

# PERIPHERAL NERVES INJURIES



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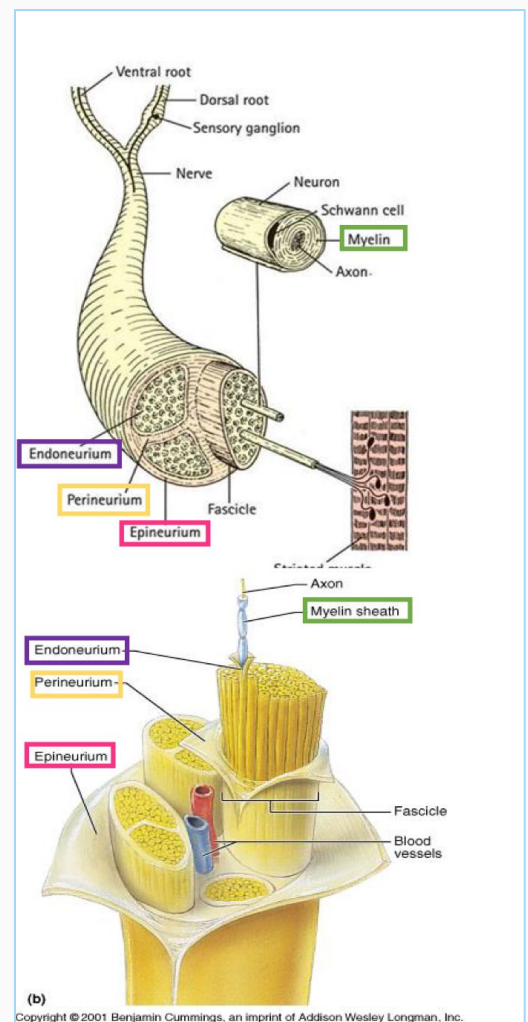
**Lecture objectives:**

**Not Available**

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**References:** Doctor's slides + 436 team

## 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 are 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 ischemia:

- **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):

<p><b>Neurapraxia</b></p>	<ul style="list-style-type: none"> <li>● <b>Reversible</b> physiological nerve conduction block (loss of sensation and muscle power) followed by spontaneous recovery after a few days or weeks.</li> <li>● <b>Due to mechanical pressure</b> causing segmental demyelination (mild nerve stretch or contusion)</li> <li>● <b>Examples:</b> Crutch palsy, Saturday night palsy, Tourniquet palsy<sup>1</sup>.</li> </ul>
<p><b>Axonotmesis</b> (cut of axons)</p>	<ul style="list-style-type: none"> <li>● More severe form of nerve injury.</li> <li>● <b>Closed fractures and dislocations.</b></li> <li>● Literally means axonal interruption.</li> <li>● Loss of conduction but the nerve is in continuity (so there is chance for healing), 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 (at the same time) 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> (the worst)</p>	<ul style="list-style-type: none"> <li>● Division of the nerve trunk as in <b>open fracture.</b></li> <li>● Disruption of all layers.</li> <li>● <b>There is healing at the injury site but usually the regenerating axons cannot reach the end organ, and the patient will have anomaly.</b></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</b> formation at the site of injury (regenerating axons, schwann cells and fibroblasts).</li> <li>● Function is never normal.</li> </ul>

## ★ Sunderland's classification (more practical classification):

<p><b>First degree injury:</b></p>	<ul style="list-style-type: none"> <li>● Includes transient ischaemia and neuropraxia.</li> <li>● Reversible.</li> </ul>
<p><b>Second degree injury:</b></p>	<ul style="list-style-type: none"> <li>● Axonotmesis.</li> <li>● Axonal degeneration, but because the endoneurium is <b>preserved</b>, regeneration can lead to complete, or near complete, recovery without the need for intervention.</li> </ul>
<p><b>Third degree injury:</b></p>	<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 (when axon heals in wrong direction).</li> </ul>

<sup>1</sup> When we do surgery sometimes we apply tourniquet to stop the bleeding and sometimes patient will have transient sensory and motor loss.

<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.

<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> <li>● <b>Epineurium is injured</b>.</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 Variable stromal disruption	Good to poor, depending upon integrity of supporting structures and distance to muscle
		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
	Fourth degree	Axon loss Endoneurial tubes disrupted Perineurium disrupted Epineurium intact	Poor Axonal misdirection Surgery usually required
		Neurotmesis	Fifth degree

## CLINICAL FEATURES:

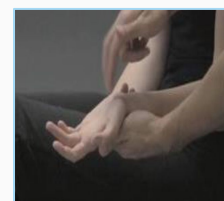
- Acute nerve injuries are easily missed, especially if associated with fractures or dislocations so the physician may focus on them and miss it.
- Ask for numbness, paraesthesia or muscle weakness in the related area. Sometimes the patient is unconscious and you can't examine them.
- Examine for signs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



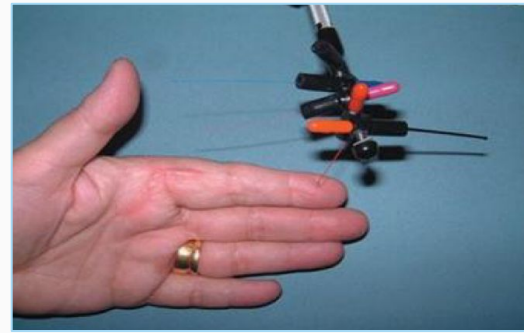
### ★ Two-point discrimination:

- 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)<sup>3</sup>. Distal humeral fracture & nerve injury > surgery > no improvement > Electronic conductive study after 6 weeks.

2- Excludes neurapraxia.

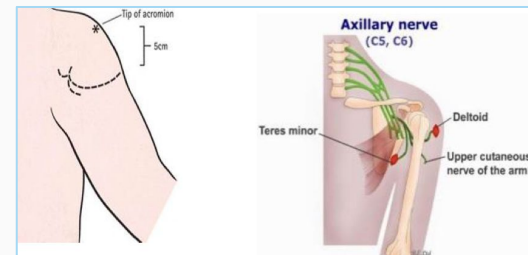
3- Does not distinguish between axonotmesis and neurotmesis.



#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.



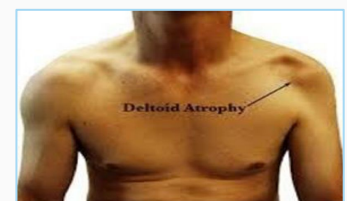
### ★ Injuries:

- Shoulder dislocation or fractures of the humeral neck.
- Iatrogenic: Lateral deltoid-splitting incisions<sup>4</sup>



### ★ Clinical features:

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



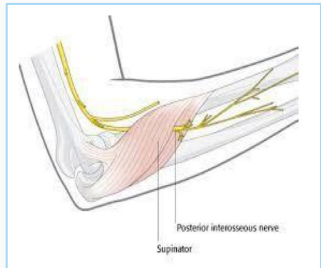

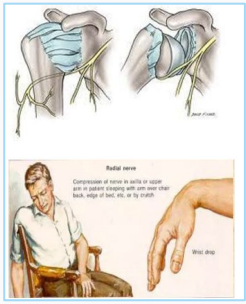
<sup>3</sup> because the degree of muscle denervation that occurs after nerve injury cannot be determined until Wallerian degeneration is complete, and this can take as short as 1 week or as long as 4 weeks

<sup>4</sup> 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
<b>Level</b>	Elbow or upper arm.	Humerus (around spiral groove)	Axilla or shoulder
<b>Injuries</b>	<ul style="list-style-type: none"> <li>● <b>Fractures or dislocations</b> at the elbow.</li> <li>● Iatrogenic lesions of the posterior interosseous nerve where it winds through the supinator muscle</li> </ul>	<ul style="list-style-type: none"> <li>● Fractures of the humerus or after prolonged tourniquet pressure.</li> </ul>	<ul style="list-style-type: none"> <li>● Trauma or operations around the shoulder.</li> <li>● More often, chronic compression in the axilla; (Saturday night palsy) or (crutch palsy).</li> </ul>
<b>Clinical features</b>	<ul style="list-style-type: none"> <li>● Cannot extend the <b>metacarpophalangeal joint (MCP joints)</b> of the hand with weakness of thumb extension.</li> <li>● <b>Wrist extension is preserved (very imp)</b> because the branch to the extensor carpi radialis longus arises proximal to the elbow.</li> </ul>	<ul style="list-style-type: none"> <li>● <b>Wrist drop.</b></li> <li>● Inability to extend the Metacarpophalangeal (MCP) joints or elevate the thumb.</li> <li>● Sensory loss at the dorsal first web space</li> </ul> <p>Reduce the fracture and if the patient is still unable to extend the wrist, book her for urgent <b>nerve exploration</b> and possible repair. (x-ray pic).</p>	<ul style="list-style-type: none"> <li>● In addition to weakness of the wrist and hand, the <b>triceps</b> is paralysed (<b>loss of elbow extension</b>) and the triceps <b>reflex is absent.</b></li> </ul>
<b>Picture</b>	 <p>Posterior interosseous nerve Supinator</p>		 <p>Radial nerve Compression of nerve in axilla or upper arm in patient sleeping with arm over chair back, edge of chair, etc. in the corner.</p> <p>Wrist drop</p>

## ★ 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 <b>wrist</b> , e.g. cuts on shattered glass or injury at level of forearm due to compression	Near the <b>elbow</b> , e.g. elbow fractures or dislocations.
Clinical features	<ul style="list-style-type: none"> <li>• Numbness of the ulnar one and a half fingers.</li> <li>• <b>Claw hand</b> deformity; with hyperextension of the MCP joints and flexion of distal IP<sup>5</sup> joints of the ring and little fingers<sup>6</sup> due to weakness of the intrinsic muscles.</li> <li>• Weak <b>finger abduction</b> (because of loss of intrinsic ms) and <b>thumb adduction</b>, makes pinch difficult.</li> <li>• <b>Hypothenar</b> and interosseous <b>wasting</b>.</li> <li>• 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 <b>adductor pollicis</b> (positive <b>Froment's sign</b>)</li> </ul>	<ul style="list-style-type: none"> <li>• Hand: not markedly deformed because the ulnar half of Flexor Digitorum Profundus is paralysed and the fingers are therefore <b>less clawed'</b> (<b>high ulnar paradox</b>).</li> <li>• <b>Explanation:</b> 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 muscles are affected so there isn't much clawing.</li> <li>• <b>Ulnar neuritis:</b> Compression or entrapment of the nerve in the medial epicondylar (<b>cubital</b>) tunnel.</li> <li>• Severe valgus deformity of the elbow or prolonged pressure on the elbows in anaesthetized or bed-ridden patients.</li> </ul>
Picture		

**\*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.

<sup>5</sup> Interphalangeal joint.

<sup>6</sup> The other fingers are working fine because they are supplied by the median nerve.

## MEDIAN NERVE:

	Low lesions (more common than higher)	High lesions
<b>Level</b>	Near the wrist.	High up in the forearm.
<b>Injury</b>	Cuts in front of the wrist or by carpal dislocations.	Forearm fractures or elbow dislocation.
<b>Clinical features</b>	<ul style="list-style-type: none"> <li>• Unable to <b>abduct the thumb</b>.</li> <li>• Sensation is lost over the radial three and a half digits.</li> <li>• <b>Thenar eminence</b> is wasted and trophic changes.</li> </ul>	<ul style="list-style-type: none"> <li>• Same as low lesions but, in addition to these paralysed muscles:               <ul style="list-style-type: none"> <li>○ The long flexors to the thumb, index and middle fingers.</li> <li>○ The radial wrist flexors.</li> <li>○ The forearm pronator muscles.</li> </ul> </li> <li>• Typically, the hand is held with the ulnar fingers flexed and the index straight (the 'pointing sign'). <b>Positive "OK" sign</b></li> <li>• Thumb and index flexors are deficient; there is a characteristic pinch defect with the distal joints in full extension</li> <li>• <b>Pucker sign</b>.</li> </ul>
<b>Picture</b>		

### ★ 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:

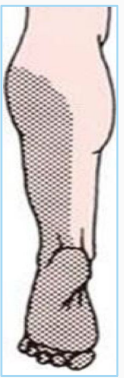
### ★ injuries:

- 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**).



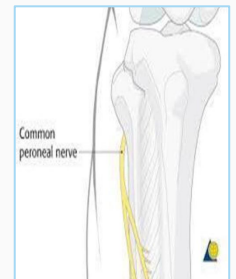
### ★ Clinical features::

- 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. **More common.**



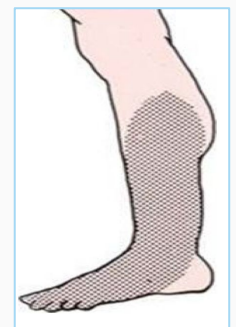
### PERONEAL NERVE:

- **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:

# Peripheral Nerves

Low quality of evidence. Early surgery should be offered as an option for adult acute SCI patients, regardless of level of lesion.

- see [Neurology, N36](#)

## Classification

**Table 18. Seddon's Classification of Peripheral Nerve Injury**

Nerve Injury	Description	Recovery
<b>Neurapraxia (class I)</b>	Axon structurally intact but fails to function	Within hours to months (average 6-8 wk)
<b>Axonotmesis (class II)</b>	Axon and myelin sheath disrupted but endoneurium and supporting structures intact → Wallerian degeneration of axon segment distal to injury	Spontaneous axonal recovery at 1 mm/d, max at 1-2 yr
<b>Neurotmesis (class III)</b>	Nerve completely transected	Need surgical repair for possibility of recovery

## Etiology

- ischemia
- nerve entrapment – nerve compressed by nearby anatomic structures, often secondary to localized, repetitive mechanical trauma with additional vascular injury to nerve
- direct trauma (e.g. transection)
- iatrogenic

## Investigations

- clinical exam: muscle bulk and tone, power, sensation, reflexes, localization via Tinel's sign (paresthesias elicited by tapping along the course of a nerve)
- electrophysiological studies: EMG/nerve conduction study (assess nerve integrity and monitoring recovery after 2-3 wk post-injury)
- labs: blood work (e.g. CBC, TSH, Vitamin B12), CSF
- imaging: C-spine, chest/bone x-rays, myelogram, CT, magnetic resonance neurography, angiogram if vascular damage is suspected

## Treatment

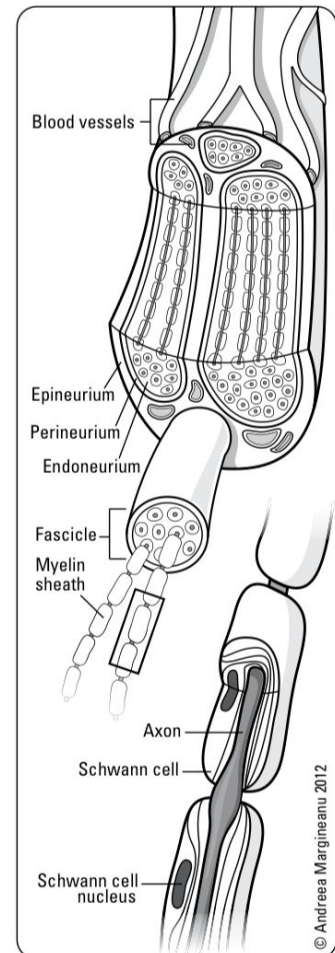
- early neurosurgical consultation if injury is suspected

**Table 19. Treatment by Injury Type**

Injury	Treatment
<b>Entrapment</b>	Conservative: Prevent repeated stress/injury, physiotherapy, NSAIDs, local anesthesia/steroid injection Surgical: Nerve decompression ± transposition for progressive deficits, muscle weakness/atrophy, failure of medical management
<b>Stretch/Contusion</b>	Follow-up clinically for recovery; exploration if no recovery in 3 mo
<b>Axonotmesis</b>	If no evidence of recovery, resect damaged segment Prompt physical therapy and rehabilitation to increase muscle function, maintain joint ROM, maximize return of useful function Recovery usually incomplete
<b>Neurotmesis</b>	Surgical repair of nerve sheath unless known to be intact (suture nerve sheaths directly if ends approximate or nerve graft [usually sural nerve]) Clean laceration: early exploration and repair Contamination or associated injuries: tag initially with nonabsorbable suture, reapproach within 10 d

## Complications

- loss of function (temporarily or permanently)
- neuropathic pain: with neuroma formation
- complex regional pain syndrome: with sympathetic nervous system involvement



**Figure 26. Peripheral nerve structure**

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## MCQS

**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?**

**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. 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

**Answers:**

- 1. B
- 2. B
- 3. A
- 4. A
- 5. A