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# 6-Peripheral Nerve Injuries

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## Objectives:

Not available

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**References:** Slides, Team 435, Apley. Slides, Team 435, Apley.

## Peripheral nerve sheaths:

All motor axons and the large sensory axons serving touch, pain and proprioception are coated with myelin (Lipoprotein derived from the accompanying Schwann cells).

<p><b>Endoneurium</b></p>	<ul style="list-style-type: none"> <li>● Outside the Schwann cell membrane, the axon is covered by a connective tissue stocking, the endoneurium.</li> <li>● It is the innermost loose irregular fibrous connective tissue protective sheath surrounding each nerve fiber (axon or dendrite) within each fascicle/bundle of a peripheral nerve.</li> <li>● This layer will be external to the myelin sheath of a myelinated axon.</li> <li>● This inner layer contains some mast cells and small blood capillaries.</li> </ul>	<p>(b) Copyright © 2001 Benjamin Cummings, an imprint of Addison Wesley Longman, Inc.</p>
<p><b>Perineurium</b></p>	<ul style="list-style-type: none"> <li>● The axons that make up a nerve are separated into bundles (fascicles) by fairly dense membranous tissue, known as the perineurium.</li> <li>● In a transected nerve, these fascicles are seen, their perineurial sheaths well defined and strong enough to be grasped by fine instruments during nerve repair.</li> <li>● It is the intermediate layer of dense irregular fibrous connective tissue protective sheath surrounding each nerve fascicle within a peripheral nerve, composed of various nerve fascicles.</li> </ul>	
<p><b>Epineurium</b></p>	<ul style="list-style-type: none"> <li>● The groups of fascicles that make up a nerve trunk are enclosed in an even thicker connective tissue coat, the epineurium.</li> <li>● The epineurium varies in thickness and is particularly strong where the nerve is subjected to movement and traction, for example near a joint.</li> <li>● Richly supplied by <b>blood vessels</b> that run longitudinally in the epineurium.</li> <li>● <b>That's why any nerve compression can lead to nerve ischemia.</b></li> <li>● It is the outermost dense irregular fibrous connective tissue protective sheath surrounding each peripheral nerve, composed of various nerve fascicles.</li> <li>● This outer layer contains some adipocytes and small blood vessels.</li> </ul>	

**You need to know this, Cause It will help you understand the types of nerve injury and what structure is affected and is intacted.**

## Causes of peripheral nerve injury:

Nerves can be injured by ischaemia, compression (**EX: hematoma, fracture, displaced joint..etc**) , traction, laceration or burning.

Damage varies in severity from transient and recoverable loss of function to complete interruption.

- **Compression:** (acute fracture of the distal radius is associated with carpal tunnel syndrome).
- **Stretch:** After surgery, for example humorous surgery and the patient present post-op with drop-wrist due to stretching of the nerve.
- **Blast:** (gunshot wound or explosion).
- **Crush:** (as when a rock falls on the wrist).
- **Transection:** (knife stab).
- **Tumor invasion.**
- **Avulsion<sup>1</sup>:** in a gunshot wound the bullet penetrates the body it pulls some tissue with it, or with retraction in the OR (to hold back tissue to expose the area).

Prognostic factors:

Good prognostic factors for recovery:	Poor outcome:
<ul style="list-style-type: none"> <li>● young <b>age: most important factor.</b></li> <li>● stretch/sharp injuries.</li> <li>● clean wounds.</li> <li>● Direct surgical repair.</li> </ul>	<ul style="list-style-type: none"> <li>● Crush injuries.</li> <li>● Infected or scarred wounds.</li> <li>● Delayed surgical repair.</li> </ul>

## Pathology:

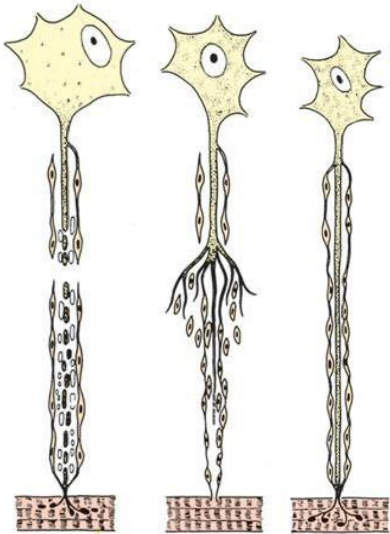
Transient ischaemia:

- Acute nerve compression.
- numbness and tingling within **15** minutes.
- loss of pain sensibility after **30** minutes.
- muscle weakness after **45** minutes.
- Relief of compression is followed by intense paraesthesia for 5 minutes ('pins and needles' after a limb 'goes to sleep'); feeling is restored within 30 seconds and full muscle power after about 10 minutes.
- Due to transient endoneurial anoxia and no nerve damage.

<sup>1</sup> To pull away.

## Classification of peripheral nerve

### ❖ Seddon's classification: (Neurapraxia, Axonotmesis, Neurotmesis):

<p><b>Neurapraxia:</b> (apraxia means loss of function)</p>	<ul style="list-style-type: none"> <li>● <b>Reversible</b> physiological nerve conduction block (loss of sensation and muscle power) followed by <b>spontaneous recovery</b> after a few days or weeks.</li> <li>● Due to mechanical pressure causing segmental demyelination (mild nerve stretch or contusion)</li> <li>● Crutch palsy, Saturday night palsy, Tourniquet palsy.</li> </ul>	
<p><b>Axonotmesis:</b> (Literally means axonal interruption)</p>	<ul style="list-style-type: none"> <li>● More severe form of nerve injury.</li> <li>● Closed fractures and dislocations.</li> <li>● Loss of conduction but the nerve is in continuity, and the <b>neural tubes (nerve sheath) are intact.</b></li> <li>● <b>Wallerian<sup>2</sup> degeneration</b> distal to the lesion.</li> <li>● Axonal regeneration starts within hours of nerve at a speed of 1–2 mm per day.</li> <li>● Eventually, they join to end-organs (motor end-plates and sensory receptors). and function is regained again.</li> </ul>	
<p><b>Neurotmesis:</b></p>	<ul style="list-style-type: none"> <li>● division of the nerve trunk as in open fracture. (Disruption of all layers)</li> <li>● If the injury is more severe, whether the nerve is in continuity or not, recovery will not occur.</li> <li>● <b>Rapid wallerian degeneration.</b></li> <li>● The <b>endoneurial tubes are destroyed.</b></li> <li>● Regenerating axons does not reach the distal segment.</li> <li>● <b>Neuroma<sup>3</sup></b> formation at the site of injury (regenerating axons, schwann cells and fibroblasts)</li> <li>● Function is never normal.</li> </ul>	

<sup>2</sup> the process of anterograde degeneration (away from the cell body) of the axons and their accompanying myelin sheaths following proximal axonal or neuronal cell body lesions.

<sup>3</sup> is a painful condition, also referred to as a "pinched nerve" or a nerve tumor. It is a benign growth of nerve tissue frequently found between the third and fourth toes. It brings on pain, a burning sensation, tingling, or numbness between the toes and in the ball of the foot.

❖ **Sunderland's classification** (a more practical classification):

<b>First degree injury:</b>	<ul style="list-style-type: none"> <li>● Includes transient ischaemia and neuropraxia.</li> <li>● reversible.</li> </ul>
<b>Second degree injury:</b>	<ul style="list-style-type: none"> <li>● axonotmesis</li> <li>● axonal degeneration, but because the endoneurium is preserved, regeneration can lead to complete, or near complete, recovery without the need for intervention.</li> </ul>
<b>Third degree injury:</b>	<ul style="list-style-type: none"> <li>● worse than axonotmesis.</li> <li>● The endoneurium is disrupted but the <b>perineurium is intact</b>.</li> <li>● Chances of the regenerating axons to reach their targets are good.</li> <li>● Fibrosis and crossed connections will limit recovery.</li> </ul>
<b>Fourth degree injury:</b>	<ul style="list-style-type: none"> <li>● Only the <b>epineurium is intact</b>.</li> <li>● The nerve trunk is still in continuity, but internal damage is severe.</li> <li>● Recovery is <b>unlikely</b>.</li> <li>● The injured segment should be excised, and the nerve <b>repaired or grafted</b>.</li> </ul>
<b>Fifth degree injury:</b>	<ul style="list-style-type: none"> <li>● The nerve is divided and will have to be repaired.</li> </ul>

## Summary for the classifications of nerve injuries.

**Table 1.** Classification systems for nerve injury.\*

Seddon classification	Sunderland classification	Pathology	Prognosis
Neurapraxia	First degree	Myelin injury or ischemia	Excellent recovery in weeks to months
Axonotmesis	Second degree	Axon loss	Good to poor, depending upon integrity of supporting structures and distance to muscle Good, depending upon distance to muscle
		Variable stromal disruption	
		Axon loss	
		Endoneurial tubes intact Perineurium intact Epineurium intact	
Third degree	Fourth degree	Axon loss	Poor Axonal misdirection Surgery may be required
		Endoneurial tubes disrupted Perineurium intact Epineurium intact	
		Axon loss	
Endoneurial tubes disrupted Perineurium disrupted Epineurium intact			
Neurotmesis	Fifth degree	Axon loss Endoneurial tubes severed Perineurium severed Epineurium severed	No spontaneous recovery Surgery required Prognosis after surgery guarded

## Assessment of nerve recovery:

- **Motor recovery is slower than sensory recovery.**
- Clinical tests of muscle power and sensitivity to light touch and pin-prick.
- low energy injury (neurapraxia) vs a high energy injury (axonotmesis or neurotmesis).

### a. Tinel's sign:

- peripheral tingling or dysaesthesia upon percussing the nerve.
- In a **neurapraxia**, Tinel's sign is **negative**.
- In **axonotmesis**, it is **positive** and advance with the regenerating axons.



### b. Two-point discrimination:

- measure of innervation density.



### c. Electromyography (EMG) and Nerve Conduction Studies (NCS):

- 1- Denervation potentials by the **third week**.

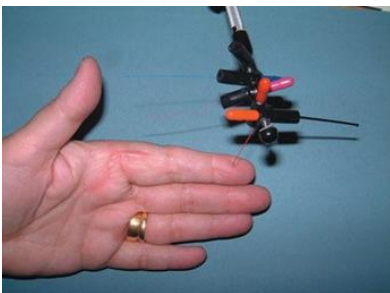
because the degree of muscle denervation that occurs after nerve injury is determined until Wallerian degeneration is complete, and this can take a week or as long as 4 weeks

- 2- Excludes neurapraxia.

- 3- Does not distinguish between axonotmesis and neurotmesis.



### d. Monofilament assessment:



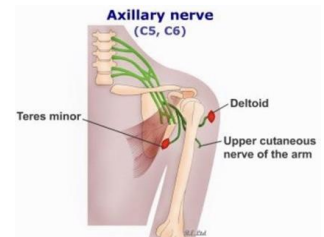
### Surgical repair:

- Best performed within 2 weeks of injury.
- Repair must be:
  - Free of tension (any tension force will decrease blood supply).
  - Within clean, well-vascularized wound bed.
- Nerve length may be gained by neurolysis or transposition. (neurolysis: release the proximal and distal tension of the nerve).
- Direct end to end repair.
- Larger gaps require grafting.

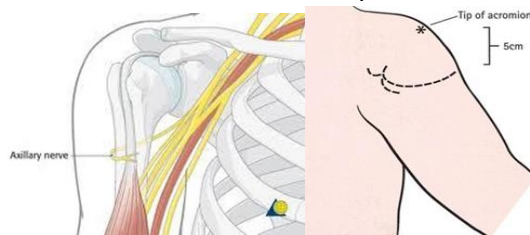
## Examples on peripheral nerve injury:

### Axillary nerve:

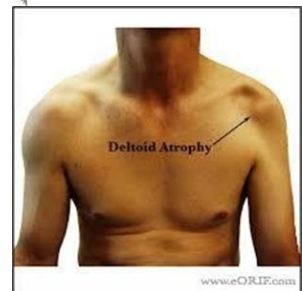
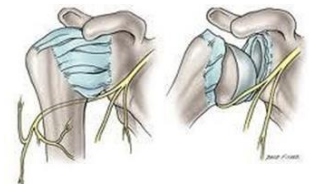
- The axillary nerve (C5, 6); from the posterior cord of the brachial plexus.
- Supplies: *Teres minor*, *deltoid* Muscles. And a patch of skin over the muscle.



- Anterior branch that curls round the **surgical neck** of the **humerus** at 5 cm below the tip of the acromion.



- Injuries:
  - Shoulder dislocation or fractures of the humeral neck.
  - Iatrogenic: Lateral deltoid-splitting incisions.<sup>4</sup>
- Clinical:
  - Shoulder weakness, and the deltoid is rapidly **wasted**.
  - numbness over the deltoid.
- 80% of cases Recover spontaneously.

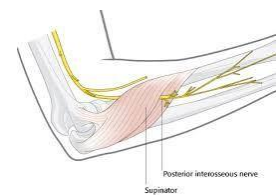


### Radial nerve: (Important)

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low lesions:


- elbow or upper arm.
- Injuries:
  - Fractures or dislocations at the elbow.
  - Iatrogenic lesions of the posterior interosseous nerve where it winds through the supinator muscle.
- Clinical:
  - **Cannot extend the MCP** joints of the hand with weakness of thumb extension.
  - Wrist extension is preserved because the branch to the extensor carpi radialis longus arises proximal to the elbow.



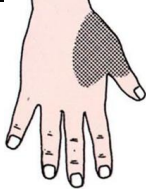
<sup>4</sup> It is an approach used to treat Fractures and nonunions of the proximal humerus

high lesions

- **humerus. around spiral groove**
- Injuries: fractures of the humerus or after prolonged tourniquet pressure.

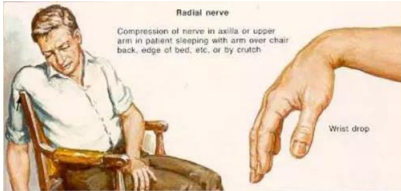


- Clinical:
  - **wrist drop.**
  - inability to extend the MCP joints or elevate the thumb.
  - sensory loss at the first web space.



very high lesions

- **axilla or shoulder**
- Injuries:
  - Trauma or operations around the shoulder.
  - More often, chronic compression in the axilla; (Saturday night palsy) or (crutch palsy).
- Clinical: In addition to weakness of the wrist and hand, the **triceps** is paralysed and the triceps **reflex is absent.**



Distal: ulnar tunnel syndrome | Proximal: Erb's palsy

**Radial nerve neuropathy**


Motor deficits:

- Wrist drop: inability to extend (dorsi-flex) the wrist
- Inability to extend the fingers at the MCP joints

Sensory deficits:

- Dorsal aspect: radial 2½ fingers (less commonly, 3½ fingers), excluding the tips of the 2<sup>nd</sup> and 3<sup>rd</sup> fingers. The 1<sup>st</sup> web space is the autonomous sensory zone of the radial nerve and is highlighted in red.
- Palmar aspect: the radial border of the thumb

Proximal lesion: complete loss of motor and sensory function  
 Distal lesion (radial tunnel syndrome): partial loss of motor function; preservation of sensory function



Motor function: wrist drop

Sensitivity: affected regions


Proximal lesion

Distal lesion

extra

Treatment:

- Open injuries: nerve explored and repaired or grafted as soon as possible.
- Closed injuries: usually recovers.
- Splinting (while waiting for recovery, the wrist is splinted in extension).
- If no recovery → Tendon transfers.





Ulnar nerve  
(Important)  
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Low lesions:

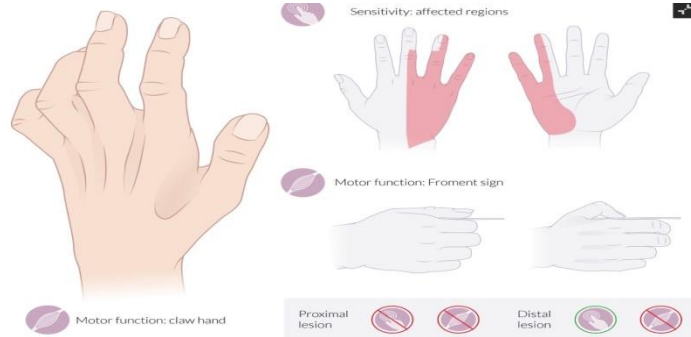
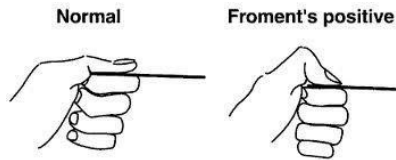
- near the wrist. (e.g. cuts on shattered glass).
- Clinical:
  - Numbness of the ulnar one and a half fingers.
  - **Claw hand** deformity; with **hyperextension of the MCP joints and flexion IP joints of the ring and little fingers** due to weakness of the intrinsic muscles.



**\*why is the morphology of claw hand like that?** Because from your anatomy it is the opposite of the muscles that were paralyzed which are the two medial lumbricals, these muscles flex the fingers at the metacarpophalangeal joints, and extend them at the interphalangeal joints.



- **Weak** finger abduction is weak and **thumb adduction**, makes pinch difficult.
- **Hypothenar** and interosseous **wasting**.
- Flexor pollicis longus **which is supplied by median nerve** compensate for loss of Thumb adductor pollicis (**Froment's sign**)



high lesions:

- near the elbow. e.g. elbow fractures or dislocations.
- Hand: not markedly deformed because the ulnar half of Flexor Digitorum Profundus is paralysed and the fingers are therefore **less clawed' (high ulnar paradox)**.
- Ulnar neuritis:
  - compression or entrapment of the nerve in the medial epicondylar (cubital) tunnel.
  - severe valgus deformity of the elbow or prolonged pressure on the elbows in anaesthetized or bed-ridden patients.



**Median nerve**  
**important**  
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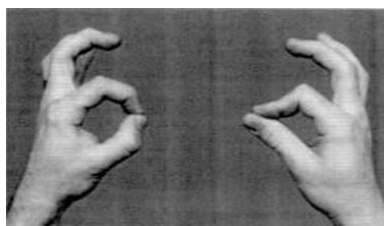
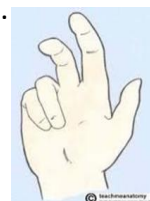
low lesions:  
more common than higher

- near the wrist.
- cuts in front of the wrist or by carpal dislocations.
- Unable to abduct the thumb.
- sensation is lost over the radial three and a half digits.
- **Thenar and trophic eminence is wasted** changes.



high lesions:

- high up in the forearm.
- forearm fractures or elbow dislocation.
- Same as low lesions, in addition to these paralysed muscles:
  - the long flexors to the thumb, index and middle fingers.
  - the radial wrist flexors.
  - the forearm pronator muscles.
- Typically, the hand is held with the ulnar fingers flexed and the index straight (**the 'pointing sign'**).
- Thumb and index flexors are deficient; there is a characteristic pinch defect with the distal joints in full extension.



isolated interosseous nerve lesions:

- extremely rare.
- Similar to those of a high lesion but without any sensory loss.

**Median nerve neuropathy**

**Motor deficits:**

- Hand of benediction: an inability to flex the index and middle fingers at the MCP and IP joints and an inability to oppose the thumb when asked to make a fist. This sign is seen only in proximal lesions of the median nerve (above the elbow).
- Bottle sign: an inability to tightly encircle a cylindrical object in the 1<sup>st</sup> web space of the hand. A gap appears between the 1<sup>st</sup> web space and the cylindrical object due to an inability to adduct, oppose, and flex the thumb.

**Sensory deficits:**

- Dorsal aspect: tips of the radial 3½ fingers.
- Palmar aspect: radial half of the palm and radial 3½ fingers.

**Proximal lesion: complete loss of motor and sensory function**  
**Distal lesion: complete sensory loss; partial impairment of motor function**

Extra

Sciatic  
nerve:

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Injuries:

- Division (**cut**) of the main sciatic nerve is rare.
- Traction lesions (traumatic hip dislocations and with **pelvic fractures**).
- Iatrogenic lesions (**total hip replacement**).

clinical features:

- In a complete lesion: the hamstrings and all muscles below the knee are paralysed and the **ankle jerk is absent**.
- Sensation is lost below the knee, except on the medial side of the leg.
- **Foot-drop and a high-stepping gait**.
- Sometimes only the deep part of the nerve is affected (common peroneal nerve lesion), which can happen after hip replacement.



Peroneal  
nerves

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- Common peroneal nerve or one of its branches.
- Often damaged at the level of the fibular neck.
- Injuries:
  - Severe traction when the knee is forced into varus (e.g. in lateral ligament injuries).
  - fractures around the knee.
  - During operative correction of gross valgus deformities.
  - Pressure from a splint or a plaster cast.
  - from lying with the leg externally rotated.
- Clinical features:
  - **Foot-drop**: can neither dorsiflex nor evert the foot.
  - high-stepping gait.
  - Sensation is lost over the front and outer half of the leg and the dorsum of the foot.



Tibial  
nerves

- Rarely injured except in open wounds.
- Clinical Features:
  - **Unable to plantar-flex** the ankle or the toes.
  - sensation is absent over the sole and part of the calf.
  - Because both the long flexors and the intrinsic muscles are involved, there is not much clawing.



## EXTRA

Injured nerve	Nerve roots	Common causes	Motor deficits	Sensory deficits
<b>Axillary nerve injury</b>	• C5–C6	<ul style="list-style-type: none"> <li>• Anterior <b>shoulder dislocation</b></li> <li>• Fracture of <b>surgical neck</b> of the humerus</li> <li>• Iatrogenic (shoulder reconstruction procedures, rotator cuff surgery, osteosynthesis of humeral fractures)</li> <li>• Compression due to mass in the axilla (e.g., nodular fasciitis, schwannoma)</li> </ul>	<ul style="list-style-type: none"> <li>• Paralysis of the deltoid muscle → impaired <b>arm abduction</b></li> <li>• Paralysis of the teres minor muscle → impaired <b>external rotation</b> of the arm</li> <li>• Muscle atrophy: <b>flattened deltoid</b></li> </ul>	<ul style="list-style-type: none"> <li>• Lateral shoulder (lower half of the deltoid region)</li> </ul>
<b>Musculocutaneous nerve injury</b>	• C5–C7	<ul style="list-style-type: none"> <li>• Trauma</li> <li>• Upper trunk <b>compression</b> (e.g., Erb palsy)</li> </ul>	<ul style="list-style-type: none"> <li>• Paralysis of brachialis and coracobrachialis muscles → impaired <b>elbow flexion</b></li> <li>• Paralysis of biceps brachii → impaired forearm <b>supination</b></li> </ul>	<ul style="list-style-type: none"> <li>• Lateral forearm, from the elbow to the base of the thumb</li> </ul>
<b>Median nerve injury</b>	• C5–T1	<ul style="list-style-type: none"> <li>• Proximal: supracondylar fracture of humerus</li> <li>• Distal: <b>carpal tunnel compression</b>, wrist laceration (suicide attempt)</li> </ul>	<ul style="list-style-type: none"> <li>• Proximal injury: <b>hand of benediction</b> (ulnar deviation upon wrist flexion)</li> <li>• Distal injury: <b>median claw</b></li> <li>• Both injuries: <b>ape hand</b></li> <li>• Inability to make OK sign (anterior interosseous nerve syndrome)</li> <li>• Muscle <b>atrophy</b>: <b>thenar muscles</b></li> </ul>	<ul style="list-style-type: none"> <li>• Palmar aspect of thumb, index and middle fingers, lateral ring finger</li> </ul>
<b>Radial nerve injury</b>	• C5–T1	<ul style="list-style-type: none"> <li>• Axilla: crutch use, <b>Saturday night palsy</b></li> <li>• Mid-arm: midshaft fracture of the humerus</li> <li>• Wrist: radial fracture, wearing tight bracelets or handcuffs</li> </ul>	<ul style="list-style-type: none"> <li>• Axillary injury: impaired forearm extension at elbow, <b>wrist drop</b></li> <li>• Mid-arm injury: <b>wrist drop</b></li> </ul>	<ul style="list-style-type: none"> <li>• Dorsal aspect of thumb, index, and middle fingers, lateral ring finger</li> </ul>
<b>Ulnar nerve injury</b>	• C7–T1	<ul style="list-style-type: none"> <li>• Proximal: fracture of medial epicondyle of humerus</li> <li>• Distal: <b>ulnar tunnel syndrome</b> (cycling, ganglion cyst), hook of hamate fracture</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Ulnar claw</b></li> <li>• Wartenberg sign</li> <li>• Froment sign</li> </ul>	<ul style="list-style-type: none"> <li>• Palmar and dorsal aspects of lateral half of ring finger, little finger</li> </ul>
<b>Sciatic nerve injury</b>	• L4–S3	<ul style="list-style-type: none"> <li>• Iatrogenic (misplaced intragluteal injection!)</li> <li>• Direct trauma (gun and/or stab wounds)</li> <li>• Hip dislocation</li> <li>• Total hip arthroplasty</li> </ul>	<ul style="list-style-type: none"> <li>• Paralysis of hamstring muscles → impaired knee flexion</li> <li>• Motor deficits of tibial nerve injury and common peroneal nerve injury</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Lower leg and foot</b></li> </ul>
<b>Tibial nerve injury</b>		<ul style="list-style-type: none"> <li>• Tibial fracture</li> <li>• Tarsal tunnel syndrome</li> </ul>	<ul style="list-style-type: none"> <li>• Paralysis of foot flexors → inability to walk on the toes or balls of the feet; inability to invert foot</li> </ul>	<ul style="list-style-type: none"> <li>• Sensory loss over sole of the foot (see <b>Morton neuroma</b>)</li> </ul>
<b>Common peroneal nerve injury</b>	• L4–S2	<ul style="list-style-type: none"> <li>• Fracture of the <b>fibular head</b></li> <li>• Compression: tight casts, sitting cross-legged, <b>Lithotomy position</b> during surgery</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Deep peroneal nerve</b>: paralysis of foot and toe extensors (dorsiflexors) → <b>foot drop</b> → <b>high-stepping gait</b></li> <li>• <b>Superficial peroneal nerve</b>: paralysis of peroneus longus and peroneus brevis → impaired pronation of the foot</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Deep peroneal nerve</b>: area between the first and second toes (flip-flop zone)</li> <li>• <b>Superficial peroneal nerve</b>: lateral surface of the lower leg, dorsum of the feet and toes, except for the space between the first and second toe (<b>deep peroneal nerve</b>)</li> </ul>

**compression neuropathy:** (found in team 435,434,433 and taken from 435. but not in our slides)

Introduction:

Nerve compression impairs epineural blood flow and axonal conduction, giving rise to symptoms such as: numbness, paraesthesia and muscle weakness.

the relief of ischaemia explains the sudden improvement in symptoms after decompressive surgery.

Prolonged or severe compression leads to segmental demyelination, target muscle atrophy and nerve fibrosis; symptoms are then less likely to resolve after decompression.

- It is a condition with sensory, motor, or mixed involvement.
- If mixed pathology, sensory function is affected first and then motor is affected this is because Motor fibers have thick myelin sheath. As a result, the first symptom to appear is hypoesthesia and lastly atrophy of the muscles which means severe disease.
- The sensory functions lost are as follows:
  - First lost → **light touch** – pressure – vibration (mild)
  - Last lost → **pain sensation loss – temperature** (severe)
- The pathophysiology of compression neuropathy:

Microvascular compression due to any cause → neural ischemia → paresthesia → Intraneural edema → more microvascular compression → demyelination → fibrosis → axonal loss

Common systemic conditions leading to compression neuropathy:

SYSTEMIC	ANATOMIC
Diabetes – Alcoholism – Renal failure – Vit B deficiency	Fibrosis – Anomalous tendon – Fracture deformity (distal radial fracture with dorsal angulation may lead to median nerve compression)
FLUID IMBALANCE	MASS
Pregnancy (carpal tunnel is very common during pregnancy) – Obesity (They usually have bilateral numbness of the hand)	Ganglion – Lipoma – Hematoma
INFLAMMATORY	
Rheumatoid arthritis - Infection - Gout - Tenosynovitis	

## Symptoms:

- Numbness.
- Night symptoms.
- Dropping of objects.
- Clumsiness.
- Weakness

## Special tests:

## Semmes-Weinstein monofilaments:

- Very fine mono-filaments that evaluate light touch; (FIRST THING TO BE LOST IS FINE TOUCH).
- The best test; can detect very early neuropathy.
- Cutaneous pressure threshold → function of large nerve fibers which is first to be affected in compression neuropathy.
- Sensing 2.83 monofilament is normal.



## Two-point discrimination:

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

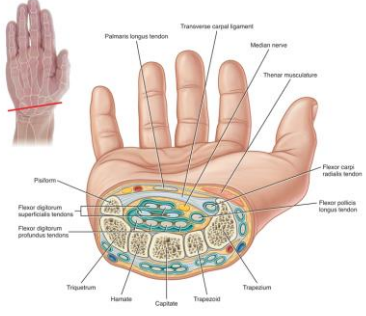

## Investigations (Electrodiagnostic testing):

- Sensory and motor nerve function can be tested through EMG and NCS.
- Done by: neurophysiologists or technicians.
- Operator dependent (disadvantage).
- Objective evidence of neuropathic condition.
- Helpful in localizing point of compromise.
- In the early disease, there is a High false-negative rate

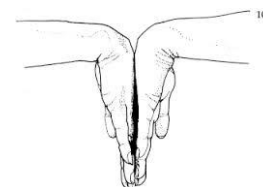
NCSs (nerve conduction studies):	EMG (Electromyography):
Tests conduction velocity, distal latency and amplitude	Tests muscle electrical activity
Demyelination → ↓conduction velocity + ↑distal latency axonal loss → ↓ potential amplitude	Muscle denervation → fibrillations - positive sharp waves

Median nerve compression:

Carpal tunnel syndrome (CTS) (most common compressive neuropathy):

<p>What?</p>	<p>Compression of the median nerve as it travels through the wrist at the carpal tunnel.</p> <ul style="list-style-type: none"> <li>● Normal pressure → 2.5 mm Hg.</li> <li>● &gt;20 mm Hg → ↓↓ epineural blood flow + nerve edema.</li> <li>● 30 mm Hg → ↓↓ nerve conduction.</li> </ul>
<p>Anatomy:</p>	<p>Boundaries:</p> <ul style="list-style-type: none"> <li>● Volar: Transverse carpal ligament (TCL) (flexor retinaculum).</li> <li>● Radial: scaphoid tubercle +trapezium.</li> <li>● Ulnar: pisiform +hook of hamate</li> <li>● Dorsal: proximal carpal row + deep extrinsic volar carpal ligaments.</li> </ul> <p>Carpal Tunnel Contents:</p> <ul style="list-style-type: none"> <li>● Median nerve</li> <li>● FPL ( Flexor Pollicis longus)</li> <li>● 4 FDS (Flexor Digitorum Superficialis)</li> <li>● 4 FDP (Flexor Digitorum Profundus)</li> </ul>  <p><small>Modified from Drake, R. Gray's atlas of anatomy, ed 2. Philadelphia: 2015, Churchill Livingstone.</small></p>
<p>Risk factors</p>	<ul style="list-style-type: none"> <li>● Obesity. (not that common)</li> <li>● Pregnancy. (Very common but most of them will recover after pregnancy).</li> <li>● Diabetes. (Can lead to neuropathy as well as carpal tunnel).</li> <li>● Thyroid disease.</li> <li>● Chronic renal failure.</li> <li>● Others → RA, storage diseases, alcoholism, acromegaly, advanced age.</li> <li>● Repetitive strain injury e.g. using computer, lady works on the kitchen and ortho trauma surgeons</li> </ul>
<p>Diagnosis</p>	<p>History: the median nerve supplies 3 and half finger, the patient will come to you complaining of numbness in 4 finger or the whole hand (which might confuse us with diabetic neuropathy or combined ulcer and median compression).</p> <ul style="list-style-type: none"> <li>● Numbness and pain.</li> <li>● Often at night.</li> <li>● Volar aspect → thumb - index - long (middle) - radial half of ring.</li> <li>● Risk factors.</li> </ul> <p>Physical examination: (affected first → light touch + vibration , affected later → pain and temperature)</p> <ul style="list-style-type: none"> <li>● Special tests:             <ul style="list-style-type: none"> <li>○ Durkan’s test: most sensitive. Examiner presses thumbs over carpal tunnel and holds pressure for 30-60 seconds. An onset of pain or paresthesia in the median nerve distribution within 30-60 seconds is a positive result of the test.</li> </ul> </li> </ul> 

- Tinel's test: performed by lightly tapping (percussing) over the nerve to elicit a sensation of tingling or "electrical shock" in the distribution of the nerve.
- Phalen's test: the area will be tightened and the nerve will be compressed.



- Semmes-Weinstein monofilament testing → early CTS diagnosis
- late findings → Weakness - loss of fine motor control - abnormal two-point discrimination
- Thenar atrophy → severe denervation

Investigations: Electrodiagnostic testing

- Not necessary for the diagnosis of CTS (we do it sometimes to rule out other differential)
- Distal sensory latencies > 3.5 msec Motor latencies > 4.5 msec

Notes:

- Special examination tests are not very sensitive in picking up the diagnosis. They can be negative and when we do NCS it will show that the patient have carpal tunnel.
- If the patient is diabetic → order NCS (to know the cause of the numbness: diabetic neuropathy or Carpal tunnel syndrome)

DDx

- Cervical radiculopathy.
- Brachial plexopathy.
- TOS (Thoracic outlet syndrome).
- Pronator syndrome.
- Ulnar neuropathy.
- Peripheral neuropathy of multiple etiologies (Mainly diabetes).

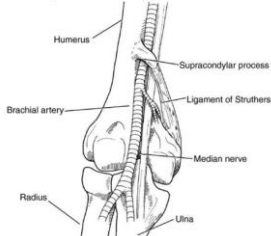


Treatment	<p>Nonoperative:</p> <ul style="list-style-type: none"> <li>● Activity modification.</li> <li>● Night splints.</li> <li>● NSAIDs.</li> <li>● steroid injection.</li> </ul> <p>Operative:</p> <ul style="list-style-type: none"> <li>● Open: Under local anesthesia. we make an incision → go through skin → Subcutaneous tissue → transverse carpal ligament → release it.</li> <li>● Endoscopic: Faster recovery.</li> </ul>			
	<table border="1" style="width: 100%;"> <tr> <th style="width: 50%;">Short term:</th> <th style="width: 50%;">Long term:</th> </tr> <tr> <td> <ul style="list-style-type: none"> <li>● Less early scar tenderness.</li> <li>● Improved short-term grip/pinch strength.</li> <li>● Better patient satisfaction scores.</li> </ul> </td> <td> <ul style="list-style-type: none"> <li>● No significant difference.</li> <li>● May have slightly higher complication rate.</li> <li>● Incomplete TCL release.</li> </ul> </td> </tr> </table> <p>Release outcome:</p> <ul style="list-style-type: none"> <li>● Pinch strength → 6 weeks</li> <li>● Grip strength → 3 months</li> </ul> <p>Persistent symptoms after release:</p> <ul style="list-style-type: none"> <li>● Incomplete release. Most likely</li> <li>● Iatrogenic median nerve injury.</li> <li>● Missed double.</li> <li>● Crush phenomenon.</li> <li>● Concomitant peripheral neuropathy.</li> <li>● Wrong diagnosis.</li> </ul>	Short term:	Long term:	<ul style="list-style-type: none"> <li>● Less early scar tenderness.</li> <li>● Improved short-term grip/pinch strength.</li> <li>● Better patient satisfaction scores.</li> </ul>
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Acute CTS: the patient comes with Hx of acute numbness for the last few hours.

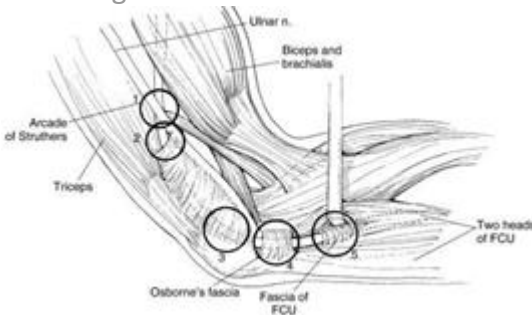
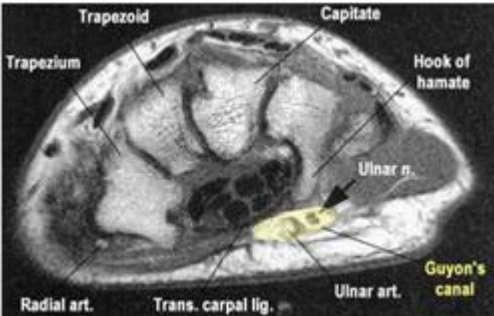
- Causes: high-energy trauma – hemorrhage – infection.
- Requires emergency decompression.

Pronator syndrome:

What?	<p>Median nerve compression at arm/forearm “elbow”(5 potential sites of compression).</p> <ol style="list-style-type: none"> <li>1. Supracondylar process: residual osseous structure on distal humerus present in population</li> <li>2. Ligament of Struthers: <ul style="list-style-type: none"> <li>● travels from tip of supracondylar to medial epicondyle</li> <li>● not to be confused with arcade of Struthers which is a site of ulnar compression neuropathy in cubital tunnel syndrome</li> </ul> </li> <li>3. Bicipital aponeurosis (a.k.a. lacertus fibrosus)</li> <li>4. Between ulnar and humeral heads of pronator teres</li> <li>5. FDS aponeurotic arch</li> </ol>	 <p>1% of process</p>
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Symptoms	<ul style="list-style-type: none"> <li>● Aching pain over proximal volar forearm</li> <li>● Sensory symptoms → palmar cutaneous branch.</li> <li>● Lack of night pain.</li> </ul>
Diagnosis	<ol style="list-style-type: none"> <li>1. History.</li> <li>2. Physical examination.</li> <li>3. NCS/EMG (if positive , we have to know the cause before intervening by ordering X-ray, CT, or MRI to know which area to release).</li> </ol>
Treatment	<p>Non-operative: splints/ NSAIDs / activity modification. Operative: if conservative failed.</p> <ul style="list-style-type: none"> <li>● Open.</li> <li>● Endoscopic.</li> </ul>

### Ulnar nerve compression:

	Cubital tunnel syndrome	Ulnar Tunnel Syndrome
Info	<p>Second most common compression neuropathy of the upper extremity</p> <p>Cubital tunnel borders:</p> <ul style="list-style-type: none"> <li>● Floor : MCL and capsule</li> <li>● Walls : medial epicondyle and olecranon</li> <li>● Roof : FCU fascia and arcuate ligament of Osborne</li> </ul> 	<p>Compression neuropathy of ulnar nerve in the Guyon's canal (where the ulnar nerve and artery pass through) .</p> <p>Causes:</p> <ul style="list-style-type: none"> <li>● Ganglion cyst : 80% of non-traumatic causes</li> <li>● Hook-of-hamate nonunion. pt comes with hx of trauma.</li> <li>● Ulnar artery thrombosis or aneurysm</li> <li>● Lipoma</li> </ul> 
symptoms	<ul style="list-style-type: none"> <li>● Numbness of ulnar half of ring finger and little finger.</li> <li>● Pain in the elbow that extends into the forearm and hand</li> <li>● Weakness of the hand and fingers</li> <li>● Provocative tests:</li> </ul> <p>Direct cubital tunnel compression – Tinel's test</p> <ul style="list-style-type: none"> <li>● Froment sign: thumb IP flexion (by FPL which is supplied by median nerve) during key pinch (weak adductor pollicis which is supplied by ulnar nerve)</li> </ul>	<ul style="list-style-type: none"> <li>● Tingling sensation within the little finger and ring</li> <li>● Finger Pain within the wrist</li> <li>● Difficulty gripping objects</li> <li>● Loss of ulnar nerve function.</li> </ul>
Investigations	Electrodiagnostic tests: diagnostic.	<ul style="list-style-type: none"> <li>● CT: hamate hook fracture. Hx of</li> </ul>

		<p>trauma → order X-ray and CT.</p> <ul style="list-style-type: none"> <li>● MRI: ganglion cyst or lipoma.</li> </ul> <p>No hx of trauma → MRI (because ganglion cyst accounts for 80% of the non-traumatic cases).</p> <ul style="list-style-type: none"> <li>● Doppler ultrasonography: ulnar artery thrombosis or aneurysm.</li> </ul>
Treatment	<p>Nonoperative treatment:</p> <ul style="list-style-type: none"> <li>● Activity modification</li> <li>● Night splints → slight extension</li> <li>● NSAIDs</li> </ul> <p>Surgical Release → Numerous techniques</p> <ul style="list-style-type: none"> <li>● In situ decompression, Anterior transposition, Subcutaneous, Submuscular, Intramuscular, Medial epicondylectomy</li> <li>● No significant difference in outcome between simple decompression and transposition.</li> </ul>	<p>(Treatment success → identify cause)</p> <ol style="list-style-type: none"> <li>Nonoperative treatment <ul style="list-style-type: none"> <li>● Activity modification.</li> <li>● Splints.</li> <li>● NSAIDs.</li> </ul> </li> <li>Operative treatment: decompressing by removing underlying cause. <ul style="list-style-type: none"> <li>● Ganglion cyst, lipoma: excision.</li> <li>● Ulnar artery thrombosis or aneurysm: call vascular surgeon.</li> <li>● Hamate hook fracture: excise that piece of the bone.</li> </ul> </li> </ol>

Radial nerve compression:

- rarely compressed and mainly motor symptoms.

## MCQ

**1-Young patient came with swollen, tender elbow with painful ROM (range of motion). positive Puker sign distally which nerve is the most likely to get injured?**

- A. axillary
- B. median
- C. radial
- D. ulnar

**2-which nerve is the most likely to be injured in anterior shoulder dislocation?**

- A. median
- B. axillary
- C. ulnar
- D. radial

**3-a distal humeral fracture will result in?**

- A. wrist drop.
- B. Thenar eminence is wasted
- C. paralysed of triceps

**4- 5-year-old patient comes with cast for his wrist fracture that happened 3 days ago came to the ER with severe pain and numbness in lateral 3 fingers, which of the following condition can explain his symptom?**

- A. carpal tunnel syndrome
- B. cubital tunnel syndrome
- C. compartment syndrome
- D. drop wrist deformity

**5- 8 years old boy sustained left supracondylar humeral trauma following a fall which of the following statements is correct if the median nerve or its branches are injured as a result of this injury:**

- A. the ok sign positive
- B. Clawing of the hand
- C. loss of thumb adduction
- D. loss of sensation of little finger