18- Peripheral Nerve Injuries

Objectives:

- Not available.

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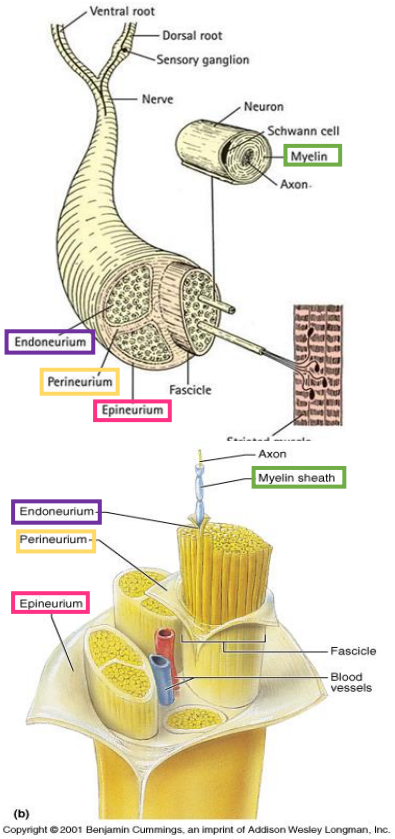
References: 435 Team, Apley, 436 Slides and Notes

Nerve structure and function:



- All motor axons and the large sensory axons serving touch, pain and proprioception are coated with **myelin** (lipoprotein derived from the accompanying Schwann cells).
- Outside the Schwann cell membrane, the axon is covered by a connective tissue stocking, the **endoneurium**.
- The axons that make up a nerve are separated into bundles (fascicles) by fairly dense membranous tissue, known as the **perineurium**.
- 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.
- The groups of fascicles that make up a nerve trunk are enclosed in an even thicker connective tissue coat, the **epineurium**.
- The epineurium varies in thickness according to the area of the nerve and is particularly strong where the nerve is subjected to movement and traction, for example near a joint.
- Richly supplied by blood vessels that run longitudinally in the epineurium.

Summary: myelin → covered by endoneurium → a lot of fascicles form perineurium* → a group of fascicles form epineurium.

*We can identify them and when we repair we try to repair them one by one.

Pathology

- Nerves can be injured by ischaemia, compression (EX: hematoma, fracture, displaced joint, etc..), traction, laceration or burning.
- Damage varies in severity from (mild) **transient** and recoverable loss of function to complete interruption.

★ Transient ischema:

- Caused by: Acute nerve compression.
- Starts with **numbness** and tingling within 15 minutes.
- Then **loss** of **pain** sensibility after 30 minutes.
- Followed by 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.

Classification of peripheral nerve injury

★ Seddon's classification (neurapraxia, axonotmesis, neurotmesis):

Neurapraxia	• Reversible physiological nerve conduction block (loss of sensation and muscle power) followed by spontaneous recovery after a few days or weeks. • Due to mechanical **pressure** causing segmental demyelination (mild nerve stretch or contusion) • Examples: Crutch palsy, Saturday night palsy, Tourniquet palsy[1].
Axonotmesis (cut of axons)	• More severe form of nerve injury. • Closed fractures and dislocations. • Literally means axonal interruption. • Loss of conduction but the **nerve is in continuity** (so there is chance for healing), and the neural tubes (nerve sheath) are intact. • **Wallerian[2] degeneration** distal to the lesion. • Axonal regeneration starts (at the same time) within hours of nerve at a speed of 1–2 mm per day. • Eventually, they join to end-organs (motor end-plates and sensory receptors), and function is regained again.
Neurotmesis (the worst)	• Division of the nerve trunk as in **open fracture**. • Disruption of all layers. • There is healing at the injury site but usually the regenerating axons cannot reach the end organ, and the patient will have anomaly. • If the injury is more severe, whether the nerve is in continuity or not, recovery will not occur. • Rapid wallerian degeneration. • The endoneurial tubes are destroyed. • Regenerating axons does not reach the distal segment. • **Neuroma** formation at the site of injury (regenerating axons, schwann cells and fibroblasts). • Function is never normal.

★ Sunderland's classification (more practical classification):

First degree injury:	• Includes transient ischaemia and neuropraxia. • Reversible.
Second degree injury:	• Axonotmesis • Axonal degeneration, but because the endoneurium is **preserved**, regeneration can lead to complete, or near complete, recovery without the need for intervention.
Third degree injury:	• Worse than axonotmesis. • The endoneurium is disrupted but the perineurium is intact.

[1] When we do surgery sometimes we apply tourniquet to stop the bleeding and sometimes patient will have transient sensory and motor loss.

[2] 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.

	• Chances of the regenerating axons to reach their targets are good. • Fibrosis and crossed connections will limit recovery (when axon heals in wrong direction).
Fourth degree injury:	• Only the epineurium is intact. • The nerve trunk is still in continuity, but internal damage is severe. • Recovery is unlikely. • The injured segment should be excised, and the nerve repaired or grafted.
Fifth degree injury:	• The nerve is divided and will have to be repaired. • Epineurium is injured.

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		Axon loss Variable stromal disruption	Good to poor, depending upon integrity of supporting structures and distance to muscle
	Second degree	Axon loss Endoneurial tubes intact Perineurium intact Epineurium intact	Good, depending upon distance to muscle
	Third degree	Axon loss Endoneurial tubes disrupted Perineurium intact Epineurium intact	Poor Axonal misdirection Surgery may be required
	Fourth degree	Axon loss Endoneurial tubes disrupted Perineurium disrupted Epineurium intact	Poor Axonal misdirection Surgery usually required
Neurotmesis	Fifth degree	Axon loss Endoneurial tubes severed Perineurium severed Epineurium severed	No spontaneous recovery Surgery required Prognosis after surgery guarded

Clinical features

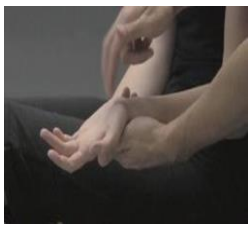
- Acute nerve injuries are easily missed, especially if associated with fractures or dislocations so the physician may focus on them and miss it.
- Ask for numbness, paraesthesia or muscle weakness in the related area. Sometimes the patient is unconscious and you can't examine them.
- Examine for signs of abnormal posture, weakness and changes in sensibility.

Assessment of nerve recovery

- Motor recovery is slower (will come last) than sensory recovery.
- Clinical tests of muscle power and sensitivity to light touch and pin-prick to follow nerve recovery.
- Low energy injury (high chance of recovery) vs a high energy injury (like MVA or fall from height not good sign for patient).

★ Tinel's sign:

- Peripheral tingling (paresthesia) or dysaesthesia upon percussing over the nerve.
- In a neurapraxia, Tinel's sign is negative.
- In axonotmesis, it is positive and advance with the regenerating axons.

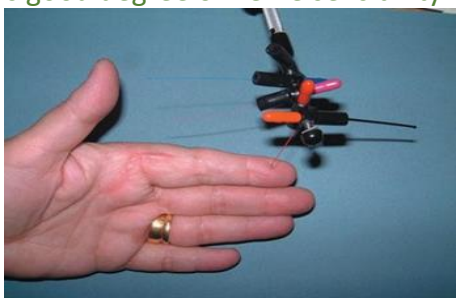


★ Two-point discrimination:

- Measure of innervation density.

★ Monofilament assessment:

- Small filament used and if patient can feel he has good degree of nerve sensitivity.



★ Electromyography (EMG) & Nerve Conduction Studies (NCS):

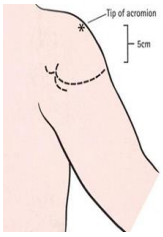
1- Denervation potentials by the third week. (In the initial stages not helpful so we don't do them before 3 weeks, but after three weeks you can see denervation potential)[3]. Distal humeral fracture & nerve injury → surgery → no improvement → Electronic conductive study **after 6 weeks.**

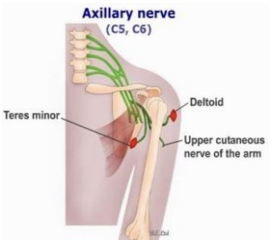
2- Excludes neurapraxia.

3- Does not distinguish between axonotmesis and neurotmesis.

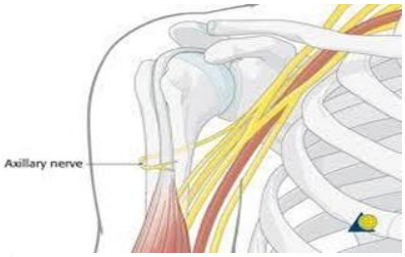
#MRI confirms the diagnosis of nerve injury.

Axillary nerve



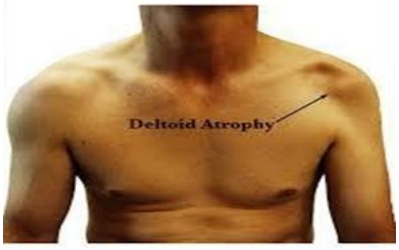


- The axillary nerve (C5, 6); arises from the posterior cord of the brachial plexus.
- Supplies:
  - Teres minor,
  - Deltoid Muscles.
  - And a patch of skin over the muscle at proximal arm.
- Anterior branch that curls round the surgical neck of the humerus at 5 cm below the tip of the acromion.



★ Injuries:

- Shoulder dislocation or fractures of the humeral neck.
- Iatrogenic: Lateral deltoid-splitting incisions.[4]



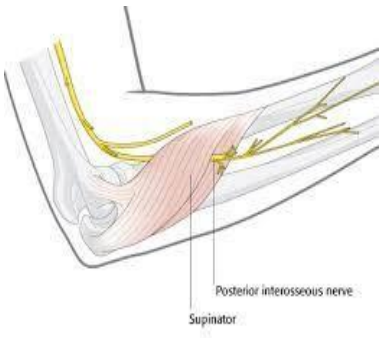
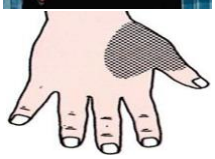
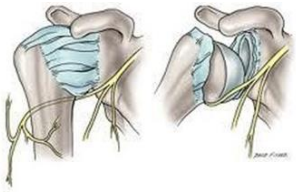
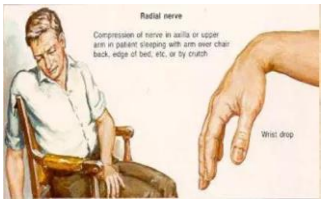
★ Clinical features:

- Shoulder weakness, and the deltoid is rapidly wasted.
- Numbness over the deltoid.
- High recovery: 80% of cases recover spontaneously.

[3] because the degree of muscle denervation that occurs after nerve injury cannot be determined until Wallerian degeneration is complete, and this can take as short as 1 week or as long as 4 weeks

[4] It is an approach used to treat Fractures and nonunions of the proximal humerus

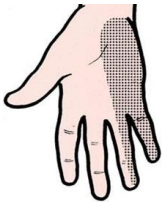
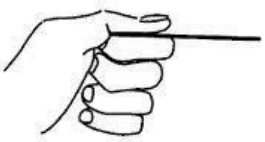
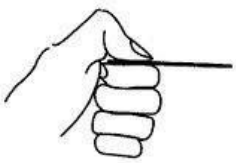
Radial nerve (Very important)

	Low lesions	High lesions	Very high lesion
Level	Elbow or upper arm.	Humerus (around spiral groove)	Axilla or shoulder
Injuries	• **Fractures** or **dislocations** at the elbow. • Iatrogenic lesions of the posterior interosseous nerve where it winds through the supinator muscle.	• Fractures of the humerus or after prolonged tourniquet pressure.	• Trauma or operations around the shoulder. • More often, chronic compression in the axilla; (Saturday night palsy) or (crutch palsy).
Clinical features	• Cannot extend the metacarpophalangeal joint (**MCP** joints) of the hand with weakness of thumb extension. • **Wrist extension is preserved** (very imp) because the branch to the extensor carpi radialis longus arises proximal to the elbow.	• Wrist drop. • Inability to extend the Metacarpophalangeal (MCP) joints or elevate the thumb. • Sensory loss at the dorsal **first web space**. Reduce the fracture and if the patient is still unable to extend the wrist, book her for urgent **nerve exploration** and possible repair. (x-ray pic)	• In addition to weakness of the wrist and hand, the **triceps** is paralysed (loss of elbow extension) and the triceps **reflex** is absent.
Pictures		  	 

★ Treatment

- Open injuries: nerve explored and repaired or grafted as soon as possible.
- Closed injuries: usually recovers.
- Splinting because otherwise he will have muscle stiffness and deformity so we splint the patient and keep the fingers extended.
- If no recovery → Tendon transfers after 6 months.
- Current literature states that injury in this nerve exactly it's **better to wait;** don't do anything, nerve repair or graft, regardless of the injury wait for 6 months and most of the patients will recover.

Ulnar nerve

	Low lesions	High lesions
Level	Near the wrist, e.g. cuts on shattered glass or injury at level of forearm due to compression.	Near the elbow, e.g. elbow fractures or dislocations.
Clinical features	• Numbness of the ulnar one and a half fingers. • Claw hand deformity; with hyperextension of the MCP joints and flexion of distal IP[5] joints of the **ring** and **little fingers**[6] due to weakness of the intrinsic muscles. • Weak **finger abduction** (because of loss of intrinsic ms) and **thumb adduction**, makes pinch difficult. • **Hypothenar** and interosseous **wasting**. • Ask patient to hold paper by the side and he won't be able to do it using the thumb and will compensate by using Flexor pollicis longus (which is supplied by median nerve) compensate for loss of Thumb **adductor pollicis** **(positive Froment's sign)**	• Hand: not markedly deformed because the ulnar half of Flexor Digitorum Profundus is paralysed and the fingers are therefore **less clawed' (high ulnar paradox).** • Explanation: in low lesions there is claw hand because the flexor digitorum profundus is working and causes flexion supplied by median nerve BUT if it is high both musclrs are affected so there isn't much clawing. • 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.
Picture	  Normal Froment's positive   	

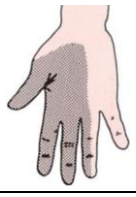
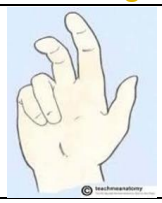
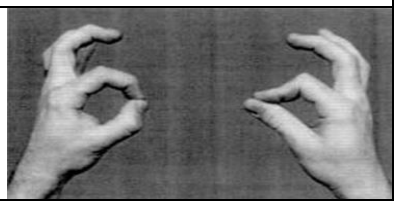
***Why is the morphology of claw hand like that?** Because from your anatomy it is the opposite of the muscles that were paralyzed which are the two medial lumbricals, these muscles flex the fingers at the metacarpophalangeal joints, and extend them at the interphalangeal joints.

[5] Interphalangeal joint.
[6] The other fingers are working fine because they are supplied by the median nerve.

Median nerve

	Low lesions (more **common** than higher)	High lesions
Level	Near the wrist.	High up in the forearm.
Injury	• Cuts in front of the wrist or by carpal dislocations.	• Forearm fractures or elbow dislocation.

Clinical features	• Unable to **abduct** the thumb.
	• Sensation is lost over the radial three and a half digits.
	• Thenar eminence is wasted and trophic changes.
		• Same as low lesions but, 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')**. Positive "OK" sign
		• Thumb and index flexors are deficient; there is a characteristic pinch defect with the distal joints in full extension.
		• Pucker sign.

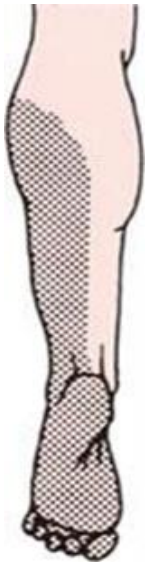
Picture	 	 

★ Isolated anterior interosseous nerve lesions:

- Extremely rare.
- Similar to those of a high lesion but without any sensory loss (this is a purely motor nerve).

What is the most sensitive median nerve clinical test? Durkan test

Sciatic nerve Dr Nabil



★ Injuries:

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

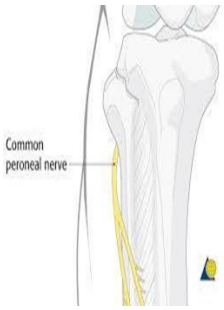
★ Clinical features:

- In a **complete lesion** at the hip: the hamstrings and all muscles below the knee are paralysed and the ankle jerk is absent.
- Very debilitating injury affects patient's quality of life.
- Sensation is lost below the knee, except on the medial side of the leg (supplied by saphenous branch of femoral).
- **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 nerve Dr Nabil

- 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.

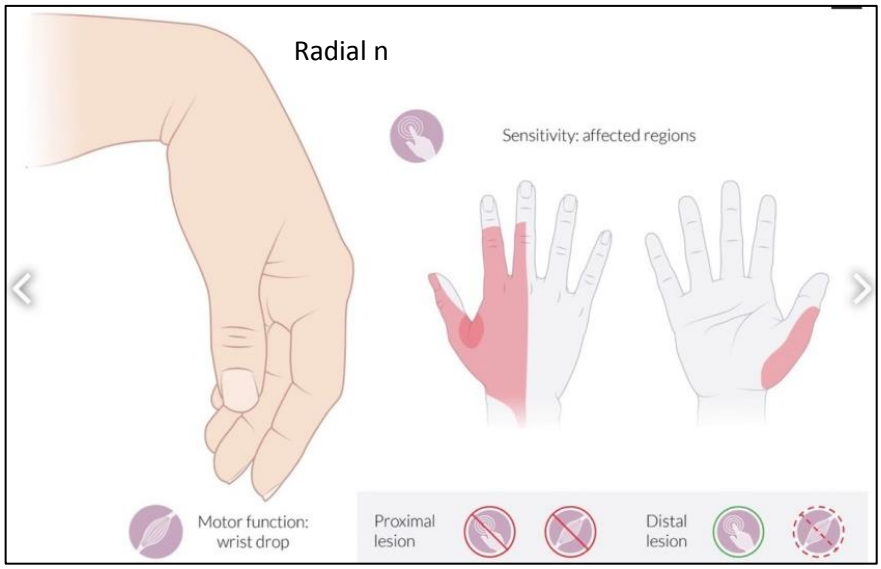
★ Clinical features

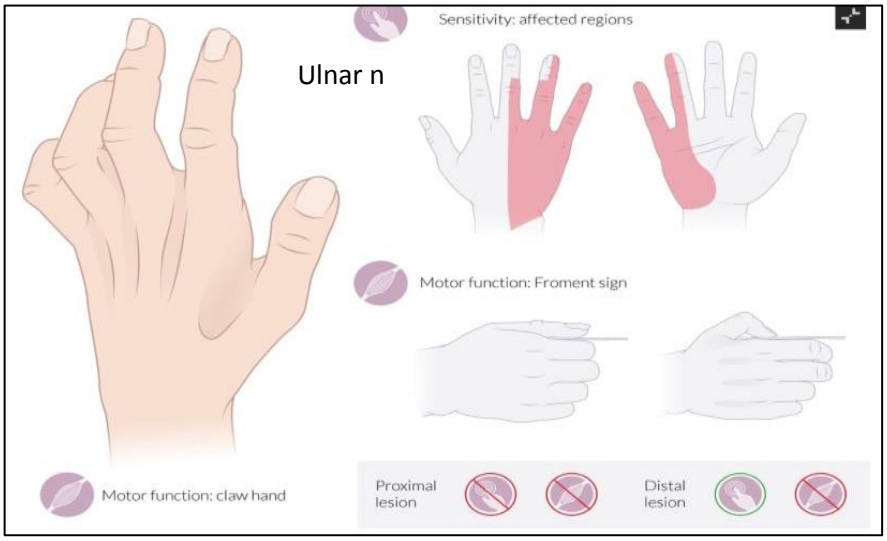
- **Foot-drop:** can neither dorsiflex nor evert the foot.
- High-stepping gait.
- Sensation is lost over the front and outer half of the leg and the dorsum of the foot.

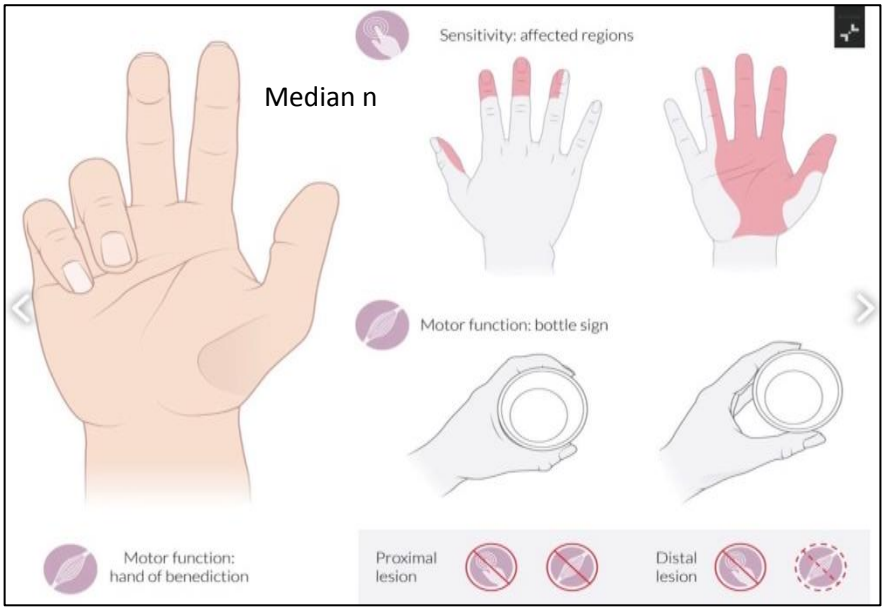
Tibial nerve

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

SUMMARY


Radial n
Sensitivity: affected regions
Motor function: wrist drop
Proximal lesion
Distal lesion


Ulnar n
Sensitivity: affected regions
Motor function: Froment sign
Motor function: claw hand
Proximal lesion
Distal lesion


Median n
Sensitivity: affected regions
Motor function: bottle sign
Motor function: hand of benediction
Proximal lesion
Distal lesion