Non-operative Treatment of Carpal Tunnel Syndrome

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Abstract

Purpose of Review To determine the current evidence for various non-operative therapies in the treatment of carpal tunnel syndrome

Recent Findings Multiple non-operative treatment modalities exist in the treatment of mild to moderate carpal tunnel syndrome. While certain modalities such as splinting and corticosteroid injections have moderate- to high-quality evidence to support use, other less commonly used treatments have fewer therapeutic indications in the current literature.

Summary Healthcare providers should be able to initiate the appropriate diagnostic evaluation and assess the utility of non-operative therapies in the treatment of carpal tunnel syndrome. Moreover, healthcare providers should also be able to understand the evidence behind each treatment and the indications for surgical intervention.

Keywords Carpal tunnel syndrome · Non-operative treatment · Splinting · Injection

Introduction

Carpal tunnel syndrome (CTS) is defined as the compression of the median nerve at the level of the transverse carpal ligament. With an annual prevalence ranging from 1 to 5%, it is the most common compressive neuropathy in the USA with higher prevalence in the female population [1, 2, 3, 4, 5]. In 2014 alone, the Center for Disease Control (CDC) estimated that over 230,000 patients underwent surgical release of the transverse carpal ligament [6]. However, multiple non-operative treatment modalities for CTS exist with varying rates of success. The healthcare provider treating patients with CTS should be familiar with the risks, benefits, and expected outcomes of non-operative and operative treatment options in order to optimize shared decision-making and patient care.

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Presentation and Diagnosis

A thorough history and physical examination are essential to the diagnosis of carpal tunnel syndrome. Patients with CTS typically present with numbness and tingling in the median nerve distribution and less commonly with pain (Fig. 1) [7, 8]. Symptoms are usually worse at nighttime, with 77% of patients who have confirmed CTS on electromyogram (EMG) reporting nighttime numbness or tingling [8–10]. Patients who present late in the course of the disease process may demonstrate profound weakness, thenar atrophy, and/or constant paresthesias (Table 1) [11].

There is debate as to whether or not the history and physical examination alone are sufficient for the definitive diagnosis of carpal tunnel syndrome [8, 10, 12–14]. Multiple criteria have been developed to predict the likelihood of CTS based solely on the history and physical examination [13, 14]. Despite this, it is the current recommendation of the American Academy of Orthopaedic Surgeons (AAOS) to complete electrodiagnostic testing prior to surgical intervention [15]. The differential diagnosis for carpal tunnel syndrome includes cervical radiculopathy, thoracic outlet syndrome, pronator syndrome, and polyneuropathy [16].

Pathophysiology/Etiology

CTS is caused by increased pressure within the carpal tunnel causing compression of the median nerve. The pathophysiology of CTS is not fully understood. However, it is thought that

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Fig. 1 Common numbness/tingling distribution in carpal tunnel syndrome

mechanical factors associated with the compression of the median nerve lead to local ischemia and progressive demyelination of both small and large fibers of the median nerve, resulting in the characteristic symptoms [17–19]. The theory of local ischemia is supported by the oft-rapid resolution of symptoms following surgical release [18].

While the majority of CTS cases are idiopathic, extensive research has been done to explore various etiologies. Potential extrinsic risk factors include trauma, radiocarpal arthritis, and repetitive work-related activities [20–21]. Intrinsic risk factors include diabetes mellitus, hypothyroidism, space-occupying masses, obesity, pregnancy, and mucopolysaccharidoses [8, 22–24].

Non-operative Treatment Modalities

Splinting

Among the non-operative treatment modalities for CTS, splint use has emerged as a first-line option for primary care

physicians and upper extremity surgeons alike (Table 2). Splints are typically prescribed for nighttime use but may also be utilized during daytime hours based on patient work and activity demands. By keeping the wrist in a neutral position, splints decrease the extremes of wrist flexion and extension, which have been shown to increase pressure within the carpal tunnel (Fig. 2) [25]. While the majority of splints do not extend past the distal palmar crease, certain splints intentionally extend distally to keep the metacarpophalangeal joints extended. This prevents the lumbrical muscles from retracting proximally, thereby theoretically decreasing the pressure within the carpal tunnel [25]. Evidence supporting the use of splints in mild to moderate CTS is abundant. In a study of 14 women with EMG evidence for bilateral CTS, splint use for 12 weeks yielded significant electrophysiologic improvements in cases of moderate CTS, though improvements were less significant among mild cases [26]. Manente et al. conducted a randomized controlled trial of 83 patients and found that patients treated with a soft hand splint at night for 4 weeks experienced significantly decreased CTS symptoms and functional limitations when compared with a control group [27]. However, no significant differences in electrophysiologic data were encountered between groups.

In order to assess differences between splint types, DeAngelis and colleagues conducted a randomized controlled trial of 120 patients treated with either a soft hand splint or a wrist splint [28]. Both groups experienced significant improvements in wrist pain and function at 3-month follow-up, though these benefits did not persist at a final 9-month follow-up appointment. In a comprehensive review of 19 studies comprising 1190 patients, Page and colleagues concluded that nighttime splinting improves short-term subjective outcomes [29]. As further studies explore optimal wrist position and duration of treatment, splinting will likely remain a mainstay of early outpatient management for patients with mild to moderate CTS.

Steroid Injections

While more invasive than other non-operative modalities, corticosteroid injections (CSI) are commonly used to treat CTS (Table 2). The rationale behind CSI is to decrease pressure

Table 1 Classification of carpal tunnel syndrome

Classification	Duration of symptoms	Weakness/atrophy	Electrodiagnostic findings
Mild	Less than 1 year	None present	Abnormal sensory nerve conduction velocity; normal distal motor latency
Moderate	Less/greater than 1 year	Minimal present	Abnormal sensory nerve conduction velocity; abnormal distal motor latency
Severe	Greater than 1 year	Marked weakness and/or atrophy	Abnormal (or absent) sensory nerve conduction velocity; abnormal (or absent) distal motor latency

Table 2 Non-operative treatment modalities for carpal tunnel syndrome

Treatment Modality	Description	AAOS recommendation
Splinting	Wrist-neutral removable wrist splints	Strong—Evidence suggests splinting will improve patient-reported outcomes
Corticosteroid injection	A single methylprednisolone (varied dosage) performed in the carpal tunnel of the affected side	Strong—Evidence suggests a corticosteroid injection will improve patient-reported outcomes
Oral medications	Oral non-steroidal anti-inflammatory drugs (NSAIDs), diuretics, gabapentin, pyridoxine	Moderate—Evidence suggests oral medications (NSAIDs, diuretics, etc.) have <i>no benefit</i> on patient-reported outcomes
	Oral corticosteroids (e.g., prednisone)	Moderate—Evidence suggests oral corticosteroid could improve patient-reported outcomes
Hand therapy	Targeted exercises focusing on nerve/tendon excursion/gliding	None
Ultrasound	Pulsed ultrasound therapy at 1–2 MHz over the volar wrist at the level of the carpal tunnel	Limited—Evidence suggests ultrasound therapy has limited benefit on patient-reported outcomes
Acupuncture	Targeted acupuncture sessions on the affected side at the level of the carpal tunnel 1–2 times per week over 1–2 months	None

Strength of recommendations courtesy of American Academy of Orthopaedic Surgeons. *Management of Carpal Tunnel Syndrome Evidence-Based Clinical Practice Guideline*. 29 Feb. 2016

within the carpal tunnel by decreasing the inflammation of the tenosynovium passing through it. Studies have shown mixed results in regard to corticosteroid injections (Fig. 3) [30, 31•, 32, 33••, 34]. In a prospective study, Blazar et al. found that 53% of patients were free from symptom recurrence at 6 months. However, only 31% remained symptom-free at 12 months. Despite the higher rate of symptom recurrence, only 44% of patients went on to repeat intervention [32]. Chesterton et al. prospectively randomized patients with mild to moderate CTS to receive one of two possible treatments: (1) a single methylprednisolone carpal tunnel injection, or (2) nighttime splint use.

Fig. 2 Wrist-neutral splint being worn for the treatment of carpal tunnel syndrome

They found that patients who received a single injection had significantly better scores on the Boston Carpal Tunnel Questionnaire (BCTQ), a disease-specific measure of self-reported symptom severity and functional status [33••].

Atroshi et al. performed a prospective, randomized study comparing two different doses of methylprednisolone injections with placebo. Patients demonstrated improved symptoms at the 10-week post injection follow-up appointment with both doses of methylprednisolone versus placebo. At 1-year follow-up; however, there was no significant difference in reported symptoms [35]. Patients who received the higher dose methylprednisolone injection were less likely to have undergone surgical intervention at 1 year. Complication rates from corticosteroid injections in the carpal tunnel are rare, with local injection site pain being the most common in roughly 13% of patients [36].

Fig. 3 A corticosteroid injection being performed for the treatment of carpal tunnel syndrome

Oral Medications

Multiple different classes of medication have been used in the treatment of CTS. These include non-steroidal anti-inflammatory drugs (NSAIDs), diuretics, and steroids. Both NSAIDs and diuretics have demonstrated no clear benefit and as such are not recommended in the treatment algorithm [37].

Currently, the AAOS has a moderate strength recommendation for the use of oral steroids in the treatment of CTS. The use of oral steroids has shown some benefit in the short-term treatment of CTS. Long-term effectiveness is debatable [38–40].

Hand Therapy

Hand therapy aims to facilitate the gliding of tendons and nerves within the carpal tunnel in order to maximize nerve and tendon excursion and to improve axonal transport and nerve conduction [41, 42]. In a randomized trial comparing splint use alone with splint use with nerve and tendon gliding exercises, Akalin et al. found that both groups experienced significant improvements at 4 weeks, though the tendon and nerve mobilization group experienced slightly greater improvements with a significant benefit in lateral pinch strength [43]. Baker and colleagues conducted a trial of splinting and therapy exercises and found that a standard wrist splint with lumbrical-intensive stretching exercises yielded improved subjective function persisting up to 24 weeks after initial intervention [44].

Along with gliding exercises, newer research has focused on improving tendon and nerve mobility via iontophoresis, the transdermal propulsion of ionized medication through a patch applied to the volar surface of the wrist. Data is limited thus far, with one trial by Gokoglu and colleagues showing symptomatic improvement at 2- and 8-week follow-ups following iontophoresis of dexamethasone sodium phosphate [45]. These improvements, however, were inferior to a matched cohort of patients receiving corticosteroid injection. Future studies are needed to further elucidate whether tendon and nerve gliding exercises, with or without iontophoretic augmentation, can translate into measurable electrophysiologic improvements in the management of CTS.

Ultrasound

Though conventionally used for diagnostic purposes and as an adjunct for targeted injections, ultrasound has also been utilized as a standalone therapeutic modality for mild to moderate CTS (Fig. 4). Ultrasound imparts high-frequency waves, which have both thermal and non-thermal effects, decreasing inflammation and stimulating nerve regeneration via enhanced blood flow and membrane permeability [46, 47]. To date, randomized trials have shown mixed results in regard to the clinical utility of ultrasound therapy in CTS. Ebenbichler

Fig. 4 Patient undergoing ultrasound therapy for carpal tunnel syndrome

and colleagues conducted a randomized controlled trial of 34 patients with EMG-confirmed bilateral CTS treated with active ultrasound therapy in one wrist and a sham procedure in the contralateral wrist [48]. Pulsed ultrasound at 1 MHz, 1.0 W/cm [2] applied to the carpal tunnel region over 15 min for ten consecutive days, followed by twice weekly treatments for five additional weeks, yielded improved pain and paresthesia symptoms, reduced sensory loss, improved median nerve motor distal latency and nerve conduction velocity, and increased grip and pinch strength when compared with sham ultrasound. Treatment effects persisted up to 6 months. Other studies investigating ultrasound as an adjunct to other treatment, such as splinting or anti-inflammatory medications, have shown additional promise [49, 50].

However, no additional placebo-controlled studies have emerged to support the independent use of ultrasound, with certain studies calling its utility into question [51–53]. A Cochrane review by Page and colleagues concluded that there is only poor evidence based on limited data to suggest that therapeutic ultrasound is more effective than placebo for treatment of CTS [54]. Additional randomized, placebo-controlled trials are needed to further investigate the potential short-term and long-term benefits of ultrasound as a standalone or adjunct treatment modality.

Acupuncture

With origins in Eastern medicine, acupuncture therapy has been utilized worldwide in the management of mild to moderate CTS. Acupuncture aims to stimulate trigger points along the meridian, a proposed pathway of energy (qi) through the body. Optimizing this energy pathway is thought to provide symptomatic relief of CTS without altering mechanical pressures within the carpal tunnel (Fig. 5). Though the precise mechanism of action remains unknown, proposed theories include promoting a neuromodulatory effect on pain perception by triggering endogenous central nervous system analgesic production and activating anti-inflammatory pathways [55–56]. Studies exploring the use of acupuncture in CTS

Fig. 5 Anatomic locations of two acupoints in treatment of carpal tunnel syndrome

have yielded mixed results. Yang and colleagues compared acupuncture needling (eight sessions over 4 weeks) with 4 weeks of oral prednisolone (20 mg daily for 2 weeks, followed by 10 mg for 2 weeks) [57]. The authors found that both interventions improved symptoms, though the acupuncture group experienced less nocturnal awakening and decreased distal motor latencies after 4 weeks compared with the steroid group. In contrast, a randomized controlled trial of acupuncture therapy versus placebo acupuncture for 6 weeks by Yao and colleagues found that both groups demonstrated improvements from baseline and that acupuncture was not superior to placebo [58].

In a recent Cochrane review compiling 12 studies and 869 patients, Choi et al. concluded that acupuncture may have little or no short-term effect on CTS symptoms in comparison with placebo or sham procedures [59]. This was largely attributed to heterogeneity of the studies and the risk of bias. The authors also stated that the adverse effects of acupuncture, such as skin bruising and local pain after needle insertion, are inconsistently reported among trials and must be documented to comprehensively assess risks and benefits prior to recommending treatment. Moving forward, future studies with improved methodology in regard to enrollment criteria, indications, and outcomes will be needed to assess the role of acupuncture as an independent therapeutic modality.

Operative Intervention

While non-operative treatment strategies are often employed prior to surgical intervention, it is important for both primary

care providers and treating hand surgeons to recognize when operative treatment is appropriate. Many patients with electrodiagnostic findings of moderate to severe carpal tunnel syndrome (Table 1) are best treated with earlier surgical release. In fact, recovery after surgery is often better for those with mild to moderate disease than those with severe disease [60]. In the case of a patient who presents with mild CTS, the aforementioned non-operative modalities may prove beneficial. The duration of non-operative treatment may also vary based on surgeon experience or patient preference, with a high variability in treatment duration currently reported in the literature [61, 62]. Regardless of treatment modality, it is important that a shared decision-making model is utilized in discussing the diagnosis and multiple treatment options available for CTS in order to optimize care of the patient.

Conclusions

Carpal tunnel syndrome is the most common compressive neuropathy, afflicting thousands of patients annually. Fortunately, numerous non-operative treatment options exist to help treat patients with mild to moderate disease. The treating healthcare provider should have an understanding of these treatment modalities and utilize them accordingly.

Compliance with Ethical Standards

Conflict of Interest Dr. Ostergaard and Dr. Meyer declare that they have no conflict of interest. Dr. Earp has stock ownership in Johnson & Johnson and Pfizer.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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