Carpal Tunnel Syndrome

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Carpal tunnel syndrome (CTS) is the most common compressive neuropathy in the upper extremity. The condition is responsible for substantial annual costs to society, both in terms of lost productivity and the costs of treatment. Accurate diagnostic criteria, the selection of treatment strategies based on high-level evidence, and outcomes data have been inconsistent despite the prevalence of the condition. The increased awareness of the need for evidence-based practice guidelines has, however, yielded important data to guide treatment of CTS. Evidence-based guidelines for diagnosis and treatment have been developed and should direct the treatment of CTS. *(J Hand Surg 2010;35A:147–152. © 2010 Published by Elsevier Inc. on behalf of the American Society for Surgery of the Hand.)*

Key words CTS, diagnosis, ECTR, OCTR, outcomes, treatment.

CME Continuing Medical Education

CARPAL TUNNEL SYNDROME (CTS) is the most common compressive neuropathy in the upper extremity. The American Academy of Orthopaedic Surgeons (AAOS) Clinical Guideline on Diagnosis of Carpal Tunnel Syndrome defines CTS as a symptomatic compression neuropathy of the median nerve at the level of the wrist, characterized physiologically by evidence of increased pressure within the carpal tunnel and decreased function of the nerve at that level.[1] Incidence in the United States has been estimated at 1 to 3 cases per 1,000 subjects per year, with a prevalence of 50 cases per 1,000 subjects per year.[1] The burden on society from lost productivity and wages, as well as the cost of treatment, continues to be substantial. A large percentage of CTS cases continues to be treated under workers' compensation coverage. A review of cumulative earnings losses of a cohort of injured workers in Washington State who filed CTS claims in 1993 and 1994 revealed that, after 6 years, the CTS claimants recovered only one-half the preinjury earnings of claimants treated for upper-extremity fractures over the same period. The CTS population was also found to have time loss from work 3 times that of the fracture cohort. Over the 6-year study period, the CTS cohort had excess earnings losses of $197 million to $382 million, equaling $45,000 to $89,000 per claimant.[2] There is little reason to believe that these totals have improved over the subsequent decade.

Despite the prevalence of CTS, uncertainty still exists regarding accurate diagnosis of the condition, optimal treatment selection, and the outcomes of various modalities used to treat the disorder. An evidence-based approach to these issues with clear answers to the questions of diagnosis, treatment, and outcomes is still elusive. The increased awareness of the need for evidence-based practice guidelines has, however, yielded important data to guide treatment of this common condition.

DIAGNOSIS AND ETIOLOGY

The diagnosis of CTS continues to generate some controversy. This centers largely around the roles of clinical diagnosis, based on symptom presentation and physical findings, versus the utility of diagnostic testing. A 2007 AAOS study group report produced a series of recommendations for diagnosing CTS based on a comprehensive review of studies in the literature. The only recommendation with high-level evidence (levels II and III) was the recommendation for physicians to obtain electrodiagnostic tests if clinical testing

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is positive and surgical management is being considered. All other recommendations lacked substantial high-level evidence in the literature to support them and were consensus recommendations of the experts in the study group.[1] Similar findings resulted from a literature review performed by Massy-Westropp et al. in 2000.[3] Both reviews found a lack of uniformity in testing protocols, making comparison of test results difficult. These findings highlight the continued need for properly designed studies with good evidence to guide diagnostic practices in CTS. To this end, Graham et al. developed a list of 6 clinical criteria (CTS-6) for the diagnosis of CTS.[4] A literature review produced a list of 20 clinical criteria that were then ranked in order of diagnostic importance in interviews with clinical experts. The 6 resulting criteria were validated by statistical analysis after evaluation by panels of multispecialty physicians treating CTS. The 6 criteria all had a statistically significant probability of being associated with a consensus diagnosis of CTS by the panel physicians (Table 1).

EDUCATIONAL OBJECTIVES

- List the most important clinical criteria that support the diagnosis of CTS.
- Describe the role of electrodiagnostic studies in the diagnosis of CTS.
- Explain the short-term and long-term roles of nonsurgical measures in the treatment of CTS.
- Compare and contrast open carpal tunnel release and endoscopic carpal tunnel release.
- State the role of advanced age and diabetes on the outcome following carpal tunnel release.

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Carpal tunnel syndrome remains a clinical diagnosis, and the role of diagnostic testing is still unclear. Electrodiagnostic tests are routinely performed, yet the validity of these tests is still largely unproved. A gold-standard test is lacking, and overreliance on electrodiagnostic test results can obscure clinical findings and may even lead to the withholding of effective treatment for patients with clear clinical criteria for CTS whose electrodiagnostic test results are in the normal range. Graham showed that the value added by electrodiagnostic testing to the clinical determination of CTS by use of the CTS-6 criteria was small.[5] This was largely because the probability of accurately diagnosing the condition based on the clinical presentation alone was already quite high. Electrodiagnostic tests were also shown to have no predictive value in determining the functional status or symptom severity in patients with CTS.[6] The role of electrodiagnostic testing, therefore, appears to be questionable. The tests are probably most appropriately used as a baseline for monitoring unexpected outcomes, such as incomplete release and nerve injury, and excluding other associated neurologic conditions, such as cervical radiculopathy. In the medico-legal arena, the overreliance on electrodiagnostic test results creates a tacit expectation of test validity that is not borne out by the available evidence in the literature.[5,6]

Other diagnostic tests for CTS have been sought, and ultrasound examination of the median nerve at the wrist does appear to correlate well with both clinical and electrodiagnostic criteria.[7,8] Identifying an increased cross-sectional area of the median nerve at the wrist with diagnostic ultrasound may be an effective tool to correlate with clinical symptoms, which also eliminates the patient discomfort associated with nerve-conduction and electromyographic testing. For this to be useful as a diagnostic test, however, validated normal ranges for cross-sectional area need to be well established.

The etiology of CTS continues to be debated and is the source of much controversy. The implications of this debate are nowhere more apparent than in the workers' compensation system. Substantial financial burden and loss of productivity result from claims for CTS in the United States every year.[1,2,9–11] Yet, the causal relationship between commonly perceived etiologic factors and the development of CTS has been tenuous at best, with little evidence to support the perceptions. An evaluation of the quality and strength of the scientific evidence supporting risk factors for CTS was reported by Ring and his associates in 2008. Quantitative analysis yielded strong associations between structural, genetic, and biologic factors and CTS, with questionable evidence for an association between environmental and occupational factors.[9] This uncertain relationship between occupational exposure and the development of CTS was also found in a prospective longitudinal study carried out on a group of 166 workers over 17 years by Nathan et al.[10,11] At 11 years, greater age, female gender, relative overweight, cigarette smoking, and job-related vibrational exposure were found to significantly increase the risk of developing CTS.[10] At the 17-year evaluation, only greater weight and female gender were found to be positively associated.[11] In contrast, a literature review of occupational risk factors found evidence of a ≥2-fold increased risk of CTS with regular prolonged use of handheld vibratory tools, as well as prolonged highly

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TABLE 1. CTS-6 Diagnostic Clinical Criteria for CTS[4]

1. Numbness and tingling in the median nerve distribution
2. Nocturnal numbness
3. Weakness and/or atrophy of the thenar musculature
4. Tinel sign
5. Phalen's test
6. Loss of 2-point discrimination

repetitious flexion and extension of the wrist with forceful gripping. There was no consistent association found between CTS and keyboard or computer work.[12] The question of work-related activity and the development of CTS appears to remain unanswered, although there is an increasing awareness of a lack of evidence to support most causal assumptions. Keyboarding and other routine clerical activities in the modern workplace, in particular, do not appear to have much scientific evidence at the present time to support their causative role in the development of CTS. Nevertheless, this perception remains well entrenched.

TREATMENT

Treatment strategies for CTS are typically grouped into nonsurgical and surgical modalities. There has been a large body of literature produced in support of both treatment options. In recent years, much of that literature has addressed comparative evaluations of nonsurgical versus surgical treatment, as well as open versus endoscopic carpal tunnel release.

The AAOS has produced a Clinical Practice Guideline for the treatment of CTS.[13] Nine recommendations were included regarding treatment strategies based on the best level of evidence available in the literature (Table 2). Both nonsurgical and surgical treatments were recommended for early CTS without denervation of the median nerve. Splinting, local steroid injection, ultrasound, and oral steroids were all recommended as possible nonsugical treatments with high-level evidence in support of their use. Surgery was recommended for failed nonsurgical treatment or at any stage if the patient preferred surgery. A recent review of the literature addressed the issue of optimal nonsurgical treatment of CTS.[14] Splinting appeared to be better than no treatment in minimizing symptom severity and functional status for up to 3 months, with questionable benefit after that time. Oral steroids also appeared to offer benefit for up to 8 weeks, with an unknown risk associated with systemic steroid use cited as a mitigating factor in their routine use. The authors found a number of studies with level II evidence to support use of local steroid injections in the treatment of CTS. Benefits of steroid injection over placebo, oral steroids, and splinting alone were shown for between 2 weeks and 6 months. These results have been supported in numerous recent studies,[14,15–19] such that both splinting and a single steroid injection[17,18] can be prescribed, alone or in combination, for early nonsurgical treatment of CTS. Patients whose symptoms improve after a steroid injection to the carpal tunnel also have a significantly better response to surgery than those who do not respond to the injection.[19] Thus, for both therapeutic and prognostic reasons, a single steroid injection is an acceptable treatment modality for early CTS.

TABLE 2. AAOS Clinical Practice Guidelines for the Treatment of CTS: Recommendations

1. Nonsurgical treatment is an option for early CTS. Surgery is an option when there is evidence of median nerve denervation.
2. A second nonsurgical treatment or surgery is recommended when initial nonsurgical treatment fails after 2 to 7 weeks.
3. There is no evidence to support specific treatment recommendations for CTS associated with diabetes, cervical radiculopathy, hypothyroidism, polyneuropathy, pregnancy, rheumatoid arthritis, or CTS in the workplace.

4a. Local steroid injection or splinting is recommended prior to treatment with surgery.

4b. Oral steroids and ultrasound are also options for treatment.

4c. Carpal tunnel release is recommended for treatment of CTS based on level I evidence.

4d. Heat therapy does not have evidence to support its use in CTS.

4e. Other nonsurgical treatment modalities are not recommended for treatment of CTS.

5. Surgical treatment with complete division of the flexor retinaculum is recommended, regardless of the technique used.
6. Skin nerve preservation, epineurotomy, flexor retinacular lengthening, internal neurolysis, tenosynovectomy, and ulnar bursa preservation are not recommended in the performance of carpal tunnel surgery.
7. Use of preoperative antibiotics is an option that may be decided upon by the surgeon.
8. Wrist immobilization is not recommended postoperatively after routine carpal tunnel release. No recommendation is made regarding use of postoperative rehabilitation.
9. It is suggested that physicians use one or more patient response tools to assess results after carpal tunnel treatment in performing research.

Long-term benefits of local steroid injections in the treatment of CTS have not been shown, and surgical decompression of the carpal tunnel is recommended after an injection is no longer effective.[14–16] In addition, a comparison of the costs of nonsurgical and surgical treatment of CTS failed to show a significant difference.[20] Surgery, therefore, remains the preferred treatment for CTS after nonsurgical treatment has been tried and failed or as primary treatment in cases where patients prefer to opt out of initial nonsurgical treatment.

Both open carpal tunnel release (OCTR) and endoscopic carpal tunnel release (ECTR) have been used extensively in treating CTS for the past 2 decades. Yet, substantial controversy has persisted as to the preferred method of releasing the carpal tunnel. Safety, efficacy, perioperative morbidity, relative costs, and the rates of return to preoperative functional status have all been used by both sides of the debate to support their positions. In an attempt to resolve this issue, numerous prospective randomized trials have been reported comparing ECTR to OCTR.[21–25] The most consistent arguments made in favor of ECTR have been less postoperative pain than OCTR and a shorter return to functional activities, particularly preoperative work status. Both findings were supported in some of the prospective studies conducted comparing the two techniques[21,26] but not in others.[22–25] No difference in return to work data was found in some studies[23,24] despite greater short-term pain in the ECTR groups. Differences in symptom severity scores, functional status, and satisfaction consistently normalized by 1 year.[22–24] This was found to remain equivalent between the two techniques at 5-year follow-up in a study by Atroshi et al.[25] In a 2009 evidence-based review of the literature regarding OCTR versus ECTR, Abrams concluded that there was slightly more support for ECTR with respect to return to work and the return of grip and pinch strength. His review also indicated that short-term differences in postoperative outcomes measures were not seen in long-term follow-up.[26]

A lower incidence of postoperative neurovascular complications has long been cited as rationale for performing OCTR over ECTR, and this conclusion was borne out in early reports shortly after ECTR was described and popularized.[27] More recent studies, nearly 2 decades after the first cases of ECTR were performed, have failed to support the notion that OCTR is substantially safer than ECTR[21–26,28,29] Abrams in his review of the evidence comparing ECTR and OCTR did find that ECTR carries a higher risk of transient neurapraxia and revision surgery than OCTR but no evidence of an increased risk of major nerve or vessel injuries.[26] This finding was corroborated in the 2005 report of a series of 753 ECTR procedures performed by a single surgeon over a 13-year period in which no serious nerve, vessel, or tendon injuries occurred.[28]

Cost has also been cited by both sides of the debate as a rationale to support either OCTR or ECTR. Chung et al. in a 1998 cost-effectiveness analysis of ECTR versus OCTR concluded that ECTR is cost-effective as long as major complications, such as median nerve injury, occur 1% less often than with OCTR.[30] Other prospective randomized comparison trials have not shown a substantial cost difference between the 2 procedures, excluding the initial increased cost of equipment purchase in ECTR.[21,22,26]

Endoscopic carpal tunnel release and OCTR both appear to be safe and effective methods of treating CTS, with high-level evidence to support this claim. No clear long-term differences in outcomes measures between the 2 methods appear to exist in the literature to support one method as clearly superior to the other. The decision as to which procedure is most appropriate, therefore, remains a matter of choice for surgeons and patients.

OUTCOMES

Both nonsurgical and surgical treatment of CTS have been shown to be effective in providing symptom relief. As discussed earlier in this article, nonsurgical treatment has been shown to have a time-limited benefit, with symptomatic improvement present for between 6 and 52 weeks.[14–19] Long-term outcomes studies, therefore, are generally limited to reports of surgical treatment. Burke et al. in 2006 noted that an earlier American Society for Surgery of the Hand questionnaire revealed that 78% of the members surveyed indicated having used severe symptoms as an indication for expeditious carpal tunnel release.[31] They set out to evaluate the relationship between the duration and severity of CTS symptoms and outcomes in 523 hands having carpal tunnel release surgery in the United States and United Kingdom. Using a validated self-assessment questionnaire, they found that all cases reported significant improvement in symptom severity and functional status scores at 6 months after surgery, regardless of the duration of symptoms. The degree of improvement was related to the severity of symptoms preoperatively. Thus, they concluded that the severity of symptoms, not the duration of symptoms, has an effect on the outcome of carpal tunnel surgery. The improvement in symptom severity scores has been shown to be measurable and statistically significant as early as 2 weeks after surgery.[32]

Advanced age and concomitant diabetes mellitus have both been considered by many surgeons to be associated with a poorer prognosis after carpal tunnel surgery. Two retrospective studies and 1 prospective study in the past 5 years failed to show an association between advanced age ($>$70) and poor response to surgery for CTS.[33–35] Statistically significant improvements in symptom severity and satisfaction were noted in all 3 studies. Thus, advanced age does not appear to be associated with poorer outcomes after carpal tunnel release. Likewise, a prospective series of 35 diabetic and 31 nondiabetic age- and gender-matched patients treated with carpal tunnel release failed to show any significant differences in improvement in sensory function, motor function, or satisfaction.[36]

Overall, patient satisfaction and improvement in symptoms and functional status after carpal tunnel surgery are quite high. Reoperation for persistent or recurrent CTS is performed in less than 5% of cases.[37] In a report of 200 cases of reoperation for CTS, technical errors in the performance of the primary release were implicated in the need for a second surgery in a majority of cases. Incomplete release of the flexor retinaculum was found in 55%, nerve adhesion in scar was found in 32%, and a nerve laceration was found in 6%. No cause for recurrent or persistent symptoms was cited in 7%.[38]

Carpal tunnel syndrome is the most common compressive neuropathy in the upper extremity. Clinical diagnosis based on patient symptoms and physical exam is standard. Electrodiagnostic testing is useful as a confirmatory tool in preoperative cases and as a baseline to direct the management of unexpected outcomes. Early CTS can be managed with nonsurgical treatment or carpal tunnel release. Carpal tunnel release should be recommended to patients who have failed nonsurgical treatment. No clear advantage of either ECTR or OCTR is evident. The outcome of surgical treatment is generally favorable and is correlated with preoperative symptom severity. Evidence-based guidelines for the diagnosis and treatment of CTS have been established. Familiarity with these guidelines should direct the safe and effective treatment of CTS.

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JOURNAL CME QUESTIONS

Carpal Tunnel Syndrome

What is the role of splinting and steroid injection in the treatment of carpal tunnel syndrome (CTS)?

a. Splinting and steroid injection have been shown to be efficacious for early nonsurgical treatment of CTS.

b. Splinting has been shown to be efficacious for early nonsurgical treatment of CTS, while steroid injections have not been shown to be efficacious.

c. Steroid injections have been shown to be efficacious for early nonsurgical treatment of CTS, while splinting has not been shown to be efficacious.

d. Neither splinting nor steroid injection has been shown to be efficacious for early nonsurgical treatment of CTS.

e. Splinting and steroid injection have been shown to provide long-term resolution of CTS.

Comparing open (OCTR) versus endoscope (ECTR) carpal tunnel release, which statement is supported in the literature?

a. OCTR is safer than ECTR.

b. ECTR carries a higher risk of transient neurapraxia and revision surgery than OCTR.

c. OCTR is more expensive then ECTR when considering a cost-effective analysis model.

d. ECTR carries a higher risk of major nerve and vessel damage than OCTR.

e. OCTR has more persistent symptoms after 1 year compared to ECTR.

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