Current options for nonsurgical management of carpal tunnel syndrome

Carpal tunnel syndrome (CTS) is the most common of the entrapment neuropathies. Surgical decompression is commonly performed and has traditionally been considered the definitive treatment for CTS. Conservative treatment options include physical therapy, bracing, steroid injections and alternative medicine. While CTS is often progressive, patients may get better without formal treatment. The resolution of symptoms is not necessarily related to the severity of the clinical findings and self-limited activity is common. The current literature suggests that bracing and corticosteroid injections may be useful in the nonsurgical treatment of CTS, although the benefits may be short term. There is limited evidence regarding the efficacy of other treatments, such as therapy, exercise, yoga, acupuncture, lasers and magnets, and further studies are needed. Surgery is recommended for progressive functional deficits and significant pain.

**Overview**

Carpal tunnel syndrome (CTS) is the most common of the entrapment neuropathies [1]. While the published incidence and prevalence of CTS is variable and complicated by the method of diagnosis, various investigations have produced estimates of population incidence ranging from 0.125 to 1% [2].

Carpal tunnel syndrome represents the compression of the median nerve within the carpal tunnel. The borders of the carpal tunnel are wrist carpal bones on the medial, lateral and dorsal aspect and the transverse carpal ligament on the volar aspect. The median nerve and nine of the finger and thumb flexor tendons pass through this space. CTS is characterized by symptoms of numbness, tingling and paresthesias, which are not always limited to the median nerve distribution. Individuals with CTS tend to initially present with intermittent symptoms that may be worse at night or with repetitive upper-extremity activity. The symptoms may improve with splinting, repositioning or vigorous shaking of the hand [3–6].

Physical examination findings in more involved cases may present with neurologic deficits, including impaired sensation, two-point discrimination in the median nerve distribution or thenar weakness. Milder cases may only present with positive carpal tunnel provocative maneuvers (e.g., with Phalen’s test and Tinel’s sign) with normal neurologic examination findings. Nerve conduction studies (NCS) are frequently performed for confirming the diagnosis of CTS.

Conservative treatment may include physical therapy, bracing, steroid injections and alternative therapies. However, surgical decompression (carpal tunnel release) is often elected.

While the reported incidence and prevalence of CTS varies widely based on the diagnostic criteria and study methods, it does appear that repetitive trauma disorders and CTS are increasing [1]. Prevalence of CTS in the general population can be difficult to estimate and is frequently reported in specific groups [7]. A Swedish study found that 3.8% of the population have a clinical diagnosis of CTS, and 4.9% have electrophysiologic evidence. A total of 2.7% of the population were found to have both [7]. CTS of a severity indicating surgery has been found in 0.7% of a general population [8]. In the general population, CTS prevalence has been estimated at 3.72% in the USA and 5.8% in The Netherlands [1,9].

The incidence of CTS in The Netherlands has been reported at 1.8 per 1000 people, with a female: male ratio of 3:1 and the highest rates in the 45–64-year-old age group [10]. Women are susceptible to the syndrome, and have been demonstrated to progress differently from males [11]. Blue-collar workers and housewives have been demonstrated to have an increased risk of CTS requiring surgery [12]. Manual labor, exposure to vibratory tools and repetitive flexion and extension of the wrist combined with gripping have been reported as risk factors for CTS, while the risk from using a computer mouse or keyboard is unclear [13–15].

**KEYWORDS:** alternative therapy, braces, carpal tunnel syndrome, conservative treatment, corticosteroid injection, exercise, treatment outcome
Surgical decompression has traditionally been considered the definitive treatment for CTS. The most common hand surgery in the USA is carpal tunnel release, with 200,000 procedures carried out each year [16]. Surgical treatment appears to be more effective for the symptoms of CTS than splinting, which has been the mainstay of conservative treatment [17]. In order to evaluate the effectiveness of nonsurgical treatments for CTS, an understanding of the efficacy of surgical treatment, as well as the natural progression of untreated CTS, is beneficial.

**Natural history**

The course of untreated CTS is not completely established [18]. The natural history and progression of CTS has been most thoroughly described in medical literature with respect to the clinical presentation of symptoms. While these symptoms may affect the patient and give the physician an indication of the impairment, they are subjective, difficult to quantify and challenging to follow over time. Electrophysiologic measurements are an integral component of the diagnosis of CTS and provide an objective measurement of the function of the studied nerve. The progression of electrophysiologic characteristics of the median nerve in CTS has had limited investigation with varied results [11].

The initial severity of carpal tunnel symptoms is not a reliable predictor of continued progression. Studies have varied results when individuals are stratified into groups based on the severity of their symptoms at the initial evaluation. Padua et al. prospectively followed 274 untreated hands for 10–15 months with patient-oriented evaluations as well as electrodiagnostic evaluations. They investigated several different outcome measures, including pain, clinical history and physical exam, self-reported symptoms and electrophysiologic findings [19]. Approximately a quarter of cases improved, a quarter worsened and half stayed the same. There was a tendency for those with initially mild symptoms to deteriorate, while severe cases improved over the course of observation. Spontaneous improvement was noted with shorter duration of symptoms and in younger subjects. Poorer outcomes were found in those with bilateral symptoms and a positive Phalen’s test [19].

Karsidag et al. followed 28 hands, with varying degrees of CTS. Evaluations by NCS were performed every 12 weeks for 1 year. All subjects received conservative therapy (bracing) during the trial. Mild cases saw no change, moderate cases saw significant improvements and the severe cases were too few in number to make relevant comparisons [11].

A retrospective review of nonsurgical NCS-confirmed CTS cases followed 261 hands. The average follow-up time was 47 months. The majority of the group had progression of their symptoms (54.9%), while a notable percentage improved (34.3%), and only a few were stable (10.8%) [20].

A total of 157 subjects with CTS with positive electrodiagnostic findings were reviewed retrospectively. Of the 72 subjects without surgery, 32% showed improvement compared with 86% of the 85 subjects that improved with carpal tunnel release [21]. A total of 132 subjects with CTS were followed for an average of 2 years and were treated without surgery, injections or braces. Upon evaluation, 47.6% improved with respect to history and examination findings, and 25% improved with respect to NCS. Only 23.4% clinically and 7.6% electrophysiologically worsened [22].

In many of these studies, it is unclear how much of the ‘natural history’ is actually the self-imposed intervention of activity modification secondary to CTS symptoms. Padua et al. monitored hand stress, which was defined as activities with repetitive hand–wrist action, hard manual work, sporadic hand stress or trauma. They found that 68% of subjects decreased their hand stress and 32% altered their work or hobby hand activities after the diagnosis of CTS [19].

**Nonsurgical management**

- **Bracing**

Splinting is commonly prescribed as a relatively inexpensive, nonoperative treatment for CTS. As CTS has been associated with forceful, repetitive hand and wrist activities [14,23], one purpose of splinting is to minimize motion at the wrist and subsequently decrease symptoms of pain and/or numbness. Splinting may also be helpful for the common symptom of nocturnal paresthesias by limiting prolonged periods of excessive wrist flexion or extension during sleep. Positions of wrist flexion and extension have been demonstrated to cause increased pressure within the carpal tunnel, similar to the findings of increased pressure in the carpal tunnel with CTS [24], and is associated with changes in nerve structure [25].

While immobilizing the wrist with a splint to prevent extremes of flexion and/or extension is a common practice in treating CTS, it is unclear as to which specific type of wrist splint to use. Often, neutral wrist splints are recommended.
Neutral wrist position results in lower carpal tunnel pressures compared with flexion or extension [26,27]. However, studies also suggest that flexion of the metacarpophalangeal joints increase carpal tunnel pressure by migration of the lumbricals into the carpal tunnel [28,29]. Soft hand splints have been designed to splint the metacarpophalangeal joint in extension in order to decrease carpal tunnel pressures [30].

We reviewed the literature for recent randomized, controlled trials involving braces/splints for CTS (Ovid MEDLINE® search, 1996 to present). Manente et al. studied a total of 83 subjects with CTS diagnosed by history, physical examination and electrodiagnostic studies. Subjects were randomized to a treatment group that wore a soft hand splint at night for 4 weeks, or to an untreated control group. The splinted group had decreased self-reported symptoms and functional limitations, although there was no significant difference in the electrophysiologic data [30]. DeAngelis et al. compared a soft hand splint to a more traditional wrist splint for CTS. A total of 120 subjects with CTS based on history, physical examination and electrodiagnostic studies were randomized into treatment with a soft hand splint or a wrist splint to be worn at night for 3 months. Both groups had decreased symptoms and functional limitations at 3 months, although these results had attenuated at 9 months. No significant differences between the splints were noted [31].

Gerritsen et al. compared splinting with surgery for CTS. A total of 176 subjects with clinical and electrodiagnostical CTS were randomized to night-time splints for 6 weeks versus carpal tunnel release. While both groups improved, surgery was found to be more effective than splinting over both the short term and long term [32]. A randomized, controlled trial to compare neutral wrist/metacarpophalangeal extension splinting versus wrist extension splinting demonstrated that the neutral wrist position was more effective in decreasing symptoms [33]. Systematic reviews of conservative treatment suggest splinting is effective over the short term in decreasing CTS symptoms [34,35]. Over the long term, surgery appears to be better than splinting for relieving symptoms, and may be more cost effective [17,36–38].

**Injections**

Corticosteroid injections are frequently used to treat CTS, and are considered to be both safe and effective for short-term management [39]. Pathology specimens from carpal tunnel release have revealed chronic synovial inflammation, and it is suggested that corticosteroid injections are effective by decreasing the swelling of the flexor synovialis [40,41]. A common belief is that corticosteroid injections can relieve the early symptoms of CTS [42], and that the response to a corticosteroid injection may predict the response to carpal tunnel release [40,42]. There is not a consensus on dose or type of corticosteroid injected, and methylprednisolone, triamcinolone and β-methasone are commonly used [42].

Intracarpal corticosteroid injections have been compared with intracarpal placebo injections, as well as to oral NSAIDs, in prospective, randomized trials.

In a double-blinded, placebo-controlled, randomized clinical trial, Armstrong et al. compared intracarpal corticosteroid and lidocaine injection to placebo (saline) and lidocaine in 81 subjects with CTS refractory in order to investigate nonsurgical management. The corticosteroid group had significantly greater symptom relief, based on a symptom satisfaction scale, compared with the placebo group; however, the results were temporary [39].

In a prospective, randomized clinical trial, Gürçay et al. compared intracarpal corticosteroid injections to oral NSAIDs in 32 subjects with CTS. Both groups concomitantly used wrist splints. Outcomes were assessed using a functional status scale and a hand dexterity scale, as well as electrophysiologic findings. Dexterity scores improved in the injection group at 3 months compared with baseline; however, the oral nonsteroidal anti-inflammatory group also had improvements in parameters of dexterity compared with baseline. The functional states scores improved in both groups at month 3 compared with baseline, with no difference between the groups. At month 3, there were no significant differences for electrophysiologic parameters between groups [43].

Both clinical and electrophysiologic parameters may be improved over the short term with carpal tunnel corticosteroid injections, although clinical improvements appear to be more prominent than electrophysiologic improvements, and these improvements decrease as the severity of carpal tunnel increases [44]. However, while some patients may have relatively long-term relief of carpal tunnel symptoms with a corticosteroid injection, it appears that patients become refractory to repeated corticosteroid injections, and that many patients will proceed to carpal tunnel release despite having had corticosteroid injections [39]. While corticosteroid injections
for CTS have been described as safe [39,44], there are several reports of median nerve injury with carpal tunnel corticosteroid injections [45–50]. In order to avoid nerve injury, injection of the carpal tunnel medial to the palmaris longus tendon has been recommended, or injection in line with the ring finger if no palmaris longus tendon is present [45,47,48]. If paresthesias are experienced, the needle should be withdrawn and redirected in an ulnar direction [45]. It is unclear as to whether surgery is superior to corticosteroid injections and further studies are needed [17].

- **Hand/occupational therapy**
  Hand therapy is a form of rehabilitation that utilizes different therapeutic interventions to restore functional use of the upper extremities. Using specialized skills to assess and evaluate each person, interventions are then chosen depending on symptom severity, patient needs and goals, comorbidities and doctor referral. Table 1 outlines the articles referenced in the following sections.

- **Modalities**
  Iontophoresis and ultrasound are modalities often used in hand therapy clinics. These modalities are used to treat hand and upper-extremity conditions such as CTS. A limited amount of literature on iontophoresis exists. An article published in the Cochrane Database of Systematic Reviews [34] was chosen for discussion in this paper, as well as an article published in the Journal of Hand Therapy [51]. Iontophoresis is a method of transdermal administration of ionized drugs in which electrically charged molecules are propelled through the skin by an external electrical field [52]. Advantages of steroid iontophoresis include being painless, noninvasive, sterile and providing local and little systemic concentration of the drug [52].

  In a prospective, nonrandomized study utilizing a standardized 3-week protocol, iontophoresis was successful in 58% of those that failed splints and ibuprofen at 6-month follow-up. No adverse effects of the treatment, including significant elevation of serum glucose in insulin-dependent diabetics, occurred [52]. A study comparing local corticosteroid injection and iontophoresis of dexamethasone sodium phosphate in CTS revealed success of both treatments, but symptom relief was greater at 2 and 8 weeks with injection of corticosteroids [53]. In addition to splinting and ibuprofen, iontophoresis may be a safe and effective alternative to surgery for treating early CTS, particularly in those patients that may not tolerate corticosteroid injections [52,53]. Therapeutic ultrasound is a modality that produces acoustical high-frequency vibrations with both thermal and nonthermal effects [54]. Deep, pulsed ultrasound over the carpal tunnel for 15 min for 20 treatments decreases pain and paresthesia symptoms, reduces sensory loss, and improves median nerve conduction and strength when compared with sham ultrasound [34,51,55]. Ultrasound treatment can also provide a positive effect on sensation and patient-reported symptoms. The average difference in symptom severity between ultrasound and placebo groups at 6 months was reported to be almost two points on a visual analog scale [55]. While superficial, continuous ultrasound in ten treatments for 5 min each time decreased pain, it was found to be no more effective than sham ultrasound and did not improve median nerve conduction [55,56].

- **Exercise**
  Mobilization exercises (e.g., tendon gliding and nerve gliding) are commonly employed for symptoms of CTS and are felt to improve axonal transport and nerve conduction [57]. Tendon and nerve gliding exercises may maximize the relative excursion of the median nerve in the carpal tunnel and the excursion of the flexor tendons relative to one another [58].

  The effectiveness of neural mobilization exercises specifically for the treatment of CTS is not well documented in randomized, controlled studies. A study published by Heebner and Roddney compared standard of care (i.e., splinting and tendon gliding) with standard of care in addition to neural mobilization (i.e., nerve gliding). At 6 months, results showed better self-reported function in the control group (bracing, education and tendon gliding group) than that of the nerve gliding group. The investigators cited numerous reasons as to why the nerve gliding group had nonsignificant findings, including large attrition rates (50% lost to follow-up), which are common in community hospital settings, poor self-reported exercise compliance and symptom severity [59].

  In another prospective, randomized trial, nerve gliding, tendon gliding and splinting was compared with splinting alone for a period of 4 weeks [60]. Statistically significant improvement was attained in all parameters in both groups. While the improvement in the mobilization group was slightly greater, the difference between the groups was not significant with the exception of lateral pinch strength [60]. In light of more current research exploring the treatment
<table>
<thead>
<tr>
<th>Study</th>
<th>Number of hands</th>
<th>Diagnostic criteria</th>
<th>Study design</th>
<th>Dosing regimen</th>
<th>Comparison group</th>
<th>Outcomes</th>
<th>Study limitations</th>
<th>Ref.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iontophoresis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Banta (1994)</td>
<td>23</td>
<td>Symptoms and NCS</td>
<td>Prospective, nonrandomized trial</td>
<td>40–45 mA/min every other day for 1 week</td>
<td>No comparison</td>
<td>Successful in 58% of those that failed splints and ibuprofen treated with 3 week protocol, at 6-month follow-up. Shortcoming: small sample size, lack of randomization and blinding, and no use of sham iontophoresis group</td>
<td>Nonrandomized, no control group</td>
<td>[52]</td>
</tr>
<tr>
<td>Gokoglu et al. (2005)</td>
<td>48 median nerves</td>
<td>Symptoms and NCS</td>
<td>Prospective, randomized trial</td>
<td>40–45 mA/min for 20 min every other day for 1 week</td>
<td>Cortisone injection</td>
<td>Significant improvement of SSS and FSS scores in both groups at 2 and 8 weeks compared with baseline; however, significant better mean SSS and FSS scores are found at week 2 and week 8 for the injection group compared with iontophoresis group</td>
<td>Unblinded</td>
<td>[53]</td>
</tr>
<tr>
<td>Ultrasound</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ebenbichler et al. (1998)</td>
<td>90</td>
<td>Symptoms and NCS</td>
<td>RCT</td>
<td>Daily five times/week for 2 weeks 15 min each, 20 treatments total</td>
<td>Sham ultrasound</td>
<td>Treatment &gt; control at 2 weeks, 7 weeks and 6 months; Sensory loss treatment &lt; control at 2 weeks, 7 weeks and 6 months; NCS treatment &gt; control at 2 weeks, 7 weeks and 6 months</td>
<td>–</td>
<td>[55]</td>
</tr>
<tr>
<td>Oztas et al. (1998)</td>
<td>30</td>
<td>Symptoms and NCS</td>
<td>RCT</td>
<td>Five times/week 5 min, ten treatments for 2 weeks.</td>
<td>Sham ultrasound</td>
<td>Within groups:  – Treatment 1: reduced pain, reduced night pain and reduced waking;  – Treatment 2: reduced pain, reduced night pain and reduced waking;  – Control: reduced pain, reduced night pain and reduced waking; Between groups: no significant differences</td>
<td>–</td>
<td>[56]</td>
</tr>
<tr>
<td>Carpal bone mineralization versus nerve gliding</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tal-Akabi and Rushton (2000)</td>
<td>21</td>
<td>Symptoms and NCS</td>
<td>Comparative investigation</td>
<td>Mobilization grade dependent on symptoms</td>
<td>No treatment</td>
<td>Within group:  – Treatment group 1: reduced pain, increased active motion flexion and extension  – Treatment group 2: reduced pain and increased motion in extension Between groups: pain relief:  – Treatment group 1 &gt; control  – Treatment group 2 &gt; control  – Treatment group 1 = treatment group 2</td>
<td>Participants not blinded</td>
<td>[61]</td>
</tr>
</tbody>
</table>

FSS: Functional status scale; NCS: Nerve conduction studies; RCT: Randomized, controlled trial; SSS: Symptoms severity scale.
<table>
<thead>
<tr>
<th>Study</th>
<th>Number of hands</th>
<th>Diagnostic criteria</th>
<th>Study design</th>
<th>Dosing regimen</th>
<th>Comparison group</th>
<th>Outcomes</th>
<th>Study limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Porrata et al. (2007)</td>
<td>19</td>
<td>Symptoms and NCS</td>
<td>–</td>
<td>Three times per day for 5 min sessions for 4 weeks</td>
<td>No control</td>
<td>4-week follow-up: average pain reduced from 8.52 to 1.05; tingling reduced from 8.15 to 0.95; numbness reduced from 8.47 to 0.95; average times patients woke per night (due to carpal tunnel syndrome) reduced from 3.05 to 0.10 7-month follow-up: (visual analog scale) average max pain was 0.65; tingling 0.4/10; numbness 1.7/10; none woke from sleep</td>
<td>No control group</td>
</tr>
<tr>
<td>Heebner et al. (2008)</td>
<td>60</td>
<td>Symptoms and NCS</td>
<td>Prospective, randomized</td>
<td>Both groups wore splints at night and during heavy lifting. Tendon gliding ten repetitions, three to five times per day; group 2: additionally instructed in median nerve gliding ten repetitions, hold stretch for 5 s, three- to five-times daily</td>
<td>Splint, tendon gliding and modification of activities of daily living</td>
<td>At 1-month follow-up: – Group 1: eight patients failed to show up – Group 2: seven patients failed to show up – Group 1: 20 participants remained – Group 2: 25 patients At 6-month follow-up: – 15 subjects in group 1 – Group 2: 14 patients At 6 months: – Group 1 had statistically better function than group 2 – There appeared to be no other differences in outcomes</td>
<td>Unblinded</td>
</tr>
<tr>
<td>Akalin et al. (2002)</td>
<td>36</td>
<td>Symptoms and NCS</td>
<td>Prospective, randomized</td>
<td>Treatment group: tendon gliding exercises and nerve gliding exercises and splinting</td>
<td>Treatment group: tendon gliding (five exercises), nerve gliding (six exercises holding each for 5 s), each ten repetitions, five times per day for 4 weeks. Within group: – Treatment group: reduced Phalen’s and Tinel’s sign, improved two patients. Discrimination, increased grip and pinch strength, reduced symptom severity and increased function – Control: reduced Phalen’s and Tinel’s sign, increased grip and pinch strength, reduced symptoms severity and increased function Between group: pinch strength improvement treatment</td>
<td>No control, unblinded, limited study size</td>
<td></td>
</tr>
</tbody>
</table>

FSS: Functional status scale; NCS: Nerve conduction studies; RCT: Randomized, controlled trial; SSS: Symptoms severity scale.
of CTS with mobilization techniques, more prospective, controlled trials are needed in order to identify populations that may benefit from this treatment.

In addition to neural mobilization, carpal bone mobilization is also widely utilized in the treatment of CTS; however, there is limited evidence of its efficacy. Although not statistically significant (due to low sample size), Tal-Akabi and Rushton found that carpal bone mobilization improved CTS symptoms when applied over the course of 3 weeks [61]. Although their study had high quality diagnostic criteria for CTS, there also existed a high risk of selection and performance bias [34]. It is evident that further investigation with larger sample sizes is necessary to support any future treatment guidelines.

C-TRAC is a custom pneumatic and dynamic hand traction device designed to increase the area of the carpal tunnel through a progressive stretching program. When the device is on the hand and the air bladder is inflated, a 'three-point' action force is exerted on the hand. This provides a stretching force, along the transverse carpal ligament. X-rays taken with and without the C-TRAC in place showed an increase in the distance between the trapezium and the hook of hamate and between the scaphoid and pisiform bones up to 3 mm [62]. No NSAIDs, splints or injections were used while patients used the C-TRAC device. At the 4-week follow-up, there were no reported side effects or complications in all patients. Results demonstrate a reduction in symptoms at both 4 and 7 months of follow-up. At the 7-month follow-up, eight of the 18 patients had no symptom recurrence, and ten had minor symptom recurrence. A total of 12 of the 18 patients reported the need to use the device an average of once every 2 months to manage the symptoms.

Comparison of other treatments, such as splinting and cortisone injections with this device, may be beneficial for future research [62]. Limitations of this study include no control group and a low number of subjects.

Further studies considering patient characteristics, such as age, duration of symptoms, general health and exercise regime, symptom severity, occupation and other comorbidities, are needed.

**Alternative therapies**

Approximately 38% of adults in the USA turn to alternative therapies for pain control [63]. Four alternative therapies (e.g., acupuncture, low-level laser, yoga and static magnetic field therapy) have limited evidence that supports safety and suggests possible therapeutic effectiveness for treating symptoms of CTS. See Table 2 for a list of recent studies investigating these and other alternative therapies.

**Acupuncture**

A 1997 NIH consensus statement concluded that acupuncture may be useful as an adjunct treatment or an acceptable alternative for managing CTS [64]. Needles and low-level lasers can both be used to stimulate acupuncture points. Yang et al. compared acupuncture needling of two acupoints (PC 5 and PC 6) during eight treatment sessions over 4 weeks, to 4 weeks of oral prednisolone (20 mg daily for 2 weeks, followed by 10 mg for 2 weeks) and found these treatments to be equally effective for improving symptoms [65]. The only between-group difference was in nocturnal awakening, a symptom that improved more in the acupuncture group (p = 0.03) compared with the prednisolone group. No changes in nerve conduction parameters occurred in either group and neither group experienced any serious side effects. Two other acupuncture studies evaluated low-level laser acupuncture in combination with microamp transcutaneous electrical nerve stimulation (TENS) [66,67]. All patients in Branco’s uncontrolled pre- to post-treatment comparison had previously failed standard medical or surgical treatments. At the end of treatment, participants reported either no pain, or pain reduction of over 50% in 33 out of 36 hands [66]. Naeser et al. compared low-level laser acupoint stimulation and microamp TENS to sham treatment in a randomized crossover design. The interventions were administered over 3–4 weeks [67]. Real treatments consisted of applying red-beam laser (continuous wave, 15 mW and 632.8 nm) to shallow acupuncture points on the affected hand, infrared laser (pulsed, 9.4 W and 904 nm) to deeper points on the upper extremity and cervical paraspinal areas, and microamps TENS to the affected wrist. After the real treatment series, significant decreases in the McGill Pain Questionnaire score, median nerve sensory latency, and Phalen and Tinel signs were demonstrated, with no change after the sham treatment series.

**Laser**

Seven trials assessed the effects of low-level laser applied along the course of the median nerve, rather than at specific acupuncture points (Table 2) [68–74]. An uncontrolled study that
<table>
<thead>
<tr>
<th>Study</th>
<th>Number of hands</th>
<th>Diagnostic criteria</th>
<th>Study design</th>
<th>Dosing regimen</th>
<th>Comparison group</th>
<th>Outcomes</th>
<th>Study limitations</th>
<th>Ref.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Acupuncture (needle)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yang et al. (2009)</td>
<td>77</td>
<td>Symptoms and NCS</td>
<td>RCT</td>
<td>Two treatments/week for 4 weeks</td>
<td>Prednisolone</td>
<td>Acupuncture and prednisolone equally effective</td>
<td>Participants not blinded</td>
<td>[65]</td>
</tr>
<tr>
<td><strong>Acupuncture (laser)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Branco and Naeser (1999)</td>
<td>36</td>
<td>Symptoms</td>
<td>Pre–post evaluation</td>
<td>Three treatments/week for 4–5 weeks</td>
<td>No control or comparison group</td>
<td>Post treatment pain reduced significantly</td>
<td>Case series</td>
<td>[66]</td>
</tr>
<tr>
<td><strong>Low-level laser</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Naeser et al. (2002)</td>
<td>11</td>
<td>Symptoms and NCS</td>
<td>RCT crossover</td>
<td>Three treatments/week for 3–4 weeks</td>
<td>Sham laser and sham microamp TENS</td>
<td>Decreased pain and median sensory latency after active treatment only</td>
<td>No between-group analyses</td>
<td>[67]</td>
</tr>
<tr>
<td>Weintraub (1997)</td>
<td>30</td>
<td>Symptoms and NCS</td>
<td>Pre–post evaluation</td>
<td>15 treatment visits</td>
<td>No control group</td>
<td>Complete resolution of symptoms in 77% of cases</td>
<td>Case series</td>
<td>[68]</td>
</tr>
<tr>
<td>Padua et al. (1998)</td>
<td>17</td>
<td>Symptoms and NCS</td>
<td>Pre–post evaluation</td>
<td>10 min session three times weekly for 2 weeks</td>
<td>No control group</td>
<td>Significant benefit in NCS and BCTQ with maximum effect 15 days</td>
<td>Case series</td>
<td>[71]</td>
</tr>
<tr>
<td>Elwakil et al. (2007)</td>
<td>60</td>
<td>Symptoms and NCS</td>
<td>Controlled trial</td>
<td>Two treatments/week for 6 weeks</td>
<td>Open carpal tunnel release</td>
<td>Significant symptom and NCS improvement in both groups</td>
<td>Not randomized, participants not blinded, no between-group analyses</td>
<td>[69]</td>
</tr>
<tr>
<td>Evcik et al. (2007)</td>
<td>81</td>
<td>Symptoms and NCS</td>
<td>RCT</td>
<td>Five treatments/week for 2 weeks</td>
<td>Sham laser</td>
<td>Significant pre–post improvements in VAS, pinch grip and functional capacity measurement in both groups. Significant improvements in sensory nerve velocity, and sensory and motor distal latencies in the laser group only</td>
<td>No between-group analyses</td>
<td>[80]</td>
</tr>
<tr>
<td>Bakhtiary et al. (2004)</td>
<td>90</td>
<td>Symptoms and NCS</td>
<td>RCT</td>
<td>Five treatments/week for 3 weeks</td>
<td>Ultrasound</td>
<td>Significantly greater symptomatic and NCS changes in ultrasound than laser group</td>
<td>Participants not blinded, no between-group analyses</td>
<td>[70]</td>
</tr>
<tr>
<td>Irvine et al. (2004)</td>
<td>15</td>
<td>Symptoms and NCS</td>
<td>RCT</td>
<td>Three treatments/week for 3 weeks</td>
<td>Sham laser</td>
<td>Significant symptomatic improvement in both groups with no between-group differences</td>
<td>–</td>
<td>[72]</td>
</tr>
<tr>
<td>Ekim et al. (2007)</td>
<td>19</td>
<td>Symptoms and NCS</td>
<td>RCT</td>
<td>Five treatments/week for 2 weeks</td>
<td>Sham laser</td>
<td>Significant improvement in pain score and functional status in active laser group compared with sham laser group. No improvement in NCS</td>
<td>–</td>
<td>[81]</td>
</tr>
</tbody>
</table>

BCTQ: Boston Carpal Tunnel Questionnaire; DASH: Disabilities of the arm, shoulder and hand; LLL: Low-level laser; NCS: Nerve conduction studies; RCT: Randomized, controlled trial; TENS: Transcutaneous electrical nerve stimulation; US: Ultrasound; VAS: Visual analog scale.
Table 2. Alternative therapy studies from 1998 to 2009 (cont.).

<table>
<thead>
<tr>
<th>Study</th>
<th>Number of hands</th>
<th>Diagnostic criteria</th>
<th>Study design</th>
<th>Dosing regimen</th>
<th>Comparison group</th>
<th>Outcomes</th>
<th>Study limitations</th>
<th>Ref.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Low-level laser (cont.).</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shoostari et al. (2008)</td>
<td>80</td>
<td>Symptoms and NCS</td>
<td>RCT</td>
<td>Five treatments/week for 3 weeks</td>
<td>Sham laser</td>
<td>Significant pre–post improvement in clinical symptoms and hand grip in active laser group only. Proximal median sensory latency, distal median motor latency and median sensory.</td>
<td>No between-group analyses</td>
<td>[73]</td>
</tr>
<tr>
<td>Chang et al. (2008)</td>
<td>36</td>
<td>Symptoms and NCS</td>
<td>RCT</td>
<td>Five treatments/week for 2 weeks</td>
<td>Sham laser</td>
<td>VAS scores significantly lower in the laser group compared with the placebo group after treatment and at follow-up. No significant NCS differences between groups after treatment.</td>
<td>–</td>
<td>[74]</td>
</tr>
<tr>
<td><strong>Low-level laser plus splinting</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yagci et al. (2009)</td>
<td>45</td>
<td>Symptoms and NCS</td>
<td>RCT</td>
<td>Ten sessions of laser therapy over 3 months</td>
<td>Wrist splints alone</td>
<td>Pre–post significant improvements on both clinical and NCS parameters in splints plus laser group only</td>
<td>–</td>
<td>[82]</td>
</tr>
<tr>
<td><strong>Low-level laser plus splinting compared with US plus splinting or splinting alone</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dincer et al. (2009)</td>
<td>100</td>
<td>Symptoms and NCS</td>
<td>RCT</td>
<td>–</td>
<td>–</td>
<td>The combinations of US or LLL therapy with splinting were more effective than splinting alone; however, LLL therapy plus splinting was more advantageous than US therapy plus splinting, especially for wrist splints</td>
<td>–</td>
<td>[83]</td>
</tr>
<tr>
<td><strong>Yoga</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Garfinkel et al. (1998)</td>
<td>42</td>
<td>Symptoms and NCS</td>
<td>RCT</td>
<td>Two sessions/week for 8 weeks</td>
<td>Wrist splints</td>
<td>Significant pre–post symptomatic improvement in yoga group but not in wrist splint group</td>
<td>No between-group analyses</td>
<td>[75]</td>
</tr>
<tr>
<td><strong>Static magnetic field therapy</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weintaub and Cole (2000)</td>
<td>8</td>
<td>Symptoms and NCS</td>
<td>Crossover</td>
<td>24 h/day magnet wear for 1 month</td>
<td>Sham magnet</td>
<td>Pre–post symptomatic improvement in four out of eight hands during active magnet wear. Significant pre–post NCS improvement in five out of eight hands</td>
<td>Inadequate statistical analyses</td>
<td>[78]</td>
</tr>
<tr>
<td>Carter et al. (2002)</td>
<td>30</td>
<td>Symptoms</td>
<td>RCT</td>
<td>Single 45-min treatment</td>
<td>Sham magnet</td>
<td>Significant pre–post symptomatic improvement in both groups. No between-group differences</td>
<td>–</td>
<td>[77]</td>
</tr>
<tr>
<td>Colbert et al. (under review)</td>
<td>60</td>
<td>Symptoms and NCS</td>
<td>RCT</td>
<td>Nightly magnet wear for 6 weeks</td>
<td>Two different strength magnets versus sham magnet</td>
<td>Significant pre–post symptomatic improvement in all three groups. No between-group differences. No change in NCS</td>
<td>–</td>
<td></td>
</tr>
</tbody>
</table>

BCTQ: Boston Carpal Tunnel Questionnaire; DASH: Disabilities of the arm, shoulder and hand; LLL: Low-level laser; NCS: Nerve conduction studies; RCT: Randomized, controlled trial; TENS: Transcutaneous electrical nerve stimulation; US: Ultrasound; VAS: Visual analog scale.
assessed the safety and effectiveness of laser exposure in 30 hands reported complete symptom resolution in 77% of hands and improvement in motor distal latency in 11 hands, with no adverse events [68]. Padua confirmed Weintraub’s findings in 17 hands and found improvements in nocturnal complaints that persisted for up to 1 year [71]. Laser therapy was also compared with three different control interventions (surgery, ultrasound and sham). In one study, low-level laser therapy was found to be as effective as surgery in 60 patients with mild-to-moderate CTS [69]. Significant symptomatic and electrophysiologic pre–post-changes were observed in an ultrasound/laser comparison in 50 hands, with slightly greater improvement in the group that received ultrasound than those who received laser therapy [70]. However, when low-level laser therapy was compared with sham treatment by Irvine et al., equally significant symptomatic improvement was reported in both groups, suggesting a possible placebo effect [72]. Two later sham-controlled trials yielded different results. Shooshtari et al. evaluated 80 CTS patients and found symptomatic and electrophysiologic improvement in the treatment group. While Chang et al. compared sham with active laser treatment in 50 patients and reported symptomatic improvement, no changes in median NCS were included [73].

A single pre–post, within-group, randomized, controlled trial compared the effects of yoga with wearing a wrist splint [75]. The yoga program consisted of 1–1.5 h sessions practiced twice per week for 8 weeks, with a focus on upper body postures and awareness of proper structural alignment. A total of 42 participants were included in this study. Participants in the yoga group experienced significant improvement in strength and pain reduction while no significant changes were reported in the wrist splint group. There was no significant impact on nighttime waking between groups. However, the study limitations include a high bias rating and minimal data on participant compliance or the occurrence of adverse events [76].

**Table 2. Alternative therapy studies from 1998 to 2009 (cont.).**

<table>
<thead>
<tr>
<th>Study</th>
<th>Number of hands</th>
<th>Diagnostic criteria</th>
<th>Study design</th>
<th>Dosing regimen</th>
<th>Comparison group</th>
<th>Outcomes</th>
<th>Study limitations</th>
<th>Ref.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pulsed electromagnetic field therapy</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weintraub and Cole (2008)</td>
<td>31</td>
<td>Symptoms and NCS</td>
<td>RCT</td>
<td>Wrist device worn for 2 h twice daily for 2 months</td>
<td>Sham device not described</td>
<td>Significant pre–post improvement in mean pain score in active magnet group, not in sham group. No significant change in NCS in inadequate statistical analyses</td>
<td>Inadequate statistical analyses</td>
<td>[79]</td>
</tr>
<tr>
<td><strong>Traditional cupping of related shoulder/next zones</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Michalsen et al. (2009)</td>
<td>52</td>
<td>Symptoms and neurological examination</td>
<td>RCT</td>
<td>Single application wet cupping</td>
<td>Local application of heat</td>
<td>Significant between group improvement in average symptom score, BCTQ and DASH at 1-week follow-up</td>
<td>Participants not blinded</td>
<td>[84]</td>
</tr>
</tbody>
</table>

BCTQ: Boston Carpal Tunnel Questionnaire; DASH: Disabilities of the arm, shoulder and hand; LLL: Low-level laser; NCS: Nerve conduction studies; RCT: Randomized, controlled trial; TENS: Transcutaneous electrical nerve stimulation; US: Ultrasound; VAS: Visual analog scale.
et al. applied a 1000 Gauss (G) SMF for 45 min to 30 wrists with ‘presumed diagnosis of CTS’ and found symptomatic improvement in the control and active groups, but no between-group differences [77]. In a smaller crossover design study, a 350 G flexible magnet was applied to eight wrists continuously for 30 days [78]. This regimen resulted in significant clinical and electrophysiologic improvement during the real versus sham magnet exposure. In a dose comparison study, Colbert et al. compared two different strength SMFs (150 or 450 G) with a nonmagnetized aluminum disk, in 60 participants [Colbert et al., Manuscript under review at Archives of Physical Medicine and Rehabilitation]. The devices were applied during the hours of sleep for 6 weeks. All three groups demonstrated pre- to post-statistically significant and clinically meaningful improvements on the Boston Carpal Tunnel Questionnaire, but no between-group differences. Pre- to post-NCS demonstrated no differences within or between groups. No adverse events were reported.

In a randomized, double-blinded, placebo-controlled trial, Weintraub and Cole observed 31 hands wearing a patented wristwatch-like device combining SMFs and dynamic magnetic fields for 4 h per day over the course of 2 months. The device contained a rotating 1150 G permanent magnet, producing biaxial magnetic rotation and oscillating polarities up to 1200 rpm, 20 times per second. At 2 months, composite neuropathy pain scale scores showed statistically significant pain reduction in the magnetic treatment group versus the sham. Alternatively, when comparing visual analog pain scale scores, sleep scores and nerve conduction, no significant between-group differences were found [79].

**Conclusion**

Carpal tunnel syndrome is a common source of pain and impaired function throughout the population and across the spectrum of occupational and recreational pursuits. While surgery is generally thought to be the definitive treatment for CTS, some people improve spontaneously and this may relate to activity modification. Nonsurgical interventions are frequently used for CTS and include splinting, medications, exercises, modalities and alternative therapies. The currently available literature suggests that splinting and oral or injected corticosteroids may be effective for the symptoms of CTS, although they often only provide short-term relief [35,37,76]. At this time, no definitive conclusions can be made with regard to the efficacy of the other commonly utilized nonsurgical interventions for CTS owing to the paucity of trials, the small number of participants in each trial, the heterogeneity of dosing regimens, the few sham-controlled studies and insufficient long-term follow-up. Effective conservative treatment and activity modification for CTS is reasonable to pursue in the patient with tolerable symptoms and the absence of progressive neurologic or functional deficits.

**Future perspective**

In the future, a better understanding of the risk factors for CTS and the characteristics that predict improvement, as well as stronger evidence with respect to the conservative treatment options, will assist with the management decisions for these patients.

**Financial & competing interests disclosure**

The authors have no relevant affiliations or financial involvement with any organization or entity with a financial interest in or financial conflict with the subject matter or materials discussed in the manuscript. This includes employment, consultancies, honoraria, stock ownership or options, expert testimony, grants or patents received or pending, or royalties.

No writing assistance was utilized in the production of this manuscript.

---

**Executive summary**

- **Carpal tunnel syndrome:**
  - Careful history and physical examination are used for diagnosis.
  - Electrophysiologic studies are used for confirmation.
- **Natural history:**
  - Resolution of symptoms is not necessarily related to severity.
- **Self-imposed activity modification is common.**
- **Nonsurgical management:**
  - Bracing and injections appear helpful.
- **Limited evidence of efficacy with other conservative treatments:**
  - Surgery recommended for progressive neurologic deficits/significant pain.
Bibliography
Papers of special note have been highlighted as:
* of interest

* Review of one early and three recent trials comparing surgical to nonsurgical treatments. Focus on corticosteroid injections and bracing.
* Recent examination of the natural evolution of carpal tunnel syndrome (CTS) in patients over the course of 24 months utilizing baseline electrophysiological and clinical criteria.
* Short-term and long-term comparison of surgical release to splinting in a multicenter, randomized trial.
Extensively rigorous review of studies investigating nonsteroidal, nonsurgical methods for treating CTS.


Recent review of hand therapy and alternative therapy methodologies for the treatment of CTS.


