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## Introduction

- Entrapment neuropathy and compression of the median nerve in the carpal tunnel
- Most common compression neuropathy in upper extremity

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## Anatomy

- Floor: palmar radiocarpal ligament and the palmar ligament complex between the carpal bones
- Roof: 3 segments of flexor retinaculum
  - Proximal segment: deep investing fascia of the forearm
  - Transverse segment: inserts on the scaphoid tuberosity and part of the trapezium radially and on the pisiform and the hook of the hamate ulnarly
  - Distal segment: aponeurosis between the thenar and hypothenar muscles.

- Contains nine tendons along with the median nerve
  - Flexor pollicis longus
  - Four flexor digitorum superficialis
  - Four flexor digitorum profundus

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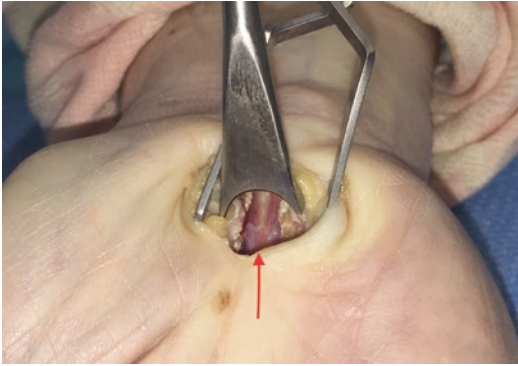
## Pathophysiology

- Nerve compression causes reduction in epineural blood flow.
  - Occurs with 20–30 mm Hg compression; intracarpal canal pressures in CTS routinely measure at least 33 mm Hg and often up to 110 mm Hg with wrist extension
- Edema in the epineurium and endoneurium (Fig. 33.1).
  - Occurs with continued or increased pressure and will increase endoneural fluid pressure fourfold and block axonal transport
- Injury to the capillary endothelium.
  - Protein leaks out into the tissues, which become more edematous, and a vicious cycle ensues
- More exudate and edema accumulate in the endoneurium, unable to diffuse across the perineurium. The perineurium resists and acts as a diffusion barrier creating in effect a “compartment syndrome” within the nerve.

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**Fig. 33.1** Edema in the epineurium and endoneurium with injury to the capillary endothelium

## Etiology

### Trauma-Related Structural Changes

- Distal radius fracture
- Lunate dislocation
- Posttraumatic arthritis/osteophytes
- Edema
- Hemorrhage

### Systemic Diseases

- Rheumatoid arthritis
- Diabetes mellitus
- Thyroid imbalance (especially hypothyroidism)
- Amyloidosis
- Hemophilia
- Alcoholism
- Raynaud's phenomenon
- Paget's disease
- Gout
- Chronic renal failure/hemodialysis

### Anomalous Anatomic Structures

- Aberrant muscles (e.g., lumbricals, palmaris longus, palmaris profundus)
- Median artery thrombosis
- Enlarged persistent median artery

## Hormonal Changes

- Pregnancy
- Menopause
- Acromegaly

## Tumors/Neoplasms

- Lipoma
- Ganglion
- Multiple myeloma

## Mechanical Overuse

- Vibrating machinery

## Diagnosis

- Paresthesias in the distribution of the median nerve: radial 3–1/2 digits.
- Clumsiness and weakness in the affected hand, worse with activity.
- Night pain and paresthesia.
- Proximal radiation of pain or paresthesias to the elbow or even the shoulder.
- Thenar atrophy is a sign of advanced CTS of long-standing duration.
- Self-administered hand diagram.
  - The most specific test (76%) for carpal tunnel syndrome

## Physical Examination

- Inspection: thenar atrophy in advanced CTS

### Phalen's Test (Fig. 33.2)

- The test is done by having patient rest their elbows on the examination table with their forearms perpendicular to the floor and let their wrists drop into flexion with gravity assistance. Paresthesias in less than 60 s, test is positive.
- Paresthesias in less than 20 s in patients with advanced CTS.

## Tinel's Sign

- Provocative test performed by tapping the median nerve over the volar carpal tunnel

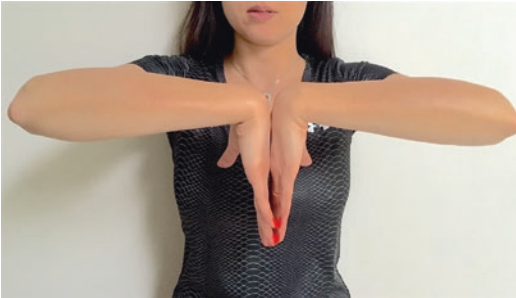
## Durkan's Test (Fig. 33.3)

- Carpal tunnel compression test.
- Most sensitive test.
- Pressing thumbs over the carpal tunnel and holding pressure for 30 s. Onset of pain or paresthesia in the median nerve distribution within 30 s is a positive test result.

## Other Provocative Tests

### Innervation-Density Tests

- Static two-point discrimination test:
  - Most commonly used innervation-density test.



**Fig. 33.2** Phalen's test



**Fig. 33.3** Durkan's Test

- Performed by applying a force through two dull points placed at known distance apart (such as 5 mm) in the longitudinal axis of a digit without blanching the skin
- Measures multiple overlapping of different sensory units and complex cortical integration.
- The test is a good measure for assessing functional nerve regeneration after nerve repair.
- Threshold tests:
  - Semmes-Weinstein monofilament pressure testing:
    - Done by applying a monofilament perpendicularly to the palmar surface of a digit until it bends. Each given monofilament requires a certain known amount of applied force to bend. The subject is asked to localize verbally, without looking, which digit is being touched.
    - Most sensitive sensory test for detecting early carpal tunnel syndrome.
    - Measures a single nerve fiber innervating a receptor or group of receptors.
  - The tourniquet test:
    - Applying a tourniquet proximal to the elbow and inflating it to a pressure higher than the patient's systolic blood pressure.
    - If numbness and tingling in the median nerve distribution develop within 60 s, the test result is positive.

## Imaging

- Rarely necessary for diagnosis

## Electrodiagnostic Studies

### Overview

- Not needed to establish diagnosis (diagnosis is clinical)
- Recommended if surgical management is being considered
- Most useful when trying to distinguish CTS from other conditions such as thoracic outlet syndrome or cervical radiculopathy

- Valuable when patient's secondary gain is suspected

### Nerve Conduction Velocity Test (NCV)

- Increase latencies (slowing) of NCV: distal sensory latency of  $>3.2$  ms, motor latencies  $>4.3$  ms.
- Decreased conduction velocities less specific than latencies: velocity of  $<52$  m/s is abnormal.

### Electromyography (EMG)

- Technique for evaluating and recording the electrical activity produced by skeletal muscles and motor units
- Detail insertional and spontaneous activity
- Potential pathologic findings:
  - Increased insertional activity
  - Sharp waves
  - Fibrillations
  - Fasciculations
  - Complex repetitive discharges

### Differential Diagnosis

- Cervical disk herniation
- Thoracic outlet syndrome
- Proximal compression of the median nerve
- Thenar atrophy from other causes: disuse, neuropathy, and pain due to first CMC arthritis
- De Quervain's tenosynovitis

### Nonoperative Treatment

#### First Line

- Nonsteroidal anti-inflammatory drugs (NSAIDs)
- Activity modification (avoid aggravating activity)
- Initial trial of full-time splinting for 3–4 weeks followed by part-time night splinting for patients with nocturnal symptoms

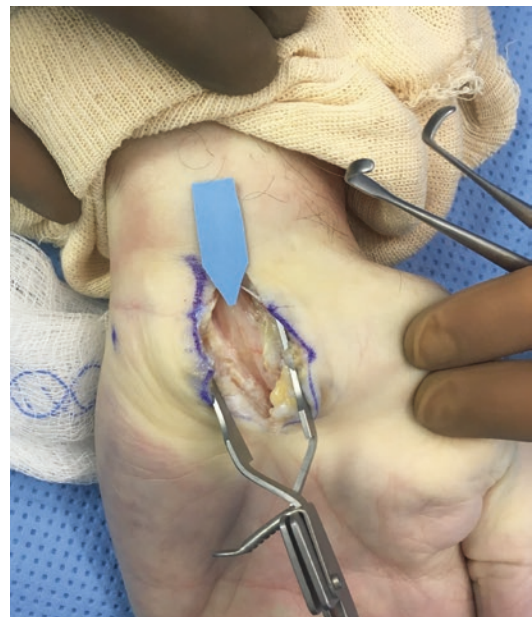
### Adjunctive Conservative Treatment

- Intracanal corticosteroid injection:
  - 80% have transient improvement of symptoms, of these 22% remain symptoms free at 1 year.
  - Good response to injection correlated with an excellent response to subsequent surgery.

### Operative Treatment

#### Open Carpal Tunnel Release (Fig. 33.4)

- Division of the transverse carpal ligament under direct vision with an open procedure
- Indication:
  - Failure of nonoperative treatment
  - Acute CTS following ORIF of a distal radius fracture
- Outcome:
  - Pinch strength returns in 6 weeks
  - Grip strength returns in 12 weeks post-op



**Fig. 33.4** Open carpal tunnel release

## Complications

- Correlate with experience of surgeon
- Incomplete release
- Progressive thenar atrophy due to injury to a motor branch of the median nerve
- Endoscopic carpal tunnel release:
  - Endoscopic release of the transverse carpal ligament.
  - Advantage: accelerated rehabilitation.
  - Long-term results same as open CTR.
  - Complication: most common complication is incomplete release.
- Revision CTR for incomplete release:
  - Indication:
    - Failure to improve following primary surgery
    - Incomplete release
  - Outcome:
    - 25% complete relief, 50% partial relief, 25% no relief

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## Suggested Reading

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