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Carpal Tunnel Syndrome

Screening and Prevention

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Patient Information

Compressive median neuropathy at the wrist, also known as carpal tunnel syndrome (CTS), is the most common entrapment neuropathy, accounting for about 90% of all such disorders. It is estimated to occur in up to 3.8% of the general population with a yearly incidence rate of 276:100 000 (1, 2). Various occupational and personal factors predispose to CTS, including age, sex, and obesity. In the working population, it is a disabling and costly condition, representing a major cause of lost workdays and workers compensation costs in the United States (3). Tingling, numbness, and pain in the median nerve distribution in the hand is the typical presentation.

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Clinical examination and electrodiagnostic testing confirm the diagnosis. Given the considerable socioeconomic impact of CTS, it is important to identify risk factors and introduce potentially effective measures for primary prevention when possible. The presumed underlying mechanism of CTS is increased pressure within the carpal tunnel, causing median nerve compression and compromising nerve circulation. Surgical sectioning of the transverse carpal ligament reduces the pressure in the tunnel and can be curative. It should be offered when conservative treatment fails to provide adequate relief and when clinical examination or electrodiagnostic changes suggest the possibility of irreversible nerve damage.

Screening and Prevention

Who is at risk for CTS?

Numerous occupational as well as nonoccupational risk factors for CTS have been recognized. Therefore, screening and prevention may be possible for some at-risk individuals. Occupational risk factors have long been recognized and primarily include repetitive, forceful hand work with wrist extension as well as vibration, cold environment, and combinations thereof (4). Workers with increased risk for CTS include workers in the construction, electronic and forestry, fish processing and cannery, frozen food/meat, furniture factory, garment and textile, and metal casting industries; aircraft mechanics; appliance and automobile manufacturers; and dental hygienists (5).

There is evidence that biomechanical occupational risk factors contribute to CTS. A recent, large, multicenter, prospective study of 2474 workers from various industries documenting workplace exposures of the dominant hand found, after adjustment of covariates, that estimated peak hand force (hazard ratio [HR], 2.08–2.17; 95% CI, 1.31–3.43), forceful repetition rate (HR, 1.84; CI,1.19–2.86), and the percentage of time spent in forceful hand exertions (HR, 2.05; CI, 1.34–3.15) were associated with increased risk for incident CTS. Associations were not observed between total hand repetition rate, percentage of duration of all hand exertions, or wrist posture and incident CTS (6). Accordingly, improvements in the design of workplace safety programs may help to prevent work-related CTS.

Nonoccupational risk factors may also predispose to CTS (**Table 1**). Increased body mass index (BMI) is an independent risk factor, especially in patients younger than 63 years (7). Moreover, increased serum low-density lipoprotein (LDL) levels was found to be a risk factor in a Japanese population, probably related to LDL-induced fibrinogenesis and median nerve enlargement (8). However, this association has not been entirely replicated in other populations (9, 10). Genetic predisposition to CTS has also been found in prospective (11) as well as twin studies, regardless of environmental risk factors (concordance for monozygotic twins, 0.35; for dizygotic twins, 0.24) (12). Familial predisposition is more common in patients with bilateral CTS (13). More rare entities include autosomal dominant CTS (14) and early childhood familial forms that may be associated with systemic genetic disorders, such as amyloidosis (15). Perhaps related to genetic predisposition, there seems to be an anatomical risk factor for CTS: Wider palm and more squared carpal tunnel and wrist measured as higher wrist ratio (anterior-to-posterior wrist dimension/medial-to-lateral wrist dimension) and wrist-to-palm ratio (anterior-to-posterior wrist dimension/palm length) were significantly associated with idiopathic CTS (16). This association may be par-

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Table 1. **Nonoccupational Risk Factors for Carpal Tunnel Syndrome**

Female sex
Age
Pregnancy
Obesity
Wrist ratio*
Family history
Renal failure/dialysis (possibly mediated through amyloid)
Amyloidosis (various forms)
Drug treatment with aromatase inhibitors (exemestane, tamoxifen)
Diabetes (with or without overt polyneuropathy)
Hypothyroidism
Acromegaly
Previous wrist fracture
Collagen vascular disease
Osteoarthritis of the wrist
Lipid abnormalities†

* Anterior to posterior wrist dimension divided by medial to lateral wrist dimension.
† Studies conflict with regard to the association between lipid abnormalities and carpal tunnel syndrome.

tially due to differences in BMI. Anatomical variations of the hook of hamate may also predispose to CTS (17). Finally, several systemic disorders may be associated with increased risk (**Table 1**).

Are there measures that can prevent CTS?

The evidence for the utility of preventive measures for CTS, such as engineering, personal, and multiple component interventions, is insufficient, and no specific guidelines have been established for primary prevention. However, at least one study showed that among workers exposed to upper extremity vibration, which is a significant risk factor for CTS, ergonomic intervention was effective in preventing progression of symptoms and findings attributable to CTS (18). Such preventive measures included the introduction of new tools with lower vibration levels and use of International Standards Organization 10819 antivibration gloves. In general, modifying the work environment and alternating tasks to reduce high-repetition work, vibration, and forceful hand exertion, when possible, may be recommended.

Occupational and nonoccupational risk factors may coexist. Studies in industrial workers showed that, in addition to vibrations associated with job tasks, greater age, female sex, relative overweight, and cigarette smoking significantly increased the risk for dominant-hand CTS (19). Specifically, BMI and age were associated with higher prevalence of CTS among construction workers (20), suggesting that weight loss may be a preventive measure for at-risk industrial workers. Finally, among hemodialysis patients, such measures as switching from conventional to a high-flux membrane as well as use of ultrapure dialysate, may reduce the risk for CTS.

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Table 2. **History and Physical Examination for Carpal Tunnel Syndrome**

History

- Dull, aching discomfort in the hand, forearm, or upper arm
- Paresthesias in the hand
- Weakness or clumsiness of the hand
- Dry skin, swelling, or color changes in the hand
- Provocation of symptoms by sleep
- Provocation of symptoms by sustained hand or arm positions
- Provocation of symptoms by repetitive actions of the hand or wrist
- Mitigation of symptoms by changing hand posture or shaking the wrist
- Hand-symptom questionnaire diagram (sensitivity 64%–93%, specificity 39%–80%); extramedian spread of sensory symptoms in up to 40% of patients
- Age >40 y (sensitivity 80%, specificity 41%)
- Nocturnal paresthesias (sensitivity 51%–84%, specificity 27%–68%)

Examination

- Hypalgesia in the median nerve territory (sensitivity 15%–51%, specificity 85%–93%); comparing index finger to little finger
- Two-point discrimination (sensitivity 6%–32%, specificity 64%–99%); using calibers whose points are set 4–6 mm apart
- Atrophy restricted to thenar (sensitivity 4%–28%, specificity 82%–99%)
- Weak thumb abduction (sensitivity 63%, specificity 66%); abductor pollicis brevis muscle
- Decreased vibratory sensation (sensitivity 20%–61%, specificity 71%–81%); comparing index finger to little finger
- Tinel sign (sensitivity 23%–60%, specificity 64%–87%); pain and paresthesias in median nerve distribution when taping the wrist
- Phalen sign (sensitivity 10%–91%, specificity 33%–86%); pain and paresthesias after flexing wrists 90 degrees for 1 min
- Hand elevation test (sensitivity 88%, specificity 99%); tingling/numbness in median fingers after elevating hand above head for 1 min

Screening and Prevention... Several occupational and nonoccupational risk factors may predispose to CTS. Although there are no evidence-based guidelines on the choice, usefulness, indications, or cost-effectiveness of screening tools, knowing the most important risk factors, such as high-force, repetitive tasks with vibrating tools, may be useful to implement preventive measures when possible.

CLINICAL BOTTOM LINE

Diagnosis

What symptoms suggest CTS?

CTS should be considered in any patient with a history of pain in the hand and arm; numbness and paresthesias in the hand; or weakness or clumsiness in the hand, especially in the median nerve distribution. However, many patients in the early stages present only with nocturnal paresthesias, which may be rather poorly localized to median territory; a few patients may have only daytime symptoms; and some may not report any pain. Typical provocative factors include worsening symptoms at night, with sustained hand and/or arm positions, or with repetitive hand and wrist movements and improvement with changing position or shaking the

21. Buch-Jaeger N, Foucher G. Correlation of clinical signs with nerve conduction tests in the diagnosis of carpal tunnel syndrome. J Hand Surg Br. 1994;19:720-4. [PMID: 7706873]
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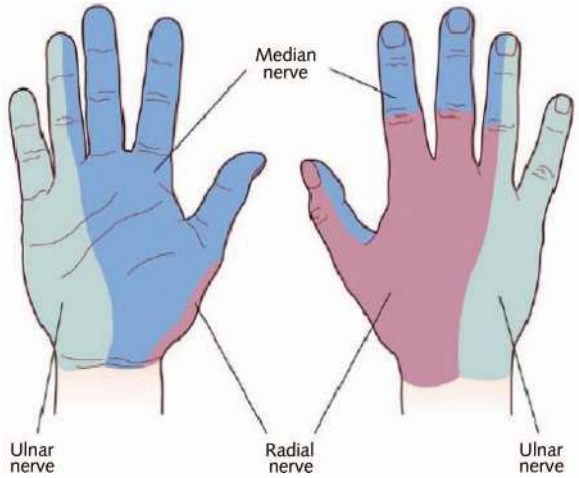
Figure. **Median nerve sensory territory and location of paresthesias in patients with CTS.**



The median nerve territory in the palm is supplied by the median palmar cutaneous branch, which does not pass through the carpal tunnel; therefore, sensory deficits in CTS are usually restricted to the median-innervated fingers. CTS = carpal tunnel syndrome.

hand (**Table 2**). A hand diagram (**Figure**) may help the patient localize the symptoms.

What physical examination findings are helpful in diagnosing CTS?

Several clinical findings or provocative tests have been traditionally used to diagnose CTS, including nocturnal paresthesias, Phalen and Tinel signs, thenar atrophy, 2-point discrimination, and vibratory and neurofilament sensory testing (21) (**Table 2**). Although the sensitivity of isolated symptoms may be limited in predicting the disease, a combination of typical neurologic symptoms, exacerbating and relieving factors, and the epidemiologic profile of the patient are essential in establishing the diagnosis. A review of multiple studies focusing on the diagnostic utility of isolated history and physical examination findings and maneuvers showed that use of a hand symptom diagram, hypoalgesia in the median nerve territory, and weakness of thumb abduction are most consistent with electrodiagnostically confirmed CTS (22). Physicians should be aware that CTS symptoms may be most commonly reported in both median and ulnar digits, followed by median digits only and a glove distribution. Furthermore, paresthesias or pain may be felt proximal to the wrist in 36.5% of hands (23).

The clinician should be aware that CTS may progress through different stages of severity with changing symptoms: In mild CTS, nocturnal paresthesias as well as swelling and pain relieved by shaking the hands or changing hand position are characteristic. In moderate CTS, symptoms persist during the day and decreasing sensation results in finger clumsiness and dropping objects. In severe CTS, numbness without pain and atrophy of the thenar eminence may occur. However, patients can have various clinical courses, including monophasic, self-limited symptoms; relapsing–remitting symptoms over many years; stable but tolerable symptoms for long periods; and rapid or slow progression of symptoms. Progression is not inevitable, and some patients

may improve spontaneously without surgical treatment (24).

Given the large differential diagnosis of CTS (**Table 3**), at a minimum, physical examination in patients with suspected CTS should include detailed neurologic assessment of the hand and arm, including motor and sensory testing, with emphasis on the motor and sensory territory of the median nerve distal to the wrist, and comparison of strength of the abductor pollicis brevis with the other hand muscles not innervated by the median nerve (e.g., the ulnar-innervated first dorsal interosseous and abductor digiti minimi) and to more proximal median-innervated muscles. Pain, temperature, and vibration should be tested on the median innervated compared with the ulnar innervated fingers.

What other conditions should be considered when evaluating a patient with possible CTS?

Several conditions can cause symptoms and findings similar to those caused by CTS (**Table 3**). A careful history and clinical examination may help to exclude most of them. However, definite exclusion of some other neurologic conditions will require laboratory testing with a nerve conduction study (NCS) and electromyography (EMG).

What is the role of NCS and EMG?

Although certain clinical findings, as discussed here, are moderately accurate in establishing the diagnosis of CTS, other isolated findings in referred patients have limited diagnostic accuracy. No data exist on the value of physical diagnosis in patients presenting to a primary care physician with symptoms suggesting CTS (22). A community-based study showed that many patients referred to an electrodiagnostic laboratory with a clinical suspicion of CTS have a different diagnosis, most commonly musculoskeletal disorders (25). Therefore, NCSs and EMG are considered to be the gold standard, not only for confirming the diagnosis of CTS with high a degree of accuracy (sensitivity >85% and specificity >95%), but also for determining the degree of severity based on nerve function and to exclude other neuromuscular conditions. NCSs also provide insight into the degree of functional impairment of the median nerve, which does not always correlate with clinical symptoms, depending on the stage and severity, thus offering a better basis for planning appropriate treatment (**Table 4**).

However, when the diagnosis of CTS is either clinically certain or highly unlikely, then EMG may not change the overall probability of diagnosing CTS to a clinically meaningful extent (26). According to guidelines from the American Association of Electrodiagnostic Medicine (27), confirmatory testing with NCS and EMG are recommended when clinical diagnosis is uncertain; when only a few or atypical clinical features are present; and when other neurologic diagnoses, in addition to or instead of CTS, are suspected. Electrodiagnostic evaluation should also be done in patients who do not respond to conservative therapy, in the presence of thenar atrophy and/or persistent numbness, or when invasive treatment is considered (28).

What is the role of imaging studies?

Imaging studies in patients with CTS may be useful if there is suspicion of local structural disease, such as deformity after previous wrist fractures, primary bone or joint disease, or local tumor. Wrist films or computed tomography are indicated only for eval-

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Table 3. **Differential Diagnosis of Carpal Tunnel Syndrome**

Disease	*Characteristics*
Cervical radiculopathy (common)	Neck pain radiating into the corresponding dermatome and paresthesias and/or sensory loss; decreased reflexes; and in severe cases, weakness in the corresponding myotome C6–C7 radiculopathies may mimic sensory symptoms of CTS while C8–T1 radiculopathies may cause thenar muscle atrophy Usually improves at night (as opposed to CTS) Sensory abnormalities in the forearm, beyond the distribution of the distal median nerve Reflex abnormalities (biceps, brachioradialis, triceps) and weakness of proximal muscles (C6–C7) or nonmedian innervated hand muscles (C8–T1) (normal in CTS) CTS and cervical radiculopathy may coexist ("double crush syndrome") Can be definitely evaluated with NCS/EMG
Polyneuropathy (diabetic, other acquired, or hereditary) or multiple mononeuropathies (common)	Sensory and/or motor deficits in a length-dependent pattern, affecting many nerves Examine lower extremities for decreased reflexes, sensory loss, and weakness NCS critical to fully characterize Multiple mononeuropathies affect more than one nerve at different sites, but if the initial presentation is with a median neuropathy, it may be difficult to distinguish from CTS before further nerves are affected
Brachial plexopathy	All trunks, and the medial and lateral cord of the brachial plexus, contribute fibers to the median nerve Upper trunk lesions cause symptoms and deficits in the C5–C6 dermatomes and myotomes, with sensory loss extending to the lateral arm and weakness affecting the deltoid, biceps, brachioradialis, and supraspinatus Middle trunk lesions mimic C7 radiculopathy (weakness of triceps, pronator teres and flexor carpi radialis, diminished triceps reflex) and rarely occur in isolation Lower trunk and medial cord lesions cause almost identical presentations (C8 portion of the radial nerve is involved in lower trunk but not medial cord lesion) with C8–T1 myotome weakness and sensory loss in digits 4 and 5 Lateral cord lesion affects the musculocutaneous nerve with biceps weakness and proximal (C6–C7) median-innervated muscle weakness EMG and NCS show abnormalities of motor and sensory nerves affected by the plexopathy, with denervation in the corresponding muscles
Vascular disorders (Raynaud syndrome)	Cold-induced vasoconstriction and pain in the hands, also affecting nonmedian territory (all fingers) Ischemia may cause paresthesias, but there are no constant neurologic deficits
Cervical myelopathy (common)	Extra- or intramedullary lesions (compressive, syringomyelia, neoplastic, inflammatory) in the cervical area (C6–T1) may cause symptoms and signs in one or both hands, which can be mistaken for CTS Distribution of neurologic abnormalities extends beyond the median nerve territory Associated features, including upper motor neuron signs in the lower extremities (spasticity, hyperreflexia) and bladder dysfunction, are common NCS findings are normal
Other CNS disorders	Transient paresthesias or motor/sensory deficits in one hand may be attributed to CTS, but other signs of CNS involvement (increased reflexes, mental or other higher cortical dysfunction, nonmedian territory involvement) and absence of pain make a diagnosis of CTS unlikely
Other painful articular and soft tissue disorders	Mechanically induced and exacerbated pain syndromes without sensory loss or muscle weakness Motor dysfunction may result from tendinitis or arthritis, with decreased passive range of motion In many patients with CTS, swelling and fibrosis of the flexor tendons within the carpal tunnel are present, which may worsen median nerve compression NCS findings are normal
Proximal median neuropathy	Compression under the ligament of Struthers (rare): anatomical variant of ligament spanning between the supracondylar process and the medial epicondyle, which may be compressing the median nerve Diagnosis supported by the presence of a supracondylar process in x-rays Pain in the elbow area and volar forearm with paresthesias in the median-innervated digits, exacerbated by supination of the forearm and extension of the elbow; the radial pulse may also be attenuated with these maneuvers Other causes include compressive casting, trauma, venipuncture, mass lesion, hematoma Sensory loss over the thenar eminence and weakness of median-innervated muscles proximal to the carpal tunnel (flexor pollicis longus, pronator teres and quadratus, flexor carpi radialis) differentiate proximal median neuropathy from CTS
Pronator teres syndrome (rare)	Compression of the nerve by a thickened band connecting the biceps muscle to the forearm, hypertrophy of the pronator teres, or a tight fibrous arch of the flexor digitorum superficialis Presents with pain at the elbow area associated with paresthesias and numbness; worsens with repetitive elbow movement but improves at night, in contrast to CTS; proximal forearm area is usually tender to pressure
Anterior interosseus syndrome (rare)	Motor deficits affecting the forearm muscles innervated by this branch of the median nerve result in the typical weakness of distal phalanx flexion of the thumb and index finger (tested with the attempt to make the "OK" sign) Anterior interosseus neuropathy is often a variant presentation of (idiopathic) brachial neuritis

CNS = central nervous system; CTS = carpal tunnel syndrome; EMG = electromyelography; NCS = nerve conduction studies.

Table 4. **Laboratory and Other Tests for Carpal Tunnel Syndrome**

Test	*Sensitivity (%)*	*Specificity (%)*	*Notes*
NCS and electromyography	>85	>95	NCS sensitivity based on the use of recommended elements of NCS for carpal tunnel syndrome A >90% sensitivity may be achieved when motor conduction techniques are used
High-resolution sonography of the carpal tunnel	57–89	65–97	When local structural disease is suspected (lower cost and time requirement favor sonography over MRI) For the diagnosis of CTS (quantitative measurement of median nerve cross-sectional area) sensitivity up to 89% and specificity of 97% reported among selected patients with CTS confirmed by electrodiagnosis, lower among unselected patients with clinically suspected CTS
High-resolution CT of the wrist			When local structural disease is suspected, evaluation of bony lesions or calcifications
MRI of the wrist	96	33-38	When local structural disease is suspected
Wrist x-ray			Detects bony but not soft tissue abnormalities; should be considered only with history of wrist trauma or restricted wrist movement
Cervical spine MRI			When cervical radiculopathy is suspected
Chest x-ray and/or MRI of brachial plexus			When brachial plexopathy or thoracic outlet syndrome is suspected
Blood studies			When CTS is associated with systemic disease (diabetes, hypothyroidism, acromegaly, gout) is suspected
Polyneuropathy evaluation			Depending on the type of neuropathy, inflammatory markers and assessment for connective tissue disease, protein electrophoresis, genetic testing for amyloidosis or other inherited neuropathies, spinal fluid examination, tissue biopsy for amyloid

CT = computed tomography; CTS = carpal tunnel syndrome; MRI = magnetic resonance imaging; NCS = nerve conduction studies.

uation of osseous carpal stenosis or bony tumors. Magnetic resonance imaging (MRI) or ultrasonography is useful for direct visualization of the median nerve and other soft tissues (tenosynovium) when there is suspicion of a soft tissue space-occupying lesion, such as a tumor, ganglion cyst, muscle hypertrophy, or palmar lipoma. The specificity of MRI for diagnosing CTS is rather low (**Table 4**).

In contrast, there is an emerging role for high-frequency ultrasound examination of the median nerve in the diagnosis of CTS. Abnormalities identified by sonography include swelling of the median nerve, flattening of the nerve in the distal carpal tunnel, or increased palmar flexion of the transverse ligament. Measurement of the median nerve cross-section in up to 3 areas (immediately proximal to the carpal tunnel inlet, at the carpal tunnel inlet, and at the carpal tunnel outlet) using similar discriminatory criteria (cutoff point around 10 mm^2, depending on the level and site in the arm) showed sensitivity ranging from 83% to 94% and specificity ranging from 65% to 73%. The sensitivity of ultrasonography in diagnosing mild CTS is much lower (30%–55%). However, ultrasound assessment was found to be useful diagnostically in a group of patients with clinical CTS findings and negative electrodiagnostic test results. Several studies showed that electrophysiologic measurements have consistently higher specificity and sensitivity than sonography (29) and are better predictors of symptom severity and functional status in patients with idiopathic CTS (30). This has been reproduced by a prospective, blinded study confirming

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the higher diagnostic value of electrodiagnostic testing than a new ultrasound approach (31). Thus, sonography may be useful but is not accurate enough to supplant NCS for CTS diagnosis (32). However, this is an evolving field and a correlation between 3-dimensional ultrasonographic findings and electrodiagnostic severity of CTS is increasingly being reported (33).

To determine whether electrodiagnostic examination can be replaced by ultrasonography to confirm CTS, Claes and colleagues (31) used a new set of normal values taking wrist circumference of patients into account and prospectively examined 156 patients with idiopathic CTS with both ultrasonography and NCSs. Of the selected patients, 83.3% met the electrodiagnostic criteria for CTS. Ultrasonography findings were normal in 67 (42.9%) of 156 patients, and within this group, NCS findings were abnormal in 44 patients (65.7%). Of 89 patients with abnormal ultrasonography findings, only 3 patients had normal findings from electrodiagnosis. The authors concluded that ultrasonography does not have the same diagnostic value and cannot replace NCSs for confirmation of clinical diagnosis of CTS. However, abnormal ultrasound results are highly predictive that electrodiagnostic results in clinically defined CTS will also be abnormal. Ultrasonography might reveal relevant anatomical information before surgery; however, it seldom directly influences patient management.

What other laboratory studies may be useful?

Although the diagnosis of CTS does not require laboratory studies, there is evidence for association of CTS with certain systemic disorders. Therefore, further diagnostic testing should be considered when symptoms of conditions associated with increased incidence of secondary CTS are present (34). Consensus guidelines are available from the American Academy of Neurology and the American Society of Plastic and Reconstructive Surgeons on the indications for specific diagnostic tests in patients presenting with CTS and suspected underlying systemic disorders. Conditions that predispose to CTS are usually clinically evident and have been diagnosed long before presentation. Fasting plasma glucose for suspected diabetes; thyroid function tests for suspected hypothyroidism; renal function and uric acid testing for suspected renal failure or gout; measurement of rheumatoid factor, erythrocyte sedimentation rate, and antinuclear antibodies for suspected rheumatoid arthritis or other connective tissue disorders; somatomedin-C, prolactin and phosphate levels, and growth hormone suppression testing for suspected acromegaly; serum protein immunofixation for paraproteinemia; and tissue biopsy for amyloid may be considered in patients with secondary CTS in the appropriate clinical setting.

When should clinicians refer patients to a specialist for diagnosis?

Most clinical signs and symptoms of CTS are not diagnostic, and many other conditions can mimic it. A specialist with expertise in electrodiagnostic studies (neurologist, physiatrist) should be consulted to assist with confirmatory NCS/EMG. Increasingly, there is also the option to consult radiologists with expertise in ultrasonographic diagnosis of CTS. Consultation for diagnosis should be considered when the diagnosis is in doubt, when conservative treatment has failed, and when surgery or other invasive treatment is being considered. The NCS provides the definitive diagnosis for most patients and helps to exclude other neuropathic or neuromuscular conditions that mimic CTS. Even in patients whose clinical diagnosis is considered definitive, preoperative electrodiagnostic assessment provides a baseline for postoperative assessment in patients with unsatisfactory surgical re-

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34. Solomon DH, Katz JN, Bohn R, Mogun H, Avorn J. Nonoccupational risk factors for carpal tunnel syndrome. J Gen Intern Med. 1999;14:310-4. [PMID: 10337041]

sults. Presurgical electrodiagnostic assessment is endorsed by several professional societies (35).

Diagnosis... Pain in the hand and arm; numbness and paresthesias in the hand; and weakness or clumsiness in the hand, occurring in the median nerve distribution, are highly suggestive of CTS. However, clinical findings are limited in their diagnostic accuracy, and several conditions can cause similar symptoms and findings. Patients should be carefully examined with this in mind, but consultation for electrodiagnostic NCS/EMG confirmation and, increasingly, ultrasonographic evaluation will be needed in most cases, especially when initial treatments fail and surgical decompression is planned. Imaging studies are useful for detecting rare structural anomalies, and further laboratory studies may confirm suspected secondary CTS due to a systemic condition.

CLINICAL BOTTOM LINE

Treatment

How should clinicians manage patients with CTS?

Optimal and cost-effective CTS management should be patient-oriented and tailored to the stage of the median neuropathy. Conservative nondrug treatments are widely accepted first-line therapies for mild CTS; however, evidence for some of these treatments is not compelling, and their effects are usually temporary. Drug therapy, including steroid injection, may also be effective only temporarily. The patient should be offered surgical decompression if these methods fail or as early as possible in advanced stages of nerve compression indicated by progressive motor deficit, severe sensory deficit, or a severe electrodiagnostic abnormality to avoid further nerve damage. In patients with secondary CTS associated with a systemic disease, treatment should be targeted at the primary disease.

What is the role of conservative measures, such as wrist splinting and activity modification?

A 2012 Cochrane review of splinting for CTS included 19 trials with 1190 participants; studies were generally of poor quality. A few trials found that splinting at night was better than no splinting, and side effects were minimal across studies (36). Splinting is inexpensive and associated with few complications and should be the first treatment option, especially in mild to moderate cases. Splints may also provide some immediate symptomatic relief for patients awaiting surgery for more severe disease. Splints should be used for at least 4 weeks, and improvement usually occurs within the first 2 weeks. Full-time splinting may be more effective than night-only splinting, and neutral position splints relieve symptoms better than cock-up (extension) splints (37). Immobilization of the wrist in neutral position decreases pressure in the carpal tunnel and improves circulation and median nerve function. To achieve a neutral wrist position, a thermoplastic custom insert is easier to mold than a prefabricated metal one; however, the latter is more cost-effective. It is important to observe the wrist position when fitting a prefabricated off-the-shelf

35. Keith MW, Masear V, Amadio PC, et al. Treatment of carpal tunnel syndrome. J Am Acad Orthop Surg. 2009;17:397-405. [PMID: 19474449]
36. Page MJ, Massy-Westropp N, O'Connor D, Pitt V. Splinting for carpal tunnel syndrome. Cochrane Database Syst Rev. 2012;7:CD010003. [PMID: 22786532]
37. Burke DT, Burke MM, Stewart GW, Cambré A. Splinting for carpal tunnel syndrome: in search of the optimal angle. Arch Phys Med Rehabil. 1994;75:1241-4. [PMID: 7979936]

wrist splint, as they tend to be more rigid and less comfortable than custom splints and are typically made to have 10 to 30 degrees of extension. CTS patients prescribed prefabricated splints should be followed up with the splint to adjust to the neutral position for better results (38).

A 2012 Cochrane review of exercise and mobilization therapy for CTS included 16 studies with 741 participants, but only 3 studies addressed the primary outcome of short-term improvement and presented enough data for inclusion; all 3 were of low quality. One study showed that exercise led to more overall improvement, a second showed that it led to greater satisfaction with care, and a third showed no effect on measures of nerve function (39). Aerobic exercise for reduction of body weight in overweight individuals may also be recommended.

What is the role of physical therapy?

A 2013 Cochrane review of ultrasound for CTS included 11 studies with 414 participants. Overall, the evidence was of low quality. Only one study reported short-term improvement as an outcome; it also found that patients receiving ultrasound were more likely to improve after 7 weeks. There was no evidence to suggest which ultrasound protocol was most beneficial (40). Short-wave diathermy treatment for mild and moderate idiopathic CTS was studied in a prospective, randomized, double-blind study and was beneficial in relieving symptoms and improving clinical scales after 3 weeks of treatment (41). A randomized, single-blind study of a yoga-based intervention showed that, compared with patients treated only with a wrist splint, those in the yoga-treated group had significantly improved grip strength and reduced pain after 8 weeks (42). However, studies addressing chiropractic or biobehavioral interventions, magnet therapy, low-level laser therapy, and laser acupuncture yielded no conclusive evidence for the use of these methods in CTS.

Which medications should clinicians prescribe first?

In general, treatment with oral medications for CTS is not well supported by experimental evidence. Nonsteroidal anti-inflammatory drugs (NSAIDs) may be tried first, especially in patients with inflammatory joint conditions (arthritis) or flexor tendinitis, although oral corticosteroids may be more effective. Two-week treatment with oral steroids led to symptom improvement compared with placebo for as long as 4 weeks (43). The latter may also cause more side effects. Lidocaine patch 5% may offer temporary pain relief. Diuretics can theoretically be useful in CTS patients with wrist edema, but their use is not supported by substantial evidence. Age older than 50 years, disease duration exceeding 10 months, and constant paresthesias are indicators that conservative management is unlikely to succeed (44). Overall, there is no satisfactory evidence from randomized, controlled clinical trials supporting the use of diuretics, NSAIDs, gabapentin, or amitriptyline.

When should clinicians consider corticosteroid injections?

Local steroid injection into the carpal canal should be considered for temporary relief in selected patients with significant pain and mild to moderate CTS. For milder cases, steroid injection may be sufficient to provide lasting effect, although this outcome is less likely in women, patients with diabetes, and those with nerve conduction abnormalities (45). Several clinical trials

38. Gravlee JR, Van Durme DJ. Braces and splints for musculoskeletal conditions. Am Fam Physician. 2007;75:342-8. [PMID: 17304865]
39. Page MJ, O'Connor D, Pitt V, Massy-Westropp N. Exercise and mobilisation interventions for carpal tunnel syndrome. Cochrane Database Syst Rev. 2012;6:CD009899. [PMID: 22696387]
40. Page MJ, O'Connor D, Pitt V, Massy-Westropp N. Therapeutic ultrasound for carpal tunnel syndrome. Cochrane Database Syst Rev. 2012; 1:CD009601. [PMID: 22259004]
41. Incebiyik S, Boyaci A, Tutoglu A. Short-term effectiveness of short-wave diathermy treatment on pain, clinical symptoms, and hand function in patients with mild or moderate idiopathic carpal tunnel syndrome. J Back Musculoskelet Rehabil. 2015;28:221-8. [PMID: 25061038]
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have shown the efficacy of corticosteroid injection in providing at least temporary relief of CTS-related pain. Injection is relatively contraindicated in patients with thenar muscle weakness and atrophy, advanced sensory loss indicating severe CTS, or acute CTS and/or wrist edema. Patients with severe CTS of more than 1 year in duration with these clinical findings and severe electrophysiologic abnormalities have a poor response to steroid injections and a high rate of relapse (45, 46). Multiple injections are not recommended because they can cause tendon rupture and median nerve injury. The number of injections should not exceed 3 or 4, and usually, if pain recurs after a second injection, patients should be advised to proceed with surgical release.

A 2007 Cochrane review of local corticosteroid injection for CTS included 12 studies with 671 participants. Two randomized trials of high quality found that injection was superior to placebo for clinical improvement at 1 month (relative risk, 2.58 [CI, 1.72 to 3.87]). Two studies found that steroid injection was superior to oral steroids, and another study found that steroid injection was not superior to splinting plus anti-inflammatory medication (47). The safest location for injection is proximal to the carpal tunnel through the flexor carpi radialis tendon to avoid injury to the median nerve. Complications of local steroid injection, aside from median nerve injury, include local infection; tendon rupture; reflex sympathetic dystrophy; and, rarely, digital ischemia (48). Iontophoresis may be an alternative, low-risk method of local steroid delivery to the carpal tunnel and deserves further study.

When should clinicians consider referral to a surgical or nonsurgical specialist?

Patients should be referred for surgical management if they do not respond to conservative treatment for pain or have progressive sensory or motor deficits or moderate-to-severe electrodiagnostic abnormalities according to widely accepted grading (49, 50). Patients with clinically or electrodiagnostically severe CTS at initial diagnosis should have surgical decompression as first-line treatment to avoid further nerve damage. In patients with bilateral CTS, simultaneous carpal tunnel release may be more cost-effective and cause less disability than consecutive bilateral release (51).

Surgical treatment of CTS is based on the evidence that increased pressure in the carpal tunnel causes compression of the median nerve. Carpal tunnel release consists of division of the transverse carpal ligament, which increases the space in the carpal tunnel, thereby reducing the pressure on the median nerve. Surgical literature on the utility of carpal tunnel release consists of several retrospective and uncontrolled studies, showing excellent outcomes in 90% to 100% of patients (52). However, referring physicians should be aware that these high success rates are usually reported from specialized hand surgery centers and that a higher percentage of patients having this procedure in general practice may have an unsatisfactory outcome. A randomized, parallel-group trial also confirmed that surgical treatment led to better outcomes than did nonsurgical treatment (53). Either open release or endoscopic carpal tunnel release can be used. A mini-open release is a newer version with a smaller incision, and single-portal or dual-portal techniques may be used for endoscopic release. Numerous studies have compared the benefits and drawbacks of these surgical ap-

46. Graham RG, Hudson DA, Solomons M, Singer M. A prospective study to assess the outcome of steroid injections and wrist splinting for the treatment of carpal tunnel syndrome. Plast Reconstr Surg. 2004; 113:550-6. [PMID: 14758217]
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52. Cseuz KA, Thomas JE, Lambert EH, Love JG, Lipscomb PR. Long-term results of operation for carpal tunnel syndrome. Mayo Clin Proc. 1966; 41:232-41. [PMID: 5907222]
53. Jarvik JG, Comstock BA, Kliot M, et al. Surgery versus non-surgical therapy for carpal tunnel syndrome: a randomised parallel-group trial. Lancet. 2009;374:1074-81. [PMID: 19782873]

proaches. Although outcome measures and results vary, no significant differences were found in terms of efficacy. Several randomized, controlled studies comparing various surgical techniques for CTS treatment failed to demonstrate any strong evidence supporting the use of one technique over the other.

A recent meta-analysis of 21 randomized, controlled trials comparing open versus endoscopic carpal tunnel release indicated that endoscopic release allows earlier return to work and improved strength during the early postoperative period. Results at 6 months or later were similar, except that patients undergoing endoscopic release were at greater risk for nerve injury and less risk for scar tenderness than those having open release. The authors concluded that additional research is required to define the learning curve of endoscopic release and to clarify the influence of surgeon volume on safety (54).

Most surgeons agree on a general list of absolute and relative contraindications for endoscopic approaches, including suspected mass lesion within the carpal tunnel, rheumatoid arthritis, prior surgery, severe tenosynovitis, or concomitant ulnar neuropathy at the wrist (55). Significant, lasting complications after carpal tunnel release include damage to the median or ulnar nerve and development of reflex sympathetic dystrophy. However, complication rates are low, both with endoscopic and open carpal tunnel release (56). With appropriate patient selection and technical expertise, carpal tunnel release is considered one of the most frequently successful interventions in medicine. In a large, cross-sectional study, poor outcome was associated with repeated surgeries or surgical complications, as well as with concurrent diagnoses of either tendonitis or epicondylitis. In contrast, better outcome was associated with abnormal NCS findings, emphasizing the importance of this diagnostic test for patient selection before surgery (57).

A recent study examining the benefit of carpal tunnel release in patients with electrophysiologically moderate (n = 47) compared with severe (n = 48) disease showed that at 1 year or longer after surgery, 1 (2%) patient with moderate CTS and 9 (19%) patients with severe CTS reported continued symptoms. Although symptoms diminished in both groups from the preoperative assessment to the 2-week postoperative assessment, patients with severe CTS had comparatively more severe symptoms at all time points, with the exception of pain at 2 weeks and 1 year or longer after surgery. At those times there was no significant difference. Preoperative electrodiagnostic severity was the factor most predictive of symptom scores. Thus, patients with severe CTS have considerable reduction in symptoms after surgery but should be informed that recovery may be more prolonged and in some cases may be incomplete 1 year after carpal tunnel release, particularly with regard to numbness (58).

Postsurgical care includes elevation of the hand, gradual exercise of the hand and forearm, and wrist splinting in a neutral or slightly extended position for 2 to 3 weeks. Early mobilization, as opposed to splinting, may result in shorter time to return to activities of daily living or work (59). If a patient does not respond to carpal tunnel release, it is important to verify that the distal ligament has been properly sectioned. Release is found to be incomplete in nearly half of patients in whom surgery has failed (60). Other causes of failure to improve after surgery include fibrous proliferation, circumferential fibrosis, incorrect diagnosis, iatrogenic injury, or recurrent tenosynovitis. A more recent study that classified selected patients having revision carpal tunnel release into those with persistent, recurrent, or new symptoms showed that diabetes and a longer interval from primary carpal tunnel release were more common in the recurrent group, whereas nerve injury was more common in the group with new symptoms. Incomplete release of the flexor retinaculum and scarring of the median nerve were com-

54. Sayegh ET, Strauch RJ. Open versus endoscopic carpal tunnel release: a meta-analysis of randomized controlled trials. Clin Orthop Relat Res. 2015; 473:1120-32. [PMID: 25135849]
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mon intraoperative findings in all groups (61).

How should clinicians follow patients with CTS?

Patients treated conservatively who do not improve or who have progression of symptoms and neurologic deficits require re-evaluation and consideration of surgical treatment. Moreover, improvement after most conservative treatments may be temporary, and symptoms may recur after initial amelioration (62). Therefore, patients receiving conservative treatment should be followed for at least 6 months to ensure clinical improvement and response to therapy, including pain relief and sensory and motor function. After invasive therapy (injection or surgery), patients should be followed more closely, with emphasis on vascular status, wound healing, and neurologic function. Return visits at 2- to 6-week intervals for up to 6 months after invasive therapy or surgery are recommended to ensure timely reevaluation and possible revision in cases of failed carpal tunnel release (63).

How should clinicians educate patients about CTS?

Patients should be educated about the nature of CTS, its known causes and risk factors, exacerbating activities, diagnostic methods, and therapeutic options. Patients who have good information about their disease will be more likely to exercise secondary prevention and to adhere to therapeutic interventions and follow-up care. Many patients feel reassured by learning about their disease, particularly if they had suspected a more serious neurologic problem or other condition.

Treatment... CTS treatment should be individualized and tailored to the severity of median nerve compression. In mild to moderate cases, evidence-supported nonsurgical therapies include splinting in neutral wrist position, mobilization therapy, and steroid injection. Secondary CTS should be recognized and the associated systemic disease treated. Lack of lasting response or findings consistent with advanced stages of median nerve compression and injury should prompt early decompressive surgery to avoid lasting nerve damage. Surgical decompression of the carpal tunnel, either open or endoscopically, is generally well-tolerated and highly successful in the hands of an expert.

CLINICAL BOTTOM LINE

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63. Jones NF, Ahn HC, Eo S. Revision surgery for persistent and recurrent carpal tunnel syndrome and for failed carpal tunnel release. Plast Reconstr Surg. 2012; 129:683-92. [PMID: 22090245]

In the Clinic
Tool Kit

Carpal Tunnel Syndrome

Patient Information

http://familydoctor.org/familydoctor/en/diseases-conditions/carpal-tunnel-syndrome.html
Information on carpal tunnel syndrome from the American Academy of Family Physicians.

www.ninds.nih.gov/disorders/carpal_tunnel/detail_carpal_tunnel.htm
Carpal tunnel syndrome fact sheet from the National Institute of Neurological Disorders and Stroke (NINDS).

www.ninds.nih.gov/disorders/carpal_tunnel/carpal_tunnel.htm
Information on carpal tunnel syndrome from the NINDS.

http://tools.aan.com/apps/disorders/index.cfm?event=database:disorder.view&disorder_id=872
Information on carpal tunnel syndrome from the American Academy of Neurology.

www.aanem.org/Education/Patient-Resources/Disorders/Carpal-Tunnel-Syndrome.aspx
Information on carpal tunnel syndrome from the American Association of Neuromuscular and Electrodiagnostic Medicine.

http://orthoinfo.aaos.org/topic.cfm?topic=A00005
Information on carpal tunnel syndrome from the American Academy of Orthopaedic Surgeons in English.

http://orthoinfo.aaos.org/topic.cfm?topic=A00621
Information on carpal tunnel syndrome from the American Academy of Orthopaedic Surgeons in Spanish.

www.nhs.uk/conditions/carpal-tunnel-syndrome/pages/whatisit.aspx
Information on carpal tunnel syndrome from the National Health Service.

Clinical Guidelines

http://onlinelibrary.wiley.com/cochranelibrary/search
Guideline on carpal tunnel syndrome from The Cochrane Library Database of Systematic Reviews.

www.aaos.org/research/guidelines/CTStreatmentguide.asp
www.aaos.org/research/guidelines/CTSTreatmentGuideline.pdf
Guideline on carpal tunnel syndrome from the American Academy of Orthopaedic Surgeons.

www.aanem.org/Practice/Practice-Guidelines.aspx
www.aanem.org/getmedia/3836fd0d-11c1-461b-8f45-5ef59dcf604b/NMUS-for-DX-of-CTS-for-web.pdf.aspx
www.aanem.org/getmedia/7ddc9ef9-ee91-4b48-9c1a-53454313001e/CTS.pdf.aspx
Guidelines on the treatment of carpal tunnel syndrome from the American Association of Neuromuscular and Electrodiagnostic Medicine.

WHAT YOU SHOULD KNOW ABOUT CARPAL TUNNEL SYNDROME

What Is Carpal Tunnel Syndrome?

Carpal tunnel syndrome is a condition caused by pinched nerves in the wrist. These nerves help your wrist and hand move and feel. When they become pinched, it can cause pain and discomfort. Risk factors for carpal tunnel syndrome are:

- A job that requires using your hand or wrist in the same way every day (such as using power tools that vibrate) or put stress on the hands (such as typing or working on an assembly line)
- Family history of carpal tunnel syndrome
- Past wrist injury
- Being overweight or obese
- Being pregnant
- Having certain health conditions like arthritis, diabetes, or underactive thyroid

What Are the Warning Signs of Carpal Tunnel Syndrome?

Symptoms can develop slowly and become more noticeable over time. These can include:

- Numbness, tingling, or pain in the fingers, hand, or forearm. Symptoms often are worse at night.
- Feeling like you are unable to make a fist or hold objects.
- Weakness in your hand and wrist.

How Is Carpal Tunnel Syndrome Diagnosed?

Your doctor will ask about your symptoms. He or she may also physically examine your arm, wrist, and fingers. In some cases, your doctor may do a test to check for muscle and nerve function. Further testing may be needed, including an ultrasound of your wrist or forearm, especially if the nerve and muscle tests are negative.

How Is Carpal Tunnel Syndrome Treated?

There are several treatment options for carpal tunnel syndrome. Your doctor may suggest using a splint to support your wrist. A splint will hold your wrist in place and help the nerves in your arm heal. Over-the-counter pain medicines can help with swelling or pain. If the pain is severe, your doctor may suggest a stronger medicine, called a steroid, which is injected into your wrist. In some cases, surgery may be needed. If not treated, carpal tunnel syndrome can cause permanent nerve damage.

Questions for My Doctor

- Should I change any of my daily activities?
- Am I at risk for permanent nerve damage?
- Do I need any further testing?
- Which treatment option is best for me?
- When can I expect my discomfort to go away?
- How can I prevent any further damage?
- How can I change my work activities?

Bottom Line

- Carpal tunnel syndrome is a condition that develops when the nerves in your wrist become pinched.
- Symptoms include numbness, pain and tingling in your forearm, wrist, and hand. They may also include feeling like you are unable to make a fist, or feeling weak in your hands and fingers.
- To diagnose carpal tunnel syndrome, your doctor will ask about your symptoms and may perform a physical examination of your arm, wrist, and fingers. Some people may need additional tests, like tests of nerve and muscle function.
- Treatment includes using a splint to stabilize your wrist and prevent more damage. Your doctor may also suggest over-the-counter pain medicines or steroid injections. In some cases, surgery may be needed.

For More Information

National Institute of Neurological Disorders and Stroke
www.ninds.nih.gov/disorders/carpal_tunnel/detail_carpal_tunnel.htm

American Academy of Family Physicians
http://familydoctor.org/familydoctor/en/diseases-conditions/carpal-tunnel-syndrome.html

American College of Rheumatology
https://www.rheumatology.org/Practice/Clinical/Patients/Diseases_And_Conditions/Carpal_Tunnel_Syndrome/

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Patient Information