

Orthopedics

432 Team

18 Peripheral Nerve Injuries



1st Edition:

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Color Code:

Slides

431 team work

Doctor's Notes

Arabic Words

Team Notes

Books' notes

Important

Other Sources

Objectives

Not Given.

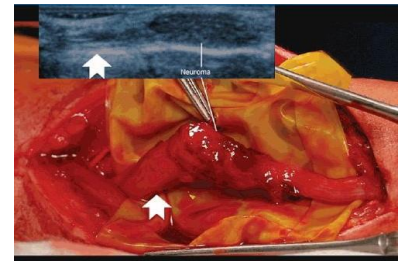
Definition of nerve injury:

It is a condition, in which the conductivity of the nerve is affected, can be partial or complete.

Compression Neuropathy:

- Compression > decreased blood flow > atrophy of myelin sheath > slow conduction > affect function.
- Any peripheral nerve can be compressed but some peripheral nerves are commonly compressed because of their anatomical location e.g. median nerve because it passes through the carpal tunnel.
- **Chronic condition** (most of the time) with sensory, motor, or mixed involvement [if mixed, **sensory is affected first and then motor is affected** because Motor fibers has a thick myelin sheath; last affected]
- So, first symptom is hypoesthesia and lastly atrophy of the muscles which means severe disease.
- Sensory loss:
 - First lost → light touch – pressure – vibration (**mild**)
 - Last lost → pain – temperature (**severe**)
- Pathology: microvascular compression → neural ischemia → paresthesias → **Intraneural edema** → more microvascular compression → demyelination → fibrosis → axonal loss

Localized edema caused by compression. It's NOT a true neuroma "psudoneuroma"



COMMON SYSTEMIC CONDITIONS LEADING TO COMPRESSION NEUROPATHY:

ANATOMIC	INFLAMMATORY
SYNOVIAL	Rheumatoid arthritis
FIBROSIS	Infection
LUMBRICAL ENCROACHMENT	Gout
ANOMALOUS TENDON	Tenosynovitis
MEDIAN ARTERY	Fluid Imbalance
FRACTURE DEFORMITY	Pregnancy
MASS (COMMON WITH ULNAR)	Obesity
GANGLION	Systemic
LIPOMA	Diabetes
HEMATOMA	Alcoholism
	Renal failure
	Raynaud

Symptoms: (alarming)

- Night symptoms
- Dropping of objects
- Clumsiness
- Weakness
- Rule out systemic causes

Physical exam: (advanced; motor problems appear)

- Examine individual muscle strength → grades 0 to 5 → pinch strength - grip strength
- Neurosensory testing:
- Dermatomal distribution
- Peripheral nerve distribution

Special Tests:

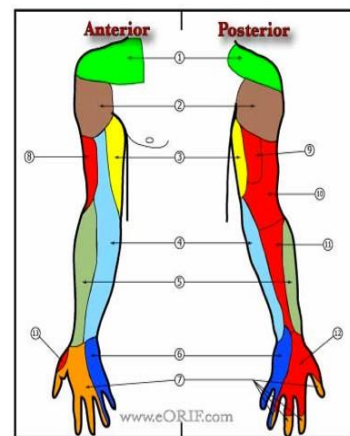
- **Semmes-Weinstein monofilaments:**
[best test]
- Cutaneous pressure threshold → function of large nerve fibers → first to be affected in compression Neuropathy (can detect very early neuropathy)
- Sensing 2.83 monofilament is normal

Two-point discrimination:

- **Static is lost first and then dynamic.**
- Performed with closed eyes
- Abnormal → Inability to perceive a difference between points > 6 mm “Late finding”

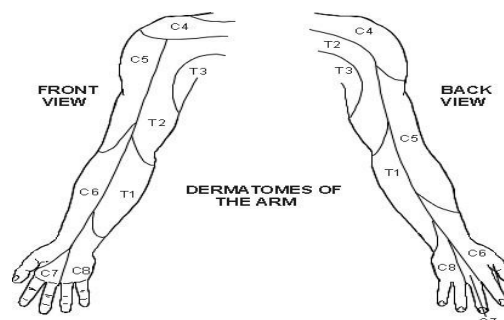
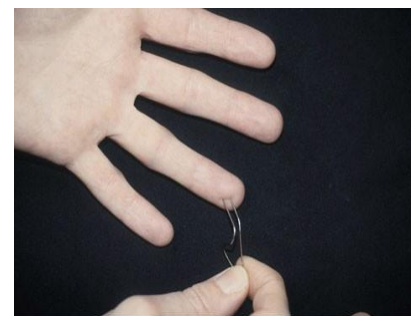
Electro-diagnostic testing:

- EMG and NCS
- Sensory and motor nerve function can be tested
- **Operator dependent (disadvantage)**
- Objective evidence of neuropathic condition
- Helpful in localizing point of compromise
- **Early disease → High false-negative rate**



Cutaneous Innervation UE

1. Supraclavicular nerve
2. Axillary nerve (superior lateral brachial cutaneous n.)
3. Intercostobrachial nerve and medial brachial cutaneous nerve
4. Medial antebrachial cutaneous nerve
5. Lateral antebrachial cutaneous nerve
6. Ulnar nerve
7. Median nerve
8. Inferior lateral brachial cutaneous branch of Radial nerve.
9. Posterior brachial cutaneous branch of Radial nerve.
10. Inferior lateral brachial cutaneous branch of Radial nerve.
11. Posterior antebrachial cutaneous branch of Radial nerve.
12. Superficial and digital branches of Radial nerve.
13. Superficial branch of Radial nerve.



EMG (Electromyography)

- Muscle electrical activity
- Muscle denervation → fibrillations
- Positive sharp waves fasciculations

NCSs (nerve conduction studies)

- **Conduction velocity and distal latency and amplitude (nerve takes time to respond)**
- **Demyelination → ↓ conduction velocity + ↑ distal latency**
- **Axonal loss → ↓ potential amplitude**

Double crush phenomena: Blockage of axonal transport at one point makes the entire axon **more susceptible** to compression elsewhere. *(if nerve compressed at one side; sensitive at another)* *(blue box has more explanation)*

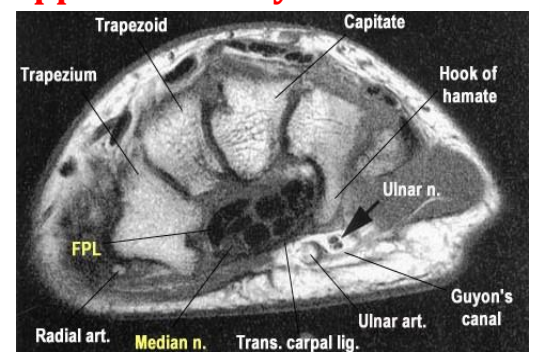
[In thoracic outlet syndrome the lower trunks of the brachial plexus are compressed which makes the ulnar nerve vulnerable to compression. e.g. if a patient with thoracic outlet syndrome comes with ulnar nerve symptoms and you treat the ulnar nerve, the patient will still have the symptoms or be slightly better because you did not treat the cause (thoracic outlet)]

Median Nerve Compression

1. Carpal Tunnel Syndrome (diagnosed clinically)
2. Pronator Syndrome
3. Anterior Interosseus Neuropathy

Carpal Tunnel Syndrome:

- **Most common compressive neuropathy in the upper extremity.**
- Anatomy of the carpal tunnel
 1. Volar → TCL (transverse carpal ligament)
 2. Radial → scaphoid tubercle + trapezium
 3. Ulnar → pisiform + hook of hamate
 4. Dorsal → proximal carpal row + deep extrinsic volar carpal ligaments



MRI of the wrist at the level of carpal tunnel

Carpal Tunnel Content:

- Median nerve + FPL (flexor pollicis longus) + 4 FDS (flexor digitorum superficialis) + 4 FDP (flexor digitorum profundus) = 10
- Normal pressure → 2.5 mm Hg
- >20 mm Hg → ↓↓ epineural blood flow + nerve edema
- >30 mm Hg → ↓↓ nerve conduction

Forms of Carpal Tunnel Syndrome:

- Idiopathic → **most common in adults**
- Mucopolysaccharidosis → most common cause in children
- Anatomic variation: (rare)
 - Persistent median artery
 - Small carpal canal
 - Anomalous muscles
 - Extrinsic mass effect

Q: a pregnant lady came to the clinic with carpal tunnel syndrome would you do surgery for her? No the symptoms may disappear by its own after the pregnancy.

Risk Factors:

- **Obesity**
- **Pregnancy**
- **Diabetes**
- **Thyroid disease**
- **Chronic renal failure**
- Inflammatory arthropathy
- Vitamin deficiency
- Storage diseases
- Alcoholism
- Advanced age
- Vibratory exposure (using drills and electrical saws) during occupational activity

Be aware: No established direct relationship between → repetitive work activities such as keyboarding and Carpal Tunnel Syndrome (those complaining of keyboard typing causing CTS; NOT true)

Acute Carpal Tunnel Syndrome Causes:

1. High-energy trauma
2. Hemorrhage
3. Infection (edema and pus causes it)
4. **Requires emergency decompression (MCQ)**

Distal radius fracture patient started to feel numb what would you do for him? Evaluate everything then take patient immediately for carpal tunnel release.

Carpal Tunnel Syndrome Diagnosis:

- Symptoms → **Paresthesias and pain**, Often at **night**
- Volar aspect → thumb - index - long - radial half of ring
- **Provocative test → carpal tunnel compression test - Durkan test → Most sensitive (important for residency not for us)**
- Other provocative tests include Tinel and Phalen
- Affected first → light touch + vibration
- Affected later → pain and temperature

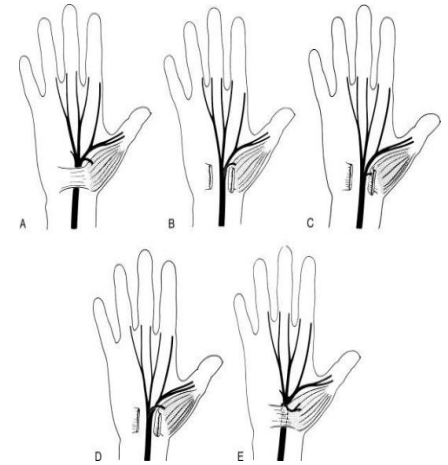
- Semmes-Weinstein monofilament testing → early CTS diagnosis
- Late findings: Weakness - loss of fine motor control - abnormal two-point discrimination
- Thenar atrophy → severe denervation
- (those presenting with late findings of CTS will not have complete relive of pain post op)

CTS - Electro-diagnostic Testing:

- Not necessary for the diagnosis of CTS (just to reassure the patient)
- Distal sensory latencies > 3.5 msec
- Motor latencies > 4.5 msec
- ↓ conduction velocity and ↓ peak amplitude → less specific
- EMG → ↑ insertional activity - sharp waves -fibrillation - APB (abductor pollicis brevis) fasciculation

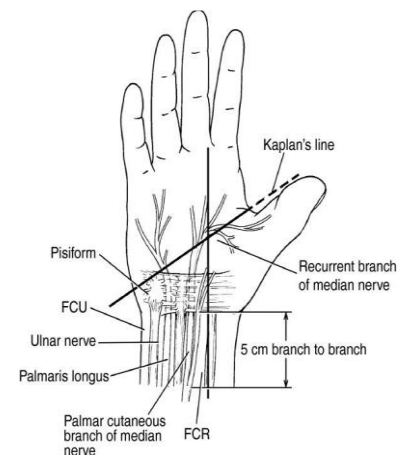
CTS - Differential diagnoses:

- **Cervical radiculopathy**(C5/C6)
- Brachial plexopathy
- **TOS (Thoracic Outlet Syndrome)**
- **Pronator syndrome**(most likely)
- **Ulnar neuropathy with Martin- Gruber anastomoses**
- Peripheral neuropathy of multiple etiologies



CTS - Treatment (non-operatively):

- Activity modification
- Night splints (less pressure)
- NSAIDS
- Single corticosteroid injections (transient relief):
 - ✓ 80% after 6 weeks
 - ✓ 20% after one year
 - ✓ Ineffective corticosteroid injection > poor prognosis > less successful surgery



CTS - treatment (Operatively):

- Can be → open - mini-open - endoscopic
- Internal median neurolysis OR flexor tenosynovectomy → No benefit
- Too ulnar surgical approach → Ulnar neurovascular injury
- Too radial surgical approach → recurrent motor branch of median nerve injury

- Recurrent motor branch variations
 - ✓ Extraligamentous → 50%
 - ✓ Subligamentous → 30%
 - ✓ Transligamentous → 20%

CTS – Endoscopic release: (more expensive)

- Short term: (within 4 to 6 weeks):
 - ✓ Less early scar tenderness.
 - ✓ Improved short-term grip/pinch strength.
- Better patient satisfaction scores Long-term:
 - ✓ **No significant difference** (*after one year*).
 - ✓ May have slightly higher complication rate.
 - ✓ Incomplete TCL (transverse carpal ligaments) release.

CTS – release outcome:

- Pinch strength → will come back in 6 weeks
- Grip strength → will come back in 3 months
- Persistent symptoms after release →
- **Incomplete release**
- **Iatrogenic median nerve injury**
- Missed double-crush phenomenon
- Concomitant peripheral neuropathy
- Space-occupying lesion
- Revision success → identify underlying failure cause

Pronator Syndrome:

- Median nerve compression @ arm/forearm
- Symptoms:
 - ✓ Proximal volar forearm pain
 - ✓ Sensory symptoms → palmar cutaneous branch
- DDx → AIN syndrome → motor and pain

Pronator syndrome where the median nerve is affected and it's more proximal (arm / forearm) and can mimic carpal tunnel.

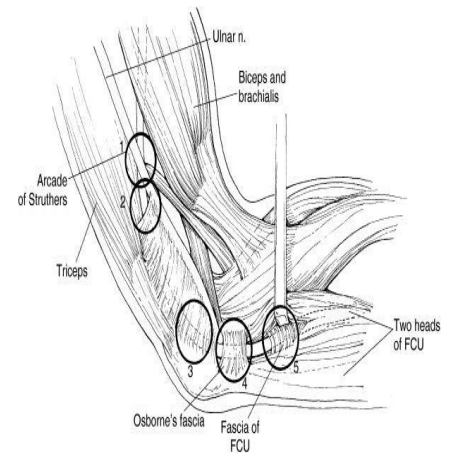
Ulnar Nerve Compression Neuropathy

Cubital Tunnel Syndrome:

- Second **most common** compression neuropathy of the upper extremity

Cubital tunnel borders:

- Floor → MCL (Medial Collateral Ligament) and capsule
- Walls → medial epicondyle and olecranon
- Roof → FCU (Flexor Carpi Ulnaris) fascia and arcuate ligament of Osborne
- Compression sites: (look at pic)



Symptoms: Paresthesias of ulnar **half of ring finger and small finger**

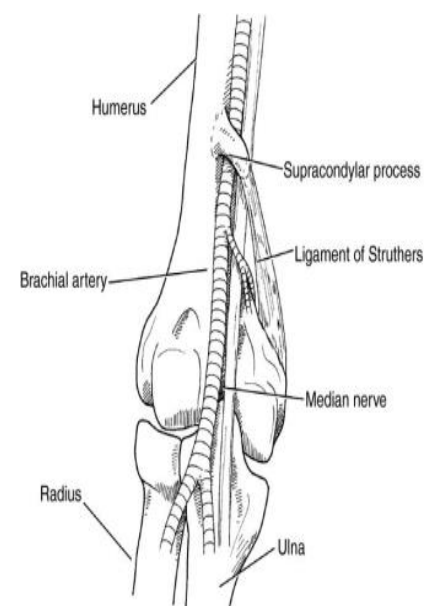
Provocative tests:

- Direct cubital tunnel compression
- Tinel sign
- Elbow hyperflexion
- Froment sign → thumb IP (interphalangeal) flexion - FPL (flexor pollicis longus) during key pinch → weak adductor pollicis

Treatment:

- Electrodiagnostic tests → diagnosis and prognosis
- Non-operative treatment:
 - ✓ Activity modification *[to prevent hyperflexion of the elbow]*
 - ✓ Night splints → slight extension
 - ✓ NSAIDs
- Surgical Release → Numerous techniques:
 - ✓ In situ decompression
 - ✓ Anterior transposition
 - ✓ Subcutaneous
 - ✓ Submuscular
 - ✓ Intramuscular
 - ✓ Medial epicondylectomy

No significant difference in outcome between simple decompression and transposition.

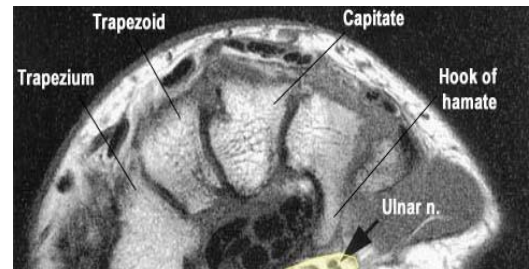


Ulnar Tunnel Syndrome:

- Compression neuropathy of ulnar nerve in the Guyon canal [*at the wrist*]

Causes:

- Ganglion cyst → 80%
- Hook-of-hamate nonunion



Investigations:

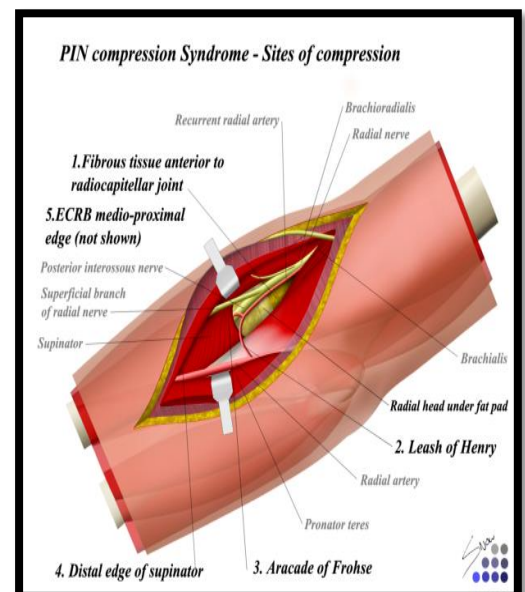
- CT → hamate hook fracture
- **MRI → ganglion cyst or other space-occupying lesion (the best test to investigate ulnar tunnel syndrome is MRI (MCQ))**
- Doppler ultrasonography → ulnar artery thrombosis

Treatment success → identify cause

- Non-operative treatment
 - ✓ Activity modification
 - ✓ Splints
 - ✓ NSAIDs
- Operative treatment → decompressing by removing underlying cause
 - ✓ Ulnar compression @ Guyon + CTS ⇒ CTS release is enough

Radial Nerve

- Radial nerve compression → rarely compressed → mainly motor symptoms.
- PIN compression → lateral elbow pain + muscle weakness.
- Radial Tunnel Syndrome →
 - lateral elbow and radial forearm pain
 - no motor or sensory dysfunction
- Cheiralgia parasthetica → superficial sensory radial nerve → pain, numbness, paresthesias over dorso-radial hand.



Peripheral Nerve Injuries

Causes →

- Compression
- Stretch
- Blast
- Crush
- Avulsion
- Transection
- Tumor invasion

Neurapraxia examples

- A. Saturday night palsy:
 - Develops when the radial nerve is compressed for long period of time, results in radial nerve palsy which is manifested as wrist drop.
- B. Honeymooner's syndrome:
 - When a partner offers his arm as cushion which results in nerve compression and Neuropraxia.
- C. Wheel chair bound person:
 - Handicapped patients who are unable to change posture without help often experience Neuropraxia secondary to superficial nerves

Good prognostic factor for recovery:

- **Young age** → most important factor
- Stretch injuries
- Clean wounds
- After direct surgical repair

Poor outcome:

- Crush or blast injuries
- Infected or scarred wounds
- Delayed surgical repair

Classification:

Neuropraxia

Axonotmesis

Neurotmesis

Neurapraxia:

- Mild nerve stretch or contusion
- Focal conduction block
- No wallerian degeneration [*no discontinuity*]
- Disruption of myelin sheath
- Epineurium, perineurium, endoneurium **intact**
- Prognosis excellent → full recovery

Axonotmesis:

- Incomplete nerve injury
- **Associated with trauma and fractures.**

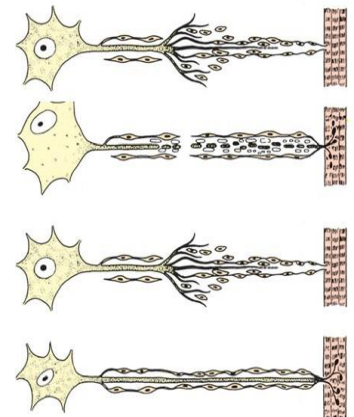
- Focal conduction block.
- Wallerian degeneration distal to injury.
- Disruption of axons
- Sequential loss of axon, endoneurium, perineurium.
- May develop neuroma-in-continuity.
- Recovery unpredictable.

Neurotmesis:

- Complete nerve injuries
- Focal conduction block
- Wallerian degeneration distal to injury
- **Disruption of all layers**, including epineurium
- Proximal nerve end forms neuroma [*painful*]
- Distal end forms glioma
- **Worst prognosis**

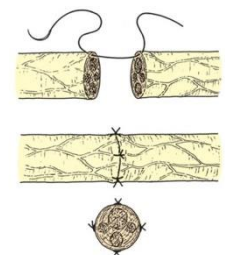
Wallerian degeneration:

- Starts in distal nerve segment
- Degradation products → removed by phagocytosis
- Myelin-producing Schwann cells → proliferate and align → form a tube → receive regenerating axons
- Nerve cell body enlarges → increased structural protein production
- Proximal axon forms sprouts → connect to the distal stump → migrate @ 1 mm/day [*so 5 mm tear will need 5 days to repair*]



Surgical repair:

- Best performed within **2 weeks** of injury
- Repair must be free of tension
- Repair must be within clean, well-vascularized wound bed
- Nerve length may be gained by neurolysis or transposition
- Repair techniques: (**No technique deemed superior**)
 - Epineurial
 - Individual fascicular
 - Group fascicular
- Nerve conduits → popular for digital nerve gaps >8 mm → polyglycolic acid and collagen based
- Larger gaps → grafting [*>20 mm*]
- Autogenous → sural - medial/lateral antebrachial cutaneous - terminal/PIN
- Vascularized



- Growth factor augmentation → insulin-like and fibroblast → promote nerve regeneration
- Chronic peripheral nerve injuries → neurotization and/or tendon transfers
- Use of nerve transfers for high radial and ulnar nerve injuries gaining popularity.

Summary

- **Compression Neuropathy:** chronic + sensation of light touch and pressure are lost first, pain and temperature are last. Risk factors: DM + Pregnancy + obesity + infection. Can cause night pain and numbness + clumsiness. the best test to do is Semmes-Weinstein monofilaments
- **Carpal Tunnel Syndrome:** risk factors are like obesity, DM and pregnancy. Durkan test = Most sensitive
- **Pronator Syndrome:** Median nerve compression at the arm or forearm
- **Ulnar Tunnel Syndrome:** Compression neuropathy of ulnar nerve in the Guyon canal, MRI is good
- **Neurapraxia:** stretch or trauma (focal) The nerve is intact but mechanical pressure has caused demyelination of axons in a limited segment
- **Axonotmesis:** there is interruption of the axons in a segment of nerve. It is seen typically after closed fractures and dislocations. There is loss of conduction but the nerve is in continuity and the neural tubes are intact.
- **Neurotmesis:** Disruption of all layers of the nerve, Wallerian degeneration distal to injury (Distal to the lesion, and for a few millimeters proximal to it, axons disintegrate and are resorbed by phagocytes) .
- **Acute Carpal Tunnel Syndrome:** is after trauma or Hemorrhage needs emergency decompression

MCQs

1. Blockage of axonal transport at one point makes the entire axon more susceptible to compression elsewhere, is the definition of what phenomenon?
 - a. [Raynaud phenomenon](#)
 - b. [Double crush phenomenon](#)
2. A pregnant female came to you complaining of pain and parenthesis in the right hand at night, you suspect Carpel tunnel syndrome, what should you do next?
 - a. [Surgical decompression](#)
 - b. [Wait until she delivers and see if the symptoms gone](#)
3. A 35 years old diabetic male construction worker came to the ER after he fell from a roof of a very tall building he came with an open fracture of his right humarus shaft he cannot extend his wrist and fingers after surgical exploring you found complete nerve cut (Disruption of all layers of the nerve), what is the classification and how is the prognosis is like?
 - A. [Neurapraxia.](#)
 - B. [Axonotmesis.](#)
 - C. [Neurotamesis](#)

Answers: 1: b , 2: b , 3: c

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