dorsal wrist ganglion (94.4% vs 61.1%)
Aspiration (without other intervention)						
Varley 1997 RCT No mention of sponsorship or COI.	3.5	N = 85 (63 female /22 male) patients that had a ganglion cyst for more than three months Age plus range for aspiratio n alone (83 (13-71)) Age plus range for aspiratio n plus steroid injection (35 (15-75))	Aspiration alone (N = 42 (32 female/10 male)) Follow-up mean and range (48 weeks (26-89)) vs Aspiration and steroid injection (N = 43 (31 female/12 male)). Follow-up mean and range (46 weeks (26-89))	Both treatment types produced a 33% success rate.	"This study demonstrates that 33% of ganglias are successfully treated by aspiration: additional injection of steroid injection is of no benefit and may cause subcutaneous fat atrophy and skin depigmentation."	Data suggest similar efficacy between groups with addition of steroid adding no benefit and may increase skin depigmentation and fat atrophy.

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Aspiration and Surgical Excision and Steroid Injection						
Balazs 2015 Randomized Control Trial No sponsorship or COI.	3.0	N=125 (85 males, 40 females). Mean age is 31 years.	Recurrence (N=11) Vs No Recurrence (N=114) Mean follow up of 45 months.	Recurrence incidence of 9% over 45 months.	Patients whose occupation or activities require forceful wrist extension should be counseled on the considerable risk of residual pain and functional limitations that may occur after open dorsal wrist ganglion excision.	Data suggest persistent pain post open dorsal wrist ganglion excision in active duty military personnel is common and these persons should be counselled on the risk of residual pain post procedure.

HAVS
Diagnostic Testing

Author/Year Study Type	Score	N	Area of Body	Diagnoses	Type of Thermography	CT used	MRI Used	More than on rater	Blinding of rater	Myelography	Surgery Performed	Clinical outcomes	Long term follow-up (mean when noted)	Results	Conclusion	Comments
Coughlin 2001 Same as OCC MED Case Control	5.5	31 subjects in two groups. Group A: 10 healthy volunteers. 5 men, 5 women. Median age of 35. Group B: 21 patients. 20 men, 1 woman.	Hand	HAVS with RP	Cold Provocation	-	-	-	-	-	-	-	-	After cold provocation, the finger temperature and time for the finger temperature to return to pre-cooling levels were able to distinguish the HAVS group and	"CPT has a good sensitivity, specificity, positive predictive value and negative predic	Data suggest CPT test has good sensitivity and specificity and supports a diagnosis of

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		Median age of 45												the normal group. The sensitivity of CPT was low after cooling, but reach up to 95% 3 min after rewarming. The accuracy of the test was also the greatest towards the last stages of rewarming. The specificity and PPV were high during precooling stages and remained relatively high during the rewarming stages. NPV was low during the precooling stage and became high (>90) during the rewarming stages.	tive value; it strongly supports the clinical diagnosis of digital vasospasm."	digital vascospasm.

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Author/Year	Score	Study Design	Population/ Case Definition	Investigative Test	Gold Standard / Comparative Test	Results	Conclusion	Comments
Bogadi-Šare 1994	3.5	Case Control	N = 45 men 29 chain-saw worker VS 16 healthy controls Mean age = 47	Finger Thermometry	Photo plethysmography	Chain-saw workers had significantly lower temperature compared to the control group. Viewing the pulse amplitude can distinguish the control group from the chain-saw workers, but cannot determine the subgroups. Plethyssmography yielded most suitable results at a diagnostic limit of 75% reduction amplitude, which gave a sensitivity of 62% and a specificity of 87%.	"The present study presents a supplementary diagnostic procedure which reflects the degree of vasoconstriction and vasodilatative ability, can confirm the clinical impression, and can be used for assessment of disability."	Data suggest there is considerable variation to cold provocation in terms of the vascular response which impedes the defining of normal vs. abnormal reactions No single test could distinguish cases from controls.
Lindsell 1999	3.0	Case Control	N = 107 76 subjects exposed to vibration VS	Vibrotactile threshold measurement, thermal threshold measurement, and finger systolic blood	No gold standard mentioned. All investigational test were compared against each other.	Results showed that as the overall numbness score increased, cold thresholds decreased	"The present study shows that thermal thresholds (hot and cold) and vibrotactile	Data suggest some vascularand neurological signs occur independently but some signs like blanching and numbness and

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			31 manual workers not exposed to vibration (Control) No mention of age or gender	pressure measurement.		(p=0.016). Also, the numbness score were positively correlated with vibrotactile thresholds at 125 Hz (p=0-033) and hot thermal thresholds (p=0.019). Finger systolic blood pressure did not correlate with the two other test ran.	thresholds (at 31.5 and 125 Hz) are affected by exposure to hand-transmitted Vibration"	tingeling may be related as they are highly correlated.
Kurozawa 1991	2.5	Case Control	N = 122 men 100 men receiving annual exam for vibration syndrome Vs 22 healthy men Mean age = 56.0	Finger systolic blood pressure after cold provocation	Cold-water immersion test	The exposed with severe VWF group had a FSBP significantly different compared to the other three groups. The FSBP resulted in a specificity of 81.7% and sensitivity of 90.3% for VWF. Cold water immersion test showed no significant differences in the skin temperature and recovery rates of three groups.	"Measurements of skin temperature after cold-water immersion were found not to be feasible for discriminating among exposed men without VWF, those with mild VWF, and those with sever VWF."	Data suggest skin temperature measurements pre and post immersion in cold water for 10 minutes cannot be used to estimate the severity of vibration induced white finger.
Lawson 1997	2.5	Case Control	N = 34 employees	Cold Provocation testing	Sensorineural tests	After initial questionnaire and	"Although neither sensorineural	Data suggests multiple tests are required to make an

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			exposed to hand transmitted vibration Mean age = 47.1			examination, the participants were split into different sensorineural stages (0, 1, 2, or 3). Cold provocation testing was done after the examination, which resulted in a sensitivity of 75% and a specificity of 61%.	test or cold provocation test results alone are confirmatory, collectively they are very supportive of a diagnosis of the hand-arm vibration syndrome"	accurate diagnosis of HAVS.

Serologic Testing or Connective Tissue Disorders Testing

Author/Year	Score	Study Design	Population/ Case Definition	Investigative Test	Gold Standard / Comparative Test	Results	Conclusion	Comments
Kennedy 1999 No mention of sponsorship OR COI.	3.0	Case Control	N = 16 men 8 men with RP secondary to vibration white finger disease (Median age of 59.5 yrs) Vs 8 healthy men (Median age of 59.0 yrs)	sICAM-1 and IL-8 enzyme immunoassay	Skin perfusion (erythrocyte flux)	Patients with HAVS have a statistically higher level of sICAM-1 (median 284.5ng/mL, range 168.2-531.8ng/mL) than the healthy patients (median 209.7ng/mL, range 99.6-285.5ng/mL, p=0.02). The healthy patients had higher IL-8 levels (Median	"The increase in sICAM-1 that occurs in patients with HAVS suggests that leucocyte adhesion is increased and that adherent neutrophils may contribute to the microvascular damage seen in this disease."	Very small sample (n=11). Data suggesting patients with HAVS had higher S-ICAM-1 levels than controls.

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						27.7pg/mL, range 16.1-70.4pg/mL) than the patients with HAVS (median 13.8pg/mL, range 11.5-25.4pg/mL, P<0.01). The skin perfusion was not significantly different between the two groups.		

LACERATION MANAGEMENT

Author/Year Study Type Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Wound Repair						
Mouzas 1975 RCT	3.5	N = 104	Dexon suture vs. silk suture vs. polyethylene suture vs. nylon suture	One wound in each Dexon, polyethylene, and nylon groups was frankly injected, 4 wounds sutured with silk injected. By 7-10 days 77.3% (17/22) of Dexon wound, 68.2% (15/22) of polyethylene wound and 73.9% (17/23) of nylon wound.	"Dexon was seen to possess certain advantages in that it caused as little tissue reaction as the other sutures but did not have to be removed subsequently."	Not clear if an RCT as randomization and allocation not described. No blinding.
Sutton 1985 RCT	3.5	N = 76	4/0 Ethilon interrupted mattress sutures vs. Steristrips applied on tincture of benzoin for closure of wounds.	"Sutures appeared to be associated with increased necrosis of the wound and slower healing than adhesive tapes, particularly when used for flap lacerations…The mean healing time for the 23 patients whose flap lacerations were closed with tapes was 39 days; 20 of these patients were neither admitted to hospital nor received grafts."	"This study shows that for most pretibial lacerations conservative management on an outpatient basis is all that is necessary, and that adhesive tapes are to be preferred for the primary closure of such wounds."	Lack of study details. May not be applicable to upper extremity lacerations.
Bernard 2001 RCT	3.5	N = 42	2-octyl cyanoacrylate vs. standard suture for the closure of excisional wounds	No differences in early complications between groups. Suture group scored higher on VAS (63.3mm for suture vs. 47.8mm for tissue adhesive); difference statistically significant (p = 0.02). Suture group had higher median score on Hollander Wound Scale, but not statistically significant (p = 0.09).	"The cosmetic outcome of cutaneous excisional surgery wounds closed with standard suturing was found to be superior to that of wounds closed with octyl cyanoacrylate."	Study not random-selection based on patient choice. Study population children and adolescents, but may be appropriate for excision wounds in general, all wounds

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						treated with subcutaneous sutures.
MacGregor 1989 RCT	3.5	N = 100	Staple vs. suture closure with local anesthetic for patients with lacerations.	Scores awarded for ease and satisfaction of closure by doctor at insertion were similar. Significantly more patients awarded staples full marks at insertion for method acceptability, although they were same at removal.	"[T]he use of staples to close traumatic skin lacerations compares favorably with the traditional method of suturing."	Sparse study details. Lack of analytical details.

HUMAN AND ANIMAL BITES AND ASSOCIATED LACERATIONS

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Dog Bites						
Elenbaas 1982 RCT	3.5	N = 63	Oxacillin x 5 days vs. placebo.	No significant difference in infection rates between two groups; 2 infections vs. 0 in antibiotic group. Both developed in hand.	"Good wound toilet and attention to adequate follow-up wound care will result in a minimal incidence of infection in dog bite injuries. Antibiotic prophylaxis does not further reduce this incidence."	High dropout rate (17/63). Study details sparse, including allocation and blinding methods.
Bite Laceration Repair						
Maimaris 1988 RCT	3.5	N = 169	Sutures vs. no sutures of dog-bite lacerations.	Overall infection rate 7.7%. No significant difference in infection rate between sutured and non-sutured lacerations. Significant difference in infection rate of hand vs. rest of body ($p < 0.01$).	"Dog bite lacerations should receive thorough surgical treatment and can be safely sutured at presentation. However, special care should be given to hand wounds and patients with delayed presentation."	Sparse study details. No blinding. Randomization and allocation details not provided.

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HAND/FINGER OSTEOARTHROSIS

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
SPLINTING AND EXERCISE						
Splint vs. Splint						
Berggren 2001 RCT	2.5	N = 33 wait-listed for CMC joint replacemen t	Three groups: 1) technical accessories, 2) semi-stabile textile splint, and 3) non-stabilizing leather splint. All received advice on ADLs.	Patients' need for operation over 7 years were 3, 4, and 3 respectively over 7 months and 2 additional patients during rest of 7 years (1 each in each splint group).	"We therefore recommend that patients with arthritis of the carpometacarpal joint of the thumb are offered a similar progamme in addition to access to accessories and splints preoperatively."	Methodological details sparse; 7-year follow-up a strength. No differences between the groups results in suggestions of either equal in/efficacy.
Splint vs. No Splint						
Adams 2014 RCT The Arthritis Research UK gave Adams research support. No mention of sponsorship.	3.0	N = 18, 27 thumbs (11 female/3 male), those with symptoms of thumb base osteoarthriti s, AUSCAN score >5 for thumb base pain, and hand function score >9 Age = Mean of 61.24	Optimal NHS occupational therapy vs Optimal NHS occupational therapy and biomechanically active splint vs Optimal NHS occupational therapy and biomechanically inactive splint *No mention of how many participants of the 18 were in each treatment group Follow-up 4 weeks	Differences in AUSCAN pain scores were statistically significant between the three groups at 4 weeks (F (2,18) = 5.892, p=0.011). Other differences in various measures were also statistically significant: AUSCAN stiffness (F (2,18) = 22.629, p < 0.001), Michigan Hand Outcomes Questionnaire ADL Both Hands (F (2,18) = 15.352, p < 0.001), MHQ Aesthetics Right Hand (F (2,18) = 4.545, p = 0.025), MHQ Aesthetics Left Hand (F (2,18) = 6.018, p = 0.010), and Global Rating of Change Scale (F (2,20) = 3.640, p = 0.047).	"Over a 4-week period patients who received thumb base splints recorded significantly less improvement in pain scores, hand disability and global change than patients who received optimal NHS OT care or optimal NHS OT care plus placebo splints. This study demonstrated that placebo splints were credible and that further work needs to be conducted on the effectiveness and efficacy of splinting for thumb base OA."	Abstract only. Small sample. Data suggest thumb splints showed not be used for thumb OA.
Weiss 2000 RCT Crossover No mention of COI or sponsorship.	3.0	N = 26 (21 female/5 male) with several grades of first carpometac arpal osteoarthriti s and radiographi	Short splint first, splint immobilized carpometacarpal joint only vs Long splint first, splint immobilized metacarpophalangeal joint, carpometacarpal joint, and wrist	Both splints decreased thumb pain significantly when evaluated with a Friedman RM ANOVA rank test (X^2F = 6.2, p = 0.001). The effect of either the long or short splint on thumb pain was not statistically significant. There was no significant difference in pinch strength with either splint when measured with a one-factor repeated-measures ANOVA (F =	"Splinting is an effective conservative treatment that helps reduce pain in patients with osteoarthritis of the first CMC joint. However, the splints did not increase pinch strength nor did they lessen the pain associated with pinch. Splinting also helped reduce subluxation (under	Included 8 participants who had additional problems (carpal tunnel syndrome, scaphotrapezial trapezoid arthritis, and de Quervain tendonitis). Data suggest splinting for first carpometacarpal joint may reduce pain but functional outcomes changes such as

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		c evidence of condition Age = Mean of 57	*All subjects wore each splint one week, no mention of how many started with short or long	1.38, p = 0.26). There was no difference in pain associated with pinching as well (X^2F = 3.92, p = 0.28). Participants reported that while wearing the short splint 42% of daily activities were easier to complete, 51% were the same, and 7% were more difficult. While wearing the long splint 16% of activities were easier, 28% the same, and 56% were more difficult. Participants rated the short splint higher on a visual analog scale compared to long splints (t = 2.85, p = 0.01).	stress) in the early stages of osteoarthritis. The shorter splint was preferred by most patients with first CMC osteoarthritis. In the past, conservative treatment for first CMC osteoarthritis has been frequently employed without qualitative or quantitative support, but the results of this study suggest that splinting is a well-tolerated and effective means of managing first CMC osteoarthritis."	improved pinch strength did not occur.
Intensive vs. Standard Exercise						
Rønningen 2008 Controlled clinical trial	3.5	N = 60 hospitalized RA patients	Intensive (daily HEP, greater number of repetitions) vs. standard exercise program for 12 weeks.	At 14 weeks, grip strength favored intensive group (p = 0.04).	"[C]ompared with a traditional programme, an intensive hand exercise programme is well tolerated and more effective in improving hand function in patients with RA."	Non-randomized, as first 30 assigned standard treatment and next 30 intensive. Suggests superiority of more intensive exercise regimen for severely affected RA.
Exercise vs. Sham						
Boustedt 2009 RCT Sponsored by grants from the Vastra Gotaland's Research Found and Goteborg's Found for Rheumatism, and The Swedish Research Council. No mention of COI.	2.5	N = 35 women with thumb base osteoarthritis No mention of mean age. 35 Females, 0 Males	Control (N = 16) – Participated in JP programme Vs Splint and Exercise (SE) Group (N = 19) – Splints 24h/day combined with daily home exercise 1 year follow up.	There was no significant difference between the two groups at baseline and before the intervention. The SE group showed a significant decrease in the pain at night, pain on motion, stiffness and disability in daily activities over the period before/after the intervention and before/at the follow up. The SE group increased their hand grip force by 27% between the intervention and at 1-year follow up.	"The splinting and exercise regimen added to a JP programme gives a greater improvement of pain, stiffness, grip force and daily activities than the JP programme alone."	Data suggest combination splinting and exercise program combined with a joint protection program improves pain, stiffness and quality of life compared to a joint protection program alone.

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NSAIDs						
Diclofenac vs. Amtolmetin						
Niccoli 2002 RCT	3.5	N = 90 hand, hip or knee OA	Amtolmetin 600mg BID for 3 days then 600mg a day for 11 days vs. Diclofenac 50mg TID vs. Rofecoxib 25mg QD for 2 weeks total treatment.	Diclofenac reduced creatinine clearance. Rofecoxib gained body weight, systolic blood pressure, diastolic blood pressure and serum sodium with decrease in daily urine volume. No significant changes in parameters with AMG. Diclofenac more efficacious than other 2 drugs (p <0.001).	"Diclofenac mainly impaired blood renal flow and the glomerular filtration rate, while rofecoxib negatively influenced the renal sodium-water exchange. AMG demonstrated a renal sparing effect, although the exact mechanism is unclear."	Sparse study details; 2-week trial. Data suggest diclofenac superior.
COMPLEMENTARY AND ALTERNATIVE THERAPIES						
Chondroitin vs. Placebo						
Verbruggen 2002 2 RCTs	3.5	N = 46	Chondroitin polysulphate 50mg IM twice weekly for 8 weeks every 4 months (46) or chondroitin sulphate 500mg TID (34) vs. placebo for 3 years	Baseline differences in destructive IP joint OA with CPS 23.9% vs. placebo 47.8%. CS 35.3% vs. placebo CS 35.9% at baseline. However, data presented compared with aggregate placebo group, precluding analysis of CS study alone. DIPs for CS study at 3 years 2.6 vs. 3.5 placebo (p = 0.155). PIPs CS 2.3 vs. 2.8, p = 0.373. MCPs CS 0.4 vs. 0.5, p = 0.70.	"The data recorded during these pilot studies should help investigators to design future long-term clinical experiments."	Pilot study. Some details sparse. Baseline differences in erosive changes suggest randomization failure for CPS study. Main publication purpose for system to assess progression of OA. High dropout rates, especially in the IM injection study.
Rovetta 2002 RCT	3.0	N = 24 DIP and/or PIP joint OA	Chondroitin sulfate 800mg a day plus naproxen 500mg a day vs. naproxen only for 2 years.	Chondroitin plus naproxen group had increase of 1 joint with erosive OA at 1 year and none at 2 years, vs. naproxen group with 6 patients, 7 joints (p <0.05).	"Chondroitin sulfate failed to stop the usual time-associated progression in the number of finger joints presenting erosions in EOA of the hands. It was, however, associated with a lower increase in the number of finger joints with erosions detected after 2 years of radiological observation."	Small sample size. Sparse details. Results suggest delayed development of new erosive changes.
Yoga vs. No Therapy						
Garfinkel 1994 RCT	3.0	N = 26 DIP or PIP joint OA	Yoga (supervised 1x a week for 8 weeks) vs. no program. After 10 weeks, controls offered to cross over (2 did not) and remaining subjects randomized. Six remained in controls.	Tenderness improved in yoga (2.20±1.32 vs. 0.4±0.94, p = 0.001). Range of motion increased (p = 0.002). Improvements in grip strengths did not differ (yoga 4.21±4.69/control 3.36±5.89, p = 0.69).	"This yoga derived program was effective in providing relief in hand OA."	Small sample sizes and some details sparse. Non-interventional control likely biases in favor of intervention.

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Multiple Modalities vs. None						
Mathieux 2009 RCT	3.0	N = 60 early RA	Multidisciplinary (n = 6) team-led program. Video, "comprehensive OT," motor training, skill training, joint protection, counseling, advice, assistive devices, splints, education, psychosocial support. Treatment for 3 months.	Health Assessment Questionnaire scores: OT (0.19±0.19) vs. controls (0.35±v0.32), p <0.001. Dominant hand grip strengths: OT (53.9±24.2 kPa) vs. controls (37.3±22.9), p = 0.021.	"[A]n early extended information programme improved hand function in patients with early RA."	Multiple modalities and lack of structure preclude assessment of value of a given modality. RA patients. Presumptive marked differences in contact time (not quantified, but appear marked) bias towards intervention.

POST-OPERATIVE REHABILITATION AND REHABILITATION OF PATIENTS WITH FUNCTIONAL DEFICITS: CTS AND OTHER DISORDERS

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
POST-OPERATIVE SPLINTING						
Rocchi 2014 RCT No mention of sponsorship. No COI.	3.5	N = 30 with acute complete tear of ulnar collateral ligament (UCL) of thumb treated with surgery. Mean age 39 years.	Standard spica splint for 4 weeks with motion limited to IP joints (n =15) vs. Modified spica splint with freedom to move MCP joint for 4 weeks with motion on both the IP and MCP joints (n = 15). All patients provided flexion-extension exercises. Follow-up at 1, 2, 6, and 12 months.	No significant differences between groups (no p-values reported for study outcomes).	"This study suggests that the surgical repair of the skier's thumb lesion, combined with the immediate restoring of active MCP ROM protected by a modified spica splint is effective and safe and allows a faster return to manual activities compared to traditional method of postoperative splinting."	Small sample but data suggest the early motion management group had less pain at 2 months compared to controls and all functional measures became similar at 12 months. The lost work time is shortened in the early-motion group by 12 days.
Finsen 1999 RCT	3.5	N = 74 with NCS under-going open CTR	All bulky dressing for 2 days, then: 1) very light dressing and move wrist and fingers "as much as comfort allowed, but avoid heavy lifting for the first" 6 post-op weeks vs. plaster of Paris splint for 2 weeks and rigid orthosis for 2 more weeks.	"Physiotherapy was usually not prescribed," apparently as an uncontrolled confounder. VAS pain and discomfort scores (pre/2 weeks/6 weeks/6 months): Immobilized (56/6/6/3) vs. mobilized (51/5/2/2).	Authors conclude that "4 weeks of postoperative immobilization confers no detectable benefit."	Sparse data. Pseudorandomization on Norwegian social security number. NCS not required. Data suggest immobilization not indicated. No advantage to splinting after carpal tunnel relsease surgery.
Bury 1995 RCT	3.0	N = 40 open CTR patients with 43 carpal tunnel releases evaluated	2 weeks of post-op wrist splinting vs. a bulky dressing only	No statistically significant differences between two groups using subjective parameters of patient satisfaction with toutcome and objective parameters of grip and lateral pinch strength,	"We found no beneficial effect from postoperative splinting after open carpal tunnel release when compared to a bulky dressing alone."	

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				complication rates, and digital and wrist range of motion. No clinical evidence of bowstringing could be noted in either group of patients.		
Martins 2006 RCT	3.0	N = 52 EDS con-firmed	Post-op immobilization vs. no immobilization for open CTR patients	Average of SSS was 33.38±7.33 in group A and 31.77±7.56 in group B. Post-op, SSS average 11.38±4.57 in group A, and 12.33±4.77 in group B (p = 0.059).	"Wrist immobilization in the immediate post-operative period have no advantages when compared with no immobilization in the end result of carpal tunnel release."	
POST-OPERATIVE REHABILITATION						
Follow-up After CTR						
Atherton 1999 RCT	4.0	N = 100 with CTR	Follow-up with general practitioner vs. hand clinic with 2-week follow-up.	More wound infections diagnosed in general practice setting (14% vs. 0%). Authors believe "most were given antibiotics, perhaps unnecessarily."	"The waiting time for assessment and suture removal was shorter at the GP surgery than in the outpatient department… but significantly more patients were diagnosed as having wound infections."	Sparse details; 1 page report. Randomization unclear. No data on risks for infection. CTR procedure not described. Limitations result low-quality study despite 4.0 grading.
Physiotherapy Post-Op						
Naik 2007 RCT No mention of sponsorship or COI.	2.5	N = 30 with Colles' fracture who underwent external fixation and removed after 2 months. Age not reported.	Maitland mobilization technique: moist heat 15 minutes followed by Maitland manipulations (Grade 1 and 2) for 1st week of treatment then Grade 3 and 4 2nd week. (n = 15) vs. Mulligan mobilization technique: most heat for 15 minutes, Mulligan manipulations in pain free glides (n = 15). No mention of follow-up time.	Mean±SD pain relief (Maitland vs. Mulligan): 3.93±1.09 vs. 4.73±1.03 (p = 0.029). Mean±SD ROM (Maitland vs. Mulligan): active ROM 12.060±6.37 vs. 7.730±2.37 (p = 0.020); passive ROM 14.460±8.67 vs. 9.660±2.89 (p=0.05). Mean±SD scores for functional tasks (Maitland vs. Mulligan): 3.2±0.86 vs. 4.4±1.05 (p = 0.002).	"Mulligan's mobilization technique could be used effectively when the pain predominates while Maitland's mobilization technique could be effectively used to restore mobility when pain is not the major concern to patients with colles' fracture."	Small sample (N = 30). Sparse methodology. Data suggest Mulligan's better for pain relief.
Physical Therapy/Occupational Therapy						
Rasotto 2015 RCT Sponsored by Italian Workers' Compensation Authority (INAIL). COI, Rassotto	3.5	N = 68 assembly line workers; no exercise contra-indications. Mean age 41.10±7.69 years.	Intervention group (IG): 2 exercise sessions per week for 9 months; each session 30 minutes of warm-up exercises, then tailored program (3 series of 5 exercises each), and cool-down (n = 34) vs. control group (CG): continue to	Mean±SD difference in pain rating baseline to end of study (IG vs. CG): neck -1.29±2.72 vs. 0.39±2.51 (p = 0.0164); shoulder -0.94±1.09 vs. 0.17±2.02 (p=0.0224); wrist -1.40±1.87 vs. -0.39±0.93 (p = 0.0007).	"This personalized approach suggests a greater effect than a non-personalized standard protocol; however any potential longer term value of customized exercise program deserves further investigation."	Very high dropout and non-compliance in exercise arm. Individualized treatment. Data suggest strength training may reduce neck and wrist pain among those relatively few who remained

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received a grant from INAIL.			perform normal daily activities (n = 34). Follow-up at 5 months and within 2 weeks from end of study.			compliant. Data subject to non-interventional control bias.
Taylor 1994 RCT No mention of sponsorship or COI.	3.5	N = 30 following removal of plaster after Colles' fracture. Mean age 62.6±8.8 years.	Experimental group: 5 minutes Maitland passive joint mobilization; superficial heat; active exercises; home advice to use affected wrist/hand for all daily activities vs. control group: sham mobilization (soft tissue massage), superficial heat, active exercises, home advice treated 2x a week. Included in study until discharged from physiotherapy.	N no significant differences between groups.	"This clinical trial found that the inclusion of passive joint mobilisation into a physiotherapy treatment regime was no more effective than soft tissue massage at increasing the range of active wrist extension in Colles' fracture patients following removal of plaster."	Pilot study with small sample size. Data suggest comparable efficacy between passive joint mobilization and soft tissue massage.

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References

1. Karl JW, Olson PR, Rosenwasser MP. The Epidemiology of Upper Extremity Fractures in the United States, 2009. *J Orthop Trauma*. 2015;29(8):e242-4.
2. U.S. Department of Labor, Bureau of Labor Statistics. Nonfatal Occupational Injuries and Illnesses Requiring Days Away from Work, 2013. Available at: http://www.bls.gov/news.release/archives/osh2_12162014.pdf. 2013.
3. Shanahan EM, Jezukaitis P. Work related upper limb disorders. *Aust Fam Physician*. 2006;35(12):946-50.
4. Buckle PW, Devereux JJ. The nature of work-related neck and upper limb musculoskeletal disorders. *Appl Ergon*. 2002;33(3):207-17.
5. Wilson d'Almeida K, Godard C, Leclerc A, Lahon G. Sickness absence for upper limb disorders in a French company. *Occup Med (Lond)*. 2008;58(7):506-8.
6. Aroori S, Spence RA. Carpal tunnel syndrome. *Ulster Med J*. 2008;77(1):6-17.
7. Dieleman JP, Kerklaan J, Huygen FJ, Bouma PA, Sturkenboom MC. Incidence rates and treatment of neuropathic pain conditions in the general population. *Pain*. 2008;137(3):681-8.
8. El Miedany Y, Ashour S, Youssef S, Mehanna A, Meky FA. Clinical diagnosis of carpal tunnel syndrome: old tests-new concepts. *Joint Bone Spine*. 2008;75(4):451-7.
9. Lawrence RC, Felson DT, Helmick CG, et al. Estimates of the prevalence of arthritis and other rheumatic conditions in the United States. Part II. *Arthritis Rheum*. 2008;58(1):26-35.
10. Rempel D, Evanoff B, Amadio PC, et al. Consensus criteria for the classification of carpal tunnel syndrome in epidemiologic studies. *Am J Public Health*. 1998;88(10):1447-51.
11. Wilder-Smith EP, Ng ES, Chan YH, Therimadasamy AK. Sensory distribution indicates severity of median nerve damage in carpal tunnel syndrome. *Clin Neurophysiol*. 2008;119(7):1619-25.
12. Nathan PA, Keniston RC, Lockwood RS, Meadows KD. Tobacco, caffeine, alcohol, and carpal tunnel syndrome in American industry. A cross-sectional study of 1464 workers. *J Occup Environ Med*. 1996;38(3):290-8.
13. Stevens JC, Sun S, Beard CM, O'Fallon WM, Kurland LT. Carpal tunnel syndrome in Rochester, Minnesota, 1961 to 1980. *Neurology*. 1988;38(1):134-8.
14. Bednar MS, Arnoczky SP, Weiland AJ. The microvasculature of the triangular fibrocartilage complex: its clinical significance. *J Hand Surg Am*. 1991;16(6):1101-5.
15. Thiru RG, Ferlic DC, Clayton ML, McClure DC. Arterial anatomy of the triangular fibrocartilage of the wrist and its surgical significance. *J Hand Surg Am*. 1986;11(2):258-63.
16. Mikic ZD. Age changes in the triangular fibrocartilage of the wrist joint. *J Anat*. 1978;126(Pt 2):367-84.
17. Cody M, Nakamura D, Small K, Yoshioka H. MR imaging of the Triangular Fibrocartilage Complex. *Magn Reson Imaging Clin N Am*. 2015;23(3):393-403.
18. Clayton JM, Hayes AC, Barnes RW. Tissue pressure and perfusion in the compartment syndrome. *J Surg Res*. 1977;22(4):333-9.
19. Naidu SH, Heppenstall RB. Compartment syndrome of the forearm and hand. *Hand Clin*. 1994;10(1):13-27.
20. Clement R, Wray RC, Jr. Operative and nonoperative treatment of mallet finger. *Ann Plast Surg*. 1986;16(2):136-41.
21. Abouna JM, Brown H. The treatment of mallet finger. The results in a series of 148 consecutive cases and a review of the literature. *Br J Surg*. 1968;55(9):653-67.
22. Peterson JJ, Bancroft LW. Injuries of the fingers and thumb in the athlete. *Clin Sports Med*. 2006;25(3):527-42, vii-viii.
23. Finkelstein H. Stenosing tendovaginitis at the radial styloid process. *J Bone Joint Surg Am*. 1930;12(3):509 -40
24. Flörcken H. Zur Frage der stenosierenden Tendovaginitis am Processus styloideus radii. 1912(suppl):1378.
25. Hauck G. Ein beitrag zur anatomie und physiologied. Finger und hand-gelenksehnenscheiden. *Arch Chir Bd* 1910;S151:136.
26. Mulpruek P, Prichasuk S, Orapin S. Trigger finger in children. *J Pediatr Orthop*. 1998;18(2):239-41.
27. Ryzewicz M, Wolf JM. Trigger digits: principles, management, and complications. *J Hand Surg Am*. 2006;31(1):135-46.
28. Troell A. On tendovaginitis and tendinitis stenosans. *Acta Chir Scand*. 1921;547-16.
29. Kapellusch J, Garg A, Hegmann K, Thiese M, Malloy E. The Strain Index and ACGIH TLV for HAL: risk of trigger digit in the WISTAH prospective cohort. *Hum Factors*. 2014;56(1):98-111.
30. Fujiwara M. A case of trigger finger following partial laceration of flexor digitorum superficialis and review of the literature. *Arch Orthop Trauma Surg*. 2005;125(6):430-2.
31. Rhoades CE, Gelberman RH, Manjarris JF. Stenosing tenosynovitis of the fingers and thumb. Results of a prospective trial of steroid injection and splinting. *Clin Orthop Relat Res*. 1984(190):236-8.

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32. Buch-Jaeger N, Foucher G, Ehrler S, Sammut D. The results of conservative management of trigger finger. A series of 169 patients. *Ann Chir Main Memb Super*. 1992;11(3):189-93.
33. Gottlieb NL. Digital flexor tenosynovitis: diagnosis and clinical significance. *J Rheumatol*. 1991;18(7):954-5.
34. Yosipovitch G, Yosipovitch Z, Karp M, Mukamel M. Trigger finger in young patients with insulin dependent diabetes. *J Rheumatol*. 1990;17(7):951-2.
35. Sperling W. Snapping finger: roengten treatment and experimental production. *Acta Radiol*. 1951;3774-80.
36. Saldana MJ. Trigger digits: diagnosis and treatment. *J Am Acad Orthop Surg*. 2001;9(4):246-52.
37. Trezies AJ, Lyons AR, Fielding K, Davis TR. Is occupation an aetiological factor in the development of trigger finger? *J Hand Surg Br*. 1998;23(4):539-40.
38. Baumgarten KM, Gerlach D, Boyer MI. Corticosteroid injection in diabetic patients with trigger finger. A prospective, randomized, controlled double-blinded study. *J Bone Joint Surg Am*. 2007;89(12):2604-11.
39. Nimigan AS, Ross DC, Gan BS. Steroid injections in the management of trigger fingers. *Am J Phys Med Rehabil*. 2006;85(1):36-43.
40. Moore JS. Flexor tendon entrapment of the digits (trigger finger and trigger thumb). *J Occup Environ Med*. 2000;42(5):526-45.
41. Muckart RD. Stenosing tendovaginitis of abductor pollicis longus and extensor pollicis brevis at the radial styloid (de Quervain's disease). *Clin Orthop Relat Res*. 1964;33201-8.
42. Piligian G, Herbert R, Hearns M, Dropkin J, Landsbergis P, Cherniack M. Evaluation and management of chronic work-related musculoskeletal disorders of the distal upper extremity. *Am J Ind Med*. 2000;37(1):75-93.
43. Pantukosit S, Petchkrua W, Stiens SA. Intersection syndrome in Buriram Hospital: a 4-yr prospective study. *Am J Phys Med Rehabil*. 2001;80(9):656-61.
44. Grundberg AB, Reagan DS. Pathologic anatomy of the forearm: intersection syndrome. *J Hand Surg Am*. 1985;10(2):299-302.
45. Idler RS, Strickland JW, Creighton JJ, Jr. Intersection syndrome. *Indiana Med*. 1990;83(9):658-9.
46. Stern PJ. Tendinitis, overuse syndromes, and tendon injuries. *Hand Clin*. 1990;6(3):467-76.
47. Browne J, Helms CA. Intersection syndrome of the forearm. *Arthritis Rheum*. 2006;54(6):2038.
48. Amadio P. De Quervain's disease and tenosynovitis. *Repetitive motions disorders of the upper extremity Rosemont, IL: American Academy of Orthopaedic Surgeons*; 1995:435-48.
49. Kelsey J. *Epidemiology of Musculoskeletal Disorders*. New York: Oxford University Press; 1982.
50. Chiodo A, Chadd E. Ulnar neuropathy at or distal to the wrist: traumatic versus cumulative stress cases. *Arch Phys Med Rehabil*. 2007;88(4):504-12.
51. Wu JS, Morris JD, Hogan GR. Ulnar neuropathy at the wrist: case report and review of literature. *Arch Phys Med Rehabil*. 1985;66(11):785-8.
52. Ablett CT, Hackett LA. Hypothenar hammer syndrome: case reports and brief review. *Clin Med Res*. 2008;6(1):3-8.
53. Jalini L, Nice CA, Bhattacharya V. Ulnar artery thrombosis due to hypothenar hammer syndrome. *Recent Pat Cardiovasc Drug Discov*. 2007;2(2):139-42.
54. Kapoor JR, Kapoor R, Assimes TL. Digital ischemia. *J Cardiovasc Med (Hagerstown)*. 2008;9(12):1285-6.
55. Marie I, Herve F, Primard E, Cailleux N, Levesque H. Long-term follow-up of hypothenar hammer syndrome: a series of 47 patients. *Medicine (Baltimore)*. 2007;86(6):334-43.
56. Dethmers RS, Houpt P. Surgical management of hypothenar and thenar hammer syndromes: a retrospective study of 31 instances in 28 patients. *J Hand Surg Br*. 2005;30(4):419-23.
57. Seror P, Lestrade M, Vacher H. Ulnar nerve compression at the wrist by a synovial cyst successfully treated with percutaneous puncture and corticosteroid injection. *Joint Bone Spine*. 2000;67(2):127-8.
58. Carlson N, Logigian EL. Radial neuropathy. *Neurol Clin*. 1999;17(3):499-523, vi.
59. Eaton CJ, Lister GD. Radial nerve compression. *Hand Clin*. 1992;8(2):345-57.
60. Plate AM, Green SM. Compressive radial neuropathies. *Instr Course Lect*. 2000;49295-304.
61. Tryfonidis M, Jass GK, Charalambous CP, Jacob S. Superficial branch of the radial nerve piercing the brachioradialis tendon to become subcutaneous: an anatomical variation with clinical relevance. *Hand Surg*. 2004;9(2):191-5.
62. Turkof E, Puig S, Choi SS, Zoch G, Dellon AL. The radial sensory nerve entrapped between the two slips of a split brachioradialis tendon: a rare aspect of Wartenberg's syndrome. *J Hand Surg Am*. 1995;20(4):676-8.
63. Adeyemi-Doro HO. Pattern of peripheral traumatic neuropathy of the upper limb in Lagos. *Injury*. 1988;19(5):329-32.
64. Wright TW, Glowczewskie F, Jr., Cowin D, Wheeler DL. Radial nerve excursion and strain at the elbow and wrist associated with upper-extremity motion. *J Hand Surg [Am]*. 2005;30(5):990-6.
65. Tzeng CY, Lee TS, Chen IC. Superficial radial nerve compression caused by a parosteal lipoma of proximal radius: a case report. *Hand Surg*. 2005;10(2-3):293-6.

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66. Lanzetta M, Foucher G. Entrapment of the superficial branch of the radial nerve (Wartenberg's syndrome). A report of 52 cases. *Int Orthop*. 1993;17(6):342-5.
67. MacIver H, Smyth G, Bird HA. Occupational disorders: non-specific forearm pain. *Best Pract Res Clin Rheumatol*. 2007;21(2):349-65.
68. Klein DM, Belsole RJ. Percutaneous treatment of carpal, metacarpal, and phalangeal injuries. *Clin Orthop Relat Res*. 2000(375):116-25.
69. Yin ZG, Zhang JB, Kan SL, Wang P. Treatment of acute scaphoid fractures: systematic review and meta-analysis. *Clin Orthop Relat Res*. 2007;460142-51.
70. Phillips TG, Reibach AM, Slomiany WP. Diagnosis and management of scaphoid fractures. *Am Fam Physician*. 2004;70(5):879-84.
71. Schubert HE. Scaphoid fracture. Review of diagnostic tests and treatment. *Can Fam Physician*. 2000;461825-32.
72. Golden GT, David D, Smith TE, et al. Fractures of the phalanges and metacarpals: An analysis of 555 fractures. *Journal of the American College of Emergency Physicians*. 1977;6(3):79-84.
73. Frazier WH, Miller M, Fox RS, Brand D, Finseth F. Hand injuries: incidence and epidemiology in an emergency service. *JACEP*. 1978;7(7):265-8.
74. Butt WD. Fractures of the hand. II. Statistical review. *Can Med Assoc J*. 1962;86775-9.
75. Seaberg DC, Angelos WJ, Paris PM. Treatment of subungual hematomas with nail trephination: a prospective study. *Am J Emerg Med*. 1991;9(3):209-10.
76. Simon RR, Wolgin M. Subungual hematoma: association with occult laceration requiring repair. *Am J Emerg Med*. 1987;5(4):302-4.
77. Bowman SH, Simon RR. Metacarpal and phalangeal fractures. *Emerg Med Clin North Am*. 1993;11(3):671-702.
78. Lee SG, Jupiter JB. Phalangeal and metacarpal fractures of the hand. *Hand Clin*. 2000;16(3):323-32, vii.
79. Hove LM. Fractures of the hand. Distribution and relative incidence. *Scand J Plast Reconstr Surg Hand Surg*. 1993;27(4):317-9.
80. Freeland AE, Hardy MA, Singletary S. Rehabilitation for proximal phalangeal fractures. *J Hand Ther*. 2003;16(2):129-42.
81. Giddins G. The non-operative management of hand fractures. *J Hand Surg* 2015;40(1):33-41.
82. McMurtry RY, Paley D, Marks P, Axelrod T. A critical analysis of Swanson ulnar head replacement arthroplasty: rheumatoid versus nonrheumatoid. *J Hand Surg Am*. 1990;15(2):224-31.
83. Reyes FA, Latta LL. Conservative management of difficult phalangeal fractures. *Clin Orthop Relat Res*. 1987(214):23-30.
84. McNemar TB, Howell JW, Chang E. Management of metacarpal fractures. *J Hand Ther*. 2003;16(2):143-51.
85. Green D, Butler T. *Fractures and dislocations in the hand. In: Rockwood and Green's Fractures in Adults. Vol 1. 4th ed.* . Baltimore, Md: Lippincott Williams & Wilkins; 1996.
86. Gedda KO. Studies on Bennett's fracture; anatomy, roentgenology, and therapy. *Acta Chir Scand Suppl*. 1954;1931-114.
87. Kozin SH, Thoder JJ, Lieberman G. Operative treatment of metacarpal and phalangeal shaft fractures. *J Am Acad Orthop Surg*. 2000;8(2):111-21.
88. Leggit JC, Meko CJ. Acute finger injuries: part II. Fractures, dislocations, and thumb injuries. *Am Fam Physician*. 2006;73(5):827-34.
89. Freeland AE, Orbay JL. Extraarticular hand fractures in adults: a review of new developments. *Clin Orthop Relat Res*. 2006;445133-45.
90. Hanel DP, Jones MD, Trumble TE. Wrist fractures. *Orthop Clin North Am*. 2002;33(1):35-57, vii.
91. Thurston AJ. 'Ao' or eponyms: the classification of wrist fractures. *ANZ J Surg*. 2005;75(5):347-55.
92. Colles A. On the fracture of the carpal extremity of the radius. Edinb Med Surg J. 1814;10:181. *Clin Orthop Relat Res*. 2006;4455-7.
93. Jupiter JB. Complex Articular Fractures of the Distal Radius: Classification and Management. *J Am Acad Orthop Surg*. 1997;5(3):119-29.
94. Shah HM, Chung KC. Robert William Smith: his life and his contributions to medicine. *J Hand Surg Am*. 2008;33(6):948-51.
95. Resnick D. *Physical injury: extraspinal sites. In: Diagnosis of Bone and Joint Disorders. 4th ed.* Philadelphia, PA: WB Saunders; 2002.
96. Richards RS, Bennett JD, Roth JH, Milne K, Jr. Arthroscopic diagnosis of intra-articular soft tissue injuries associated with distal radial fractures. *J Hand Surg Am*. 1997;22(5):772-6.
97. Bruckner JD, Alexander AH, Lichtman DM. Acute dislocations of the distal radioulnar joint. *Instr Course Lect*. 1996;4527-36.

Copyright© 2016 Reed Group, Ltd.

98. Pye SR ONT, Lunt M, et al. Risk factors for Colles' fracture in men and women: results from the European Prospective Osteoporosis Study. *Osteoporosis Intl*. 2003;14(3):213-8.
99. Hung VS, Bodavula VK, Dubin NH. Digital anaesthesia: comparison of the efficacy and pain associated with three digital nerve block techniques. *J Hand Surg [Br]*. 2005;30(6):581-4.
100. Vogt MT, Cauley JA, Tomaino MM, Stone K, Williams JR, Herndon JH. Distal radius fractures in older women: a 10-year follow-up study of descriptive characteristics and risk factors. The study of osteoporotic fractures. *J Am Geriatr Soc*. 2002;50(1):97-103.
101. Ahn AK, Chang D, Plate AM. Triangular fibrocartilage complex tears: a review. *Bull NYU Hosp Jt Dis*. 2006;64(3-4):114-8.
102. Schmidt H. The anatomy of the ulnocarpal complex. *Orthopade*. 2004;33(6):628-37.
103. Naqvi SG, Reynolds T, Kitsis C. Interobserver reliability and intraobserver reproducibility of the Fernandez classification for distal radius fractures. *J Hand Surg Eur Vol*. 2009;34(4):483-5.
104. Andersen DJ, Blair WF, Steyers CM, Jr., Adams BD, el-Khouri GY, Brandser EA. Classification of distal radius fractures: an analysis of interobserver reliability and intraobserver reproducibility. *J Hand Surg Am*. 1996;21(4):574-82.
105. Cooney W, Linscheid L, Dobyns J. Fractures and dislocations of the wrist. In: Rockwood CJ, Green D, eds. *Fractures in Adults*. Philadelphia, Pa: JB Lippincott; 1996:745-820.
106. Stoffelen D, Broos P. Minimally displaced distal radius fractures: do they need plaster treatment? *J Trauma*. 1998;44(3):503-5.
107. Cooney WP, 3rd, Linscheid RL, Dobyns JH. External pin fixation for unstable Colles' fractures. *J Bone Joint Surg Am*. 1979;61(6A):840-5.
108. Vaughan PA, Lui SM, Harrington IJ, Maistrelli GL. Treatment of unstable fractures of the distal radius by external fixation. *J Bone Joint Surg Br*. 1985;67(3):385-9.
109. van Eerten PV, Lindeboom R, Oosterkamp AE, Goslings JC. An X-ray template assessment for distal radial fractures. *Arch Orthop Trauma Surg*. 2008;128(2):217-21.
110. Cole RJ, Bindra RR, Evanoff BA, Gilula LA, Yamaguchi K, Gelberman RH. Radiographic evaluation of osseous displacement following intra-articular fractures of the distal radius: reliability of plain radiography versus computed tomography. *J Hand Surg Am*. 1997;22(5):792-800.
111. Flinkkila T, Raatikainen T, Hamalainen M. AO and Frykman's classifications of Colles' fracture. No prognostic value in 652 patients evaluated after 5 years. *Acta Orthop Scand*. 1998;69(1):77-81.
112. Thomason K, Smith KL. The reliability of measurements taken from computer-stored digitalised x-rays of acute distal radius fractures. *J Hand Surg Eur Vol*. 2008;33(3):369-72.
113. Tanaka S, Petersen M, Cameron L. Prevalence and risk factors of tendinitis and related disorders of the distal upper extremity among U.S. workers: comparison to carpal tunnel syndrome. *Am J Ind Med*. 2001;39(3):328-35.
114. Lowden CM, Attiah M, Garvin G, Macdermid JC, Osman S, Faber KJ. The prevalence of wrist ganglia in an asymptomatic population: magnetic resonance evaluation. *J Hand Surg Br*. 2005;30(3):302-6.
115. Limpaphayom N, Wilairatana V. Randomized controlled trial between surgery and aspiration combined with methylprednisolone acetate injection plus wrist immobilization in the treatment of dorsal carpal ganglion. *J Med Assoc Thai*. 2004;87(12):1513-7.
116. Rizzo M, Berger RA, Steinmann SP, Bishop AT. Arthroscopic resection in the management of dorsal wrist ganglions: results with a minimum 2-year follow-up period. *J Hand Surg Am*. 2004;29(1):59-62.
117. Matthews P. Ganglia of the flexor tendon sheaths in the hand. *J Bone Joint Surg Br*. 1973;55(3):612-7.
118. Gude W, Morelli V. Ganglion cysts of the wrist: pathophysiology, clinical picture, and management. *Curr Rev Musculoskelet Med*. 2008;1(3-4):205-11.
119. Schrank C, Meirer R, Stäbler A, Nerlich A, Reiser M, Putz R. Morphology and topography of intraosseous ganglion cysts in the carpus: an anatomic, histopathologic, and magnetic resonance imaging correlation study. *J Hand Surg Am*. 2003;28(1):52-61.
120. Thornburg L. Ganglions of the hand and wrist. *J Am Acad Orthop Surg*. 1999;7(4):231-8.
121. Young L, Bartell T, Logan S. Ganglions of the hand and wrist. *South Med J*. 1988;81(6):751-60.
122. Cherniack M, Brammer AJ, Lundstrom R, et al. The Hand-Arm Vibration International Consortium (HAVIC): prospective studies on the relationship between power tool exposure and health effects. *Journal of occupational and environmental medicine*. 2007;49(3):289-301.
123. Lin W, Chunzhi Z, Qiang Z, Kai Z, Xiaoli Z. The study on hand-arm vibration syndrome in China. *Ind Health*. 2005;43(3):480-3.
124. Bovenzi M, Ronchese F, Mauro M. A longitudinal study of peripheral sensory function in vibration-exposed workers. *Int Arch Occup Environ Health*. 2011;84(3):325-34.

Copyright© 2016 Reed Group, Ltd.

125. Åström C, Rehn B, Lundström R, Nilsson T, Burström L, Sundelin G. Hand-arm vibration syndrome (HAVS) and musculoskeletal symptoms in the neck and the upper limbs in professional drivers of terrain vehicles—a cross sectional study. *Appl Ergon*. 2006;37(6):793-9.
126. Pyykko I. Clinical aspects of the hand-arm vibration syndrome. A review. *Scand J Work Environ Health*. 1986;12(5):439-47.
127. Pelmear PL, Leong D. Review of occupational standards and guidelines for hand-arm (segmental) vibration syndrome (HAVS). *Appl Occup Environ Hyg*. 2000;15(3):291-302.
128. Sutinen P, Toppila E, Starck J, Brammer A, Zou J, Pyykko I. Hand-arm vibration syndrome with use of anti-vibration chain saws: 19-year follow-up study of forestry workers. *Int Arch Occup Environ Health*. 2006;79(8):665-71.
129. Pelmear PL, Taylor W. Hand-arm vibration syndrome. *J Fam Pract*. 1994;38(2):180-5.
130. Sauni R, Paakkonen R, Virtema P, et al. Vibration-induced white finger syndrome and carpal tunnel syndrome among Finnish metal workers. *Int Arch Occup Environ Health*. 2009;82(4):445-53.
131. Falkiner S. Diagnosis and treatment of hand-arm vibration syndrome and its relationship to carpal tunnel syndrome. *Aust fam Physician*. 2003;32(7):530-4.
132. Fenga C, Rapisarda V, Valentino M, et al. Hand-arm vibration syndrome and upper limbs diseases in the forest workers of Italia meridionale. *G Ital Med Lav Ergon*. 2007;29(3 Suppl):592-3.
133. Chetter IC, Kent PJ, Kester RC. The hand arm vibration syndrome: a review. *Cardiovasc Surg*. 1998;6(1):1-9.
134. Govindaraju SR, Bain JL, Eddinger TJ, Riley DA. Vibration causes acute vascular injury in a two-step process: vasoconstriction and vacuole disruption. *Anat Rec (Hoboken)*. 2008;291(8):999-1006.
135. Krajnak K, Dong R, Flavahan S, Welcome D, Flavahan N. Acute vibration increases α2C-adrenergic smooth muscle constriction and alters thermosensitivity of cutaneous arteries. *Journal of Applied Physiology*. 2006;100(4):1230-7.
136. Bovenzi M, D'Agostin F, Rui F, Ambrosi L, Zefferino R. Salivary endothelin and vascular disorders in vibration-exposed workers. *Scand J Work Environ Health*. 2008;34(2):133-41.
137. Pelmear PL. The clinical assessment of hand-arm vibration syndrome. *Occup Med (Lond)*. 2003;53(5):337-41.
138. ISO I. 5349-1: Mechanical vibration—measurement and evaluation of human exposure to hand-transmitted vibration—part 1: general requirements. *Geneva, Switzerland: International Organization for Standardization*; 2001.
139. Sauni R, Paakkonen R, Virtema P, Toppila E, Uitti J. Dose-response relationship between exposure to hand-arm vibration and health effects among metalworkers. *Ann Occup Hyg*. 2009;53(1):55-62.
140. Krajnak K, Riley DA, Wu J, et al. Frequency-dependent effects of vibration on physiological systems: experiments with animals and other human surrogates. *Ind Health*. 2012;50(5):343-53.
141. American National Standards Institute. (revision/replacement of ANSI S3.34-1986) ANSI S2.70-2006: Guide for the Measurement and Evaluation of Human Exposure to Vibration Transmitted to the Hand. New York, May 2006.
142. The National Institute for Occupational Safety and Health. Criteria for a recommended standard. Occupational Exposure to Hand-Arm Vibration. Washington, DC: Department of Health and Human Services; 1989. DHHS Publication no. 89-106.
143. American Conference of Governmental Industrial Hygienists (ACGIH). *Guide to Occupational Exposure Guidelines*. Cincinnati, OH: ACGIH; 2009.
144. Bovenzi M. Exposure-response relationship in the hand-arm vibration syndrome: an overview of current epidemiology research. *Int Arch Occup Environ Health*. 1998;71(8):509-19.
145. Gell N, Werner RA, Franzblau A, Ulin SS, Armstrong TJ. A longitudinal study of industrial and clerical workers: incidence of carpal tunnel syndrome and assessment of risk factors. *J Occup Rehabil*. 2005;15(1):47-55.
146. Garg A, Kapellusch J, Hegmann K, et al. The Strain Index (SI) and Threshold Limit Value (TLV) for Hand Activity Level (HAL): risk of carpal tunnel syndrome (CTS) in a prospective cohort. *Ergonomics*. 2012;55(4):396-414.
147. Hollander J, Blasko B, Singer A, Valentine S, Thode H, Jr, Henry M. Poor correlation of short- and long-term cosmetic appearance of repaired lacerations. *Acad Emerg Med*. 1995;2(11):983-7.
148. Pearson A, Wolford R. Management of skin trauma. *Prim Care*. 2000;27(2):475-92.
149. Cheung K, Hatchell A, Thoma A. Approach to traumatic hand injuries for primary care physicians. *Can Fam Physician*. 2013;59(6):614-8.
150. Singer AJ, Hollander JE. Tissue adhesives for laceration closure. *Jama*. 1997;278(9):703-4.
151. Singer AJ, Hollander JE, Valentine SM, Turque TW, McCuskey CF, Quinn JV. Prospective, randomized, controlled trial of tissue adhesive (2-octylcyanoacrylate) vs standard wound closure techniques for laceration repair. Stony Brook Octylcyanoacrylate Study Group. *Acad Emerg Med*. 1998;5(2):94-9.

Copyright© 2016 Reed Group, Ltd.

152. Wood PB. Wound infection in undressed sutured wounds of the hand. *Br J Surg*. 1971;58(7):543-5.
153. Patrick GR, O'Rourke KM. Dog and cat bites: epidemiologic analyses suggest different prevention strategies. *Public Health Rep*. 1998;113(3):252-7.
154. Weiss HB, Friedman DI, Coben JH. Incidence of dog bite injuries treated in emergency departments. *JAMA*. 1998;279(1):51-3.
155. Control CfD, Prevention. Nonfatal dog bite-related injuries treated in hospital emergency departments--United States, 2001. *MMWR: Morbidity and mortality weekly report*. 2003;52(26):605-10.
156. O'Neil ME, Mack KA, Gilchrist J. Epidemiology of non-canine bite and sting injuries treated in U.S. emergency departments, 2001-2004. *Public Health Rep*. 2007;122(6):764-75.
157. Jeyaretnam J, Jones H. Physical, chemical and biological hazards in veterinary practice. *Aust Vet J*. 2000;78(11):751-8.
158. Cancio-Bello TP, de Medina M, Shorey J, Valledor MD, Schiff ER. An institutional outbreak of hepatitis B related to a human biting carrier. *J Infect Dis*. 1982;146(5):652-6.
159. Solomons HC, Elardo R. Biting in day care centers: incidence, prevention, and intervention. *J Pediatr Health Care*. 1991;5(4):191-6.
160. Conlon HA. Human bites in the classroom: incidence, treatment, and complications. *J Sch Nurs*. 2007;23(4):197-201.
161. Sonder GJ, Bovee LP, Coutinho RA, Baayen D, Spaargaren J, van den Hoek A. Occupational exposure to bloodborne viruses in the Amsterdam police force, 2000-2003. *Am J Prev Med*. 2005;28(2):169-74.
162. Boenning D, GR F, JM C. Dog bites in children: Epidemiology, microbiology and penicillin prophylatic therapy. *Am J Emerg Med*. 1983;117-21.
163. Skurka J, Willert C, Yogev R. Wound infection following dog bite despite prophylactic penicillin. *Infection*. 1986;14(3):134-5.
164. Zubowicz VN, Gravier M. Management of early human bites of the hand: a prospective randomized study. *Plast Reconstr Surg*. 1991;88(1):111-4.
165. Irlenbusch U, Dominick G. Investigations in generalized osteoarthritis. Part 2: special histological features in generalized osteoarthritis (histological investigations in Heberden's nodes using a histological score). *Osteoarthritis and cartilage*. 2006;14(5):428-34.
166. Irlenbusch U, Schäller T. Investigations in generalized osteoarthritis. Part 1: genetic study of Heberden's nodes. *Osteoarthritis and cartilage*. 2006;14(5):423-7.
167. Chan L, Turner JA, Comstock BA, et al. The relationship between electrodiagnostic findings and patient symptoms and function in carpal tunnel syndrome. *Arch Phys Med Rehabil*. 2007;88(1):19-24.
168. Dale AM, Strickland J, Symanzik J, Franzblau A, Evanoff B. Reliability of hand diagrams for the epidemiologic case definition of carpal tunnel syndrome. *J Occup Rehabil*. 2008;18(3):233-48.
169. Burke DT, Burke MA, Bell R, Stewart GW, Mehdi RS, Kim HJ. Subjective swelling: a new sign for carpal tunnel syndrome. *Am J Phys Med Rehabil*. 1999;78(6):504-8.
170. Franzblau A, Flaschner D, Albers JW, Blitz S, Werner R, Armstrong T. Medical screening of office workers for upper extremity cumulative trauma disorders. *Arch Environ Health*. 1993;48(3):164-70.
171. Franzblau A, Werner RA, Johnston E, Torrey S. Evaluation of current perception threshold testing as a screening procedure for carpal tunnel syndrome among industrial workers. *J Occup Med*. 1994;36(9):1015-21.
172. Katz JN, Larson MG, Sabra A, et al. The carpal tunnel syndrome: diagnostic utility of the history and physical examination findings. *Ann Intern Med*. 1990;112(5):321-7.
173. Katz JN, Stirrat CR. A self-administered hand diagram for the diagnosis of carpal tunnel syndrome. *J Hand Surg [Am]*. 1990;15(2):360-3.
174. Katz JN, Stirrat CR, Larson MG, Fossel AH, Eaton HM, Liang MH. A self-administered hand symptom diagram for the diagnosis and epidemiologic study of carpal tunnel syndrome. *J Rheumatol*. 1990;17(11):1495-8.
175. Armstrong T, Dale AM, Franzblau A, Evanoff BA. Risk factors for carpal tunnel syndrome and median neuropathy in a working population. *J Occup Environ Med*. 2008;50(12):1355-64.
176. Atroshi I, Gummesson C, Johnsson R, Ornstein E, Ranstam J, Rosen I. Prevalence of carpal tunnel syndrome in a general population. *Jama*. 1999;282(2):153-8.
177. Charles N, Vial C, Chauplannaz G, Bady B. Clinical validation of antidromic stimulation of the ring finger in early electrodiagnosis of mild carpal tunnel syndrome. *Electroencephalogr Clin Neurophysiol*. 1990;76(2):142-7.
178. Hegmann KT, Garg A, Wertsch J, MS. T. Prevalence of Median Nerve Related Symptoms and Signs in a Cohort at Baseline. Presented at the Fifth International Scientific Conference on Prevention of Work-related Musculoskeletal Disorders. ETH Zurich, Zurich, Switzerland. July 13, 2004. Premus. 2004485-6.
179. Jablecki CK, Andary MT, Floeter MK, et al. WITHDRAWN: Second AAEM literature review of the usefulness of nerve conduction studies and needle electromyography for the evaluation of patients with carpal tunnel syndrome. *Muscle Nerve*. 2002.

Copyright© 2016 Reed Group, Ltd.

180. Makanji H, Zhao M, Mudgal C, Jupiter J, Ring D. Correspondence between clinical presentation and electrophysiological testing for potential carpal tunnel syndrome. *J Hand Surg*. 2013;38(5):489-95.
181. Salerno DF, Franzblau A, Werner RA, Bromberg MB, Armstrong TJ, Albers JW. Median and ulnar nerve conduction studies among workers: normative values. *Muscle Nerve*. 1998;21(8):999-1005.
182. Seror P. Sensitivity of the various tests for the diagnosis of carpal tunnel syndrome. *Journal of Hand Surgery (British and European Volume)*. 1994;19(6):725-8.
183. Stevens JC. AAEE minimonograph #26: The electrodiagnosis of carpal tunnel syndrome. *Muscle Nerve*. 1987;10(2):99-113.
184. Uncini A, Di Muzio A, Awad J, Manente G, Tafuro M, Gambi D. Sensitivity of three median-to-ulnar comparative tests in diagnosis of mild carpal tunnel syndrome. *Muscle Nerve*. 1993;16(12):1366-73.
185. Werner RA, Franzblau A, Gell N, Hartigan AG, Ebersole M, Armstrong TJ. Incidence of carpal tunnel syndrome among automobile assembly workers and assessment of risk factors. *J Occup Environ Med*. 2005;47(10):1044-50.
186. Wong S, Griffith J, Hui A, Tang A, Wong K. Discriminatory sonographic criteria for the diagnosis of carpal tunnel syndrome. *Arthritis & Rheumatism*. 2002;46(7):1914-21.
187. Wong SM, Griffith JF, Hui AC, Lo SK, Fu M, Wong KS. Carpal Tunnel Syndrome: Diagnostic Usefulness of Sonography 1. *Radiology*. 2004;232(1):93-9.
188. Dale AM, Harris-Adamson C, Rempel D, et al. Prevalence and incidence of carpal tunnel syndrome in US working populations: pooled analysis of six prospective studies. *Scand J Work Environ Health*. 2013;39(5):495-505.
189. Thiese MS, Gerr F, Hegmann KT, et al. Effects of Varying Case Definition on Carpal Tunnel Syndrome Prevalence Estimates in a Pooled Cohort. *Arch Phys Med Rehabil*. 2014;95(12):2320-6.
190. Fahey J, Bollinger J. Trigger-finger in adults and children. *The Journal of Bone & Joint Surgery*. 1954;36(6):1200-18.
191. Quinnell R. Conservative management of trigger finger. *The Practitioner*. 1980;224(1340):187-90.
192. Compere E. Bilateral snapping thumbs. *Ann Surg*. 1933;97(5):773-7.
193. Kolind-Sorensen V. Treatment of trigger fingers. *Acta Orthop Scand*. 1970;41(4):428-32.
194. Ho P, Griffiths J, Lo W, Yen C, Hung L. Current treatment of ganglion of the wrist. *Hand Surgery*. 2001;6(01):49-58.
195. Singer AJ, Hollander JE, Quinn JV. Evaluation and management of traumatic lacerations. *N Engl J Med*. 1997;337(16):1142-8.
196. Balci K, Utku U. Carpal tunnel syndrome and metabolic syndrome. *Acta Neurol Scand*. 2007;116(2):113-7.
197. Bernard BP. Musculoskeletal Disorders and Workplace Factors. A Critical Review of Epidemiologic Evidence for Work-Related Musculoskeletal Disorders of the Neck, Upper Extremity, and Low Back. *National Institute for Occupational Safety and Health*. 1997.
198. Chammas M, Bousquet P, Renard E, Poirier J-L, Jaffiol C, Allieu Y. Dupuytren's disease, carpal tunnel syndrome, trigger finger, and diabetes mellitus. *J Hand Surg Am*. 1995;20(1):109-14.
199. Gelfman R, Melton L, Yawn B, Wollan P, Amadio P, Stevens J. Long-term trends in carpal tunnel syndrome. *Neurology*. 2009;72(1):33-41.
200. Goodson JT, DeBerard MS, Wheeler AJ, Colledge AL. Occupational and biopsychosocial risk factors for carpal tunnel syndrome. *Journal of Occupational and Environmental Medicine*. 2014;56(9):965-72.
201. Hanrahan LP, Higgins D, Anderson H, Smith M. Wisconsin occupational carpal tunnel syndrome surveillance: the incidence of surgically treated cases. *Wis Med J*. 1993;92(12):685-9.
202. Nathan PA, Keniston RC, Myers LD, Meadows KD. Obesity as a risk factor for slowing of sensory conduction of the median nerve in industry. A cross-sectional and longitudinal study involving 429 workers. *J Occup Med*. 1992;34(4):379-83.
203. Renard E, Jacques D, Chammas M, et al. Increased prevalence of soft tissue hand lesions in type 1 and type 2 diabetes mellitus: various entities and associated significance. *Diabete Metab*. 1994;20(6):513-21.
204. Roquelaure Y, Mechali S, Dano C, et al. Occupational and personal risk factors for carpal tunnel syndrome in industrial workers. *Scand J Work Environ Health*. 1997;23(5):364-9.
205. Mondelli M, Aprile I, Ballerini M, et al. Sex differences in carpal tunnel syndrome: comparison of surgical and non-surgical populations. *Eur J Neurol*. 2005;12(12):976-83.
206. Mondelli M, Rossi S, Monti E, et al. Long term follow-up of carpal tunnel syndrome during pregnancy: a cohort study and review of the literature. *Electromyogr Clin Neurophysiol*. 2007;47(6):259-71.
207. Silverstein BA, Fine LJ, Armstrong TJ. Occupational factors and carpal tunnel syndrome. *Am J Ind Med*. 1987;11(3):343-58.
208. Solomon DH, Katz JN, Bohn R, Mogun H, Avorn J. Nonoccupational risk factors for carpal tunnel syndrome. *J Gen Intern Med*. 1999;14(5):310-4.

Copyright© 2016 Reed Group, Ltd.

209. Tanaka S, Wild DK, Cameron LL, Freund E. Association of occupational and non-occupational risk factors with the prevalence of self-reported carpal tunnel syndrome in a national survey of the working population. *Am J Ind Med*. 1997;32(5):550-6.
210. Werner RA, Albers JW, Franzblau A, Armstrong TJ. The relationship between body mass index and the diagnosis of carpal tunnel syndrome. *Muscle Nerve*. 1994;17(6):632-6.
211. Wolf JM, Mountcastle S, Owens BD. Incidence of carpal tunnel syndrome in the US military population. *Hand (N Y)*. 2009;4(3):289-93.
212. Institute of Medicine, Panel on Musculoskeletal Disorders and the Workplace Commission on Behavioral and Social Sciences and Education National Research Council and Institute of Medicine. *Musculoskeletal Disorders and the Workplace. Low Back and Upper Extremities.* Washington, D.C.: National Academy Press; 2001.
213. Bonfiglioli R, Mattioli S, Armstrong TJ, et al. Validation of the ACGIH TLV for hand activity level in the OCTOPUS cohort: a two-year longitudinal study of carpal tunnel syndrome. *Scand J Work Environ Health*. 2013;39(2):155-63.
214. Burt S, Deddens JA, Crombie K, Jin Y, Wurzelbacher S, Ramsey J. A prospective study of carpal tunnel syndrome: workplace and individual risk factors. *Occup Environ Med*. 2013;70(8):568-74.
215. Evanoff B, Dale AM, Deych E, Ryan D, Franzblau A. Risk factors for incident carpal tunnel syndrome: results of a prospective cohort study of newly-hired workers. *Work*. 2012;41 Suppl 14450-2.
216. Harris-Adamson C, Eisen E, Kapellusch J, et al. Biomechanical risk factors for carpal tunnel syndrome: a pooled study of 2474 workers. *Occup Environ Med*. 2015;72(1):33-41.
217. Harris-Adamson C, Eisen EA, Dale AM, et al. Personal and workplace psychosocial risk factors for carpal tunnel syndrome: a pooled study cohort. *Occup Environ Med*. 2013;70(8):529-37.
218. Kapellusch Jm JM, Gerr FE, Malloy EJ, et al. Exposure-response relationships for the ACGIH threshold limit value for hand-activity level: results from a pooled data study of carpal tunnel syndrome. *Scand J Work Environ Health*. 2014;40(6):610-20.
219. Violante FS, Armstrong TJ, Fiorentini C, et al. Carpal tunnel syndrome and manual work: a longitudinal study. *J Occup Environ Med*. 2007;49(11):1189-96.
220. Bednar JM, Osterman AL. The role of arthroscopy in the treatment of traumatic triangular fibrocartilage injuries. *Hand Clin*. 1994;10(4):605-14.
221. Haims AH, Schweitzer ME, Morrison WB, et al. Limitations of MR imaging in the diagnosis of peripheral tears of the triangular fibrocartilage of the wrist. *American Journal of Roentgenology*. 2002;178(2):419-22.
222. Coleman H. Injuries of the articular disc at the wrist. *J Bone Joint Surg [Br]*. 1960;42522-9.
223. Palmer AK. Triangular fibrocartilage complex lesions: a classification. *J Hand Surg Am*. 1989;14(4):594-606.
224. Palmer AK, Werner FW. The triangular fibrocartilage complex of the wrist—anatomy and function. *J Hand Surg Am*. 1981;6(2):153-62.
225. Melone Jr C, Nathan R. Traumatic Disruption of the Triangular Fibrocartilage Complex: Pathoanatomy. *Clin Orthop Relat Res*. 1992;27565-73.
226. Nagle DJ. Triangular fibrocartilage complex tears in the athlete. *Clin Sports Med*. 2001;20(1):155-66.
227. Dellaero DT, Levin LS. Compartment syndrome of the hand. Etiology, diagnosis, and treatment. *Am J Orthop (Belle Mead NJ)*. 1996;25(6):404-8.
228. McQueen MM, Christie J, Court-Brown CM. Compartment pressures after intramedullary nailing of the tibia. *J Bone Joint Surg Br*. 1990;72(3):395-7.
229. Moed BR, Strom DE. Compartment syndrome after closed intramedullary nailing of the tibia: a canine model and report of two cases. *J Orthop Trauma*. 1991;5(1):71-7.
230. Ouellette EA, Kelly R. Compartment syndromes of the hand. *J Bone Joint Surg Am*. 1996;78(10):1515-22.
231. Schnall SB, Vu-Rose T, Holtom PD, Doyle B, Stevanovic M. Tissue pressures in pyogenic flexor tenosynovitis of the finger. Compartment syndrome and its management. *J Bone Joint Surg Br*. 1996;78(5):793-5.
232. Melhorn JM, Ackerman W, Glass L, Deitz D. Understanding work-relatedness. In: Melhorn J, Ackerman W, eds. *Guides to the Evaluation of Disease and Injury Causation*. Chicago, Ill: AMA Press: Springer; 2008:13-32.
233. Freiberg A, Mulholland R, Levine R. Nonoperative treatment of trigger fingers and thumbs. *J Hand Surg Am*. 1989;14(3):553-8.
234. Hadji-Zavar A. Quervain's stenosing tenosynovitis and snapping finger]. *Z Unfallmed Berufskr*. 1959;52275-97.
235. Hauck G. Über eine Tendovaginitis stenosans der Beugesehnenscheide mit dem Phänomen des schnellenden Fingers. *Arch f Klin Chir*. 1923;123233.
236. Hume MC, Gellman H, McKellop H, Brumfield RH. Functional range of motion of the joints of the hand. *J Hand Surg Am*. 1990;15(2):240-3.
237. Lapidus P, Fenton R. Stenosing tenovaginitis at the wrist and fingers: report of 423 cases in 369 patients with 354 operations. *AMA archives of surgery*. 1952;64(4):475-87.

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238. Lenggenhager K. The genesis and therapy of the trigger finger. *Minnesota medicine*. 1969;52(1):11.
239. Lipscomb PR. Tenosynovitis of the hand and the wrist: carpal tunnel syndrome, de Quervain's disease, trigger digit. *Clin Orthop*. 1959;13(Spring):164-80.
240. Ploetz E. Funktioneller Bau und funktionelle Anpassung der Gleitsehnen. *Z Orthop*. 1938;67212-34.
241. Rayan GM. Stenosing tenosynovitis in bowlers. *Am J Sports Med*. 1990;18(2):214-5.
242. Sairanen E. The trigger finger as a rheumatic manifestation. *Acta Rheumatologica Scandinavica*. 1957;3(1-4):266-72.
243. Vogel K, Koob T. Structural specialization in tendons under compression. *Intl Rev Cytology*. 1989;115267-93.
244. Zelle OL, Schnepp KH. Snapping thumb: Tendovaginitis stenosans. *The American Journal of Surgery*. 1936;33(2):321-2.
245. Gorsche R, Wiley J, Renger R, Brant R, Gemer T, Sasyniuk T. Prevalence and incidence of stenosing flexor tenosynovitis (trigger finger) in a meat-packing plant. *J Occup Environ Med*. 1998;40(6):556-60.
246. Creighton Jr J, Idler R, Strickland J. Trigger finger and thumb. *Indiana medicine: the journal of the Indiana State Medical Association*. 1990;83(4):260-2.
247. Poulsen K. Sehnenscheidenentzündung im ersten Fach des Antibrachium, begleitet von Traktionsperiostitis am Processus styloideus radii. *DMW-Deutsche Medizinische Wochenschrift*. 1911;37(18):843-.
248. Thorpe A. Results of surgery for trigger finger. *Journal of Hand Surgery (British and European Volume)*. 1988;13(2):199-201.
249. Fogh-Andersen P. Digitus saltans. *Nord Med*. 1947;341151-2.
250. Moore JS. De Quervain's tenosynovitis. Stenosing tenosynovitis of the first dorsal compartment. *J Occup Environ Med*. 1997;39(10):990-1002.
251. Alberton GM, High WA, Shin AY, Bishop AT. Extensor triggering in de Quervain's stenosing tenosynovitis. *J Hand Surg Am*. 1999;24(6):1311-4.
252. Pelmear P, Leong D. Review of occupational standards and guidelines for hand-arm (segmental) vibration syndrome (HAVS). *Applied Occ Env Hygiene*. 2000;15(3):291-302.
253. D'Arcy CA, McGee S. The rational clinical examination. Does this patient have carpal tunnel syndrome? *JAMA*. 2000;283(23):3110-7.
254. Dale AM, Descatha A, Coomes J, Franzblau A, Evanoff B. Physical examination has a low yield in screening for carpal tunnel syndrome. *Am J Ind Med*. 2011;54(1):1-9.
255. Szabo RM, Slater RR, Farver TB, Stanton DB, Sharman WK. The value of diagnostic testing in carpal tunnel syndrome. *J Hand Surg Am*. 1999;24(4):704-14.
256. Boyer K, Wies J, Turkelson CM. Effects of bias on the results of diagnostic studies of carpal tunnel syndrome. *J Hand Surg Am*. 2009;34(6):1006-13.
257. Jerosch-Herold C. A study of the relative responsiveness of five sensibility tests for assessment of recovery after median nerve injury and repair. *Journal of Hand Surgery (British and European Volume)*. 2003;28(3):255-60.
258. Patel MR, Bassini L. A comparison of five tests for determining hand sensibility. *J Reconstr Microsurg*. 1999;15(7):523-6.
259. Rozental T, Beredjiklian P, Guyette T, Weiland A. Intra- and interobserver reliability of sensibility testing in asymptomatic individuals. *Ann Plast Surg*. 2000;44(6):605-9.
260. Strauch B, Lang A, Ferder M, Keyes-Ford M, Freeman K, Newstein D. The ten test. *Plast Reconstr Surg*. 1997;99(4):1074-8.
261. Sansone J, Gatzke A, Aslinia F, Rolak L, Yale S. Jules Tinel (1879-1952) and Paul Hoffmann (1884-1962). *Clin Med Res*. 2006;4(1):85-9.
262. Phalen GS. The carpal-tunnel syndrome. Seventeen years' experience in diagnosis and treatment of six hundred fifty-four hands. *J Bone Joint Surg Am*. 1966;48(2):211-28.
263. Tetro AM, Evanoff BA, Hollstien SB, Gelberman RH. A new provocative test for carpal tunnel syndrome. Assessment of wrist flexion and nerve compression. *J Bone Joint Surg Br*. 1998;80(3):493-8.
264. Maitra A, Dorani B. The conservative treatment of mallet finger with a simple splint: a case report. *Arch Emerg Med*. 1993;10(3):244-8.
265. Bates S. Flexor Tendon Anatomy. *Emedicine*. 2008.
266. Moore S, Garg A. Upper extremity disorders in a pork processing plant: relationships between job risk factors and morbidity. *Am Industrial Hygiene Assoc*. 1994;55(8):703-15.
267. Nasca R. " Trigger finger." A common hand problem. *J Arkansas Med Soc*. 1980;76(10):388.
268. An H. Trigger finger, a report on a series of cases. *The Medical journal of Malaysia*. 1978;33(1):7-9.
269. Berger M. Painful tendon problems of the hand: trigger thumb, trigger finger and de Quervain's syndrome. *Orthopaedic Nursing*. 1982;1(5):20-3.
270. Conklin JE, White WL. Stenosing tenosynovitis and its possible relation to the carpal tunnel syndrome. *The Surgical clinics of North America*. 1960;40531.

Copyright© 2016 Reed Group, Ltd.

271. Eastwood D, Gupta K, Johnson D. Percutaneous release of the trigger finger: an office procedure. *J Hand Surg Am*. 1992;17(1):114-7.
272. Gamstedt A, Holm-Glad J, OHLSON CG, Sundström M. Hand abnormalities are strongly associated with the duration of diabetes mellitus. *Journal of Internal Medicine*. 1993;234(2):189-93.
273. Griggs SM, Weiss A-PC, Lane LB, Schwenker C, Akelman E, Sachar K. Treatment of trigger finger in patients with diabetes mellitus. *J Hand Surg Am*. 1995;20(5):787-9.
274. Hombal J, Owen R. Carpal tunnel decompression and trigger digits. *Hand*. 1970;2(2):192-6.
275. Jahss S. Trigger finger in children. *Journal of the American Medical Association*. 1936;107(18):1463-4.
276. Kelly Jr A, Jacobson H. Hand Disability due to tenosynovitis *Industrial Med Surg*. 1964;33570.
277. Ranney D, Wells R, Moore A. Upper limb musculoskeletal disorders in highly repetitive industries: precise anatomical physical findings. *Ergonomics*. 1995;38(7):1408-23.
278. Sampson S, Wisch D, Badalamente M. Complications of conservative and surgical treatment of de Quervain's disease and trigger fingers. *Hand Clin*. 1994;10(1):73-82.
279. Hodgkins T, Lipscomb P. Bilateral trigger fingers in a child: report of case. *Proceedings of the staff meetings Mayo Clinic*; 1956:279.
280. Anderson B, Kaye S. Treatment of flexor tenosynovitis of the hand ('trigger finger') with corticosteroids. A prospective study of the response to local injection. *Arch Intern Med*. 1991;151(1):153-6.
281. Gould E. Treatment of tenosynovitis and ganglion. *Br Med J*. 1938;2415-6.
282. Griffiths D. Tenosynovitis and tendovaginitis. *Br Med J (Clin Res Ed)*. 1952;1645-7.
283. Khoo D, Carmichael SW, Spinner RJ. Ulnar nerve anatomy and compression. *Orthop Clin North Am*. 1996;27(2):317-38.
284. Freeland P. Scaphoid tubercle tenderness: a better indicator of scaphoid fractures? *Arch Emerg Med*. 1989;6(1):46-50.
285. Mallee WH, Henny EP, van Dijk CN, Kamminga SP, van Enst WA, Kloen P. Clinical diagnostic evaluation for scaphoid fractures: a systematic review and meta-analysis. *J Hand Surg Am*. 2014;39(9):1683-91 e2.
286. Hankin F, Smith P, Braunstein E. Evaluation of the carpal scaphoid. *Am Fam Physician*. 1986;34(2):129-32.
287. Cockshott W. Distal avulsion fractures of the scaphoid. *The British journal of radiology*. 1980;53(635):1037-40.
288. McLaughlin H, Parkes II J. Fracture of the carpal navicular (scaphoid) bone: gradations in therapy based upon pathology. *J Trauma Acute Care Surg*. 1969;9(4):311-9.
289. Terry Jr. D, Ramin J. The navicular fat stripe: a useful roentgen feature for evaluating wrist trauma. *Am J Roentgenology*. 1975;124(1):25-8.
290. Fowler JR, Hughes TB. Scaphoid fractures. *Clin Sports Med*. 2015;34(1):37-50.
291. Chen S. The scaphoid compression test. *Journal of Hand Surgery (British and European Volume)*. 1989;14(3):323-5.
292. Goldsmith S, Yang S. Magnetic resonance imaging in the diagnosis of occult dorsal wrist ganglions. *Journal of Hand Surgery (European Volume)*. 2008;33(5):595-9.
293. Gerhardsson L, Hagberg M. Work ability in vibration-exposed workers. *Occup Med (Lond)*. 2014;64(8):629-34.
294. Rolke R, Rolke S, Vogt T, et al. Hand-arm vibration syndrome: clinical characteristics, conventional electrophysiology and quantitative sensory testing. *Clin Neurophysiol*. 2013;124(8):1680-8.
295. Cameron NE, Cotter MA. The relationship of vascular changes to metabolic factors in diabetes mellitus and their role in the development of peripheral nerve complications. *Diabetes Metabolism Reviews-Clinical and Scientific Advances in Diabetes Research*. 1994;10(3):189-224.
296. Kuorinka I, Hannu H, Ilkka E. Prevention of musculoskeletal disorders at work: Validation and reliability in a multicenter intervention study *International Journal of Industrial Ergonomics*. 1995;15:437-46.
297. Onder B, Yalcin E, Selcuk B, Kurtaran A, Akyuz M. Carpal tunnel syndrome and metabolic syndrome co-occurrence. *Rheumatol Int*. 2013;33(3):583-6.
298. Nakamichi K, Tachibana S. Hypercholesterolemia as a risk factor for idiopathic carpal tunnel syndrome. *Muscle Nerve*. 2005;32(3):364-7.
299. Garg A, Hegmann KT, Wertsch JJ, et al. The WISTAH hand study: a prospective cohort study of distal upper extremity musculoskeletal disorders. *BMC Musculoskelet Disord*. 2012;1390.
300. Werner RA, Franzblau A, Gell N, Ulin SS, Armstrong TJ. A longitudinal study of industrial and clerical workers: predictors of upper extremity tendonitis. *J Occup Rehabil*. 2005;15(1):37-46.
301. Harris C, Eisen EA, Goldberg R, Krause N, Rempel D. 1st place, PREMUS best paper competition: workplace and individual factors in wrist tendinosis among blue-collar workers--the San Francisco study. *Scand J Work Environ Health*. 2011;37(2):85-98.

Copyright© 2016 Reed Group, Ltd.

302. Thomsen JF, Hansson GA, Mikkelsen S, Lauritzen M. Carpal tunnel syndrome in repetitive work: a follow-up study. *Am J Ind Med*. 2002;42(4):344-53.
303. Gerawarapong C. Comparison of sensitivities between median-thumb sensory distal latency and conventional nerve conduction studies in electrodiagnosis of carpal tunnel syndrome. *J Med Assoc Thai*. 2014;97(9):969-76.
304. Geoghegan J, Clark D, Bainbridge L, Smith C, Hubbard R. Risk factors in carpal tunnel syndrome. *The Journal of Hand Surgery: British & European Volume*. 2004;29(4):315-20.
305. Kozak A, Schedlbauer G, Wirth T, Euler U, Westermann C, Nienhaus A. Association between work-related biomechanical risk factors and the occurrence of carpal tunnel syndrome: an overview of systematic reviews and a meta-analysis of current research. *BMC Musculoskelet Disord*. 2015;16(1):231.
306. Maghsoudipour M, Moghimi S, Dehghaan F, Rahimpanah A. Association of occupational and non-occupational risk factors with the prevalence of work related carpal tunnel syndrome. *J Occup Rehabil*. 2008;18(2):152-6.
307. Nordander C, Ohlsson K, Åkesson I, et al. Exposure–response relationships in work-related musculoskeletal disorders in elbows and hands–A synthesis of group-level data on exposure and response obtained using uniform methods of data collection. *Applied ergonomics*. 2013;44(2):241-53.
308. Palmer KT, Harris EC, Coggon D. Carpal tunnel syndrome and its relation to occupation: a systematic literature review. *Occup Med (Lond)*. 2007;57(1):57-66.
309. Petit A, Ha C, Bodin J, et al. Risk factors for carpal tunnel syndrome related to the work organization: A prospective surveillance study in a large working population. *Applied ergonomics*. 2015;471-10.
310. Silverstein B. *The prevalence of upper extremity cumulative trauma disorders in industry (ergonomics, occupational epidemiology)*: University of Michigan; 1985.
311. Roquelaure Y, Ha C, Nicolas G, et al. Attributable risk of carpal tunnel syndrome according to industry and occupation in a general population. *Arthritis Care Res (Hoboken)*. 2008;59(9):1341-8.
312. Genovese E. Work-relatedness. In: Glass LS (ed.) Occupational Medicine Practice Guidelines: Evaluation and Management of Common Health Problems and Functional Recovery in Workers. 2nd edition. Elk Grove Village, Ill: American College of Occupational and Environmental Medicine. 2004.
313. Latko W, Armstrong T, Franzblau A, Ulin S, Werner R, Albers J. Cross-sectional study of the relationship between repetitive work and the prevalence of upper limb musculoskeletal disorders. *Am J Ind Med*. 1999;36(2):248-59.
314. Moore J, Garg A. The Strain Index: a proposed method to analyze jobs for risk of distal upper extremity disorders. . *Am Indus Hyg Assoc J*. 1995;56443-58.
315. Lozano-Calderon S, Anthony S, Ring D. The quality and strength of evidence for etiology: example of carpal tunnel syndrome. *J Hand Surg Am*. 2008;33(4):525-38.
316. Melhorn J, Martin D, Brooks C, Seaman S. Upper limb. In: Melhorn JM, Ackerman WE (eds). Guides to the Evaluation of Disease and Injury Causation. *Chicago, Ill: AMA Press*. 2008141-202.
317. Leclerc A, Landre M-F, Chastang J-F, Niedhammer I, Roquelaure Y. Upper-limb disorders in repetitive work. *Scand J Work Environ Health*. 2001268-78.
318. Nathan PA, Meadows KD, Istvan JA. Predictors of carpal tunnel syndrome: an 11-year study of industrial workers. *J Hand Surg [Am]*. 2002;27(4):644-51.
319. Atroshi I, Gummesson C, Johnsson R, McCabe SJ, Ornstein E. Severe carpal tunnel syndrome potentially needing surgical treatment in a general population. *J Hand Surg [Am]*. 2003;28(4):639-44.
320. English C, Maclaren W, Court-Brown C, et al. Relations between upper limb soft tissue disorders and repetitive movements at work. *Am J Ind Med*. 1995;27(1):75-90.
321. Franklin GM, Haug J, Heyer N, Checkoway H, Peck N. Occupational carpal tunnel syndrome in Washington State, 1984-1988. *Am J Public Health*. 1991;81(6):741-6.
322. Raffi GB, Lodi V, Malenchini G, et al. Cumulative trauma disorders of the upper limbs in workers on an agricultural farm. *Arh Hig Rada Toksikol*. 1996;47(1):19-23.
323. Andersen JH, Thomsen JF, Overgaard E, et al. Computer use and carpal tunnel syndrome: a 1-year follow-up study. *JAMA*. 2003;289(22):2963-9.
324. Atroshi I, Gummesson C, Ornstein E, Johnsson R, Ranstam J. Carpal tunnel syndrome and keyboard use at work: a population-based study. *Arthritis Rheum*. 2007;56(11):3620-5.
325. Davis L, Wellman H, Punnett L. Surveillance of work-related carpal tunnel syndrome in Massachusetts, 1992–1997: A report from the Massachusetts sentinel event notification system for occupational risks (SENSOR)*. *Am J Ind Med*. 2001;39(1):58-71.
326. de Krom MC, Kester AD, Knipschild PG, Spaans F. Risk factors for carpal tunnel syndrome. *Am J Epidemiol*. 1990;132(6):1102-10.
327. Garland FC, Garland CF, Doyle EJ, Jr., et al. Carpal tunnel syndrome and occupation in U.S. Navy enlisted personnel. *Arch Environ Health*. 1996;51(5):395-407.

Copyright© 2016 Reed Group, Ltd.

328. Nathan PA, Keniston RC. Carpal tunnel syndrome and its relation to general physical condition. *Hand Clin*. 1993;9(2):253-61.
329. Silverstein B, Viikari-Juntura E, Kalat J. Use of a prevention index to identify industries at high risk for work-related musculoskeletal disorders of the neck, back, and upper extremity in Washington state, 1990–1998. *Am J Ind Med*. 2002;41(3):149-69.
330. Stevens JC, Witt JC, Smith BE, Weaver AL. The frequency of carpal tunnel syndrome in computer users at a medical facility. *Neurology*. 2001;56(11):1568-70.
331. Wellman H, Davis L, Punnett L, Dewey R. Work-related carpal tunnel syndrome (WR-CTS) in Massachusetts, 1992–1997: Source of WR-CTS, outcomes, and employer intervention practices. *Am J Ind Med*. 2004;45(2):139-52.
332. Ali KM, Sathiyasekaran BW. Computer professionals and Carpal Tunnel Syndrome (CTS). *Int J Occup Saf Ergon*. 2006;12(3):319-25.
333. Coggon D, Ntani G, Harris EC, et al. Differences in risk factors for neurophysiologically confirmed carpal tunnel syndrome and illness with similar symptoms but normal median nerve function: a case-control study. *BMC Musculoskelet Disord*. 2013;14240.
334. Eleftheriou A, Rachiotis G, Varitimidis SE, Koutis C, Malizos KN, Hadjichristodoulou C. Cumulative keyboard strokes: a possible risk factor for carpal tunnel syndrome. *J Occup Med Toxicol*. 2012;7(1):16.
335. Nathan PA. Intrinsic causes of keyboard injuries. *J Occup Med*. 1993;35(11):1084-6.
336. Nordstrom DL, Vierkant RA, DeStefano F, Layde PM. Risk factors for carpal tunnel syndrome in a general population. *Occup Environ Med*. 1997;54(10):734-40.
337. Gerr F, Marcus M, Ensor C, et al. A prospective study of computer users: I. Study design and incidence of musculoskeletal symptoms and disorders. *Am J Ind Med*. 2002;41(4):221-35.
338. Mediouni Z, Bodin J, Dale AM, et al. Carpal tunnel syndrome and computer exposure at work in two large complementary cohorts. *BMJ Open*. 2015;5(9):e008156.
339. Lassen C, Mikkelsen S, Kryger A, et al. Elbow and wrist/hand symptoms among 6,943 computer operators: A 1-year follow-up study (the NUDATA study). *Am J Ind Med*. 2004;46(5):521-33.
340. Brandt LP, Andersen JH, Lassen CF, et al. Neck and shoulder symptoms and disorders among Danish computer workers. *Scand J Work Environ Health*. 2004;30(5):399-409.
341. Moore J, Swanson N. The effect of alternative keyboards on musculoskeletal symptoms and disorders. *Proceedings of the Human–Computer Interaction International Conference, Crete*. 2003;103-7.
342. Tittiranonda P, Rempel D, Armstrong T, Burastero S. Effect of four computer keyboards in computer users with upper extremity musculoskeletal disorders. *Am J Ind Med*. 1999;35(6):647-61.
343. Byström S, Hall C, Welander T, Kilbom Å. Clinical disorders and pressure-pain threshold of the forearm and hand among automobile assembly line workers. *Journal of Hand Surgery (British and European Volume)*. 1995;20(6):782-90.
344. Punnett L, Robins JM, Wegman DH, Keyserling WM. Soft tissue disorders in the upper limbs of female garment workers. *Scand J Work Environ Health*. 1985417-25.
345. Gold JE, d'Errico A, Katz JN, Gore R, Punnett L. Specific and non-specific upper extremity musculoskeletal disorder syndromes in automobile manufacturing workers. *Am J Ind Med*. 2009;52(2):124-32.
346. Servi JT, Dienst Jr WL, Dightman L, Dworkin MS, Thompson RK, Howe WB. Wrist pain from overuse: detecting and relieving intersection syndrome. *Physician and sportsmedicine*. 1997;25(12):41-57.
347. Palmer RE. Sports injuries of the hand. *Instr Course Lect*. 1994;4325-30.
348. Descatha A, Leproust H, Roure P, Ronan C, Roquelaure Y. Is the intersection syndrome is an occupational disease? *Joint Bone Spine*. 2008;75(3):329-31.
349. Hanlon DP, Luellen JR. Intersection syndrome: a case report and review of the literature. *J Emerg Med*. 1999;17(6):969-71.
350. Steinberg D. Intersection Syndrome Treatment & Management. Available at: http://emedicine.medscape.com/article/1242239-treatment. *Medscape*. 2015.
351. Zeiss J, Jakab E. MR demonstration of an anomalous muscle in a patient with coexistent carpal and ulnar tunnel syndrome. Case report and literature summary. *Clin Imaging*. 1995;19(2):102-5.
352. Cerinic MM, Generini S, Pignone A, Casale R. The nervous system in systemic sclerosis (scleroderma). Clinical features and pathogenetic mechanisms. *Rheum Dis Clin North Am*. 1996;22(4):879-92.
353. Lori S, Matucci-Cerinic M, Casale R, et al. Peripheral nervous system involvement in systemic sclerosis: the median nerve as target structure. *Clin Exp Rheumatol*. 1996;14(6):601-5.
354. Seibold J. Scleroderma. In: Ruddy S, Harris EJ, Sledge C, eds. *Kelley's Textbook of Rheumatology 12th edition*. Philadelphia: WB Saunders; 2001:1211-40.
355. Hadler NM, Gillings DB, Imbus HR, et al. Hand structure and function in an industrial setting. *Arthritis Rheum*. 1978;21(2):210-20.

Copyright© 2016 Reed Group, Ltd.

356. Franzblau A, Armstrong TJ, Werner RA, Ulin SS. A cross-sectional assessment of the ACGIH TLV for hand activity level. *J Occup Rehabil*. 2005;15(1):57-67.
357. Keogh JP, Gucer PW, Gordon JL, Nuwayhid I. Patterns and predictors of employer risk-reduction activities (ERRAs) in response to a work-related upper extremity cumulative trauma disorder (UECTD): reports from workers' compensation claimants. *Am J Ind Med*. 2000;38(5):489-97.
358. Lincoln AE, Vernick JS, Ogaitis S, Smith GS, Mitchell CS, Agnew J. Interventions for the primary prevention of work-related carpal tunnel syndrome. *Am J Prev Med*. 2000;18(4 Suppl):37-50.
359. O'Connor DM, S.; Massy-Westropp, N.; Pitt, V. Non-surgical treatment (other than steroid injection) for carpal tunnel syndrome (Review). *Cochrane Database Syst Rev*. 2012(1):1-106.
360. Marklin RW, Simoneau GG. Design features of alternative computer keyboards: a review of experimental data. *J Orthop Sports Phys Ther*. 2004;34(10):638-49.
361. Verhagen AP, Bierma-Zeinstra SM, Feleus A, et al. Ergonomic and physiotherapeutic interventions for treating upper extremity work related disorders in adults. *Cochrane Database Syst Rev*. 2004(1):CD003471.
362. Rempel D, Tittiranonda P, Burastero S, Hudes M, So Y. Effect of keyboard keyswitch design on hand pain. *J Occup Environ Med*. 1999;41(2):111-9.
363. Rempel DM, Krause N, Goldberg R, Benner D, Hudes M, Goldner GU. A randomised controlled trial evaluating the effects of two workstation interventions on upper body pain and incident musculoskeletal disorders among computer operators. *Occup Environ Med*. 2006;63(5):300-6.
364. Verhagen AP, Karels C, Bierma-Zeinstra S, et al. Ergonomic and physiotherapeutic interventions for treating work-related complaints of the arm, neck or shoulder in adults. *Cochrane Database Syst Rev*. 2006;3:CD003471.
365. Rempel D, Lee DL, Dawson K, Loomer P. The effects of periodontal curette handle weight and diameter on arm pain: a four-month randomized controlled trial. *J Am Dent Assoc*. 2012;143(10):1105-13.
366. Gerr F, Marcus M, Monteilh C, Hannan L, Ortiz D, Kleinbaum D. A randomised controlled trial of postural interventions for prevention of musculoskeletal symptoms among computer users. *Occup Environ Med*. 2005;62(7):478-87.
367. Arnetz BB, Sjögren B, Rydéhn B, Meisel R. Early workplace intervention for employees with musculoskeletal-related absenteeism: a prospective controlled intervention study. *Journal of occupational and environmental medicine*. 2003;45(5):499-506.
368. Herbert R, Gerr F, Dropkin J. Clinical evaluation and management of work-related carpal tunnel syndrome. *Am J Ind Med*. 2000;37(1):62-74.
369. Simmer-Beck M, Bray KK, Branson B, Glaros A, Weeks J. Comparison of muscle activity associated with structural differences in dental hygiene mirrors. *J Dent Hyg*. 2006;80(1):8.
370. Conlon CF, Krause N, Rempel DM. A randomised controlled trial evaluating an alternative mouse and forearm support on upper body discomfort and musculoskeletal disorders among engineers. *Occup Environ Med*. 2008;65(5):311-8.
371. van den Heuvel SG, de Looze MP, Hildebrandt VH, Thé KH. Effects of software programs stimulating regular breaks and exercises on work-related neck and upper-limb disorders. *Scand J Work Environ Health*. 2003106-16.
372. Galinsky T, Swanson N, Sauter S, Dunkin R, Hurrell J, Schleifer L. Supplementary breaks and stretching exercises for data entry operators: a follow-up field study. *Am J Ind Med*. 2007;50(7):519-27.
373. Galinsky TL, Swanson NG, Sauter SL, Hurrell JJ, Schleifer LM. A field study of supplementary rest breaks for data-entry operators. *Ergonomics*. 2000;43(5):622-38.
374. Lee K, Swanson N, Sauter S, Wickstrom R, Waikar A, Mangum M. A review of physical exercises recommended for VDT operators. *Appl Ergon*. 1992;23(6):387-408.
375. Carter J, Banister E. Musculoskeletal problems in VDT work: a review. *Ergonomics*. 1994;37(10):1623-48.
376. Fenety A, Walker JM. Short-term effects of workstation exercises on musculoskeletal discomfort and postural changes in seated video display unit workers. *Phys Ther*. 2002;82(6):578-89.
377. Feuerstein M, Nicholas RA, Huang GD, Dimberg L, Ali D, Rogers H. Job stress management and ergonomic intervention for work-related upper extremity symptoms. *Appl Ergon*. 2004;35(6):565-74.
378. Henning RA, Jacques P, Kissel GV, Sullivan AB, Alteras-Webb SM. Frequent short rest breaks from computer work: effects on productivity and well-being at two field sites. *Ergonomics*. 1997;40(1):78-91.
379. Silverstein BA, Armstrong TJ, Longmate A, Woody D. Can in-plant exercise control musculoskeletal symptoms? *J Occup Med*. 1988;30(12):922-7.
380. Balci R, Aghazadeh F. Effects of exercise breaks on performance, muscular load, and perceived discomfort in data entry and cognitive tasks. *Computers Industrial Engineering*. 2004;46:399-411.
381. Balci R, Aghazadeh F. The effect of work-rest schedules and type of task on the discomfort and performance of VDT users. *Ergonomics*. 2003;46(5):455-65.

Copyright© 2016 Reed Group, Ltd.

382. Floru R, Cail F. Data entry task on VDU: underload or overload. *Selected papers from the International Scientific Conference on Work with display units 86*: North-Holland Publishing Co.; 1987:756-67.
383. Kopardekar P, Mital A. The effect of different work-rest schedules on fatigue and performance of a simulated directory assistance operator's task. *Ergonomics*. 1994;37(10):1697-707.
384. McLean L, Tingley M, Scott RN, Rickards J. Computer terminal work and the benefit of microbreaks. *Appl Ergon*. 2001;32(3):225-37.
385. Sauter S, Swanson N, Luzak H, Cakir A, Cakir G. The effects of frequent rest breaks on performance and musculoskeletal comfort in repetitive VDT work. *Work With Display Units '92 Conference*; 1992:1-4.
386. Ketola R, Toivonen R, Häkkänen M, Luukkonen R, Takala E-P, Viikari-Juntura E. Effects of ergonomic intervention in work with video display units. *Scand J Work Environ Health*. 200218-24.
387. Werner RA, Franzblau A, Gell N. Randomized controlled trial of nocturnal splinting for active workers with symptoms of carpal tunnel syndrome. *Arch Phys Med Rehabil*. 2005;86(1):1-7.
388. Lincoln AE, Feuerstein M, Shaw WS, Miller VI. Impact of case manager training on worksite accommodations in workers' compensation claimants with upper extremity disorders. *J Occup Environ Med*. 2002;44(3):237-45.
389. Ripat J, Scatliff T, Giesbrecht E, Quanbury A, Friesen M, Kelso S. The effect of alternate style keyboards on severity of symptoms and functional status of individuals with work related upper extremity disorders. *J Occup Rehabil*. 2006;16(4):707-18.
390. Hedge A, Morimoto S, McCrobie D. Effects of keyboard tray geometry on upper body posture and comfort. *Ergonomics*. 1999;42(10):1333-49.
391. Bonzani PJ, Millender L, Keelan B, Mangieri MG. Factors prolonging disability in work-related cumulative trauma disorders. *J Hand Surg [Am]*. 1997;22(1):30-4.
392. Gimeno D, Amick B, Habeck R, Ossmann J, Katz J. The role of job strain on return to work after carpal tunnel surgery. *Occup Environ Med*. 2005;62(11):778-85.
393. Turner JA, Franklin G, Fulton-Kehoe D, et al. Early predictors of chronic work disability associated with carpal tunnel syndrome: a longitudinal workers' compensation cohort study. *Am J Ind Med*. 2007;50(7):489-500.
394. Abasolo L, Carmona L, Hernandez-Garcia C, et al. Musculoskeletal work disability for clinicians: time course and effectiveness of a specialized intervention program by diagnosis. *Arthritis Rheum*. 2007;57(2):335-42.
395. Feuerstein M, Callan-Harris S, Hickey P, Dyer D, Armbruster W, Carosella AM. Multidisciplinary rehabilitation of chronic work-related upper extremity disorders. Long-term effects. *J Occup Med*. 1993;35(4):396-403.
396. JM. M. Return to work: filling out the forms. In Melhorn JM, DiPaola J, (eds). 8th Annual Occupational Orthopaedics and Workers' Compensation: A Multidisciplinary Perspective. Rosemont, Ill: American Academy of Orthopaedic Surgeons. 2006659-700.
397. Melhorn J. Carpal tunnel syndrome: three points of view on risk and recovery. *J Workers Comp*. 2006;1555-64.
398. Melhorn J. Working with common upper extremity problems. In: Talmage JB, JM M, eds. *A Physician's Guide to Return to Work*. Chicago, Ill: AMA Press; 2005:181-214.
399. Talmage JB MJ. How to Think About Work Ability and Work Restrictions - Capacity, Tolerance, and Risk. *A Physician's Guide to Return to Work*. Chicago, Ill: American Medical Association; 2005:7-18.
400. ACOEM Stay-at-Work and Return-to-Work Process Improvement Committee. Preventing needless work disability by helping people stay employed. *J Occup Environ Med*. 2006;48(9):972-87.
401. McQueen MM, Gelbke MK, Wakefield A, Will EM, Gaebler C. Percutaneous screw fixation versus conservative treatment for fractures of the waist of the scaphoid: a prospective randomised study. *J Bone Joint Surg Br*. 2008;90(1):66-71.
402. Vinnars B, Pietreanu M, Bodestedt A, Ekenstam F, Gerdin B. Nonoperative compared with operative treatment of acute scaphoid fractures. A randomized clinical trial. *J Bone Joint Surg Am*. 2008;90(6):1176-85.
403. Patel PR, Miller MA. Postcare recommendations for emergency department wounds. *Emergency medicine clinics of North America*. 2007;25(1):147-58.
404. Checkosky CM, Bolanowski SJ, Cohen JC. Assessment of vibrotactile sensitivity in patients with carpal tunnel syndrome. *Journal of occupational and environmental medicine*. 1996;38(6):593-601.
405. Crossman MW, Gilbert CA, Travlos A, Craig KD, Eisen A. Nonneurologic hand pain versus carpal tunnel syndrome: do psychological measures differentiate? *Am J Phys Med Rehabil*. 2001;80(2):100-7.
406. Jablecki CK, Andary MT, Floeter MK, et al. Practice parameter: Electrodiagnostic studies in carpal tunnel syndrome. Report of the American Association of Electrodiagnostic Medicine, American Academy of Neurology, and the American Academy of Physical Medicine and Rehabilitation. *Neurology*. 2002;58(11):1589-92.
407. Kang EK, Lim JY, Shin HI, Gong HS, Oh JH, Paik NJ. Comparison between nerve conduction studies and current perception threshold test in carpal tunnel syndrome. *Neurophysiol Clin*. 2008;38(2):127-31.

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408. Megerian JT, Kong X, Gozani SN. Utility of nerve conduction studies for carpal tunnel syndrome by family medicine, primary care, and internal medicine physicians. *J Am Board Fam Med*. 2007;20(1):60-4.
409. Melvin JL, Schuchmann JA, Lanese RR. Diagnostic specificity of motor and sensory nerve conduction variables in the carpal tunnel syndrome. *Arch Phys Med Rehabil*. 1973;54(2):69-74.
410. Mondelli M, Aretini A. Low sensitivity of F-wave in the electrodiagnosis of carpal tunnel syndrome. *J Electromyogr Kinesiol*. 2015;25(2):247-52.
411. Mondelli M, Aretini A, Rossi S. Ulnar Neuropathy at the Elbow in Diabetes. *Am J Phys Med Rehabil*. 2008.
412. Slutsky DJ. Use of nerve conduction studies and the pressure-specified sensory device in the diagnosis of carpal tunnel syndrome. *J Hand Surg Eur Vol*. 2009;34(1):60-5.
413. Smith NJ. Nerve conduction studies for carpal tunnel syndrome: essential prelude to surgery or unnecessary luxury? *J Hand Surg Br*. 2002;27(1):83-5.
414. Spindler HA, Dellon AL. Nerve conduction studies and sensibility testing in carpal tunnel syndrome. *J Hand Surg Am*. 1982;7(3):260-3.
415. Steinberg DR, Gelberman RH, Rydevik B, Lundborg G. The utility of portable nerve conduction testing for patients with carpal tunnel syndrome: a prospective clinical study. *J Hand Surg Am*. 1992;17(1):77-81.
416. Strickland JW, Gozani SN. Accuracy of in-office nerve conduction studies for median neuropathy: a meta-analysis. *J Hand Surg Am*. 2011;36(1):52-60.
417. Walters RJ, Murray NM. Transcarpal motor conduction velocity in carpal tunnel syndrome. *Muscle Nerve*. 2001;24(7):966-8.
418. Werner RA, Albers JW. Relation between needle electromyography and nerve conduction studies in patients with carpal tunnel syndrome. *Arch Phys Med Rehabil*. 1995;76(3):246-9.
419. Werner RA, Andary M. Electrodiagnostic evaluation of carpal tunnel syndrome. *Muscle Nerve*. 2011;44(4):597-607.
420. Werner RA, Franzblau A, Albers JW, Buchele H, Armstrong TJ. Use of screening nerve conduction studies for predicting future carpal tunnel syndrome. *Occup Environ Med*. 1997;54(2):96-100.
421. Andary MT, Fankhauser MJ, Ritson JL, et al. Comparison of sensory mid-palm studies to other techniques in carpal tunnel syndrome. *Electromyogr Clin Neurophysiol*. 1996;36(5):279-85.
422. Balbierz JM, Cottrell AC, Cottrell WD. Is needle examination always necessary in evaluation of carpal tunnel syndrome? *Arch Phys Med Rehabil*. 1998;79(5):514-6.
423. Burnham RS, Burnham TR. Effect of hand warming on electrodiagnostic testing results and diagnosis in patients with suspected carpal tunnel syndrome. *Arch Phys Med Rehabil*. 2009;90(12):2062-5.
424. Dale AM, Gardner BT, Zeringue A, Werner R, Franzblau A, Evanoff B. The effectiveness of post-offer pre-placement nerve conduction screening for carpal tunnel syndrome. *J Occup Environ Med*. 2014;56(8):840-7.
425. Dunne CA, Thompson PW, Cole J, et al. Carpal tunnel syndrome: evaluation of a new method of assessing median nerve conduction at the wrist. *Ann Rheum Dis*. 1996;55(6):396-8.
426. Glowacki KA, Breen CJ, Sachar K, Weiss AP. Electrodiagnostic testing and carpal tunnel release outcome. *J Hand Surg Am*. 1996;21(1):117-21.
427. Havton LA, Hotson JR, Kellerth JO. Correlation of median forearm conduction velocity with carpal tunnel syndrome severity. *Clin Neurophysiol*. 2007;118(4):781-5.
428. Lee WJ, Liao YC, Wei SJ, Tsai CW, Chang MH. How to make electrodiagnosis of carpal tunnel syndrome with normal distal conductions? *J Clin Neurophysiol*. 2011;28(1):45-50.
429. Loong S.C. SCS. Comparison of median and ulnar sensory nerve action potentials in the diagnosis of the carpal tunnel syndrome. *Journal of neurology, Neurosurgery & Psychiatry*. 1971;34(1):750-4.
430. Parkhad SP, S. Utility of Nerve Conduction Study in Early Diagnosis of Carpal Tunnel Syndrome (CTS). *National Journal of Physiology, Pharmacy & Pharmacology*. 2013;4(1):9-14.
431. Prakash KM, Fook-Chong S, Leoh TH, et al. Sensitivities of sensory nerve conduction study parameters in carpal tunnel syndrome. *J Clin Neurophysiol*. 2006;23(6):565-7.
432. Pransky G, Long R, Hammer K, Schulz LA, Himmelstein J, Fowke J. Screening for carpal tunnel syndrome in the workplace. An analysis of portable nerve conduction devices. *J Occup Environ Med*. 1997;39(8):727-33.
433. Redmond MD, Rivner MH. False positive electrodiagnostic tests in carpal tunnel syndrome. *Muscle Nerve*. 1988;11(5):511-8.
434. Neligan A, O'Sullivan SS, Mullins GM, et al. A review of nerve conduction studies in cases of suspected compression neuropathies of the upper limb. *Eur Neurol*. 2010;63(1):11-6.
435. Uzar E, Tamam Y, Acar A, et al. Sensitivity and specificity of terminal latency index and residual latency in the diagnosis of carpal tunnel syndrome. *Eur Rev Med Pharmacol Sci*. 2011;15(9):1078-84.
436. Carroll GJ. Comparison of median and radial nerve sensory latencies in the electrophysiological diagnosis of carpal tunnel syndrome. *Electroencephalogr Clin Neurophysiol*. 1987;68(2):101-6.
437. Celik B. Review of different electrodiagnostic studies in mild carpal tunnel syndrome. *Neurosurgery Quarterly*. 2008;18(2):83-8.

Copyright© 2016 Reed Group, Ltd.

438. Chang MH, Liao YC, Lee YC, Hsieh PF, Liu LH. Electrodiagnosis of carpal tunnel syndrome: which transcarpal conduction technique is best? *J Clin Neurophysiol*. 2009;26(5):366-71.
439. Choi SJ, Ahn DS. Correlation of clinical history and electrodiagnostic abnormalities with outcome after surgery for carpal tunnel syndrome. *Plast Reconstr Surg*. 1998;102(7):2374-80.
440. Dhong ES, Han SK, Lee BI, Kim WK. Correlation of electrodiagnostic findings with subjective symptoms in carpal tunnel syndrome. *Ann Plast Surg*. 2000;45(2):127-31.
441. Katz RT. NC-stat as a screening tool for carpal tunnel syndrome in industrial workers. *J Occup Environ Med*. 2006;48(4):414-8.
442. Scelsa SN, Herskovitz S, Bieri P, Berger AR. Median mixed and sensory nerve conduction studies in carpal tunnel syndrome. *Electroencephalogr Clin Neurophysiol*. 1998;109(3):268-73.
443. Taylor-Gjevre RM, Gjevre JA, Nair B. Suspected carpal tunnel syndrome: Do nerve conduction study results and symptoms match? *Can Fam Physician*. 2010;56(7):e250-4.
444. Cherniack MG, Moalli D, Viscolli C. A comparison of traditional electrodiagnostic studies, electroneurometry, and vibrometry in the diagnosis of carpal tunnel syndrome. *J Hand Surg Am*. 1996;21(1):122-31.
445. Leffler C, Gozani S, Nguyen Z, Cros D. An Automated Electrodiagnostic Technique for Detection of Carpal Tunnel Syndrome. *American Academy of Clinical Neurophysiology*. 20002-10

446. Lo YL, Fook-Chong S, Leoh TH, et al. Rapid ultrasonographic diagnosis of radial entrapment neuropathy at the spiral groove. *J Neurol Sci*. 2008;271(1-2):75-9.
447. Rha DW, Im SH, Kim SK, Chang WH, Kim KJ, Lee SC. Median nerve conduction study through the carpal tunnel using segmental nerve length measured by ultrasonographic and conventional tape methods. *Arch Phys Med Rehabil*. 2011;92(1):1-6.
448. Witt JC, Hentz JG, Stevens JC. Carpal tunnel syndrome with normal nerve conduction studies. *Muscle Nerve*. 2004;29(4):515-22.
449. Jordan R, Carter T, Cummins C. A systematic review of the utility of electrodiagnostic testing in carpal tunnel syndrome. *Br J Gen Pract*. 2002;52(481):670-3.
450. AAEM position statements. Who is qualified to practice electrodiagnostic medicine? *Muscle Nerve Suppl*. 1999;8:S263-5.
451. Buch-Jaeger N, Foucher G. Correlation of clinical signs with nerve conduction tests in the diagnosis of carpal tunnel syndrome. *J Hand Surg Br*. 1994;19(6):720-4.
452. Dale AM, Agboola F, Yun A, Zeringue A, Al-Lozi MT, Evanoff B. Comparison of automated versus traditional nerve conduction study methods for median nerve testing in a general worker population. *PM R*. 2015;7(3):276-82.
453. Elkowitz SJ, Dubin NH, Richards BE, Wilgis EF. Clinical utility of portable versus traditional electrodiagnostic testing for diagnosing, evaluating, and treating carpal tunnel syndrome. *Am J Orthop (Belle Mead NJ)*. 2005;34(8):362-4.
454. Atroshi I, Gummesson C, Johnsson R, Ornstein E. Diagnostic properties of nerve conduction tests in population-based carpal tunnel syndrome. *BMC Musculoskelet Disord*. 2003;49.
455. Kuntzer T. Carpal tunnel syndrome in 100 patients: sensitivity, specificity of multi-neurophysiological procedures and estimation of axonal loss of motor, sensory and sympathetic median nerve fibers. *J Neurol Sci*. 1994;127(2):221-9.
456. Nathan PA, Keniston RC, Meadows KD, Lockwood RS. Predictive value of nerve conduction measurements at the carpal tunnel. *Muscle Nerve*. 1993;16(12):1377-82.
457. Guidelines in electrodiagnostic medicine. Technology review: the Neurometer Current Perception Threshold (CPT). *Muscle Nerve Suppl*. 1999;8S247-59.
458. American Association of Electrodiagnostic M, Chaudhry V. Guidelines in electrodiagnostic medicine. Technology review: Nervepace Digital Electroneurometer. *Muscle Nerve Suppl*. 1999;8:S243-6.
459. Aydin G, Keles I, Ozbudak Demir S, Baysal AI. Sensitivity of median sensory nerve conduction tests in digital branches for the diagnosis of carpal tunnel syndrome. *Am J Phys Med Rehabil*. 2004;83(1):17-21.
460. Bodofsky EB, Wu KD, Campellone JV, Greenberg WM, Tomaio AC. A sensitive new median-ulnar technique for diagnosing mild Carpal Tunnel Syndrome. *Electromyogr Clin Neurophysiol*. 2005;45(3):139-44.
461. Chang MH, Liu LH, Lee YC, Wei SJ, Chiang HL, Hsieh PF. Comparison of sensitivity of transcarpal median motor conduction velocity and conventional conduction techniques in electrodiagnosis of carpal tunnel syndrome. *Clin Neurophysiol*. 2006;117(5):984-91.
462. Graham B. The value added by electrodiagnostic testing in the diagnosis of carpal tunnel syndrome. *J Bone Joint Surg Am*. 2008;90(12):2587-93.
463. Khosrawi S, Dehghan F. Determination of the median nerve residual latency values in the diagnosis of carpal tunnel syndrome in comparison with other electrodiagnostic parameters. *J Res Med Sci*. 2013;18(11):934-8.

Copyright© 2016 Reed Group, Ltd.

464. Lew HL, Date ES, Pan SS, Wu P, Ware PF, Kingery WS. Sensitivity, specificity, and variability of nerve conduction velocity measurements in carpal tunnel syndrome. *Arch Phys Med Rehabil*. 2005;86(1):12-6.
465. Pastare D, Therimadasamy AK, Lee E, Wilder-Smith EP. Sonography versus nerve conduction studies in patients referred with a clinical diagnosis of carpal tunnel syndrome. *J Clin Ultrasound*. 2009;37(7):389-93.
466. Sheu JJ, Yuan RY, Chiou HY, Hu CJ, Chen WT. Segmental study of the median nerve versus comparative tests in the diagnosis of mild carpal tunnel syndrome. *Clin Neurophysiol*. 2006;117(6):1249-55.
467. Violante FS, Bonfiglioli R, Isolani L, Raffi GB. Levels of agreement of nerve conduction studies and symptoms in workers at risk of carpal tunnel syndrome. *Int Arch Occup Environ Health*. 2004;77(8):552-8.
468. Wang YJ, Yan SH. Improvement of diagnostic rate of carpal tunnel syndrome with additional median-to-ulnar comparative nerve conduction studies. *Acta Neurol Taiwan*. 2013;22(4):152-7.
469. Zagnoli F, Andre V, Le Dreff P, Garcia JF, Bellard S. Idiopathic carpal tunnel syndrome. Clinical, electrodiagnostic, and magnetic resonance imaging correlations. *Rev Rhum Engl Ed*. 1999;66(4):192-200.
470. Concannon MJ, Gainor B, Petroski GF, Puckett CL. The predictive value of electrodiagnostic studies in carpal tunnel syndrome. *Plast Reconstr Surg*. 1997;100(6):1452-8.
471. Lee KY, Lee YJ, Koh SH. Usefulness of the median terminal latency ratio in the diagnosis of carpal tunnel syndrome. *Clin Neurophysiol*. 2009;120(4):765-9.
472. Homan MM, Franzblau A, Werner RA, Albers JW, Armstrong TJ, Bromberg MB. Agreement between symptom surveys, physical examination procedures and electrodiagnostic findings for the carpal tunnel syndrome. *Scand J Work Environ Health*. 1999;25(2):115-24.
473. Jackson DA, Clifford JC. Electrodiagnosis of mild carpal tunnel syndrome. *Arch Phys Med Rehabil*. 1989;70(3):199-204.
474. Uncini A, Lange DJ, Solomon M, Soliven B, Meer J, Lovelace RE. Ring finger testing in carpal tunnel syndrome: a comparative study of diagnostic utility. *Muscle Nerve*. 1989;12(9):735-41.
475. Zaher A, Mattar M, Gomaa M, Zaher A. Value of contemporary investigation tools in management of carpal tunnel syndrome. *Neurol Psychiat Neurosurg*. 2012;49(4):375-80.
476. Altinok MT, Baysal O, Karakas HM, Firat AK. Sonographic evaluation of the carpal tunnel after provocative exercises. *J Ultrasound Med*. 2004;23(10):1301-6.
477. Buchberger W, Judmaier W, Birbamer G, Lener M, Schmidauer C. Carpal tunnel syndrome: diagnosis with high-resolution sonography. *AJR Am J Roentgenol*. 1992;159(4):793-8.
478. Fujimoto K, Kanchiku T, Kido K, Imajo Y, Funaba M, Taguchi T. Diagnosis of severe carpal tunnel syndrome using nerve conduction study and ultrasonography. *Ultrasound Med Biol*. 2015;41(10):2575-80.
479. Lee D, van Holsbeeck MT, Janevski PK, Ganos DL, Ditmars DM, Darian VB. Diagnosis of carpal tunnel syndrome. Ultrasound versus electromyography. *Radiol Clin North Am*. 1999;37(4):859-72, x.
480. Mondelli M, Filippou G, Gallo A, Frediani B. Diagnostic utility of ultrasonography versus nerve conduction studies in mild carpal tunnel syndrome. *Arthritis Rheum*. 2008;59(3):357-66.
481. Roll SC, Case-Smith J, Evans KD. Diagnostic accuracy of ultrasonography vs. electromyography in carpal tunnel syndrome: a systematic review of literature. *Ultrasound Med Biol*. 2011;37(10):1539-53.
482. Seror P. Sonography and electrodiagnosis in carpal tunnel syndrome diagnosis, an analysis of the literature. *Eur J Radiol*. 2008;67(1):146-52.
483. Cartwright MS, Hobson-Webb LD, Boon AJ, et al. Evidence-based guideline: neuromuscular ultrasound for the diagnosis of carpal tunnel syndrome. *Muscle Nerve*. 2012;46(2):287-93.
484. Descatha A, Huard L, Aubert F, Barbato B, Gorand O, Chastang JF. Meta-analysis on the performance of sonography for the diagnosis of carpal tunnel syndrome. *Semin Arthritis Rheum*. 2012;41(6):914-22.
485. Fowler JR, Gaughan JP, Ilyas AM. The sensitivity and specificity of ultrasound for the diagnosis of carpal tunnel syndrome: a meta-analysis. *Clin Orthop Relat Res*. 2011;469(4):1089-94.
486. McDonagh C, Alexander M, Kane D. The role of ultrasound in the diagnosis and management of carpal tunnel syndrome: a new paradigm. *Rheumatology (Oxford)*. 2015;54(1):9-19.
487. Tai TW, Wu CY, Su FC, Chern TC, Jou IM. Ultrasonography for diagnosing carpal tunnel syndrome: a meta-analysis of diagnostic test accuracy. *Ultrasound Med Biol*. 2012;38(7):1121-8.
488. Ziswiler HR, Reichenbach S, Vogelin E, Bachmann LM, Villiger PM, Juni P. Diagnostic value of sonography in patients with suspected carpal tunnel syndrome: a prospective study. *Arthritis Rheum*. 2005;52(1):304-11.
489. Visser LH, Smidt MH, Lee ML. High-resolution sonography versus EMG in the diagnosis of carpal tunnel syndrome. *J Neurol Neurosurg Psychiatry*. 2008;79(1):63-7.
490. Wang LY, Leong CP, Huang YC, Hung JW, Cheung SM, Pong YP. Best diagnostic criterion in high-resolution ultrasonography for carpal tunnel syndrome. *Chang Gung Med J*. 2008;31(5):469-76.
491. Wiesler ER, Chloros GD, Cartwright MS, Smith BP, Rushing J, Walker FO. The use of diagnostic ultrasound in carpal tunnel syndrome. *J Hand Surg Am*. 2006;31(5):726-32.
492. Yesildag A, Kutluhan S, Sengul N, et al. The role of ultrasonographic measurements of the median nerve in the diagnosis of carpal tunnel syndrome. *Clin Radiol*. 2004;59(10):910-5.

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493. Keberle M, Jenett M, Kenn W, et al. Technical advances in ultrasound and MR imaging of carpal tunnel syndrome. *Eur Radiol*. 2000;10(7):1043-50.
494. Kleindienst A, Hamm B, Hildebrandt G, Klug N. Diagnosis and staging of carpal tunnel syndrome: comparison of magnetic resonance imaging and intra-operative findings. *Acta Neurochir (Wien)*. 1996;138(2):228-33.
495. Kleindienst A, Hamm B, Lanksch WR. Carpal tunnel syndrome: staging of median nerve compression by MR imaging. *J Magn Reson Imaging*. 1998;8(5):1119-25.
496. Kobayashi S, Hayakawa K, Nakane T, et al. Visualization of intraneural edema using gadolinium-enhanced magnetic resonance imaging of carpal tunnel syndrome. *J Orthop Sci*. 2009;14(1):24-34.
497. Koh SH, Kwon BC, Park C, Hwang SY, Lee JW, Kim SS. A comparison of the performance of anatomical MRI and DTI in diagnosing carpal tunnel syndrome. *Eur J Radiol*. 2014;83(11):2065-73.
498. Lindberg PG, Feydy A, Le Viet D, Maier MA, Drape JL. Diffusion tensor imaging of the median nerve in recurrent carpal tunnel syndrome - initial experience. *Eur Radiol*. 2013;23(11):3115-23.
499. Martins RS, Siqueira MG, Simplicio H, Agapito D, Medeiros M. Magnetic resonance imaging of idiopathic carpal tunnel syndrome: correlation with clinical findings and electrophysiological investigation. *Clin Neurol Neurosurg*. 2008;110(1):38-45.
500. Mesgarzadeh M, Schneck CD, Bonakdarpour A. Carpal tunnel: MR imaging. Part I. Normal anatomy. *Radiology*. 1989;171(3):743-8.
501. Mesgarzadeh M, Schneck CD, Bonakdarpour A, Mitra A, Conaway D. Carpal tunnel: MR imaging. Part II. Carpal tunnel syndrome. *Radiology*. 1989;171(3):749-54.
502. Middleton WD, Kneeland JB, Kellman GM, et al. MR imaging of the carpal tunnel: normal anatomy and preliminary findings in the carpal tunnel syndrome. *AJR Am J Roentgenol*. 1987;148(2):307-16.
503. Mogk JP, Keir PJ. Evaluation of the carpal tunnel based on 3-D reconstruction from MRI. *J Biomech*. 2007;40(10):2222-9.
504. Momose T, Uchiyama S, Kobayashi S, Nakagawa H, Kato H. Structural changes of the carpal tunnel, median nerve and flexor tendons in MRI before and after endoscopic carpal tunnel release. *Hand Surg*. 2014;19(2):193-8.
505. Monagle K, Dai G, Chu A, Burnham RS, Snyder RE. Quantitative MR imaging of carpal tunnel syndrome. *AJR Am J Roentgenol*. 1999;172(6):1581-6.
506. Murphy RX, Jr., Chernofsky MA, Osborne MA, Wolson AH. Magnetic resonance imaging in the evaluation of persistent carpal tunnel syndrome. *J Hand Surg Am*. 1993;18(1):113-20.
507. Musluoglu L, Celik M, Tabak H, Forta H. Clinical, electrophysiological and magnetic resonance imaging findings in carpal tunnel syndrome. *Electromyogr Clin Neurophysiol*. 2004;44(3):161-5.
508. Pasternack, II, Malmivaara A, Tervahartiala P, Forsberg H, Vehmas T. Magnetic resonance imaging findings in respect to carpal tunnel syndrome. *Scand J Work Environ Health*. 2003;29(3):189-96.
509. Allmann KH, Horch R, Uhl M, et al. MR imaging of the carpal tunnel. *Eur J Radiol*. 1997;25(2):141-5.
510. Barcelo C, Faruch M, Lapegue F, Bayol MA, Sans N. 3-T MRI with diffusion tensor imaging and tractography of the median nerve. *Eur Radiol*. 2013;23(11):3124-30.
511. Beck JD, Jones RB, Malone WJ, Heimbach JL, Ebbitt T, Klena JC. Magnetic resonance imaging after endoscopic carpal tunnel release. *J Hand Surg Am*. 2013;38(2):331-5.
512. Bower JA, Stanisz GJ, Keir PJ. An MRI evaluation of carpal tunnel dimensions in healthy wrists: Implications for carpal tunnel syndrome. *Clin Biomech (Bristol, Avon)*. 2006;21(8):816-25.
513. Brahme SK, Hodler J, Braun RM, Sebrechts C, Jackson W, Resnick D. Dynamic MR imaging of carpal tunnel syndrome. *Skeletal Radiol*. 1997;26(8):482-7.
514. Britz GW, Haynor DR, Kuntz C, Goodkin R, Gitter A, Kliot M. Carpal tunnel syndrome: correlation of magnetic resonance imaging, clinical, electrodiagnostic, and intraoperative findings. *Neurosurgery*. 1995;37(6):1097-103.
515. Campagna R, Pessis E, Feydy A, et al. MRI assessment of recurrent carpal tunnel syndrome after open surgical release of the median nerve. *AJR Am J Roentgenol*. 2009;193(3):644-50.
516. Chen CK, Chung CB, Yeh L, et al. Carpal tunnel syndrome caused by tophaceous gout: CT and MR imaging features in 20 patients. *AJR Am J Roentgenol*. 2000;175(3):655-9.
517. Chen HC, Wang YY, Lin CH, et al. A knowledge-based approach for carpal tunnel segmentation from magnetic resonance images. *J Digit Imaging*. 2013;26(3):510-20.
518. Cudlip SA, Howe FA, Clifton A, Schwartz MS, Bell BA. Magnetic resonance neurography studies of the median nerve before and after carpal tunnel decompression. *J Neurosurg*. 2002;96(6):1046-51.
519. Deniz FE, Oksuz E, Sarikaya B, et al. Comparison of the diagnostic utility of electromyography, ultrasonography, computed tomography, and magnetic resonance imaging in idiopathic carpal tunnel syndrome determined by clinical findings. *Neurosurgery*. 2012;70(3):610-6.

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520. Fornander L, Nyman T, Hansson T, Ragnehed M, Brismar T. Age- and time-dependent effects on functional outcome and cortical activation pattern in patients with median nerve injury: a functional magnetic resonance imaging study. *J Neurosurg*. 2010;113(1):122-8.
521. Goetz JE, Kunze NM, Main EK, et al. MRI-apparent localized deformation of the median nerve within the carpal tunnel during functional hand loading. *Ann Biomed Eng*. 2013;41(10):2099-108.
522. Goetz JE, Thedens DR, Kunze NM, Lawler EA, Brown TD. Day-to-day variability of median nerve location within the carpal tunnel. *Clin Biomech (Bristol, Avon)*. 2010;25(7):660-5.
523. Healy C, Watson JD, Longstaff A, Campbell MJ. Magnetic resonance imaging of the carpal tunnel. *J Hand Surg Br*. 1990;15(2):243-8.
524. Hiltunen J, Kirveskari E, Numminen J, Lindfors N, Goransson H, Hari R. Pre- and post-operative diffusion tensor imaging of the median nerve in carpal tunnel syndrome. *Eur Radiol*. 2012;22(6):1310-9.
525. Horch RE, Allmann KH, Laubenberger J, Langer M, Stark GB. Median nerve compression can be detected by magnetic resonance imaging of the carpal tunnel. *Neurosurgery*. 1997;41(1):76-82; discussion -3.
526. Iannicelli E, Chianta GA, Salvini V, Almberger M, Monacelli G, Passariello R. Evaluation of bifid median nerve with sonography and MR imaging. *J Ultrasound Med*. 2000;19(7):481-5.
527. Kabakci N, Gurses B, Firat Z, et al. Diffusion tensor imaging and tractography of median nerve: normative diffusion values. *AJR Am J Roentgenol*. 2007;189(4):923-7.
528. Naraghi A, da Gama Lobo L, Menezes R, et al. Diffusion tensor imaging of the median nerve before and after carpal tunnel release in patients with carpal tunnel syndrome: feasibility study. *Skeletal Radiol*. 2013;42(10):1403-12.
529. Pierre-Jerome C, Bekkelund SI. Magnetic resonance assessment of the double-crush phenomenon in patients with carpal tunnel syndrome: a bilateral quantitative study. *Scand J Plast Reconstr Surg Hand Surg*. 2003;37(1):46-53.
530. Pierre-Jerome C, Bekkelund SI, Mellgren SI, Nordstrom R. Bilateral fast magnetic resonance imaging of the operated carpal tunnel. *Scand J Plast Reconstr Surg Hand Surg*. 1997;31(2):171-7.
531. Pierre-Jerome C, Bekkelund SI, Mellgren SI, Torbergsen T. Quantitative magnetic resonance imaging and the electrophysiology of the carpal tunnel region in floor cleaners. *Scand J Work Environ Health*. 1996;22(2):119-23.
532. Radack DM, Schweitzer ME, Taras J. Carpal tunnel syndrome: are the MR findings a result of population selection bias? *AJR Am J Roentgenol*. 1997;169(6):1649-53.
533. Seyfert S, Boegner F, Hamm B, Kleindienst A, Klatt C. The value of magnetic resonance imaging in carpal tunnel syndrome. *J Neurol*. 1994;242(1):41-6.
534. Shafer-Crane GA, Meyer RA, Schlinger MC, Bennett DL, Robinson KK, Rechtien JJ. Effect of occupational keyboard typing on magnetic resonance imaging of the median nerve in subjects with and without symptoms of carpal tunnel syndrome. *Am J Phys Med Rehabil*. 2005;84(4):258-66.
535. Soccetti A, Raffaelli P, Giovagnoni A, Ercolani P, Mercante O, Pelliccioni G. MR imaging in the diagnosis of carpal tunnel syndrome. *Ital J Orthop Traumatol*. 1992;18(1):123-7.
536. Stein D, Neufeld A, Pasternak O, et al. Diffusion tensor imaging of the median nerve in healthy and carpal tunnel syndrome subjects. *J Magn Reson Imaging*. 2009;29(3):657-62.
537. Sugimoto H, Miyaji N, Ohsawa T. Carpal tunnel syndrome: evaluation of median nerve circulation with dynamic contrast-enhanced MR imaging. *Radiology*. 1994;190(2):459-66.
538. Tsujii M, Hirata H, Morita A, Uchida A. Palmar bowing of the flexor retinaculum on wrist MRI correlates with subjective reports of pain in carpal tunnel syndrome. *J Magn Reson Imaging*. 2009;29(5):1102-5.
539. Wu HT, Schweitzer ME, Culp RW. Potential MR signs of recurrent carpal tunnel syndrome: initial experience. *J Comput Assist Tomogr*. 2004;28(6):860-4.
540. Yao L, Gai N. Median nerve cross-sectional area and MRI diffusion characteristics: normative values at the carpal tunnel. *Skeletal Radiol*. 2009;38(4):355-61.
541. Cha JG, Han JK, Im SB, Kang SJ. Median nerve T2 assessment in the wrist joints: preliminary study in patients with carpal tunnel syndrome and healthy volunteers. *J Magn Reson Imaging*. 2014;40(4):789-95.
542. Chalian M, Behzadi AH, Williams EH, Shores JT, Chhabra A. High-resolution magnetic resonance neurography in upper extremity neuropathy. *Neuroimaging Clin N Am*. 2014;24(1):109-25.
543. Somay G, Somay H, Cevik D, Sungur F, Berkman Z. The pressure angle of the median nerve as a new magnetic resonance imaging parameter for the evaluation of carpal tunnel. *Clin Neurol Neurosurg*. 2009;111(1):28-33.
544. Brienza M, Pujia F, Colaiacomo MC, et al. 3T diffusion tensor imaging and electroneurography of peripheral nerve: a morphofunctional analysis in carpal tunnel syndrome. *J Neuroradiol*. 2014;41(2):124-30.
545. Bulut HT, Yildirim A, Ekmekci B, Gunbey HP. The diagnostic and grading value of diffusion tensor imaging in patients with carpal tunnel syndrome. *Acad Radiol*. 2014;21(6):767-73.

Copyright© 2016 Reed Group, Ltd.

546. Jarvik JG, Yuen E, Haynor DR, et al. MR nerve imaging in a prospective cohort of patients with suspected carpal tunnel syndrome. *Neurology*. 2002;58(11):1597-602.
547. Uchiyama S, Itsubo T, Yasutomi T, Nakagawa H, Kamimura M, Kato H. Quantitative MRI of the wrist and nerve conduction studies in patients with idiopathic carpal tunnel syndrome. *J Neurol Neurosurg Psychiatry*. 2005;76(8):1103-8.
548. Wang CK, Jou IM, Huang HW, et al. Carpal tunnel syndrome assessed with diffusion tensor imaging: comparison with electrophysiological studies of patients and healthy volunteers. *Eur J Radiol*. 2012;81(11):3378-83.
549. Bak L, Bak S, Gaster P, et al. MR imaging of the wrist in carpal tunnel syndrome. *Acta Radiol*. 1997;38(6):1050-2.
550. Deryani E, Aki S, Muslumanoglu L, Rozanes I. MR imaging and electrophysiological evaluation in carpal tunnel syndrome. *Yonsei Med J*. 2003;44(1):27-32.
551. Guggenberger R, Markovic D, Eppenberger P, et al. Assessment of median nerve with MR neurography by using diffusion-tensor imaging: normative and pathologic diffusion values. *Radiology*. 2012;265(1):194-203.
552. Horng YS, Chang HC, Lin KE, Guo YL, Liu DH, Wang JD. Accuracy of ultrasonography and magnetic resonance imaging in diagnosing carpal tunnel syndrome using rest and grasp positions of the hands. *J Hand Surg Am*. 2012;37(8):1591-8.
553. Sambandam SN, Priyanka P, Gul A, Ilango B. Critical analysis of outcome measures used in the assessment of carpal tunnel syndrome. *Int Orthop*. 2008;32(4):497-504.
554. Appleby MA, Neville-Smith M, Parrott MW. Functional outcomes post carpal tunnel release: a modified replication of a previous study. *J Hand Ther*. 2009;22(3):240-8; quiz 9.
555. Bakhsh H, Ibrahim I, Khan W, Smitham P, Goddard N. Assessment of validity, reliability, responsiveness and bias of three commonly used patient-reported outcome measures in carpal tunnel syndrome. *Ortop Traumatol Rehabil*. 2012;14(4):335-40.
556. Becker SJ, Makanji HS, Ring D. Expected and actual improvement of symptoms with carpal tunnel release. *J Hand Surg Am*. 2012;37(7):1324-9 e1-5.
557. Buckley T, Mitten D, Elfar J. The effect of informed consent on results of a standard upper extremity intake questionnaire. *J Hand Surg Am*. 2013;38(2):366-71.
558. Gong HS, Oh JH, Kim WS, Kim SH, Rhee SH, Baek GH. The effect of dividing muscles superficial to the transverse carpal ligament on carpal tunnel release outcomes. *J Hand Surg Am*. 2011;36(9):1475-81.
559. Greenslade JR, Mehta RL, Belward P, Warwick DJ. Dash and Boston questionnaire assessment of carpal tunnel syndrome outcome: what is the responsiveness of an outcome questionnaire? *J Hand Surg Br*. 2004;29(2):159-64.
560. Hobby JL, Watts C, Elliot D. Validity and responsiveness of the patient evaluation measure as an outcome measure for carpal tunnel syndrome. *J Hand Surg Br*. 2005;30(4):350-4.
561. Imaeda T, Toh S, Wada T, et al. Validation of the Japanese Society for Surgery of the Hand Version of the Quick Disability of the Arm, Shoulder, and Hand (QuickDASH-JSSH) questionnaire. *J Orthop Sci*. 2006;11(3):248-53.
562. Iwatsuki K, Nishikawa K, Chaki M, Sato A, Morita A, Hirata H. Comparative responsiveness of the Hand 20 and the DASH-JSSH questionnaires to clinical changes after carpal tunnel release. *J Hand Surg Eur Vol*. 2014;39(2):145-51.
563. Jeon SH, Lee JH, Chung MS, et al. Responsiveness of the Korean version of the disabilities of the arm, shoulder and hand questionnaire (K-DASH) after carpal tunnel release. *Clin Orthop Surg*. 2011;3(2):147-51.
564. Jerosch-Herold C, Shepstone L, Miller L, Chapman P. The responsiveness of sensibility and strength tests in patients undergoing carpal tunnel decompression. *BMC Musculoskelet Disord*. 2011;12244.
565. Koldas Dogan S, Ay S, Evcik D, Baser O. Adaptation of Turkish version of the questionnaire Quick Disability of the Arm, Shoulder, and Hand (Quick DASH) in patients with carpal tunnel syndrome. *Clin Rheumatol*. 2011;30(2):185-91.
566. Kotsis SV, Chung KC. Responsiveness of the Michigan Hand Outcomes Questionnaire and the Disabilities of the Arm, Shoulder and Hand questionnaire in carpal tunnel surgery. *J Hand Surg Am*. 2005;30(1):81-6.
567. Lue YJ, Lu YM, Lin GT, Liu YF. Validation of the Chinese version of the Boston Carpal Tunnel Questionnaire. *J Occup Rehabil*. 2014;24(1):139-45.
568. Niekel MC, Lindenhovius AL, Watson JB, Vranceanu AM, Ring D. Correlation of DASH and QuickDASH with measures of psychological distress. *J Hand Surg Am*. 2009;34(8):1499-505.
569. Park DJ, Kang JH, Lee JW, et al. Cross-cultural adaptation of the Korean version of the Boston carpal tunnel questionnaire: its clinical evaluation in patients with carpal tunnel syndrome following local corticosteroid injection. *J Korean Med Sci*. 2013;28(7):1095-9.
570. Rosales RS, Delgado EB, Diez de la Lastra-Bosch I. Evaluation of the Spanish version of the DASH and carpal tunnel syndrome health-related quality-of-life instruments: cross-cultural adaptation process and reliability. *J Hand Surg Am*. 2002;27(2):334-43.

Copyright© 2016 Reed Group, Ltd.

571. Unglaub F, Wolf E, Goldbach C, Hahn P, Kroeber MW. Subjective and functional outcome after revision surgery in carpal tunnel syndrome. *Arch Orthop Trauma Surg*. 2008;128(9):931-6.
572. Van Vliet MM, Maradey JA, Homa KA, Kerrigan CL. The usefulness of patient-reported measures for clinical practice. *Plast Reconstr Surg*. 2013;132(1):105-12.
573. Vranceanu AM, Kadzielski J, Hwang R, Ring D. A patient-specific version of the Disabilities of the Arm, Shoulder, and Hand Questionnaire. *J Hand Surg Am*. 2010;35(5):824-6.
574. Wi SM, Gong HS, Bae KJ, Roh YH, Lee YH, Baek GH. Responsiveness of the Korean version of the Michigan Hand Outcomes Questionnaire after carpal tunnel release. *Clin Orthop Surg*. 2014;6(2):203-7.
575. Zyluk A, Piotuch B. A Comparison of DASH, PEM and Levine questionnaires in outcome measurement of carpal tunnel release. *Handchir Mikrochir Plast Chir*. 2011;43(3):162-6.
576. Alderson M, McGall D. The Alderson-McGall hand function questionnaire for patients with Carpal Tunnel syndrome: a pilot evaluation of a future outcome measure. *J Hand Ther*. 1999;12(4):313-22.
577. Atroshi I, Breidenbach WC, McCabe SJ. Assessment of the carpal tunnel outcome instrument in patients with nerve-compression symptoms. *J Hand Surg Am*. 1997;22(2):222-7.
578. Ball C, Pearse M, Kennedy D, Hall A, Nanchahal J. Validation of a one-stop carpal tunnel clinic including nerve conduction studies and hand therapy. *Ann R Coll Surg Engl*. 2011;93(8):634-8.
579. Caliandro P, Giannini F, Pazzaglia C, et al. A new clinical scale to grade the impairment of median nerve in carpal tunnel syndrome. *Clin Neurophysiol*. 2010;121(7):1066-71.
580. Cevik MU, Altun Y, Uzar E, et al. Diagnostic value of F-wave inversion in patients with early carpal tunnel syndrome. *Neurosci Lett*. 2012;508(2):110-3.
581. de la Llave-Rincon AI, Fernandez-de-Las-Penas C, Perez-de-Heredia-Torres M, Martinez-Perez A, Valenza MC, Pareja JA. Bilateral deficits in fine motor control and pinch grip force are not associated with electrodiagnostic findings in women with carpal tunnel syndrome. *Am J Phys Med Rehabil*. 2011;90(6):443-51.
582. Descatha A, Dale AM, Franzblau A, Evanoff B. Natural history and predictors of long-term pain and function among workers with hand symptoms. *Arch Phys Med Rehabil*. 2013;94(7):1293-9.
583. Fernandez-de-Las-Penas C, Cleland JA, Plaza-Manzano G, et al. Clinical, physical, and neurophysiological impairments associated with decreased function in women with carpal tunnel syndrome. *J Orthop Sports Phys Ther*. 2013;43(9):641-9.
584. Gehrmann S, Tang J, Kaufmann RA, Goitz RJ, Windolf J, Li ZM. Variability of precision pinch movements caused by carpal tunnel syndrome. *J Hand Surg Am*. 2008;33(7):1069-75.
585. Kim JY, Yoon JS, Kim SJ, Won SJ, Jeong JS. Carpal tunnel syndrome: Clinical, electrophysiological, and ultrasonographic ratio after surgery. *Muscle Nerve*. 2012;45(2):183-8.
586. Leit ME, Weiser RW, Tomaino MM. Patient-reported outcome after carpal tunnel release for advanced disease: a prospective and longitudinal assessment in patients older than age 70. *J Hand Surg Am*. 2004;29(3):379-83.
587. Levine DW, Simmons BP, Koris MJ, et al. A self-administered questionnaire for the assessment of severity of symptoms and functional status in carpal tunnel syndrome. *J Bone Joint Surg Am*. 1993;75(11):1585-92.
588. Li K, Evans PJ, Seitz WH, Jr., Li ZM. Carpal tunnel syndrome impairs sustained precision pinch performance. *Clin Neurophysiol*. 2015;126(1):194-201.
589. Mattos DJ, Domenech SC, Borges Junior NG, Santos MJ. Effect of fatigue on grip force control during object manipulation in carpal tunnel syndrome. *Motor Control*. 2012;16(4):521-36.
590. Mody GN, Anderson GA, Thomas BP, Pallapati SC, Santoshi JA, Antonisamy B. Carpal tunnel syndrome in Indian patients: use of modified questionnaires for assessment. *J Hand Surg Eur Vol*. 2009;34(5):671-8.
591. Mondelli M, Ginanneschi F, Rossi S, Reale F, Padua L, Giannini F. Inter-observer reproducibility and responsiveness of a clinical severity scale in surgically treated carpal tunnel syndrome. *Acta Neurol Scand*. 2002;106(5):263-8.
592. Ortiz-Corredor F, Calambas N, Mendoza-Pulido C, Galeano J, Diaz-Ruiz J, Delgado O. Factor analysis of carpal tunnel syndrome questionnaire in relation to nerve conduction studies. *Clin Neurophysiol*. 2011;122(10):2067-70.
593. Tamburin S, Cacciatori C, Praitano ML, et al. Median nerve small- and large-fiber damage in carpal tunnel syndrome: a quantitative sensory testing study. *J Pain*. 2011;12(2):205-12.
594. Tan JS, Tan AB. Outcomes of open carpal tunnel releases and its predictors: a prospective study. *Hand Surg*. 2012;17(3):341-5.
595. Zyluk A, Szlosser Z. The results of carpal tunnel release for carpal tunnel syndrome diagnosed on clinical grounds, with or without electrophysiological investigations: a randomized study. *J Hand Surg Eur Vol*. 2013;38(1):44-9.
596. Zyluk A, Walaszek I. The effect of the involvement of the dominant or non-dominant hand on grip/pinch strengths and the Levine score in patients with carpal tunnel syndrome. *J Hand Surg Eur Vol*. 2012;37(5):427-31.

Copyright© 2016 Reed Group, Ltd.

597. Weber RA, DeSalvo DJ, Rude MJ. Five-year follow-up of carpal tunnel release in patients over age 65. *J Hand Surg Am*. 2010;35(2):207-11.
598. Flinn SR, Pease WS, Freimer ML. Score reliability and construct validity of the Flinn Performance Screening Tool for adults with symptoms of carpal tunnel syndrome. *Am J Occup Ther*. 2012;66(3):330-7.
599. Fok M, Leung HB, Lee WM. Evaluation of a Hong Kong Chinese version of a self-administered questionnaire for assessing symptom severity and functional status of carpal tunnel syndrome: cross-cultural adaptation and reliability. *Hong Kong Med J*. 2007;13(5):342-7.
600. Louie DL, Earp BE, Collins JE, et al. Outcomes of open carpal tunnel release at a minimum of ten years. *J Bone Joint Surg Am*. 2013;95(12):1067-73.
601. Katz JN, Gelberman RH, Wright EA, Abrahamsson SO, Lew RA. A preliminary scoring system for assessing the outcome of carpal tunnel release. *J Hand Surg Am*. 1994;19(4):531-8.
602. Baker NA, Moehling KK, Desai AR, Gustafson NP. Effect of carpal tunnel syndrome on grip and pinch strength compared with sex- and age-matched normative data. *Arthritis Care Res (Hoboken)*. 2013;65(12):2041-5.
603. Lowe BD, Freivalds A. Effect of carpal tunnel syndrome on grip force coordination on hand tools. *Ergonomics*. 1999;42(4):550-64.
604. Schreuders TA, Roebroeck ME, Jaquet JB, Hovius SE, Stam HJ. Long-term outcome of muscle strength in ulnar and median nerve injury: comparing manual muscle strength testing, grip and pinch strength dynamometers and a new intrinsic muscle strength dynamometer. *J Rehabil Med*. 2004;36(6):273-8.
605. Zhang W, Johnston JA, Ross MA, et al. Effects of carpal tunnel syndrome on adaptation of multi-digit forces to object weight for whole-hand manipulation. *PLoS One*. 2011;6(11):e27715.
606. Netscher D, Steadman AK, Thornby J, Cohen V. Temporal changes in grip and pinch strength after open carpal tunnel release and the effect of ligament reconstruction. *J Hand Surg Am*. 1998;23(1):48-54.
607. Olsen KM, Knudson DV. Change in strength and dexterity after open carpal tunnel release. *Int J Sports Med*. 2001;22(4):301-3.
608. Tredgett MW, Davis TR. Rapid repeat testing of grip strength for detection of faked hand weakness. *J Hand Surg Br*. 2000;25(4):372-5.
609. Zieske L, Ebersole GC, Davidge K, Fox I, Mackinnon SE. Revision carpal tunnel surgery: a 10-year review of intraoperative findings and outcomes. *J Hand Surg Am*. 2013;38(8):1530-9.
610. Akalin E, El O, Peker O, et al. Treatment of carpal tunnel syndrome with nerve and tendon gliding exercises. *Am J Phys Med Rehabil*. 2002;81(2):108-13.
611. Baysal O, Altay Z, Ozcan C, Ertem K, Yologlu S, Kayhan A. Comparison of three conservative treatment protocols in carpal tunnel syndrome. *Int J Clin Pract*. 2006;60(7):820-8.
612. Muller M, Tsui D, Schnurr R, Biddulph-Deisroth L, Hard J, MacDermid JC. Effectiveness of hand therapy interventions in primary management of carpal tunnel syndrome: a systematic review. *J Hand Ther*. 2004;17(2):210-28.
613. Page MJ, O'Connor D, Pitt V, Massy-Westropp N. Exercise and mobilisation interventions for carpal tunnel syndrome. *Cochrane Database Syst Rev*. 2012;13(6).
614. Pinar L, Enhos A, Ada S, Gungor N. Can we use nerve gliding exercises in women with carpal tunnel syndrome? *Adv Ther*. 2005;22(5):467-75.
615. Rozmaryn LM, Dovelle S, Rothman ER, Gorman K, Olvey KM, Bartko JJ. Nerve and tendon gliding exercises and the conservative management of carpal tunnel syndrome. *J Hand Ther*. 1998;11(3):171-9.
616. Ashworth NL. Carpal tunnel syndrome. *BMJ Clin Evid*. 2011;2011.
617. Medina McKeon J, Yancosek K. Neural gliding techniques for the treatment of carpal tunnel syndrome: a systematic review. *J Sport Rehabil*. 2008;17(3):324-41.
618. Seradge H, Jia YC, Owens W. In vivo measurement of carpal tunnel pressure in the functioning hand. *J Hand Surg Am*. 1995;20(5):855-9.
619. Szabo RM, Bay BK, Sharkey NA, Gaut C. Median nerve displacement through the carpal canal. *J Hand Surg Am*. 1994;19(6):901-6.
620. Totten PA, Hunter JM. Therapeutic techniques to enhance nerve gliding in thoracic outlet syndrome and carpal tunnel syndrome. *Hand Clin*. 1991;7(3):505-20.
621. Bialosky JE, Bishop MD, Price DD, Robinson ME, Vincent KR, George SZ. A randomized sham-controlled trial of a neurodynamic technique in the treatment of carpal tunnel syndrome. *J Orthop Sports Phys Ther*. 2009;39(10):709-23.
622. Brininger TL, Rogers JC, Holm MB, Baker NA, Li ZM, Goitz RJ. Efficacy of a fabricated customized splint and tendon and nerve gliding exercises for the treatment of carpal tunnel syndrome: a randomized controlled trial. *Arch Phys Med Rehabil*. 2007;88(11):1429-35.
623. Schmid AB, Elliott JM, Strudwick MW, Little M, Coppieters MW. Effect of splinting and exercise on intraneural edema of the median nerve in carpal tunnel syndrome--an MRI study to reveal therapeutic mechanisms. *J Orthop Res*. 2012;30(8):1343-50.

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624. Bardak AN, Alp M, Erhan B, Paker N, Kaya B, Onal AE. Evaluation of the clinical efficacy of conservative treatment in the management of carpal tunnel syndrome. *Adv Ther*. 2009;26(1):107-16.
625. Heebner ML, Roddey TS. The effects of neural mobilization in addition to standard care in persons with carpal tunnel syndrome from a community hospital. *J Hand Ther*. 2008;21(3):229-40.
626. Horng YS, Hsieh SF, Tu YK, Lin MC, Wang JD. The comparative effectiveness of tendon and nerve gliding exercises in patients with carpal tunnel syndrome: a randomized trial. *Am J Phys Med Rehabil*. 2011;90(6):435-42.
627. Tal-Akabi A, Rushton A. An investigation to compare the effectiveness of carpal bone mobilisation and neurodynamic mobilisation as methods of treatment for carpal tunnel syndrome. *Man Ther*. 2000;5(4):214-22.
628. Garfinkel MS, Singhal A, Katz WA, Allan DA, Reshetar R, Schumacher HR, Jr. Yoga-based intervention for carpal tunnel syndrome: a randomized trial. *JAMA*. 1998;280(18):1601-3.
629. Williams K, Abildso C, Steinberg L, et al. Evaluation of the effectiveness and efficacy of Iyengar yoga therapy on chronic low back pain. *Spine (Phila Pa 1976)*. 2009;34(19):2066-76.
630. Banta CA. A prospective, nonrandomized study of iontophoresis, wrist splinting, and antiinflammatory medication in the treatment of early-mild carpal tunnel syndrome. *J Occup Med*. 1994;36(2):166-8.
631. Celiker R, Arslan S, Inanici F. Corticosteroid injection vs. nonsteroidal antiinflammatory drug and splinting in carpal tunnel syndrome. *Am J Phys Med Rehabil*. 2002;81(3):182-6.
632. de Pablo P, Katz JN. Pharmacotherapy of carpal tunnel syndrome. *Expert Opin Pharmacother*. 2003;4(6):903-9.
633. Giele H. Evidence-based treatment of carpal tunnel syndrome. *Curr Orthop*. 2001;15(4):249-55.
634. O'Connor D, Marshall S, Massy-Westropp N. Non-surgical treatment (other than steroid injection) for carpal tunnel syndrome. *Cochrane Database Syst Rev*. 2003(1):CD003219.
635. Piazzini DB, Aprile I, Ferrara PE, et al. A systematic review of conservative treatment of carpal tunnel syndrome. *Clin Rehabil*. 2007;21(4):299-314.
636. Chang M, Chiang H, Lee S-J, Ger L, Lo Y. Oral drug of choice in carpal tunnel syndrome. *Neurology*. 1998;51(2):390-3.
637. Davis PT, Hulbert JR, Kassak KM, Meyer JJ. Comparative efficacy of conservative medical and chiropractic treatments for carpal tunnel syndrome: a randomized clinical trail. *J Manipulative Physiol Ther*. 1998;21(5):317-26.
638. Nalamachu S, Crockett RS, Gammaitoni AR, Gould EM. A comparison of the lidocaine patch 5% vs naproxen 500 mg twice daily for the relief of pain associated with carpal tunnel syndrome: a 6-week, randomized, parallel-group study. *MedGenMed*. 2006;8(3):33.
639. Husby T, Haugstvedt JR, Fyllingen G, Skoglund LA. Acute postoperative swelling after hand surgery: an exploratory, double-blind, randomised study with paracetamol, naproxen, and placebo. *Scand J Plast Reconstr Surg Hand Surg*. 2001;35(1):91-8.
640. Yildiz N, Atalay NS, Gungen GO, Sanal E, Akkaya N, Topuz O. Comparison of ultrasound and ketoprofen phonophoresis in the treatment of carpal tunnel syndrome. *J Back Musculoskelet Rehabil*. 2011;24(1):39-47.
641. Jarvik JG, Comstock BA, Kliot M, et al. Surgery versus non-surgical therapy for carpal tunnel syndrome: a randomised parallel-group trial. *Lancet*. 2009;374(9695):1074-81.
642. Gurcay E, Unlu E, Gurcay AG, Tuncay R, Cakci A. Evaluation of the effect of local corticosteroid injection and anti-inflammatory medication in carpal tunnel syndrome. *Scott Med J*. 2009;54(1):4-6.
643. Chang MH, Ger LP, Hsieh PF, Huang SY. A randomised clinical trial of oral steroids in the treatment of carpal tunnel syndrome: a long term follow up. *J Neurol Neurosurg Psychiatry*. 2002;73(6):710-4.
644. Herskovitz S, Berger AR, Lipton RB. Low-dose, short-term oral prednisone in the treatment of carpal tunnel syndrome. *Neurology*. 1995;45(10):1923-5.
645. Hui AC, Wong SM, Tang A, Mok V, Hung LK, Wong KS. Long-term outcome of carpal tunnel syndrome after conservative treatment. *Int J Clin Pract*. 2004;58(4):337-9.
646. Hui AC, Wong SM, Wong KS, et al. Oral steroid in the treatment of carpal tunnel syndrome. *Ann Rheum Dis*. 2001;60(8):813-4.
647. Mishra S, Prabhakar S, Lal V, Modi M, Das CP, Khurana D. Efficacy of splinting and oral steroids in the treatment of carpal tunnel syndrome: a prospective randomized clinical and electrophysiological study. *Neurol India*. 2006;54(3):286-90.
648. Wong S, Hui A, Tang A, et al. Local vs systemic corticosteroids in the treatment of carpal tunnel syndrome. *Neurology*. 2001;56(11):1565-7.
649. Ashworth NL. Carpal tunnel syndrome. *Clin Evid (Online)*. 2010;2010.
650. Gerritsen AA, de Krom MC, Struijs MA, Scholten RJ, de Vet HC, Bouter LM. Conservative treatment options for carpal tunnel syndrome: a systematic review of randomised controlled trials. *J Neurol*. 2002;249(3):272-80.
651. Goodyear-Smith F, Arroll B. What can family physicians offer patients with carpal tunnel syndrome other than surgery? A systematic review of nonsurgical management. *Ann Fam Med*. 2004;2(3):267-73.

Copyright© 2016 Reed Group, Ltd.

652. Pal B, Mangion P, Hossain MA, Wallace AS, Diffey BL. Should diuretics be prescribed for idiopathic carpal tunnel syndrome? Results of a controlled trial. *Clin Rehabil*. 1988;2(299-301).
653. Atluri S, Sudarshan G. Development of a screening tool to detect the risk of inappropriate prescription opioid use in patients with chronic pain. *Pain Physician*. 2004;7(3):333-8.
654. Cheng M, Sauer B, Johnson E, Porucznik C, Hegmann K. Comparison of opioid-related deaths by work-related injury. *Am J Industrial Med*. 2013;56308-16.
655. Eriksen J, Sjogren P, Bruera E, Ekholm O, Rasmussen NK. Critical issues on opioids in chronic non-cancer pain: an epidemiological study. *Pain*. 2006;125(1-2):172-9.
656. Green TC, Grau LE, Carver HW, Kinzly M, Heimer R. Epidemiologic trends and geographic patterns of fatal opioid intoxications in Connecticut, USA: 1997-2007. *Drug Alcohol Depend*. 2011;115(3):221-8.
657. Dunn KM, Saunders KW, Rutter CM, et al. Opioid prescriptions for chronic pain and overdose: a cohort study. *Ann Intern Med*. 2010;152(2):85-92.
658. Grattan A, Sullivan M, Saunders K, Campbell C, Von Korff M. Depression and prescription opioid misuse among chronic opioid therapy recipients with no history of substance abuse. *Annals Fam Med*. 2012;10(4):304-11.
659. Hadidi MS, Ibrahim MI, Abdallat IM, Hadidi KA. Current trends in drug abuse associated fatalities - Jordan, 2000-2004. *Forensic Sci Int*. 2009;186(1-3):44-7.
660. Hall A, Logan J, Toblin R, et al. Patterns of abuse among unintentional pharmaceutical overdose fatalities. *JAMA*. 2008;300(22):2613-20.
661. Manchikanti L, Damron KS, McManus CD, Barnhill RC. Patterns of illicit drug use and opioid abuse in patients with chronic pain at initial evaluation: a prospective, observational study. *Pain Physician*. 2004;7(4):431-7.
662. Nyhlen A, Fridell M, Backstrom M, Hesse M, Krantz P. Substance abuse and psychiatric co-morbidity as predictors of premature mortality in Swedish drug abusers: a prospective longitudinal study 1970-2006. *BMC Psychiatry*. 2011;11122.
663. Paulozzi L, Baldwin G, Franklin G, et al. CDC Grand Rounds: Prescription Drug Overdoses-a U.S. Epidemic. *MMWR*. 2012;61(1):10-3.
664. Paulozzi LJ, Logan JE, Hall AJ, McKinstry E, Kaplan JA, Crosby AE. A comparison of drug overdose deaths involving methadone and other opioid analgesics in West Virginia. *Addiction*. 2009;104(9):1541-8.
665. Shah NG, Lathrop SL, Reichard RR, Landen MG. Unintentional drug overdose death trends in New Mexico, USA, 1990-2005: combinations of heroin, cocaine, prescription opioids and alcohol. *Addiction*. 2008;103(1):126-36.
666. Toblin RL, Paulozzi LJ, Logan JE, Hall AJ, Kaplan JA. Mental illness and psychotropic drug use among prescription drug overdose deaths: a medical examiner chart review. *J Clin Psychiatry*. 2010;71(4):491-6.
667. Webster L, Cochella S, Dasgupta N, et al. An analysis of the root causes for opioid-related overdose deaths in the United States. *Pain Med*. 2011;12(Suppl 2):S26-35.
668. Wunsch M, Nakamoto K, Behonick G, Massello W. Opioid deaths in rural Virginia: a description of the high prevalence of accidental fatalities involving prescribed medications. *Am J Addict*. 2009;18(1).
669. Wysowski DK. Surveillance of prescription drug-related mortality using death certificate data. *Drug Saf*. 2007;30(6):533-40.
670. Wysowski DK, Governale LA, Swann J. Trends in outpatient prescription drug use and related costs in the US: 1998-2003. *Pharmacoeconomics*. 2006;24(3):233-6.
671. Centers for Disease Control and Prevention. Unintentional deaths from drug poisoning by urbanization of area — New Mexico, 1994–2003. *MMWR*. 2005;54(35):870-3.
672. Centers for Disease Control and Prevention. Adult Use of Prescription Opioid Pain Medications - Utah, 2008. *MMWR*. 2010;59(6):153-7.
673. Dean M. Opioids in renal failure and dialysis patients. *J Pain Symptom Manage*. 2004;28(5):497-504.
674. Deyo RA, Smith DH, Johnson ES, et al. Opioids for back pain patients: primary care prescribing patterns and use of services. *J Am Board Fam Med*. 2011;24(6):717-27.
675. Fareed A, Casarella J, Roberts M, et al. High dose versus moderate dose methadone maintenance: is there a better outcome? *J Addict Dis*. 2009;28(4):399-405.
676. Goodridge D, Lawson J, Rocker G, Marciniuk D, Rennie D. Factors associated with opioid dispensation for patients with COPD and lung cancer in the last year of life: A retrospective analysis. *Int J Chron Obstruct Pulmon Dis*. 2010;599-105.
677. Mills K, Teesson M, Ross J, Darke S, Shanahan M. The costs and outcomes of treatment for opioid dependence associated with posttraumatic stress disorder. *Psychiatr Serv*. 2005;56(8):940-5.
678. Seal KH, Shi Y, Cohen G, et al. Association of mental health disorders with prescription opioids and high-risk opioid use in US veterans of Iraq and Afghanistan. *JAMA*. 2012;307(9):940-7.
679. Walter SR, Thein HH, Amin J, et al. Trends in mortality after diagnosis of hepatitis B or C infection: 1992-2006. *J Hepatol*. 2011;54(5):879-86.

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680. Gomes T, Redelmeier DA, Juurlink DN, Dhalla IA, Camacho X, Mamdani MM. Opioid dose and risk of road trauma in Canada: a population-based study. *JAMA Intern Med*. 2013;173(3):196-201.
681. Cifuentes M, Webster B, Genevay S, Pransky G. The course of opioid prescribing for a new episode of disabling low back pain: opioid features and dose escalation. *Pain*. 2010;151(1):22-9.
682. Volinn E, Fargo JD, Fine PG. Opioid therapy for nonspecific low back pain and the outcome of chronic work loss. *Pain*. 2009;142(3):194-201.
683. Dersh J, Mayer T, Gatchel R, Polatin P, Theodore B, Mayer E. Prescription opioid dependence is associated with poorer outcomes in disabling spinal disorders. *Spine (Phila Pa 1976)*. 2008;33(20):2219-27.
684. Innes GD, Croskerry P, Worthington J, Beveridge R, Jones D. Ketorolac versus acetaminophen-codeine in the emergency department treatment of acute low back pain. *J Emerg Med*. 1998;16(4):549-56.
685. Veenema K, Leahey N, S. S. Ketorolac versus meperidine: ED treatment of severe musculoskeletal low back pain. *Am J Emerg Med*. 2000;18(4):404-7.
686. Reneman MF, Jorritsma W, Schellekens JM, Goeken LN. Concurrent validity of questionnaire and performance-based disability measurements in patients with chronic nonspecific low back pain. *J Occup Rehabil*. 2002;12(3):119-29.
687. Swinkels-Meewisse IE, Roelofs J, Oostendorp RA, Verbeek AL, Vlaeyen JW. Acute low back pain: pain-related fear and pain catastrophizing influence physical performance and perceived disability. *Pain*. 2006;120(1-2):36-43.
688. Bohnert AS, Valenstein M, Bair MJ, et al. Association between opioid prescribing patterns and opioid overdose-related deaths. *JAMA*. 2011;305(13):1315-21.
689. Church CA, Stewart Ct, TJ OL, Wallace D. Rofecoxib versus hydrocodone/acetaminophen for postoperative analgesia in functional endoscopic sinus surgery. *Laryngoscope*. 2006;116(4):602-6.
690. Nussmeier NA, Whelton AA, Brown MT, et al. Safety and efficacy of the cyclooxygenase-2 inhibitors parecoxib and valdecoxib after noncardiac surgery. *Anesthesiology*. 2006;104(3):518-26.
691. Dirks J, Fredensborg BB, Christensen D, Fomsgaard JS, Flyger H, Dahl JB. A randomized study of the effects of single-dose gabapentin versus placebo on postoperative pain and morphine consumption after mastectomy. *Anesthesiology*. 2002;97(3):560-4.
692. Legeby M, Sandelin K, Wickman M, Olofsson C. Analgesic efficacy of diclofenac in combination with morphine and paracetamol after mastectomy and immediate breast reconstruction. *Acta Anaesthesiol Scand*. 2005;49(9):1360-6.
693. Pettersson PH, Jakobsson J, Owall A. Intravenous acetaminophen reduced the use of opioids compared with oral administration after coronary artery bypass grafting. *J Cardiothorac Vasc Anesth*. 2005;19(3):306-9.
694. Wininger SJ, Miller H, Minkowitz HS, et al. A randomized, double-blind, placebo-controlled, multicenter, repeat-dose study of two intravenous acetaminophen dosing regimens for the treatment of pain after abdominal laparoscopic surgery. *Clin Ther*. 2010;32(14):2348-69.
695. Buchler MW, Seiler CM, Monson JR, et al. Clinical trial: alvimopan for the management of post-operative ileus after abdominal surgery: results of an international randomized, double-blind, multicentre, placebo-controlled clinical study. *Aliment Pharmacol Ther*. 2008;28(3):312-25.
696. Wolff BG, Michelassi F, Gerkin TM, et al. Alvimopan, a novel, peripherally acting mu opioid antagonist: results of a multicenter, randomized, double-blind, placebo-controlled, phase III trial of major abdominal surgery and postoperative ileus. *Ann Surg*. 2004;240(4):728-34; discussion 34-5.
697. Dierking G, Duedahl TH, Rasmussen ML, et al. Effects of gabapentin on postoperative morphine consumption and pain after abdominal hysterectomy: a randomized, double-blind trial. *Acta Anaesthesiol Scand*. 2004;48(3):322-7.
698. Pizzi LT, Toner R, Foley K, et al. Relationship between potential opioid-related adverse effects and hospital length of stay in patients receiving opioids after orthopedic surgery. *Pharmacotherapy*. 2012;32(6):502-14.
699. Christensen KS, Cohen AE, Mermelstein FH, et al. The analgesic efficacy and safety of a novel intranasal morphine formulation (morphine plus chitosan), immediate release oral morphine, intravenous morphine, and placebo in a postsurgical dental pain model. *Anesth Analg*. 2008;107(6):2018-24.
700. Nader A, Kendall MC, Wixson RL, Chung B, Polakow LM, McCarthy RJ. A randomized trial of epidural analgesia followed by continuous femoral analgesia compared with oral opioid analgesia on short- and long-term functional recovery after total knee replacement. *Pain Med*. 2012;13(7):937-47.
701. Belknap SM, Moore H, Lanzotti SA, et al. Application of software design principles and debugging methods to an analgesia prescription reduces risk of severe injury from medical use of opioids. *Clin Pharmacol Ther*. 2008;84(3):385-92.
702. Federation of State Medical Boards. Model Policy on the Use of Opioid Analgesics in the Treatment of Chronic Pain. 2013.
703. International Association of Industrial Accident Boards and Commissions. Reducing Inappropriate Opioid Use in Treatment of Injured Workers: A Policy Guide. 2013. http://www.iaiabc.org/files/OpioidPolicies_05-29-13.pdf.

Copyright© 2016 Reed Group, Ltd.

704. Brouwer S, Dijkstra PU, Stewart RE, Goeken LN, Groothoff JW, Geertzen JH. Comparing self-report, clinical examination and functional testing in the assessment of work-related limitations in patients with chronic low back pain. *Disabil Rehabil*. 2005;27(17):999-1005.
705. Buelow AK, Haggard R, Gatchel RJ. Additional validation of the pain medication questionnaire in a heterogeneous sample of chronic pain patients. *Pain Pract*. 2009;9(6):428-34.
706. Food and Drug Administration. Letter to Dr. Andrew Kolodny in Response to the Citizen Petition Submitted by Physicians for Responsible Opioid Prescribing. 2013.
707. Fox CD, Steger HG, Jennison JH. Ratio scaling of pain perception with the submaximum effort tourniquet technique. *Pain*. 1979;7(1):21-9.
708. Gross DP, Battie MC. Construct validity of a kinesiophysical functional capacity evaluation administered within a worker's compensation environment. *J Occup Rehabil*. 2003;13(4):287-95.
709. Hartrick CT, Kovan JP, Shapiro S. The numeric rating scale for clinical pain measurement: a ratio measure? *Pain Pract*. 2003;3(4):310-6.
710. Lund I, Lundeberg T, Sandberg L, Budh CN, Kowalski J, Svensson E. Lack of interchangeability between visual analogue and verbal rating pain scales: a cross sectional description of pain etiology groups. *BMC Med Res Methodol*. 2005;531.
711. Mahowald ML, Singh JA, Majeski P. Opioid use by patients in an orthopedics spine clinic. *Arthritis Rheum*. 2005;52(1):312-21.
712. Morasco BJ, Cavanagh R, Gritzner S, Dobscha SK. Care management practices for chronic pain in veterans prescribed high doses of opioid medications. *Fam Pract*. 2013.
713. Reneman MF, Schiphorts Preuper HR, Kleen M, Geertzen JH, Dijkstra PU. Are pain intensity and pain related fear related to functional capacity evaluation performances of patients with chronic low back pain? *J Occup Rehabil*. 2007;17(2):247-58.
714. Schiphorst Preuper H, Reneman M, Boonstra A, et al. Relationship between psychological factors and performance-based and self-reported disability in chronic low back pain. *Eur Spine J*. 2008;17(11):1448-56.
715. Smeets RJ, van Geel AC, Kester AD, Knottnerus JA. Physical capacity tasks in chronic low back pain: what is the contributing role of cardiovascular capacity, pain and psychological factors? *Disabil Rehabil*. 2007;29(7):577-86.
716. Von Korff M, Merrill JO, Rutter CM, Sullivan M, Campbell CI, Weisner C. Time-scheduled vs. pain-contingent opioid dosing in chronic opioid therapy. *Pain*. 2011;152(6):1256-62.
717. Cifuentes M, Powell R, Webster B. Shorter time between opioid prescriptions associated with reduced work disability among acute low back pain opioid users. *J Occup Environ Med*. 2012;54(4):491-6.
718. Hartrick C, Gatchel R, Conroy S. Identification and management of pain medication abuse and misuse: current state and future directions. *Expert Rev Neurother*. 2012;12(5).
719. Kidner CL, Gatchel RJ, Mayer TG. MMPI disability profile is associated with degree of opioid use in chronic work-related musculoskeletal disorders. *Clin J Pain*. 2010;26(1):9-15.
720. Naliboff BD, Wu SM, Schieffer B, et al. A randomized trial of 2 prescription strategies for opioid treatment of chronic nonmalignant pain. *J Pain*. 2011;12(2):288-96.
721. Chou R, Fanciullo GJ, Fine PG, et al. Clinical guidelines for the use of chronic opioid therapy in chronic noncancer pain. *J Pain*. 2009;10(2):113-30.
722. Goldberg K, Simel D, Oddone E. Effect of an opioid management system on opioid prescribing and unscheduled visits in a large primary care clinic. *JCOM*. 2005;12(12):621-8.
723. Manchikanti L, Manchukonda R, Damron KS, Brandon D, McManus CD, Cash K. Does adherence monitoring reduce controlled substance abuse in chronic pain patients? *Pain Physician*. 2006;9(1):57-60.
724. Manchikanti L, Manchukonda R, Pampati V, et al. Does random urine drug testing reduce illicit drug use in chronic pain patients receiving opioids? *Pain Physician*. 2006;9(2):123-9.
725. Starrels JL, Becker WC, Alford DP, Kapoor A, Williams AR, Turner BJ. Systematic review: treatment agreements and urine drug testing to reduce opioid misuse in patients with chronic pain. *Ann Intern Med*. 2010;152(11):712-20.
726. Wiedemer N, Harden P, Arndt I, Gallagher R. The opioid renewal clinic: a primary care, managed approach to opioid therapy in chronic pain patients at risk for substance abuse. *Pain Med*. 2007;8(7):573-84.
727. Chelminski PR, Ives TJ, Felix KM, et al. A primary care, multi-disciplinary disease management program for opioid-treated patients with chronic non-cancer pain and a high burden of psychiatric comorbidity. *BMC Health Serv Res*. 2005;5(1):3.
728. Compton PA, Wu SM, Schieffer B, Pham Q, Naliboff BD. Introduction of a self-report version of the Prescription Drug Use Questionnaire and relationship to medication agreement noncompliance. *J Pain Symptom Manage*. 2008;36(4):383-95.
729. Hariharan J, Lamb GC, Neuner JM. Long-term opioid contract use for chronic pain management in primary care practice. A five year experience. *J Gen Intern Med*. 2007;22(4):485-90.

Copyright© 2016 Reed Group, Ltd.

730. Ives TJ, Chelminski PR, Hammett-Stabler CA, et al. Predictors of opioid misuse in patients with chronic pain: a prospective cohort study. *BMC Health Serv Res*. 2006;646.
731. Vaglienti RM, Huber SJ, Noel KR, Johnstone RE. Misuse of prescribed controlled substances defined by urinalysis. *W V Med J*. 2003;99(2):67-70.
732. Burchman S, Pagel P. Implementation of a formal treatment agreement for outpatient management of chronic nonmalignant pain with opioid analgesics. *J Pain Symptom Manage*. 1995;10(7):556-63.
733. Appenzeller BM, Agirman R, Neuberg P, Yegles M, Wennig R. Segmental determination of ethyl glucuronide in hair: a pilot study. *Forensic Sci Int*. 2007;173(2-3):87-92.
734. Cooper GA, Kronstrand R, Kintz P. Society of Hair Testing guidelines for drug testing in hair. *Forensic Sci Int*. 2012;218(1-3):20-4.
735. Kulaga V, Velazquez-Armenta Y, Aleksa K, Vergee Z, Koren G. The effect of hair pigment on the incorporation of fatty acid ethyl esters (FAEE). *Alcohol Alcohol*. 2009;44(3):287-92.
736. Lamoureux F, Gaulier JM, Sauvage FL, Mercerolle M, Vallejo C, Lachatre G. Determination of ethyl-glucuronide in hair for heavy drinking detection using liquid chromatography-tandem mass spectrometry following solid-phase extraction. *Anal Bioanal Chem*. 2009;394(7):1895-901.
737. Lees R, Kingston R, Williams TM, Henderson G, Lingford-Hughes A, Hickman M. Comparison of ethyl glucuronide in hair with self-reported alcohol consumption. *Alcohol Alcohol*. 2012;47(3):267-72.
738. Politi L, Zucchella A, Morini L, Stramesi C, Polettini A. Markers of chronic alcohol use in hair: comparison of ethyl glucuronide and cocaethylene in cocaine users. *Forensic Sci Int*. 2007;172(1):23-7.
739. Substance Abuse and Mental Health Services Administration. Federal Guidelines for Opioid Treatment. 2013.
740. Auerbach K. Drug testing methods. In: Lessenger J, Roper G, eds. *Drug Courts: A New Approach to Treatment and Rehabilitation*. New York, NY: Springer Science+Business Media; 2007:215-33.
741. Heit H, Gourlay D. Urine drug testing in pain medicine. *J Pain Symptom Manage*. 2004;27(3):260-7.
742. Jortani S, Stauble E, Wong S. Chapter 1. Pharmacogenetics in clinical and forensic toxicology: opioid overdoses and deaths. In: Mozayani A, Raymon L, eds. *Handbook of Drug Interactions A Clinical and Forensic Guide*. New York, NY: Humana Press; 2012:3-22.
743. Ellis JM, Folkers K, Levy M, et al. Response of vitamin B-6 deficiency and the carpal tunnel syndrome to pyridoxine. *Proc Natl Acad Sci U S A*. 1982;79(23):7494-8.
744. Guzmán FL, Gonzalez-Buitrago J, De Arriba F, Mateos F, Moyano J, López-Alburquerque T. Carpal tunnel syndrome and vitamin B6. *Klinische Wochenschrift*. 1989;67(1):38-41.
745. Spooner GR, Desai HB, Angel JF, Reeder BA, Donat JR. Using pyridoxine to treat carpal tunnel syndrome. Randomized control trial. *Can Fam Physician*. 1993;392122-7.
746. Stransky M, Rubin A, Lava NS, Lazaro RP. Treatment of carpal tunnel syndrome with vitamin B6: a double-blind study. *South Med J*. 1989;82(7):841-2.
747. Keniston RC, Nathan PA, Leklem JE, Lockwood RS. Vitamin B6, vitamin C, and carpal tunnel syndrome: a cross-sectional study of 441 adults. *Journal of occupational and environmental medicine*. 1997;39(10):949-59.
748. Franzblau A, Rock CL, Werner RA, Albers JW, Kelly MP, Johnston EC. The relationship of vitamin B6 status to median nerve function and carpal tunnel syndrome among active industrial workers. *Journal of occupational and environmental medicine*. 1996;38(5):485-91.
749. Sato Y, Honda Y, Iwamoto J, Kanoko T, Satoh K. Amelioration by mecobalamin of subclinical carpal tunnel syndrome involving unaffected limbs in stroke patients. *J Neurol Sci*. 2005;231(1-2):13-8.
750. Galer BS, Rowbotham MC, Perander J, Friedman E. Topical lidocaine patch relieves postherpetic neuralgia more effectively than a vehicle topical patch: results of an enriched enrollment study. *Pain*. 1999;80(3):533-8.
751. Nalamachu S, Crockett RS, Mathur D. Lidocaine patch 5 for carpal tunnel syndrome: how it compares with injections: a pilot study. *J Fam Pract*. 2006;55(3):209-14.
752. US Food and Drug Administration. Botox and Botox Cosmetic (botulinum toxin type A) and Myobloc (botulinum toxin type B). *MedWatch*. 2009.
753. Jensen MP, Gammaitoni AR, Olaleye DO, Oleka N, Nalamachu SR, Galer BS. The pain quality assessment scale: assessment of pain quality in carpal tunnel syndrome. *J Pain*. 2006;7(11):823-32.
754. Moghtaderi AR, Jazayeri SM, Azizi S. EMLA cream for carpal tunnel syndrome: how it compares with steroid injection. *Electromyogr Clin Neurophysiol*. 2009;49(6-7):287-9.
755. Hui AC, Wong SM, Leung HW, Man BL, Yu E, Wong LK. Gabapentin for the treatment of carpal tunnel syndrome: a randomized controlled trial. *Eur J Neurol*. 2011;18(5):726-30.
756. Carter R, Aspy CB, Mold J. The effectiveness of magnet therapy for treatment of wrist pain attributed to carpal tunnel syndrome. *J Fam Pract*. 2002;51(1):38-40.
757. Colbert AP, Markov MS, Carlson N, Gregory WL, Carlson H, Elmer PJ. Static magnetic field therapy for carpal tunnel syndrome: a feasibility study. *Arch Phys Med Rehabil*. 2010;91(7):1098-104.

Copyright© 2016 Reed Group, Ltd.

758. Weintraub MI, Cole SP. Neuromagnetic treatment of pain in refractory carpal tunnel syndrome: An electrophysiological and placebo analysis. *J Back Musculoskelet Rehabil*. 2000;15(2):77-81.
759. Dakowicz A, Kuryliszyn-Moskal A, Kosztyla-Hojna B, Moskal D, Latosiewicz R. Comparison of the long-term effectiveness of physiotherapy programs with low-level laser therapy and pulsed magnetic field in patients with carpal tunnel syndrome. *Adv Med Sci*. 2011;56(2):270-4.
760. Weintraub MI, Cole SP. A randomized controlled trial of the effects of a combination of static and dynamic magnetic fields on carpal tunnel syndrome. *Pain Med*. 2008;9(5):493-504.
761. Arikan F. The effectiveness of pulsed magnetic field therapy in idiopathic carpal tunnel syndrome: a randomized, double blind, sham controlled trial. *J Phys Med Rehabil Sci*. 2011;141-8.
762. Huisstede BM, Hoogvliet P, Randsdorp MS, Glerum S, van Middelkoop M, Koes BW. Carpal tunnel syndrome. Part I: effectiveness of nonsurgical treatments--a systematic review. *Arch Phys Med Rehabil*. 2010;91(7):981-1004.
763. Gerritsen AA, de Vet HC, Scholten RJ, Bertelsmann FW, de Krom MC, Bouter LM. Splinting vs surgery in the treatment of carpal tunnel syndrome: a randomized controlled trial. *JAMA*. 2002;288(10):1245-51.
764. Premoselli S, Sioli P, Grossi A, Cerri C. Neutral wrist splinting in carpal tunnel syndrome: a 3- and 6-months clinical and neurophysiologic follow-up evaluation of night-only splint therapy. *Eura Medicophys*. 2006;42(2):121-6.
765. Walker WC, Metzler M, Cifu DX, Swartz Z. Neutral wrist splinting in carpal tunnel syndrome: a comparison of night-only versus full-time wear instructions. *Arch Phys Med Rehabil*. 2000;81(4):424-9.
766. Manente G, Torrieri F, Di Blasio F, Staniscia T, Romano F, Uncini A. An innovative hand brace for carpal tunnel syndrome: a randomized controlled trial. *Muscle Nerve*. 2001;24(8):1020-5.
767. Stralka SW, Jackson JA, Lewis AR. Treatment of hand and wrist pain. A randomized clinical trial of high voltage pulsed, direct current built into a wrist splint. *AAOHN J*. 1998;46(5):233-6.
768. Burke DT, Burke MM, Stewart GW, Cambre A. Splinting for carpal tunnel syndrome: in search of the optimal angle. *Arch Phys Med Rehabil*. 1994;75(11):1241-4.
769. Nobuta S, Sato K, Nakagawa T, Hatori M, Itoi E. Effects of wrist splinting for Carpal Tunnel syndrome and motor nerve conduction measurements. *Ups J Med Sci*. 2008;113(2):181-92.
770. Page MJ, Massy-Westropp N, O'Connor D, Pitt V. Splinting for carpal tunnel syndrome. *Cochrane Database Syst Rev*. 2012;7CD010003.
771. Peters S, Page MJ, Coppieters MW, Ross M, Johnston V. Rehabilitation following carpal tunnel release. *Cochrane Database Syst Rev*. 2013;6CD004158.
772. Stevinson C, Devaraj VS, Fountain-Barber A, Hawkins S, Ernst E. Homeopathic arnica for prevention of pain and bruising: randomized placebo-controlled trial in hand surgery. *J R Soc Med*. 2003;96(2):60-5.
773. King S, Thomas JJ, Rice MS. The immediate and short-term effects of a wrist extension orthosis on upper-extremity kinematics and range of shoulder motion. *Am J Occup Ther*. 2003;57(5):517-24.
774. De Angelis MV, Pierfelice F, Di Giovanni P, Staniscia T, Uncini A. Efficacy of a soft hand brace and a wrist splint for carpal tunnel syndrome: a randomized controlled study. *Acta Neurol Scand*. 2009;119(1):68-74.
775. Storey P AD, Dear H, Bradley M, Burke F. Pilot randomised controlled trial comparing C-Trac splints with Beta Wrist Braces for the management of carpal tunnel syndrome. *Hand Ther*. 2013;18(2):35-41.
776. Gerritsen AA, Korthals-de Bos IB, Laboyrie PM, de Vet HC, Scholten RJ, Bouter LM. Splinting for carpal tunnel syndrome: prognostic indicators of success. *J Neurol Neurosurg Psychiatry*. 2003;74(9):1342-4.
777. Ucan H, Yagci I, Yilmaz L, Yagmurlu F, Keskin D, Bodur H. Comparison of splinting, splinting plus local steroid injection and open carpal tunnel release outcomes in idiopathic carpal tunnel syndrome. *Rheumatol Int*. 2006;27(1):45-51.
778. Korthals-de Bos IB, Gerritsen AA, van Tulder MW, et al. Surgery is more cost-effective than splinting for carpal tunnel syndrome in the Netherlands: results of an economic evaluation alongside a randomized controlled trial. *BMC Musculoskelet Disord*. 2006;786.
779. Fusakul Y, Aranyavalai T, Saensri P, Thiengwittayaporn S. Low-level laser therapy with a wrist splint to treat carpal tunnel syndrome: A double-blinded randomized controlled trial. *Lasers in Medical Science*. 2014;29(3):1279-87.
780. Hall B, Lee HC, Fitzgerald H, Byrne B, Barton A, Lee AH. Investigating the effectiveness of full-time wrist splinting and education in the treatment of carpal tunnel syndrome: a randomized controlled trial. *Am J Occup Ther*. 2013;67(4):448-59.
781. Kumnerddee W, Kaewtong A. Efficacy of acupuncture versus night splinting for carpal tunnel syndrome: a randomized clinical trial. *J Med Assoc Thai*. 2010;93(12):1463-9.
782. Macdermid JC, Vincent JI, Gan BS, Grewal R. A blinded placebo-controlled randomized trial on the use of astaxanthin as an adjunct to splinting in the treatment of carpal tunnel syndrome. *Hand (N Y)*. 2012;7(1):1-9.
783. Soyupek F, Kutluhan S, Uslusoy G, Ilgun E, Eris S, Askin A. The efficacy of phonophoresis on electrophysiological studies of the patients with carpal tunnel syndrome. *Rheumatol Int*. 2012;32(10):3235-42.

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784. Bhatia R, Field J, Grote J, Huma H. Does splintage help pain after carpal tunnel release? *J Hand Surg [Br]*. 2000;25(2):150.
785. Dincer U, Cakar E, Kiralp MZ, Kilac H, Dursun H. The effectiveness of conservative treatments of carpal tunnel syndrome: splinting, ultrasound, and low-level laser therapies. *Photomed Laser Surg*. 2009;27(1):119-25.
786. Gurcay E, Unlu E, Gurcay AG, Tuncay R, Cakci A. Assessment of phonophoresis and iontophoresis in the treatment of carpal tunnel syndrome: a randomized controlled trial. *Rheumatol Int*. 2012;32(3):717-22.
787. Koca I, Boyaci A, Tutoglu A, Ucar M, Kocaturk O. Assessment of the effectiveness of interferential current therapy and TENS in the management of carpal tunnel syndrome: a randomized controlled study. *Rheumatol Int*. 2014;34(12):1639-45.
788. Madjdinasab N ZN, Assarzadegan F, Ali AM, Pipelzadeh M. Efficacy comparison of splint and oral steroid therapy in nerve conduction velocity and latency median nerve in carpal tunnel syndrome in south west of Iran. *Pak J Med Sci*. 2008;24(5):725-28.
789. Sevim S, Dogu O, Camdeviren H, et al. Long-term effectiveness of steroid injections and splinting in mild and moderate carpal tunnel syndrome. *Neurol Sci*. 2004;25(2):48-52.
790. Branco K, Naeser MA. Carpal tunnel syndrome: clinical outcome after low-level laser acupuncture, microamps transcutaneous electrical nerve stimulation, and other alternative therapies--an open protocol study. *J Altern Complement Med*. 1999;5(1):5-26.
791. Sim H, Shin BC, Lee MS, Jung A, Lee H, Ernst E. Acupuncture for carpal tunnel syndrome: a systematic review of randomized controlled trials. *J Pain*. 2011;12(3):307-14.
792. Yao E, Gerritz PK, Henricson E, et al. Randomized controlled trial comparing acupuncture with placebo acupuncture for the treatment of carpal tunnel syndrome. *PM R*. 2012;4(5):367-73.
793. Yang CP, Hsieh CL, Wang NH, et al. Acupuncture in patients with carpal tunnel syndrome: A randomized controlled trial. *Clin J Pain*. 2009;25(4):327-33.
794. Yang CP, Wang NH, Li TC, et al. A randomized clinical trial of acupuncture versus oral steroids for carpal tunnel syndrome: a long-term follow-up. *J Pain*. 2011;12(2):272-9.
795. Ho CY, Lin HC, Lee YC, et al. Clinical effectiveness of acupuncture for carpal tunnel syndrome. *Am J Chin Med*. 2014;42(2):303-14.
796. Khosrawi S, Moghtaderi A, Haghighat S. Acupuncture in treatment of carpal tunnel syndrome: A randomized controlled trial study. *J Res Med Sci*. 2012;17(1):1-7.
797. Cai D. Warm-needling plus Tuina relaxing for the treatment of carpal tunnel syndrome. *J Tradit Chin Med*. 2010;30(1):23-4.
798. Thomas RE, Vaidya SC, Herrick RT, Congleton JJ. The effects of biofeedback on carpal tunnel syndrome. *Ergonomics*. 1993;36(4):353-61.
799. Ekim A, Armagan O, Tascioglu F, Oner C, Colak M. Effect of low level laser therapy in rheumatoid arthritis patients with carpal tunnel syndrome. *Swiss Med Wkly*. 2007;137(23-24):347-52.
800. Padua L, Padua R, Moretti C, Nazzaro M, Tonali P. Clinical outcome and neurophysiological results of low-power laser irradiation in carpal tunnel syndrome. *Lasers Med Sci*. 1999;14198-202.
801. Fitz-Ritson D. Lasers and their therapeutic application in chiropractic. *The Journal of the Canadian Chiropractic Association*. 2001;45(1):26.
802. Evcik D, Kavuncu V, Cakir T, Subasi V, Yaman M. Laser therapy in the treatment of carpal tunnel syndrome: a randomized controlled trial. *Photomed Laser Surg*. 2007;25(1):34-9.
803. Irvine J, Chong SL, Amirjani N, Chan KM. Double-blind randomized controlled trial of low-level laser therapy in carpal tunnel syndrome. *Muscle Nerve*. 2004;30(2):182-7.
804. Tascioglu F, Degirmenci NA, Ozkan S, Mehmetoglu O. Low-level laser in the treatment of carpal tunnel syndrome: clinical, electrophysiological, and ultrasonographical evaluation. *Rheumatol Int*. 2012;32(2):409-15.
805. Bakhtiary AH, Rashidy-Pour A. Ultrasound and laser therapy in the treatment of carpal tunnel syndrome. *Aust J Physiother*. 2004;50(3):147-51.
806. Saeed F-U-R, Hanif S, Aasim M. The effects of laser and ultrasound therapy on carpal tunnel syndrome. 2012.
807. Yagci I, Elmas O, Akcan E, Ustun I, Gunduz OH, Guven Z. Comparison of splinting and splinting plus low-level laser therapy in idiopathic carpal tunnel syndrome. *Clin Rheumatol*. 2009;28(9):1059-65.
808. Chang WD, Wu JH, Jiang JA, Yeh CY, Tsai CT. Carpal tunnel syndrome treated with a diode laser: a controlled treatment of the transverse carpal ligament. *Photomed Laser Surg*. 2008;26(6):551-7.
809. Naeser MA, Hahn KA, Lieberman BE, Branco KF. Carpal tunnel syndrome pain treated with low-level laser and microamperes transcutaneous electric nerve stimulation: A controlled study. *Arch Phys Med Rehabil*. 2002;83(7):978-88.
810. Raeissadat A, Soltani ZR. Study of long term effects of laser therapy versus local corticosteroid injection in patients with carpal tunnel syndrome. *J Lasers Med Sci* 2010;1(1):24-30.

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811. Shooshtari SM, Badiee V, Taghizadeh SH, Nematollahi AH, Amanollahi AH, Grami MT. The effects of low level laser in clinical outcome and neurophysiological results of carpal tunnel syndrome. *Electromyogr Clin Neurophysiol*. 2008;48(5):229-31.
812. Stasinopoulos D, Stasinopoulos I, Johnson MI. Treatment of carpal tunnel syndrome with polarized polychromatic noncoherent light (Bioptron light): A preliminary, prospective, open clinical trial. *Photomedicine and Laser Surgery*. 2005;23(2):225-8.
813. Sucher BM. Palpatory diagnosis and manipulative management of carpal tunnel syndrome. *J Am Osteopath Assoc*. 1994;94(8):647-63.
814. Brantingham JW, Cassa TK, Bonnefin D, et al. Manipulative and multimodal therapy for upper extremity and temporomandibular disorders: a systematic review. *J Manipulative Physiol Ther*. 2013;36(3):143-201.
815. Clar C, Tsertsvadze A, Court R, Hundt GL, Clarke A, Sutcliffe P. Clinical effectiveness of manual therapy for the management of musculoskeletal and non-musculoskeletal conditions: systematic review and update of UK evidence report. *Chiropr Man Therap*. 2014;22(1):12.
816. Heiser R, O'Brien VH, Schwartz DA. The use of joint mobilization to improve clinical outcomes in hand therapy: a systematic review of the literature. *J Hand Ther*. 2013;26(4):297-311; quiz
817. Hunt K, Hung S, Boddy K, Ernst E. Chiropractic manipulation for carpal tunnel syndrome: a systematic review. *Hand Ther*. 2009.
818. McHardy A, Hoskins W, Pollard H, Onley R, Windsham R. Chiropractic treatment of upper extremity conditions: a systematic review. *J Manipulative Physiol Ther*. 2008;31(2):146-59.
819. Burke J, Buchberger DJ, Carey-Loghmani MT, Dougherty PE, Greco DS, Dishman JD. A pilot study comparing two manual therapy interventions for carpal tunnel syndrome. *J Manipulative Physiol Ther*. 2007;30(1):50-61.
820. Pratelli E, Pintucci M, Cultrera P, et al. Conservative treatment of carpal tunnel syndrome: comparison between laser therapy and Fascial Manipulation((R)). *J Bodyw Mov Ther*. 2015;19(1):113-8.
821. Bialosky J, Bishop M, Robinson M, Price D, George S. Heightened pain sensitivity in individuals with signs and symptoms of carpal tunnel syndrome and the relationship to clinical outcomes following a manual therapy intervention. *Man Ther*. 2011;16(6):602-8.
822. Madenci E, Altindag O, Koca I, Yilmaz M, Gur A. Reliability and efficacy of the new massage technique on the treatment in the patients with carpal tunnel syndrome. *Rheumatol Int*. 2012;32(10):3171-9.
823. Moraska A, Chandler C, Edmiston-Schaetzel A, Franklin G, Calenda EL, Enebo B. Comparison of a targeted and general massage protocol on strength, function, and symptoms associated with carpal tunnel syndrome: a randomized pilot study. *J Altern Complement Med*. 2008;14(3):259-67.
824. Moraska A, Pollini RA, Boulanger K, Brooks MZ, Teitlebaum L. Physiological adjustments to stress measures following massage therapy: a review of the literature. *Evid Based Complement Alternat Med*. 2010;7(4):409-18.
825. Blankfield RP, Sulzmann C, Fradley LG, Tapolyai AA, Zyzanski SJ. Therapeutic touch in the treatment of carpal tunnel syndrome. *J Am Board Fam Pract*. 2001;14(5):335-42.
826. Dziedzic K, Hill J, Lewis M, Sim J, Daniels J, Hay EM. Effectiveness of manual therapy or pulsed shortwave diathermy in addition to advice and exercise for neck disorders: a pragmatic randomized controlled trial in physical therapy clinics. *Arthritis Rheum*. 2005;53(2):214-22.
827. Garrett CL, Draper DO, Knight KL. Heat distribution in the lower leg from pulsed short-wave diathermy and ultrasound treatments. *J Athl Train*. 2000;35(1):50-5.
828. Goats GC. Continuous short-wave (radio-frequency) diathermy. *Br J Sports Med*. 1989;23(2):123-7.
829. Frasca G, Maggi L, Padua L, et al. Short-term effects of local microwave hyperthermia on pain and function in patients with mild to moderate carpal tunnel syndrome: a double blind randomized sham-controlled trial. *Clin Rehabil*. 2011;25(12):1109-18.
830. Incebiyik S, Boyaci A, Tutoglu A. Short-term effectiveness of short-wave diathermy treatment on pain, clinical symptoms, and hand function in patients with mild or moderate idiopathic carpal tunnel syndrome. *J Back Musculoskeletal Rehabil*. 20141-8.
831. Ebenbichler G, Resch K, Nicolakis P, et al. Ultrasound treatment for treating the carpal tunnel syndrome: randomised “sham” controlled trial. *Br Med J*. 1998;316(7133):731-5.
832. Oztas O, Turan B, Bora I, Karakaya MK. Ultrasound therapy effect in carpal tunnel syndrome. *Arch Phys Med Rehabil*. 1998;79(12):1540-4.
833. Piravej K, Boonhong J. Effect of ultrasound thermotherapy in mild to moderate carpal tunnel syndrome. *J Med Assoc Thai*. 2004;87 Suppl 2S100-6.
834. Page MJ, O'Connor D, Pitt V, Massy-Westropp N. Therapeutic ultrasound for carpal tunnel syndrome. *Cochrane Database Syst Rev*. 2013;3CD009601.
835. Bilgici A, Ulusoy H, Kuru O, Canturk F. The comparison of ultrasound treatment and local steroid injection plus splinting in the carpal tunnel syndrome: a randomized controlled trial. *Bratisl Lek Listy*. 2010;111(12):659-65.

Copyright© 2016 Reed Group, Ltd.

836. Chang YW, Hsieh SF, Horng YS, Chen HL, Lee KC, Horng YS. Comparative effectiveness of ultrasound and paraffin therapy in patients with carpal tunnel syndrome: a randomized trial. *BMC Musculoskelet Disord*. 2014;15399.
837. Armagan O, Bakilan F, Ozgen M, Mehmetoglu O, Oner S. Effects of placebo-controlled continuous and pulsed ultrasound treatments on carpal tunnel syndrome: a randomized trial. *Clinics (Sao Paulo)*. 2014;69(8):524-8.
838. Duymaz T, Sindel D, Kesikta N, Müslümano lL. Efficacy of some combined conservative methods in the treatment of carpal tunnel syndrome: a randomized controlled clinical and electrophysiological trial. *Turkish J Rheumatology*. 2012;27(1):38-46.
839. Aygul R, Ulvi H, Karatay S, Deniz O, Varoglu AO. Determination of sensitive electrophysiologic parameters at follow-up of different steroid treatments of carpal tunnel syndrome. *J Clin Neurophysiol*. 2005;22(3):222-30.
840. Bakhtiary AH, Fatemi E, Emami M, Malek M. Phonophoresis of dexamethasone sodium phosphate may manage pain and symptoms of patients with carpal tunnel syndrome. *Clin J Pain*. 2013;29(4):348-53.
841. Amirjani N, Ashworth N, Watt M, Gordon T, Chan K. Corticosteroid iontophoresis to treat carpal tunnel syndrome: A double-blind randomized controlled trial. *Muscle & nerve*. 2009;39(5):627-33.
842. Gokoglu F, Fndkoglu G, Yorgancoglu ZR, Okumus M, Ceceli E, Kocaoglu S. Evaluation of iontophoresis and local corticosteroid injection in the treatment of carpal tunnel syndrome. *Am J Phys Med Rehabil*. 2005;84(2):92-6.
843. Armstrong T, Devor W, Borschel L, Contreras R. Intracarpal steroid injection is safe and effective for short-term management of carpal tunnel syndrome. *Muscle Nerve*. 2004;29(1):82-8.
844. Dammers J, Veering M, Vermeulen M. Injection with methylprednisolone proximal to the carpal tunnel: randomised double blind trial. *Bmj*. 1999;319(7214):884-6.
845. Dammers JW, Roos Y, Veering MM, Vermeulen M. Injection with methylprednisolone in patients with the carpal tunnel syndrome: a randomised double blind trial testing three different doses. *J Neurol*. 2006;253(5):574-7.
846. Demirci S, Kutluhan S, Koyuncuoglu HR, et al. Comparison of open carpal tunnel release and local steroid treatment outcomes in idiopathic carpal tunnel syndrome. *Rheumatol Int*. 2002;22(1):33-7.
847. Feuerstein M, Burrell LM, Miller VI, Lincoln A, Huang GD, Berger R. Clinical management of carpal tunnel syndrome: a 12-year review of outcomes. *Am J Ind Med*. 1999;35(3):232-45.
848. Girlanda P, Dattola R, Venuto C, Mangiapane R, Nicolosi C, Messina C. Local steroid treatment in idiopathic carpal tunnel syndrome: short- and long-term efficacy. *J Neurol*. 1993;240(3):187-90.
849. Habib GS, Badarny S, Rawashdeh H. A novel approach of local corticosteroid injection for the treatment of carpal tunnel syndrome. *Clin Rheumatol*. 2006;25(3):338-40.
850. Hamamoto Filho PT, Leite FV, Ruiz T, Resende LA. A systematic review of anti-inflammatories for mild to moderate carpal tunnel syndrome. *J Clin Neuromuscul Dis*. 2009;11(1):22-30.
851. Hui A, Wong S, Leung C, et al. A randomized controlled trial of surgery vs steroid injection for carpal tunnel syndrome. *Neurology*. 2005;64(12):2074-8.
852. Ly-Pen D, Andreu JL. Treatment of carpal tunnel syndrome. *Med Clin (Barc)*. 2005;125(15):585-9.
853. Ly-Pen D, Andreu JL, de Blas G, Sanchez-Olaso A, Millan I. Surgical decompression versus local steroid injection in carpal tunnel syndrome: a one-year, prospective, randomized, open, controlled clinical trial. *Arthritis Rheum*. 2005;52(2):612-9.
854. Ozdogan H, Yazici H. The efficacy of local steroid injections in idiopathic carpal tunnel syndrome: a double-blind study. *Br J Rheumatol*. 1984;23(4):272-5.
855. Wong S, Hui A, Lo SK, Chiu J, Poon W, Wong L. Single vs. two steroid injections for carpal tunnel syndrome: a randomised clinical trial. *Int J Clin Pract*. 2005;59(12):1417-21.
856. Schnetzler KA. Acute carpal tunnel syndrome. *J Am Acad Orthop Surg*. 2008;16(5):276-82.
857. Szabo RM. Acute carpal tunnel syndrome. *Hand Clin*. 1998;14(3):419-29, ix.
858. Hegmann K, Gaines W J, Keller R. Session #104: Advancements in Upper Extremity Ergonomics and Neuromusculoskeletal Disorders. *ACOEM State-of-the-Art Conference; Bridging Canyons to the 21st Century*. Phoenix, Arizona: J Occup Environ Med; 1998:745.
859. Burke FD, Bradley MJ, Sinha S, Wilgis EF, Dubin NH. Primary care management of patients with carpal tunnel syndrome referred to surgeons: are non-operative interventions effectively utilised? *Postgrad Med J*. 2007;83(981):498-501.
860. Atroshi I, Flondell M, Hofer M, Ranstam J. Methylprednisolone injections for the carpal tunnel syndrome: a randomized, placebo-controlled trial. *Ann Intern Med*. 2013;159(5):309-17.
861. Andreu JL, Ly-Pen D. A randomized controlled trial of surgery vs steroid injection for carpal tunnel syndrome. *Neurology*. 2006;66(6):955-6; author reply -6.
862. Wang AA, Whitaker E, Hutchinson DT, Coleman DA. Pain levels after injection of corticosteroid to hand and elbow. *Am J Orthop (Belle Mead NJ)*. 2003;32(8):383-5.
863. O'Gradaigh D, Merry P. Corticosteroid injection for the treatment of carpal tunnel syndrome. *Ann Rheum Dis*. 2000;59(11):918-9.

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864. Ustun N, Tok F, Yagz AE, et al. Ultrasound-guided vs. blind steroid injections in carpal tunnel syndrome: A single-blind randomized prospective study. *Am J Phys Med Rehabil*. 2013;92(11):999-1004.
865. Karadas O, Tok F, Akarsu S, Tekin L, Balaban B. Triamcinolone acetonide vs procaine hydrochloride injection in the management of carpal tunnel syndrome: randomized placebo-controlled study. *J Rehabil Med*. 2012;44(7):601-4.
866. Karadas O, Tok F, Ulas UH, Odabasi Z. The effectiveness of triamcinolone acetonide vs. procaine hydrochloride injection in the management of carpal tunnel syndrome: a double-blind randomized clinical trial. *Am J Phys Med Rehabil*. 2011;90(4):287-92.
867. Ly-Pen D, Andreu JL, Millan I, de Blas G, Sanchez-Olaso A. Comparison of surgical decompression and local steroid injection in the treatment of carpal tunnel syndrome: 2-year clinical results from a randomized trial. *Rheumatology (Oxford)*. 2012;51(8):1447-54.
868. Peters-Veluthamaningal C, Winters JC, Groenier KH, Meyboom-de Jong B. Randomised controlled trial of local corticosteroid injections for carpal tunnel syndrome in general practice. *BMC Fam Pract*. 2010;1154.
869. Kamanli A, Bezgincan M, Kaya A. Comparison of local steroid injection into carpal tunnel via proximal and distal approach in patients with carpal tunnel syndrome. *Bratisl Lek Listy*. 2011;112(6):337-41.
870. Seok H, Kim SH. The effectiveness of extracorporeal shock wave therapy vs. local steroid injection for management of carpal tunnel syndrome: a randomized controlled trial. *Am J Phys Med Rehabil*. 2013;92(4):327-34.
871. Stepic N, Novakovic M, Martic V, Peric D. Effects of perineural steroid injections on median nerve conduction during the carpal tunnel release. *Vojnosanit Pregl*. 2008;65(11):825-9.
872. Ozkul Y, Sabuncu T, Yazgan P, Nazligul Y. Local insulin injection improves median nerve regeneration in NIDDM patients with carpal tunnel syndrome. *Eur J Neurol*. 2001;8(4):329-34.
873. Ashraf A, Moghtaderi AR, Yazdani AH, Mirshams S. Evaluation of effectiveness of local insulin injection in none insulin dependent diabetic patient with carpal tunnel syndrome. *Electromyogr Clin Neurophysiol*. 2009;49(4):161-6.
874. Breuer B, Sperber K, Wallenstein S, et al. Clinically significant placebo analgesic response in a pilot trial of botulinum B in patients with hand pain and carpal tunnel syndrome. *Pain Med*. 2006;7(1):16-24.
875. Tsai CP, Liu CY, Lin KP, Wang KC. Efficacy of botulinum toxin type A in the relief of Carpal tunnel syndrome: A preliminary experience. *Clin Drug Investig*. 2006;26(9):511-5.
876. Li M, Goldberger BA, Hopkins C. Fatal case of Botox-related anaphylaxis? *J Forensic Sci*. 2005;50(1):169-72.
877. Scholten RJ, Mink van der Molen A, Uitdehaag BM, Bouter LM, de Vet HC. Surgical treatment options for carpal tunnel syndrome. *Cochrane Database Syst Rev*. 2007(4):CD003905.
878. Serra L, Panagiotopoulos K, Bucciero A, et al. Endoscopic release in carpal tunnel syndrome: analysis of clinical results in 200 cases. *Minim Invasive Neurosurg*. 2003;46(1):11-5.
879. Shapiro S. Microsurgical carpal tunnel release. *Neurosurgery*. 1995;37(1):66-70.
880. Straub TA. Endoscopic carpal tunnel release: a prospective analysis of factors associated with unsatisfactory results. *Arthroscopy*. 1999;15(3):269-74.
881. Brown MG, Keyser B, Rothenberg ES. Endoscopic carpal tunnel release. *J Hand Surg [Am]*. 1992;17(6):1009-11.
882. Chaise F, Bellemere P, Friol JP, Gaisne E, Poirier P, Menadi A. Professional absenteeism and surgery for carpal tunnel syndrome. Results of a prospective series of 233 patients. *Chir Main*. 2001;20(2):117-21.
883. Chow JC. The Chow technique of endoscopic release of the carpal ligament for carpal tunnel syndrome: four years of clinical results. *Arthroscopy*. 1993;9(3):301-14.
884. Davies BW, Pennington GA, Fritz AM. Two-portal endoscopic carpal tunnel release: an outcome analysis of 333 hands. *Ann Plast Surg*. 1998;40(5):542-8.
885. Gainer JV, Jr., Nugent GR. Carpal tunnel syndrome: report of 430 operations. *South Med J*. 1977;70(3):325-8.
886. Hankins CL, Brown MG, Lopez RA, Lee AK, Dang J, Harper RD. A 12-year experience using the Brown two-portal endoscopic procedure of transverse carpal ligament release in 14,722 patients: defining a new paradigm in the treatment of carpal tunnel syndrome. *Plast Reconstr Surg*. 2007;120(7):1911-21.
887. Jerosch-Herold C, Leite JC, Song F. A systematic review of outcomes assessed in randomized controlled trials of surgical interventions for carpal tunnel syndrome using the International Classification of Functioning, Disability and Health (ICF) as a reference tool. *BMC Musculoskelet Disord*. 2006;796.
888. Lichtman DM, Florio RL, Mack GR. Carpal tunnel release under local anesthesia: evaluation of the outpatient procedure. *J Hand Surg [Am]*. 1979;4(6):544-6.
889. Mondelli M, Padua L, Reale F. Carpal tunnel syndrome in elderly patients: results of surgical decompression. *J Peripher Nerv Syst*. 2004;9(3):168-76.
890. Mondelli M, Padua L, Reale F, Signorini AM, Romano C. Outcome of surgical release among diabetics with carpal tunnel syndrome. *Arch Phys Med Rehabil*. 2004;85(1):7-13.

Copyright© 2016 Reed Group, Ltd.

891. Nazzi V, Franzini A, Messina G, Broggi G. Carpal tunnel syndrome: matching minimally invasive surgical techniques. Technical note. *J Neurosurg*. 2008;108(5):1033-6.
892. Okutsu I, Hamanaka I, Tanabe T, Takatori Y, Ninomiya S. Complete endoscopic carpal tunnel release in long-term haemodialysis patients. *J Hand Surg [Br]*. 1996;21(5):668-71.
893. Scholten RJ, Gerritsen AA, Uitdehaag BM, van Geldere D, de Vet HC, Bouter LM. Surgical treatment options for carpal tunnel syndrome. *Cochrane Database Syst Rev*. 2004(4):CD003905.
894. Thoma A, Veltri K, Haines T, Duku E. A systematic review of reviews comparing the effectiveness of endoscopic and open carpal tunnel decompression. *Plast Reconstr Surg*. 2004;113(4):1184-91.
895. Thoma A, Veltri K, Haines T, Duku E. A meta-analysis of randomized controlled trials comparing endoscopic and open carpal tunnel decompression. *Plast Reconstr Surg*. 2004;114(5):1137-46.
896. Tuzuner S, Özkaynak S, Acikbas C, Yildirim A. Median nerve excursion during endoscopic carpal tunnel release. *Neurosurgery*. 2004;54(5):1155-61.
897. Verdugo RJ, Salinas RA, Castillo JL, Cea JG. Surgical versus non-surgical treatment for carpal tunnel syndrome. *Cochrane Database Syst Rev*. 2008(4):CD001552.
898. Verdugo RJ, Salinas RS, Castillo J, Cea JG. Surgical versus non-surgical treatment for carpal tunnel syndrome. *Cochrane Database Syst Rev*. 2003(3):CD001552.
899. Weber RA, Rude MJ. Clinical outcomes of carpal tunnel release in patients 65 and older. *J Hand Surg [Am]*. 2005;30(1):75-80.
900. Sanati KA, Mansouri M, Macdonald D, Ghafghazi S, Macdonald E, Yadegarfar G. Surgical techniques and return to work following carpal tunnel release: a systematic review and meta-analysis. *J Occup Rehabil*. 2011;21(4):474-81.
901. Scholten RJ, Gerritsen AA, Uitdehaag BM, van Geldere D, de Vet HC, Bouter LM. Surgical treatment options for carpal tunnel syndrome. *Cochrane Database Syst Rev*. 2002(4):CD003905.
902. Shi Q, MacDermid JC. Is surgical intervention more effective than non-surgical treatment for carpal tunnel syndrome? A systematic review. *J Orthop Surg Res*. 2011;617.
903. Vasiliadis HS, Georgoulas P, Shrier I, Salanti G, Scholten RJ. Endoscopic release for carpal tunnel syndrome. *Cochrane Database Syst Rev*. 2014;1CD008265.
904. Bernstein RA. Endoscopic carpal tunnel release. *Conn Med*. 1994;58(7):387-94.
905. Brief R, Brief LP. Endoscopic carpal tunnel release: report of 146 cases. *Mt Sinai J Med*. 2000;67(4):274-7.
906. Chow JC. Endoscopic release of the carpal ligament for carpal tunnel syndrome: 22-month clinical result. *Arthroscopy*. 1990;6(4):288-96.
907. Dumontier C, Sokolow C, Leclercq C, Chauvin P. Early results of conventional versus two-portal endoscopic carpal tunnel release. A prospective study. *J Hand Surg [Br]*. 1995;20(5):658-62.
908. Menon J. Endoscopic carpal tunnel release: preliminary report. *Arthroscopy*. 1994;10(1):31-8.
909. Pagnanelli DM, Barrer SJ. Carpal tunnel syndrome: surgical treatment using the Paine retinaculatome. *J Neurosurg*. 1991;75(1):77-81.
910. Povlsen B, Tegnell L, Revell M, Adolfsson L. Touch allodynia following endoscopic (single portal) or open decompression for carpal tunnel syndrome. *J Hand Surg [Br]*. 1997;22(3):325-7.
911. Sennwald GR, Benedetti R. The value of one-portal endoscopic carpal tunnel release: a prospective randomized study. *Knee Surg Sports Traumatol Arthrosc*. 1995;3(2):113-6.
912. Slattery PG. Endoscopic carpal tunnel release. Use of the modified Chow technique in 215 cases. *Med J Aust*. 1994;160(3):104-7.
913. Worseg AP, Kuzbari R, Korak K, et al. Endoscopic carpal tunnel release using a single-portal system. *Br J Plast Surg*. 1996;49(1):1-10.
914. Agee JM, McCarroll HR, Jr., Tortosa RD, Berry DA, Szabo RM, Peimer CA. Endoscopic release of the carpal tunnel: a randomized prospective multicenter study. *J Hand Surg [Am]*. 1992;17(6):987-95.
915. Brown RA, Gelberman RH, Seiler JG, 3rd, et al. Carpal tunnel release. A prospective, randomized assessment of open and endoscopic methods. *J Bone Joint Surg Am*. 1993;75(9):1265-75.
916. Erdmann MW. Endoscopic carpal tunnel decompression. *J Hand Surg [Br]*. 1994;19(1):5-13.
917. Saw NL, Jones S, Shepstone L, Meyer M, Chapman PG, Logan AM. Early outcome and cost-effectiveness of endoscopic versus open carpal tunnel release: a randomized prospective trial. *J Hand Surg [Br]*. 2003;28(5):444-9.
918. Trumble TE, Diao E, Abrams RA, Gilbert-Anderson MM. Single-portal endoscopic carpal tunnel release compared with open release : a prospective, randomized trial. *J Bone Joint Surg Am*. 2002;84-A(7):1107-15.
919. Concannon MJ, Brownfield ML, Puckett CL. The incidence of recurrence after endoscopic carpal tunnel release. *Plast Reconstr Surg*. 2000;105(5):1662-5.
920. Chow JC, Hantes ME. Endoscopic carpal tunnel release: thirteen years' experience with the Chow technique. *J Hand Surg [Am]*. 2002;27(6):1011-8.

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921. Jugovac I, Burgic N, Micovic V, et al. Carpal tunnel release by limited palmar incision vs traditional open technique: randomized controlled trial. *Croat Med J*. 2002;43(1):33-6.
922. Atroshi I, Larsson G-U, Ornstein E, Hofer M, Johnsson R, Ranstam J. Outcomes of endoscopic surgery compared with open surgery for carpal tunnel syndrome among employed patients: randomised controlled trial. *Br Med J*. 2006;332(7556):1473.
923. Ferdinand RD, MacLean JG. Endoscopic versus open carpal tunnel release in bilateral carpal tunnel syndrome. A prospective, randomised, blinded assessment. *J Bone Joint Surg Br*. 2002;84(3):375-9.
924. Jacobsen MB, Rahme H. A prospective, randomized study with an independent observer comparing open carpal tunnel release with endoscopic carpal tunnel release. *J Hand Surg [Br]*. 1996;21(2):202-4.
925. MacDermid JC, Richards RS, Roth JH, Ross DC, King GJ. Endoscopic versus open carpal tunnel release: a randomized trial. *J Hand Surg [Am]*. 2003;28(3):475-80.
926. Abdullah AF, Wolber PH, Ditto III EW. Sequelae of carpal tunnel surgery: Rationale for the design of a surgical approach. *Neurosurgery*. 1995;37(5):931-6.
927. Ahčan U, Arnez ZM, Bajrović F, Zorman P. Surgical technique to reduce scar discomfort after carpal tunnel surgery. *J Hand Surg Am*. 2002;27(5):821-7.
928. Bhattacharya R, Birdsall PD, Finn P, Stothard J. A randomized controlled trial of knifelight and open carpal tunnel release. *J Hand Surg [Br]*. 2004;29(2):113-5.
929. Blair WF, Goetz DD, Ross MA, Steyers CM, Chang P. Carpal tunnel release with and without epineurotomy: a comparative prospective trial. *J Hand Surg [Am]*. 1996;21(4):655-61.
930. Borisch N, Haussmann P. Neurophysiological recovery after open carpal tunnel decompression: comparison of simple decompression and decompression with epineurotomy. *J Hand Surg [Br]*. 2003;28(5):450-4.
931. Forward DP, Singh AK, Lawrence TM, Sithole JS, Davis TR, Oni JA. Preservation of the ulnar bursa within the carpal tunnel: does it improve the outcome of carpal tunnel surgery? A randomized, controlled trial. *J Bone Joint Surg Am*. 2006;88(11):2432-8.
932. Helm RH, Vaziri S. Evaluation of carpal tunnel release using the Knifelight instrument. *J Hand Surg [Br]*. 2003;28(3):251-4.
933. Jones SM, Stuart PR, Stothard J. Open carpal tunnel release. Does a vascularized hypothenar fat pad reduce wound tenderness? *J Hand Surg [Br]*. 1997;22(6):758-60.
934. Klein RD, Kotsis SV, Chung KC. Open carpal tunnel release using a 1-centimeter incision: technique and outcomes for 104 patients. *Plast Reconstr Surg*. 2003;111(5):1616-22.
935. Leinberry CF, Hammond NL, 3rd, Siegfried JW. The role of epineurotomy in the operative treatment of carpal tunnel syndrome. *J Bone Joint Surg Am*. 1997;79(4):555-7.
936. Lorgelly PK, Dias JJ, Bradley MJ, Burke FD. Carpal tunnel syndrome, the search for a cost-effective surgical intervention: a randomised controlled trial. *Ann R Coll Surg Engl*. 2005;87(1):36-40.
937. Lowry WE, Jr., Follender AB. Interfascicular neurolysis in the severe carpal tunnel syndrome. A prospective, randomized, double-blind, controlled study. *Clin Orthop Relat Res*. 1988;227251-4.
938. Mackinnon S, Murray J, Szalai J, et al. Internal neurolysis fails to improve the results of primary carpal tunnel decompression. *J Hand Surg Am*. 1991;16(2):211-8.
939. Shum C, Parisien M, Strauch RJ, Rosenwasser MP. The role of flexor tenosynovectomy in the operative treatment of carpal tunnel syndrome. *J Bone Joint Surg Am*. 2002;84-A(2):221-5.
940. Siegmeth AW, Hopkinson-Woolley JA. Standard open decompression in carpal tunnel syndrome compared with a modified open technique preserving the superficial skin nerves: a prospective randomized study. *J Hand Surg [Am]*. 2006;31(9):1483-9.
941. Zyluk A, Strychar J. A comparison of two limited open techniques for carpal tunnel release. *J Hand Surg Br*. 2006;31(5):466-72.
942. Cobb TK, Amadio PC. Reoperation for carpal tunnel syndrome. *Hand Clin*. 1996;12(2):313-23.
943. Cobb TK, Amadio PC, Leatherwood DF, Schleck CD, Ilstrup DM. Outcome of reoperation for carpal tunnel syndrome. *J Hand Surg [Am]*. 1996;21(3):347-56.
944. De Kesel R, Donceel P, De Smet L. Factors influencing return to work after surgical treatment for carpal tunnel syndrome. *Occup Med (Lond)*. 2008;58(3):187-90.
945. Atroshi I, Hofer M, Larsson G-U, Ornstein E, Johnsson R, Ranstam J. Open compared with 2-portal endoscopic carpal tunnel release: a 5-year follow-up of a randomized controlled trial. *J Hand Surg Am*. 2009;34(2):266-72.
946. Wong KC, Hung LK, Ho PC, Wong JM. Carpal tunnel release. A prospective, randomised study of endoscopic versus limited-open methods. *J Bone Joint Surg Br*. 2003;85(6):863-8.
947. Bessette L, Keller RB, Liang MH, Simmons BP, Fossel AH, Katz JN. Patients' preferences and their relationship with satisfaction following carpal tunnel release. *J Hand Surg [Am]*. 1997;22(4):613-20.

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948. Ejiri S, Kikuchi S, Maruya M, Sekiguchi Y, Kawakami R, Konno S. Short-term results of endoscopic (Okutsu method) versus palmar incision open carpal tunnel release: a prospective randomized controlled trial. *Fukushima J Med Sci*. 2012;58(1):49-59.
949. Kang HJ, Koh IH, Lee TJ, Choi YR. Endoscopic carpal tunnel release is preferred over mini-open despite similar outcome: a randomized trial. *Clin Orthop Relat Res*. 2013;471(5):1548-54.
950. Larsen MB, Sorensen AI, Crone KL, Weis T, Boeckstyns ME. Carpal tunnel release: a randomized comparison of three surgical methods. *J Hand Surg Eur Vol*. 2013;38(6):646-50.
951. Tarallo M, Fino P, Sorvillo V, Parisi P, Scuderi N. Comparative analysis between minimal access versus traditional accesses in carpal tunnel syndrome: a perspective randomised study. *J Plast Reconstr Aesthet Surg*. 2014;67(2):237-43.
952. Aslani HR, Alizadeh K, Eajazi A, et al. Comparison of carpal tunnel release with three different techniques. *Clin Neurol Neurosurg*. 2012;114(7):965-8.
953. Menovsky T, Bartels RH, van Lindert EL, Grotenhuis JA. Skin closure in carpal tunnel surgery: a prospective comparative study between nylon, polyglactin 910 and stainless steel sutures. *Hand Surg*. 2004;9(1):35-8.
954. Foulkes GD, Atkinson RE, Beuchel C, Doyle JR, Singer DI. Outcome following epineurotomy in carpal tunnel syndrome: a prospective, randomized clinical trial. *J Hand Surg [Am]*. 1994;19(4):539-47.
955. Crnkovic T, Bilic R, Trkulja V, Cesarik M, Gotovac N, Kolundzic R. The effect of epineurotomy on the median nerve volume after the carpal tunnel release: a prospective randomised double-blind controlled trial. *Int Orthop*. 2012;36(9):1885-92.
956. Dias JJ, Bhowal B, Wildin CJ, Thompson JR. Carpal tunnel decompression. Is lengthening of the flexor retinaculum better than simple division? *J Hand Surg [Br]*. 2004;29(3):271-6.
957. Citron ND, Bendall SP. Local symptoms after open carpal tunnel release. A randomized prospective trial of two incisions. *J Hand Surg [Br]*. 1997;22(3):317-21.
958. Provinciali L, Giattini A, Splendiani G, Logullo F. Usefulness of hand rehabilitation after carpal tunnel surgery. *Muscle Nerve*. 2000;23(2):211-6.
959. Macaire P, Singelyn F, Narchi P, Paqueron X. Ultrasound- or nerve stimulation-guided wrist blocks for carpal tunnel release: a randomized prospective comparative study. *Reg Anesth Pain Med*. 2008;33(4):363-8.
960. Chandra PS, Singh PK, Goyal V, Chauhan AK, Thakkur N, Tripathi M. Early versus delayed endoscopic surgery for carpal tunnel syndrome: prospective randomized study. *World Neurosurg*. 2013;79(5-6):767-72.
961. Bruser P, Richter M, Larkin G, Lefering R. The operative treatment of carpal tunnel syndrome and its relevance to endoscopic release. *Eur J Plast Surg*. 1999;2280-4.
962. Cellocco P, Rossi C, Bizzarri F, Patrizio L, Costanzo G. Mini-open blind procedure versus limited open technique for carpal tunnel release: a 30-month follow-up study. *J Hand Surg [Am]*. 2005;30(3):493-9.
963. Finsen V, Andersen K, Russwurm H. No advantage from splinting the wrist after open carpal tunnel release. A randomized study of 82 wrists. *Acta Orthop Scand*. 1999;70(3):288-92.
964. Mackenzie DJ, Hainer R, Wheatley MJ. Early recovery after endoscopic vs. short-incision open carpal tunnel release. *Ann Plast Surg*. 2000;44(6):601-4.
965. Nitz AJ, Dobner JJ. Upper extremity tourniquet effects in carpal tunnel release. *J Hand Surg [Am]*. 1989;14(3):499-504.
966. Hansen TB, Kirkeby L, Fisker H, Larsen K. Randomised controlled study of two different techniques of skin suture in endoscopic release of carpal tunnel. *Scand J Plast Reconstr Surg Hand Surg*. 2009;43(6):335-8.
967. Heidarian A, Abbasi H, Hasanzadeh Hoseinabadi M, Hajialibeyg A, Kalantar Motamedi SM, Seifirad S. Comparison of Knifelight Surgery versus Conventional Open Surgery in the Treatment of Carpal Tunnel Syndrome. *Iran Red Crescent Med J*. 2013;15(5):385-8.
968. Ucar BY, Demirtas A, Bulut M, Azboy I, Ucar D. Carpal tunnel decompression: two different mini-incision techniques. *Eur Rev Med Pharmacol Sci*. 2012;16(4):533-8.
969. Tian Y, Zhao H, Wang T. Prospective comparison of endoscopic and open surgical methods for carpal tunnel syndrome. *Chin Med Sci J*. 2007;22(2):104-7.
970. Delaunay L, Chelly JE. Blocks at the wrist provide effective anesthesia for carpal tunnel release. *Can J Anaesth*. 2001;48(7):656-60.
971. Waegeneers S, Haentjens P, Wylock P. Operative treatment of carpal tunnel syndrome. *Acta Orthop Belg*. 1993;59(4):367-70.
972. Rivera JJ, Villecco DJ, Dehner BK, Burkard JF, Osborne LA, Pellegrini JE. The efficacy of ketorolac as an adjunct to the Bier block for controlling postoperative pain following nontraumatic hand and wrist surgery. *AANA J*. 2008;76(5):341-5.
973. Peng PW, Coleman MM, McCartney CJ, et al. Comparison of anesthetic effect between 0.375% ropivacaine versus 0.5% lidocaine in forearm intravenous regional anesthesia. *Reg Anesth Pain Med*. 2002;27(6):595-9.

Copyright© 2016 Reed Group, Ltd.

974. Alayurt S, Memis D, Pamukcu Z. The addition of sufentanil, tramadol or clonidine to lignocaine for intravenous regional anaesthesia. *Anaesth Intensive Care*. 2004;32(1):22-7.
975. Bernard J-M, Macaire P. Dose-range effects of clonidine added to lidocaine for brachial plexus block. *Anesthesiology*. 1997;87(2):277-84.
976. Bigat Z, Boztug N, Hadimioglu N, Cete N, Coskunfirat N, Ertok E. Does dexamethasone improve the quality of intravenous regional anesthesia and analgesia? A randomized, controlled clinical study. *Anesth Analg*. 2006;102(2):605-9.
977. Bigat Z, Karsli B, Boztug N, Cete N, Ertok E. Comparison of the effect of low-dose ropivacaine and lidocaine in intravenous regional anaesthesia : a randomised, double-blind clinical study. *Clin Drug Investig*. 2005;25(3):209-14.
978. Lawrence TM, Desai VV. Topical anaesthesia to reduce pain associated with carpal tunnel surgery. *J Hand Surg Br*. 2002;27(5):462-4.
979. Nabhan A, Steudel WI, Dedeman L, Al-Khayat J, Ishak B. Subcutaneous local anesthesia versus intravenous regional anesthesia for endoscopic carpal tunnel release: a randomized controlled trial. *J Neurosurg*. 2011;114(1):240-4.
980. Patil S, Ramakrishnan M, Stothard J. Local anaesthesia for carpal tunnel decompression: a comparison of two techniques. *J Hand Surg Br*. 2006;31(6):683-6.
981. Reuben SS, Duprat KM. Comparison of wound infiltration with ketorolac versus intravenous regional anesthesia with ketorolac for postoperative analgesia following ambulatory hand surgery. *Reg Anesth*. 1996;21(6):565-8.
982. Braithwaite BD, Robinson GJ, Burge PD. Haemostasis during carpal tunnel release under local anaesthesia: a controlled comparison of a tourniquet and adrenaline infiltration. *J Hand Surg Br*. 1993;18(2):184-6.
983. Lee HJ, Cho YJ, Gong HS, Rhee SH, Park HS, Baek GH. The effect of buffered lidocaine in local anesthesia: a prospective, randomized, double-blind study. *J Hand Surg Am*. 2013;38(5):971-5.
984. Ozer H, Solak S, Oguz T, Ocguder A, Colakoglu T, Babacan A. Alkalinisation of local anaesthetics prescribed for pain relief after surgical decompression of carpal tunnel syndrome. *J Orthop Surg (Hong Kong)*. 2005;13(3):285-9.
985. Sorensen AM, Dalsgaard J, Hansen TB. Local anaesthesia versus intravenous regional anaesthesia in endoscopic carpal tunnel release: a randomized controlled trial. *J Hand Surg Eur Vol*. 2013;38(5):481-4.
986. Watts AC, Gaston P, Hooper G. Randomized trial of buffered versus plain lidocaine for local anaesthesia in open carpal tunnel decompression. *J Hand Surg Br*. 2004;29(1):30-1.
987. Watts AC, McEachan J. The use of a fine-gauge needle to reduce pain in open carpal tunnel decompression: a randomized controlled trial. *J Hand Surg Br*. 2005;30(6):615-7.
988. Yiannakopoulos CK. Carpal ligament decompression under local anaesthesia: the effect of lidocaine warming and alkalinisation on infiltration pain. *J Hand Surg Br*. 2004;29(1):32-4.
989. Heuser A, Kourtev H, Winter S, et al. Telerehabilitation using the Rutgers Master II glove following carpal tunnel release surgery: proof-of-concept. *IEEE Trans Neural Syst Rehabil Eng*. 2007;15(1):43-9.
990. Melhorn J. Understanding the types of carpal tunnel syndrome. *J Workers Comp*. 1998;752-73.
991. Chung KC, Zimmerman NB, Travis MT. Wrist arthrography versus arthroscopy: a comparative study of 150 cases. *J Hand Surg Am*. 1996;21(4):591-4.
992. Golimbu C, Firooznia H, Melone Jr C, Rafii M, Weinreb J, Leber C. Tears of the triangular fibrocartilage of the wrist: MR imaging. *Radiology*. 1989;173(3):731-3.
993. Potter HG, Asnis-Ernberg L, Weiland AJ, Hotchkiss RN, Peterson MG, McCORMACK RR. The Utility of High-Resolution Magnetic Resonance Imaging in the Evaluation of the Triangular Fibrocartilage Complex of the Wrist*. *The Journal of Bone & Joint Surgery*. 1997;79(11):1675-84.
994. Schers TJ, van Heusden HA. Evaluation of chronic wrist pain: Arthroscopy superior to arthrography: comparison in 39 patients. *Acta Orthop*. 1995;66(6):540-2.
995. Skahen JR, Palmer AK, Levinsohn EM, Buckingham SC, Szeverenyi NM. Magnetic resonance imaging of the triangular fibrocartilage complex. *J Hand Surg Am*. 1990;15(4):552-7.
996. Slutsky DJ. Distal radioulnar joint arthroscopy and the volar ulnar portal. *Tech Hand Up Extrem Surg*. 2007;11(1):38-44.
997. Sahin G, Dogan BE, Demirtas M. Virtual MR arthroscopy of the wrist joint: a new intraarticular perspective. *Skeletal Radiol*. 2004;33(1):9-14.
998. Park MJ, Jagadish A, Yao J. The rate of triangular fibrocartilage injuries requiring surgical intervention. *Orthopedics*. 2010;33(11):806.
999. Palmer AK. Triangular fibrocartilage disorders: injury patterns and treatment. *Arthroscopy*. 1990;6(2):125-32.
1000. Estrella EP, Hung LK, Ho PC, Tse WL. Arthroscopic repair of triangular fibrocartilage complex tears. *Arthroscopy*. 2007;23(7):729-37, 37 e1.

Copyright© 2016 Reed Group, Ltd.

1001. Corso SJ, Savoie FH, Geissler WB, Whipple TL, Jiminez W, Jenkins N. Arthroscopic repair of peripheral avulsions of the triangular fibrocartilage complex of the wrist: a multicenter study. *Arthroscopy*. 1997;13(1):78-84.
1002. de Araujo W, Poehling GG, Kuzma GR. New Tuohy needle technique for triangular fibrocartilage complex repair: preliminary studies. *Arthroscopy*. 1996;12(6):699-703.
1003. Ruch DS, Yang CC, Smith BP. Results of acute arthroscopically repaired triangular fibrocartilage complex injuries associated with intra-articular distal radius fractures. *Arthroscopy*. 2003;19(5):511-6.
1004. Westkaemper JG, Mitsionis G, Giannakopoulos PN, Sotereanos DG. Wrist arthroscopy for the treatment of ligament and triangular fibrocartilage complex injuries. *Arthroscopy*. 1998;14(5):479-83.
1005. Hermansdorfer JD, Kleinman WB. Management of chronic peripheral tears of the triangular fibrocartilage complex. *J Hand Surg Am*. 1991;16(2):340-6.
1006. Minami A, Kato H. Ulnar shortening for triangular fibrocartilage complex tears associated with ulnar positive variance. *J Hand Surg Am*. 1998;23(5):904-8.
1007. Daniels M, Reichman J, Brezis M. Mannitol treatment for acute compartment syndrome. *Nephron*. 1998;79(4):492-3.
1008. Woo WW, Man SY, Lam PK, Rainer TH. Randomized double-blind trial comparing oral paracetamol and oral nonsteroidal antiinflammatory drugs for treating pain after musculoskeletal injury. *Ann Emerg Med*. 2005;46(4):352-61.
1009. Bouachour G, Cronier P, Gouello JP, Toulemonde JL, Talha A, Alquier P. Hyperbaric oxygen therapy in the management of crush injuries: a randomized double-blind placebo-controlled clinical trial. *J Trauma*. 1996;41(2):333-9.
1010. Garcia-Covarrubias L, McSwain NE, Jr., Van Meter K, Bell RM. Adjuvant hyperbaric oxygen therapy in the management of crush injury and traumatic ischemia: an evidence-based approach. *Am Surg*. 2005;71(2):144-51.
1011. Dougherty JE. The role of hyperbaric oxygen therapy in crush injuries. *Crit Care Nurs Q*. 2013;36(3):299-309.
1012. Eskes A, Vermeulen H, Lucas C, Ubbink DT. Hyperbaric oxygen therapy for treating acute surgical and traumatic wounds. *Cochrane Database Syst Rev*. 2013(12):CD008059.
1013. Eskes AM, Ubbink DT, Lubbers MJ, Lucas C, Vermeulen H. Hyperbaric oxygen therapy: solution for difficult to heal acute wounds? Systematic review. *World J Surg*. 2011;35(3):535-42.
1014. Greensmith JE. Hyperbaric oxygen therapy in extremity trauma. *J Am Acad Orthop Surg*. 2004;12(6):376-84.
1015. Botte MJ, Gelberman RH. Acute compartment syndrome of the forearm. *Hand Clin*. 1998;14(3):391-403.
1016. Friedrich JB, Shin AY. Management of forearm compartment syndrome. *Hand Clin*. 2007;23(2):245-54, vii.
1017. Gelberman RH, Zakaib GS, Mubarak SJ, Hargens AR, Akeson WH. Decompression of forearm compartment syndromes. *Clin Orthop Relat Res*. 1978(134):225-9.
1018. Mubarak SJ, Pedowitz RA, Hargens AR. Compartment syndromes. *Curr Orthop*. 1989;336-40.
1019. Ortiz JA, Jr., Berger RA. Compartment syndrome of the hand and wrist. *Hand Clin*. 1998;14(3):405-18.
1020. Weinstein SM, Herring SA. Nerve problems and compartment syndromes in the hand, wrist, and forearm. *Clin Sports Med*. 1992;11(1):161-88.
1021. Gourgiotis S, Villias C, Germanos S, Foukas A, Ridolfini MP. Acute limb compartment syndrome: a review. *J Surg Educ*. 2007;64(3):178-86.
1022. Hayakawa H, Aldington DJ, Moore RA. Acute traumatic compartment syndrome: a systematic review of results of fasciotomy. *Trauma*. 2009;11(1):5-35.
1023. Kalyani BS, Fisher BE, Roberts CS, Giannoudis PV. Compartment syndrome of the forearm: a systematic review. *J Hand Surg Am*. 2011;36(3):535-43.
1024. Wall CJ, Lynch J, Harris IA, et al. Clinical practice guidelines for the management of acute limb compartment syndrome following trauma. *ANZ J Surg*. 2010;80(3):151-6.
1025. Nakamura R, Horii E, Tanaka Y, Imaeda T, Hayakawa N. Three-dimensional CT imaging for wrist disorders. *J Hand Surg Br*. 1989;14(1):53-8.
1026. Hashizume H, Asahara H, Nishida K, Inoue H, Konishiike T. Histopathology of Kienbock's disease. Correlation with magnetic resonance and other imaging techniques. *J Hand Surg Br*. 1996;21(1):89-93.
1027. Imaeda T, Nakamura R, Miura T, Makino N. Magnetic resonance imaging in Kienbock's disease. *J Hand Surg Br*. 1992;17(1):12-9.
1028. Kato H, Usui M, Minami A. Long-term results of Kienbock's disease treated by excisional arthroplasty with a silicone implant or coiled palmaris longus tendon. *J Hand Surg Am*. 1986;11(5):645-53.
1029. Lichtman DM, Alexander AH, Mack GR, Gunther SF. Kienbock's disease--update on silicone replacement arthroplasty. *J Hand Surg Am*. 1982;7(4):343-7.
1030. Lichtman DM, Mack GR, MacDonald RI, Gunther SF, Wilson JN. Kienbock's disease: the role of silicone replacement arthroplasty. *J Bone Joint Surg Am*. 1977;59(7):899-908.

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1031. Horita K, Ikuta Y, Murakami T, Ochi M, Mochizuki Y. An experimental study on the bone-core tendon ball replacement for the treatment of Kienböck's disease. *J Jpn Soc Surg Hand*. 1990;7767-71.
1032. Minami A, Kimura T, Suzuki K. Long-term results of Kienbock's disease treated by triscaphe arthrodesis and excisional arthroplasty with a coiled palmaris longus tendon. *J Hand Surg Am*. 1994;19(2):219-28.
1033. Rhee SK, Kim HM, Bahk WJ, Kim YW. A comparative study of the surgical procedures to treat advanced Kienbock's disease. *J Korean Med Sci*. 1996;11(2):171-8.
1034. Sakai A, Toba N, Oshige T, Menuki K, Hirasawa H, Nakamura T. Kienbock disease treated by excisional arthroplasty with a palmaris longus tendon ball: a comparative study of cases with or without bone core. *Hand Surg*. 2004;9(2):145-9.
1035. Ueba Y, Nosaka K, Seto Y, Ikeda N, Nakamura T. An operative procedure for advanced Kienbock's disease. Excision of the lunate and subsequent replacement with a tendon-ball implant. *J Orthop Sci*. 1999;4(3):207-15.
1036. Yajima H, Ono H, Tamai S. Temporary internal fixation of the scaphotrapezio-trapezoidal joint for the treatment of Kienbock's disease: a preliminary study. *J Hand Surg Am*. 1998;23(3):402-10.
1037. Zelouf DS, Ruby LK. External fixation and cancellous bone grafting for Kienbock's disease: a preliminary report. *J Hand Surg Am*. 1996;21(5):746-53.
1038. Meier R, Van Griensven M, Krimmer H. Scaphotrapeziotrapezoid (STT)-arthrodesis in Kienböck's disease. *The Journal of Hand Surgery: British & European Volume*. 2004;29(6):580-4.
1039. Watson HK, Ryu J, DiBella A. An approach to Kienböck's disease: triscaphe arthrodesis. *J Hand Surg Am*. 1985;10(2):179-87.
1040. Nakamura R, Imaeda T, Miura T. Radial shortening for Kienböck's disease: factors affecting the operative result. *Journal of Hand Surgery (British and European Volume)*. 1990;15(1):40-5.
1041. Takahara M, Watanabe T, Tsuchida H, Yamahara S, Kikuchi N, Ogino T. Long-term follow-up of radial shortening osteotomy for Kienbock disease. Surgical technique. *J Bone Joint Surg Am*. 2009;91 Suppl 2184-90.
1042. Soejima O, Iida H, Komine S, Kikuta T, Naito M. Lateral closing wedge osteotomy of the distal radius for advanced stages of Kienböck's disease. *J Hand Surg Am*. 2002;27(1):31-6.
1043. Watson HK, Wollstein R, Joseph E, Manzo R, Weinzweig J, Ashmead D. Scaphotrapeziotrapezoid arthrodesis: a follow-up study. *J Hand Surg Am*. 2003;28(3):397-404.
1044. Begley B, Engber W. Proximal row carpectomy in advanced Kienböck's disease. *J Hand Surg*. 1994;19(6):1016-8.
1045. Culp R, McGuigan F, Turner M, Lichtman D, Osterman A, McCarroll H. Proximal row carpectomy: a multicenter study. *J Hand Surg Am*. 1993;18(1):19-25.
1046. Diao E, Andrews A, Beall M. Proximal row carpectomy. *Hand Clin*. 2005;21(4):553-9.
1047. Mehrpour SR, Kamrani RS, Aghamirsalim MR, Sorbi R, Kaya A. Treatment of Kienbock disease by lunate core decompression. *J Hand Surg Am*. 2011;36(10):1675-7.
1048. Rodrigues-Pinto R, Freitas D, Costa LD, et al. Clinical and radiological results following radial osteotomy in patients with Kienbock's disease: four- to 18-year follow-up. *J Bone Joint Surg Br*. 2012;94(2):222-6.
1049. Lu LJ, Gong X, Wang KL. Vascularized capitate transposition for advanced Kienbock disease: application of 40 cases and their anatomy. *Ann Plast Surg*. 2006;57(6):637-41.
1050. Taljanovic MS, Karantanas A, Griffith JF, DeSilva GL, Rieke JD, Sheppard JE. Imaging and treatment of scaphoid fractures and their complications. *Semin Musculoskelet Radiol*. 2012;16(2):159-73.
1051. Guly HR. Injuries initially misdiagnosed as sprained wrist (beware the sprained wrist). *Emerg Med J*. 2002;19(1):41-2.
1052. Michlovitz S, Hun L, Erasala GN, Hengehold DA, Weingand KW. Continuous low-level heat wrap therapy is effective for treating wrist pain. *Arch Phys Med Rehabil*. 2004;85(9):1409-16.
1053. Muckle D. Comparative study of ibuprofen and aspirin in soft-tissue injuries. *Rheumatology*. 1974;13(3):141-7.
1054. Muckle D. A double-blind trial of flurbiprofen and aspirin in soft-tissue trauma. *Rheumatology*. 1977;16(1):58-61.
1055. Kleinbaum Y, Heyman Z, Ganel A, Blankstein A. Sonographic imaging of mallet finger. *Ultraschall Med*. 2005;26(3):223-6.
1056. Bianchi S. Ultrasound of the peripheral nerves. *Joint Bone Spine*. 2008;75(6):643-9.
1057. Auchincloss JM. Mallet-finger injuries: a prospective, controlled trial of internal and external splintage. *Hand*. 1982;14(2):168-73.
1058. Garberman SF, Diao E, Peimer CA. Mallet finger: results of early versus delayed closed treatment. *J Hand Surg [Am]*. 1994;19(5):850-2.
1059. Kinninmonth AW, Holburn F. A comparative controlled trial of a new perforated splint and a traditional splint in the treatment of mallet finger. *J Hand Surg [Br]*. 1986;11(2):261-2.

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1060. Warren R, Kay N, Ferguson D. Mallet finger: comparison between operative and conservative management in those cases failing to be cured by splintage. *Journal of Hand Surgery (British and European Volume)*. 1988;13(2):159-60.
1061. Hong E. Hand injuries in sports medicine. *Primary Care: Clinics in Office Practice*. 2005;32(1):91-103.
1062. Smit JM, Beets MR, Zeebregts CJ, Rood A, Welters CF. Treatment options for mallet finger: a review. *Plast Reconstr Surg*. 2010;126(5):1624-9.
1063. Betts-Symonds GW, Hodgkinson V, Densley G, Hogan D. Functional bracing--5. The development of a functional brace for the treatment of mallet fingers. *Nurs Times*. 1982;78(49):2080-2.
1064. Chan DY. Management of simple finger injuries: the splinting regime. *Hand Surg*. 2002;7(2):223-30.
1065. Valdes K, Naughton N, Algar L. Conservative treatment of mallet finger: A systematic review. *J Hand Ther*. 2015;28(3):237-45; quiz 46.
1066. Handoll HH, Vaghela MV. Interventions for treating mallet finger injuries. *Cochrane Database Syst Rev*. 2004(3):CD004574.
1067. O'Brien LJ, Bailey MJ. Single blind, prospective, randomized controlled trial comparing dorsal aluminum and custom thermoplastic splints to stack splint for acute mallet finger. *Arch Phys Med Rehabil*. 2011;92(2):191-8.
1068. Pike J, Mulpuri K, Metzger M, Ng G, Wells N, Goetz T. Blinded, prospective, randomized clinical trial comparing volar, dorsal, and custom thermoplastic splinting in treatment of acute mallet finger. *J Hand Surg Am*. 2010;35(4):580-8.
1069. Tocco S, Boccolari P, Landi A, et al. Effectiveness of cast immobilization in comparison to the gold-standard self-removal orthotic intervention for closed mallet fingers: a randomized clinical trial. *J Hand Ther*. 2013;26(3):191-200; quiz 1.
1070. Toker S, Turkmen F, Pekince O, Korucu I, Karalezli N. Extension Block Pinning Versus Hook Plate Fixation for Treatment of Mallet Fractures. *J Hand Surg Am*. 2015;40(8):1591-6.
1071. Gruber JS, Bot AG, Ring D. A prospective randomized controlled trial comparing night splinting with no splinting after treatment of mallet finger. *Hand (N Y)*. 2014;9(2):145-50.
1072. Tarbhai K, Hannah S, von Schroeder HP. Trigger finger treatment: a comparison of 2 splint designs. *J Hand Surg Am*. 2012;37(2):243-9, 9 e1.
1073. Akhtar S, Bradley MJ, Quinton DN, Burke FD. Management and referral for trigger finger/thumb. *Br Med J*. 2005;331(7507):30-3.
1074. Colbourn J, Heath N, Manary S, Pacifico D. Effectiveness of splinting for the treatment of trigger finger. *J Hand Ther*. 2008;21(4):336-43.
1075. Murphy D, Failla JM, Koniuch MP. Steroid versus placebo injection for trigger finger. *J Hand Surg [Am]*. 1995;20(4):628-31.
1076. Lambert MA, Morton RJ, Sloan JP. Controlled study of the use of local steroid injection in the treatment of trigger finger and thumb. *J Hand Surg [Br]*. 1992;17(1):69-70.
1077. Peters-Veluthamaningal C, Winters JC, Groenier KH, Jong BM. Corticosteroid injections effective for trigger finger in adults in general practice: a double-blinded randomised placebo controlled trial. *Ann Rheum Dis*. 2008;67(9):1262-6.
1078. Taras JS, Raphael JS, Pan WT, Movagharnia F, Sotereanos DG. Corticosteroid injections for trigger digits: is intrasheath injection necessary? *J Hand Surg [Am]*. 1998;23(4):717-22.
1079. Cecen GS, Gulabi D, Saglam F, Tanju NU, Bekler HI. Corticosteroid injection for trigger finger: blinded or ultrasound-guided injection? *Arch Orthop Trauma Surg*. 2015;135(1):125-31.
1080. Kazuki K, Egi T, Okada M, Takaoka K. Clinical outcome of extrasynovial steroid injection for trigger finger. *Hand Surg*. 2006;11(1-2):1-4.
1081. Kamhin M, Engel J, Heim M. The fate of injected trigger fingers. *The Hand*. 1983(2):218-20.
1082. Akhtar S, Burke FD. Study to outline the efficacy and illustrate techniques for steroid injection for trigger finger and thumb. *Postgrad Med J*. 2006;82(973):763-6.
1083. Benson LS, Ptaszek AJ. Injection versus surgery in the treatment of trigger finger. *J Hand Surg [Am]*. 1997;22(1):138-44.
1084. Clark DD, Ricker JH, MacCollum MS. The efficacy of local steroid injection in the treatment of stenosing tenovaginitis. *Plast Reconstr Surg*. 1973;51(2):179-80.
1085. Fleisch SB, Spindler KP, Lee DH. Corticosteroid injections in the treatment of trigger finger: a level I and II systematic review. *J Am Acad Orthop Surg*. 2007;15(3):166-71.
1086. Goldfarb CA, Gelberman RH, McKeon K, Chia B, Boyer MI. Extra-articular steroid injection: early patient response and the incidence of flare reaction. *J Hand Surg Am*. 2007;32(10):1513-20.
1087. Marks MR, Gunther SF. Efficacy of cortisone injection in treatment of trigger fingers and thumbs. *J Hand Surg [Am]*. 1989;14(4):722-7.
1088. Newport ML, Lane LB, Stuchin SA. Treatment of trigger finger by steroid injection. *J Hand Surg [Am]*. 1990;15(5):748-50.

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1089. Sato ES, Gomes Dos Santos JB, Belloti JC, Albertoni WM, Faloppa F. Treatment of trigger finger: randomized clinical trial comparing the methods of corticosteroid injection, percutaneous release and open surgery. *Rheumatology (Oxford)*. 2012;51(1):93-9.
1090. Zyluk A, Jagielski G. Percutaneous A1 pulley release vs steroid injection for trigger digit: the results of a prospective, randomized trial. *J Hand Surg Eur Vol*. 2011;36(1):53-6.
1091. Callegari L, Spano E, Bini A, Valli F, Genovese E, Fugazzola C. Ultrasound-guided injection of a corticosteroid and hyaluronic acid: a potential new approach to the treatment of trigger finger. *Drugs R D*. 2011;11(2):137-45.
1092. Pataradool K, Buranapuntaruk T. Proximal phalanx injection for trigger finger: randomized controlled trial. *Hand Surg*. 2011;16(3):313-7.
1093. Ring D, Lozano-Calderon S, Shin R, Bastian P, Mudgal C, Jupiter J. A prospective randomized controlled trial of injection of dexamethasone versus triamcinolone for idiopathic trigger finger. *J Hand Surg Am*. 2008;33(4):516-22; discussion 23-4.
1094. Shakeel H, Ahmad TS. Steroid injection versus NSAID injection for trigger finger: a comparative study of early outcomes. *J Hand Surg Am*. 2012;37(7):1319-23.
1095. Taras JS, Raphael JS, Pan WT, Movagharnia F, Sotereanos DG. Corticosteroid injections for trigger digits: is intrasheath injection necessary? *J Hand Surg Am*. 1998;23(4):717-22.
1096. Jianmongkol S, Kosuwon W, Thammaroj T. Intra-tendon sheath injection for trigger finger: the randomized controlled trial. *Hand Surg*. 2007;12(2):79-82.
1097. Gilberts EC, Beekman WH, Stevens HJ, Wereldsma JC. Prospective randomized trial of open versus percutaneous surgery for trigger digits. *J Hand Surg [Am]*. 2001;26(3):497-500.
1098. Maneerit J, Sriworakun C, Budhraja N, Nagavajara P. Trigger thumb: results of a prospective randomised study of percutaneous release with steroid injection versus steroid injection alone. *J Hand Surg [Br]*. 2003;28(6):586-9.
1099. Gilberts EC, Wereldsma JC. Long-term results of percutaneous and open surgery for trigger fingers and thumbs. *Int Surg*. 2002;87(1):48-52.
1100. Lorthioir J. Surgical treatment of trigger-finger by a subcutaneous method. *J Bone Joint Surg Am*. 1958;40(4):793-5.
1101. Tanaka J, Muraji M, Negoro H, Yamashita H, Nakano T, Nakano K. Subcutaneous release of trigger thumb and fingers in 210 fingers. *Journal of Hand Surgery (British and European Volume)*. 1990;15(4):463-5.
1102. Dierks U, Hoffmann R, Meek MF. Open versus percutaneous release of the A1-pulley for stenosing tendovaginitis: a prospective randomized trial. *Tech Hand Up Extrem Surg*. 2008;12(3):183-7.
1103. Bamroongshawgasame T. A comparison of open and percutaneous pulley release in trigger digits. *J Med Assoc Thai*. 2010;93(2):199-204.
1104. Cebesoy O, Kose KC, Baltaci ET, Isik M. Percutaneous release of the trigger thumb: is it safe, cheap and effective? *Int Orthop*. 2007;31(3):345-9.
1105. Gilberts E, Wereldsma J. Long-term results of percutaneous and open surgery for trigger fingers and thumbs. *International surgery*. 2001;87(1):48-52.
1106. Topper SM, Jones DE, Klajnbart JO, Friedel SP. Trigger finger: the effect of partial release of the first annular pulley on triggering. *Am J Orthop*. 1997;26(10):675-7.
1107. Fu YC, Huang PJ, Tien YC, Lu YM, Fu HH, Lin GT. Revision of incompletely released trigger fingers by percutaneous release: results and complications. *J Hand Surg Am*. 2006;31(8):1288-91.
1108. Yiannakopoulos CK, Ignatiadis IA. Transdermal anaesthesia for percutaneous trigger finger release. *Hand Surg*. 2006;11(3):159-62.
1109. Chao M, Wu S, Yan T. The effect of miniscalpel-needle versus steroid injection for trigger thumb release. *J Hand Surg Eur Vol*. 2009;34(4):522-5.
1110. Pegoli L, Cavalli E, Cortese P, Parolo C, Pajardi G. A comparison of endoscopic and open trigger finger release. *Hand Surg*. 2008;13(3):147-51.
1111. Chien AJ, Jacobson JA, Martel W, Kabeto MU, Marcantonio DR. Focal radial styloid abnormality as a manifestation of de Quervain tenosynovitis. *AJR Am J Roentgenol*. 2001;177(6):1383-6.
1112. Costa CR, Morrison WB, Carrino JA. MRI features of intersection syndrome of the forearm. *AJR Am J Roentgenol*. 2003;181(5):1245-9.
1113. de Lima JE, Kim HJ, Albertotti F, Resnick D. Intersection syndrome: MR imaging with anatomic comparison of the distal forearm. *Skeletal Radiol*. 2004;33(11):627-31.
1114. Lee RP, Hatem SF, Recht MP. Extended MRI findings of intersection syndrome. *Skeletal Radiol*. 2009;38(2):157-63.
1115. Nieuwenhuis WP, Krabben A, Stomp W, et al. Evaluation of magnetic resonance imaging-detected tenosynovitis in the hand and wrist in early arthritis. *Arthritis Rheumatol*. 2015;67(4):869-76.

Copyright© 2016 Reed Group, Ltd.

1116. Parellada AJ, Gopez AG, Morrison WB, et al. Distal intersection tenosynovitis of the wrist: a lesser-known extensor tendinopathy with characteristic MR imaging features. *Skeletal Radiol*. 2007;36(3):203-8.
1117. Hadidy A, Hadidi S, Haroun A, et al. DeQuervain's tenosynovitis imaging: ultrasonography veruss magnetic resonance imaging. *J Bahrain Med Society*. 2009;21(4):328-33.
1118. Steinberg D. Intersection Syndrome. Available at: http://www.emedicine.com/orthoped/topic407.htm. *Emedicine*. 2008.
1119. Menendez ME, Thornton E, Kent S, Kalajian T, Ring D. A prospective randomized clinical trial of prescription of full-time versus as-desired splint wear for de Quervain tendinopathy. *Int Orthop*. 2015;39(8):1563-9.
1120. Mardani-Kivi M, Karimi Mobarakeh M, Bahrami F, Hashemi-Motlagh K, Saheb-Ekhtiari K, Akhoondzadeh N. Corticosteroid injection with or without thumb spica cast for de Quervain tenosynovitis. *J Hand Surg Am*. 2014;39(1):37-41.
1121. Mehdinasab SA, Alemohammad SA. Methylprednisolone acetate injection plus casting versus casting alone for the treatment of de Quervain's tenosynovitis. *Arch Iran Med*. 2010;13(4):270-4.
1122. Jirarattanaphochai K, Saengnipanthkul S, Vipulakorn K, Jianmongkol S, Chatuparisute P, Jung S. Treatment of de Quervain disease with triamcinolone injection with or without nimesulide. A randomized, double-blind, placebo-controlled trial. *J Bone Joint Surg Am*. 2004;86-A(12):2700-6.
1123. Mazieres B, Rouanet S, Guillon Y, Scarsi C, Reiner V. Topical ketoprofen patch in the treatment of tendinitis: a randomized, double blind, placebo controlled study. *J Rheumatol*. 2005;32(8):1563-70.
1124. May JJ, Lovell G, Hopkins WG. Effectiveness of 1% diclofenac gel in the treatment of wrist extensor tenosynovitis in long distance kayakers. *J Sci Med Sport*. 2007;10(1):59-65.
1125. Anderson M, Tichenor CJ. A patient with de Quervain's tenosynovitis: a case report using an Australian approach to manual therapy. *Phys Ther*. 1994;74(4):314-26.
1126. Brosseau L, Casimiro L, Milne S, et al. Deep transverse friction massage for treating tendinitis. *Cochrane Database Syst Rev*. 2002(1):CD003528.
1127. Hadianfard M, Ashraf A, Fakheri M, Nasiri A. Efficacy of acupuncture versus local methylprednisolone acetate injection in De Quervain's tenosynovitis: a randomized controlled trial. *J Acupunct Meridian Stud*. 2014;7(3):115-21.
1128. Avci S, Yilmaz C, Sayli U. Comparison of nonsurgical treatment measures for de Quervain's disease of pregnancy and lactation. *J Hand Surg Am*. 2002;27(2):322-4.
1129. Kosuwon W. Treatment of de quervain tenosynovitis: A prospective randomized controlled study comparing the results of steroid injection with and without immobilization in a splint. *Journal of Clinical Epidemiology*. 1996;49(Suppl 1):S5.
1130. Lane LB, Boretz RS, Stuchin SA. Treatment of de Quervain's disease:role of conservative management. *J Hand Surg Br*. 2001;26(3):258-60.
1131. Lapidus PW, Guidotti FP. Stenosing tenovaginitis of the wrist and fingers. *Clin Orthop Relat Res*. 1972;8387-90.
1132. Peters-Veluthamaningal C, van der Windt DA, Winters JC, Meyboom-de Jong B. Corticosteroid injection for de Quervain's tenosynovitis. *Cochrane Database Syst Rev*. 2009(3):CD005616.
1133. Peters-Veluthamaningal C, Winters JC, Groenier KH, Meyboom-DeJong B. Randomised controlled trial of local corticosteroid injections for de Quervain's tenosynovitis in general practice. *BMC Musculoskelet Disord*. 2009;10131.
1134. Richie CA, 3rd, Briner WW, Jr. Corticosteroid injection for treatment of de Quervain's tenosynovitis: a pooled quantitative literature evaluation. *J Am Board Fam Pract*. 2003;16(2):102-6.
1135. Anderson BC, Manthey R, Brouns MC. Treatment of De Quervain's tenosynovitis with corticosteroids. A prospective study of the response to local injection. *Arthritis Rheum*. 1991;34(7):793-8.
1136. Sakai N. Selective corticosteroid injection into the extensor pollicis brevis tenosynovium for de Quervain's disease. *Orthopedics*. 2002;25(1):68-70.
1137. Jeyapalan K, Choudhary S. Ultrasound-guided injection of triamcinolone and bupivacaine in the management of de Quervain′ s disease. *Skeletal Radiol*. 2009;38(11):1099-103.
1138. Rankin ME, Rankin EA. Injection therapy for management of stenosing tenosynovitis (de Quervain's disease) of the wrist. *J Natl Med Assoc*. 1998;90(8):474-6.
1139. Witt J, Pess G, Gelberman RH. Treatment of de Quervain tenosynovitis. A prospective study of the results of injection of steroids and immobilization in a splint. *J Bone Joint Surg Am*. 1991;73(2):219-22.
1140. Zingas C, Failla JM, Van Holsbeeck M. Injection accuracy and clinical relief of de Quervain's tendinitis. *J Hand Surg Am*. 1998;23(1):89-96.
1141. Weiss AP, Akelman E, Tabatabai M. Treatment of de Quervain's disease. *J Hand Surg Am*. 1994;19(4):595-8.

Copyright© 2016 Reed Group, Ltd.

1142. Kume K, Amano K, Yamada S, Kuwaba N, Ohta H. In de Quervain's with a separate EPB compartment, ultrasound-guided steroid injection is more effective than a clinical injection technique: a prospective open-label study. *J Hand Surg Eur Vol*. 2012;37(6):523-7.
1143. Sawaizumi T, Nanno M, Ito H. De Quervain's disease: efficacy of intra-sheath triamcinolone injection. *Int Orthop*. 2007;31(2):265-8.
1144. Williams JG. Surgical management of traumatic non-infective tenosynovitis of the wrist extensors. *J Bone Joint Surg Br*. 1977;59-B(4):408-10.
1145. Abrisham SJ, Karbasi MH, Zare J, Behnamfar Z, Tafti AD, Shishesaz B. De qeurvian tenosynovitis: clinical outcomes of surgical treatment with longitudinal and transverse incision. *Oman Med J*. 2011;26(2):91-3.
1146. Witmer B, DiBenedetto M, Kang CG. An improved approach to the evaluation of the deep motor branch of the ulnar nerve. *Electromyogr Clin Neurophysiol*. 2002;42(8):485-93.
1147. Alaranta H, Seppalainen AM. Neuropathy and the automatic analysis of electromyographic signals from vibration exposed workers. *Scand J Work Environ Health*. 1977;3(3):128-34.
1148. Chatterjee DS, Barwick DD, Petrie A. Exploratory electromyography in the study of vibration-induced white finger in rock drillers. *Br J Ind Med*. 1982;39(1):89-97.
1149. Lander L, Lou W, House R. Nerve conduction studies and current perception thresholds in workers assessed for hand-arm vibration syndrome. *Occup Med (Lond)*. 2007;57(4):284-9.
1150. Hirata M, Sakakibara H. Sensory nerve conduction velocities of median, ulnar and radial nerves in patients with vibration syndrome. *Int Arch Occup Environ Health*. 2007;80(4):273-80.
1151. Aszmann O, Dellon AL. Decompression of multiple peripheral nerves in the treatment of diabetic neuropathy: a prospective, blinded study. *Acta Chirurgica Austriaca*. 2001;33(3):117-20.
1152. Dellon AL. Treatment of symptomatic diabetic neuropathy by surgical decompression of multiple peripheral nerves. *Plast Reconstr Surg*. 1992;89(4):689-97; discussion 98-9.
1153. Corwin HM. Compression neuropathies of the upper extremity. *Clin Occup Environ Med*. 2006;5(2):333-52, viii.
1154. Spindler HA, Dellon AL. Nerve conduction studies in the superficial radial nerve entrapment syndrome. *Muscle Nerve*. 1990;13(1):1-5.
1155. Verhaar J, Spaans F. Radial tunnel syndrome. An investigation of compression neuropathy as a possible cause. *J Bone Joint Surg Am*. 1991;73(4):539-44.
1156. Braidwood A. Superficial radial neuropathy. *Journal of Bone & Joint Surgery, British Volume*. 1975;57(3):380-3.
1157. Kleinert JM, Mehta S. Radial nerve entrapment. *Orthop Clin North Am*. 1996;27(2):305-15.
1158. Rinkel WD, Schreuders TA, Koes BW, Huisstede BM. Current evidence for effectiveness of interventions for cubital tunnel syndrome, radial tunnel syndrome, instability, or bursitis of the elbow: a systematic review. *Clin J Pain*. 2013;29(12):1087-96.
1159. Calder KM, Gabriel DA, McLean L. Differences in EMG spike shape between individuals with and without non-specific arm pain. *J Neurosci Methods*. 2009;178(1):148-56.
1160. Huellner MW, Burkert A, Strobel K, et al. Imaging non-specific wrist pain: interobserver agreement and diagnostic accuracy of SPECT/CT, MRI, CT, bone scan and plain radiographs. *PLoS One*. 2013;8(12):e85359.
1161. van Eijsden-Besseling M, Staal J, van Attekum A, de Bie R, van den Heuvel W. No difference between postural exercises and strength and fitness exercises for early, non-specific, work-related upper limb disorders in visual display unit workers: a randomised trial. *Aust J Physiother*. 2008;54(2):95-101.
1162. Tiel-van Buul M, van Beek E, Borm J, Gubler F, Broekhuizen A, van Royen E. The value of radiographs and bone scintigraphy in suspected scaphoid fracture. A statistical analysis. *J Hand Surg Br*. 1993;18(3):403-6.
1163. Leslie I, Dickson R. The fractured carpal scaphoid. Natural history and factors influencing outcome. *Journal of Bone & Joint Surgery, British Volume*. 1981;63(2):225-30.
1164. Ilica AT, Ozyurek S, Kose O, Durusu M. Diagnostic accuracy of multidetector computed tomography for patients with suspected scaphoid fractures and negative radiographic examinations. *Jpn J Radiol*. 2011;29(2):98-103.
1165. Mallee W, Doornberg JN, Ring D, van Dijk CN, Maas M, Goslings JC. Comparison of CT and MRI for diagnosis of suspected scaphoid fractures. *J Bone Joint Surg Am*. 2011;93(1):20-8.
1166. Memarsadeghi M, Breitenseher MJ, Schaefer-Prokop C, et al. Occult scaphoid fractures: comparison of multidetector CT and MR imaging--initial experience. *Radiology*. 2006;240(1):169-76.
1167. Smith ML, Bain GI, Chabrel N, Turner P, Carter C, Field J. Using computed tomography to assist with diagnosis of avascular necrosis complicating chronic scaphoid nonunion. *J Hand Surg Am*. 2009;34(6):1037-43.
1168. Temple CL, Ross DC, Bennett JD, Garvin GJ, King GJ, Faber KJ. Comparison of sagittal computed tomography and plain film radiography in a scaphoid fracture model. *J Hand Surg Am*. 2005;30(3):534-42.
1169. Fotiadou A, Patel A, Morgan T, Karantanas AH. Wrist injuries in young adults: the diagnostic impact of CT and MRI. *Eur J Radiol*. 2011;77(2):235-9.

Copyright© 2016 Reed Group, Ltd.

1170. Herneth AM, Siegmeth A, Bader TR, et al. Scaphoid fractures: evaluation with high-spatial-resolution US initial results. *Radiology*. 2001;220(1):231-5.
1171. Patel NK, Davies N, Mirza Z, Watson M. Cost and clinical effectiveness of MRI in occult scaphoid fractures: a randomised controlled trial. *Emerg Med J*. 2013;30(3):202-7.
1172. Querellou S, Arnaud L, Williams T, et al. Role of SPECT/CT compared with MRI in the diagnosis and management of patients with wrist trauma occult fractures. *Clin Nucl Med*. 2014;39(1):8-13.
1173. Kumar S, O'Connor A, Despois M, Galloway H. Use of early magnetic resonance imaging in the diagnosis of occult scaphoid fractures: the CAST Study (Canberra Area Scaphoid Trial). *N Z Med J*. 2005;118(1209):U1296.
1174. Carpenter CR, Pines JM, Schuur JD, Muir M, Calfee RP, Raja AS. Adult scaphoid fracture. *Acad Emerg Med*. 2014;21(2):101-21.
1175. Ganel A, Engel J, Oster Z, Farine I. Bone scanning in the assessment of fractures of the scaphoid. *J Hand Surg Am*. 1979;4(6):540-3.
1176. Murphy D, Eisenhauer M, Powe J, Pavlofsky W. Can a day 4 bone scan accurately determine the presence or absence of scaphoid fracture? *Annals Emerg Med*. 1995;26(4):434-8.
1177. Tiel-van Buul M, van Beek E, Broekhuizen A, Bakker A, Bos K, van Royen E. Radiography and scintigraphy of suspected scaphoid fracture. A long-term study in 160 patients. *J Bone Joint Surg Br*. 1993;75(1):61-5.
1178. Brismar J. Skeletal scintigraphy of the wrist in suggested scaphoid fracture. *Acta Radiologica*. 1988;29(1):101-7.
1179. Brooks S, Cicuttini FM, Lim S, Taylor D, Stuckey SL, Wluka AE. Cost effectiveness of adding magnetic resonance imaging to the usual management of suspected scaphoid fractures. *Br J Sports Med*. 2005;39(2):75-9.
1180. Bergh TH, Steen K, Lindau T, et al. Costs analysis and comparison of usefulness of acute MRI and 2 weeks of cast immobilization for clinically suspected scaphoid fractures. *Acta Orthop*. 2015;86(3):303-9.
1181. Bhat M, McCarthy M, Davis TR, Oni JA, Dawson S. MRI and plain radiography in the assessment of displaced fractures of the waist of the carpal scaphoid. *J Bone Joint Surg Br*. 2004;86(5):705-13.
1182. Breitenseher MJ, Trattnig S, Gabler C, et al. MRI in radiologically occult scaphoid fractures. Initial experiences with 1.0 Tesla (whole body-middle field equipment) versus 0.2 Tesla (dedicated low-field equipment). *Radiologe*. 1997;37(10):812-8.
1183. Brydie A, Raby N. Early MRI in the management of clinical scaphoid fracture. *Br J Radiol*. 2003;76(905):296-300.
1184. Cook PA, Yu JS, Wiand W, Cook AJ, 2nd, Coleman CR, Cook AJ. Suspected scaphoid fractures in skeletally immature patients: application of MRI. *J Comput Assist Tomogr*. 1997;21(4):511-5.
1185. De Zwart A, Beeres F, Ring D, et al. MRI as a reference standard for suspected scaphoid fractures. *Br J Radiol*. 2012;85(1016):1098-101.
1186. Fowler C, Sullivan B, Williams LA, McCarthy G, Savage R, Palmer A. A comparison of bone scintigraphy and MRI in the early diagnosis of the occult scaphoid waist fracture. *Skeletal Radiol*. 1998;27(12):683-7.
1187. Fox MG, Gaskin CM, Chhabra AB, Anderson MW. Assessment of scaphoid viability with MRI: a reassessment of findings on unenhanced MR images. *AJR Am J Roentgenol*. 2010;195(4):W281-6.
1188. Gabler C, Kukla C, Breitenseher MJ, Trattnig S, Vecsei V. Diagnosis of occult scaphoid fractures and other wrist injuries. Are repeated clinical examinations and plain radiographs still state of the art? *Langenbecks Arch Surg*. 2001;386(2):150-4.
1189. Low G, Raby N. Can follow-up radiography for acute scaphoid fracture still be considered a valid investigation? *Clin Radiol*. 2005;60(10):1106-10.
1190. Ng AW, Griffith JF, Taljanovic MS, Li A, Tse WL, Ho PC. Is dynamic contrast-enhanced MRI useful for assessing proximal fragment vascularity in scaphoid fracture delayed and non-union? *Skeletal Radiol*. 2013;42(7):983-92.
1191. Tibrewal S, Jayakumar P, Vaidya S, Ang SC. Role of MRI in the diagnosis and management of patients with clinical scaphoid fracture. *Int Orthop*. 2012;36(1):107-10.
1192. Unay K, Gokcen B, Ozkan K, Poyanli O, Eceviz E. Examination tests predictive of bone injury in patients with clinically suspected occult scaphoid fracture. *Injury*. 2009;40(12):1265-8.
1193. Beeres FJ, Hogervorst M, Kingma LM, Le Cessie S, Coerkamp EG, Rhemrev SJ. Observer variation in MRI for suspected scaphoid fractures. *Br J Radiol*. 2008;81(972):950-4.
1194. Tiel-van Buul M, Roolker W, Verbeeten B, Broekhuizen A. Magnetic resonance imaging versus bone scintigraphy in suspected scaphoid fracture. *Eur J Nucl Med*. 1996;23(8):971-5.
1195. Bretlau T, Christensen OM, Edstrom P, Thomsen HS, Lausten GS. Diagnosis of scaphoid fracture and dedicated extremity MRI. *Acta Orthop Scand*. 1999;70(5):504-8.
1196. Hunter JC, Escobedo EM, Wilson AJ, Hanel DP, Zink-Brody GC, Mann FA. MR imaging of clinically suspected scaphoid fractures. *AJR Am J Roentgenol*. 1997;168(5):1287-93.

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1197. Jorgsholm P, Thomsen NO, Besjakov J, Abrahamsson SO, Bjorkman A. The benefit of magnetic resonance imaging for patients with posttraumatic radial wrist tenderness. *J Hand Surg Am*. 2013;38(1):29-33.
1198. Kitsis C, Taylor M, Chandey J, et al. Imaging the problem scaphoid. *Injury*. 1998;29(7):515-20.
1199. Kusano N, Churei Y, Shiraishi E, Kusano T. Diagnosis of occult carpal scaphoid fracture: a comparison of magnetic resonance imaging and computed tomography techniques. *Tech Hand Up Extrem Surg*. 2002;6(3):119-23.
1200. Lozano-Calderon S, Blazar P, Zurakowski D, Lee SG, Ring D. Diagnosis of scaphoid fracture displacement with radiography and computed tomography. *J Bone Joint Surg Am*. 2006;88(12):2695-703.
1201. Raby N. Magnetic resonance imaging of suspected scaphoid fractures using a low field dedicated extremity MR system. *Clin Radiol*. 2001;56(4):316-20.
1202. Larribe M, Gay A, Freire V, Bouvier C, Chagnaud C, Souteyrand P. Usefulness of dynamic contrast-enhanced MRI in the evaluation of the viability of acute scaphoid fracture. *Skeletal Radiol*. 2014;43(12):1697-703.
1203. Moller JM, Larsen L, Bovin J, et al. MRI diagnosis of fracture of the scaphoid bone: impact of a new practice where the images are read by radiographers. *Acad Radiol*. 2004;11(7):724-8.
1204. Gaebler C, Kukla C, Breitenseher M, Trattnig S, Mittlboeck M, Vecsei V. Magnetic resonance imaging of occult scaphoid fractures. *J Trauma*. 1996;41(1):73-6.
1205. Schmitt R, Frohner S, van Schoonhoven J, Lanz U, Golles A. Idiopathic osteonecrosis of the scaphoid (Preiser's disease)--MRI gives new insights into etiology and pathology. *Eur J Radiol*. 2011;77(2):228-34.
1206. Senevirathna S, Rajeev A, Newby M. The value of delayed MRI scans in the assessment of acute wrist injuries. *Acta Orthop Belg*. 2013;79(3):275-9.
1207. Sharifi MD, Moghaddam HZ, Zakeri H, Ebrahimi M, Saeedian H, Hashemian AM. The Accuracy of Pain Measurement in Diagnosis of Scaphoid Bone Fractures in Patients with Magnetic Resonance Imaging: Report of 175 Cases. *Med Arch*. 2015;69(3):161-4.
1208. Fusetti C, Poletti PA, Pradel PH, et al. Diagnosis of occult scaphoid fracture with high-spatial-resolution sonography: a prospective blind study. *J Trauma*. 2005;59(3):677-81.
1209. Hauger O, Bonnefoy O, Moinard M, Bersani D, Diard F. Occult fractures of the waist of the scaphoid: early diagnosis by high-spatial-resolution sonography. *AJR Am J Roentgenol*. 2002;178(5):1239-45.
1210. Zhong-Gang Y, Jian-Bing Z, Shi-Lian K, Xiao-Gang W. Diagnosing suspected scaphoid fractures: a systematic review and meta-analysis. *Clin Orthop Relat Res*. 2010;468(3):723-34.
1211. Adey L, Souer JS, Lozano-Calderon S, Palmer W, Lee SG, Ring D. Computed tomography of suspected scaphoid fractures. *J Hand Surg Am*. 2007;32(1):61-6.
1212. Hannemann PF, Brouwers L, van der Zee D, et al. Multiplanar reconstruction computed tomography for diagnosis of scaphoid waist fracture union: a prospective cohort analysis of accuracy and precision. *Skeletal Radiol*. 2013;42(10):1377-82.
1213. Rhemrev SJ, van Leerdam RH, Beeres FJ, Arndt JW, Meylaerts SA. Bone scintigraphy in patients with clinical suspicion of a scaphoid fracture. *Eur J Emerg Med*. 2010;17(2):124-5.
1214. Nguyen Q, Chaudhry S, Sloan R, Bhoora I, Willard C. The clinical scaphoid fracture: early computed tomography as a practical approach. *Ann R Coll Surg Engl*. 2008;90(6):488-91.
1215. Biondetti P, Vannier M, Gilula L, Knapp R. Wrist: coronal and transaxial CT scanning. *Radiology*. 1987;163(1):149-51.
1216. Pennes D, Jonsson K, Buckwalter K. Direct coronal CT of the scaphoid bone. *Radiology*. 1989;171(3):870-1.
1217. Clementson M, Jorgsholm P, Besjakov J, Bjorkman A, Thomsen N. Union of scaphoid waist fractures assessed by CT scan. *J Wrist Surg*. 2015;4(1):49-55.
1218. Hannemann PF, van Wezenbeek MR, Kolkman KA, et al. CT scan-evaluated outcome of pulsed electromagnetic fields in the treatment of acute scaphoid fractures: a randomised, multicentre, double-blind, placebo-controlled trial. *Bone Joint J*. 2014;96-B(8):1070-6.
1219. Cruickshank J, Meakin A, Breadmore R, et al. Early computerized tomography accurately determines the presence or absence of scaphoid and other fractures. *Emerg Med Australas*. 2007;19(3):223-8.
1220. Mallee W, Wang J, Poolman R, et al. Computed tomography versus magnetic resonance imaging versus bone scintigraphy for clinically suspected scaphoid fractures in patients with negative plain radiographs. *Cochrane Database Syst Rev*. 2015;6:CD010023.
1221. Stordahl A, Schjoth A, Woxholt G, Fjermeros H. Bone scanning of fractures of the scaphoid. *J Hand Surg Br*. 1984;9(2):189-90.
1222. Rolfe EB, Garvie NW, Khan MA, Ackery DM. Isotope bone imaging in suspected scaphoid trauma. *Br J Radiol*. 1981;54(645):762-7.
1223. Nielsen PT, Hedeboe J, Thommesen P. Bone scintigraphy in the evaluation of fracture of the carpal scaphoid bone. *Acta Orthop Scand*. 1983;54(2):303-6.

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1224. O'Carroll PF, Doyle J, Duffy G. Radiography and scintigraphy in the diagnosis of carpal scaphoid fractures. *Ir J Med Sci*. 1982;151(7):211-3.
1225. Beeres FJ, Hogervorst M, den Hollander P, Rhemrev S. Outcome of routine bone scintigraphy in suspected scaphoid fractures. *Injury*. 2005;36(10):1233-6.
1226. Beeres FJ, Hogervorst M, Rhemrev SJ, den Hollander P, Jukema GN. A prospective comparison for suspected scaphoid fractures: bone scintigraphy versus clinical outcome. *Injury*. 2007;38(7):769-74.
1227. Hiscox C, LaMothe J, White N, Bromley M, Oddone Paolucci E, Hildebrand K. Diagnosis of occult scaphoid fractures: a randomized, controlled trial comparing bone scans to radiographs for diagnosis. *CJEM*. 2014;16(4):296-303.
1228. Murphy DG, Eisenhauer MA, Powe J, Pavlofsky W. Can a day 4 bone scan accurately determine the presence or absence of scaphoid fracture? *Ann Emerg Med*. 1995;26(4):434-8.
1229. Symes TH, Stothard J. A systematic review of the treatment of acute fractures of the scaphoid. *J Hand Surg Eur Vol*. 2011;36(9):802-10.
1230. Dias J, Wildin C, Bhowal B, Thompson J. Should acute scaphoid fractures be fixed? *The Journal of Bone & Joint Surgery*. 2005;87(10):2160-8.
1231. Alshryda S, Shah A, Odak S, Al-Shryda J, Ilango B, Murali S. Acute fractures of the scaphoid bone: systematic review and meta-analysis. *the surgeon*. 2012;10(4):218-29.
1232. Hambidge J, Desai V, Schranz P, Compson J, Davis T, Barton N. Acute fractures of the scaphoid. Treatment by cast immobilisation with the wrist in flexion or extension? *J Bone Joint Surg Br*. 1999;81(1):91-2.
1233. Lawton JN, Nicholls MA, Charoglu CP. Immobilization for scaphoid fracture: forearm rotation in long arm thumb-spica versus Munster thumb-spica casts. *Orthopedics*. 2007;30(8):612-4.
1234. Clay NR, Dias JJ, Costigan PS, Gregg PJ, Barton NJ. Need the thumb be immobilised in scaphoid fractures? A randomised prospective trial. *J Bone Joint Surg Br*. 1991;73(5):828-32.
1235. Gellman H, Caputo R, Carter V, Aboulafia A, McKay M. Comparison of short and long thumb-spica casts for non-displaced fractures of the carpal scaphoid. *J Bone Joint Surg Am*. 1989;71(3):354-7.
1236. Saeden B, Tornkvist H, Ponzer S, Hoglund M. Fracture of the carpal scaphoid. A prospective, randomised 12-year follow-up comparing operative and conservative treatment. *J Bone Joint Surg Br*. 2001;83(2):230-4.
1237. Skirven T, Trope J. Complications of immobilization. *Hand Clin*. 1994;10(1):53-61.
1238. Schramm JM, Nguyen M, Wongworawat MD, Kjellin I. Does thumb immobilization contribute to scaphoid fracture stability? *Hand (N Y)*. 2008;3(1):41-3.
1239. Cohen AP, Shaw DL. Focused rigidity casting: a prospective randomised study. *J R Coll Surg Edinb*. 2001;46(5):265-70.
1240. London P. The broken scaphoid bone: the case against pessimism. *J Bone Joint Surg Br*. 1961;43(2):237-44.
1241. Sjolin SU, Andersen JC. Clinical fracture of the carpal scaphoid--supportive bandage or plaster cast immobilization? *J Hand Surg [Br]*. 1988;13(1):75-6.
1242. Gumucio CA, Fernando B, Young VL, Gilula LA, Kraemer BA. Management of scaphoid fractures: a review and update. *South Med J*. 1989;82(11):1377-88.
1243. Christodoulou AG, Colton CL. Scaphoid fractures in children. *J Pediatr Orthop*. 1986;6(1):37-9.
1244. Cooney WP, Dobyns JH, Linscheid RL. Fractures of the scaphoid: a rational approach to management. *Clin Orthop Relat Res*. 1980(149):90-7.
1245. Szabo RM, Manske D. Displaced fractures of the scaphoid. *Clin Orthop Relat Res*. 1988(230):30-8.
1246. Buijze GA, Goslings JC, Rhemrev SJ, et al. Cast immobilization with and without immobilization of the thumb for nondisplaced and minimally displaced scaphoid waist fractures: a multicenter, randomized, controlled trial. *J Hand Surg Am*. 2014;39(4):621-7.
1247. Dias JJ, Dhukaram V, Abhinav A, Bhowal B, Wildin CJ. Clinical and radiological outcome of cast immobilisation versus surgical treatment of acute scaphoid fractures at a mean follow-up of 93 months. *J Bone Joint Surg Br*. 2008;90(7):899-905.
1248. Adolfsson L, Lindau T, Arner M. Acutrak screw fixation versus cast immobilisation for undisplaced scaphoid waist fractures. *J Hand Surg [Br]*. 2001;26(3):192-5.
1249. Bond CD, Shin AY, McBride MT, Dao KD. Percutaneous screw fixation or cast immobilization for nondisplaced scaphoid fractures. *J Bone Joint Surg Am*. 2001;83-A(4):483-8.
1250. Dias JJ, Wildin CJ, Bhowal B, Thompson JR. Should acute scaphoid fractures be fixed? A randomized controlled trial. *J Bone Joint Surg Am*. 2005;87(10):2160-8.
1251. Toby EB, Butler TE, McCormack TJ, Jayaraman G. A comparison of fixation screws for the scaphoid during application of cyclical bending loads. *J Bone Joint Surg Am*. 1997;79(8):1190-7.
1252. Vinnars B, Ekenstam FA, Gerdin B. Comparison of direct and indirect costs of internal fixation and cast treatment in acute scaphoid fractures: a randomized trial involving 52 patients. *Acta Orthop*. 2007;78(5):672-9.

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1253. Braga-Silva J, Peruchi FM, Moschen GM, Gehlen D, Padoin AV. A comparison of the use of distal radius vascularised bone graft and non-vascularised iliac crest bone graft in the treatment of non-union of scaphoid fractures. *J Hand Surg Eur Vol*. 2008;33(5):636-40.
1254. Caporrino FA, Dos Santos JB, Penteado FT, de Moraes VY, Belloti JC, Faloppa F. Dorsal vascularized grafting for scaphoid nonunion: a comparison of two surgical techniques. *J Orthop Trauma*. 2014;28(3):e44-8.
1255. Garg B, Goyal T, Kotwal P, Sankineani S, Tripathy S. Local distal radius bone graft versus iliac crest bone graft for scaphoid nonunion: a comparative study. *Musculoskeletal Surg*. 2013;97(2):109-14.
1256. Raju PK, Kini SG. Fixation techniques for non-union of the scaphoid. *J Orthop Surg (Hong Kong)*. 2011;19(1):80-4.
1257. Ribak S, Medina CE, Mattar R, Jr., Ulson HJ, Ulson HJ, Etchebehere M. Treatment of scaphoid nonunion with vascularised and nonvascularised dorsal bone grafting from the distal radius. *Int Orthop*. 2010;34(5):683-8.
1258. Drac P, Cizmar I, Manak P, et al. Comparison of the results and complications of palmar and dorsal miniinvasive approaches in the surgery of scaphoid fractures. A prospective randomized study. *Biomed Pap Med Fac Univ Palacky Olomouc Czech Repub*. 2014;158(2):277-81.
1259. Jeon IH, Micic ID, Oh CW, Park BC, Kim PT. Percutaneous screw fixation for scaphoid fracture: a comparison between the dorsal and the volar approaches. *J Hand Surg Am*. 2009;34(2):228-36 e1.
1260. Parvizi J, Vegari D. Pulsed low-intensity ultrasound for fracture healing. *Foot Ankle Clin*. 2005;10(4):595-608, vii.
1261. Pounder NM, Harrison AJ. Low intensity pulsed ultrasound for fracture healing: a review of the clinical evidence and the associated biological mechanism of action. *Ultrasonics*. 2008;48(4):330-8.
1262. Riboh JC, Leversedge FJ. The use of low-intensity pulsed ultrasound bone stimulators for fractures of the hand and upper extremity. *J Hand Surg Am*. 2012;37(7):1456-61.
1263. Rubin C, Bolander M, Ryaby JP, Hadjiargyrou M. The use of low-intensity ultrasound to accelerate the healing of fractures. *J Bone Joint Surg Am*. 2001;83-A(2):259-70.
1264. Siska PA, Gruen GS, Pape HC. External adjuncts to enhance fracture healing: what is the role of ultrasound? *Injury*. 2008;39(10):1095-105.
1265. Barry M. Low intensity pulsed ultrasound (LIPUS) for promoting fracture healing. Evidence-based Review. *ACC Research: Evidence-Based Healthcare Review*. 20151-37.
1266. Nelson FR, Brighton CT, Ryaby J, et al. Use of physical forces in bone healing. *J Am Acad Orthop Surg*. 2003;11(5):344-54.
1267. Smoljanovic T, Grgurevic L, Jelic M, et al. Regeneration of the skeleton by recombinant human bone morphogenetic proteins. *Coll Antropol*. 2007;31(3):923-32.
1268. Virk MS, Lieberman JR. Biologic adjuvants for fracture healing. *Arthritis Res Ther*. 2012;14(6):225.
1269. Griffin XL, Smith N, Parsons N, Costa ML. Ultrasound and shockwave therapy for acute fractures in adults. *Cochrane Database Syst Rev*. 2012(2):CD008579.
1270. Ricardo M. The effect of ultrasound on the healing of muscle-pediculated bone graft in scaphoid non-union. *Int Orthop*. 2006;30(2):123-7.
1271. Bilic R, Simic P, Jelic M, et al. Osteogenic protein-1 (BMP-7) accelerates healing of scaphoid non-union with proximal pole sclerosis. *Int Orthop*. 2006;30(2):128-34.
1272. Batrick N, Hashemi K, Freij R. Treatment of uncomplicated subungual haematoma. *Emerg Med J*. 2003;20(1):65.
1273. Bonisteel PS. Practice tips. Trephining subungual hematomas. *Can Fam Physician*. 2008;54(5):693.
1274. Brown RE. Acute nail bed injuries. *Hand Clin*. 2002;18(4):561-75.
1275. Farrington GH. Subungual Haematoma--an Evaluation of Treatment. *Br Med J*. 1964;1(5385):742-4.
1276. Hart RG, Kleinert HE. Fingertip and nail bed injuries. *Emerg Med Clin North Am*. 1993;11(3):755-65.
1277. Meek S, White M. Subungual haematomas: is simple trephining enough? *J Accid Emerg Med*. 1998;15(4):269-71.
1278. Newmeyer WL, Kilgore ES, Jr. Common injuries of the fingernail and nail bed. *Am Fam Physician*. 1977;16(4):93-5.
1279. Palamarchuk HJ, Kerzner M. An improved approach to evacuation of subungual hematoma. *J Am Podiatr Med Assoc*. 1989;79(11):566-8.
1280. Roser SE, Gellman H. Comparison of nail bed repair versus nail trephination for subungual hematomas in children. *J Hand Surg Am*. 1999;24(6):1166-70.
1281. Salter SA, Ciocon DH, Gowrishankar TR, Kimball AB. Controlled nail trephination for subungual hematoma. *Am J Emerg Med*. 2006;24(7):875-7.
1282. Wang QC, Johnson BA. Fingertip injuries. *Am Fam Physician*. 2001;63(10):1961-6.
1283. Dean B, Becker G, Little C. The management of the acute traumatic subungual haematoma: a systematic review. *Hand Surg*. 2012;17(1):151-4.

Copyright© 2016 Reed Group, Ltd.

1284. Ciocon D, Gowrishankar TR, Herndon T, Kimball AB. How low should you go: novel device for nail trephination. *Dermatol Surg*. 2006;32(6):828-33.
1285. Kaya TI, Tursen U, Baz K, Ikizoglu G. Extra-fine insulin syringe needle: an excellent instrument for the evacuation of subungual hematoma. *Dermatol Surg*. 2003;29(11):1141-3.
1286. Suprock MD, Hood JM, Lubahn JD. Role of antibiotics in open fractures of the finger. *J Hand Surg Am*. 1990;15(5):761-4.
1287. Stevenson J, McNaughton G, Riley J. The use of prophylactic flucloxacillin in treatment of open fractures of the distal phalanx within an accident and emergency department: a double-blind randomized placebo-controlled trial. *J Hand Surg Br*. 2003;28(5):388-94.
1288. Sloan JP, Dove AF, Maheson M, Cope AN, Welsh KR. Antibiotics in open fractures of the distal phalanx? *J Hand Surg Br*. 1987;12(1):123-4.
1289. Centers for Disease Control and Prevention. The pre-travel consultation. Routine vaccine-preventable diseases. 2009. wwwn.cdc.gov/travel/yellowbook/2010/chapter-2/tetanus.aspx.
1290. Hardy MA. Principles of metacarpal and phalangeal fracture management: a review of rehabilitation concepts. *J Orthop Sports Phys Ther*. 2004;34(12):781-99.
1291. Chalmer J, Blakeway M, Adams Z, Milan SJ. Conservative interventions for treating hyperextension injuries of the proximal interphalangeal joints of the fingers. *Cochrane Database Syst Rev*. 2013(2):CD009030.
1292. DaCruz DJ, Slade RJ, Malone W. Fractures of the distal phalanges. *J Hand Surg Br*. 1988;13(3):350-2.
1293. Carpenter S, Rohde RS. Treatment of phalangeal fractures. *Hand Clin*. 2013;29(4):519-34.
1294. Baratz ME, Divelbiss B. Fixation of phalangeal fractures. *Hand Clin*. 1997;13(4):541-55.
1295. Knoop K, Trott A, Syverud S. Comparison of digital versus metacarpal blocks for repair of finger injuries. *Ann Emerg Med*. 1994;23(6):1296-300.
1296. Williams JG, Lalonde DH. Randomized comparison of the single-injection volar subcutaneous block and the two-injection dorsal block for digital anesthesia. *Plast Reconstr Surg*. 2006;118(5):1195-200.
1297. Yin ZG, Zhang JB, Kan SL, Wang P. A comparison of traditional digital blocks and single subcutaneous palmar injection blocks at the base of the finger and a meta-analysis of the digital block trials. *J Hand Surg [Br]*. 2006;31(5):547-55.
1298. Cummings AJ, Tisol WB, Meyer LE. Modified transthecal digital block versus traditional digital block for anesthesia of the finger. *J Hand Surg Am*. 2004;29(1):44-8.
1299. Hill RG, Jr., Patterson JW, Parker JC, Bauer J, Wright E, Heller MB. Comparison of transthecal digital block and traditional digital block for anesthesia of the finger. *Ann Emerg Med*. 1995;25(5):604-7.
1300. Keramidas EG, Rodopoulou SG, Tsoutsos D, Miller G, Ioannovich J. Comparison of transthecal digital block and traditional digital block for anesthesia of the finger. *Plast Reconstr Surg*. 2004;114(5):1131-4; discussion 5-6.
1301. Low CK, Vartany A, Engstrom JW, Poncelet A, Diao E. Comparison of transthecal and subcutaneous single-injection digital block techniques. *J Hand Surg Am*. 1997;22(5):901-5.
1302. Low CK, Wong HP, Low YP. Comparison between single injection transthecal and subcutaneous digital blocks. *J Hand Surg Br*. 1997;22(5):582-4.
1303. Maitra A, Burdett-Smith P. The conservative management of proximal phalangeal fractures of the hand in an accident and emergency department. *J Hand Surg Br*. 1992;17(3):332-6.
1304. Papaloizos MY, Le Moine P, Prues-Latour V, Borisch N, Della Santa DR. Proximal fractures of the fifth metacarpal: a retrospective analysis of 25 operated cases. *J Hand Surg Br*. 2000;25(3):253-7.
1305. McKerrell J, Bowen V, Johnston G, Zondervan J. Boxer's fractures--conservative or operative management? *J Trauma*. 1987;27(5):486-90.
1306. Braakman M, Oderwald EE, Haentjens MH. Functional taping of fractures of the 5th metacarpal results in a quicker recovery. *Injury*. 1998;29(1):5-9.
1307. Harding IJ, Parry D, Barrington RL. The use of a moulded metacarpal brace versus neighbour strapping for fractures of the little finger metacarpal neck. *J Hand Surg [Br]*. 2001;26(3):261-3.
1308. Kuokkanen HO, Mulari-Keranen SK, Niskanen RO, Haapala JK, Korkala OL. Treatment of subcapital fractures of the fifth metacarpal bone: a prospective randomised comparison between functional treatment and reposition and splinting. *Scand J Plast Reconstr Surg Hand Surg*. 1999;33(3):315-7.
1309. Statius Muller MG, Poolman RW, van Hoogstraten MJ, Steller EP. Immediate mobilization gives good results in boxer's fractures with volar angulation up to 70 degrees: a prospective randomized trial comparing immediate mobilization with cast immobilization. *Arch Orthop Trauma Surg*. 2003;123(10):534-7.
1310. Hofmeister EP, Kim J, Shin AY. Comparison of 2 methods of immobilization of fifth metacarpal neck fractures: a prospective randomized study. *J Hand Surg Am*. 2008;33(8):1362-8.
1311. Kim JK, Kim DJ. Antegrade intramedullary pinning versus retrograde intramedullary pinning for displaced fifth metacarpal neck fractures. *Clin Orthop Relat Res*. 2015;473(5):1747-54.

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1312. Konradsen L, Nielsen PT, Albrecht-Beste E. Functional treatment of metacarpal fractures 100 randomized cases with or without fixation. *Acta Orthop Scand*. 1990;61(6):531-4.
1313. Krukhaug Y, Ugland S, Lie SA, Hove LM. External fixation of fractures of the distal radius: a randomized comparison of the Hoffman compact II non-bridging fixator and the Dynawrist fixator in 75 patients followed for 1 year. *Acta Orthop*. 2009;80(1):104-8.
1314. McMahon PJ, Woods DA, Burge PD. Initial treatment of closed metacarpal fractures. A controlled comparison of compression glove and splintage. *J Hand Surg Br*. 1994;19(5):597-600.
1315. Randall T, Portney L, Harris BA. Effects of joint mobilization on joint stiffness and active motion of the metacarpal-phalangeal joint. *J Orthop Sports Phys Ther*. 1992;16(1):30-6.
1316. Winter M, Balaguer T, Bessiere C, Carles M, Lebreton E. Surgical treatment of the boxer's fracture: transverse pinning versus intramedullary pinning. *J Hand Surg Eur Vol*. 2007;32(6):709-13.
1317. Poolman RW, Goslings JC, Lee JB, Statius Muller M, Steller EP, Struijs PA. Conservative treatment for closed fifth (small finger) metacarpal neck fractures. *Cochrane Database Syst Rev*. 2005(3):CD003210.
1318. Arafa M, Haines J, Noble J, Carden D. Immediate mobilization of fractures of the neck of the fifth metacarpal. *Injury*. 1986;17(4):277-8.
1319. Breddam M, Hansen TB. Subcapital fractures of the fourth and fifth metacarpals treated without splinting and reposition. *Scand J Plast Reconstr Surg Hand Surg*. 1995;29(3):269-70.
1320. Ford DJ, Ali MS, Steel WM. Fractures of the fifth metacarpal neck: is reduction or immobilisation necessary? *J Hand Surg Br*. 1989;14(2):165-7.
1321. Jones AR. Reduction of angulated metacarpal fractures with a custom fracture-brace. *J South Orthop Assoc*. 1995;4(4):269-76.
1322. Trabelsi A, Dusserre F, Asencio G, Bertin R. Orthopedic treatment of fifth metacarpal neck fractures: prospective study. *Chir Main*. 2001;20(3):226-30.
1323. Toronto R, Donovan PJ, Macintyre J. An alternative method of treatment for metacarpal fractures in athletes. *Clin J Sport Med*. 1996;6(1):4-8.
1324. Kanatli U, Kazimoglu C, Ugurlu M, Esen E. Evaluation of functional results in conservatively treated boxer's fractures. *Acta Orthop Traumatol Turc*. 2002;36(5):429-31.
1325. Kjaer-Petersen K, Jurik AG, Petersen LK. Intra-articular fractures at the base of the fifth metacarpal. A clinical and radiographical study of 64 cases. *J Hand Surg Br*. 1992;17(2):144-7.
1326. Horton TC, Hatton M, Davis TR. A prospective randomized controlled study of fixation of long oblique and spiral shaft fractures of the proximal phalanx: closed reduction and percutaneous Kirschner wiring versus open reduction and lag screw fixation. *J Hand Surg Br*. 2003;28(1):5-9.
1327. Sletten IN, Hellund JC, Olsen B, Clementsen S, Kvernmo HD, Nordsletten L. Conservative treatment has comparable outcome with bouquet pinning of little finger metacarpal neck fractures: a multicentre randomized controlled study of 85 patients. *J Hand Surg Eur Vol*. 2015;40(1):76-83.
1328. Hansen FV, Staunstrup H, Mikkelsen S. A comparison of 3 and 5 weeks immobilization for older type 1 and 2 Colles' fractures. *Journal of Hand Surgery (British and European Volume)*. 1998;23(3):400-1.
1329. Sorensen JS, Freund KG, Kejla G. Functional fracture bracing in metacarpal fractures: the Galveston metacarpal brace versus a plaster-of-Paris bandage in a prospective study. *J Hand Ther*. 1993;6(4):263-5.
1330. Strub B, Schindele S, Sonderegger J, Sproedt J, von Campe A, Gruenert JG. Intramedullary splinting or conservative treatment for displaced fractures of the little finger metacarpal neck? A prospective study. *J Hand Surg Eur Vol*. 2010;35(9):725-9.
1331. Braakman M, Verburg AD, Oderwald EE. Are routine radiographs during conservative treatment of fractures of the fourth and fifth metacarpals useful? *Acta Orthop Belg*. 1996;62(3):151-5.
1332. Saunders SR. Physical therapy management of hand fractures. *Phys Ther*. 1989;69(12):1065-76.
1333. Freeland A. *Hand fractures: repair, reconstruction, and rehabilitation*: Churchill Livingstone; 2000.
1334. Eccles MV. Hand volumetrics. *Br J Phys Med*. 1956;19(1):5-8.
1335. Feehan LM, Bassett K. Is there evidence for early mobilization following an extraarticular hand fracture? *J Hand Ther*. 2004;17(2):300-8.
1336. Bombaci H, Polat A, Deniz G, Akinci O. The value of plain X-rays in predicting TFCC injury after distal radial fractures. *J Hand Surg Eur Vol*. 2008;33(3):322-6.
1337. Metz VM, Gilula LA. Imaging techniques for distal radius fractures and related injuries. *Orthop Clin North Am*. 1993;24(2):217-28.
1338. Spence LD, Savenor A, Nwachuku I, Tilsley J, Eustace S. MRI of fractures of the distal radius: comparison with conventional radiographs. *Skeletal Radiol*. 1998;27(5):244-9.
1339. Harness NG, Ring D, Zurakowski D, Harris GJ, Jupiter JB. The influence of three-dimensional computed tomography reconstructions on the characterization and treatment of distal radial fractures. *J Bone Joint Surg Am*. 2006;88(6):1315-23.

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1340. Catalano LW, 3rd, Barron OA, Glickel SZ. Assessment of articular displacement of distal radius fractures. *Clin Orthop Relat Res*. 2004(423):79-84.
1341. Katz MA, Beredjiklian PK, Bozentka DJ, Steinberg DR. Computed tomography scanning of intra-articular distal radius fractures: does it influence treatment? *J Hand Surg Am*. 2001;26(3):415-21.
1342. Avery DM, 3rd, Matullo KS. Distal radial traction radiographs: interobserver and intraobserver reliability compared with computed tomography. *J Bone Joint Surg Am*. 2014;96(7):582-8.
1343. Johnston GH, Friedman L, Kriegler JC. Computerized tomographic evaluation of acute distal radial fractures. *J Hand Surg Am*. 1992;17(4):738-44.
1344. Adolphson P, Abbaszadegan H, Jonsson U, Dalen N, Sjoberg HE, Kalen S. No effects of piroxicam on osteopenia and recovery after Colles' fracture. A randomized, double-blind, placebo-controlled, prospective trial. *Arch Orthop Trauma Surg*. 1993;112(3):127-30.
1345. Barrington R. Single-blind study of diflunisal versus mefenamic acid in the treatment of pain after Colles' fracture. *Curr Med Res Opin*. 1980;6(9):630-3.
1346. Davis TR, Ackroyd CE. Non-steroidal anti-inflammatory agents in the management of Colles' fractures. *Br J Clin Pract*. 1988;42(5):184-9.
1347. Thomas AP, Brooks S. The use of an oral prostaglandin inhibitor following splintage in fractures of the distal radius--a prospective trial. *Injury*. 1986;17(3):179-81.
1348. Christensen OM, Christiansen TG, Krasheninnikoff M, Hansen FF. Length of immobilisation after fractures of the distal radius. *Int Orthop*. 1995;19(1):26-9.
1349. Davis TR, Buchanan JM. A controlled prospective study of early mobilization of minimally displaced fractures of the distal radial metaphysis. *Injury*. 1987;18(4):283-5.
1350. Dias JJ, Wray CC, Jones JM, Gregg PJ. The value of early mobilisation in the treatment of Colles' fractures. *J Bone Joint Surg Br*. 1987;69(3):463-7.
1351. McAuliffe TB, Hilliar KM, Coates CJ, Grange WJ. Early mobilisation of Colles' fractures. A prospective trial. *J Bone Joint Surg Br*. 1987;69(5):727-9.
1352. Millett PJ, Rushton N. Early mobilization in the treatment of Colles' fracture: a 3 year prospective study. *Injury*. 1995;26(10):671-5.
1353. Vang Hansen F, Staunstrup H, Mikkelsen S. A comparison of 3 and 5 weeks immobilization for older type 1 and 2 Colles' fractures. *J Hand Surg [Br]*. 1998;23(3):400-1.
1354. Earnshaw SA, Aladin A, Surendran S, Moran CG. Closed reduction of colles fractures: comparison of manual manipulation and finger-trap traction: a prospective, randomized study. *J Bone Joint Surg Am*. 2002;84-A(3):354-8.
1355. Lagerstrom C, Nordgren B, Olerud C. Evaluation of grip strength measurements after Colles' fracture: a methodological study. *Scand J Rehabil Med*. 1999;31(1):49-54.
1356. Lagerstrom C, Nordgren B, Rahme H. Recovery of isometric grip strength after Colles' fracture: a prospective two-year study. *Scand J Rehabil Med*. 1999;31(1):55-62.
1357. Abbaszadegan H, Conradi P, Jonsson U. Fixation not needed for undisplaced Codes' fracture. *Acta Orthop*. 1989;60(1):60-2.
1358. Ledingham WM, Wytch R, Goring CC, Mathieson AB, Wardlaw D. On immediate functional bracing of Colles' fracture. *Injury*. 1991;22(3):197-201.
1359. Moir J, Murali S, Ashcroft G, Wardlaw D, Matheson A. A new functional brace for the treatment of Colles' fractures. *Injury*. 1995;26(9):587-93.
1360. O'Connor D, Mullett H, Doyle M, Mofidi A, Kutty S, O'Sullivan M. Minimally displaced Colles' fractures: a prospective randomized trial of treatment with a wrist splint or a plaster cast. *J Hand Surg [Br]*. 2003;28(1):50-3.
1361. Stewart HD, Innes AR, Burke FD. Functional cast-bracing for Colles' fractures. A comparison between cast-bracing and conventional plaster casts. *J Bone Joint Surg Br*. 1984;66(5):749-53.
1362. Wilson C, Venner RM. Colles' fracture. Immobilisation in pronation or supination? *J R Coll Surg Edinb*. 1984;29(2):109-11.
1363. Cohen MS, Frillman T. Distal radius fractures: a prospective randomized comparison of fibreglass tape with QuickCast. *Injury*. 1997;28(4):305-9.
1364. Grafstein E, Stenstrom R, Christenson J, et al. A prospective randomized controlled trial comparing circumferential casting and splinting in displaced Colles fractures. *CJEM*. 2010;12(3):192-200.
1365. Moroni A, Vannini F, Faldini C, Pegreffi F, Giannini S. Cast vs external fixation: a comparative study in elderly osteoporotic distal radial fracture patients. *Scand J Surg*. 2004;93(1):64-7.
1366. Wong TC, Chiu Y, Tsang WL, Leung WY, Yam SK, Yeung SH. Casting versus percutaneous pinning for extra-articular fractures of the distal radius in an elderly Chinese population: a prospective randomised controlled trial. *J Hand Surg Eur Vol*. 2010;35(3):202-8.

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1367. Arora R, Lutz M, Deml C, Krappinger D, Haug L, Gabl M. A prospective randomized trial comparing nonoperative treatment with volar locking plate fixation for displaced and unstable distal radial fractures in patients sixty-five years of age and older. *J Bone Joint Surg Am*. 2011;93(23):2146-53.
1368. Bong MR, Egol KA, Leibman M, Koval KJ. A comparison of immediate postreduction splinting constructs for controlling initial displacement of fractures of the distal radius: a prospective randomized study of long-arm versus short-arm splinting. *J Hand Surg Am*. 2006;31(5):766-70.
1369. Bunger C, Solund K, Rasmussen P. Early results after Colles' fracture: functional bracing in supination vs dorsal plaster immobilization. *Arch Orthop Trauma Surg*. 1984;103(4):251-6.
1370. Gupta A. The treatment of Colles' fracture. Immobilisation with the wrist dorsiflexed. *J Bone Joint Surg Br*. 1991;73(2):312-5.
1371. Rosetzsky A. Colles' fractures treated by plaster and polyurethane braces: a controlled clinical study. *J Trauma*. 1982;22(11):910-3.
1372. Sarmiento A, Zagorski JB, Sinclair WF. Functional bracing of Colles' fractures: a prospective study of immobilization in supination vs. pronation. *Clin Orthop Relat Res*. 1980(146):175-83.
1373. Tumia N, Wardlaw D, Hallett J, Deutman R, Mattsson SA, Sanden B. Aberdeen Colles' fracture brace as a treatment for Colles' fracture. A multicentre, prospective, randomised, controlled trial. *J Bone Joint Surg Br*. 2003;85(1):78-82.
1374. Wahlstrom O. Treatment of Colles' fracture. A prospective comparison of three different positions of immobilization. *Acta Orthop Scand*. 1982;53(2):225-8.
1375. Wik TS, Aurstad AT, Finsen V. Colles' fracture: dorsal splint or complete cast during the first 10 days? *Injury*. 2009;40(4):400-4.
1376. Uzzaman K, Awal K, Alam M. Closed reduction and percutaneous Kirschner wire fixation combined with plaster cast versus conventional plaster cast immobilization in the treatment of Colles' fracture - a prospective randomized comparative study. *J Dhaka Med College*. 2008;17(2).
1377. Ismatullah. Efficacy of plaster casting versus external fixation in comminuted distal radius fractures. *J Postgrad Med Inst*. 2012;26(3):311-6.
1378. Gupta H. A randomized controlled trial comparing results of closed reduction and plaster immobilization versus external fixator in unstable fractures of distal radius. *J College of Med Sci*. 2011;7(4).
1379. Kongsholm J, Olerud C. Reduction of Colles' fractures without anaesthesia using a new dynamic bone alignment system. *Injury*. 1987;18(2):133-6.
1380. Kongsholm J, Olerud C. Neurological complications of dynamic reduction of Colles' fractures without anesthesia compared with traditional manipulation after local infiltration anesthesia. *J Orthop Trauma*. 1987;1(1):43-7.
1381. Kelly A, Warwick D, Crichlow T, Bannister G. Is manipulation of moderately displaced Colles' fracture worthwhile? A prospective randomized trial. *Injury*. 1997;28(4):283-7.
1382. van der Linden W, R. Ericson. Colles' fracture. How should its displacement be measured and how should it be immobilized? *J Bone Joint Surg Am*. 1981;63(8):1285-8.
1383. Cobb AG, Houghton GR. Local anaesthetic infiltration versus Bier's block for Colles' fractures. *Br Med J (Clin Res Ed)*. 1985;291(6510):1683-4.
1384. Kendall JM, Allen P, Younge P, Meek SM, McCabe SE. Haematoma block or Bier's block for Colles' fracture reduction in the accident and emergency department--which is best? *J Accid Emerg Med*. 1997;14(6):352-6.
1385. Abbaszadegan H, Jonsson U. Regional anesthesia preferable for Colles' fracture. Controlled comparison with local anesthesia. *Acta Orthop Scand*. 1990;61(4):348-9.
1386. Singh G, Manglik R, et al. Analgesia for the reduction of Colles fracture. A comparison of hematoma block and intravenous sedation. *Online J Curr Clin Trials*. 1992;Doc No 23.
1387. Haasio J. Cubital nerve block vs haematoma block for the manipulation of Colles' fracture. *Ann Chir Gynaecol*. 1990;79(3):168-71.
1388. Fathi M, Moezzi M, Abbasi S, Farsi D, Zare MA, Hafezimoghadam P. Ultrasound-guided hematoma block in distal radial fracture reduction: a randomised clinical trial. *Emerg Med J*. 2015;32(6):474-7.
1389. Wahlstrom O. Stimulation of fracture healing with electromagnetic fields of extremely low frequency (EMF of ELF). *Clin Orthop Relat Res*. 1984(186):293-301.
1390. Cheing GL, Wan JW, Kai Lo S. Ice and pulsed electromagnetic field to reduce pain and swelling after distal radius fractures. *J Rehabil Med*. 2005;37(6):372-7.
1391. Lazovic M, Kocic M, Dimitrijevic L, Stankovic I, Spalevic M, Ciric T. Pulsed electromagnetic field during cast immobilization in postmenopausal women with Colles' fracture. *Srp Arh Celok Lek*. 2012;140(9-10):619-24.
1392. Christensen OM, Kunov A, Hansen FF, Christiansen TC, Krasheninnikoff M. Occupational therapy and Colles' fractures. *Int Orthop*. 2001;25(1):43-5.

Copyright© 2016 Reed Group, Ltd.

1393. Watt CF, Taylor NF, Baskus K. Do Colles' fracture patients benefit from routine referral to physiotherapy following cast removal? *Arch Orthop Trauma Surg*. 2000;120(7-8):413-5.
1394. Pasila M, Karaharju EO, Lepisto PV. Role of physical therapy in recovery of function after Colles' fracture. *Arch Phys Med Rehabil*. 1974;55(3):130-4.
1395. Oskarsson GV, A. Hjall, et al. Physiotherapy: an overestimated factor in after-treatment of fractures in the distal radius? *Arch Orthop Trauma Surg*. 1997;116373-5.
1396. Filipova V, Lonzaric D, Jesensek Papez B. Efficacy of combined physical and occupational therapy in patients with conservatively treated distal radius fracture: randomized controlled trial. *Wien Klin Wochenschr*. 2015;127 Suppl 5282-7.
1397. Kay S, Haensel N, Stiller K. The effect of passive mobilisation following fractures involving the distal radius: a randomised study. *Aust J Physiother*. 2000;46(2):93-101.
1398. Wakefield AE, McQueen MM. The role of physiotherapy and clinical predictors of outcome after fracture of the distal radius. *J Bone Joint Surg Br*. 2000;82(7):972-6.
1399. Kay S, McMahon M, Stiller K. An advice and exercise program has some benefits over natural recovery after distal radius fracture: a randomised trial. *Aust J Physiother*. 2008;54(4):253-9.
1400. Valdes K, Naughton N, Burke CJ. Therapist-supervised hand therapy versus home therapy with therapist instruction following distal radius fracture. *J Hand Surg Am*. 2015;40(6):1110-6 e1.
1401. Magnus CR, Arnold CM, Johnston G, et al. Cross-education for improving strength and mobility after distal radius fractures: a randomized controlled trial. *Arch Phys Med Rehabil*. 2013;94(7):1247-55.
1402. Pring DJ, Barber L, Williams DJ. Bipolar fixation of fractures of the distal end of the radius: a comparative study. *Injury*. 1988;19(3):145-8.
1403. Young CF, Nanu AM, Checketts RG. Seven-year outcome following Colles' type distal radial fracture. A comparison of two treatment methods. *J Hand Surg [Br]*. 2003;28(5):422-6.
1404. Kreder HJ, Agel J, McKee MD, Schemitsch EH, Stephen D, Hanel DP. A randomized, controlled trial of distal radius fractures with metaphyseal displacement but without joint incongruity: closed reduction and casting versus closed reduction, spanning external fixation, and optional percutaneous K-wires. *J Orthop Trauma*. 2006;20(2):115-21.
1405. McQueen MM, Hajducka C, Court-Brown CM. Redisplaced unstable fractures of the distal radius: a prospective randomised comparison of four methods of treatment. *J Bone Joint Surg Br*. 1996;78(3):404-9.
1406. Merchan EC, Breton AF, Galindo E, Peinado JF, Beltran J. Plaster cast versus Clyburn external fixation for fractures of the distal radius in patients under 45 years of age. *Orthop Rev*. 1992;21(10):1203-9.
1407. Howard PW, Stewart HD, Hind RE, Burke FD. External fixation or plaster for severely displaced comminuted Colles' fractures? A prospective study of anatomical and functional results. *J Bone Joint Surg Br*. 1989;71(1):68-73.
1408. Jenkins N, Jones D, Mintowt-Czyz W. External fixation and recovery of function following fractures of the distal radius in young adults. *Injury*. 1988;19(4):235-8.
1409. Jenkins NH, Jones DG, Johnson SR, Mintowt-Czyz WJ. External fixation of Colles' fractures. An anatomical study. *J Bone Joint Surg Br*. 1987;69(2):207-11.
1410. Kapoor H, Agarwal A, Dhaon BK. Displaced intra-articular fractures of distal radius: a comparative evaluation of results following closed reduction, external fixation and open reduction with internal fixation. *Injury*. 2000;31(2):75-9.
1411. Stein H, Volpin G, Horesh Z, Hoerer D. Cast or external fixation for fracture of the distal radius: a prospective study of 126 cases. *Acta Orthop*. 1990;61(5):453-6.
1412. Abbaszadegan H, Jonsson U. External fixation or plaster cast for severely displaced Colles' fractures? Prospective 1-year study of 46 patients. *Acta Orthop Scand*. 1990;61(6):528-30.
1413. Roumen RM, Hesp WL, Bruggink ED. Unstable Colles' fractures in elderly patients. A randomised trial of external fixation for redisplacement. *J Bone Joint Surg Br*. 1991;73(2):307-11.
1414. Ludvigsen TC, Johansen S, Svenningsen S, Saetermo R. External fixation versus percutaneous pinning for unstable Colles' fracture. Equal outcome in a randomized study of 60 patients. *Acta Orthop Scand*. 1997;68(3):255-8.
1415. Pritchett JW. External fixation or closed medullary pinning for unstable Colles fractures? *J Bone Joint Surg Br*. 1995;77(2):267-9.
1416. Strohm PC, Muller CA, Boll T, Pfister U. Two procedures for Kirschner wire osteosynthesis of distal radial fractures. A randomized trial. *J Bone Joint Surg Am*. 2004;86-A(12):2621-8.
1417. Allain J, le Guilloux P, Le Mouel S, Goutallier D. Trans-styloid fixation of fractures of the distal radius. A prospective randomized comparison between 6- and 1-week postoperative immobilization in 60 fractures. *Acta Orthop Scand*. 1999;70(2):119-23.
1418. Sanchez-Sotelo J, Munuera L, Madero R. Treatment of fractures of the distal radius with a remodellable bone cement: a prospective, randomised study using Norian SRS. *J Bone Joint Surg Br*. 2000;82(6):856-63.

Copyright© 2016 Reed Group, Ltd.

1419. Schmalholz A. Bone cement for redislocated Colles' fracture. A prospective comparison with closed treatment. *Acta Orthop Scand*. 1989;60(2):212-7.
1420. Kopylov P, Runnqvist K, Jonsson K, Aspenberg P. Norian SRS versus external fixation in redisplaced distal radial fractures. A randomized study in 40 patients. *Acta Orthop Scand*. 1999;70(1):1-5.
1421. Schmalholz A. External skeletal fixation versus cement fixation in the treatment of redislocated Colles' fracture. *Clin Orthop Relat Res*. 1990(254):236-41.
1422. Kopylov P, Aspenberg P, Yuan X, Ryd L. Radiostereometric analysis of distal radial fracture displacement during treatment: a randomized study comparing Norian SRS and external fixation in 23 patients. *Acta Orthop Scand*. 2001;72(1):57-61.
1423. Ekenstam Fa, Jakobsson OP, Wadin K. Repair of the triangular ligament in Colles' fracture: no effect in a prospective randomized study. *Acta Orthop*. 1989;60(4):393-6.
1424. Hahnloser D, Platz A, Amgwerd M, Trentz O. Internal fixation of distal radius fractures with dorsal dislocation: pi-plate or two 1/4 tube plates? A prospective randomized study. *J Trauma*. 1999;47(4):760-5.
1425. Abramo A, Kopylov P, Geijer M, Tagil M. Open reduction and internal fixation compared to closed reduction and external fixation in distal radial fractures: a randomized study of 50 patients. *Acta Orthop*. 2009;80(4):478-85.
1426. Atroshi I, Brogren E, Larsson GU, Kloow J, Hofer M, Berggren AM. Wrist-bridging versus non-bridging external fixation for displaced distal radius fractures: a randomized assessor-blind clinical trial of 38 patients followed for 1 year. *Acta Orthop*. 2006;77(3):445-53.
1427. Cassidy C, Jupiter JB, Cohen M, et al. Norian SRS cement compared with conventional fixation in distal radial fractures. A randomized study. *J Bone Joint Surg Am*. 2003;85-A(11):2127-37.
1428. Egol K, Walsh M, Tejwani N, McLaurin T, Wynn C, Paksima N. Bridging external fixation and supplementary Kirschner-wire fixation versus volar locked plating for unstable fractures of the distal radius: a randomised, prospective trial. *J Bone Joint Surg Br*. 2008;90(9):1214-21.
1429. Grewal R, MacDermid JC, King GJ, Faber KJ. Open reduction internal fixation versus percutaneous pinning with external fixation of distal radius fractures: a prospective, randomized clinical trial. *J Hand Surg Am*. 2011;36(12):1899-906.
1430. Grewal R, Perey B, Wilmink M, Stothers K. A randomized prospective study on the treatment of intra-articular distal radius fractures: open reduction and internal fixation with dorsal plating versus mini open reduction, percutaneous fixation, and external fixation. *J Hand Surg Am*. 2005;30(4):764-72.
1431. Jeyam M, Andrew JG, Muir LT, McGovern A. Controlled trial of distal radial fractures treated with a resorbable bone mineral substitute. *J Hand Surg Br*. 2002;27(2):146-9.
1432. Karantana A, Downing ND, Forward DP, et al. Surgical treatment of distal radial fractures with a volar locking plate versus conventional percutaneous methods: a randomized controlled trial. *J Bone Joint Surg Am*. 2013;95(19):1737-44.
1433. Kreder HJ, Hanel DP, Agel J, et al. Indirect reduction and percutaneous fixation versus open reduction and internal fixation for displaced intra-articular fractures of the distal radius: a randomised, controlled trial. *J Bone Joint Surg Br*. 2005;87(6):829-36.
1434. Krishnan J, Wigg AE, Walker RW, Slavotinek J. Intra-articular fractures of the distal radius: a prospective randomised controlled trial comparing static bridging and dynamic non-bridging external fixation. *J Hand Surg Br*. 2003;28(5):417-21.
1435. Leung F, Tu YK, Chew WY, Chow SP. Comparison of external and percutaneous pin fixation with plate fixation for intra-articular distal radial fractures. A randomized study. *J Bone Joint Surg Am*. 2008;90(1):16-22.
1436. Rozental TD, Blazar PE, Franko OI, Chacko AT, Earp BE, Day CS. Functional outcomes for unstable distal radial fractures treated with open reduction and internal fixation or closed reduction and percutaneous fixation. A prospective randomized trial. *J Bone Joint Surg Am*. 2009;91(8):1837-46.
1437. Wei DH, Raizman NM, Bottino CJ, Jobin CM, Strauch RJ, Rosenwasser MP. Unstable distal radial fractures treated with external fixation, a radial column plate, or a volar plate. A prospective randomized trial. *J Bone Joint Surg Am*. 2009;91(7):1568-77.
1438. Wong AS, Jebson PJ, Murray PM, Trigg SD. The use of routine wrist radiography is not useful in the evaluation of patients with a ganglion cyst of the wrist. *Hand*. 2007;2(3):117-9.
1439. Sakamoto A, Oda Y, Iwamoto Y. Intraosseous Ganglia: a series of 17 treated cases. *Biomed Res Int*. 2013;2013462730.
1440. Anderson S, Steinbach L, Stauffer E, Voegelin E. MRI for differentiating ganglion and synovitis in the chronic painful wrist. *Am J Roentgenology*. 2006;186(3):812-8.
1441. Cardinal E, Buckwalter KA, Braunstein EM, Mih AD. Occult dorsal carpal ganglion: comparison of US and MR imaging. *Radiology*. 1994;193(1):259-62.
1442. Goldsmith S, Yang SS. Magnetic resonance imaging in the diagnosis of occult dorsal wrist ganglions. *J Hand Surg Eur Vol*. 2008;33(5):595-9.

Copyright© 2016 Reed Group, Ltd.

1443. Vo P, Wright T, Hayden F, Dell P, Chidgey L. Evaluating dorsal wrist pain: MRI diagnosis of occult dorsal wrist ganglion. *J Hand Surg Am*. 1995;20(4):667-70.
1444. Osterwalder JJ, Widrig R, Stober R, Gachter A. Diagnostic validity of ultrasound in patients with persistent wrist pain and suspected occult ganglion. *J Hand Surg Am*. 1997;22(6):1034-40.
1445. Dias J, Dhukaram V, Kumar P. The natural history of untreated dorsal wrist ganglia and patient reported outcome 6 years after intervention. *The Journal of Hand Surgery: European Volume*. 2007;32(5):502-8.
1446. Latif A, Ansar A, Butt MQ. Treatment of ganglions; a five year experience. *J Pak Med Assoc*. 2014;64(11):1278-81.
1447. Stephen AB, Lyons AR, Davis TR. A prospective study of two conservative treatments for ganglia of the wrist. *J Hand Surg Br*. 1999;24(1):104-5.
1448. Korman J, Pearl R, Hentz VR. Efficacy of immobilization following aspiration of carpal and digital ganglions. *J Hand Surg Am*. 1992;17(6):1097-9.
1449. Richman J, Gelberman R, Engber W, Salamon P, Bean D. Ganglions of the wrist and digits: results of treatment by aspiration and cyst wall puncture. *J Hand Surg Am*. 1987;12(6):1041-3.
1450. Paul AS, Sochart DH. Improving the results of ganglion aspiration by the use of hyaluronidase. *J Hand Surg [Br]*. 1997;22(2):219-21.
1451. Dogo D, Hassan A, Babayo U. Treatment of ganglion using hypertonic saline as sclerosant. *West African journal of medicine*. 2003;22(1):13-4.
1452. Park S, Iida T, Yoshimura K, Kawasaki Y. Phenol cauterization for ganglions of the hand, wrist, and foot: a preliminary report. *Ann Plast Surg*. 2002;48(6):582-5.
1453. Khan PS, Hayat H. Surgical excision versus aspiration combined with intralesional triamcinolone acetonide injection plus wrist immobilization therapy in the treatment of dorsal wrist ganglion; a randomized controlled trial. *J Hand Microsurg*. 2011;3(2):55-7.
1454. Head L, Gencarelli JR, Allen M, Boyd KU. Wrist ganglion treatment: systematic review and meta-analysis. *J Hand Surg Am*. 2015;40(3):546-53 e8.
1455. Tadjerbashi K, Rosales RS, Atroshi I. Intervention randomized controlled trials involving wrist and shoulder arthroscopy: a systematic review. *BMC Musculoskelet Disord*. 2014;15252.
1456. Kang L, Akelman E, Weiss AP. Arthroscopic versus open dorsal ganglion excision: a prospective, randomized comparison of rates of recurrence and of residual pain. *J Hand Surg Am*. 2008;33(4):471-5.
1457. Rocchi L, Canal A, Fanfani F, Catalano F. Articular ganglia of the volar aspect of the wrist: arthroscopic resection compared with open excision. A prospective randomised study. *Scand J Plast Reconstr Surg Hand Surg*. 2008;42(5):253-9.
1458. Varley GW, Needoff M, Davis TR, Clay NR. Conservative management of wrist ganglia. Aspiration versus steroid infiltration. *J Hand Surg Br*. 1997;22(5):636-7.
1459. Jagers Op Akkerhuis M, Van Der Heijden M, Brink P. Hyaluronidase versus surgical excision of ganglia: a prospective, randomized clinical trial.
. *J Hand Surg Br*. 2002;27(3):256-8.
1460. Balazs GC, Donohue MA, Drake ML, Ipsen D, Nanos GP, 3rd, Tintle SM. Outcomes of Open Dorsal Wrist Ganglion Excision in Active-Duty Military Personnel. *J Hand Surg Am*. 2015;40(9):1739-47.
1461. Brammer AJ, Taylor W, Lundborg G. Sensorineural stages of the hand-arm vibration syndrome. *Scand J Work Environ Health*. 1987;13(4):279-83.
1462. Gemne G, Pyykkö I, Taylor W, Pelmear PL. The Stockholm Workshop scale for the classification of cold-induced Raynaud's phenomenon in the hand-arm vibration syndrome (revision of the Taylor-Pelmear scale). *Scand J Work Environ Health*. 1987275-8.
1463. Kao DS, Yan J-G, Zhang L-L, Kaplan RE, Riley DA, Matloub HS. Serological Tests for Diagnosis and Staging of hand–arm vibration syndrome (HAVS). *Hand*. 2008;3(2):129-34.
1464. Youakim S. The validity of Raynaud's phenomenon symptoms in HAVS cases. *Occup Med*. 2008;58(6):431-5.
1465. Laskar S, Harada N. Different conditions of cold water immersion test for diagnosing hand-arm vibration syndrome. *Environmental health and preventive medicine*. 2005;10(6):351-9.
1466. Lindsell C. Test battery for assessing vascular disturbances of fingers. *Environ Health Prev Med*. 2005;10(6):341-50.
1467. Bovenzi M. Finger thermometry in the assessment of subjects with vibration-induced white finger. *Scand J Work Environ Health*. 1987348-51.
1468. International Organization for Standardization. ISO 14835-1:2005 Mechanical Vibration and Shock - Cold Provocation Tests for the Assessment of Peripheral Vascular Function - Part 1: Measurement and Evaluation of Finger Skin Temperature. Geneve: ISO; 2005.

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1469. International Organization for Standardization. ISO 14835-2:2005 Mechanical Vibration and Shock - Cold Provocation Tests for the Assessment of Peripheral Vascular Function - Part 2: Measurement and Evaluation of Finger Systolic Blood Pressure. Geneve: ISO; 2005.
1470. Thompson A, House R, Manno M. Assessment of the hand-arm vibration syndrome: thermometry, plethysmography and the Stockholm Workshop Scale. *Occup Med (Lond)*. 2008;58(3):223-4.
1471. Poole K, Elms J, Mason H. The diagnostic value of finger systolic blood pressure and cold-provocation testing for the vascular component of hand–arm vibration syndrome in health surveillance. *Occupational medicine*. 2004;54(8):520-7.
1472. Poole K, Elms J, Mason H. Cold-provocation testing for the vascular component of hand-arm vibration syndrome in health surveillance. *Industrial health*. 2006;44(4):577-83.
1473. Harada N, Mahbub M. Diagnosis of vascular injuries caused by hand-transmitted vibration. *Int Arch Occup Environ Health*. 2008;81(5):507-18.
1474. Proud G, Burke F, Lawson I, McGeoch K, Miles J. Cold provocation testing and hand–arm vibration syndrome—an audit of the results of the Department of Trade and Industry scheme for the evaluation of miners. *British journal of surgery*. 2003;90(9):1076-9.
1475. Jankovic S, Stankovic S, Borjanovic S, Tenjovic L, Bogdanovic M. Cold stress dynamic thermography for evaluation of vascular disorders in hand-arm vibration syndrome. *Journal of occupational health*. 2008;50(5):423-5.
1476. Nasu Y, Kurozawa Y, Fujiwara Y, et al. Multicenter study on finger systolic blood pressure test for diagnosis of vibration-induced white finger. *Intl Arch Occup Environ Health* 2008;81(5):639-44.
1477. McGeoch K, Lawson I, Burke F, Proud G, Miles J. Use of sensorineural tests in a large volume of medico-legal compensation claims for HAVS. *Occupational medicine*. 2004;54(8):528-34.
1478. Coughlin PA, Bonser R, Turton EP, Kent PJ, Kester RC. A comparison between two methods of aesthesiometric assessment in patients with hand-arm vibration syndrome. *Occup Med (Lond)*. 2001;51(4):272-7.
1479. Coughlin PA, Chetter IC, Kent PJ, Kester RC. The analysis of sensitivity, specificity, positive predictive value and negative predictive value of cold provocation thermography in the objective diagnosis of the hand-arm vibration syndrome. *Occup Med (Lond)*. 2001;51(2):75-80.
1480. Lawson IJ, Nevell DA. Review of objective tests for the hand-arm vibration syndrome. *Occup Med (Lond)*. 1997;47(1):15-20.
1481. Lindsell CJ, Griffin MJ. Thermal thresholds, vibrotactile thresholds and finger systolic blood pressures in dockyard workers exposed to hand-transmitted vibration. *Int Arch Occup Environ Health*. 1999;72(6):377-86.
1482. Bogadi-Sare A, Zavalic M. Diagnostic value of finger thermometry and photoplethysmography in the assessment of hand-arm vibration syndrome. *Int Arch Occup Environ Health*. 1994;66(2):137-40.
1483. Kurozawa Y, Nasu Y, Nose T. Diagnostic value of finger systolic blood pressure in the assessment of vasospastic reactions in the finger skin of vibration-exposed subjects after finger and body cooling. *Scand J Work Environ Health*. 1991;17(3):184-9.
1484. Kanazuka M, Shigekiyo T, Toibana N, Saito S. Increase in plasma thrombomodulin level in patients with vibration syndrome. *Thromb Res*. 1996;82(1):51-6.
1485. Kennedy G, Khan F, McLaren M, Belch JJ. Endothelial activation and response in patients with hand arm vibration syndrome. *Eur J Clin Invest*. 1999;29(7):577-81.
1486. Letz R, Cherniack MG, Gerr F, Hershman D, Pace P. A cross sectional epidemiological survey of shipyard workers exposed to hand-arm vibration. *British journal of industrial medicine*. 1992;49(1):53-62.
1487. Nowak J, Barregård L, Benthin G, Granung G, Wennmalm Å. Thromboxane metabolite excretion in patients with hand-arm vibration syndrome. *Clinical Physiology*. 1996;16(4):361-7.
1488. Blankenship RB, Baker T. Imaging modalities in wounds and superficial skin infections. *Emergency medicine clinics of North America*. 2007;25(1):223-34.
1489. Fornage BD, Schernberg FL. Sonographic diagnosis of foreign bodies of the distal extremities. *AJR Am J Roentgenol*. 1986;147(3):567-9.
1490. Soubeyrand M, Biau D, Jomaah N, Pradel C, Dumontier C, Nourissat G. Penetrating volar injuries of the hand: diagnostic accuracy of US in depicting soft-tissue lesions. *Radiology*. 2008;249(1):228-35.
1491. Tahmasebi M, Zareizadeh H, Motamedfar A. Accuracy of ultrasonography in detecting radiolucent soft-tissue foreign bodies. *Indian J Radiol Imaging*. 2014;24(2):196-200.
1492. Wu TS, Roque PJ, Green J, et al. Bedside ultrasound evaluation of tendon injuries. *Am J Emerg Med*. 2012;30(8):1617-21.
1493. Banerjee B, Das R. Sonographic detection of foreign bodies of the extremities. *The British journal of radiology*. 1991;64(758):107-12.
1494. Crawford R, Matheson A. Clinical value of ultrasonography in the detection and removal of radiolucent foreign bodies. *Injury*. 1989;20(6):341-3.
1495. Gilbert F, Campbell R, Bayliss A. The role of ultrasound in the detection of non-radiopaque foreign bodies. *Clin Radiol*. 1990;41(2):109-12.

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1496. Hill R, Conron R, Greissinger P, Heller M. Ultrasound for the detection of foreign bodies in human tissue. *Ann Emerg Med*. 1997;29(3):353-6.
1497. Levine W, Leslie B. The use of ultrasonography to detect a radiolucent foreign body in the hand: a case report. *J Hand Surg Am*. 1993;18(2):218-20.
1498. Moscati R, Mayrose J, Reardon R, Janicke D, Jehle D. A multicenter comparison of tap water versus sterile saline for wound irrigation. *Academic Emergency Medicine*. 2007;14(5):404-9.
1499. Bansal B, Wiebe R, Perkins S, Abramo T. Tap water for irrigation of lacerations. *Am J Emerg Med*. 2002;20(5):469-72.
1500. Gravett A, Sterner S, Clinton JE, Ruiz E. A trial of povidone-iodine in the prevention of infection in sutured lacerations. *Ann Emerg Med*. 1987;16(2):167-71.
1501. Dire D, Welsh A. A comparison of wound irrigation solutions used in the emergency department. *Ann Emerg Med*. 1990;19(6):704-8.
1502. Chisholm CD, Cordell WH, Rogers K, Woods JR. Comparison of a new pressurized saline canister versus syringe irrigation for laceration cleansing in the emergency department. *Ann Emerg Med*. 1992;21(11):1364-7.
1503. Perelman VS, Francis GJ, Rutledge T, Foote J, Martino F, Dranitsaris G. Sterile versus nonsterile gloves for repair of uncomplicated lacerations in the emergency department: a randomized controlled trial. *Ann Emerg Med*. 2004;43(3):362-70.
1504. Chale S, Singer AJ, Marchini S, McBride MJ, Kennedy D. Digital versus local anesthesia for finger lacerations: a randomized controlled trial. *Acad Emerg Med*. 2006;13(10):1046-50.
1505. Robson AK, Bloom PA. Suturing of digital lacerations: digital block or local infiltration? *Ann R Coll Surg Engl*. 1990;72(6):360-1.
1506. Pryor GJ, Kilpatrick WR, Opp DR. Local anesthesia in minor lacerations: topical TAC vs lidocaine infiltration. *Ann Emerg Med*. 1980;9(11):568-71.
1507. Kuhn M, Rossi SO, Plummer JL, Raftos J. Topical anaesthesia for minor lacerations: MAC versus TAC. *Med J Aust*. 1996;164(5):277-80.
1508. Vinci RJ, Fish SS. Efficacy of topical anesthesia in children. *Arch Pediatr Adolesc Med*. 1996;150(5):466-9.
1509. Ernst AA, Marvez-Valls E, Nick TG, Weiss SJ. LAT (lidocaine-adrenaline-tetracaine) versus TAC (tetracaine-adrenaline-cocaine) for topical anesthesia in face and scalp lacerations. *Am J Emerg Med*. 1995;13(2):151-4.
1510. Schilling CG, Bank DE, Borchert BA, Klatzko MD, Uden DL. Tetracaine, epinephrine (adrenalin), and cocaine (TAC) versus lidocaine, epinephrine, and tetracaine (LET) for anesthesia of lacerations in children. *Ann Emerg Med*. 1995;25(2):203-8.
1511. Zempsky WT, Karasic RB. EMLA versus TAC for topical anesthesia of extremity wounds in children. *Ann Emerg Med*. 1997;30(2):163-6.
1512. Singer AJ, Stark MJ. LET versus EMLA for pretreating lacerations: a randomized trial. *Acad Emerg Med*. 2001;8(3):223-30.
1513. Ernst AA, Marvez-Valls E, Nick TG, Wahle M. Comparison trial of four injectable anesthetics for laceration repair. *Acad Emerg Med*. 1996;3(3):228-33.
1514. Quinn J, Cummings S, Callaham M, Sellers K. Suturing versus conservative management of lacerations of the hand: randomised controlled trial. *Bmj*. 2002;325(7359):299.
1515. Jones JS, Gartner M, Drew G, Pack S. The shorthand vertical mattress stitch: evaluation of a new suture technique. *Am J Emerg Med*. 1993;11(5):483-5.
1516. Alam M, Posten W, Martini MC, Wrone DA, Rademaker AW. Aesthetic and functional efficacy of subcuticular running epidermal closures of the trunk and extremity: a rater-blinded randomized control trial. *Arch Dermatol*. 2006;142(10):1272-8.
1517. Singer AJ, Gulla J, Hein M, Marchini S, Chale S, Arora BP. Single-layer versus double-layer closure of facial lacerations: a randomized controlled trial. *Plast Reconstr Surg*. 2005;116(2):363-8; discussion 9-70.
1518. Durani P, McGrouther DA, Ferguson MW. Current scales for assessing human scarring: a review. *J Plast Reconstr Aesthet Surg*. 2009;62(6):713-20.
1519. Karounis H, Gouin S, Eisman H, Chalut D, Pelletier H, Williams B. A randomized, controlled trial comparing long-term cosmetic outcomes of traumatic pediatric lacerations repaired with absorbable plain gut versus nonabsorbable nylon sutures. *Acad Emerg Med*. 2004;11(7):730-5.
1520. Mouzas GL, Yeadon A. Does the choice of suture material affect the incidence of wound infection? A comparison of dexon (polyglycolic acid) sutures with other commonly used sutures in an accident and emergency department. *Br J Surg*. 1975;62(12):952-5.
1521. Al-Abdullah T, Plint AC, Fergusson D. Absorbable versus nonabsorbable sutures in the management of traumatic lacerations and surgical wounds: a meta-analysis. *Pediatr Emerg Care*. 2007;23(5):339-44.
1522. Su BW, Solomons M, Barrow A, et al. Device for zone-II flexor tendon repair. A multicenter, randomized, blinded, clinical trial. *J Bone Joint Surg Am*. 2005;87(5):923-35.

Copyright© 2016 Reed Group, Ltd.

1523. Orlinsky M, Goldberg RM, Chan L, Puertos A, Slajer HL. Cost analysis of stapling versus suturing for skin closure. *Am J Emerg Med*. 1995;13(1):77-81.
1524. Barnett P, Jarman FC, Goodge J, Silk G, Aickin R. Randomised trial of histoacryl blue tissue adhesive glue versus suturing in the repair of paediatric lacerations. *J Paediatr Child Health*. 1998;34(6):548-50.
1525. Bruns TB, Robinson BS, Smith RJ, et al. A new tissue adhesive for laceration repair in children. *J Pediatr*. 1998;132(6):1067-70.
1526. Bruns TB, Simon HK, McLario DJ, Sullivan KM, Wood RJ, Anand KJ. Laceration repair using a tissue adhesive in a children's emergency department. *Pediatrics*. 1996;98(4 Pt 1):673-5.
1527. Handschel JG, Depprich RA, Dirksen D, Runte C, Zimmermann A, Kubler NR. A prospective comparison of octyl-2-cyanoacrylate and suture in standardized facial wounds. *Int J Oral Maxillofac Surg*. 2006;35(4):318-23.
1528. Holger JS, Wandersee SC, Hale DB. Cosmetic outcomes of facial lacerations repaired with tissue-adhesive, absorbable, and nonabsorbable sutures. *Am J Emerg Med*. 2004;22(4):254-7.
1529. Hollander JE, Singer AJ. Application of tissue adhesives: rapid attainment of proficiency. Stony Brook Octylcyanoacrylate Study Group. *Acad Emerg Med*. 1998;5(10):1012-7.
1530. Quinn J, Wells G, Sutcliffe T, et al. A randomized trial comparing octylcyanoacrylate tissue adhesive and sutures in the management of lacerations. *JAMA*. 1997;277(19):1527-30.
1531. Quinn J, Wells G, Sutcliffe T, et al. Tissue adhesive versus suture wound repair at 1 year: randomized clinical trial correlating early, 3-month, and 1-year cosmetic outcome. *Ann Emerg Med*. 1998;32(6):645-9.
1532. Shamiyeh A, Schrenk P, Stelzer T, Wayand WU. Prospective randomized blind controlled trial comparing sutures, tape, and octylcyanoacrylate tissue adhesive for skin closure after phlebectomy. *Dermatol Surg*. 2001;27(10):877-80.
1533. Simon HK, McLario DJ, Bruns TB, Zempsky WT, Wood RJ, Sullivan KM. Long-term appearance of lacerations repaired using a tissue adhesive. *Pediatrics*. 1997;99(2):193-5.
1534. Simon HK, Zempsky WT, Bruns TB, Sullivan KM. Lacerations against Langer's lines: to glue or suture? *J Emerg Med*. 1998;16(2):185-9.
1535. Singer AJ, Quinn JV, Clark RE, Hollander JE, Group TS. Closure of lacerations and incisions with octylcyanoacrylate: a multicenter randomized controlled trial. *Surgery*. 2002;131(3):270-6.
1536. Singer AJ, Quinn JV, Thode HC, Jr., Hollander JE. Determinants of poor outcome after laceration and surgical incision repair. *Plast Reconstr Surg*. 2002;110(2):429-35; discussion 36-7.
1537. Sinha S, Naik M, Wright V, Timmons J, Campbell AC. A single blind, prospective, randomized trial comparing n-butyl 2-cyanoacrylate tissue adhesive (Indermil) and sutures for skin closure in hand surgery. *J Hand Surg [Br]*. 2001;26(3):264-5.
1538. Toriumi DM, O'Grady K, Desai D, Bagal A. Use of octyl-2-cyanoacrylate for skin closure in facial plastic surgery. *Plast Reconstr Surg*. 1998;102(6):2209-19.
1539. Goktas N, Karcioglu O, Coskun F, Karaduman S, Menderes A. Comparison of tissue adhesive and suturing in the repair of lacerations in the emergency department. *Eur J Emerg Med*. 2002;9(2):155-8.
1540. Mattick A, Clegg G, Beattie T, Ahmad T. A randomised, controlled trial comparing a tissue adhesive (2-octylcyanoacrylate) with adhesive strips (Steristrips) for paediatric laceration repair. *Emerg Med J*. 2002;19(5):405-7.
1541. Zempsky WT, Grem C, Nichols J, Parrotti D. Prospective comparison of cosmetic outcomes of simple facial lacerations closed with Steri-Strips or Dermabond. *Academic Emergency Medicine*. 2001;8(5):438.
1542. Quinn J, Drzewiecki A, Li M, et al. A randomized, controlled trial comparing a tissue adhesive with suturing in the repair of pediatric facial lacerations. *Ann Emerg Med*. 1993;22(7):1130-5.
1543. Osmond MH, Quinn JV, Sutcliffe T, Jarmuske M, Klassen TP. A randomized, clinical trial comparing butylcyanoacrylate with octylcyanoacrylate in the management of selected pediatric facial lacerations. *Acad Emerg Med*. 1999;6(3):171-7.
1544. Singer AJ, Giordano P, Fitch JL, Gulla J, Ryker D, Chale S. Evaluation of a new high-viscosity octylcyanoacrylate tissue adhesive for laceration repair: a randomized, clinical trial. *Acad Emerg Med*. 2003;10(10):1134-7.
1545. Kundra RK, Newman S, Saithna A, Lewis AC, Srinivasan S, Srinivasan K. Absorbable or non-absorbable sutures? A prospective, randomised evaluation of aesthetic outcomes in patients undergoing elective day-case hand and wrist surgery. *Ann R Coll Surg Engl*. 2010;92(8):665-7.
1546. Moazzam A, Gordon DJ. Cross-suturing as an aid to wound closure: a prospective randomised trial using the forearm flap donor site as a model. *Br J Plast Surg*. 2003;56(7):695-700.
1547. Sener A, Demircan A, Keles A, Bildik F, Karakurt K. Comparison of local infiltration anesthesia and peripheral nerve block: a randomized prospective study in hand lacerations. *Turk J Med Sci*. 2015;45(3):694-9.
1548. Bernard L, Doyle J, Friedlander SF, Eichenfield LF, Gibbs NF, Cunningham BB. A prospective comparison of octyl cyanoacrylate tissue adhesive (dermabond) and suture for the closure of excisional wounds in children and adolescents. *Arch Dermatol*. 2001;137(9):1177-80.

Copyright© 2016 Reed Group, Ltd.

1549. MacGregor FB, McCombe AW, King PM, Macleod DA. Skin stapling of wounds in the accident department. *Injury*. 1989;20(6):347-8.
1550. Sutton R, Pritty P. Use of sutures or adhesive tapes for primary closure of pretibial lacerations. *Br Med J (Clin Res Ed)*. 1985;290(6482):1627.
1551. Howell J, Chisholm C. Outpatient wound preparation and care: a national survey. *Ann Emerg Med*. 1992;21(8):976-81.
1552. Hinman CD, Maibach H. Effect of air exposure and occlusion on experimental human skin wounds. *Nature*. 1963;200377-8.
1553. Jones J. Winter's concept of moist wound healing: a review of the evidence and impact on clinical practice. *Journal of wound care*. 2005;14(6):273-6.
1554. Winter G. Formation of the scab and the rate of epithelization of superficial wounds in the skin of the young domestic pig. 1962.
1555. Heal C, Buettner P, Raasch B, et al. Can sutures get wet? Prospective randomised controlled trial of wound management in general practice. *Bmj*. 2006;332(7549):1053-6.
1556. DeBoard RH, Rondeau DF, Kang CS, Sabbaj A, McManus JG. Principles of basic wound evaluation and management in the emergency department. *Emerg Med Clin North Am*. 2007;25(1):23-39.
1557. Roberts AH, Roberts FE, Hall RI, Thomas IH. A prospective trial of prophylactic povidone iodine in lacerations of the hand. *J Hand Surg [Br]*. 1985;10(3):370-4.
1558. Roberts AH, Teddy PJ. A prospective trial of prophylactic antibiotics in hand lacerations. *Br J Surg*. 1977;64(6):394-6.
1559. Lindsey D, Nava C, Marti M. Effectiveness of penicillin irrigation in control of infection in sutured lacerations. *J Trauma*. 1982;22(3):186-9.
1560. Morgan WJ, Hutchison D, Johnson HM. The delayed treatment of wounds of the hand and forearm under antibiotic cover. *Br J Surg*. 1980;67(2):140-1.
1561. Thirlby RC, Blair AJ, 3rd, Thal ER. The value of prophylactic antibiotics for simple lacerations. *Surg Gynecol Obstet*. 1983;156(2):212-6.
1562. Dire DJ, Coppola M, Dwyer DA, Lorette JJ, Karr JL. Prospective evaluation of topical antibiotics for preventing infections in uncomplicated soft-tissue wounds repaired in the ED. *Academic Emergency Medicine*. 1995;2(1):4-10.
1563. Brakenbury PH, Muwanga C. A comparative double blind study of amoxycillin/clavulanate vs placebo in the prevention of infection after animal bites. *Arch Emerg Med*. 1989;6(4):251-6.
1564. Dire DJ, Hogan DE, Walker JS. Prophylactic oral antibiotics for low-risk dog bite wounds. *Pediatr Emerg Care*. 1992;8(4):194-9.
1565. Elenbaas RM, McNabney WK, Robinson WA. Prophylactic oxacillin in dog bite wounds. *Ann Emerg Med*. 1982;11(5):248-51.
1566. Rosen RA. The use of antibiotics in the initial management of recent dog-bite wounds. *Am J Emerg Med*. 1985;3(1):19-23.
1567. Jones DA, Stanbridge TN. A clinical trial using co-trimoxazole in an attempt to reduce wound infection rates in dog bite wounds. *Postgrad Med J*. 1985;61(717):593-4.
1568. Elenbaas RM, McNabney WK, Robinson WA. Evaluation of prophylactic oxacillin in cat bite wounds. *Ann Emerg Med*. 1984;13(3):155-7.
1569. Talan DA, Citron DM, Abrahamian FM, Moran GJ, Goldstein EJ. Bacteriologic analysis of infected dog and cat bites. Emergency Medicine Animal Bite Infection Study Group. *N Engl J Med*. 1999;340(2):85-92.
1570. Maimaris C, Quinton DN. Dog-bite lacerations: a controlled trial of primary wound closure. *Arch Emerg Med*. 1988;5(3):156-61.
1571. Buurke JH, Grady JH, de Vries J, Baten CT. Usability of thenar eminence orthoses: report of a comparative study. *Clin Rehabil*. 1999;13(4):288-94.
1572. Weiss S, LaStayo P, Mills A, Bramlet D. Prospective analysis of splinting the first carpometacarpal joint: an objective, subjective, and radiographic assessment. *Journal of Hand Therapy*. 2000;13(3):218-27.
1573. Zhang W, Doherty M, Leeb B, et al. EULAR evidence based recommendations for the management of hand osteoarthritis: report of a Task Force of the EULAR Standing Committee for International Clinical Studies Including Therapeutics (ESCISIT). *Annals of the rheumatic diseases*. 2007;66(3):377-88.
1574. Berggren M, A. Joost-Davidsson, J. Lindstrand, G. Nylander, B. Povlsen. Reduction in the need for operation after conservative treatment of osteoarthritis of the first carpometacarpal joint: a seven year prospective study. *Scand J Plast Reconstr Surg Hand Surg*. 2001;35(4):415-7.
1575. Estes JP, Bochenek C, Fassler P. Osteoarthritis of the fingers. *J Hand Ther*. 2000;13(2):108-23.
1576. Glickel SZ. Clinical assessment of the thumb trapeziometacarpal joint. *Hand Clin*. 2001;17(2):185-95.
1577. Poole JU, Pellegrini VD. Arthritis of the thumb basal joint complex. *Journal of Hand Therapy*. 2000;13(2):91-107.

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1578. Rogers MW, Wilder FV. The effects of strength training among persons with hand osteoarthritis: a two-year follow-up study. *J Hand Ther*. 2007;20(3):244-9; quiz 50.
1579. Rogers MW, Wilder FV. Exercise and hand osteoarthritis symptomatology: a controlled crossover trial. *J Hand Ther*. 2009;22(1):10-7; discussion 9-20; quiz 18.
1580. Stamm TA, Machold KP, Smolen JS, et al. Joint protection and home hand exercises improve hand function in patients with hand osteoarthritis: a randomized controlled trial. *Arthritis Rheum*. 2002;47(1):44-9.
1581. Rannou F, Dimet J, Boutron I, et al. Splint for base-of-thumb osteoarthritis: a randomized trial. *Ann Intern Med*. 2009;150(10):661-9.
1582. Weiss S, Lastayo P, Mills A, Bramlet D. Splinting the degenerative basal joint: custom-made or prefabricated neoprene? *J Hand Ther*. 2004;17(4):401-6.
1583. Wajon A, Ada L. No difference between two splint and exercise regimens for people with osteoarthritis of the thumb: a randomised controlled trial. *Aust J Physiother*. 2005;51(4):245-9.
1584. Bani MA, Arazpour M, Kashani RV, Mousavi ME, Hutchins SW. Comparison of custom-made and prefabricated neoprene splinting in patients with the first carpometacarpal joint osteoarthritis. *Disabil Rehabil Assist Technol*. 2013;8(3):232-7.
1585. Becker SJ, Bot AG, Curley SE, Jupiter JB, Ring D. A prospective randomized comparison of neoprene vs thermoplast hand-based thumb spica splinting for trapeziometacarpal arthrosis. *Osteoarthritis Cartilage*. 2013;21(5):668-75.
1586. Villafane JH, Cleland JA, Fernandez-de-Las-Penas C. The effectiveness of a manual therapy and exercise protocol in patients with thumb carpometacarpal osteoarthritis: a randomized controlled trial. *J Orthop Sports Phys Ther*. 2013;43(4):204-13.
1587. Carreira A, Jones A, Natour J. Assessment of the effectiveness of a functional splint for osteoarthritis of the trapeziometacarpal joint of the dominant hand: a randomized controlled study. *J Rehabil Med*. 2010;42469-74.
1588. Ronningen A, Kjeken I. Effect of an intensive hand exercise programme in patients with rheumatoid arthritis. *Scand J Occup Ther*. 2008;15(3):173-83.
1589. Adams J, Boucas SB, Hislop K, et al. The effectiveness and efficacy of splints for thumb base osteoarthritis: A pilot randomized controlled trial. *Rheumatology (United Kingdom)*; 2014:i41-i2.
1590. Boustedt C, Nordenskiold U, Lundgren Nilsson A. Effects of a hand-joint protection programme with an addition of splinting and exercise: one year follow-up. *Clin Rheumatol*. 2009;28(7):793-9.
1591. Berenbaum F, Grifka J, Brown J, et al. Efficacy of lumiracoxib in osteoarthritis: a review of nine studies. *Journal of international medical research*. 2005;33(1):21-41.
1592. Garner SE, Fidan DD, Frankish R, Maxwell L. Rofecoxib for osteoarthritis. *Cochrane Database Syst Rev*. 2005(1):CD005115.
1593. Jagtap SA, Lahoti S, Anwaruddin K, Ram S, Ballary C, Desai A. Evaluation of efficacy, safety and tolerability of valdecoxib in osteo-arthritis patients--an Indian study. *J Indian Med Assoc*. 2002;100(11):673-4.
1594. Towheed T. Systematic review of therapies for osteoarthritis of the hand. *Osteoarthritis and Cartilage*. 2005;13(6):455-62.
1595. Lisse JR, Perlman M, Johansson G, et al. Gastrointestinal tolerability and effectiveness of rofecoxib versus naproxen in the treatment of osteoarthritis: a randomized, controlled trial. *Ann Intern Med*. 2003;139(7):539-46.
1596. Niccoli L, Bellino S, Cantini F. Renal tolerability of three commonly employed non-steroidal anti-inflammatory drugs in elderly patients with osteoarthritis. *Clinical and experimental rheumatology*. 2002;20(2):201-7.
1597. Pope J, McCrea K, Stevens A, Ouimet J. Treatment of osteoarthritis of the hip and knee: a comparison of NSAID use in patients for whom surgery was and was not recommended. *Clinical and experimental rheumatology*. 2003;22(2):171-6.
1598. Amadio P, Cummings D. Evaluation of acetaminophen in the management of osteoarthritis of the knee. *CURRENT THERAPEUTIC RESEARCH-CLINICAL AND EXPERIMENTAL*. 1983;34(1):59-66.
1599. Pincus T, Koch G, Lei H, et al. Patient preference for Placebo, aAetaminophen (Paracetamol) or Celecoxib Efficacy Studies (PACES): two randomised, double blind, placebo controlled, crossover clinical trials in patients with knee or hip osteoarthritis. *Ann Rheum Dis*. 2004;63(8):931-9.
1600. Boureau F, Schneid H, Zeghari N, Wall R, Bourgeois P. The IPSO study: ibuprofen, paracetamol study in osteoarthritis. A randomised comparative clinical study comparing the efficacy and safety of ibuprofen and paracetamol analgesic treatment of osteoarthritis of the knee or hip. *Ann Rheum Dis*. 2004;63(9):1028-34.
1601. Bradley JD, Brandt KD, Katz BP, Kalasinski LA, Ryan SI. Comparison of an antiinflammatory dose of ibuprofen, an analgesic dose of ibuprofen, and acetaminophen in the treatment of patients with osteoarthritis of the knee. *N Engl J Med*. 1991;325(2):87-91.
1602. Case JP, Baliunas AJ, Block JA. Lack of efficacy of acetaminophen in treating symptomatic knee osteoarthritis: a randomized, double-blind, placebo-controlled comparison trial with diclofenac sodium. *Arch Intern Med*. 2003;163(2):169-78.

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1603. Geba GP, Weaver AL, Polis AB, Dixon ME, Schnitzer TJ. Efficacy of rofecoxib, celecoxib, and acetaminophen in osteoarthritis of the knee: a randomized trial. *Jama*. 2002;287(1):64-71.
1604. Golden H, Moskowitz R, Minic M. Analgesic efficacy and safety of nonprescription doses of naproxen sodium compared with acetaminophen in the treatment of osteoarthritis of the knee. *Am J Therapeutics*. 2004;11(2):85-94.
1605. Pincus T, Koch GG, Sokka T, et al. A randomized, double-blind, crossover clinical trial of diclofenac plus misoprostol versus acetaminophen in patients with osteoarthritis of the hip or knee. *Arthritis Rheum*. 2001;44(7):1587-98.
1606. Temple AR, Benson GD, Zinsenheim JR, Schweinle JE. Multicenter, randomized, double-blind, active-controlled, parallel-group trial of the long-term (6-12 months) safety of acetaminophen in adult patients with osteoarthritis. *Clin Ther*. 2006;28(2):222-35.
1607. Towheed TE, Maxwell L, Judd MG, Catton M, Hochberg MC, Wells G. Acetaminophen for osteoarthritis. *Cochrane Database Syst Rev*. 2006(1):CD004257.
1608. Miceli-Richard C, Le Bars M, Schmidely N, Dougados M. Paracetamol in osteoarthritis of the knee. *Ann Rheum Dis*. 2004;63(8):923-30.
1609. Agrawal NM, Caldwell J, Kivitz AJ, et al. Comparison of the upper gastrointestinal safety of Arthrotec® 75 and nabumetone in osteoarthritis patients at high risk for developing nonsteroidal anti-inflammatory drug-induced gastrointestinal ulcers. *Clin Ther*. 1999;21(4):659-74.
1610. Bocanegra TS, Weaver AL, Tindall EA, et al. Diclofenac/misoprostol compared with diclofenac in the treatment of osteoarthritis of the knee or hip: a randomized, placebo controlled trial. Arthrotec Osteoarthritis Study Group. *J Rheumatol*. 1998;25(8):1602-11.
1611. Fenton C, Keating GM, Wagstaff AJ. Valdecoxib: a review of its use in the management of osteoarthritis, rheumatoid arthritis, dysmenorrhoea and acute pain. *Drugs*. 2004;64(11):1231-61.
1612. Melo Gomes J, Roth S, Zeeh J, Bruyn G, Woods E, Geis G. Double-blind comparison of efficacy and gastroduodenal safety of diclofenac/misoprostol, piroxicam, and naproxen in the treatment of osteoarthritis. *Ann Rheum Dis*. 1993;52(12):881-5.
1613. Agrawal NM, Aziz K. Prevention of gastrointestinal complications associated with nonsteroidal antiinflammatory drugs. *J Rheumatol Suppl*. 1998;5117-20.
1614. Desai J, Sanyal S, Goo T, et al. Primary prevention of adverse gastroduodenal effects from short-term use of non-steroidal anti-inflammatory drugs by omeprazole 20 mg in healthy subjects: a randomized, double-blind, placebo-controlled study. *Digestive Dis Sci*. 2008;53(8):2059-65.
1615. Goldstein J, Cryer B, Amer F, Hunt B. Celecoxib plus aspirin versus naproxen and lansoprazole plus aspirin: a randomized, double-blind, endoscopic trial. *Clin Gastroenterology Hepatology*. 2007;5(10):1167-74.
1616. Hawkey C, Weinstein W, Stricker K, et al. Clinical trial: comparison of the gastrointestinal safety of lumiracoxib with traditional nonselective nonsteroidal anti-inflammatory drugs early after the initiation of treatment–findings from the Therapeutic Arthritis Research and Gastrointestinal Event Trial. *Alimentary pharmacology & therapeutics*. 2008;27(9):838-45.
1617. Lazzaroni M, Bianchi Porro G. Non-steroidal anti-inflammatory drug gastropathy: clinical results with H2 antagonists and proton pump inhibitors. *Ital J Gastroenterol Hepatol*. 1999;31 Suppl 1S73-8.
1618. Lazzaroni M, Porro GB. Management of NSAID-Induced Gastrointestinal Toxicity. *Drugs*. 2009;69(1):51-69.
1619. Niwa Y, Nakamura M, Ohmiya N, et al. Efficacy of rebamipide for diclofenac-induced small-intestinal mucosal injuries in healthy subjects: a prospective, randomized, double-blinded, placebo-controlled, cross-over study. *J Gastroenterology*. 2008;43(4):270-6.
1620. Bianchi Porro G. Peptic ulcer therapy with cimetidine versus tripotassium dicitrato bismuthate in rheumatoid arthritis patients undergoing chronic NSAID treatment. *Alimentary Pharmacology Thera*. 1998;12(4):343-7.
1621. Yeomans N, Lanas A, Labenz J, et al. Efficacy of esomeprazole (20 mg once daily) for reducing the risk of gastroduodenal ulcers associated with continuous use of low-dose aspirin. *Am J Gastroenterology*. 2008;103(10):2465-73.
1622. Levi F, Louarn CL, Reinberg A. Timing optimizes sustained-release indomethacin treatment of osteoarthritis. *Clinical Pharmacology & Therapeutics*. 1985;37(1):77-84.
1623. Stengaard-Pedersen K, Ekesbo R, Karvonen A-L, Lyster M. Celecoxib 200 mg qd is efficacious in the management of osteoarthritis of the knee or hip regardless of the time of dosing. *Rheumatology*. 2004;43(5):592-5.
1624. Graham DY, Agrawal NM, Campbell DR, et al. Ulcer prevention in long-term users of nonsteroidal anti-inflammatory drugs: results of a double-blind, randomized, multicenter, active-and placebo-controlled study of misoprostol vs lansoprazole. *Archives of Internal Medicine*. 2002;162(2):169-75.
1625. Antman E, Bennett J, Daugherty A, Furberg C, Roberts H, Taubert KA. Use of nonsteroidal antiinflammatory drugs an update for clinicians: a scientific statement from the American Heart Association. *Circulation*. 2007;115(12):1634-42.

Copyright© 2016 Reed Group, Ltd.

1626. Towheed T. Pennsaid therapy for osteoarthritis of the knee: a systematic review and metaanalysis of randomized controlled trials. *J Rheumatol*. 2006;33(3):567-73.
1627. Pope JE, Prashker M, Anderson J. The efficacy and cost effectiveness of N of 1 studies with diclofenac compared to standard treatment with nonsteroidal antiinflammatory drugs in osteoarthritis. *J Rheumatol*. 2004;31(1):140-9.
1628. Grifka JK, Zacher J, Brown JP, et al. Efficacy and tolerability of lumiracoxib versus placebo in patients with osteoarthritis of the hand. *Clin Exp Rheumatol*. 2004;22(5):589-96.
1629. Barthel HR, Peniston JH, Clark MB, Gold MS, Altman RD. Correlation of pain relief with physical function in hand osteoarthritis: randomized controlled trial post hoc analysis. *Arthritis Res Ther*. 2010;12(1):R7.
1630. Smith AS, Dore CJ, Dennis L, Julius A, Mackworth-Young CG. A randomised controlled trial of subcutaneous sodium salicylate therapy for osteoarthritis of the thumb. *Postgrad Med J*. 2010;86(1016):341-5.
1631. Widrig R, Suter A, Saller R, Melzer J. Choosing between NSAID and arnica for topical treatment of hand osteoarthritis in a randomised, double-blind study. *Rheumatol Int*. 2007;27(6):585-91.
1632. Gabay C, Medinger-Sadowski C, Gascon D, Kolo F, Finckh A. Symptomatic effects of chondroitin 4 and chondroitin 6 sulfate on hand osteoarthritis: a randomized, double-blind, placebo-controlled clinical trial at a single center. *Arthritis Rheum*. 2011;63(11):3383-91.
1633. Rothacker D, Difigilo C, Lee I. A clinical trial of topical 10% trolamine salicylate in osteoarthritis. *Curr Ther Res*. 1994;55(5):584-97.
1634. Rothacker DQ, Lee I, Littlejohn TW, 3rd. Effectiveness of a single topical application of 10|x% trolamine salicylate cream in the symptomatic treatment of osteoarthritis. *J Clin Rheumatol*. 1998;4(1):6-12.
1635. Zacher J, Altman R, Bellamy N, et al. Topical diclofenac and its role in pain and inflammation: an evidence-based review. *Curr Med Res Opin*. 2008;24(4):925-50.
1636. Altman RD, Dreiser RL, Fisher CL, Chase WF, Dreher DS, Zacher J. Diclofenac sodium gel in patients with primary hand osteoarthritis: a randomized, double-blind, placebo-controlled trial. *J Rheumatol*. 2009;36(9):1991-9.
1637. McCarthy GM, McCarty DJ. Effect of topical capsaicin in the therapy of painful osteoarthritis of the hands. *J Rheumatol*. 1992;19(4):604-7.
1638. Schnitzer T, Morton C, Coker S. Topical capsaicin therapy for osteoarthritis pain: Achieving a maintenance regimen. *Seminars in Arthritis and Rheumatism*. 1994;23(6, Supplement 3):34-40.
1639. Garfinkel MS, Schumacher HR, Jr., Husain A, Levy M, Reshetar RA. Evaluation of a yoga based regimen for treatment of osteoarthritis of the hands. *J Rheumatol*. 1994;21(12):2341-3.
1640. Rovetta G, Monteforte P, Molfetta G, Balestra V. Chondroitin sulfate in erosive osteoarthritis of the hands. *Int J Tissue React*. 2002;24(1):29-32.
1641. Randall C, Randall H, Dobbs F, Hutton C, Sanders H. Randomized controlled trial of nettle sting for treatment of base-of-thumb pain. *J R Soc Med*. 2000;93(6):305-9.
1642. Reeves KD, Hassanein K. Randomized, prospective, placebo-controlled double-blind study of dextrose prolotherapy for osteoarthritic thumb and finger (DIP, PIP, and trapeziometacarpal) joints: evidence of clinical efficacy. *J Altern Complement Med*. 2000;6(4):311-20.
1643. Shin K, Kim JW, Moon KW, et al. The efficacy of diacerein in hand osteoarthritis: a double-blind, randomized, placebo-controlled study. *Clin Ther*. 2013;35(4):431-9.
1644. Mathieux R, Marotte H, Battistini L, Sarrazin A, Berthier M, Miossec P. Early occupational therapy programme increases hand grip strength at 3 months: results from a randomised, blind, controlled study in early rheumatoid arthritis. *Ann Rheum Dis*. 2009;68(3):400-3.
1645. Verbruggen G, Goemaere S, Veys EM. Systems to assess the progression of finger joint osteoarthritis and the effects of disease modifying osteoarthritis drugs. *Clin Rheumatol*. 2002;21(3):231-43.
1646. Bellamy N, Campbell J, Haraoui B, et al. Dimensionality and clinical importance of pain and disability in hand osteoarthritis: Development of the Australian/Canadian (AUSCAN) Osteoarthritis Hand Index. *Osteoarthritis and Cartilage*. 2002;10(11):855-62.
1647. Bellamy N, Campbell J, Haraoui B, et al. Clinimetric properties of the AUSCAN Osteoarthritis Hand Index: an evaluation of reliability, validity and responsiveness. *Osteoarthritis and Cartilage*. 2002;10(11):863-9.
1648. Brosseau L, Robinson V, Wells G, et al. Low level laser therapy (Classes I, II and III) for treating osteoarthritis. *The Cochrane Library*. 2004.
1649. Brosseau L, Wells G, Marchand S, et al. Randomized controlled trial on low level laser therapy (LLLT) in the treatment of osteoarthritis (OA) of the hand. *Lasers Surg Med*. 2005;36(3):210-9.
1650. Day R, Brooks P, Conaghan P, Petersen M. A double blind, randomized, multicenter, parallel group study of the effectiveness and tolerance of intraarticular hyaluronan in osteoarthritis of the knee. *J Rheumatol*. 2004;31(4):775-82.
1651. Fuchs S, Mönikes R, Wohlmeiner A, Heyse T. Intra-articular hyaluronic acid compared with corticoid injections for the treatment of rhizarthrosis. *Osteoarthritis and Cartilage*. 2006;14(1):82-8.

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1652. Heyworth BE, Lee JH, Kim PD, Lipton CB, Strauch RJ, Rosenwasser MP. Hylan versus corticosteroid versus placebo for treatment of basal joint arthritis: a prospective, randomized, double-blinded clinical trial. *J Hand Surg [Am]*. 2008;33(1):40-8.
1653. Jalava S, Saario R. Treatment of finger joints with local steroids. A double-blind study. *Scand J Rheumatol*. 1983;12(1):12-4.
1654. Meenagh GK, Patton J, Kynes C, Wright GD. A randomised controlled trial of intra-articular corticosteroid injection of the carpometacarpal joint of the thumb in osteoarthritis. *Ann Rheum Dis*. 2004;63(10):1260-3.
1655. Roux C, Fontas E, Breuil V, Brocq O, Albert C, Euller-Ziegler L. Injection of intra-articular sodium hyaluronidate (Sinovial®) into the carpometacarpal joint of the thumb (CMC1) in osteoarthritis. A prospective evaluation of efficacy. *Joint Bone Spine*. 2007;74(4):368-72.
1656. Stahl S, Karsh-Zafrir I, Ratzon N, Rosenberg N. Comparison of intraarticular injection of depot corticosteroid and hyaluronic acid for treatment of degenerative trapeziometacarpal joints. *J Clin Rheumatol*. 2005;11(6):299-302.
1657. Stolzer BL, Eisenbeis CH, Jr., Barr JH, Jr., Crittenden JO, Margolis HM. Intra-articular injections of adrenocorticosteroids in patients with arthritis. *Pa Med J*. 1962;6511-4.
1658. Wollstein R, Chaimsky G, Carlson L, Watson HK, Wollstein G, Saleh J. Evaluating short-term pain after steroid injection. *Am J Orthop*. 2007;36(3):128-31.
1659. Wenham CY, Hensor EM, Grainger AJ, et al. A randomized, double-blind, placebo-controlled trial of low-dose oral prednisolone for treating painful hand osteoarthritis. *Rheumatology (Oxford)*. 2012;51(12):2286-94.
1660. Bahadir C, Onal B, Dayan VY, Gurer N. Comparison of therapeutic effects of sodium hyaluronate and corticosteroid injections on trapeziometacarpal joint osteoarthritis. *Clin Rheumatol*. 2009;28(5):529-33.
1661. Figen Ayhan F, Ustun N. The evaluation of efficacy and tolerability of Hylan G-F 20 in bilateral thumb base osteoarthritis: 6 months follow-up. *Clin Rheumatol*. 2009;28(5):535-41.
1662. Monfort J, Rotes-Sala D, Segales N, et al. Comparative efficacy of intra-articular hyaluronic acid and corticoid injections in osteoarthritis of the first carpometacarpal joint: results of a 6-month single-masked randomized study. *Joint Bone Spine*. 2015;82(2):116-21.
1663. Spolidoro Paschoal Nde O, Natour J, Machado F, de Oliveira H, Furtado R. Effectiveness of Triamcinolone Hexacetonide Intraarticular Injection in Interphalangeal Joints: A 12-week Randomized Controlled Trial in Patients with Hand Osteoarthritis. *J Rheumatol*. 2015;42(10):1869-77.
1664. Jahangiri A, Moghaddam FR, Najafi S. Hypertonic dextrose versus corticosteroid local injection for the treatment of osteoarthritis in the first carpometacarpal joint: a double-blind randomized clinical trial. *J Orthop Sci*. 2014;19(5):737-43.
1665. Atroshi I, Axelsson G, Nilsson E-L. Osteotomy versus tendon arthroplasty in trapeziometacarpal arthrosis 17 patients followed for 1 year. *Acta Orthop*. 1998;69(3):287-90.
1666. Belcher HJ, Nicholl JE. A comparison of trapeziectomy with and without ligament reconstruction and tendon interposition. *J Hand Surg [Br]*. 2000;25(4):350-6.
1667. Davis T, Brady O, Barton N, Lunn P, Burke F. Trapeziectomy Alone, with Tendon Interposition or with Ligament Reconstruction? A randomized prospctive study. *Journal of Hand Surgery (British and European Volume)*. 1997;22(6):689-94.
1668. Field J, Buchanan D. To suspend or not to suspend: a randomised single blind trial of simple trapeziectomy versus trapeziectomy and flexor carpi radialis suspension. *J Hand Surg Eur Vol*. 2007;32(4):462-6.
1669. Gibbons C, Gosal H, Choudri A, Magnussen P. Trapeziectomy for basal thumb joint osteoarthritis: 3-to 19-year follow-up. *Int Orthop*. 1999;23(4):216-8.
1670. Horlock N, Belcher HJ. Early versus late mobilisation after simple excision of the trapezium. *J Bone Joint Surg Br*. 2002;84(8):1111-5.
1671. Manske PR. Commentary: Excision of the trapezium. *J Hand Surg Am*. 2004;29(6):1078-9.
1672. Nilsson A, Liljensten E, Bergström C, Sollerman C. Results from a degradable TMC joint spacer (Artelon) compared with tendon arthroplasty. *J Hand Surg Am*. 2005;30(2):380-9.
1673. Tagil M, Kopylov P. Swanson versus APL arthroplasty in the treatment of osteoarthritis of the trapeziometacarpal joint: a prospective and randomized study in 26 patients. *J Hand Surg [Br]*. 2002;27(5):452-6.
1674. Wajon A, Ada L, Edmunds I. Surgery for thumb (trapeziometacarpal joint) osteoarthritis. *Cochrane Database Syst Rev*. 2005(4):CD004631.
1675. De Smet L, Sioen W, Spaepen D, van Ransbeeck H. Treatment of basal joint arthritis of the thumb: trapeziectomy with or without tendon interposition/ligament reconstruction. *Hand Surg*. 2004;9:5-9.
1676. De Smet L, Vanfleteren L, Sioen W, Spaepen D, Van Ransbeeck H. Ligament reconstruction/tendon interposition arthroplasty for thumb basal joint osteoarthritis preliminary results of a prospective outcome study. *Acta Orthop Belg*. 2002;68(1):20-3.
1677. Vandenbroucke J, De Schrijver F, De Smet L, Fabry G. Simple trapezectomy for treatment of trapeziometacarpal osteoarthritis of the thumb. *Clin Rheumatol*. 1997;16(3):239-42.

Copyright© 2016 Reed Group, Ltd.

1678. Young BT, Rayan GM. Arthroplasty for trapeziometacarpal arthrosis. *J Okla State Med Assoc*. 1998;91(2):53-9.
1679. Chung KC, Burns PB, Wilgis EF, et al. A multicenter clinical trial in rheumatoid arthritis comparing silicone metacarpophalangeal joint arthroplasty with medical treatment. *J Hand Surg Am*. 2009;34(5):815-23.
1680. Kenniston J, Bozentka D. Treatment of advanced carpometacarpal joint disease: arthrodesis. *Hand Clin*. 2008;24(3):285-94.
1681. Pettersson K, Wagnsjo P, Hulin E. Replacement of proximal interphalangeal joints with new ceramic arthroplasty: a prospective series of 20 proximal interphalangeal joint replacements. *Scand J Plast Reconstr Surg Hand Surg*. 2006;40(5):291-6.
1682. Davis T, Pace A. Trapeziectomy for trapeziometacarpal joint osteoarthritis: is ligament reconstruction and temporary stabilisation of the pseudarthrosis with a Kirschner wire important? *Journal of Hand Surgery (European Volume)*. 2009;34(3):312-21.
1683. Davis TR, Brady O, Dias JJ. Excision of the trapezium for osteoarthritis of the trapeziometacarpal joint: a study of the benefit of ligament reconstruction or tendon interposition. *J Hand Surg [Am]*. 2004;29(6):1069-77.
1684. Delaney R, Trail IA, Nuttall D. A comparative study of outcome between the Neuflex and Swanson metacarpophalangeal joint replacements. *J Hand Surg [Br]*. 2005;30(1):3-7.
1685. McArthur P, Milner R. A prospective randomized comparison of Sutter and Swanson silastic spacers. *Journal of Hand Surgery (British and European Volume)*. 1998;23(5):574-7.
1686. Moller K, Sollerman C, Geijer M, Kopylov P, Tagil M. Avanta versus Swanson silicone implants in the MCP joint--a prospective, randomized comparison of 30 patients followed for 2 years. *J Hand Surg [Br]*. 2005;30(1):8-13.
1687. Sollerman C, Geijer M. Polyurethane versus silicons for endoprosthetic replacement of the metacarpophalangeal joints in rheumatoid arthritis. *Scandinavian Journal of Plastic and Reconstructive Surgery and Hand Surgery*. 1996;30(2):145-50.
1688. Kriegs-Au G, Petje G, Fojtl E, Ganger R, Zachs I. Ligament reconstruction with or without tendon interposition to treat primary thumb carpometacarpal osteoarthritis. A prospective randomized study. *J Bone Joint Surg Am*. 2004;86-A(2):209-18.
1689. Ulrich-Vinther M, Puggaard H, Lange B. Prospective 1-year follow-up study comparing joint prosthesis with tendon interposition arthroplasty in treatment of trapeziometacarpal osteoarthritis. *J Hand Surg [Am]*. 2008;33(8):1369-77.
1690. Prosser R, Hancock MJ, Nicholson L, Merry C, Thorley F, Wheen D. Rigid versus semi-rigid orthotic use following TMC arthroplasty: a randomized controlled trial. *J Hand Ther*. 2014;27(4):265-70; quiz 71.
1691. Blair WF, Steyers CM. Extensor tendon injuries. *Orthop Clin North Am*. 1992;23(1):141-8.
1692. Bury TF, Akelman E, Weiss AP. Prospective, randomized trial of splinting after carpal tunnel release. *Ann Plast Surg*. 1995;35(1):19-22.
1693. Martins RS, Siqueira MG, Simplicio H. Wrist immobilization after carpal tunnel release: a prospective study. *Arq Neuropsiquiatr*. 2006;64(3A):596-9.
1694. Cook AC, Szabo RM, Birkholz SW, King EF. Early mobilization following carpal tunnel release. A prospective randomized study. *J Hand Surg [Br]*. 1995;20(2):228-30.
1695. Crowley TP, Stevenson S, Taghizadeh R, Addison P, Milner RH. Early active mobilization following UCL repair With Mitek bone anchor. *Tech Hand Up Extrem Surg*. 2013;17(3):124-7.
1696. Germann G, Wagner H, Blome-Eberwein S, Karle B, Wittemann M. Early dynamic motion versus postoperative immobilization in patients with extensor indicis proprius transfer to restore thumb extension: a prospective randomized study. *J Hand Surg Am*. 2001;26(6):1111-5.
1697. Hermann M, Nilsen T, Eriksen CS, Slatkowsky-Christensen B, Haugen IK, Kjeken I. Effects of a soft prefabricated thumb orthosis in carpometacarpal osteoarthritis. *Scand J Occup Ther*. 2014;21(1):31-9.
1698. Jerosch-Herold C, Shepstone L, Chojnowski AJ, Larson D, Barrett E, Vaughan SP. Night-time splinting after fasciectomy or dermo-fasciectomy for Dupuytren's contracture: a pragmatic, multi-centre, randomised controlled trial. *BMC Musculoskelet Disord*. 2011;12136.
1699. Sillem H, Backman CL, Miller WC, Li LC. Comparison of two carpometacarpal stabilizing splints for individuals with thumb osteoarthritis. *J Hand Ther*. 2011;24(3):216-25; quiz 126; discussion 227-30.
1700. Rocchi L, Merolli A, Morini A, Monteleone G, Foti C. A modified spica-splint in postoperative early-motion management of skier's thumb lesion: a randomized clinical trial. *Eur J Phys Rehabil Med*. 2014;50(1):49-57.
1701. Sen S, Ugur B, Aydin ON, Ogurlu M, Gezer E, Savk O. The analgesic effect of lornoxicam when added to lidocaine for intravenous regional anaesthesia. *Br J Anaesth*. 2006;97(3):408-13.
1702. Ashworth HL, Ong C, Seed PT, Venn PJ. The influence of timing and route of administration of intravenous ketorolac on analgesia after hand surgery. *Anaesthesia*. 2002;57(6):535-9.
1703. Cornesse D, Senard M, Hans GA, et al. Comparison between two intraoperative intravenous loading doses of paracetamol on pain after minor hand surgery: two grams versus one gram. *Acta Chir Belg*. 2010;110(5):529-32.

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1704. Jankovic RJ, Visnjic MM, Milic DJ, Stojanovic MP, Djordjevic DR, Pavlovic MS. Does the addition of ketorolac and dexamethasone to lidocaine intravenous regional anesthesia improve postoperative analgesia and tourniquet tolerance for ambulatory hand surgery? *Minerva Anestesiol*. 2008;74(10):521-7.
1705. Reuben SS, Steinberg RB, Kreitzer JM, Duprat KM. Intravenous regional anesthesia using lidocaine and ketorolac. *Anesth Analg*. 1995;81(1):110-3.
1706. Rawal N, Allvin R, Amilon A, Ohlsson T, Hallen J. Postoperative analgesia at home after ambulatory hand surgery: a controlled comparison of tramadol, metamizol, and paracetamol. *Anesth Analg*. 2001;92(2):347-51.
1707. Sai S, Fujii K, Hiranuma K, Sato T, Nemoto T. Preoperative ampiroxicam reduces postoperative pain after hand surgery. *J Hand Surg Br*. 2001;26(4):377-9.
1708. Spagnoli AM, Rizzo MI, Palmieri A, Sorvillo V, Quadrini L, Scuderi N. A single blind controlled comparison of tramadol/paracetamol combination and paracetamol in hand and foot surgery. A prospective study. *In Vivo*. 2011;25(2):291-5.
1709. Jeffrey SL, Belcher HJ. Use of Arnica to relieve pain after carpal-tunnel release surgery. *Altern Ther Health Med*. 2002;8(2):66-8.
1710. Hochberg J. A randomized prospective study to assess the efficacy of two cold-therapy treatments following carpal tunnel release. *J Hand Ther*. 2001;14(3):208-15.
1711. Pomerance J, Fine I. Outcomes of carpal tunnel surgery with and without supervised postoperative therapy. *J Hand Surg Am*. 2007;32(8):1159-63.
1712. Dilek B, Gozum M, Sahin E, et al. Efficacy of paraffin bath therapy in hand osteoarthritis: a single-blinded randomized controlled trial. *Arch Phys Med Rehabil*. 2013;94(4):642-9.
1713. Field T, Diego M, Delgado J, Garcia D, Funk CG. Hand pain is reduced by massage therapy. *Complement Ther Clin Pract*. 2011;17(4):226-9.
1714. Giessler GA, Przybilski M, Germann G, Sauerbier M, Megerle K. Early free active versus dynamic extension splinting after extensor indicis proprius tendon transfer to restore thumb extension: a prospective randomized study. *J Hand Surg Am*. 2008;33(6):864-8.
1715. Guzelkucuk U, Duman I, Taskaynatan MA, Dincer K. Comparison of therapeutic activities with therapeutic exercises in the rehabilitation of young adult patients with hand injuries. *J Hand Surg Am*. 2007;32(9):1429-35.
1716. Krischak GD, Krasteva A, Schneider F, Gulkin D, Gebhard F, Kramer M. Physiotherapy after volar plating of wrist fractures is effective using a home exercise program. *Arch Phys Med Rehabil*. 2009;90(4):537-44.
1717. Mitsukane M, Sekiya N, Himei S, Oyama K. Immediate effects of repetitive wrist extension on grip strength in patients with distal radial fracture. *Arch Phys Med Rehabil*. 2015;96(5):862-8.
1718. Rath S, Selles RW, Schreuders TA, Stam HJ, Hovius SE. A randomized clinical trial comparing immediate active motion with immobilization after tendon transfer for claw deformity. *J Hand Surg Am*. 2009;34(3):488-94, 94 e1-5.
1719. Rostami HR, Arefi A, Tabatabaei S. Effect of mirror therapy on hand function in patients with hand orthopaedic injuries: a randomized controlled trial. *Disabil Rehabil*. 2013;35(19):1647-51.
1720. Souer JS, Buijze G, Ring D. A prospective randomized controlled trial comparing occupational therapy with independent exercises after volar plate fixation of a fracture of the distal part of the radius. *J Bone Joint Surg Am*. 2011;93(19):1761-6.
1721. Atherton WG, Faraj AA, Riddick AC, Davis TR. Follow-up after carpal tunnel decompression - general practitioner surgery or hand clinic? A randomized prospective study. *J Hand Surg [Br]*. 1999;24(3):296-7.
1722. Rasotto C, Bergamin M, Simonetti A, et al. Tailored exercise program reduces symptoms of upper limb work-related musculoskeletal disorders in a group of metalworkers: A randomized controlled trial. *Man Ther*. 2015;20(1):56-62.
1723. Naik V, Chitra J, Khatri S. Effectiveness of Maitland versus Mulligan mobilization technique following post surgical management of Colles' fracture - RCT. *Indian J Physiother Occup Ther*. 2007;1(4).
1724. Taylor N, Bennell K. The effectiveness of passive joint mobilisation on the return of active wrist extension following Colles' fracture: a clinical trial. *New Zealand J Phsysiother*. 199424-8.
1725. Freshwater M. Chapter 90: Dupuytren's Disease. *Thorne CH Grabb and Smith's Plastic Surgery, Sixth Edition*: Lippincott Williams & Wilkins; 2007.
1726. Brenner P, Mailänder P, Berger A. Epidemiology of Dupuytren's disease. *Dupuytren's disease*: Springer; 1994:244-54.
1727. Early P. Population studies in Dupuytren's contracture. *Journal of Bone & Joint Surgery, British Volume*. 1962;44(3):602-13.
1728. Rafter D, Kenny R, Gilmore M, Walsh C. Dupuytren's contracture--a survey of a hospital population. *Irish medical journal*. 1980;73(6):227-8.
1729. Ross DC. Epidemiology of Dupuytren's disease. *Hand Clin*. 1999;15(1):53-62, vi.
1730. Strickland JW, Idler RS, Creighton JC. Dupuytren's disease. *Indiana Med*. 1990;83(6):408-9.

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1731. Ullah AS, Dias JJ, Bhowal B. Does a 'firebreak' full-thickness skin graft prevent recurrence after surgery for Dupuytren's contracture?: a prospective, randomised trial. *J Bone Joint Surg Br*. 2009;91(3):374-8.
1732. van Rijssen AL, Gerbrandy FS, Ter Linden H, Klip H, Werker PM. A comparison of the direct outcomes of percutaneous needle fasciotomy and limited fasciectomy for Dupuytren's disease: a 6-week follow-up study. *J Hand Surg Am*. 2006;31(5):717-25.
1733. Bulstrode NW, Bisson M, Jemec B, Pratt AL, McGrouther DA, Grobbelaar AO. A prospective randomised clinical trial of the intra-operative use of 5-fluorouracil on the outcome of dupuytren's disease. *J Hand Surg Br*. 2004;29(1):18-21.
1734. Lucas G, Brichet A, Roquelaure Y, Leclerc A, Descatha A. Dupuytren's disease: personal factors and occupational exposure. *Am J Ind Med*. 2008;51(1):9-15.
1735. Hurst LC, Badalamente MA. Nonoperative treatment of Dupuytren's disease. *Hand Clin*. 1999;15(1):97-107, vii.
1736. Seegenschmiedt MH, Olschewski T, Guntrum F. Radiotherapy optimization in early-stage Dupuytren's contracture: first results of a randomized clinical study. *Int J Radiat Oncol Biol Phys*. 2001;49(3):785-98.
1737. Badalamente MA, Hurst LC. Efficacy and safety of injectable mixed collagenase subtypes in the treatment of Dupuytren's contracture. *J Hand Surg Am*. 2007;32(6):767-74.
1738. Badalamente MA, Hurst LC, Hentz VR. Collagen as a clinical target: nonoperative treatment of Dupuytren's disease. *J Hand Surg Am*. 2002;27(5):788-98.
1739. Witthaut J, Bushmakin AG, Gerber RA, Cappelleri JC, Le Graverand-Gastineau MP. Determining clinically important changes in range of motion in patients with Dupuytren's Contracture: secondary analysis of the randomized, double-blind, placebo-controlled CORD I study. *Clin Drug Investig*. 2011;31(11):791-8.
1740. Gilpin D, Coleman S, Hall S, Houston A, Karrasch J, Jones N. Injectable collagenase Clostridium histolyticum: a new nonsurgical treatment for Dupuytren's disease. *J Hand Surg Am*. 2010;35(12):2027-38 e1.
1741. Hurst LC, Badalamente MA, Hentz VR, et al. Injectable collagenase clostridium histolyticum for Dupuytren's contracture. *N Engl J Med*. 2009;361(10):968-79.
1742. Mickelson DT, Noland SS, Watt AJ, Kollitz KM, Vedder NB, Huang JI. Prospective randomized controlled trial comparing 1- versus 7-day manipulation following collagenase injection for dupuytren contracture. *J Hand Surg Am*. 2014;39(10):1933-41 e1.
1743. U.S. Food and Drug Administration. Joint Meeting of the Drug Safety and Risk Management Advisory Committee with the Anesthetic and Life Support Drugs Advisory Committee and the Nonprescription Drugs Advisory Committee 2009.
1744. Citron ND, Nunez V. Recurrence after surgery for Dupuytren's disease: a randomized trial of two skin incisions. *J Hand Surg Br*. 2005;30(6):563-6.
1745. Mäkelä E, Jaroma H, Harju A, Anttila S, Vainio J. Dupuytren's contracture: the long-term results after day surgery. *The Journal of Hand Surgery: British & European Volume*. 1991;16(3):272-4.
1746. Rodrigo J, Niebauer J, Brown R, Doyle J. Treatment of Dupuytren's contracture. Long-term results after fasciotomy and fascial excision. *The Journal of Bone & Joint Surgery*. 1976;58(3):380-7.
1747. Tonkin M, Burke F, Varian J. Dupuytren’s contracture: a comparative study of fasciectomy and dermofasciectomy in one hundred patients. *Journal of Hand Surgery (British and European Volume)*. 1984;9(2):156-62.
1748. Bhatia R, Blackshaw G, Barr V, Savage R. Comparative study of "staples versus sutures" in skin closure following Dupuytren's surgery. *J Hand Surg Br*. 2002;27(1):53-4.
1749. Kan HJ, Selles RW, van Nieuwenhoven CA, Zhou C, Khouri RK, Hovius SE. Percutaneous Aponeurotomy and Lipofilling (PALF) versus Limited Fasciectomy in Patients with Primary Dupuytren's Contracture: A Prospective, Randomized, Controlled Trial. *Plast Reconstr Surg*. 2016;137(6):1800-12.
1750. Kemler MA, Houpt P, van der Horst CM. A pilot study assessing the effectiveness of postoperative splinting after limited fasciectomy for Dupuytren's disease. *J Hand Surg Eur Vol*. 2012;37(8):733-7.
1751. McGrouther DA, Jenkins A, Brown S, Gerber RA, Szczypa P, Cohen B. The efficacy and safety of collagenase clostridium histolyticum in the treatment of patients with moderate Dupuytren's contracture. *Curr Med Res Opin*. 2014;30(4):733-9.
1752. van Rijssen AL, Werker PM. Percutaneous needle fasciotomy for recurrent Dupuytren disease. *J Hand Surg Am*. 2012;37(9):1820-3.
1753. Harris JS, Sinnott PL, Holland JP, et al. Methodology to update the practice recommendations in the American College of Occupational and Environmental Medicine's Occupational Medicine Practice Guidelines. *Journal of Occupational and Environmental Medicine*. 2008;50(3):282-95.

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