The skin of the hand

The skin of the palm is thick and immobile because it is firmly attached to the underlying deep fascia (palmar aponeurosis). The palmar skin is rich with sweat glands but it has no hair and no sebaceous glands. It shows several longitudinal and transverse creases where the skin is firmly bound to the deep fascia. These flexion creases [Figure.51] include:

1. **Flexion creases of the wrist (wrist creases):** The *Proximal and Distal wrist creases* are produced as a result of folding of the skin due to repeated flexion of the wrist. The distal wrist crease corresponds to the proximal border of the flexor retinaculum.

![Figure 51: The flexion creases of the palm of the hand](image)

2. **Palmar flexion creases:** Usually there are four major palmar creases—two horizontal and two longitudinal which together roughly form an M-shaped pattern:

   (a) **Radial longitudinal crease:** partly encircles the thenar eminence (ball of the thumb) and is formed due to action of short muscles of the thumb.

   (b) **Midpalmar longitudinal crease:** indicates the lateral limit of the hypothenar eminence (ball of the little finger). It is formed due to the action of short muscles of the little finger.
(c) **Proximal transverse palmar crease:** It starts at the lateral border of the palm in common with the radial longitudinal crease & extends medially and slight proximally across the palm.

(d) **Distal transverse palmar crease:** begins at or near the interdigital cleft between the index and little fingers and crosses the palm with slight distal convexity.

**3. Digital flexion creases:** Each of the medial four digits have three transverse flexion creases (proximal, middle & distal), while the thumb has two transverse creases (proximal & distal).

The skin on the dorsum of the hand is thin and loose when the hand is relaxed. The hairs are present on the dorsum of the hand and on the proximal parts of the digits, especially in males. The long extensor tendons and dorsal venous network are clearly visible through the skin.

**The palmar aponeurosis and palmar fascial spaces**

The palmar aponeurosis is a thick triangular part of the deep fascia of the hand [Figure.52] lying in the central part of the palm. It Helps to improve the grip of hand by fixing the skin and protects the underlying tendons, nerves, and vessels.

The apex of the aponeurosis is attached to the distal border of the flexor retinaculum where it receives the tendon of palmaris longus. The base lies at the level of the metacarpal heads where it divides into 4 slips. Each slip divides into 2 bands; one passes to the overlying skin and the other passes deeply to the root of the finger dividing further into 2 slips around the long flexor tendons and fusing on each side with the fibrous flexor sheath and the deep transverse metacarpal ligament.

The medial border of the palmar aponeurosis attaches to the 5th metacarpal shaft as the medial palmar septum. The medial (hypothenar) compartment lies medial to the medial palmar septum and contains the small muscles of the little finger.

The lateral border of the aponeurosis attaches to the 1st metacarpal shaft as the lateral palmar septum. The lateral (thenar) compartment lies lateral to the lateral palmar septum and contains the small muscles of the thumb except adductor pollicis.

A third septum; the intermediate palmar septum; passes from the deep surface of the aponeurosis to the 3rd metacarpal bone dividing the area between the medial and lateral palmar septa into 2 spaces [Figure.53]:

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**Figure.52**

**Figure.53**
The thenar space; lies laterally (between the lateral and intermediate palmar septa) and is related posteriorly by the adductor pollicis and the first lumbrical muscles. The thenar compartment is lateral to this space. Anteriorly it is related by the nerves & vessels of the lateral 1 ½ fingers.

The mid-palmar space; lies medially (between the medial and intermediate palmar septa) and is related anteriorly by the long flexor tendons (flexor digitorum superficialis and flexor digitorum profundus), the 2\textsuperscript{nd}, 3\textsuperscript{rd} and 4\textsuperscript{th} lumbricals and blood vessels and nerves of the medial 3 ½ fingers. The hypothenar compartment is medial to this space. The interosseous muscles lie posterior to it.

Proximally, the two spaces are closed from the forearm by the walls of the carpal tunnel. Distally they are continuous with extensions over the lumbrical muscles (lumbrical canals).

The pulp spaces of the fingers are other potential spaces that lie in the finger pulps as the deep fascia fuses with the periosteum of the distal phalanx via multiple septa.
The synovial (tendon) sheaths of the long flexors [Figure.54]
These sheaths surround the tendons of the long flexors; flexor digitorum superficialis, flexor digitorum profundus and flexor pollicis longus; starting a fingerbreadth (2-3 cm) proximal to the flexor retinaculum and ending distally at variable points. The synovial sheaths of the long flexors are arranged in 3 groups;

- The **radial bursa**; is the synovial sheath that surrounds the flexor pollicis longus tendon extending to the point of insertion of flexor pollicis longus (i.e. the distal phalanx of the thumb).

- The **ulnar bursa**; is the common synovial sheath for the eight tendons of flexor digitorum superficialis and flexor digitorum profundus. It starts 2-3 cm proximal to the flexor retinaculum and continues only with the tendons of the little finger to the level of the distal phalanx. For the middle 3 fingers it ends at the level of the proximal transverse crease of the palm and the tendons become exposed for a short distance; to give origin for the lumbricals; before entering the individual digital sheaths.
The digital synovial sheaths; are 3 sheaths which surround the long flexor tendons of the index, middle and ring fingers. Each sheath begins just distal to the level of the distal palmar crease and ends at the base of the distal phalanx.

The fibrous flexor sheaths and arrangement of the long flexor tendons at the fingers

The fibrous flexor sheaths [Figure.55] are thickened tunnels of deep fascia which lie on the anterior surface of each finger extending from the head of the corresponding metacarpal bone to the base of the distal phalanx and attach to the sides of the phalanges. The proximal end of each sheath is open while the distal end is closed. Thus, together with the phalanges and interphalangeal joints they form blind tunnels housing the tendons of the long flexors. They are strong over the phalanges but lax over the interphalangeal joints. Their function is to prevent the long flexor tendons from springing away from the digits during flexion of the fingers.

In the medial 4 fingers, there is a special arrangement of the tendons of flexor digitorum superficialis and flexor digitorum profundus at their insertion. Because flexor digitorum profundus is deeper and has a more distal insertion than flexor digitorum superficialis, each tendon of flexor digitorum superficialis flattens and splits into 2 bands at the base of the
proximal phalanx. These 2 bands embrace the tendon of flexor digitorum profundus allowing its passage towards the distal phalanx and then they reunite into one band which splits again to be inserted to the sides of the middle phalanx. The split bands of flexor digitorum superficialis tendon with the tendon of flexor digitorum profundus passing between them is known as the **chiasma tendinum**.

![Figure 55: The flexor fibrous sheath and chiasma tendinum.](image)

**Intrinsic muscles of the hand**
The small or intrinsic muscles of the hand may be divided into 5 groups;

- **Palmaris brevis muscle** (if present): lies in the superficial fascia over the hypothenar eminence. It helps to tens the palmar aponeurosis. It is supplied by the superficial branch of the ulnar nerve.

- **The palmar and dorsal interossei** arise lie between the metacarpal shafts. The palmar interossei adduct the fingers while the dorsal ones abduct the fingers.

- **The lumbrical muscles** are four muscle that arise from the tendons of the flexor digitorum profundus muscle. The lateral two are supplied by the median nerve while the medial two are supplied by the ulnar nerve. They act with the interossei to flex the metacarpophalangeal joints and extend the interphalangeal joints at the same time.

- **The thenar muscles**; are the short muscles of the thumb which include flexor pollicis brevis, abductor pollicis brevis, adductor pollicis and opponens pollicis. Their actions
are indicated by their names. All these muscles are supplied by the median nerve except adductor pollicis which is supplied by the deep branch of the ulnar nerve.

- **The hypothenar muscles:** are the short muscles of the little finger which include flexor digiti minimi, abductor digiti minimi and opponens digiti minimi. Their actions are indicated by their names. They are all supplied by the deep branch of the ulnar nerve.

In the lab: Distinguishing the intrinsic muscles of the hand [Figure.56, 57]

- The thenar muscles are arranged as two superficial & two deep. The superficial two are abductor pollicis brevis laterally & flexor pollicis brevis medially. The two deep ones are opponens pollicis laterally & adductor pollicis medially. Adductor pollicis has a large triangular head.
- The hypothenar muscle are arranged as one superficial (flexor digiti minimi) and two deep. The deep ones are abductor digiti minimi medially & opponens digiti minimi laterally.
- The lumbricals arise from the tendons of flexor digitorum profundus.
- The palmar interossei insert to the lateral 2 & medial 2 digits. The dorsal interosseous attach to the middle 3 fingers (each usually has 2 heads).
The extensor (dorsal) expansion [Figure.58]
The extensor expansion is a triangular fascial expansion on the dorsal surface of each digit joined by the tendons of the long extensors, the lumbricals and the interossei. Each expansion consists of two parts:

- The **central part**; is joined by the long extensor tendons i.e. extensor pollicis longus and extensor pollicis brevis for the thumb, extensor indicis and extensor digitorum for the index, extensor digitorum for the middle and ring fingers, extensor digiti minimi and extensor digitorum for the little finger.

- The margins or **peripheral part**; is formed by musculofascial bands derived from the lumbricals and interossei.

Each extensor expansion starts just proximal to the metacarpophalangeal joints and forms a hood over the joint and part of the proximal phalanx. The base of the triangle passes anteriorly on each side of the metacarpal head to the deep transverse metacarpal ligament. The margins of the expansion on each side are thickened by the insertions of the tendons of the corresponding interossei and lumbricals. Each margin spans the 2nd phalanx obliquely starting anterior to the proximal interphalangeal joint and ending dorsal to the distal interphalangeal joint. Distal to the metacarpophalangeal joints, the central part of the extensor expansion receives additional fibers from the margins and splits into 3 bundles:

- The central bundle inserts to the base of the middle phalanx.
The other peripheral 2 bundles diverge to fuse with the rest of the thick margin and then unite into a single bundle to be inserted to the dorsal surfaces of the distal phalanx.

Figure 58: The extensor expansion of the fingers.
Arterial supply of the hand

The ulnar artery

The ulnar artery enters the hand by passing anterior to the flexor retinaculum, lateral to the ulnar nerve. It then divides into two branches;

- A large **superficial palmar** branch; joins with one of the branches of the radial artery to form the superficial palmar arch.
- A smaller **deep branch**; joins the continuation of the radial artery to form the deep palmar arch.

The radial artery

The radial artery enters the hand by winding around the lateral aspect of the wrist over the scaphoid bone to the dorsum of the 1st metacarpal. As it runs deep to the tendon of extensor pollicis longus, it gives proper dorsal digital arteries to both sides of the thumb and to the lateral side of the index. It then leaves the dorsum of the hand towards the palm by passing between the proximal ends of the 1st and 2nd metacarpal bones between the 2 heads of the first dorsal interosseous muscle. Here, it gives two branches:

- The **princeps pollicis** artery; passes to the metacarpal of the thumb and divides into 2 palmar digital arteries, one on each side of the tendon of flexor pollicis longus.
- The **radialis indicis** artery: passes distally to supply the lateral side of the index as the lateral proper digital artery.

Therefore, the radial artery supplies the lateral 1 ½ fingers. After giving these 2 branches, the radial artery continues medially and unites with the deep branch of the ulnar artery to complete the deep palmar arch.

The superficial palmar arch

This arterial arch lies at the level of the distal border of the thenar eminence when the thumb is fully extended. The arch and its branches lie between the palmar aponeurosis anteriorly and the tendons of the long flexors posteriorly. It is formed by the curve of the superficial branch of the ulnar artery with one or more of the following branches from the radial artery: the superficial palmar branch (most commonly), branch of the radialis indicis or princeps pollicis arteries or both. The arch gives 2 groups of palmar digital branches:

- **Proper palmar digital artery of the little finger**: supplies the medial side of the little finger.
- **Three common palmar digital arteries**. These arteries run in the 2nd, 3rd and 4th intermetacarpal spaces towards the interdigital clefts where each of them receives a corresponding **palmar metacarpal artery** from the deep palmar arch and then divides into two proper palmar digital branches to the opposite sides of each two adjacent fingers. Therefore, the superficial arch supplies the medial 3 ½ fingers.
The deep palmar arch

The deep palmar arch lies a fingerbreadth proximal to the superficial arch, posterior to the tendons of the long flexors. It represents the continuation of the radial artery as it curves medially to join the deep branch of the ulnar artery. It gives the following branches;

- **Three palmar metacarpal arteries;** which run in the 2\(^{nd}\), 3\(^{rd}\) and 4\(^{th}\) intermetacarpal spaces to join the distal ends of the common palmar digital arteries of the superficial arch and may sometimes replace them.

- **Palmar and dorsal recurrent carpal branches;** participate in the anastomosis around the wrist.

- **Perforating branches;** perforate the interossei and run posteriorly to join the dorsal metacarpal arteries.

![Figure 59: The palmar arterial arches](image-url)
Arteries of the dorsum of the hand

These arteries are derived from the radial artery and the dorsal carpal rete.

- The radial artery gives three branches to the dorsum of the hand;
  - The **two proper dorsal digital arteries** to both sides of the **thumb**.
  - The **proper dorsal digital artery** to the lateral side of the **index**.

- The dorsal carpal rete (arch) is a mesh of anastomosing arteries on the dorsum of the wrist (i.e. carpal bones) that supplies the dorsal surface of the hand and fingers. It is formed by the dorsal carpal branches of the radial and ulnar arteries, the dorsal recurrent branches of the deep palmar arch and the terminal parts of the anterior and posterior interosseous arteries. The rete gives the following branches to the dorsum of the hand;
  - The **proper dorsal digital artery** of the **little finger**; supplies the medial side of the little finger.
  - **Three common dorsal metacarpal arteries**; run in the 2nd, 3rd and 4th intermetacarpal spaces towards the interdigital clefts where each one receives a perforating branch from the deep palmar arch and then divides into 2 proper dorsal digital arteries to the opposite sides of each two adjacent fingers.

Nerves of the hand

The median nerve [Figure.60]

This nerve enters the hand by passing through the carpal tunnel posterior to the flexor retinaculum, lateral to the tendons of flexor digitorum superficialis and flexor digitorum profundus and medial to the tendon of flexor carpi radialis. Near the distal border of the retinaculum, it divides into 6 branches;

- The **recurrent branch**; is the most lateral branch that enters the thenar compartment to supply flexor pollicis brevis, abductor pollicis brevis and opponens pollicis.

- **Three proper palmar digital nerves**; the first two supply the skin of both sides of the thumb while the third supplies the lateral side of the index and the first lumbrical muscle.

- **Two common palmar digital nerves**; run in the 2nd & 3rd intermetacarpal spaces. The lateral one supplies the second lumbrical, and then they both split into two proper palmar digital nerves to supply the medial side of the index, both sides of the middle and the lateral side of the ring fingers.
The ulnar nerve [Figure.61]
The ulnar nerve enters the hand by passing anterior to the flexor retinaculum where it divides into superficial and deep branches.

- The **superficial branch**; supplies palmaris brevis muscle, and then passes deep to it to divide into a **proper palmar digital nerve** to the medial side of the **little finger** and a **common palmar digital nerve**. The common palmar digital nerve runs in the 4\textsuperscript{th} intermetacarpal space, communicates with the adjacent common palmar digital branch of the median and then divides into two proper palmar digital nerves to the opposite sides of the little and ring fingers.

- The **deep branch**; supplies the hypothenar muscles and passes with the deep branch of the ulnar artery and curves laterally across the metacarpal bases to reach and supply the medial two lumbricals (i.e. 3\textsuperscript{rd} & 4\textsuperscript{th}), all the interossei and adductor pollicis.

**The superficial branch of the radial nerve**
This nerve passes posterior to the lateral part of the extensor retinaculum to supply the lateral 2/3 of the dorsum of the hand, the ball of the thumb and the lateral 3½ fingers via 5 dorsal digital nerves. It supplies the dorsum of the digits only to the level of the proximal
interphalangeal joints. Sometimes, the superficial branch of the radial nerve supplies only the lateral 2½ fingers dorsally, in which case the medial 2½ fingers are supplied by the ulnar nerve.

Figure 61: Distribution of the ulnar nerve in the hand.

Small joints of the hand
The Intercarpal joints
The synovial plane joints between the carpal bones share a common articular cavity. The fibrous capsule of the joints is reinforced by numerous ligaments. Although movement at the intercarpal joints is limited, they do contribute to the positioning of the hand in abduction, adduction, flexion, and, particularly, extension.

The carpometacarpal joints
There are five carpometacarpal joints between the metacarpals and the related distal row of carpal bones. The bones of the distal row articulate with the metacarpal bones at the carpometacarpal joints as follows:

- The trapezium with the 1st metacarpal.
- The trapezoid with the 2nd metacarpal.
- The capitate with the 3rd and part of the 2nd metacarpal.
- The hamate with 4th and 5th metacarpals.
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The saddle joint between first metacarpal and the trapezium is the carpometacarpal joint of the thumb that has a wide range of mobility that is not a feature of the rest of the digits. Movements at this carpometacarpal joint are flexion, extension, abduction, adduction and circumduction produced by the long and short muscles of the thumb.

The carpometacarpal joints between 2nd to the 5th metacarpals and the carpal bones are simple plane joints allowing only limited gliding movements. Movement of the joints increases medially so that the 5th metacarpal slides to the greatest degree.

The metacarpophalangeal joints
These are synovial condylar joints formed between the distal heads of the metacarpals and the proximal phalanges of the digits. They allow flexion, extension, abduction, adduction, and circumduction. The capsule of each joint is reinforced by medial and lateral collateral ligaments. The deep transverse metacarpal ligament connects the capsules of the metacarpophalangeal joints of the medial 4 fingers to each other.

The interphalangeal joints
The interphalangeal joints of the hand are hinge joints that allow mainly flexion and extension. They are reinforced by medial and lateral collateral ligaments and palmar ligaments.

Nerve injuries in the upper limb
Peripheral nerve injuries may result from either division (complete or partial) or compression of the nerve. In nerve division, the muscles supplied by the nerve will be paralyzed and sensation is lost (anesthesia) in the skin area supplied by the nerve distal to the site of injury. In nerve compression, the muscles supplied by the nerve become weakened not paralyzed and there will be abnormal sensation of pins and needles in the skin (paresthesia) distal to the site of injury. Proximal to the site of injury, the muscles and skin supplied by the nerve or its branches remain intact.

Brachial plexus injuries
Complete lesions of all the roots of the brachial plexus are rare. Incomplete injuries are common and are usually caused by traction or pressure; they may affect the upper or lower parts of the plexus.

Upper lesions of the brachial plexus
These lesions result from depression of the shoulder on the same side of the affected limb and excessive displacement of the head to the opposite side. It usually occurs in newborns
of difficult delivery or in adults after a blow to or a fall on the shoulder. The injury causes excessive traction or even tearing of C5 and C6 roots affecting the following nerves;

- The suprascapular nerve; causing paralysis of supraspinatus (the initiator of abduction) and infraspinatus (a lateral rotator of the shoulder).
- The nerve to subclavius; causing paralysis of the subclavius and loss of its function.
- The musculocutaneous nerve; causing paralysis and loss of the functions of biceps brachii (elbow flexion and supination and shoulder flexion), coracobrachialis (shoulder flexion) and most of brachialis (elbow flexion).
- The axillary nerve; causing paralysis of deltoid (mainly shoulder abduction is affected) and teres minor (a lateral rotator of the shoulder).

The combination of these motor effects cause the limb to hang limply by the trunk, medially rotated by the unopposed action of the sternocostal fibers of pectoralis major with the elbow extended and the forearm pronated (loss of supination); a combination known as Erb-Duchenne Palsy (waiter’s tip position). Although supinator is not supplied by any of the mentioned nerves but it is also paralyzed since it is supplied by C6 fibers running through the radial nerve.

In addition to the motor effects, there is sensory loss over the lateral side of the arm and forearm (C5 and C6 dermatomes). The paralysis of subclavius leads to loss of its protective effect to the sternoclavicular joint. Repeated hammering of the clavicle on the manubrium sterni will result in accelerated joint damage.

**Lower lesions of the brachial plexus**

These lesions are usually caused by excessive abduction of the arm as in a person falling from a height and clutching at an object to save themselves. They can also be produced by the presence of a cervical rib or the presence of enlarged lower deep cervical lymph nodes.

The T1 fibers are mainly affected. T1 fibers run in the ulnar and median nerves to supply all the small muscles of the hand. As these muscles become paralyzed the following features occur;

- The extensor action of the long extensors is unopposed by the flexor action of the lumbricals and interossei at the metacarpophalangeal joints causing hyperextension of these joints.
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- **The flexor action of flexor digitorum superficialis and flexor digitorum profundus is unopposed by the extensor action of the lumbricals and interossei at the interphalangeal joints causing flexion of these joints.**

The combined metacarpophalangeal hyperextension and interphalangeal flexion gives the hand a **clawed appearance.**

There is sensory loss along the medial side of the arm (T1 dermatome) and if the C8 root is also affected the loss extends to the forearm, medial $\frac{1}{3}$ of the palm and medial 1½ fingers (C8 dermatome).

**Long thoracic nerve injury**
This may be injured by blows or pressure on the posterior triangle of the neck or during radical mastectomy. Its damage causes paralysis of serratus anterior muscle resulting in weakened lateral rotation of the scapula during abduction and loss of the muscle tone causes loss of its effect in holding the scapula against the rib cage. The patient suffers from difficulty in raising the arm above the head i.e. abduction of the shoulder above the horizontal plane. The medial border and inferior angle of the scapula protrude posteriorly; a condition known as **winging of the scapula.**

**Axillary nerve injury**
This nerve is commonly injured in inferior dislocation of the shoulder or fractures of the surgical neck of the humerus. The following features occur;

- Failure to abduct the shoulder beyond 15-30° due to paralysis of deltoid. The little amount of abduction possible is the action of supraspinatus.
- Loss of sensation over the lower ½ of deltoid muscle (area of the upper lateral cutaneous nerve of the arm).

**Radial nerve injury**

**In the axilla**
Damage to the radial nerve in the axilla is commonly caused by the pressure of the upper end of a badly fitting crutch pressing up into the armpit or by fractures and dislocations of the proximal end of the humerus. Such damage results in the following features:

**Motor**

- The triceps and anconeus are paralyzed and elbow extension is lost.
- All the muscles of the posterior compartment of the forearm; long extensors of the wrist and fingers; are paralyzed causing the unopposed flexors to flex the wrist and
fingers and **wrist drop** results. With the wrist flexed, the fingers cannot be flexed tightly for a firm grip. If the proximal phalanges and wrist are passively extended by the other hand, the interphalangeal joints can be extended by the action of the lumbricals and interossei via the extensor expansion.

- Although brachioradialis and supinator are also paralyzed, **supination is still possible** in elbow flexion by the action of biceps brachii.

**Sensory:**

- There is sensory loss of the lower lateral and posterior parts of the arm and in the narrow strip in the middle of the back of the forearm (lower lateral and posterior cutaneous nerves of the arm and posterior cutaneous nerve of the forearm).

- There is sensory loss over the dorsal $\frac{2}{3}$ of the hand and the roots of the lateral $3 \frac{1}{2}$ fingers.

**In the radial groove**

Damage to the radial nerve in the radial groove is commonly caused by fractures of the shaft of the humerus (mainly the distal part) resulting in the following features;

**Motor**

- The effect on the long extensors, brachioradialis and supinator is the same as in injuries in the radial groove mentioned earlier.

- Triceps and anconeus are spared and elbow extension is not affected because their nerve supply arises proximal to the site of injury (branches to the long and medial heads of triceps arise in the axilla and branches to the lateral and medial heads and to anconeus arise in the proximal part of the radial groove).

**Sensory**

- There is sensory loss over the dorsal $\frac{2}{3}$ of the hand and the roots of the lateral $3 \frac{1}{2}$ fingers.

- The lower lateral arm and posterior part of the forearm are spared since their nerves arise proximal to the site of injury.

**Injury to the superficial branch of the radial nerve**

This injury may result from stab wounds causing sensory loss over the area of the hand supplied by this nerve.

**Injury to the deep branch of the radial nerve**

The deep branch of the radial nerve may be injured in fractures or dislocations of the proximal end of the radius. Since the nerve is motor only, there will be no sensory loss.
Because Supinator, brachioradialis and extensor carpi radialis longus are supplied by the radial nerve or its deep branch at a more proximal level they will not be damaged. Extensor carpi radialis longus is a powerful extensor that will keep the wrist extended and wrist drop will not occur. However, there still will be weakness of the long extensors of the digits that is compensated by the actions of the lumbricals and interossei.

**Median nerve injury**

**At the elbow**
The median nerve may be injured at the elbow by supracondylar fractures of the humerus or may be trapped between the two heads of pronator teres resulting in the following effects;

**Motor**

- All the muscles of the flexor compartment of the forearm are paralyzed; except flexor carpi ulnaris and the medial 2 tendons of flexor digitorum profundus. As a result, the forearm is kept in supine position. Wrist flexion is weak but not lost because flexor carpi ulnaris flexes the wrist but also adducts it.

- The little and ring fingers flex (normal medial 2 tendons of flexor digitorum profundus) more than the index and middle fingers at the interphalangeal joints (Benediction sign). The interossei can perform weak flexion at the metacarpophalangeal joints of the index and middle fingers but the first 2 lumbricals are paralyzed. This causes the index and middle fingers to lag behind the ring and little fingers when an attempt is made to make a fist slowly.

- Flexion of the terminal phalanx of the thumb is lost due to paralysis of flexor pollicis longus.

- The thenar muscles are paralyzed and wasted and the thenar eminence becomes flattened. The thumb is adducted and laterally rotated and cannot be opposed to other fingers. The hand looks flattened and **apelike**.

**Sensory**

Sensory loss occurs in the skin of the lateral 2/3 of the palm and the lateral 3½ fingers extending on the dorsum of the fingers to the level of the proximal interphalangeal joints.

**At the wrist**
This is commonly caused by stab wounds or broken glass dividing the nerve as it passes posterior to the flexor retinaculum. The clinical findings are;
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The apelike hand and damage to the thenar muscles as in damage at the elbow mentioned earlier. The muscles of the forearm are not affected and wrist movement is intact.

Sensory loss occurs in the skin of the lateral \( \frac{2}{3} \) of the palm and the lateral 3½ fingers extending on the dorsum of the fingers to the level of the proximal interphalangeal joints.

The median nerve is more commonly **compressed** at the wrist by excessive synovial fluid in the ulnar and radial bursae; a condition known as **carpal tunnel syndrome**. In this case, the thenar muscles will be weakened not paralyzed and the paresthesia will be limited to the fingers only. The skin of the lateral \( \frac{2}{3} \) of the palm is spared because the palmar cutaneous branch of the median nerve runs anterior to the flexor retinaculum and thus escapes being compressed by the synovial sheaths.

**Ulnar nerve injury**

**At the elbow**

Injury of the ulnar nerve at the elbow is common and is associated with fractures of the medial epicondyle of the humerus. It may also be trapped between the two heads of flexor carpi ulnaris. The clinical findings include:

**Motor**

- Paralysis of flexor carpi ulnaris weakens wrist flexion and when the patient attempts to flex the wrist the movement is associated with lateral deviation due to the unopposed action of flexor carpi radialis.

- Paralysis of the medial 2 tendons of flexor digitorum profundus prevents flexion of the distal interphalangeal joints of the little and ring fingers.

- All the small muscles of the hand (including adductor pollicis) will be paralyzed; except the thenar muscles and the first 2 lumbricals which are supplied by the median nerve. The thumb cannot be adducted due to paralysis of adductor pollicis, the fingers cannot be abducted and adducted due to paralysis of the dorsal and palmar interossei and the metacarpophalangeal joints will be hyperextended while the interphalangeal joints will be flexed due to paralysis of the lumbricals and interossei. The resulting deformity is called the **claw-hand** deformity. The deformity is more prominent in the little and ring fingers because the first 2 lumbricals are not paralyzed. The distal interphalangeal joints of the index and middle fingers are flexed by the tension in the flexor digitorum profundus tendons.
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**Sensory**

The entire skin area of ulnar nerve supply will show sensory loss i.e. the medial \( \frac{1}{3} \) of the hand and medial 1½ fingers anteriorly and posteriorly.

**At the wrist**

Because of its superficial position at the wrist, the ulnar nerve is commonly injured here by stab wounds or suicidal cuts. The effects are;

**Motor**

The claw hand deformity is similar to that seen in injuries at the elbow except that the distal interphalangeal joints of all fingers are flexed by the tension in the flexor digitorum profundus tendons since both parts of the muscle are functional.

**Sensory**

The main ulnar nerve and its palmar cutaneous branch are affected but the dorsal cutaneous branch is usually spared since it arises at a level more proximal to the injury. Therefore, the sensory loss is limited to the medial \( \frac{1}{3} \) of the palm and the palmar surface of the medial 1 ½ fingers extending dorsally to the level of the proximal interphalangeal joints.

**Combined ulnar and median nerve injury**

A combined injury to the ulnar and median nerves at the elbow causes a true claw hand of severe type. The wrist joint is hyperextended due to paralysis of all the flexors and the unopposed action of the extensors of the wrist joint. The metacarpophalangeal joints are hyperextended due to paralysis of the lumbricals and interossei. The long extensors cannot extend the interphalangeal joints but they hyperextend the metacarpophalangeal joints because the palmar plate with the attached dorsal expansion are drawn distally to the metacarpal heads. The interphalangeal joints are partially flexed due to the tension of the long flexors and not due to their tone since they are paralyzed. This sever type of claw hand may also be seen in injuries to the medial cord of the brachial plexus.