Carpal Tunnel Syndrome

Background

Carpal tunnel syndrome (CTS) refers to the compression of the median nerve as it travels through the carpal tunnel, which can cause pain, paresthesia, and weakness in the median nerve distribution (Kothari, 2024). CTS is a common disorder, often seen in clinical practice, with a prevalence of approximately 1 to 5 percent of the population, and often results in a significant reduction in job productivity and lost days of work.

Pathophysiology

The median nerve provides sensation to the thumb, index finger, middle finger, and sometimes the ring finger. It travels down the forearm and enters the hand through a narrow tunnel formed by the bones of the wrist and the transverse carpal ligament. Injury, inflammation, or swelling in this area may cause compression of the median nerve, which can result in symptoms of CTS.

Causes (Kothari, 2024)

- Injury, inflammation, swelling, or thickening of the flexor tendons around the median nerves
- Fibrosis surrounding the flexor tendons
- Congenitally small anatomic space within the carpal tunnel
- Lesions, cysts, or neoplasms that compress the median nerve
- Systemic illnesses that cause edema or inflammation (e.g., rheumatoid arthritis)

Risk Factors (Kothari, 2024; Erickson, 2019)

Risk Factors for Carpal Tunnel Syndrome*		
Obesity	Osteoarthritis and rheumatoid arthritis	Genetic predisposition
Female gender	Hypothyroidism	Aromatase inhibitor use
Perimenopause	Tendonitis	Trauma
Pregnancy – symptoms often resolve after delivery	Preexisting median mononeuropathy	Workplace factors (repetition, forceful exertion, vibration)
Diabetes mellitus	Connective tissue diseases	Repetitive hand/wrist use
Amyloidosis (more common in older adults with bilateral symptoms)		

**Assess patients for risk factors but note that the presence of only one does not rule in CTS. Studies support that physical activity is associated with a decreased risk of developing CTS*.

Symptoms (Kothari, 2024a)

- Characteristic symptoms
  - Pain (often described as dull and aching) and paresthesia (numbness or tingling) of the fingers (thumb, index finger, middle finger, and one-half of the ring finger), entire hand, forearm, and possibly above the elbow and radiating to the shoulder (excluding the neck)
  - Weakness or clumsiness of the hand
  - Occurrence of any of these symptoms in the median distribution

    - Symptoms may begin to present in the nighttime
- Provocative factors
    - Sleep
    - Sustained flexing or extending wrists or raising the arms (e.g., driving, reading, typing)
    - Proposed occupational factors (controversial)
        -Repetitive movements of the hand or wrist
        -Working with vibrating tools
        -wrist or palm pressure that is ongoing
        -Forceful use of hand or wrist
        -cold temperatures while using hands
- Mitigating factors
    - Changes in hand position
    - Shaking the hand
    - Placing the hand under warm water

Physical Examination

- Test sensation in all areas of the hand, forearm, and upper arm
- Evaluate for weakness of the thumb in both abduction and opposition

Common Diagnostic Tests (Kothari, 2024a; Alvarez & Brown, 2024)

No single test should be used to diagnose CTS. A combination of physical exams, diagnostic questionnaires, and electrodiagnostic studies provides better accuracy to rule in CTS or exclude it.

One validated risk score, the CTS-6, helps diagnose CTS. It relies on assigning points to 6 symptoms, including thenar atrophy or weakness, positive Tinel sign, numbness predominantly or exclusively in the median nerve distribution, positive Phalen test, nocturnal numbness, and loss of 2-point discrimination. A score of twelve or higher was found to have a sensitivity of 89% and specificity of 80% in one 2014 study.

Tests Used to Facilitate the Diagnosis of Carpal Tunnel Syndrome

Test	Maneuver	Positive Test
Phalen Test	Hold wrist in a fixed flexion position for 1 minute	Development of or increase in pain and/or paresthesia along median nerve (Sensitivity 68%, Specificity 73%)
Tinel Test	Tap vigorously over the median nerve, proximal to or on top of the carpal tunnel	Pain and/or tingling feeling or electrical shocks along the median nerve (Sensitivity 50%, Specificity 77%)
Manual carpal compression test (Durkan test)	Apply pressure over the transverse carpal ligament for 30 seconds	Pain or paresthesia (Sensitivity 64%, Specificity 83%)
Hand elevation test	Patient raises hands over head for one minute	Symptoms of CTS are reproduced (sensitivity and specificity possibly similar to Phalen and Tinnel test)
Upper limb neurodynamic test	Abduct and externally rotate the shoulder and flex the elbow at 90 degrees. Then supinate the	Positive test if CTS symptoms occur or worsen with elbow extension.

	forearm, extend the wrist and fingers, and extend the elbow.	
Nerve Conduction Studies (NCS) *used in patients with moderate to severe symptoms or atypical symptoms	Motor and sensory conduction studies of the median nerve; quantify disease severity and differentiate muscle conditions from neurological disorders	Slowed conduction velocities indicate CTS; more severe compression may result in motor or sensory nerve action potential amplitude; mild CTS may not show any conduction abnormalities
Electromyography (EMG) *used in patients with moderate to severe symptoms or atypical symptoms	Assess for changes in the muscles innervated by the median nerve; excludes other conditions such as polyneuropathy, plexopathy, and radiculopathy (pinched nerve)	Active denervation or chronic changes that may indicate denervation and reinnervation
Magnetic Resonance Imaging (MRI) or Ultrasound *reserved for cases where anatomical abnormality is suspected or explanation not found on EMG	Use only in rare cases to rule out a mass or lesion; MRI should **not** be used routinely for CTS diagnosis.	Ultrasound: skilled practitioner needed, caution interpreting results in older adults MRI: Detects abnormalities of the median nerve, flexor tendons, vascular structures, and transverse carpal ligament

Treatment

Patient management is based on the severity of CTS symptoms and the degree of injury that is noted on electrodiagnostic studies.

Grading Severity of CTS (Kothari, 2024b)		
Clinical Grading	**Signs and Symptoms**	**Electrodiagnostic criteria**
Mild	• Tingling or discomfort in the median nerve distribution • No sensory loss or weakness, no sleep disruption, no difficulty with hand function or interference with activities of daily living (ADLs).	• Normal Motor studies. Prolonged sensory latencies. No axon loss
Moderate	• Persistent numbness/sensory loss in the median distribution or mild nocturnal symptoms at night that disrupt sleep. • Symptoms may interfere slightly with hand function, but the patient is able to perform all ADLs.	• Prolonged sensory and motor latencies. No axon loss.
Severe	• Weakness in the median distribution or if symptoms are disabling and prevent the patient from one or two ADLs, or if nocturnal symptoms routinely disrupt sleep.	• Evidence of axon loss

Nonsurgical Management (Kothari, 2024b)

Nonsurgical treatment should be implemented first line for patients with clinically mild CTS and patients with moderate to severe symptoms who do not show axon loss on diagnostic testing. These treatments include splinting, glucocorticoids, physical and occupational therapy, yoga, and therapeutic ultrasound. A combination of therapies may be more effective than any single treatment. Improvement may take up to 6 months.

- Lifestyle modifications
  - Avoid repetitive motions.
  - Take frequent breaks.
  - Use ergonomic equipment.
  - Alternate job functions.
- Wrist splinting
  - Wrist splinting in neutral position and 0° extension with over the counter or custom-fit wrist splints for night-time use and as needed for daytime symptoms
  - Minimum of 4 to 8 weeks; if symptoms persist after one month, continue splinting for another 1 to 2 months and add another therapy (oral or injection corticosteroid)
- Corticosteroid injections – should be the next option (before oral corticosteroids) if splinting is unsuccessful
  - Reduces tissue inflammation
  - Effective for short-term (one to three months) relief
  - Single injection of methylprednisolone (20 to 40 mg) with 1% lidocaine
  - Contraindicated with Thenar muscle weakness and/or atrophy or advanced sensory loss
  - Limit frequency of injections for CTS to no more than once every six months per wrist; for recurrent symptoms after two injections, consider combining injections with splinting or other nonsurgical treatments
  - For patients whose symptoms continue despite nonsurgical therapy, refer for consideration of surgery.
  - Risks include worsening of median nerve compression, accidental injection into the median or ulnar nerve, and digital flexor tendon rupture
- Oral corticosteroids
  - Provide short-term relief
  - Use in patients who decline injection therapy
  - Prednisone 20 mg daily for 10 to 14 days
  - Do not use for more than 4 weeks due to adverse effects
  - Screen patients for medical conditions that may require increased monitoring while on steroids (e.g., can increase blood sugars in patients with diabetes)
- Exercises
  - Yoga may be beneficial for pain control.
  - Refer to physical and occupational therapists with certification in hand therapy
    - **Nerve and tendon gliding** – may restore normal movement of the median nerve
    - **Carpal bone mobilization** – movement of the bones and joints in the wrist
- Ultrasound therapy

  - Ultrasound promotes soft tissue healing and transdermal absorption of medications; however, evidence is limited
  - Deep, pulsed ultrasound may decrease pain and improve sensory loss, nerve conduction, and strength
  - Effectiveness may depend on the characteristics of the ultrasound used
- Ineffective therapies: nonsteroidal anti-inflammatory drugs (NSAIDs), diuretics, vitamin B6, perineural dextrose injections, and electrical, magnetic, and laser therapy have not proven beneficial for the treatment of CTS.

Surgical Management (Hunter & Simmons, 2024)

- Surgical approach: carpal ligament release may be performed as an open procedure, endoscopically, or using ultrasound-guided minimally invasive techniques.
  - When electrodiagnostic tests show severe and ongoing median nerve injury, surgery is recommended, unless the cause is temporary, such as pregnancy.
  - Performed in an outpatient setting under local anesthesia by a specialist
  - Postoperative Care:
    - Elevate the hand until swelling resolves.
    - Encourage active motion of all fingers and the wrist. Immobilization is not recommended and may affect rehabilitation.

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