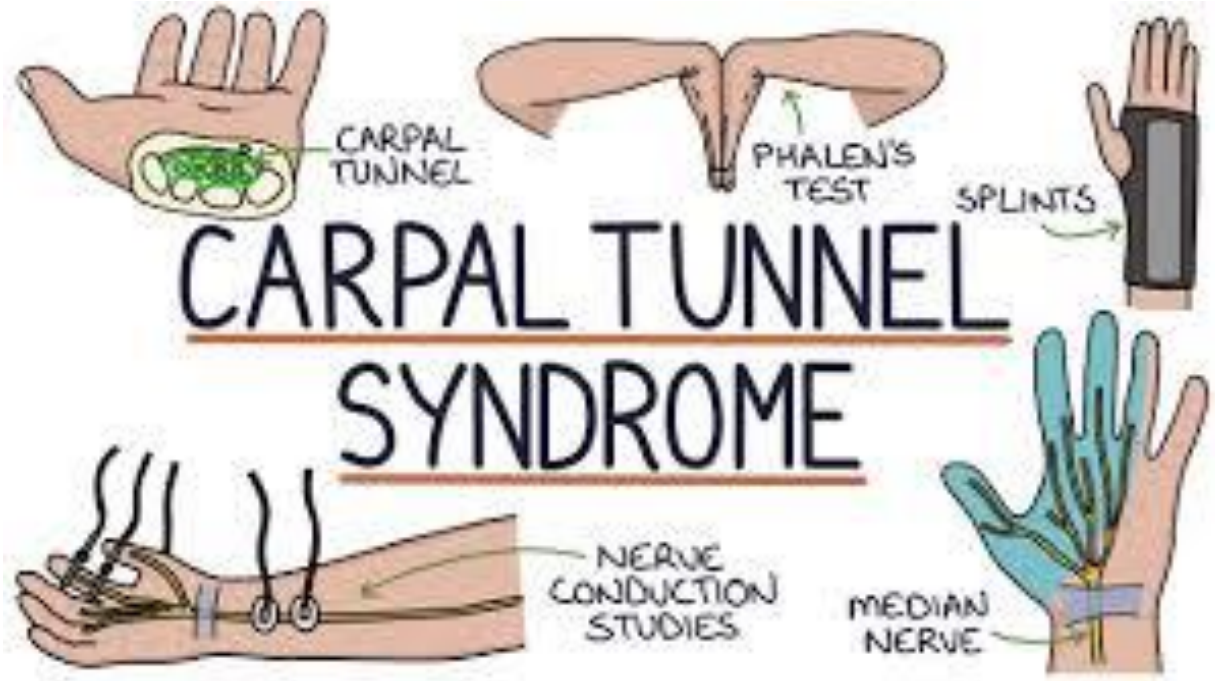
Carpal Tunnel Syndrome



Ian Mullikin, MD

November 7, 2025

Virginia Mason Franciscan Health
A member of CommonSpirit

Objectives

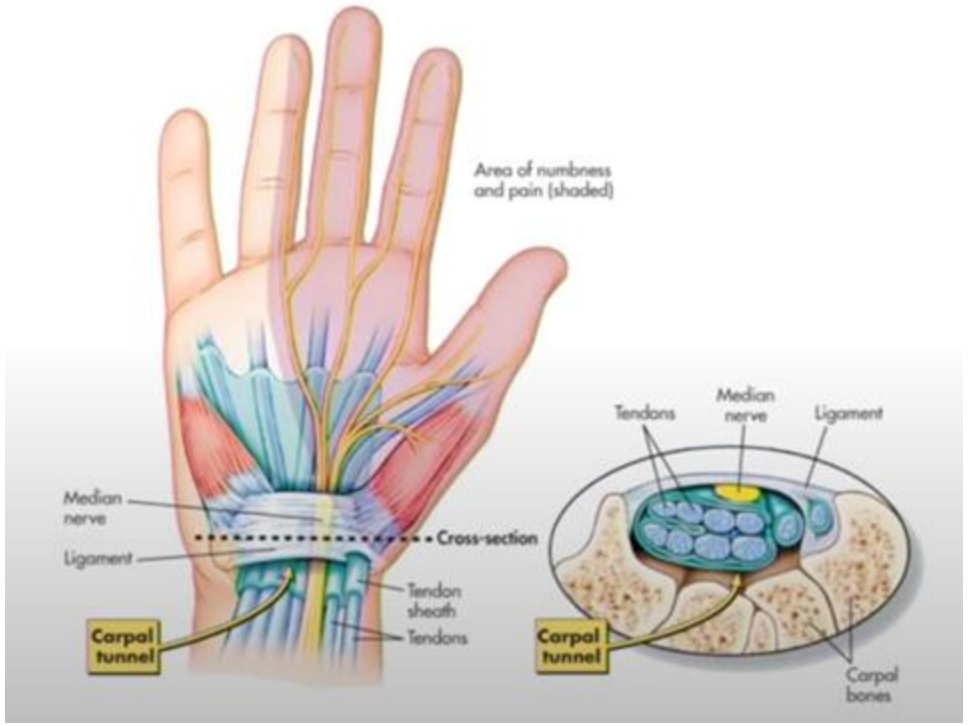
- Understand relevant anatomy of the carpal tunnel
- Carpal tunnel diagnosis
- Indications for surgery
- Expected outcomes?

Carpal Tunnel Syndrome

- Most common upper extremity entrapment neuropathy
- Prevalence is 5% of general population
- $2 billion annual medical costs
- >500,000 carpal tunnel releases done annually

Anatomy

- Carpal tunnel
  - -Carpal bones dorsally
  - -Transverse carpal ligament volarly
- Deep to palmaris longus
- Contains
  - - Median nerve
  - - 9 flexor tendons



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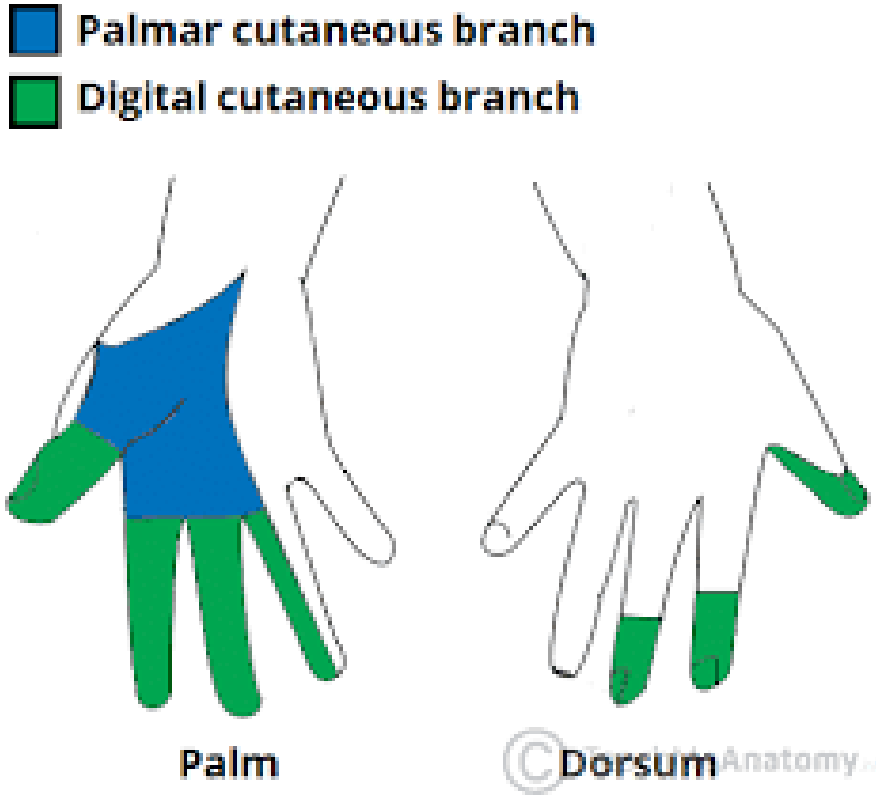
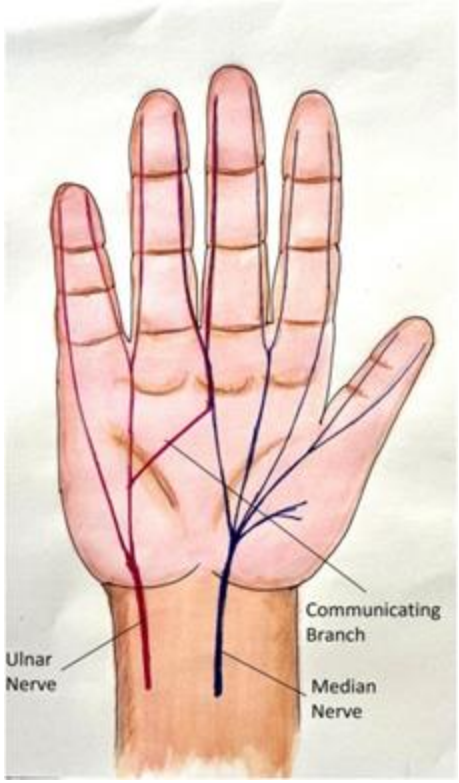


Anatomy

- Anomalies Exist
- Berrettini Connection
  - - Ulnar to Median nerve

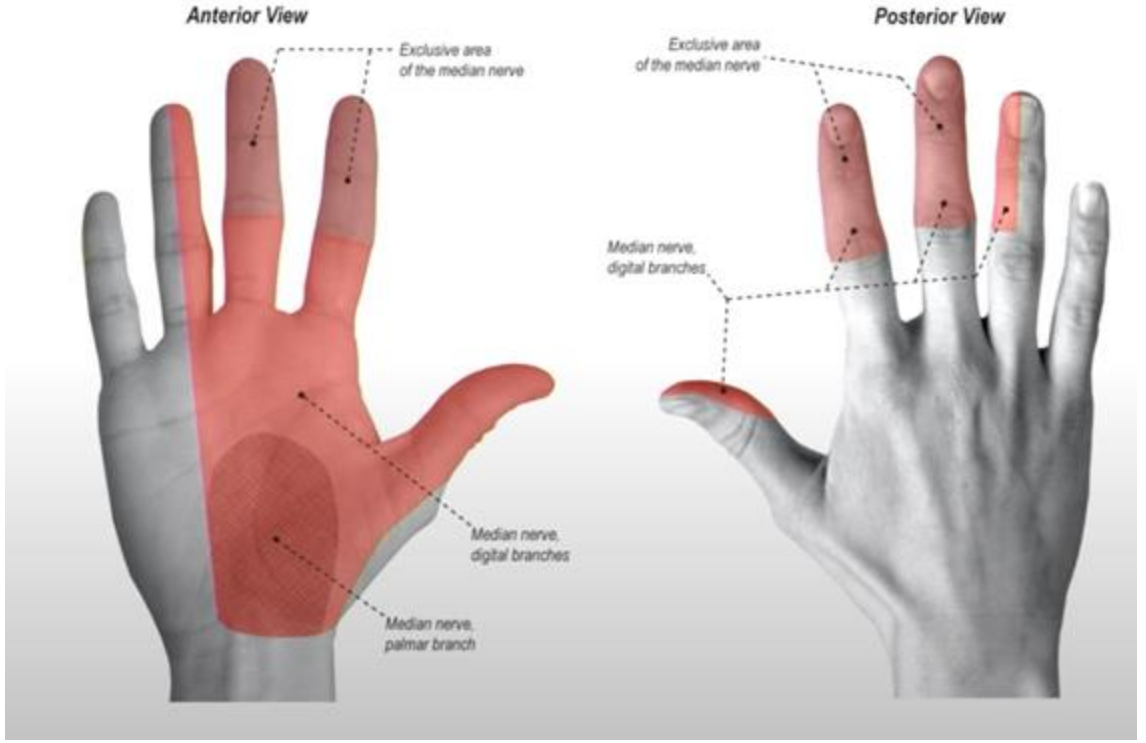


Risk Factors

- Strong Evidence
  - - Increased BMI
  - - High hand/wrist repetition rate
- Moderate Evidence
  - - Assembly line work
  - - Computer work
  - - Gardening
  - - Rheumatoid Arthritis
- Rare: tumors, aberrant anatomy
- Physiology: DM, alcoholism, inflammatory

History

- Intermittent numbness, tingling, and pain in the median nerve distribution
- Nocturnal symptoms
- Driving, reading a book, holding a phone
- Severe disease – constant numbness and thenar weakness, dropping things



Physical Exam

- Sensibility testing
  - - Two point discrimination
  - - Monofilament testing
- Strength testing:
  - - Thenar atrophy
  - - Thumb palmar abduction
- Provocative Tests
  - - Tinels
  - - Phalens
  - - Durkans
  - - Combined

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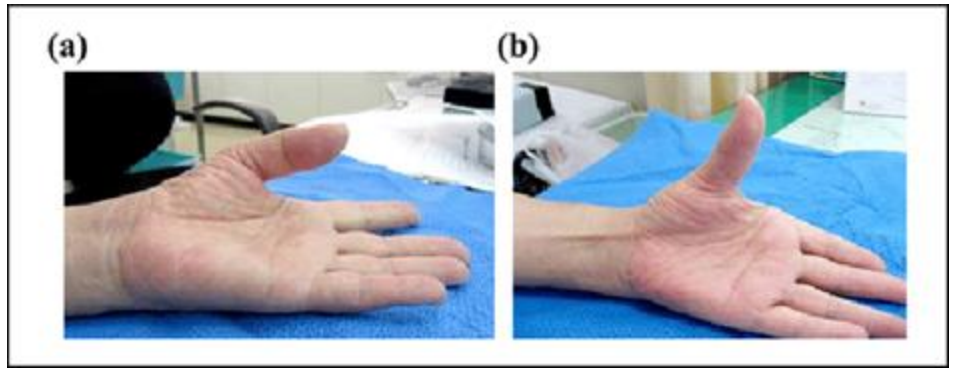
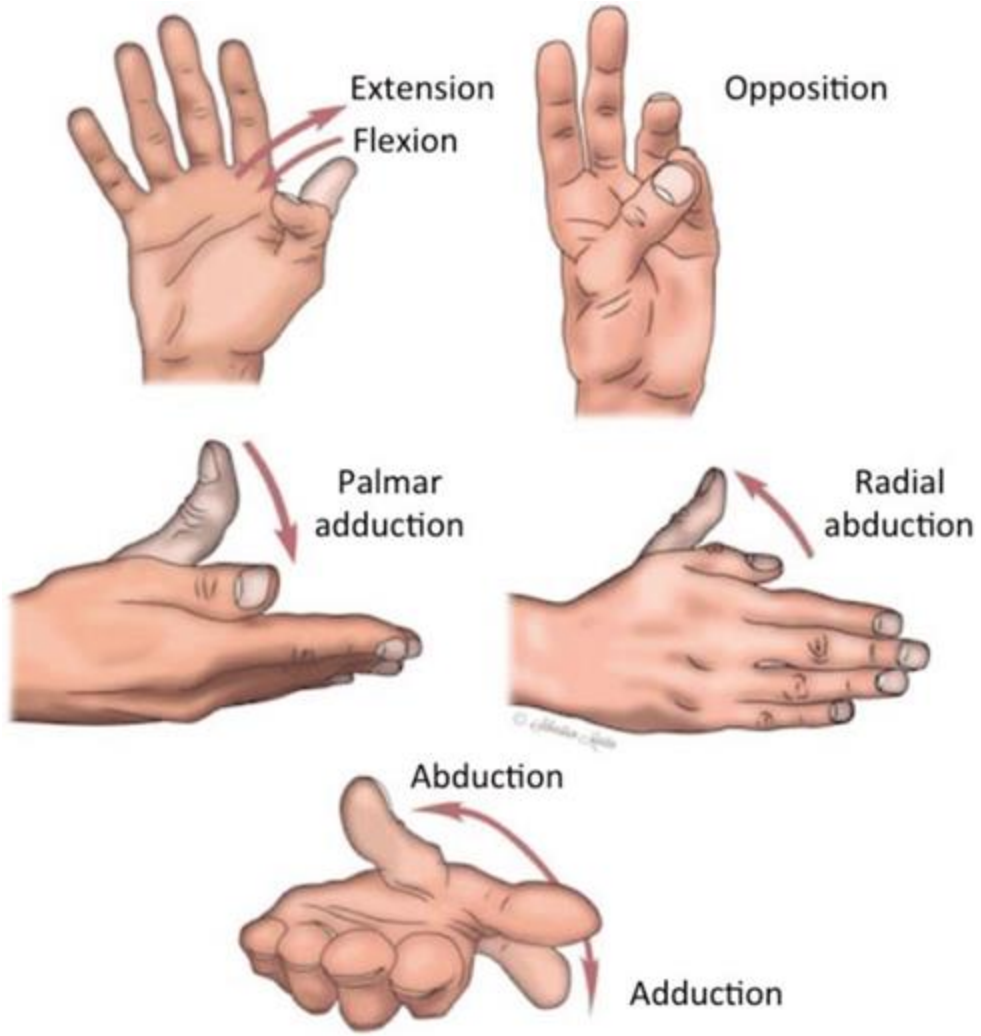


Thumb Motion



Tinels

- The Tinel sign is elicited by tapping or percussing on the distal wrist crease over the median nerve
- Jules Tinel
  - - French Neurologist
  - - *The Sign of Tingling in Lesions of Peripheral Nerves* – Oct 1915
- Paul Hoffman
  - - German physiologist
  - - *On a Method of Evaluating the Success of a Nerve Suture – Mar 1915*
- Trotter and Davies
  - - First commented 1909 that sensations elicited distal to the point of nerve resection are referred to the area or point of nerve resection

Phalens

- George Phalen
  - - Credited with coming up with “carpal tunnel syndrome”
  - - 3 diagnostic criteria
    - - Hypoesthesia in median nerve
    - - Positive tinel sign at the wrist crease
    - - Positive wrist flexion-test (Phalens)

NEUROPATHY OF THE MEDIAN NERVE DUE TO COMPRESSION BENEATH THE TRANSVERSE CARPAL LIGAMENT *

BY GEORGE S. PHALEN, M.D., W. JAMES GARDNER, M.D., AND ALBERT A. LA LONDE, M.D.,
CLEVELAND, OHIO

From the Cleveland Clinic and the Frank E. Bunts Educational Institute, Cleveland

Neuropathy due to compression of the median nerve at the wrist occasionally may be associated with advanced hypertrophic arthritis or with trauma involving the wrist joint or the carpus. In some of these cases the onset of the neuropathy may occur several years after injury, producing a so-called "tardy median palsy" which is, in most respects, similar to a "tardy ulnar palsy" as far as its pathogenesis is concerned. It is easy to see how a "tardy median palsy" might develop. The median nerve lies superficial to the flexor tendons of the fingers, immediately beneath the transverse carpal ligament **; these structures completely fill the carpal tunnel. Narrowing of the carpal tunnel secondary to fracture or hypertrophic arthritis may compress the median nerve between the bones of the carpus and the transverse carpal ligament. Zachary recently reported two such cases, one with old bilateral fracture of the carpal navicular and the other with a malunited Colles's fracture.

We are concerned here, however, with the spontaneous development of neuropathy due to compression of the median nerve beneath the transverse carpal ligament, without antecedent or associated injury or disease. Marie and Foix, in 1913, reported a case with severe bilateral atrophy of the thenar muscles; at autopsy, a definite neuroma of the median nerve was found, just proximal to the transverse carpal ligament. These authors felt that there had been a so-called strangulation of the nerve beneath the ligament and they suggested that, if the diagnosis could be made early enough in other similar cases, section of the ligament might prevent atrophy of the thenar muscles. Moersch, in 1938, reported a case of median neuritis with bilateral atrophy of the thenar muscles. Although no treatment was instituted in this case, Moersch also suggested that the transverse carpal ligament be sectioned early, to prevent irreversible changes in the median nerve.

In 1946, Cannon and Love reported a series of thirty-eight cases of "tardy median palsy". In nine of these cases, surgical division of the transverse carpal ligament was carried out with satisfactory results. Only three of the nine cases, however, apparently can be classified as spontaneous median palsy, without associated injury or disease. Brain, Wright, and Wilkinson presented, in 1947, a detailed report of six cases of spontaneous bilateral compression of the median nerves in the carpal tunnel. All six cases were treated successfully by section of the transverse carpal ligament. These workers also stated that they had seen eight additional patients in whom the diagnosis had not been verified by surgical exploration.

In the past year the authors have observed four cases of spontaneous neuropathy, due to compression of the median nerve beneath the transverse carpal ligament. Three of these cases, reported here, have been treated by surgical division of the transverse carpal ligament, with excellent results.

CASE 1. A negro woman, thirty-four years old, was first seen on January 15, 1948. She complained of periodic episodes of numbness in both hands, lasting from a few minutes to half an hour. These symptoms had been present for a year in the right hand and for six or seven months in the left hand; they were much less severe in the left hand. The numbness and paresthesia were always limited to the thumb, the index finger, and the middle finger; and were aggravated by carrying heavy objects or by active use of the hands.

* Read at the Annual Meeting of the American Society for Surgery of the Hand, Chicago, Illinois, January 21, 1949.

** Some anatomists call this structure the volar carpal ligament.

Phalens

- *In performing the so called wrist-flexion test, the patient is asked to hold their forearms vertically and allow both hands to drop into complete flexion at the wrist for approximately one minute. In this position the median nerve is squeezed between the proximal edge of the transverse carpal ligament and the adjacent flexor tendons ad radius. Maintaining this position for a long time eventually causes numbness and tingling over the distribution of the median nerve*
  - - Phalen 1950

Durkans

- JA Durkan 1991
  - - New test for the diagnosis of carpal tunnel
  - - Consists of application of direct pressure on the carpal tunnel and the underlying median nerve

CTS-6 Tool

CTS-6 Evaluation Tool

The Value Added by Electrodiagnostic Testing in the Diagnosis of Carpal Tunnel Syndrome *Brent Graham J Bone Joint Surg Am.* 2008;90:2587-2593

Symptoms and History

1. **Numbness predominantly or exclusively in the median nerve territory** _____ **(3.5)**
   Sensory symptoms are mostly in the thumb, index, middle and/or ring fingers

2. **Nocturnal numbness** _____ **(4)**
   Symptoms are predominantly the patient sleep; numbness wakes patient from sleep

Physical examination

3. **Thenar atrophy and/or weakness** _____ **(5)**
   The bulk the thenar area is reduced or where manual motor testing shows strength of grade 4 less

4. **Positive Phalen's test** _____ **(5)**
   Flexion of the wrist reproduces her worsened symptoms of numbness in the median nerve territory

5. **Loss of 2 point discrimination** _____ **(4.5)**
   Failure to discriminate 2 points held 5 mm or less apart from one another, in the median innervated digits

6. **Positive Tinel sign** _____ **(4)**
   Light tapping over the median nerve at the level of the carpal tunnel causing radiating paraesthesias

Total _____ **(26)**

>12 = 0.80 probably of carpal tunnel syndrome
>5 = 0.25 probably of carpal tunnel syndrome

Diagnosis

- Physical exam
- Electrodiagnostic Studies
- MRI
- Ultrasound

Nerve Conduction Studies

- Can be useful adjunct
- Reference point for recurrences
- Gives severity
- Can pick up missed cubital tunnel

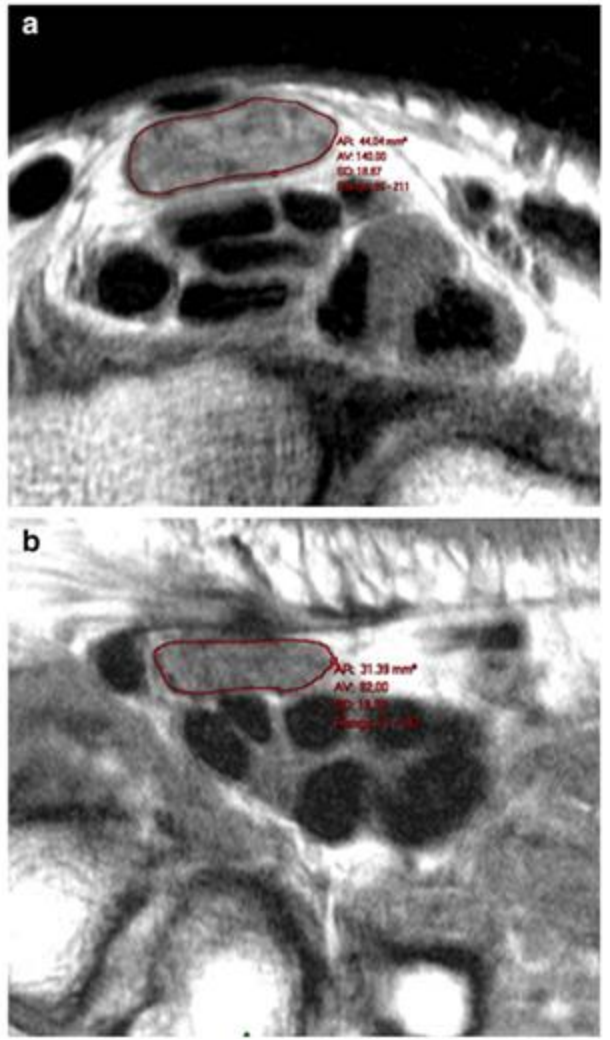
HAND-HELD NERVE CONDUCTION STUDY (NCS)

Limited evidence supports that a hand-held nerve conduction study (NCS) device might be used for the diagnosis of carpal tunnel syndrome.

Strength of Recommendation: Limited Evidence ★★☆☆

MRI

- Can calculate the circumferential surface area (CSA) both proximal and distal to carpal tunnel
  - - Area >15mm^2 indicative of carpal tunnel
  - - Area >19mm^2 proximal



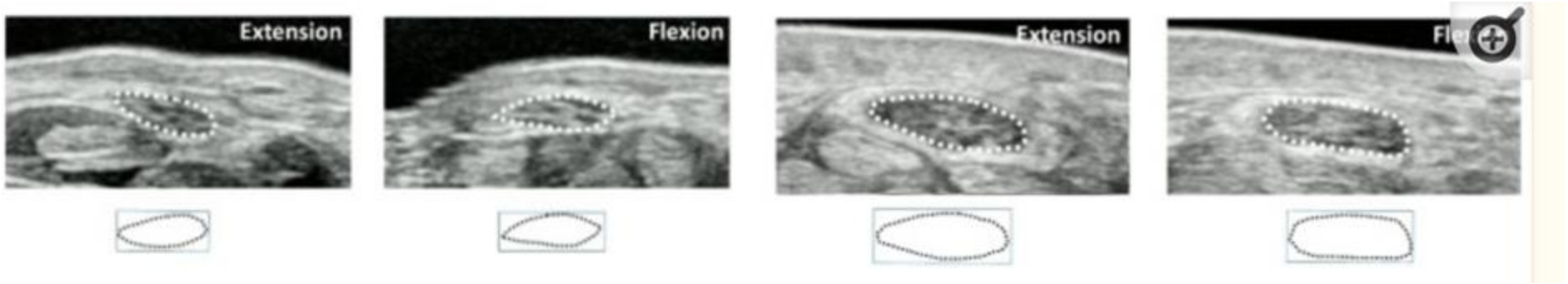
MRI

Moderate evidence supports not routinely using MRI for the diagnosis of carpal tunnel syndrome.

Strength of Recommendation: Moderate Evidence ★★★☆

Ultrasound

- Similar to MRI with evaluation of circumferential surface area
- Less expensive/quicker
- Ability to test dynamic posture of nerve



DIAGNOSTIC ULTRASOUND

Limited evidence supports not routinely using ultrasound for the diagnosis of carpal tunnel syndrome.

Strength of Recommendation: Limited Evidence ★★☆☆

Red Flag Symptoms

- Weakness without sensory symptoms
- Weakness and atrophy in multiple distributions
- Bulbar symptoms
  - - Tongue fasciculations, speech swallowing difficulties
- Progressively bilateral/global sx

ALS

THE HAND SURGERY LANDSCAPE

Misdiagnosis in Amyotrophic Lateral Sclerosis

Cameron G. Thomson, MD,*† Paul R. Hutchinson, MD,*‡ Peter J. Stern, MD*

- Sx often start in the extremities
- Progressive motor impairment
- Upper motor neuron and lower motor neuron findings
  - - UMN: increased DTRs, spastic paralysis, increased tone
  - - LMN: decreased DTRs, atrophy, flaccid paralysis, fasciculations
- EMG/MRI CSF studies can be used to adjunct

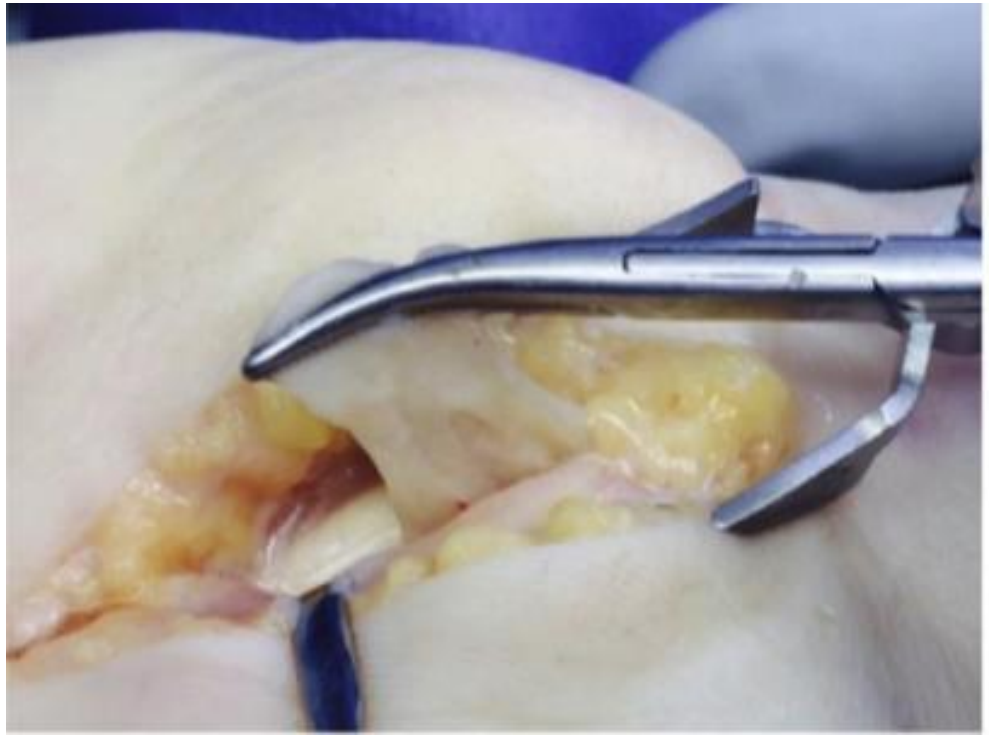
More Red Flag Symptoms

Tier 1

- ☐ Male age ≥ 50 years old
- ☐ Female age ≥ 60 years old
- ☐ Bilateral carpal tunnel symptoms or prior release surgery

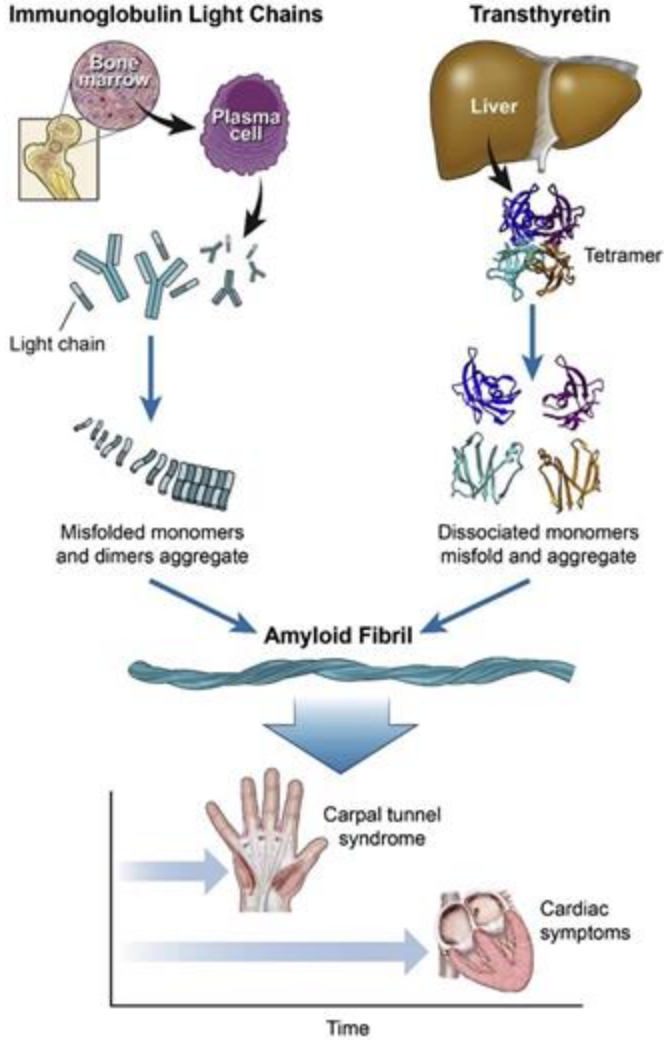
Tier 2

- ☐ Spinal stenosis
- ☐ Biceps tendon rupture
- ☐ Artial fibrillation or flutter (active or previous history)
- ☐ Pacemaker
- ☐ Congestive heart failure
- ☐ Family history of ATTR amyloidosis



Amyloidosis

- Present in 10% of men age 50 and older and women 60 and older undergoing carpal tunnel surgery
- Carpal tunnel presents bilaterally years before cardiac and multisystem involvement
- Early diagnosis is better



Treatments

- Role for prevention
  - - Physical activity

DECREASED RISK OF CTS

Moderate evidence supports that physical activity/exercise is associated with the decreased risk of developing carpal tunnel syndrome (CTS).

Strength of Recommendation: Moderate Evidence ★★★☆

Treatment

- Non-operative
  - - Strong support for uses of wrist braces
  - - Neutral brace

Treatment

- Oral Pain Medications
  - - NSAIDS, gabapentin (moderate evidence to suggest no benefit)
  - - Oral steroids (moderate evidence to suggest benefit)

Treatment

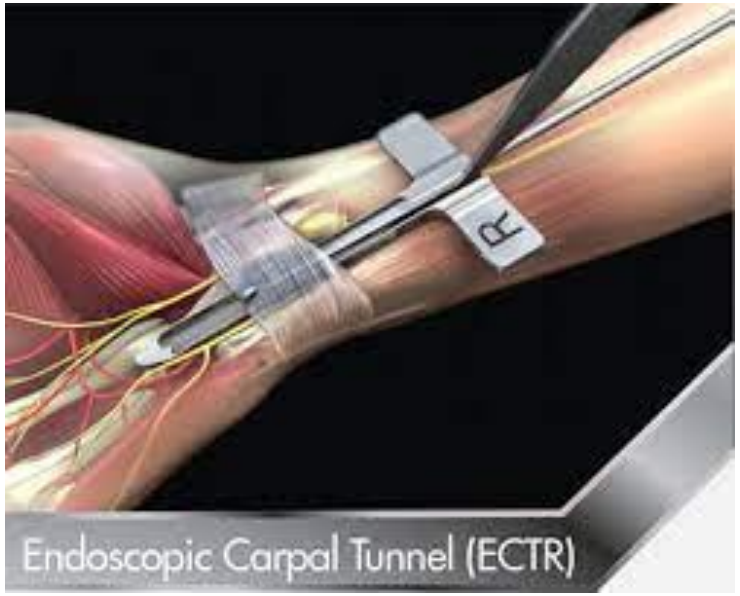
- Steroid Injection
  - - Effective in providing relief
  - - Can be curative
  - - Good marker for setting surgical expectations

Surgery

- Indications
  - - Failure of non-operative treatment
  - - Good response to injection
  - - Progressive loss of sensation
  - - Axonal involvement with moderate or severe sx

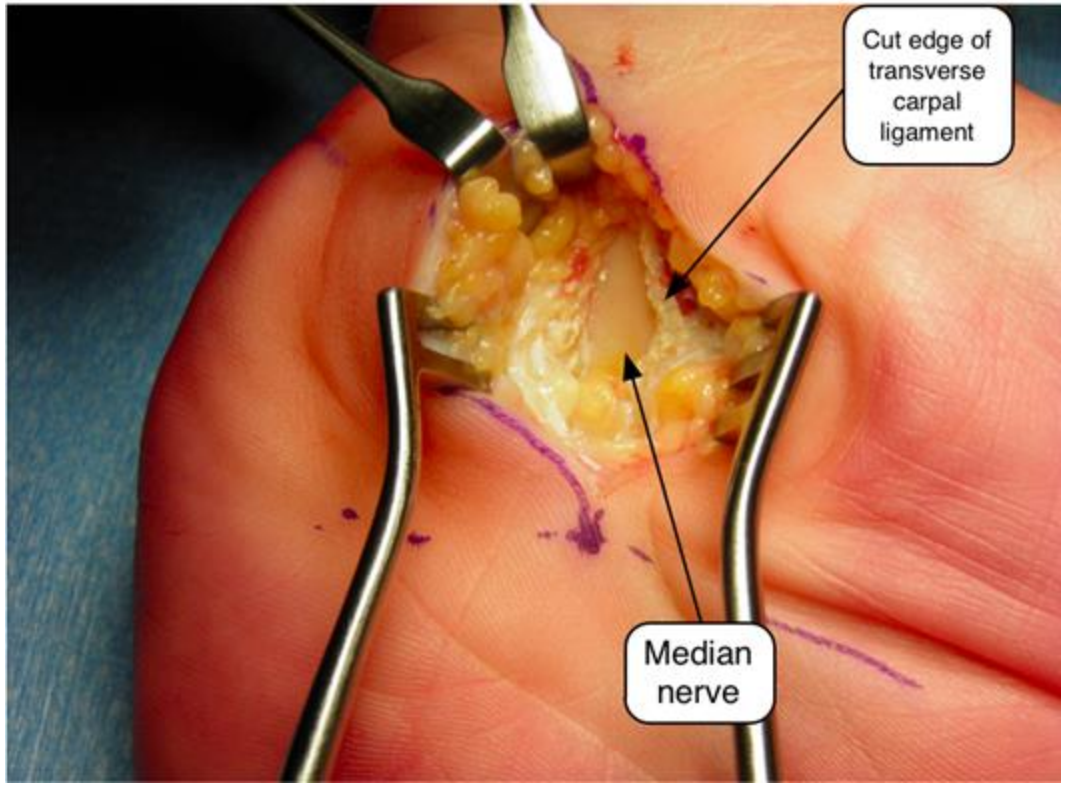
Surgery

- Open vs Endoscopic
  - - Endoscopic
    - - Higher satisfaction rates
    - - Earlier return to work
    - - Greater key pinch
    - - Higher nerve neuropraxia rates
    - - Fewer scar complications



Open CTR

- Reasons to open
  - - Laceration of nerve
  - - Known anatomic variants
    - - Bifid nerve
    - - Recurrent motor branch anomaly
    - - Ancillary muscles in carpal tunnel
  - - Tenosynovitis
  - - Calcific tendonitis
  - - Amyloidoisis
  - - Masses (schwannomas, ganglions…)



Outcomes

- EMG Improvement
  - - Sensory improves by 3 months
  - - Motor improves by 6 months
  - - Conduction velocities were increased by 2 weeks
  - - EDS trend towards normal but remain abnormal at 2 years
- 2 point discrimination improved by 2 weeks
- Pinch and grip strength improved by 6 and 9 months

Electromyographic changes after carpal tunnel release

This prospective clinical study was designed to quantitate post-carpal tunnel release electromyographic (EMG) changes in the median nerve, and changes in static two-point discrimination, pinch strength, and grip strength. Carpal tunnel release was performed in 54 hands of 36 patients (average age of patients was 44.6 years). The EMG and clinical studies were completed just before surgery, at 2 weeks, and then at postoperative periods of 3, 6, 9, 12, 18, and 24 months. The sensory latencies and motor latencies were significantly ($p < 0.05$) improved at the 3- and 6-month postoperative periods, respectively. The motor and sensory conduction velocities were significantly ($p < 0.05$) improved as early as 2 weeks postoperatively. Two-point discrimination values were significantly ($p < 0.05$) improved at 2 weeks postoperatively. For the pinch and grip strengths, significant ($p < 0.05$) improvement did not occur until the 6- and 9-month postoperative periods, respectively. These results should be of considerable value, especially in the evaluation of the post-carpal tunnel release patient with persistent or recurrent symptoms. (J HAND SURG 11A:876-80, 1986.)

Donald G. Shurr, L.P.T., M.A., William F. Blair, M.D., *and* George Bassett, M.D., *Iowa City, Iowa, and Wilmington, Del.*

Outcomes

- Generally more predictable
  - - Less severe disease
  - - Younger patients
- Improvements are seen in severe disease
  - - Numbness resolved in 39-94%
  - - Paresthesias in 55-98%
  - - Pain improved in 64-100%
  - - 2 point improved
  - - Pinch/grip showed improvement


SCIENTIFIC ARTICLE

A Systematic Review of the Outcomes of Carpal Ligament Release in Severe Carpal Tunnel Syndrome

Abigail Meyers, BS,* Michael J. Annunziata, MD,* Antonio Rampazzo, MD, PhD,* Bahar Bassiri Gharb, MD, PhD*

My Preferences

- Exam concerning for CTS
- Obtain EDS
  - - Interim: night splints
- Mild sx: trial non-op
  - - Injection
  - - Spints
  - - Therapy/NSAIDs
- Moderate/Severe: send for surgery
- If unsure about dx…
  - - Trial injection

Questions?