REVIEW ARTICLE

AN OSTEOPATHIC APPROACH TO CARPAL TUNNEL SYNDROME

Samantha N. Baxter, OMS-III, MS[1]; Alexandra C. Millhuff, OMS-II, BS[1]; Gautam J. Desai, DO, FACOFP *dist.*[1]; Dennis J. Dowling, MA, DO, FAAO[2]

[1]Kansas City University College of Osteopathic Medicine
[2]National Board of Osteopathic Medical Examiners

KEYWORDS:

Carpal tunnel syndrome

Median nerve

Neuropathy

OMT

Wrist

ABSTRACT:

Carpal tunnel syndrome (CTS) is a common cause of medical and workforce-related expenses in the United States. It is also frustrating for patients who have difficulty using the affected hand, impairing their activities of daily living and decreasing their quality of life. By utilizing the philosophy of osteopathic medicine, providers can better implement a treatment plan by working with the patient to find one that incorporates all aspects of the patient's environment. By using the practice of osteopathic manipulative therapy (OMT), osteopathic physicians can often effectively treat the patient's symptoms without side effects found in medications. This is especially useful in patients who may be unable to take certain medications, such as pregnant patients. Other treatment modalities are also reviewed in this manuscript.

INTRODUCTION

Carpal tunnel syndrome (CTS) is a common peripheral neuropathy caused by the median nerve's compression as it passes through the carpal tunnel. Symptoms of numbness, tingling and pain usually occur gradually in the hand's palmar surface and primarily affect the thumb, index finger, middle finger, and ring finger. Severe symptoms include the impaired motor function of the wrist and hand and weakened grip. CTS is primarily an overuse injury of the hand or wrist but is also associated with systemic disorders such as pregnancy, obesity, diabetes mellitus and hypothyroidism. It also may be caused by trauma.[1]

CTS has been associated with reduced quality of life. It mainly affects middle-aged adults, although children can be affected as well. Because CTS is especially common for working adults, it is associated with decreased productivity, psychological distress and overall lower quality of life due to poor hand function and discomfort. This results in increased financial burden and healthcare costs for patients suffering from CTS, with an estimated $45,000–$89,000 income loss per CTS patient over 6 years and the total cost associated with CTS in the United States passing $2 billion annually.[2,3] Surgery is among the most used interventions, which further increases CTS's economic toll and delays patients' ability to return to work.

The authors believe that osteopathic manipulative treatment (OMT) may have an effective role in treating CTS and could decrease the economic and lifestyle burdens associated with the dysfunction. This article aims to explain the osteopathic findings of CTS and the manual approach to treatment.

EPIDEMIOLOGY

CTS is the most common peripheral neuropathy syndrome worldwide, with an incidence of 99/100,000 cases per year and a 7%–19% prevalence rate in the general population.[4–6] Most studies suggest that CTS occurs more commonly in women than men, having a frequency of 9.2% for women compared to 6% for men.[7] Incident rates for women peak between ages 45 and 54, although incidence rates continue to increase with age for men.[8] Certain systemic conditions are associated with an increased occurrence of CTS. Diabetics without neuropathy have a prevalence rate of 14%, and those with neuropathy have a 30% prevalence rate.[7] For pregnant women, the incidence of CTS has been reported up to 62%, likely due to hormonal and musculoskeletal changes.[9,10] The contributing factors to the development of CTS in hypothyroidism and the thyroid stimulating hormone's role are not clearly understood. It has been suggested that mucinous deposition onto the median nerve may increase the likelihood of CTS development, especially in combination with repetitive movements of the wrist.[11] Increased body mass index (BMI) due to hypothyroidism may also contribute to the development and severity of symptoms.

CORRESPONDENCE:
Gautam J. Desai, DO, FACOFP *dist.* | gdesai@kansascity.edu

 Print ISSN: 1877-573X
DOI: 10.33181/13054

SYMPTOMS

The main symptoms of CTS are caused by compression of the median nerve as it crosses the carpal tunnel. Patients typically complain of pain and a sensation of numbness in the distribution of the median nerve (the ipsilateral thumb, index, middle, and sometimes the radial half of the 4th finger). This distribution is variable in patients based on where the compression is occurring and their unique anatomy. Some patients may report worse symptoms at night, resulting in nighttime wakening. This may be temporarily ameliorated by shaking the hand or running water over the hand. Many patients report bilateral symptoms, although the severity may be different for each hand. Activities that involve flexion or extension at the wrist may exacerbate symptoms. Patients may describe difficulty in playing sports, cooking, typing or other activities. Some notice their manual dexterity has diminished on the affected side.[12]

RISK FACTORS

Although CTS affects a wide range of patients, it is particularly common in working-age adults due to repetitive hand use such as writing or typing. CTS is also associated with obesity, with an 8% increased risk of developing CTS for every 1 unit increase in BMI.[13] A small portion of CTS cases are correlated with endocrine disorders such as diabetes mellitus, hypothyroidism and acromegaly. Inflammation of the wrist due to trauma or inflammatory rheumatic disorders are also risk factors for developing CTS.[14]

ANATOMY

The carpal tunnel is located at the proximal palmar wrist, surrounded by carpal bones on the “floor” and “side walls” of the structure with the transverse carpal ligament composing the "roof" of the tunnel.

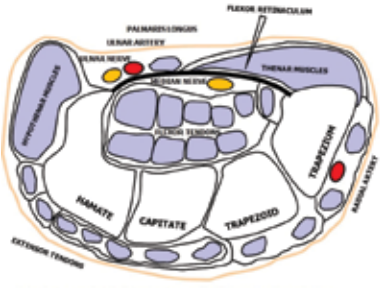
FIGURE 1:

Bones of the carpal tunnel

Its contents include 9 flexor tendons and the median nerve.

FIGURE 2:

Cross section of distal carpal tunnel

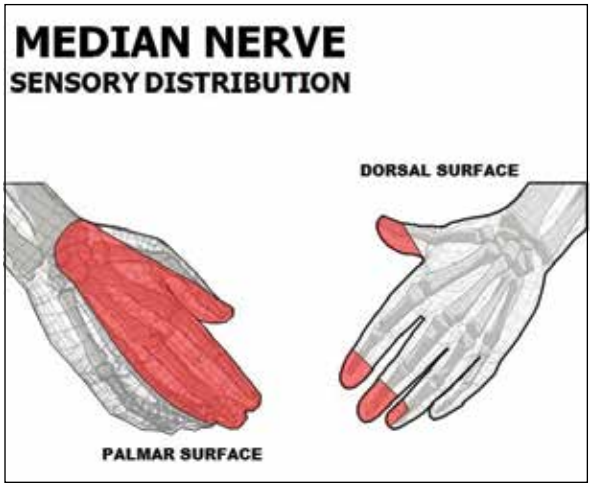


CROSS SECTION OF DISTAL ROW OF CARPAL TUNNEL

The median nerve supplies motor innervation to the thenar muscles and sensory innervation to the thumb, index finger, middle finger and radial side of the ring finger. Thus, entrapment of the median nerve in CTS patients is responsible for pain and paresthesia in these fingers and muscle weakness in pinching and other grasping maneuvers. Entrapment of the median nerve may arise from mechanical compression due to swollen flexor tendons or edema but can also be caused by other forms of injury, such as ischemic stress on the median nerve. Loss of sensation to the palm is usually spared in CTS because palmar cutaneous sensory branches of the median nerve typically branch proximal to where the nerve passes through the carpal tunnel. Hence, entrapment of the median nerve within the carpal tunnel characteristically affects the sensation of the radial 3½ fingers but not the palm.[15,16]

FIGURE 3:

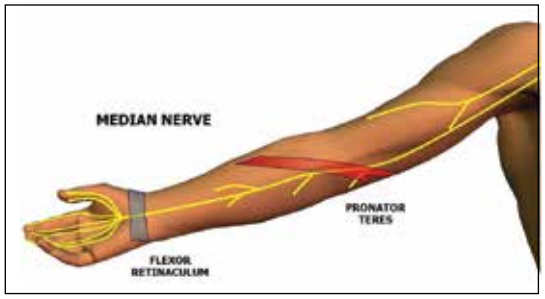
Median nerve distribution



Symptoms that affect the medial side of the 4th finger should raise suspicion of ulnar nerve compromise that could originate in the Guyon canal, between the olecranon and the medial epicondyle or higher.

FIGURE 4:

Median nerve path



Dorsal symptoms should also lead to the possibility of radial nerve involvement. Palpatory findings of the skin or subcutaneous changes and observation of Dupuytren’s contractures may indicate fascial and ligamentous thickenings that would narrow the volume, especially at the flexor retinaculum. Localized pain on movement

may also include suspicion of other clinical phenomena, such as tendinitis, tenosynovitis, ganglion cysts, arthritis trigger fingers, etc. Any condition that results in weakness (eg, multiple sclerosis, amyotrophic lateral sclerosis, Guillain-Barré syndrome), pain and swelling (eg, Raynaud's syndrome, systemic lupus erythematosus, gout) or space-occupying lesions (eg, amyloidosis, lipomas), and more central neurological impairment (eg, stroke, Parkinsonism, spinal cord compression, brachial plexopathy, thoracic outlet syndrome) and other musculoskeletal conditions (eg, Charcot-Marie-Tooth disease, complex regional pain syndrome, fibromyalgia) may contribute to or mimic elements of CTS. The determination of one of these diagnoses does not exclude the possibility that several neuromusculoskeletal problems may be occurring simultaneously.

PATHOPHYSIOLOGY

As the median nerve passes through the carpal tunnel, it is at risk for compression and subsequent ischemic damage. Unlike the normal pressure of 5 mm Hg in the carpal tunnel at rest, activities like typing increase the pressure to a level high enough that blood flow to the nerve is impaired and the risk for ischemia increases.[17] As the pressure continues to rise, ischemia transitions from a transient phenomenon to one that causes more permanent damage to the nerve. The pattern of damage begins with sensory demyelination, which then progresses to motor demyelination; ultimately, the loss of functioning of the axons of sensory and motor branches will result and the patient's symptoms will progress.[17] The loss of neuronal input to the hand and wrist muscles leads to sensory loss in the distribution of the median nerve and motor axon involvement contributes to atrophy of muscles innervated by the affected nerve and its branches. This damage is responsible for the pain, tingling and weakness experienced by the patient. Other causes of ischemia include stretching or thickening of connective tissue in the carpal tunnel that impinges on the median nerve.[17] Thenar eminence atrophy and subsequent hand weakness are late complications of severe carpal tunnel syndrome that is inadequately treated or for which the patient has not sought timely evaluation and treatment.[18]

CORRELATION WITH PREGNANCY

During pregnancy, hormonal changes or the onset of lactation alters the fluid distribution among the compartments in the body and puts the patient at greater risk for median nerve compression. Although it is commonly believed that CTS is most prevalent during the third trimester, a woman can develop it at any time during the pregnancy or post-delivery. The persistence of symptoms postpartum may contribute to increased retreatment rates among pregnant women compared to nonpregnant patients. Early treatment should focus on conservative measures, such as splinting and/or injections; neuropathic pain medications are to be avoided to prevent effects on fetus development.[18] Sometimes, patients experience gradual improvement without interventions. If symptoms persist postpartum, surgical decompression may be pursued.

PHYSICAL EXAM AND SPECIAL TESTS

A complete physical examination will include evaluating the upper extremity, including the glenohumeral joint, elbow, wrist and hand. There can be single, double, triple and even quadruple "crush" phenomena contributing to the clinical condition. This phenomenon occurs when the nerve is compressed in more than one location, which can cause symptoms in other regions as well. The neck should also be examined to rule out other causes of symptoms, such as cervical radiculopathy or stenosis, affecting the nerve roots that contribute to forming the median nerve at a more proximal location.[19] Muscular strength testing and 2-point discrimination may also be performed to assess nerve function and distribution through the arm. Asymmetry of elicited tendon reflexes, including the triceps, biceps and brachioradialis, may contribute to refining the diagnosis. Special orthopedic tests for carpal tunnel syndrome include the Phalen maneuver (and reverse Phalen) and Tinel's sign at the wrist.

Phalen's maneuver: The patient's forearms are held parallel to the ground and instructed to place the posterior aspects of both hands against each other perpendicular to the forearms. Positive: reproduction of the symptoms in the median nerve distribution in a minute or less.

Reverse Phalen's maneuver: The patient's forearms are held parallel to the ground and instructed to place the anterior aspects (palms) of both hands against each other perpendicular to the forearms ("prayer" position). Positive: reproduction of the symptoms in the median nerve distribution in a minute or less.

FIGURE 5A:

Phalen's maneuver

FIGURE 5B:

Reverse Phalen's maneuver

FIGURE 6:

Tinel test

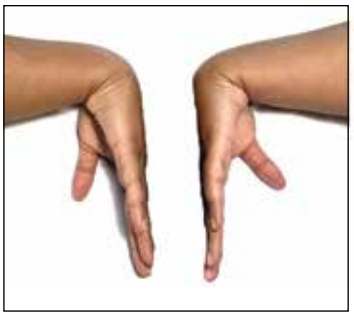
Tinel test: The patient's hand is in the supinated position and the physician taps vigorously with fingertips or reflex hammer over the median nerve in the region of the flexor retinaculum. Positive: reproduction of the symptoms in the median nerve distribution).

When compressing the median nerve over the carpal tunnel using Durkan's test, if symptoms are elicited within 30 seconds after the maneuver's induction, it is both a sensitive and specific test.[19] The carpal tunnel sign with the patient orienting the wrists at 90 degrees flexion may reproduce the symptoms.

Carpal tunnel sign: The patient's forearms are held parallel to the ground and instructed to place both hands at 90 degrees of flexion to the forearms. Positive test: reproduction of the symptoms in the median nerve distribution in a minute or less)

FIGURE 7:

Carpal tunnel sign



Nighttime pain and the flick maneuver are also indicators of CTS that can be obtained from the patient's history. Polyneuropathies and osteoarthritis must also be ruled out as causes for the presenting symptoms.[12] In addition, any test that places stress on the median nerve as it passes through the wrist may be used to diagnose CTS. Manual dexterity maneuvers, such as Froment's sign, the bottle sign, the nail sign and Ochsner's clasping test, may demonstrate movement deficits.

Froment's sign: The patient is instructed to grip a piece of paper between the thumb and radial side of the index finger. The physician attempts to pull the paper. Positive test: the patient will use the flexor pollicis longus (median nerve innervation) to flex the thumb interphalangeal joint as a substitute for a weakened adductor pollicis muscle, indicating ulnar nerve pathology.

FIGURE 8A:

Normal Froment's sign

FIGURE 8B:

Abnormal Froment's sign

Bottle sign: The patient is instructed to grip a bottle. Positive test: the inability to completely contour to the rounded surface of the bottle indicates palsy of the median nerve.

FIGURE 9A:

Normal bottle sign

FIGURE 9B:

Abnormal bottle sign

Nail sign: The patient is instructed to touch the tips of the nails of the thumb and index finger. Positive test: the inability to perform the maneuver indicates median nerve involvement.

FIGURE 10A:

Normal nail sign

FIGURE 10B:

Abnormal nail sign

Ochsner's clasping test: The patient is instructed to interlace the fingers of both hands. Positive: the index finger on the side of median nerve involvement will be unable to flex and will protrude.

FIGURE 11:

Ochsner's clasping test

Other pathologies, such as vascular circulation, should be addressed with the application of the Adson's and Allen tests. Adson's test involves having the patient extend and abduct their arm, then turn their head to the side being tested. A positive test is one with a diminished radial pulse due to compression of the subclavian artery by a cervical rib/muscle. The Allen test involves compressing the radial and ulnar arteries simultaneously, then, when the hand is pale, releasing pressure on one artery at a time to check for blood flow from each source. During examination, cervical etiology can be screened through Spurling's test—cervical compression via a caudad force on top of the head while the patient is seated. A positive test is indicated by radicular pain down the patient's arm. Cervical distraction—pulling the head cephalad, relieving pressure on the cervical nerves—may also be used, a positive test being an improvement in symptoms. The Hoffman test, although not extremely sensitive, is very specific for upper motor neuron impingement. The examiner conducts this test by holding the middle finger loosely, then flicking down the patient's middle fingernail, allowing the finger to extend upward reflexively. A positive test occurs when there is flexion and adduction of the thumb on the same hand.

OFFICIAL DIAGNOSTIC CRITERIA/ DIAGNOSTIC TESTING

The diagnosis of carpal tunnel syndrome is made based primarily on clinical evidence and physical examination; therefore, a thorough history and physical examination are extremely important in diagnosing and managing CTS. Factors such as paresthesias, muscle weakness, 2-point discrimination, thenar eminence atrophy, and the results of special tests must be obtained to form the diagnosis. Diagnostic testing that may be employed before the initial evaluation of CTS in the clinical setting may include electrodiagnostic studies, magnetic resonance imaging (MRI), computed tomography and x-rays.[20] The decision to use diagnostic imaging ahead of a clinical diagnosis is dependent on the physician's preference and may or may not affect the decision to decompress the carpal tunnel surgically. Electromyography (EMG) and nerve conduction studies are employed after the patient is evaluated in the clinical setting and are not traditionally employed as prediagnostic testing. Generally, these tests are not recommended prior to 6–8 weeks following the onset of symptoms, due to the greater potential of false-negative findings. Most frequently performed at the same session, these tests may not be easily tolerated by patients for various reasons. The National Institute for Occupational Safety and Health recommends evaluating the ergonomics of the workspace to optimize working conditions and minimize the development of CTS. Vibration, repetitive flexion and extension maneuvers, and the length of time over which these types of motions are performed in various occupations were evaluated in relation to activity factors and determined to increase CTS's risk as a workplace injury.[21] During the initial evaluation of CTS in the clinical setting, ergonomic factors should be explored and discussed with the patient to better understand the potential mechanisms for the development of CTS.

EMG AND INDICATIONS

The use of EMG and other electrodiagnostic techniques is reserved for confirmation of a clinical diagnosis and the exclusion of other mononeuropathies or damage to the median nerve more proximally. Ultrasound and electrodiagnostic testing may be performed before surgical intervention to validate CTS diagnosis and predict outcomes post-procedure. In studies performed comparing the 2 modalities, it was determined that both ultrasound and EDT were sensitive in detecting CTS, with similar values for sensitivity and specificity between them.[22] The comparable values for these diagnostic procedures make them both likely options for use in patients with CTS who determine the need for surgical release. Their use may not exclude CTS but are helpful in the confirmation of the diagnosis. Ultrasound can be utilized concomitantly with injection treatments. In the absence of trauma, plain x-rays may not offer much assistance. CT scans may also be limited, other than being more sensitive for occult fractures, and may not sufficiently demonstrate soft tissue contribution as an etiology. The use of MRI without contrast may be useful and will be required if the treatment course includes surgery. However, sonography has fairly good accuracy in locating edema and other compressions of the median nerve.[23]

TREATMENT OPTIONS AND ORDER

Despite a wide variety of treatment options, there is no consensus on a CTS treatment that is universally accepted. Surgery is a common and effective treatment option for CTS, but other nonsurgical options are used, such as bracing, medications, stretching, physical therapy, osteopathic and other forms of manipulation, yoga, acupuncture, and herbals.

NON-SURGICAL APPROACHES

BRACING

Bracing may be used to immobilize the wrist of a CTS patient to relieve symptoms. The rationale for bracing is due to the observation that CTS symptoms tend to increase in severity with increased activity and improve after a period of inactivity. Symptoms may become more severe with activity due to increased carpal tunnel pressure associated with flexion and extension of the wrist. Thus, immobilizing the wrist in a neutral position can maximize space in the carpal tunnel and relieve some median nerve compression. Though some randomized controlled trials have shown that bracing alone is an effective CTS treatment,[24, 25] other studies have shown that splinting is not as effective as other treatment options such as surgery or is only effective in early phases of CTS.[26,27] Wrist splints may require adjustment to attain a custom-fitting to better facilitate proper positioning.

MEDICATIONS

Oral medications, such as nonsteroidal anti-inflammatory drugs (NSAIDs), are commonly used to treat CTS symptoms. Despite being widely used, NSAIDs have not been supported by any class 1 trial evidence for treating CTS but have been reported to improve symptoms in the short-term.[28] NSAID use may be discouraged or contraindicated in various conditions such as bleeding tendencies, liver damage, drug-drug interactions, pre-existing kidney or gastrointestinal (GI) injuries and diseases, and pregnancy. Acetaminophen may be the preferred drug for pain management in these specific cases but does not provide inflammatory improvement. Oral steroids may be used to treat CTS but similarly may only have short-term effects and should be used with caution in the presence of comorbid conditions such as diabetes mellitus.[29] It should be noted that narcotics are not indicated for pain management except in post-trauma patients. Local corticosteroid injections have shown to be more effective than oral medications but are also usually only effective in the short term. The injection site is typically on the wrist's anterior (volar) aspect, just adjacent to the median nerve. An ultrasound may be used to locate the injection site. A corticosteroid injection may include a mixture with one or more anesthetic agents (eg, lidocaine, bupivacaine) and is commonly performed by a specialist. Side effects may include nerve damage, joint infection or a temporary increase in blood sugar. It is speculated that the above medications mask the symptoms of CTS but do not resolve the pathology.[30]

STRETCHES/PHYSICAL THERAPY/OCCUPATIONAL THERAPY/YOGA

Yoga sessions that emphasize upper body stretching and relaxation techniques have been shown to improve short-term CTS symptoms. The effects of yoga may be partly due to the improvement of posture and exercise ability. However, yoga may not be an easily accessible option for many patients, as yoga studios can be expensive or not locally available. Given recent circumstances of the need to practice social distancing, there may not be the opportunity to be properly instructed in yoga practice. Physical therapy has also been a useful conservative treatment for CTS by having patient practice exercises for wrist mobility and strength. Physical therapists can also work with patients to develop more ergonomic postures and less likely to cause a CTS resurgence.[31] Modalities such as electric stimulation and therapeutic ultrasound may facilitate the reduction of edema and muscle contractions that contribute to the narrowing of the carpal tunnel space. Occupational therapy may be necessary in the rehabilitation of manual dexterity and strength as well, especially following surgery. Stretching is also a useful and easy treatment option for CTS patients, particularly myofascial self-stretching of the transverse carpal ligament. Self-stretching is also inexpensive and can be practiced independently at home by patients themselves.[32]

ACUPUNCTURE

Some patients may inquire about the efficacy of acupuncture, either traditional or laser acupuncture, to treat CTS. There are many types of acupuncture, and most involve the deliberate insertion of needles into specific points (acupoints) of the body. The theory is that the needles, either alone or with the addition of heat or electrical stimulation, may affect the body's life energy (qi, or chi). Some of the challenges of researching acupuncture are like the challenges inherent in researching osteopathic manipulative treatment (OMT). Each patient's treatment is typically individualized, making it difficult to have one specific treatment protocol. A recent Cochran review found that evidence is lacking to recommend the use of acupuncture for this condition, as many of the trials reviewed had small sample sizes and inconclusive results, especially for the long term.[33]

HERBAL THERAPIES AND SUPPLEMENTS

Patients may inquire about the use of supplements or phytochemicals, which they encounter when searching for "natural" remedies for CTS on the internet. Some websites recommend the use of vitamin B6, but that has not been shown to be of use in CTS patients who have no underlying deficiency. Many of the studies in the literature examining the use of different phytochemicals for CTS have inconclusive results or small sample sizes, and there are no herbal products that have been demonstrated to be efficacious or recommended with good evidence.[34]

SURGERY

Surgical decompression of the carpal tunnel should be pursued only when the patient has failed more conservative treatment measures. A surgical incision achieves decompression through the transverse carpal ligament. The risks of surgery include a

worsening of presenting symptoms; the possibility of needing a second surgery; persistent numbness; and complications from the procedure itself, including infection, scarring and loss of function. Pain along the incision site is the most commonly reported complication post-decompression.[35] The need for surgery is dependent upon the diagnostic factors and presenting symptoms and the patient's preference. The variability in development and progression of CTS makes it difficult to determine which patients will need surgery and which will only require more conservative methods for the resolution of symptoms. Traditionally, carpal tunnel release (CTR) was performed under general or intravenous (IV) anesthesia in an operating room, but many surgeons perform it as an outpatient procedure either in a surgical center or clinic.[36] During surgery, hydrodissection may be performed using ultrasound by injecting a mixture of corticosteroids and lidocaine between the transverse carpal ligament and the median nerve. This is done to break up adhesions and improve outcomes post-surgery, although the duration and usefulness of this procedure have not been fully explored.[37] CTR may be performed using a large palmar incision—a minimally invasive open technique—or endoscopic techniques. The formation of scar tissue has been proposed as a measure of success for patients undergoing CTR. Selection of technique should be based on the skill set, experience and preference of the surgeon performing the procedure. After CTR, the recovery period varies among patients and the procedure utilized, but patients may experience relief of symptoms as soon as a week, with a return to normal activities at 2 weeks.[19] Minimization of scar tissue and shorter incision lengths may lessen the risk of postoperative complications; the use of local anesthetic in minimally invasive procedures may also lessen risks by avoiding general anesthesia and the complications that may accompany it.[38] If the patient is hesitant about surgical decompression, a course of less invasive treatments may be prescribed beforehand to decrease symptoms and lessen the need for operative management.

PREOPERATIVE CONSIDERATIONS

Preoperative evaluations, including a physical examination performed by a primary care provider and clearance from other physicians, may be necessary for high-risk patients. Diabetic patients, patients with alcohol abuse disorders and elderly patients may experience less satisfactory outcomes due to surgical management, including recurrence of symptoms or dissatisfaction with outcomes.[39] Patients should be counseled about the risks of surgery before any procedure is performed. The percent of the reduction in numbness has been related to the patient's age and sex; in general, younger patients are more likely to have a greater reduction of symptoms than elderly patients.[39] However, the wide variability of CTR outcomes does not allow for the accurate prediction of symptom reduction in independent variables and should not be the guiding factor in determining whether a patient should undergo surgical management.

OTHER THERAPIES

Patients may ask about treatment with electrical stimulation, lasers or magnets. None of these has been proven to be effective in the treatment of CTS. Ergonomic evaluation and optimization may supplement other treatment modalities pursued by the patient and may decrease the likelihood of symptoms returning after treatment is completed.

OSTEOPATHIC MANIPULATIVE TREATMENT

Studies involving the efficacy of OMT are difficult to perform for a variety of reasons, including difficulty with performing blinded studies; the establishment of specific protocols, as OMT tends to be individualized; and patient preference to receive optimum treatment and to not be placed into randomized groupings. In addition, sham/placebo interventions may be too obvious, and, often, multiple other interventions have been attempted prior to and during courses of OMT. However, studies have been performed that demonstrated clinical, electrophysiological and radiological improvement following treatment.[40–42] Patients have even noted subjective improvement on the Boston Carpal Tunnel Syndrome Questionnaire, transverse carpal ligament length and a sensory symptom diagram that reaches statistical significance in the absence of electrodiagnostic and ultrasound evidence of improvement (eg, no cross-sectional area of the median nerve or transverse carpal ligament bowing).

In terms of the type of intervention and benefit/risk consideration, OMT falls on the spectrum alongside physical and occupational therapies, before injections and surgery. The goals of OMT are to reduce sympathetic input and spinal/rib restrictions though the upper thoracic, lower cervical and thoracic inlet regions; improve arthrodial mobility; reduce nerve compression as well as localized and regional edema; improve muscle and tendon contraction and dimensions; improve function; and reduce the patients' symptoms.[43,44] Treatment should address regions proximal and distal to the carpal tunnel as well.[45]

Treatment with OMT begins with a diagnosis of muscle strains, counterstrain tender points, fascial restriction reduction in passive and active ranges of motion, and specific arthrodial somatic dysfunctions (SD). Although noting asymmetry as one of the hallmarks of SD, bilateral CTS is fairly common and quality of reduction may be more important than quantity. It is also important to reassess the palpatory findings following treatment. The subjective response may be immediate or delayed.[43–53]

Counterstrain for pronator teres

- Clinical findings: tenderness at forearm distal to the popliteal crease; positive Durkan's test; positive Tinel's sign at pronator teres muscle; restriction in forearm supination, as the median nerve passes between the two muscular bellies of the pronator teres
- Monitoring: the physician monitors a tender point located over the pronator teres
- Patient position: seated or supine
- Physician position: standing or seated alongside the side of the finding

Method:

1. With the pad of 1 finger, the physician monitors the tender point throughout the whole procedure. Although the patient is to remain passive, they can note the level of tenderness at this point.
2. The patient's elbow is flexed to at least 90 degrees and pronated to an amount that significantly (greater than 70%) reduces the tenderness noted at the palpated tender point.
3. Flexion of the wrist can be added to shorten forearm flexors that share a common origin (medial epicondyle) with the pronator teres.
4. The position is held for 90 seconds or until tissue tension is noted to decrease.
5. The patient's arm is repositioned.
6. The tender point and regional restrictions are reassessed.

FIGURE 12:

Counterstrain for pronator teres

Muscle energy technique for a posterior radial head diagnosis

- Clinical findings: restriction in forearm supination and/or elbow extension; restriction of glide of the radial head on the capitulum; tenderness at the radial head (spasm of the pronator teres restricts supination)
- Monitoring: the physician monitors the radial head
- Patient position: seated or supine
- Physician position: standing or seated alongside the side of the finding

Method:

1. With the thumb and another finger, the physician grasps the radial head posteriorly and anteriorly.
2. The patient's elbow is extended and externally rotated to the physiological limit.
3. Extension of the wrist can be added as a means of lengthening forearm flexors that share a common origin (medial epicondyle) with the pronator teres, as well as shortening the forearm extensor muscles.
4. The patient is directed to supinate the forearm by flexing the elbow and turning the palm downwards for 3–5 seconds.
5. The physician provides isometric resistance throughout the patient's effort.
6. The patient is instructed to relax the effort for 3–5 seconds.
7. The patient's arm is repositioned to increase extension and supination, approaching the new barrier.
8. The procedure is repeated at least two additional times and is followed by new engagements of the barriers.
9. The range of motion of the regional restrictions and rotation of the radial head are reassessed.

FIGURE 13:

Radial head muscle energy technique

High-velocity low-amplitude (HVLA) for a posterior radial head diagnosis

- Clinical findings: restriction in forearm supination and/or elbow extension, restriction of glide of the radial head on the capitulum; tenderness at the radial head, as spasm of the pronator teres restricts supination
- Monitoring: the physician monitors the radial head
- Patient position: seated or supine
- Physician position: standing or seated alongside the side of the finding

Method:

1. With the thumb and another finger, the physician grasps the radial head posteriorly and anteriorly.
2. The patient's elbow is extended and externally rotated to the physiological limit.
3. Extension of the wrist can be added as a means of lengthening forearm flexors that share a common origin (medial epicondyle) with the pronator teres, as well as shortening the forearm extensor muscles.
4. The physician provides an anterior HVLA thrust of the radial head while simultaneously adding further supination and extension.

5. The patient's arm is repositioned to neutral.

6. The range of motion of the regional restrictions and rotation of the radial head are reassessed.

FIGURS 14:

Radial Head HVLA

Myofascial release of the wrist

- Clinical findings: restriction of wrist mobility, CTS symptoms and clinical findings
- Monitoring: the physician monitors the wrist with the fingers performing the maneuvers
- Patient position: seated or supine
- Physician position: standing or seated alongside the side of the finding

Method:

1. The patient's hand is parallel to the table or floor with the palm facing upward.
2. The physician places his 4th and 5th digits of one hand between the patient's 4th and 5th digits and the 4th and 5th digits of the other hand between the patient's 1st and 2nd digits. The physician's hands are relatively vertical with palms oriented toward each other.
3. Dorsiflexion/extension of the patient's wrist is introduced.
4. The physician's thumbs are placed on the lateral and medial attachments of the wrist flexor retinaculum (transverse carpal ligament).
5. Transverse distraction is applied to the flexor retinaculum by:
   a. Increasing the dorsiflexion by the physician lifting his 4th and 5th fingers;
   b. Separating the patient's 1st and 5th fingers laterally; and
   c. Utilizing the thumbs of both hands to introduce lateral stretching at both sides of the carpal tunnel.
6. This can be done as a single sustained effort while monitoring for a release of the soft tissue restriction or as a rhythmic, repetitive application.
7. If the dorsiflexion component exacerbates the patient's symptoms, this element can be skipped.
8. The dysfunction is reassessed.

FIGURE 15:

Myofascial release

Flexor retinaculum stretch

- Clinical findings: restriction of wrist mobility, CTS symptoms and clinical findings
- Monitoring: the physician monitors the wrist with the fingers performing the maneuvers
- Patient position: seated or supine
- Physician position: standing or seated alongside the side of the finding

Method:

1. The patient's hand is oriented parallel to the table or floor with the palm facing upward.
2. The physician places his hands and 2nd through 4th fingers on the patient's hand's underside/dorsum.
3. The physician's thumb pads are placed on the anterior wrist at the flexor retinaculum level at the center of the hand.
4. Dorsiflexion/extension of the patient's wrist is introduced.
5. The physician's thumbs are moved along the wrist in opposite directions laterally and medially toward the carpal attachments of the wrist flexor retinaculum (transverse carpal ligament).
6. Transverse distraction is repeatedly applied to the flexor retinaculum, utilizing both hands' thumbs to introduce lateral stretching at both sides of the carpal tunnel.
7. This can be done as a single sustained effort while monitoring for a release of the soft tissue restriction or, more commonly, as a rhythmic, repetitive application.
8. If the dorsiflexion component exacerbates the patient's symptoms, this element can be eliminated.
9. The dysfunction is reassessed.

FIGURE 16:

Flexor retinaculum spread

Counterstrain to the wrist

- Clinical findings: restriction of wrist mobility, CTS symptoms and clinical findings, tenderness of muscle tendon or ligament
- Monitoring: the physician monitors the wrist with the fingers performing the maneuvers
- Patient position: seated or supine
- Physician position: standing or seated alongside the side of the finding

Method:

1. With the pad of 1 finger, the physician monitors the tender point throughout the whole procedure. Although the patient is to remain passive, it is possible for them to note the level of tenderness at this point.
2. The patient's wrist is:
   a. Flexed if the tender point is on the ventral aspect;
   b. Extended if the tender point is on the dorsal surface;
   c. Deviated laterally if the tender point is on the radial side (extension or abduction of the thumb can facilitate positioning); or
   d. Directed medially if the tender point is on the ulnar region.
3. The position is adjusted to an amount that significantly (greater than 70%) reduces the tenderness noted at the palpated tender point.
4. Finger flexion, extension, abduction and/or adduction can be introduced to further modify the decrease in tension and tenderness.
5. The position is held for 90 seconds or until tissue tension is noted to decrease.
6. The patient's arm is repositioned.
7. The tender-point and regional restrictions are reassessed.

FIGURE 17:

Counterstrain wrist

Opponens roll technique

- Clinical findings: restriction of wrist mobility, CTS symptoms and clinical findings
- Monitoring: the physician monitors the wrist with the fingers and hands performing the maneuvers
- Patient position: seated or supine
- Physician position: standing or seated alongside the side of the finding

Method:

1. The physician grasps the patient's hypothenar region with one hand and the thenar thumb region with the other hand with the patient's hand's palm side upwards.
2. The physician then pulls the patient's thenar region laterally while simultaneously moving the thumb into extension to create traction.
3. The physician increases progressive stretch by further extending and abducting the opponens and abductor muscles.
4. This can be performed several times to increase the amount of stretch of the soft tissue.
5. The patient's hand is slowly released.
6. The regional restrictions are reassessed.

FIGURE 18:

Opponens roll

Carpal-carpal mobilization of the wrist

- Clinical findings: restriction of wrist mobility, CTS symptoms and clinical findings
- Monitoring: the physician monitors the wrist with the fingers and hands performing the maneuvers
- Patient position: seated or supine
- Physician position: standing or seated alongside the side of the finding

Method:

1. The physician places the palm of 1 hand against the dorsum of the patient's wrist and the palm of the other hand against the patient's ventral surface at the proximal carpal row, at approximately the distal wrist crease. The physician's hands are oriented perpendicular to the hand to be treated.
2. The physician then interlaces the fingers of both hands.
3. The physician introduces a mild compressive force with both hands.
4. The forces can be applied in such a manner as to be directed slightly offline and create flexion and extension at the carpo-radioulnar joints, the midcarpal joints and the carpo-metacarpal joints.
5. This is performed several times to create low-velocity, low-amplitude articulatory motions into the restricted joints.
6. The patient's hand is slowly released.
7. The regional restrictions are reassessed.

FIGURE 19:

Carpal-carpal mobilization of wrist

Lunate-carpal mobilization

- Clinical findings: restriction of wrist mobility, CTS symptoms and clinical findings, tenderness of muscle tendon or ligament
- Monitoring: the physician monitors the wrist with the fingers and hands performing the maneuvers
- Patient position: seated or supine (preferably)
- Physician position: standing or seated alongside the side of the finding

Method:

1. The physician places the thumbs of both hands overlapped against the dorsum of the patient's wrist at the proximal carpal row, at approximately the location of the lunate.
2. The physician's thenar and hypothenar eminences of both hands are wrapped around the wrists' medial and lateral edges.
3. The physician then interlaces the fingers of both hands over the anterior surface of the patient's wrist.
4. The physician introduces a mild compressive force with both hands, creating a bowing towards the center of the ventral wrist.
5. The patient is instructed to make a fist and flex at the wrist.
6. The physician further encourages the medial and lateral compression.
7. The patient is then instructed to extend the wrist while simultaneously opening the hand and abducting all fingers.
8. The physician introduces ventral glide of the lunate by pushing the overlapping thumb pads in a fulcrum-like fashion against the dorsum of the wrist.
9. This is performed several times to create low-velocity low-amplitude articulatory motions into the restricted joints.
10. The patient's hand is slowly released.
11. The regional restrictions are reassessed.

FIGURE 20A:

Lunate-carpal mobilization

FIGURE 20B:

Lunate-carpal mobilization

FIGURE 20C:

Lunate-carpal mobilization

FIGURE 20D:

Lunate-carpal mobilization

HVLA of the carpal joints

- Clinical findings: restriction of wrist mobility, CTS symptoms and clinical findings
- Monitoring: the physician monitors the wrist with the fingers and hands performing the maneuvers
- Patient position: seated or supine (preferably)
- Physician position: standing or seated alongside the side of the finding

Method:

1. The physician places the thumbs of both hands against the dorsum of the patient's wrist, bridging two adjacent carpal bones.
2. The physician's thenar and hypothenar eminences of both hands are wrapped around the medial and lateral edges of the 1st and 5th metacarpals and fingers.
3. The physician then interlaces the 2nd through 5th fingers of both hands firmly over the patient's palms' anterior surface.
4. The physician introduces a mild compressive force with both hands to spread the patient's metacarpals and carpals.
5. The physician introduces rapid articulatory ventral glide and separation of the restricted joint by creating a thrusting impulse that may be accompanied by wrist extension.
6. Other adjacent restricted joints can likewise be addressed.
7. The patient's hand is slowly released.
8. The regional restrictions are reassessed.

FIGURE 21:

HVLA initial

FIGURE 22:

HVLA final

SUMMARY

Carpal tunnel syndrome is the world's most common mononeuropathy, affecting a wide range of patients. Although various treatment options exist for CTS, there is no "one-size-fits-all" treatment plan upon which a physician can rely. By treating CTS in a stepwise fashion, beginning with more conservative measures before performing elective surgical decompression, physicians can tailor the treatment plan to the individual patient. Outcomes for therapies will vary depending on the patient's physiology, presentation, and personal preference. Physicians should approach the treatment and diagnosis of CTS as a team effort and work closely with the patient to form a therapeutic plan that will be most beneficial while encouraging increased treatment compliance. Encouraging questions, providing adequate education about available diagnosis and treatment options, having the patient participate in their treatment (eg, change in ergonomics, exercise, etc,) and giving guidance on which steps to take will contribute greatly to the positive outcomes of treatment.

AUTHOR DISCLOSURE(S)

No relevant financial affiliations or conflicts of interest. If the authors used any personal details or images of patients or research subjects, written permission or consent from the patient has been obtained. This work was not supported by any outside funding.

REFERENCES

1. Gül Yurdakul F, Bodur H, Öztop Çakmak Ö, *et al*. On the severity of carpal tunnel syndrome: diabetes or metabolic syndrome. *J Clin Neurol*. 2015;11(3):234-240. doi:10.3988/jcn.2015.11.3.234
2. Foley M, Silverstein B, Polissar N. The economic burden of carpal tunnel syndrome: long-term earnings of CTS claimants in Washington state. *Am J Ind Med*. 2007;50(3):155–172. doi:10.1002/ajim.20430
3. Stapleton MJ. Occupation and carpal tunnel syndrome. *ANZ J Surg*. 2006;76(6):494–496. doi:10.1111/j.1445-2197.2006.03770.x
4. Olney RK. Carpal tunnel syndrome: complex issues with a "simple" condition. *Neurology*. 2001;56(11):1431–1432. doi:10.1212/wnl.56.11.1431

5. von Schroeder HP, Botte MJ. Carpal tunnel syndrome. *Hand Clin*. 1996;12(4):643–655. PMID: 8953285
6. Ferry S, Pritchard T, Keenan J, Croft P, Silman AJ. Estimating the prevalence of delayed median nerve conduction in the general population. *Br J Rheumatol*. 1998;37(6):630–635. doi:10.1093/rheumatology/37.6.630
7. Ibrahim I, Khan WS, Goddard N, *et al*.Carpal tunnel syndrome: a review of the recent literature. *Open Orthop J*. 2012;6:69–76. doi:10.2174/1874325001206010069
8. Ashworth NL. Carpal tunnel syndrome. *Am Fam Physician*. 2016;94(10):830–831. PMID: 27929273
9. Padua L, Aprile I, Caliandro P, *et al*. Symptoms and neurophysiological picture of carpal tunnel syndrome in pregnancy. *Clin Neurophysiol*. 2001;112(10):1946–1951. doi:10.1016/s1388-2457(01)00637-x
10. Osterman M, Ilyas AM, Matzon JL. Carpal tunnel syndrome in pregnancy. *Orthop Clin North Am*. 2012;43(4):515–520. doi:10.1016/j.ocl.2012.07.020
11. Karne SS, Bhalerao NS. Carpal tunnel syndrome in hypothyroidism. *J Clin Diagn Res*. 2016;10(2):36–38. doi:10.7860/JCDR/2016/16464.7316
12. Padua L, Coraci D, Erra C, *et al*.. Carpal tunnel syndrome: clinical features, diagnosis, and management. *Lancet Neurol*. 2016;15(12):1273–1284. doi:10.1016/S1474-4422(16)30231-9
13. Nordstrom DL, Vierkant RA, DeStefano F, Layde PM. Risk factors for carpal tunnel syndrome in a general population. *Occup Environ Med*. 1997;54(10):734–740. doi:10.1136/oem.54.10.734
14. Solomon DH, Katz JN, Bohn R, Mogun H, Avorn J. Nonoccupational risk factors for carpal tunnel syndrome. *J Gen Intern Med*. 1999;14(5):310–314. doi:10.1046/j.1525-1497.1999.00340.x
15. Newington L, Harris EC, Walker-Bone K. Carpal tunnel syndrome and work. *Best Pract Res Clin Rheumatol*. 2015;29(3):440–453. doi:10.1016/j.berh.2015.04.026
16. Zamborsky R, Kokavec M, Simko L, *et al*. Carpal tunnel syndrome: symptoms, causes and treatment options. Literature review. *Ortop Traumatol Rehabil*. 2017;19(1):1–8. doi:10.5604/15093492.1232629
17. Wang L. Guiding treatment for carpal tunnel syndrome. *Phys Med Rehabil Clin N Am*. 2018;29(4):751–760. doi:10.1016/j.pmr.2018.06.009
18. Weimer LH. Neuromuscular disorders in pregnancy. *Handb Clin Neurol*. 2020;172:201–218. doi:10.1016/B978-0-444-64240-0.00012-X
19. Wipperman J, Goerl K. Carpal tunnel syndrome: diagnosis and management. *Am Fam Physician*. 2016;94(12):993–999. PMID: 28075090
20. Sears ED, Lu YT, Wood SM, et al. *Diagnostic testing requested before surgical evaluation for carpa*l tunnel syndrome. *J Hand Surg Am*. 2017;42(8):623–629. doi:10.1016/j.jhsa.2017.05.006
21. Putz-Anderson V, Bernard BP, Burt SE, *et al*. *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: 104.
22. Pimentel BFR, Faloppa F, Tamaoki MJS, Belloti JC. Effectiveness of ultrasonography and nerve conduction studies in the diagnosing of carpal tunnel syndrome: clinical trial on accuracy. *BMC Musculoskelet Disord*. 2018;19(1):115. doi:10.1186/s12891-018-2036-4
23. Sucher BM. Carpal tunnel syndrome: ultrasonographic imaging and pathologic mechanisms of median nerve compression. *J Am Osteopath Assoc*. 2009;109(12):641–647. doi:10.7556/jaoa.2009.109.12.641
24. 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):1020–1025. doi:10.1002/mus.1105
25. 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):448–459. doi:10.5014/ajot.2013.006031
26. Verdugo RJ, Salinas RA, Castillo JL, Cea JG. Surgical versus non-surgical treatment for carpal tunnel syndrome. *Cochrane Database Syst Rev*. 2008;2008(4):CD001552. doi:10.1002/14651858.CD001552.pub2
27. Uchiyama S, Itsubo T, Nakamura K, Kato H, Yasutomi T, Momose T. Current concepts of carpal tunnel syndrome: pathophysiology, treatment, and evaluation. *J Orthop Sci*. 2010;15(1):1–13. doi:10.1007/s00776-009-1416-x
28. Katz JN, Amick BC 3rd, Keller R, *et al*. Determinants of work absence following surgery for carpal tunnel syndrome. *Am J Ind Med*. 2005;47(2):120–130. doi:10.1002/ajim.20127
29. 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. doi:10.1016/j.apmr.2010.03.022
30. Huisstede BM, Randsdorp MS, van den Brink J, Franke TPC, Koes BW, Hoogvliet P. Effectiveness of oral pain medication and corticosteroid injections for carpal tunnel syndrome: a systematic review. *Arch Phys Med Rehabil*. 2018;99(8):1609–1622.e10. doi:10.1016/j.apmr.2018.03.003
31. Michlovitz SL. Conservative interventions for carpal tunnel syndrome. *J Orthop Sports Phys Ther*. 2004;34(10):589–600. doi:10.2519/jospt.2004.34.10.589
32. Shem K, Wong J, Dirlikov B. Effective self-stretching of carpal ligament for the treatment of carpal tunnel syndrome: a double-blinded randomized controlled study. *J Hand Ther*. 2020;33(3):272–280. doi:10.1016/j.jht.2019.12.002
33. Choi GH, Wieland LS, Lee H, Sim H, Lee MS, Shin BC. Acupuncture and related interventions for the treatment of symptoms associated with carpal tunnel syndrome. *Cochrane Database Syst Rev*. 2018;12(2):CD011215. doi:10.1002/14651858.CD011215.pub2
34. Kothari MJ. Carpal tunnel syndrome: clinical manifestations and diagnosis. *UpToDate*. 2020. Updated July 14, 2021. Accessed November 14, 2020. https://www.uptodate.com/contents/carpal-tunnelsyndrome-clinical-manifestations-and-diagnosis
35. Karl JW, Gancarczyk SM, Strauch RJ. Complications of carpal tunnel release. *Orthop Clin North Am*. 2016;47(2):425–433. doi:10.1016/j.ocl.2015.09.015
36. Calandruccio JH, Thompson NB. Carpal tunnel syndrome: making evidence-based treatment decisions. *Orthop Clin North Am*. 2018;49(2):223–229. doi:10.1016/j.ocl.2017.11.009
37. Wu YT, Chen SR, Li TY, *et al*. Nerve hydrodissection for carpal tunnel syndrome: a prospective, randomized, double-blind, controlled trial. *Muscle Nerve*. 2019;59(2):174–180. doi:10.1002/mus.26358
38. Yüce , Kahyaoğlu O, Çavuşoğlu H, Aydın Y. Minimally invasive open surgical approach and outcomes for carpal tunnel syndrome. *Sisli Etfal Hastan Tip Bul*. 2019;53(3):247–251. doi:10.14744/SEMB.2019.94759
39. Watchmaker JD, Watchmaker GP. Independent variables affecting outcome of carpal tunnel release surgery. *Hand* (N Y). 2017;13(3):1558944717703739. doi:10.1177/1558944717703739

40. Sucher BM. Palpatory diagnosis and manipulative management of carpal tunnel syndrome. *J Am Osteopath Assoc*. 1994;94(8);647–663. PMID: 7960973

41. Sucher BM. Myofascial manipulative release of carpal tunnel syndrome: documentation with MRI. *J Am Osteopath Assoc*. 1993;93(12);1273–1278. PMID: 8307807

42. Burnham T, Higgins DC, Burnham RS, Heath DM. Effectiveness of osteopathic manipulative treatment for carpal tunnel syndrome: a pilot project. *J Am Osteopath Assoc*. 2015;115(3):138–148. doi:10.7556/jaoa.2015.027

43. Heinking KP. Upper extremities. In: Chila AG. *Foundations of Osteopathic Medicine*. 3rd ed. Wolters Kluwer; 2011:640–659.

44. Elkiss ML, Heinking KP, Huby RJ, Fraix MP, Giusti RE. Osteopathic considerations in neurology. In: Seffinger MA. *Foundations of Osteopathic Medicine*. 4th ed. Wolters Kluwer; 2018:1258–1288.

45. Siu G, Jaffe JD, Rafique M, Weinik MM. Osteopathic manipulative medicine for carpal tunnel syndrome. *J Am Osteopath Assoc*. 2012;112(3):127–139. PMID: 22411967

46. Personal communication with Stefan Hagopian, DO, FAAO.

47. DiGiovanna EL, Dowling, DJ. Muscle energy treatment of the upper extremities. In: DiGiovanna EL, Schiowitz S, Dowling DJ. *An Osteopathic Approach to Diagnosis and Treatment*. 3rd ed. Lippincott Williams & Wilkins; 2004:433–443.

48. DiGiovanna EL. Counterstrain of the upper extremities. In: DiGiovanna EL, Schiowitz S, Dowling DJ. *An Osteopathic Approach to Diagnosis and Treatment*. 3rd ed. Lippincott Williams & Wilkins: 2004;436–441.

49. Schiowitz SL. Facilitated positional release of the upper extremities. In: DiGiovanna EL, Schiowitz S, Dowling DJ. *An Osteopathic Approach to Diagnosis and Treatment*. 3rd ed. Lippincott Williams & Wilkins: 2004;442–443.

50. DiGiovanna EL. Articulatory and thrusting techniques of the upper extremities. In: DiGiovanna EL, Schiowitz S, Dowling DJ. *An Osteopathic Approach to Diagnosis and Treatment*. 3rd ed. Lippincott Williams & Wilkins; 2004:444–451.

51. DiStefano LA. Upper extremity technique. In: *Greenman's Principles of Manual Medicine*. 5th ed. Wolters Kluwer: 2017;317–418.

52. Nicholas AS, Nicholas EA. *Atlas of Osteopathic Techniques*. Wolters Kluwer; 2008.

53. Funk, SL, Ed. *Outline of Osteopathic Manipulative Procedure: The Kimberly Manual*. 2000 ed. Walsworth Publishing Co.; 2000.

CALENDAR OF EVENTS

NOVEMBER 5–7, 2021
AOMA 41st Annual Fall Seminar
Arizona Osteopathic Medical Association
Virtual
azosteo.org

DECEMBER 3–5, 2021
IOA 40th Annual Winter Update
Indiana Osteopathic Association
Indianapolis, IN
inosteo.org

JANUARY 13–16, 2022
Midwinter Osteopathic Family Practice Conference
Iowa Chapter ACOFP
Hybrid
acofp-ia.org

JANUARY 20–23, 2022
Winter Family Medicine Update
Michigan Association of Osteopathic Family Physicians
Boyne Falls, MI
maofp.org

JANUARY 27–30, 2022
Winter Family Medicine Update
Missouri Society of the American College of Osteopathic Family Physicians
Columbia, MO
msacofp.org

MARCH 16, 2022
ACOFP Congress of Delegates
American College of Osteopathic Family Physicians
Dallas, TX
acofp.org

MARCH 17–20, 2022
ACOFP 59th Annual Convention & Scientific Seminars
American College of Osteopathic Family Physicians
Dallas, TX
acofp.org

CME Resource: *Osteopathic Family Physician* Offers 2 Hours of 1-B CME

ACOFP members who read Osteopathic Family Physician can receive two hours of Category 1-B continuing medical education credit for completing quizzes in the journal. Visit the eLearning center at www.acofp.org to access the quizzes.