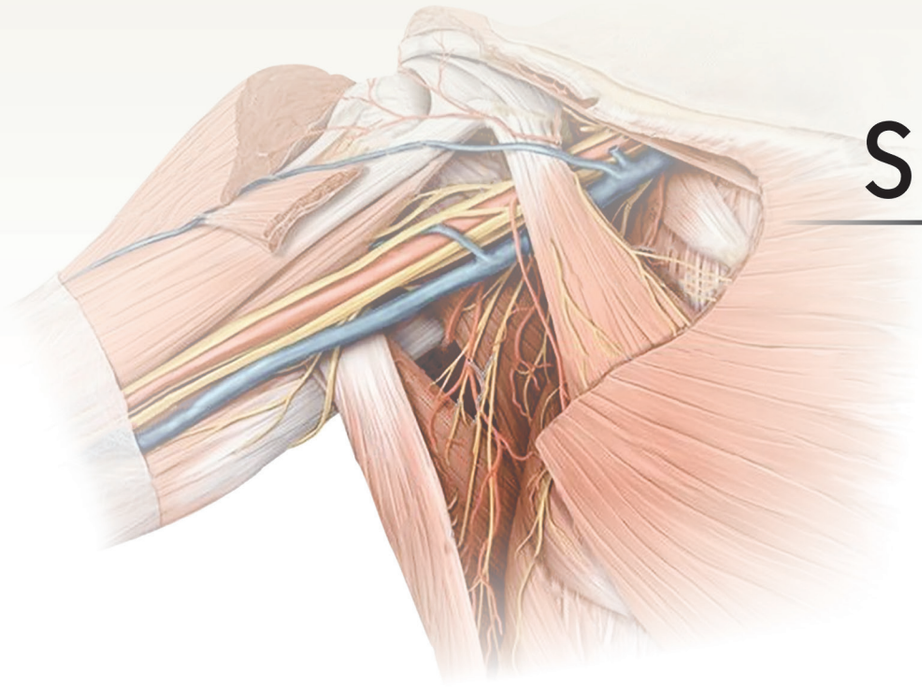


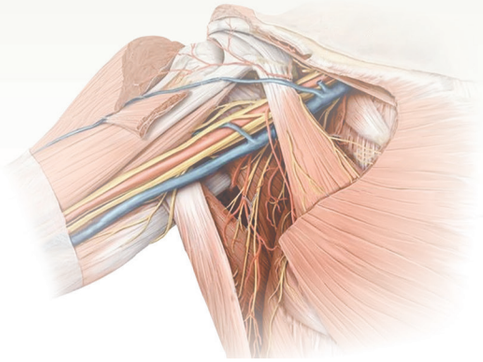
Section

1

Upper Limb

1. Introduction
2. Bones
3. Pectoral Region
4. Axilla
5. Back
6. Scapular Region
7. Cutaneous Nerves, Superficial Veins and Lymphatic Drainage
8. Arm
9. Forearm and Hand
10. Joints of Upper Limb
11. Surface Marking and Radiological Anatomy of Upper Limb

Appendix 1: Major Nerves and Arteries of Upper Limb



Chapter

1

Introduction

Knowledge of anatomy is essential to create a strong foundation for clinical expertise and patient care proficiency. Anatomy is about knowing the nomenclature of the human body structure and its functioning mechanism. Cadaveric dissection is a major attraction for all the students of medicine.

With the evolution of the erect posture in man, the function of weight-bearing was taken over by the lower limbs. Thus, the upper limbs, especially the hands, became free and gradually evolved with great manipulative skills. This has become possible because of a wide range of mobility at the shoulder. The whole upper limb works as a jointed lever. The human hand is a grasping tool. It is exquisitely adaptable to perform various complex functions under the control of a large area of the brain. The unique positions of humans as master mechanics of the animal world is because of the skilled movements of their hands.

PARTS OF THE UPPER LIMB

It has been seen that the upper limb is made up of four parts (Plate 1.1, Table 1.1):

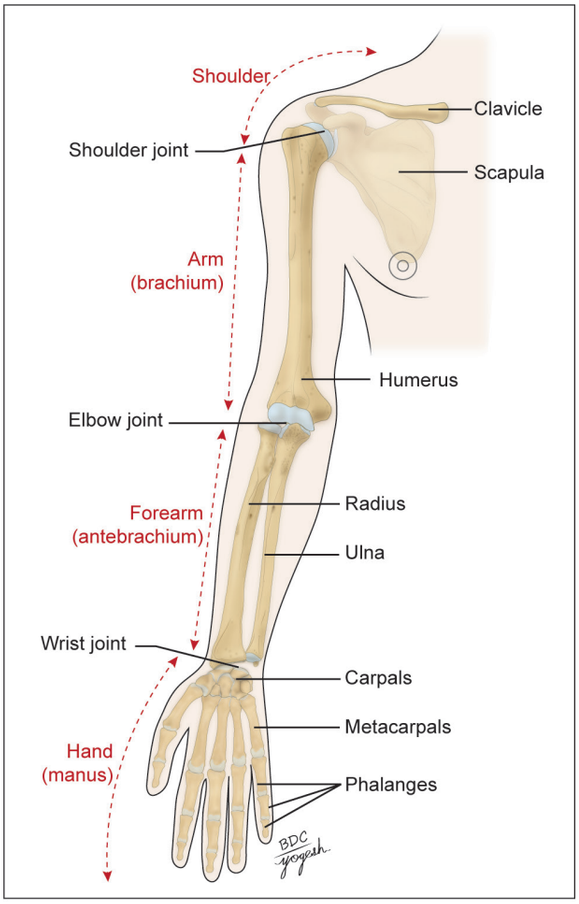
1. Shoulder region
2. Arm or brachium
3. Forearm or antebrachium
4. Hand or manus.

1. *Shoulder region*: It includes:

a. *Pectoral* or *breast region* on the front of the chest
b. *Axilla* or *armpit*
c. *Scapular region* on the back, comprising parts around the scapula
d. *Bones and joints*: The bones of the shoulder girdle are the *clavicle* and the *scapula*. Of these, only the clavicle articulates with the axial skeleton at the *sternoclavicular joint*. The scapula is mobile and is held in position by muscles. The clavicle and scapula articulate with each other at the *acromioclavicular joint*.

2. *Arm (upper arm or brachium)*: It extends from the shoulder to the elbow (cubitus). The bone of the arm is the *humerus*. Its upper end meets the scapula and forms the *shoulder joint*. The shoulder joint permits movements of the arm.

Plate 1.1: Parts and bones of upper limb



3. *Forearm (antebrachium)*: It extends from the elbow to the wrist. The bones of the forearm are the *radius* and *ulna*. At their upper ends, they meet the lower end of the humerus to form the *elbow joint*. Their lower ends meet the carpal bones to form the *wrist joint*. The radius and ulna meet each other at the *radioulnar joints*. The elbow joint permits movements of the forearm, namely *flexion* and *extension*. The radioulnar joints permit rotatory movements of the forearm called *pronation* and *supination*. In a mid-flexed elbow, the palm faces upwards in supination and downwards in pronation.

TABLE 1.1: Parts of the upper limb

Parts	*Subdivisions*	*Bones*	*Joints*
Shoulder region	a. Pectoral region b. Axilla or armpit c. Scapular region	Clavicle Scapula	Sternoclavicular joint Acromioclavicular joint
Upper arm (arm or brachium)	—	Humerus	Shoulder joint
Forearm (antebrachium)	—	Radius Ulna	Elbow joint Radioulnar joints
Hand	Wrist (carpus) Hand proper (metacarpus) 5 digits (lateral to medial): 1st – thumb or pollex 2nd – index or forefinger 3rd – middle finger 4th – ring finger 5th – little finger	8 carpal bones 5 metacarpal bones 14 phalanges: two for the thumb, and three for each of the four fingers	Wrist joint (radiocarpal joint) Intercarpal joints Carpometacarpal joints Intermetacarpal joints Metacarpophalangeal joints Proximal and distal interphalangeal joints

During the movement of pronation, the radius rotates around the ulna.

4. *Hand* (*manus*): It includes:

a. *Wrist* or carpus, supported by 8 carpal bones arranged in two rows.

b. *Hand proper* or metacarpus, supported by 5 metacarpal bones.

c. *Five digits* (thumb and four fingers). Each finger is supported by three phalanges, but the thumb has only 2 phalanges (in total 14 phalanges).

The *carpal bones* form the wrist joint with the radius, *intercarpal joints* with one another, and *carpometacarpal joints* with the metacarpals.

The phalanges form *metacarpophalangeal joints* with the metacarpals and *interphalangeal joints* with one another.

FUNCTIONAL ANATOMY OF UPPER LIMB

In human beings, the upper limb is highly evolved. The upper limb has its own peculiarities that make it different from the lower limb. Table 1.2 shows homologous parts of upper and lower limbs.

Peculiarities of the Upper Limb

- The skillful activities performed by human beings are due to the following peculiarities of the upper limb:
  1. Smaller and shorter upper limb than lower limb
  2. Freely moveable shoulder joint
  3. Long arm and forearm bones
  4. Presence of a carrying angle (angle between long axis of arm and forearm)
  5. Supination and pronation movements as adaptability to pick the food and eat using upper limb
  6. Arrangements of carpal bones in two rows
  7. Laterally placed thumb
  8. Separated long, slender digits
  9. Nail and nail bed protecting the terminal phalanx
  10. Grasping and skill movements of hand
  11. Opposition actions of thumb and little finger.

TABLE 1.2: Homologous parts of the limbs

Upper limb	*Lower limb*
Shoulder girdle	Hip girdle
Shoulder joint	Hip joint
Arm with humerus	Thigh with femur
Elbow joint	Knee joint
Forearm with radius and ulna	Leg with tibia and fibula
Wrist joint	Ankle joint
Hand with a. Carpus b. Metacarpus c. 5 digits	Foot with a. Tarsus b. Metatarsus c. 5 digits

Transmission of Force in Upper Limb

The weight transmission in upper limb occurs in the following manner (Flowchart 1.1, Plate 1.2):

Weight → hand → wrist joint → radius → interosseous membrane → ulna → elbow joint → humerus → shoulder joint → scapula → coracoclavicular ligament → clavicle → sternoclavicular joint and costoclavicular ligament → axial skeleton.

Flowchart 1.1: Lines of force transmission

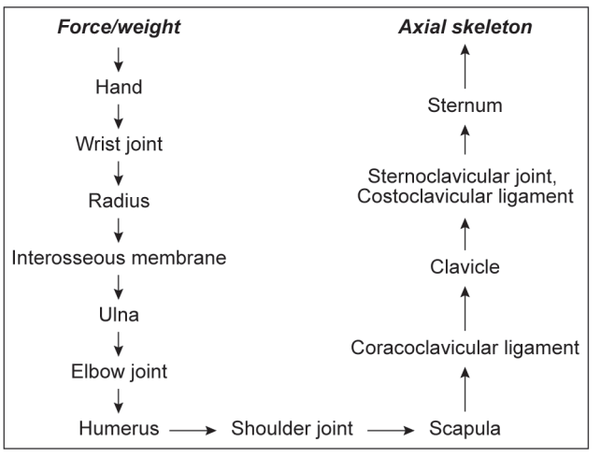
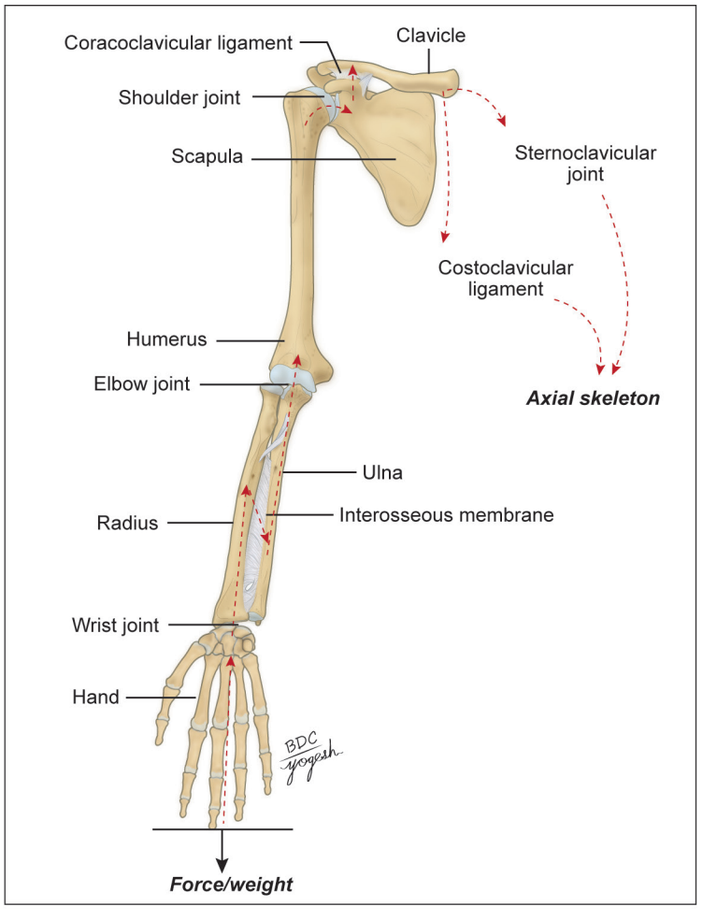


Plate 1.2: Line of force transmission in the upper limb

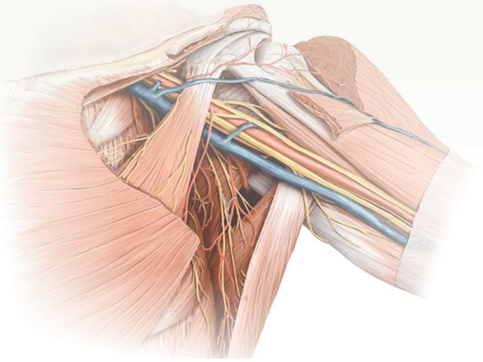


BDC's Anatomy *e*-book

1. Evolution of upper limb
2. Study of Anatomy
3. How to identify structures in cadaver?
4. Instruments required for the dissection
5. Viva voce questions

Chapter

2



Bones

Competencies:
AN8.1 Identify the given bone, its side, important features and keep it in anatomical position.
AN8.2 Identify and describe joints formed by the given bone.

- The study of bones of the upper limb has a clinical significance. It helps to understand the attachment of various muscles and ligaments, various joints, their movements and their applied aspects, such as bone fractures and anomalies.
- Each upper limb is supported with 32 bones as follows:

Clavicle	1
Scapula	1
Humerus	1
Radius	1
Ulna	1
Carpals	8
Metacarpals	5
Phalanges	14
Total	**32 bones**

Competencies:
AN8.1 Identify the given bone, its side, anatomical position, joint formation, important features and clinical anatomy (clavicle, scapula, humerus, radius, ulna, carpal bones).
AN8.2 Demonstrate important muscle attachments on the given bone.

CLAVICLE

The clavicle (Latin *a small key*) is a long bone. It supports the shoulder so that the arm can swing clearly away from the trunk. The clavicle transmits the weight of the limb to the sternum. The bone has a curved part called the shaft and two ends, lateral and medial.

Side Determination and Anatomical Position

For the side determination, hold the clavicle horizontally in such a way that:

1. Its lateral end is flat, and the medial end is large and quadrilateral.
2. The shaft is slightly curved so that it is convex forwards in its medial 2/3rd, and concave forwards in its lateral 1/3rd.
3. The inferior surface is grooved longitudinally in its middle 1/3rd.

Peculiarities of the Clavicle

1. It is the only long bone that lies horizontally.
2. It is subcutaneous throughout.
3. It is the first bone to start ossifying.
4. It is the only long bone that ossifies in membrane.
5. It is the only long bone that has two primary centres of ossification.
6. There is medullary cavity in its medial 2/3rd.
7. It is occasionally pierced by the middle supraclavicular nerve.

Features

Shaft

The shaft (Plate 2.1a, Figs 2.1a and b, Flowchart 2.1) is divisible into the lateral one-third and the medial two-thirds.

1. *Lateral one-third*

The lateral one-third of the shaft is flattened from above downwards. It has two borders – anterior and posterior; and two surfaces – superior and inferior.

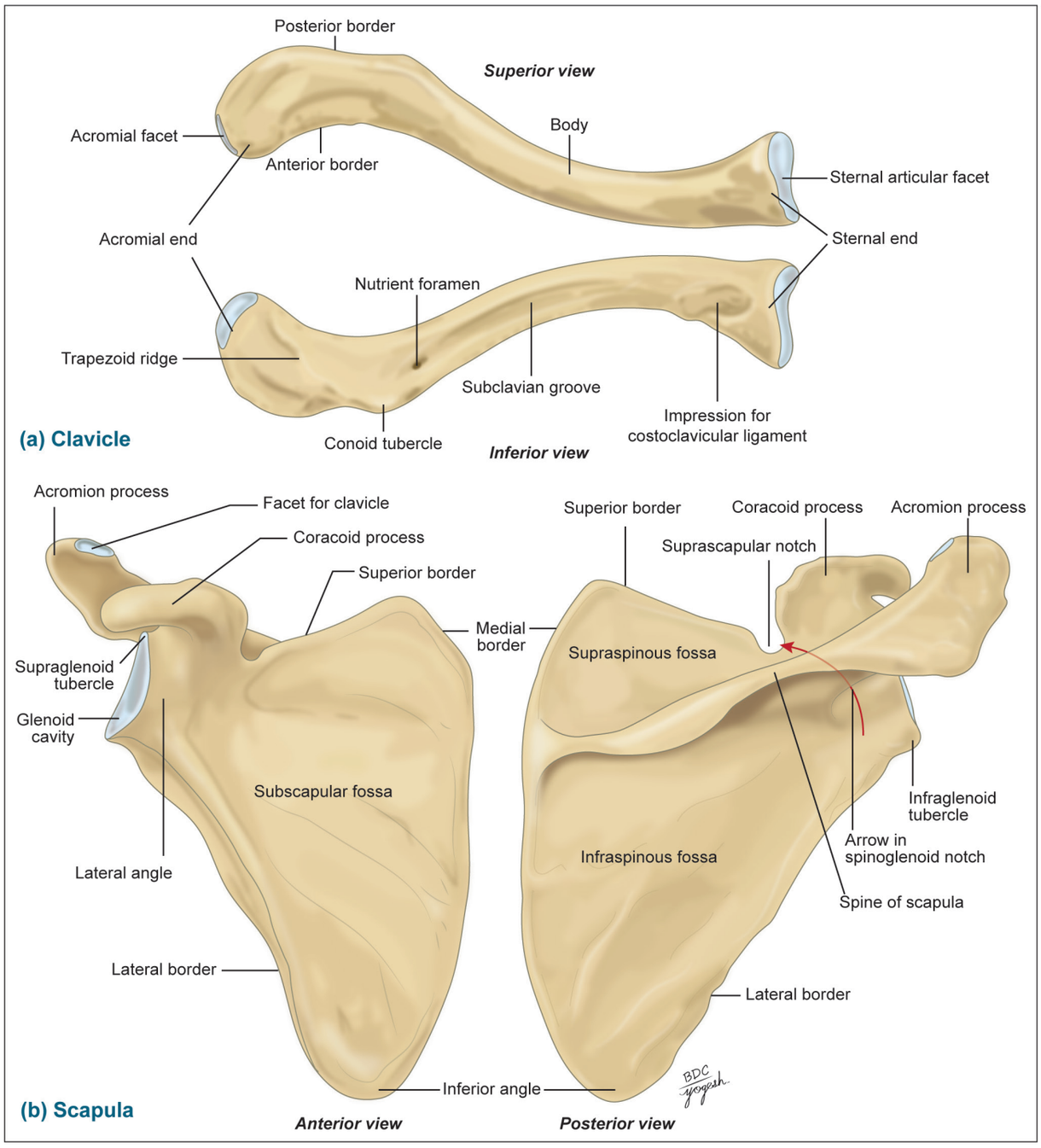
Borders: The *anterior border* is concave forwards. The *posterior border* is convex backwards.

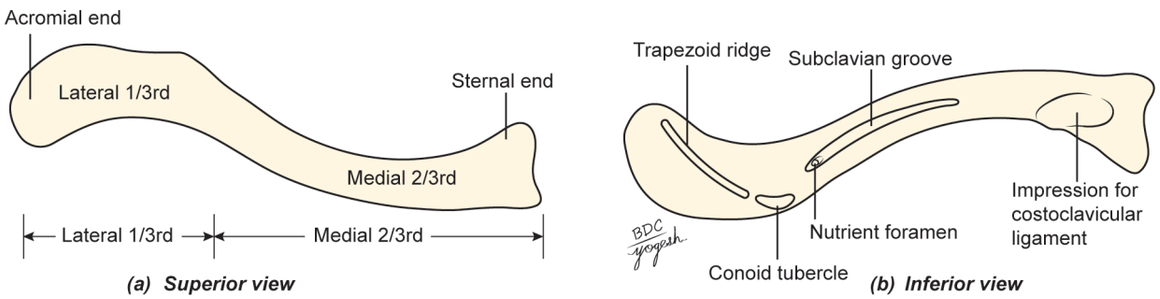
Surfaces: The *superior surface* is subcutaneous, and the *inferior surface* presents an elevation called the *conoid tubercle* (Greek cone) and a ridge called the *trapezoid ridge*.

2. *Medial two-thirds*

The medial two-thirds of the shaft is rounded and is said to have four surfaces: anterior, posterior, superior and inferior. The *anterior surface* is convex forwards. The *posterior surface* is smooth. The *superior surface* is rough in its medial part. The *inferior surface* has a rough oval impression at the medial end. The lateral half of this surface has a longitudinal *subclavian groove*. The *nutrient foramen* lies at the lateral end of the groove.

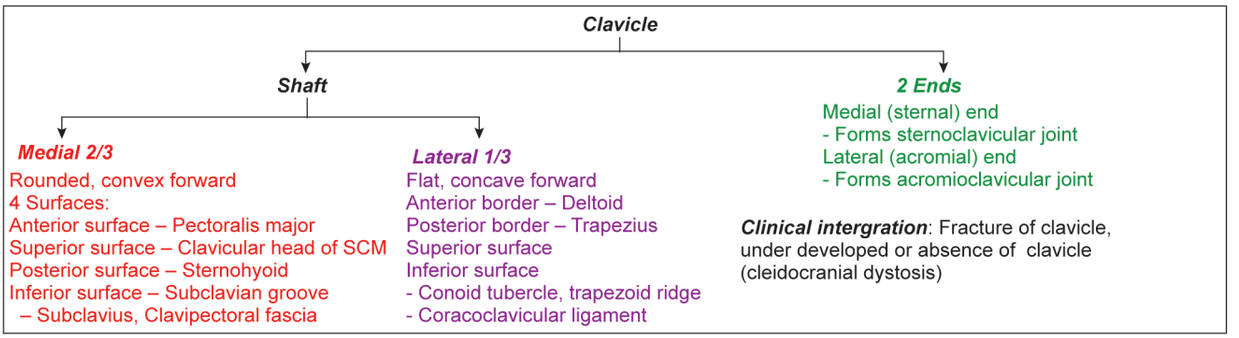
Plate 2.1: Clavicle and Scapula (a) Features of right clavicle (superior and inferior views). (b) Features of right scapula (anterior and posterior views)





Figs 2.1a and b: General features of right clavicle: (a) Superior aspect and (b) inferior aspect

Flowchart 2.1: Features of clavicle



Ends of Clavicle

1. ***Lateral or acromial end*** (*Greek peak of shoulder*) is flattened from above downwards. It bears a facet that articulates with the acromion process of the scapula to form the *acromioclavicular joint*.
2. ***Medial or sternal end*** is quadrangular and articulates with the clavicular notch of the manubrium sterni to form the *sternoclavicular joint*.

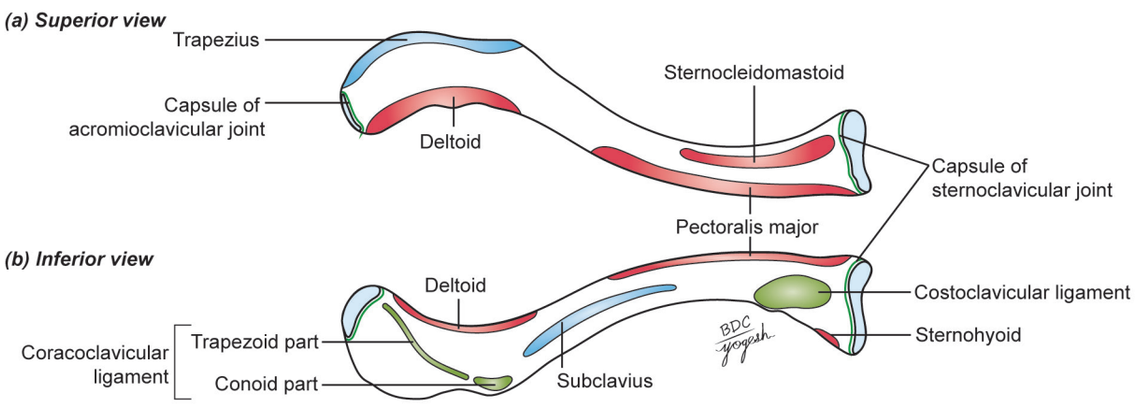
Attachments (Figs 2.2a and b)

1. *At the lateral end,* the margin of the articular surface for its acromioclavicular joint gives attachment to the joint capsule.
2. *At the medial end,* the margin of the articular surface for the sternum gives attachment to:
   a. Fibrous capsule of sternoclavicular joint all around.
   b. Articular disc posterosuperiorly.
   c. Interclavicular ligament superiorly.
3. *Lateral one-third of shaft*
   a. Anterior border gives origin to the deltoid muscle.
   b. Posterior border provides insertion to the trapezius muscle.
   c. Conoid tubercle and trapezoid ridge give attachment to the conoid and trapezoid parts of the coracoclavicular ligament.
4. *Medial two-thirds of the shaft*
   a. Anterior surface gives origin to the pectoralis major.
   b. Medial half of the superior surface gives origin to the clavicular head of the sternocleidomastoid.
   c. Posterior surface close to medial end gives origin to sternohyoid muscle.
   d. The subclavian groove gives insertion to the subclavius muscle. The margins of the groove give attachment to the clavipectoral fascia.
   e. The oval impression on the inferior surface at the medial end gives attachment to the costoclavicular ligament.
   f. The *subclavian* vessels and *divisions of trunks of brachial plexus* pass towards the axilla lying between the inferior surface of the clavicle and upper surface of first rib. Subclavius muscle acts as a cushion.

The nutrient foramen transmits a branch of the suprascapular artery.

OSSIFICATION

- The clavicle is the first bone in the body to ossify (Fig. 2.3). It has ***membranocartilaginous*** ossification: Most of the bone ossifies in the membrane, except its medial end, which ossifies in cartilage. It ossifies from two primary centres and one secondary centre.
- The two primary centres appear in the shaft between the fifth and sixth weeks of intrauterine life, and fuse about the 45th day.
- The secondary centre for the medial end appears during 15–17 years, and fuses with the shaft during 21–22 years. Occasionally, there may be a secondary centre for the acromial end.



Figs 2.2a and b: Attachments of right clavicle: (a) Superior aspect and (b) inferior aspect

The sternal end of the clavicle is the growing end of the clavicle because secondary centre epiphysis at this end appears in the late teens and fuses by the age of 21–22 years. Hence, nutrient foramen is directed away from sternal end.

CLINICAL ANATOMY

- The clavicle is commonly fractured by falling on the outstretched hand (indirect violence). The most common site of fracture is the junction between the two curvatures of the bone, which is the weakest point. The lateral fragment may be displaced downwards by the weight of the limb as trapezius muscle alone is unable to support the weight of upper limb (Fig. 2.4a). The *medial fragment* is elevated due to sternocleidomastoid muscle. Fracture of clavicle is treated by immobilisation with figure-of-eight bandage (Fig. 2.4b).
- The clavicles may be congenitally absent, or imperfectly developed with defective ossification of the skull bones in a disease called *cleidocranial dysostosis*. In this condition, the shoulders can be approximated anteriorly in front of the chest (Fig. 2.5).

A nonunion of two primary centres of ossification results in ***clavicular dysostosis***. In this condition, the medial and lateral parts of clavicle remain separate.

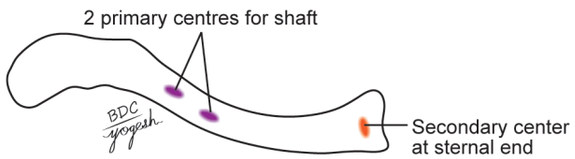
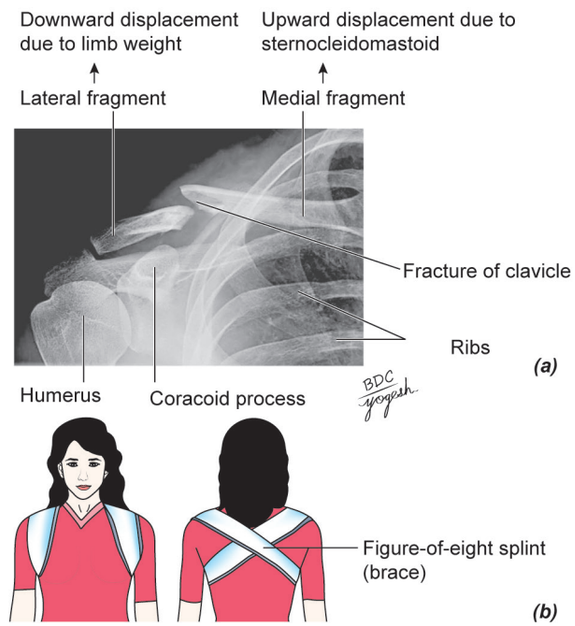


Fig. 2.3: Ossification of clavicle



Figs 2.4a and b: Fracture of clavicle: (a) Radiological findings and (b) figure-of-eight splint

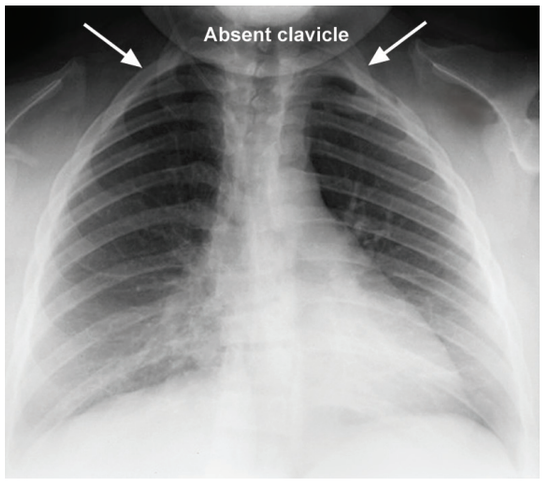


Fig. 2.5: Absence of clavicles in cleidocranial dysostosis

Competencies:
AN8.1 Identify the given bone, its side, anatomical position, joint formation, important features and clinical anatomy (clavicle, scapula, humerus, radius, ulna, carpal bones).
AN8.2 Demonstrate important muscle attachments on the given bone.

SCAPULA

The scapula (Latin *shoulder blade*) is a thin bone placed on the posterolateral aspect of the thoracic cage. The scapula has two surfaces, three borders, three angles and three processes (Plate 2.1b, Fig. 2.6, Flowchart 2.2).

Side Determination and Anatomical Position

For the side determination, hold the scapula in such a way that:

1. Its lateral or glenoid (Greek *socket*) angle is large and bears the glenoid cavity.
2. The dorsal surface is divided by the triangular spine into the supraspinous and infraspinous fossae (Figs 2.6 and 2.7).
3. Its acute inferior angle is directed downwards.

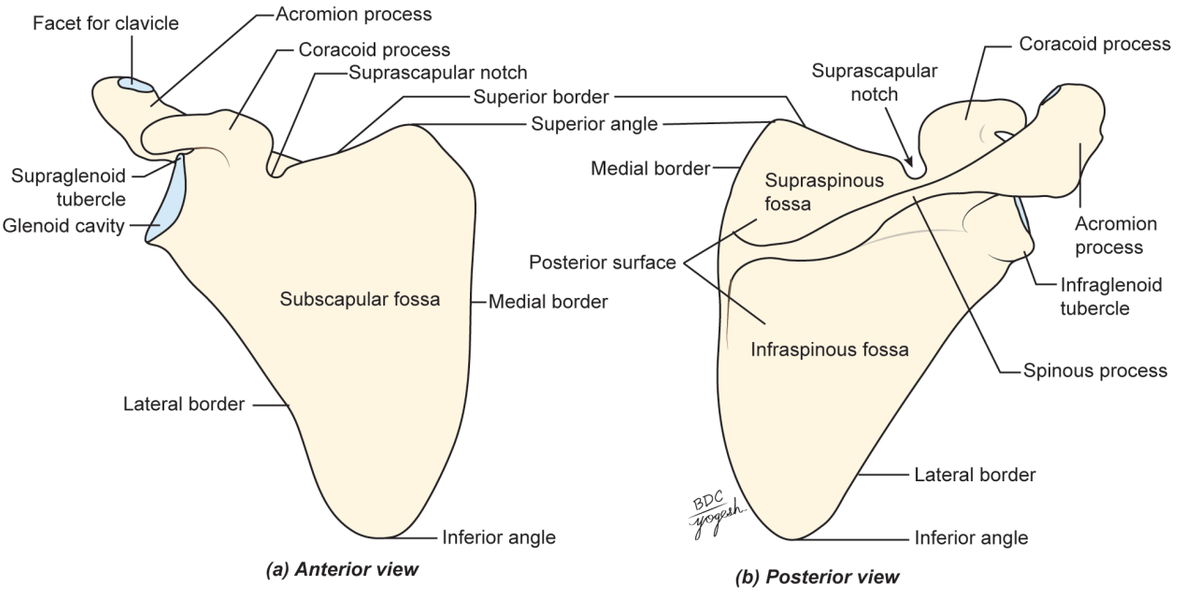
Features

Scapula has (Figs 2.6a and b):

- *Two surfaces*: Costal and dorsal
- *Three borders*: Superior, medial and lateral
- *Three angles*: Superior, inferior and lateral
- *Three processes*: Spinous, acromion and coracoid.

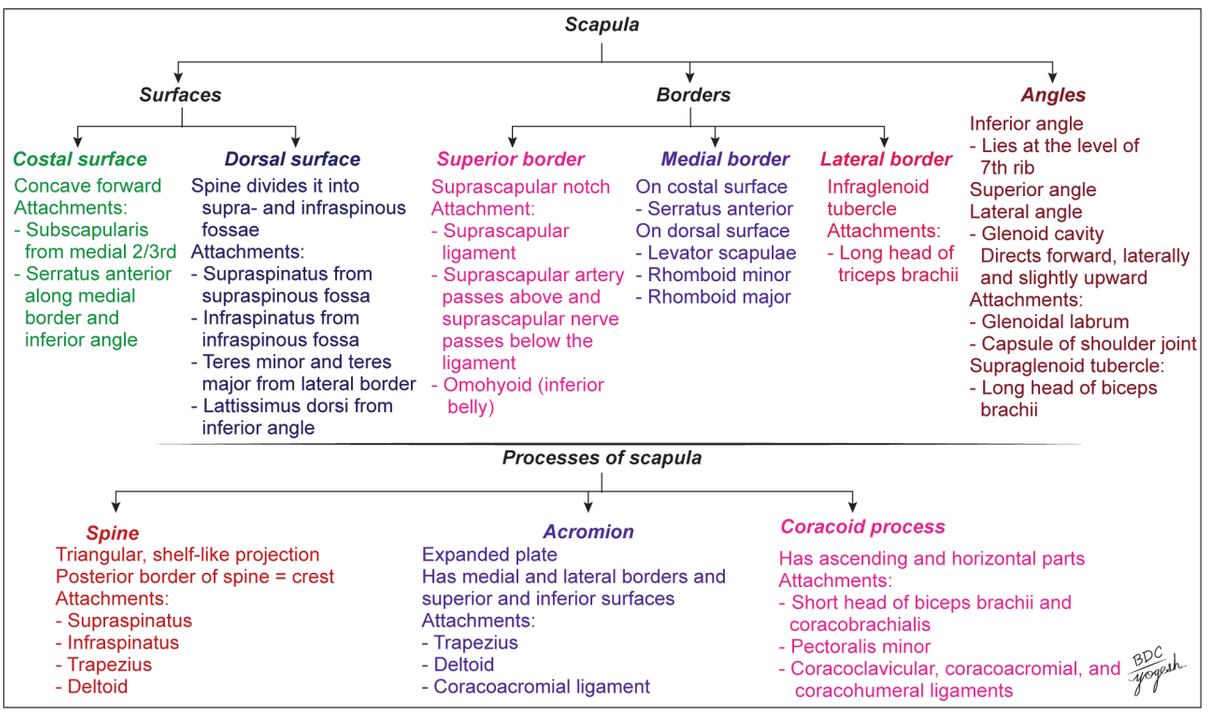
Surfaces

1. **Costal surface** or subscapular fossa: It is concave and is directed medially and forwards. It is marked by three longitudinal ridges. Another thick ridge adjoins the lateral border. This part of the bone is almost rod-like.
2. **Dorsal surface:** It gives attachment to the *spine of the scapula*, which divides the surface into a smaller *supraspinous fossa* and a larger *infraspinous fossa*. The two fossae are connected by the *spinoglenoid notch* situated lateral to the root of the spine.



Figs 2.6a and b: General features of right scapula: (a) Costal surface and (b) dorsal surface

Flowchart 2.2: Features of scapula



Borders

1. **Superior border:** It is shortest. Near the root of the coracoid process, it presents the *suprascapular notch.*
2. **Lateral border:** It is thick. At the upper end, it presents the *infraglenoid tubercle*.
3. **Medial border:** It is thin. It extends from the superior angle to the inferior angle.

Angles

1. **Superior angle:** It lies at the junction of superior and medial borders of scapula.
2. **Inferior angle:** It is more pointed and directed downwards. It covers the 7th rib or 7th intercostal space.
3. **Lateral** or **glenoid angle:** It is broad and bears the glenoid cavity or fossa, which is directed forward, laterally and slightly upwards. A supraglenoid tubercle is present above the glenoid cavity.

Processes

1. **Spine** or spinous process is a triangular plate of bone with three borders (anterior, lateral and posterior) and two surfaces. The posterior border of spine is called

the *crest of the spine*. The crest has upper and lower lips. The spine divides the dorsal surface of scapula into the supraspinous and infraspinous fossae.

2. **Acromion** process, an expanded plate, has two borders, medial and lateral; two surfaces, superior and inferior; and a facet for the clavicle.
3. **Coracoid process** (Greek *like a crow's beak*) is directed forwards and slightly laterally. It is bent and finger-like. It comprises a root; lateral and medial borders, superior aspect an a tip.

Attachments (Figs 2.7 to 2.9)

Surfaces

1. Subscapularis muscle arises from the medial two-thirds of the subscapular fossa.
2. Supraspinatus arises from the medial two-thirds of the supraspinous fossa, including the upper surface of the spine.
3. Infraspinatus arises from the medial two-thirds of the infraspinous fossa, including the lower surface of the spine.

Borders

4. Inferior belly of the omohyoid arises from the upper border near the suprascapular notch.
5. Transverse scapular or suprascapular ligament bridges across the suprascapular notch and converts it into a foramen, which transmits the suprascapular nerve. The suprascapular vessels lie above the ligament.
6. Long head of the triceps brachii arises from the infraglenoid tubercle.
7. Teres minor arises by two slips from the upper two-thirds of the rough strip on the dorsal surface along the lateral border. Circumflex scapular artery lies between the two slips.
8. Teres major arises from the lower one-third of the rough strip on the dorsal aspect of the lateral border.
9. Levator scapulae is inserted along the dorsal aspect of the medial border, from the superior angle up to the root of the spine.
10. Rhomboid minor is inserted into dorsal aspect of the medial border opposite the root of the spine.
11. Rhomboid major is inserted into dorsal aspect of the medial border between the root of the spine and the inferior angle.

Angles

12. Serratus anterior is inserted along the medial border of the costal surface: One digitation from the superior angle to the root of spine, two digitations to the medial border and five digitations to the inferior angle.
13. Latissimus dorsi arises from inferior angle.
14. The margin of the glenoid cavity gives attachment to the capsule of the shoulder joint and to the glenoidal labrum (Latin *lip*). The long head of the biceps brachii arises from the supraglenoid tubercle.
15. Long head of biceps brachii arises from the supraglenoid tubercle.

Spine, acromion and coracoid process

16. Trapezius is inserted into the upper border of the crest of the spine and into the medial border of the acromion process.
17. Deltoid arises from the lower border of the crest of the spine and from the lateral border of the acromion. The acromial fibres are *multipennate*.
18. The margin of the facet for clavicle on the medial aspect of the acromion process gives attachment to the *capsule of the* acromioclavicular joint (Fig. 2.10).
19. Pectoralis minor is inserted into the medial border and superior surface of the coracoid process.
20. Short head of biceps brachii arises from lateral part of the tip of coracoid process. The coracobrachialis arises from medial part of the tip of coracoid process.
21. Coracohumeral ligament is attached to the root of the coracoid process.
22. Coracoclavicular ligament is attached to the coracoid process: The trapezoid part on the superior aspect and the conoid part near the root.
23. Coracoacromial ligament is attached (a) to the lateral border of the coracoid process and (b) to the medial side of the tip of the acromion process.

OSSIFICATION

- The scapula ossifies **eight centres:** from one primary centre and seven secondary centres.
- The primary centre appears near the glenoid cavity during the eighth week of development.
- The first secondary centre appears in the middle of the coracoid process during the first year and fuses by the 15th year. The subcoracoid centre appears in the root of the coracoid process during the 10th year and fuses by the 14th to 17th years (Fig. 2.10).
- The other centres, including two for the acromion process, one for the lower part of rim of the glenoid cavity, one for the medial border and one for the inferior angle, appear at puberty and fuse by the 20th year.

CLINICAL ANATOMY

- Paralysis of the serratus anterior causes 'winging' of the scapula. The medial border of the bone becomes unduly prominent, and the arm cannot be abducted beyond 90° (Fig. 2.11).
- The *scaphoid* scapula is a developmental anomaly, in which the medial border is concave.

Sprengel's deformity is a congenital anomaly in which scapula is situated higher in the back (Otto GK Sprengel, German Surgeon, 1852–1915). It occurs due to the developmental failure of descent of scapula and shoulder from the neck to its adult position.

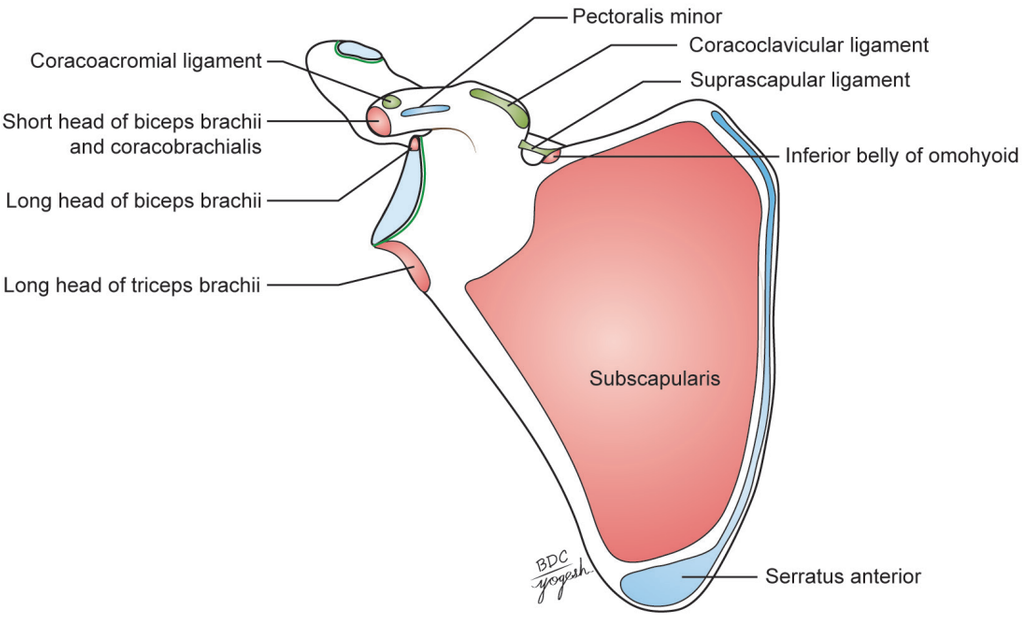


Fig. 2.7: Attachments of right scapula: Costal aspect

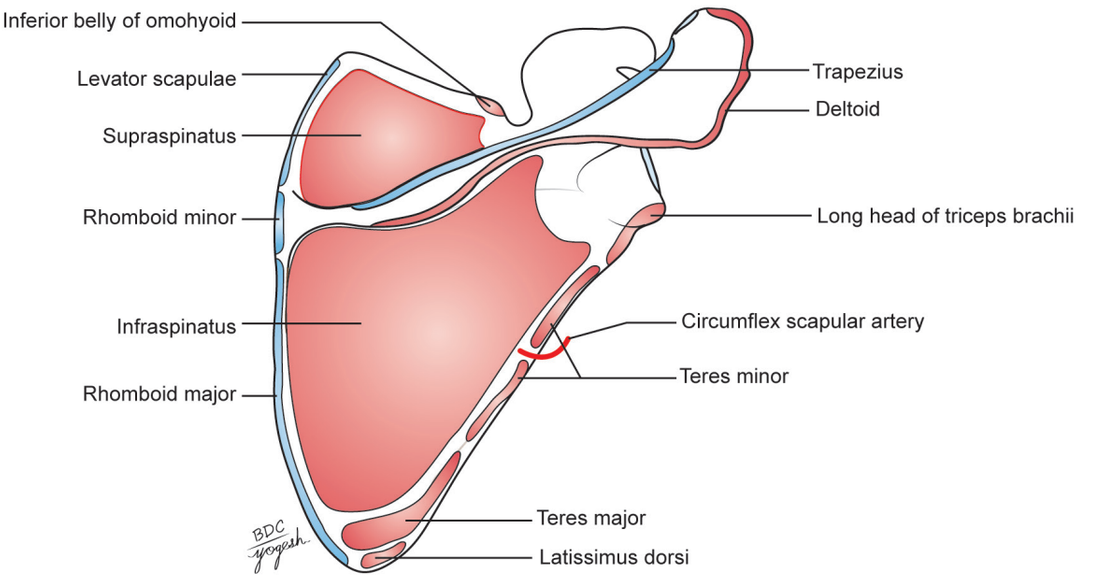


Fig. 2.8: Attachments of right scapula: Dorsal aspect

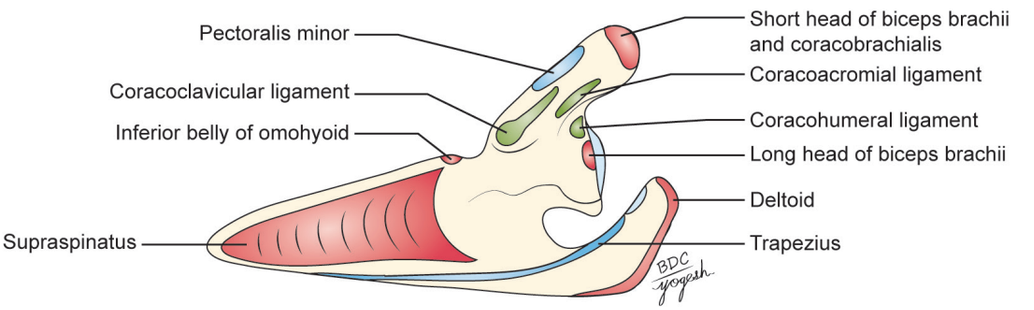
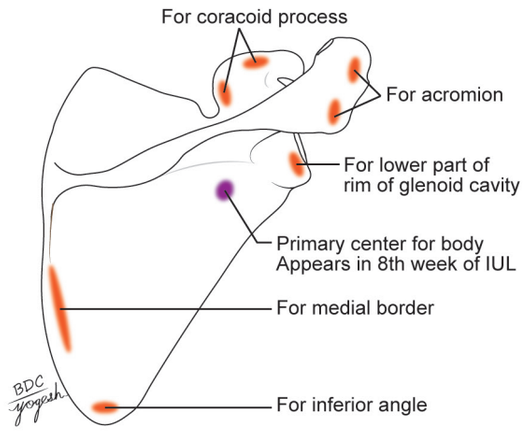


Fig. 2.9: Right scapula: Superior aspect



Secondary centres	Appearance	Fusion
• For tip of coracoid process	1st year of puberty	15th year
• All other centres	Puberty	20th year

Fig. 2.10: Ossification of scapula

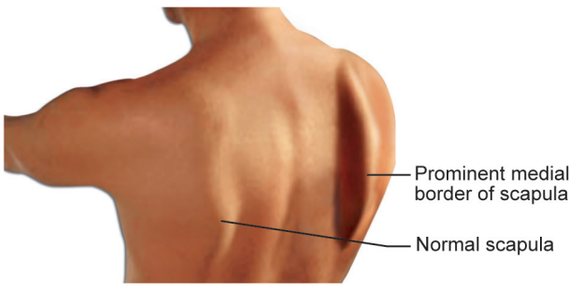


Fig. 2.11: Winging of right scapula

HUMERUS

The humerus is the bone of the arm. It is the longest bone of the upper limb (Fig. 2.12, Plate 2.2, Flowchart 2.3).

Side Determination and Anatomical Position

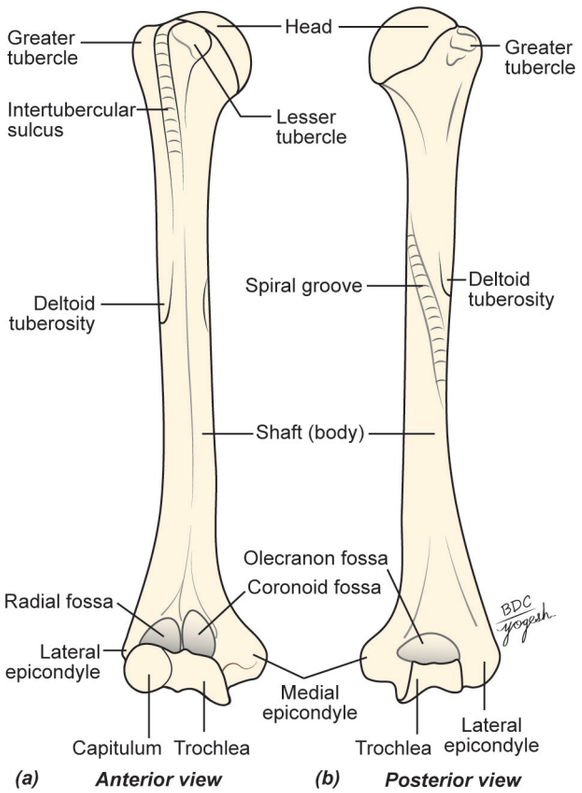
For the side determination, hold the humerus vertically in such a way that:

1. The upper end is rounded to form the head.
2. The lesser tubercle projects from the front of the upper end and is limited laterally by the intertubercular sulcus or bicipital groove.
3. The lower end is expanded from side-to-side and has a prominent medial epicondyle.

Features

Upper End

1. ***Head*:** It is directed medially, backwards and upwards. It articulates with the glenoid cavity of the scapula to form the shoulder joint. The head forms about one-third of a sphere and is much larger than the glenoid cavity (Fig. 2.12).
2. ***Neck*:** Humerus has three necks:
   a. *Anatomical neck* is the line separating the head from the rest of the upper end.
   b. *Morphological neck* lies at junction of upper end of diaphysis with upper epiphysis. It disappears in adults.



Figs 2.12a and b: General features of right humerus: (a) Seen from front and (b) seen from back

   c. *Surgical neck* is the narrow line separating the upper end of humerus from the shaft. It lies 0.5 cm below morphological neck.
3. ***Lesser tubercle*** (Latin *lump*) is an elevation on the anterior aspect of the upper end.
4. ***Greater tubercle*** is an elevation that forms the lateral part of the upper end. Its upper and posterior aspect is marked by three smooth impressions: upper, middle and lower.
5. ***Intertubercular sulcus*** or *bicipital groove* separates the lesser tubercle medially from the anterior part of the greater tubercle. The sulcus has medial and lateral lips that represent downward prolongations of the lesser and greater tubercles.

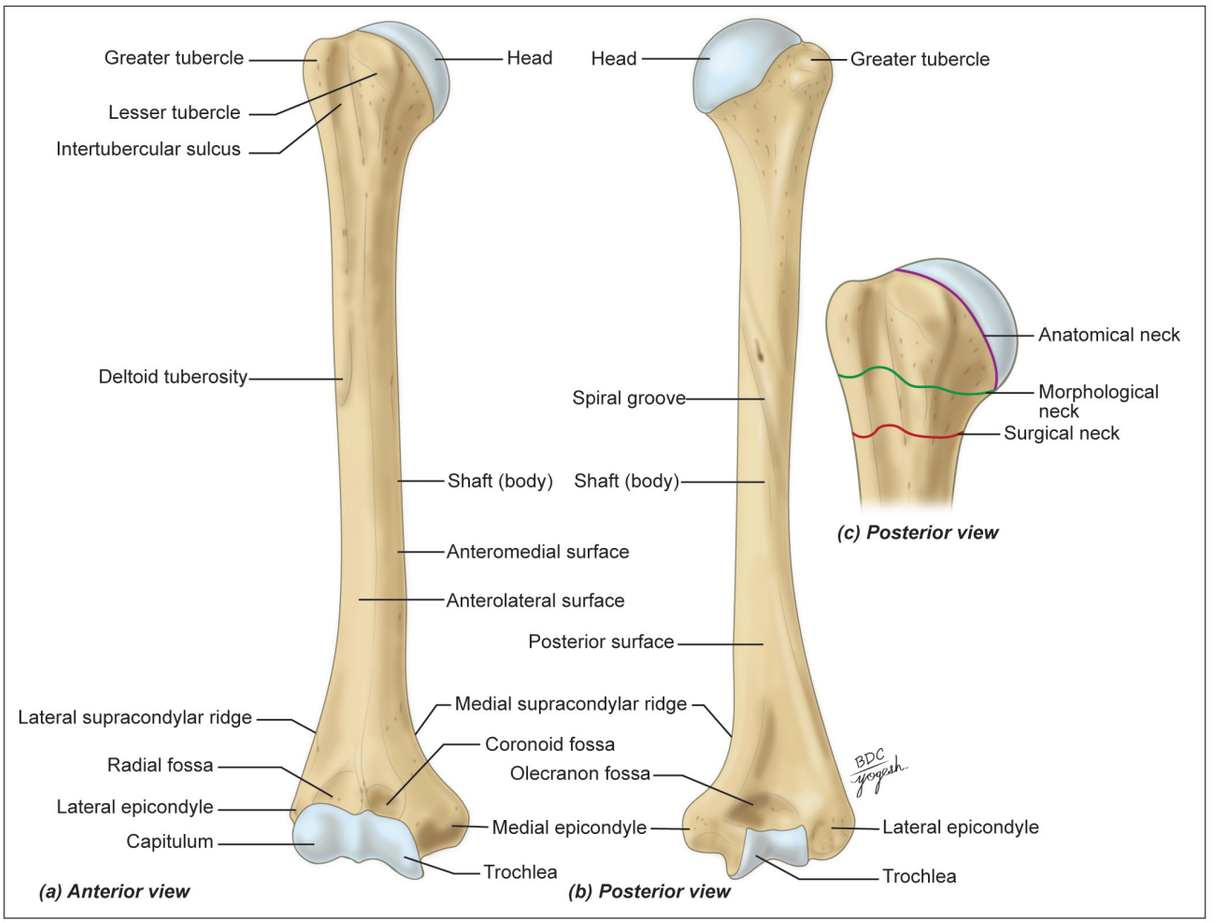
Shaft

The shaft is rounded in the upper half and triangular in the lower half. It has three borders and three surfaces.

Borders

1. ***Anterior border:*** Upper one-third of the *anterior border* forms the lateral lip of the intertubercular centre's sulcus. In its middle part, it forms the anterior margin of the *deltoid tuberosity*. The lower half of the anterior border is smooth and rounded.
2. ***Lateral border:*** It is prominent only at the lower end, where it forms the *lateral supracondylar ridge*. In the upper part, it is barely traceable up to the posterior surface of the greater tubercle. In the middle part, it is interrupted by the *radial* or *spiral groove*.

Plate 2.2: Humerus



Flowchart 2.3: Features and attachments of humerus

Parts of humerus

Upper end	Shaft	Lower end
Head	Cylindrical in upper half	Medial epicondyle
Neck	Triangular in lower half	Trochlea
Greater tubercle	Borders: anterior, medial, and lateral	Capitulum
Lesser tubercle	Surfaces: anteromedial, anterolateral and posterior	Lateral epicondyle
Intertubercular sulcus		Coronoid fossa
		Radial fossa
		Olecranon fossa

Features of upper end of humerus

Head	Lesser tubercle	Greater tubercle
Globular, 1/3 of sphere	Small anterior projection	Large lateral projection
Form shoulder joint	Subscapularis	3 impressions:
Anatomical neck: separates head from remaining upper end		Upper – Supraspinatus
		Middle – Infraspinatus
		Lower – Teres minor

Intertubercular sulcus (bicipital groove)

Parts	Contents
Medial lip – Teres major	Tendon of long head of biceps brachii with synovial sheath
Floor – Latissimus dorsi	Ascending branch of anterior circumflex humeral artery
Lateral lip – Pectoralis major	

Shaft of humerus

Borders	Surfaces
Anterior border	*Anteromedial surface*
Medial border	Nutrient foramen
Brachialis	*Anterolateral surface*
Medial supracondylar ridge	Deltoid tuberosity
Pronator teres	Brachioradialis
Medial intermuscular septum	Extensor carpi radialis longus
Lateral border	*Posterior surface*
Lateral supracondylar ridge	Radial groove: radial nerve, Profunda brachii artery
Lateral intermuscular septum	Oblique ridge
	Lateral head of triceps brachii
	Area below radial groove: Medial head of triceps brachii

Lower end of humerus

Capitulum	Trochlea	Condyles
Rounded, lateral projection	Pulley-shaped medial projection	Medial condyle
Articulates with head of radius	Articulates with trochlear notch of ulna	Common flexor tendon
		Lateral condyle
		Common extensor tendon
		Anconeus

Fossae

Anterior	Coronoid fossa	Lodges coronoid process of ulna
	Radial fossa	Lodges head of radius
Posterior	Olecranon fossa	Deeper fossa lodge olecranon process of ulna

3. ***Medial border:*** Upper part of the *medial border* forms the medial lip of the intertubercular sulcus. About its middle, it presents a rough strip. It is continuous below with the *medial supracondylar ridge*.

Surfaces

1. ***Anterolateral surface:*** It lies between the anterior and lateral borders. A little above the middle, it is marked by a V-shaped *deltoid tuberosity (Greek triangular-shaped).*
2. ***Anteromedial surface:*** It lies between the anterior and medial borders. Its upper one-third is narrow and forms the floor of the intertubercular sulcus. A nutrient foramen is present near the medial border below its middle part.
3. ***Posterior surface:*** It lies between the medial and lateral borders. Its upper part is marked by an oblique ridge. The middle one-third is crossed by the *radial groove*.

Lower End

The lower end of the humerus is expanded from side-to-side, and has articular and non-articular parts. The *articular part* includes the following:

1. **Capitulum** (Latin *little head*): It is a rounded projection that articulates with the head of the radius.
2. **Trochlea** (Greek *pulley*): It is a pulley-shaped surface. It articulates with the trochlear notch of the ulna. The medial edge of the trochlea projects down 6 mm more than the lateral edge – this results in the formation of the *carrying angle* (*see* Fig. 10.14).

The *non-articular part* includes the following:

1. **Medial epicondyle:** It is a prominent bony projection on the medial side of the lower end. It is subcutaneous and is easily felt on the medial side of the elbow.
2. *Medial supracondylar ridge* is a sharp ridge just above the medial epicondyle.
3. **Lateral epicondyle:** It is smaller than the medial epicondyle. Its anterolateral part has a muscular impression.
4. The sharp lateral margin just above the lower end is called the *lateral supracondylar ridge.*
5. **Coronoid fossa:** It is a depression just above the anterior aspect of the trochlea. It accommodates the coronoid process of the ulna when the elbow is flexed.
6. **Radial fossa:** It is a depression present just above the anterior aspect of the capitulum. It accommodates the head of the radius when the elbow is flexed.
7. **Olecranon fossa** *(Greek ulna head)*: It lies just above the posterior aspect of the trochlea. It accommodates the olecranon process of the ulna when the elbow is extended.

Attachments (Figs 2.13 a and b)

Upper end

1. Capsular ligament of the shoulder joint is attached to the anatomical neck except on the medial side, where the line of attachment extends down by about 1–2 cm on the shaft. The capsular attachment is interrupted at the intertubercular sulcus to provide passage to the tendon of the long head of the biceps brachii.
2. Subscapularis is inserted into the lesser tubercle.
3. Supraspinatus is inserted into the uppermost impression on the greater tubercle.
4. Infraspinatus is inserted into the middle impression on the greater tubercle.
5. Teres minor is inserted into the lower impression on the greater tubercle.
6. Pectoralis major is inserted into the lateral lip of the intertubercular sulcus.
7. Latissimus dorsi is inserted into the floor of the intertubercular sulcus.
8. Teres major is inserted into the medial lip of the intertubercular sulcus.
9. The contents of the intertubercular sulcus are:
   a. *Tendon of the long head of the biceps brachii* and its synovial sheath.
   b. Ascending branch of the anterior circumflex humeral artery.

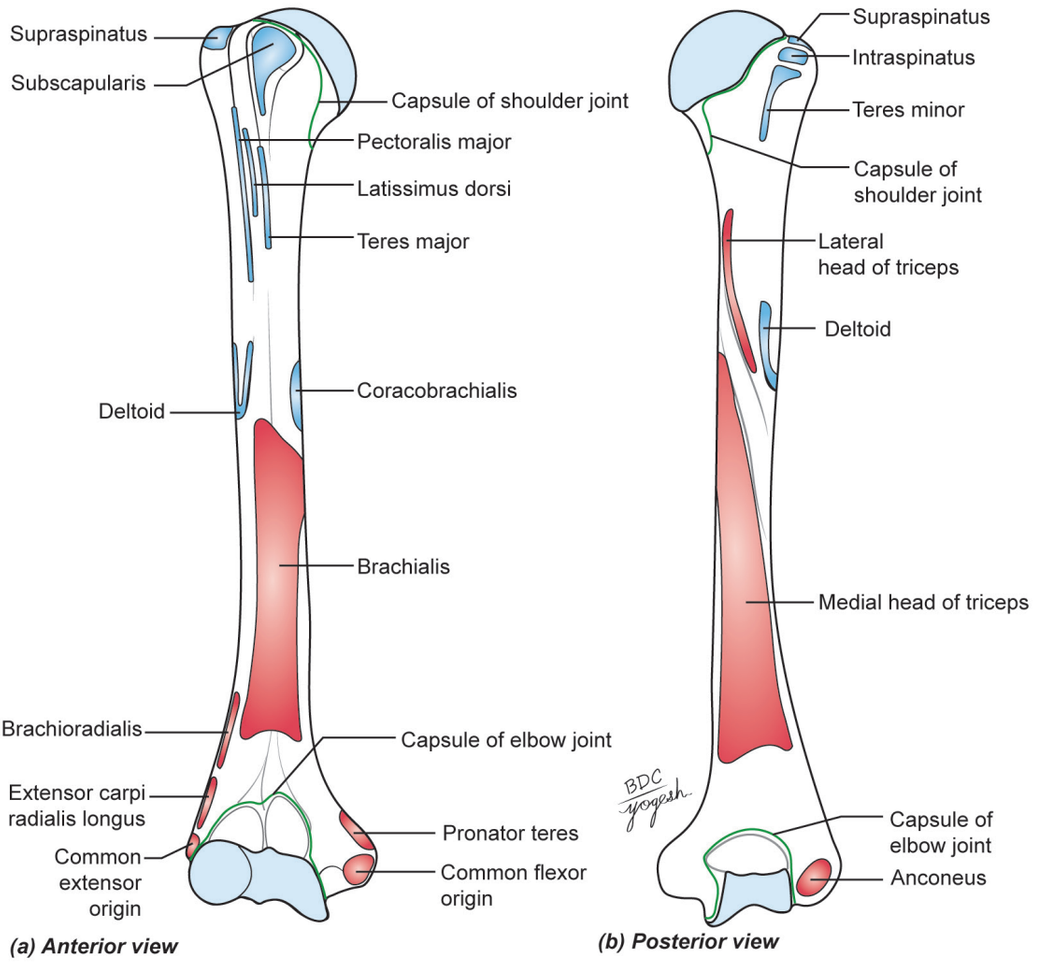
(*Mnemonic*: for the Attachments of bicipital groove: "*Lady between 2 majors*": Lateral lip – pectoralis major, Medial lip – teres major, Floor – latissimus dorsi).

Shaft

10. Coracobrachialis is inserted into the rough area on the middle of the medial border.
11. Deltoid is inserted into the deltoid tuberosity.
12. Brachialis arises from the lower halves of the anteromedial and anterolateral surfaces of the shaft. Part of the area extends onto the posterior aspect.
13. Lateral head of triceps brachii arises from oblique ridge on the upper part of posterior surface above the radial groove, while its *medial head* arises from posterior surface below the radial groove.

Lower end

14. *Common flexor origin:* The superficial flexor muscles of the forearm arise by a common origin from the anterior aspect of the medial epicondyle as the common flexor origin.
15. Pronator teres (humeral head) arises from the lower one-third of the medial supracondylar ridge.
16. *Common extensor origin*: The superficial extensor muscles of the forearm and supinator arise from the lateral epicondyle as *common extensor origin*.
17. Anconeus arises from the posterior surface of the lateral epicondyle.
18. Brachioradialis arises from the upper two-thirds of the lateral supracondylar ridge.
19. Extensor carpi radialis longus arises from the lower one-third of the lateral supracondylar ridge.
20. Capsular ligament of the elbow joint is attached to the lower end along a line that reaches the upper limits of the radial and coronoid fossae anteriorly and of the olecranon fossa posteriorly.



Figs 2.13a and b: Attachments of right humerus: (a) Anterior view and (b) posterior view

OSSIFICATION

The humerus ossifies from one primary and seven secondary centres as follows:

One primary centre for shaft appears in 8th week of intrauterine life.

Three secondary centres for upper end:

- One for head – appears by 1st year.
- One for greater tubercle – appears by 2nd year.
- One for lesser tubercle – appears by 5th year.

These centres fuse with each other to form a single upper end by 6th year and fuse with shaft by 20th year.

Four secondary centres for lower end

- One for capitulum and lateral part of trochlea – appears by 1st year.
- One for medial part of trochlea – appears by 10th year
- One for lateral epicondyle – appears by 12th year
- These centres fuse by 14th year and with the rest of shaft by 16th year.
- One for medial epicondyle – appears by the 6th year and fuses with rest of the bone by 20th year.

CLINICAL ANATOMY

- *Nerves related to humerus*: It is related to the following three nerves (Fig. 2.14):
  1. Axillary nerve around the surgical neck
  2. Radial nerve in radial groove
  3. Ulnar nerve posterior to the medial epicondyle.
- The common sites of fracture of humerus are the surgical neck, shaft and supracondylar region. Fracture of surgical neck may involve axillary nerve.
- *Supracondylar fracture* is common in young age. It is produced by a fall on the outstretched hand. The lower fragment is mostly displaced backwards, so that the elbow is unduly prominent, as in dislocation of the elbow joint. This fracture may cause injury to the median nerve. It may also lead to *Volkmann's ischaemic contracture* caused by occlusion of the brachial artery (Figs 2.15a and b).
- The humerus has a poor blood supply at the junction of its upper one-third and lower two- thirds. Fractures at this site show delayed union or non-union.
- The head of the humerus commonly dislocates inferiorly (subglenoid). It may be anterior (commonest) or posterior to the infraglenoid tubercle (Fig. 2.16).

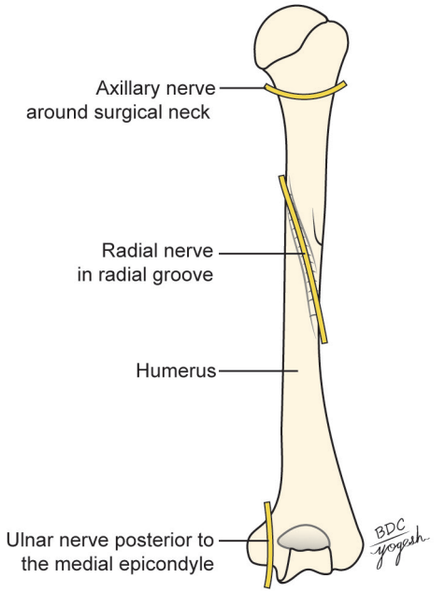
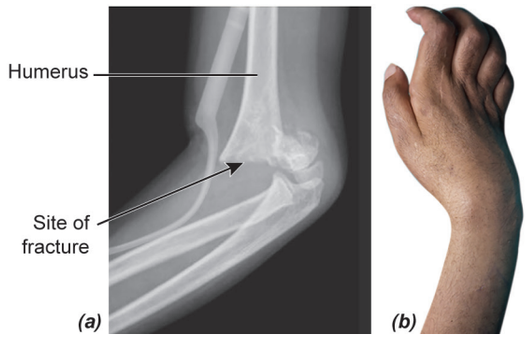


Fig. 2.14: Relation of axillary, radial and ulnar nerves to the back of humerus



Figs 2.15a and b: (a) X-ray of supracondylar fracture of humerus, position of brachial artery shown and (b) Volkmann's ischaemic contracture

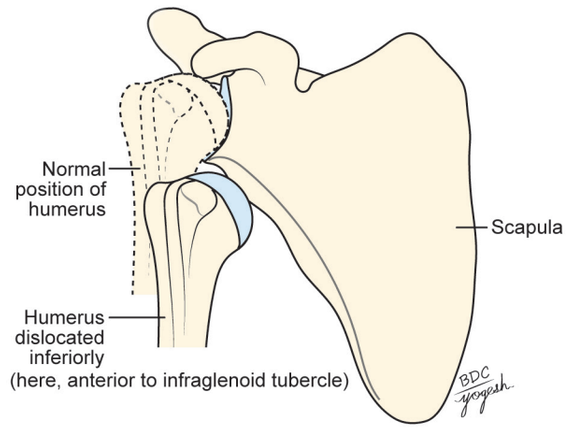


Fig. 2.16: Inferior dislocation of humerus

RADIUS

The radius is the lateral bone of the forearm, and is homologous with the tibia of the lower limb (Latin *radius* = ray) (Fig. 2.17, Plate 2.3, Flowchart 2.4).

Side Determination and Anatomical Position

For the side determination, hold the radius vertically in such a way that:

1. Upper end has a disc-shaped head and a narrow neck, while lower end is expanded with a styloid process. Close to neck, it presents a radial tuberosity.
2. Lower end presents a tubercle on the posterior surface called dorsal tubercle of Lister.
3. The medial border of the shaft is the sharpest border.

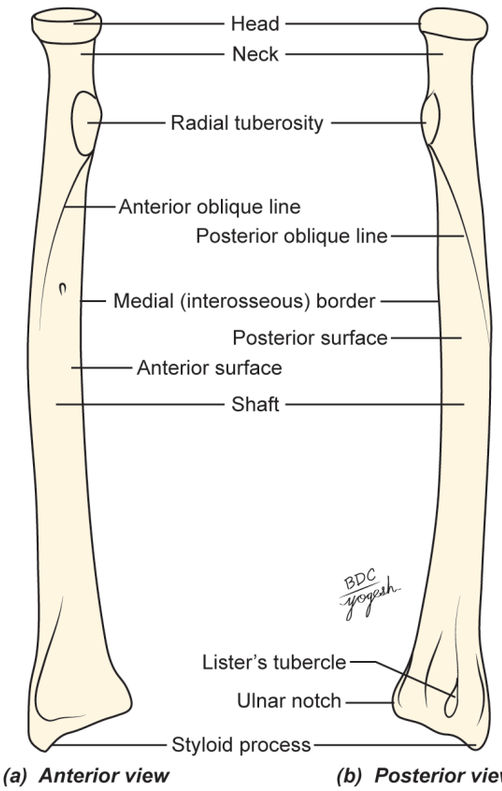
Features

Upper End

1. **Head:** It is disc-shaped and is covered with hyaline cartilage (Fig. 2.17). It has a superior concave surface, that articulates with the capitulum of the humerus at the elbow joint. The circumference of the head is also articular. It fits into a socket formed by the radial notch of the ulna and the *annular ligament*, thus forming the *superior radioulnar joint*.
2. **Neck:** It is enclosed by the narrow lower margin of the annular ligament.
3. **Radial tuberosity:** It lies just below the medial part of the neck. It has a rough posterior part and a smooth anterior part.

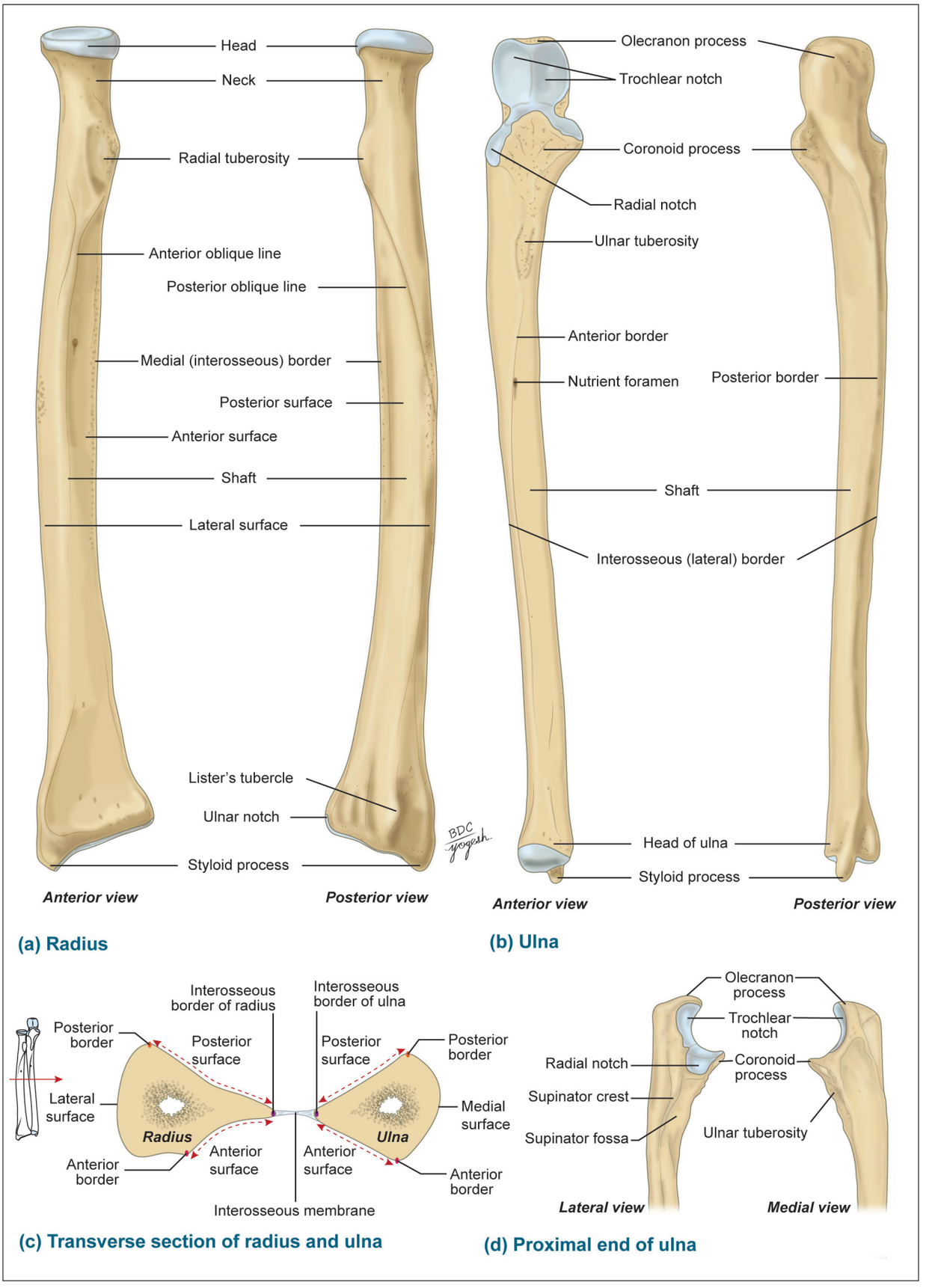
Shaft

It has three borders and three surfaces (Plate 2.3c, Fig. 2.17).

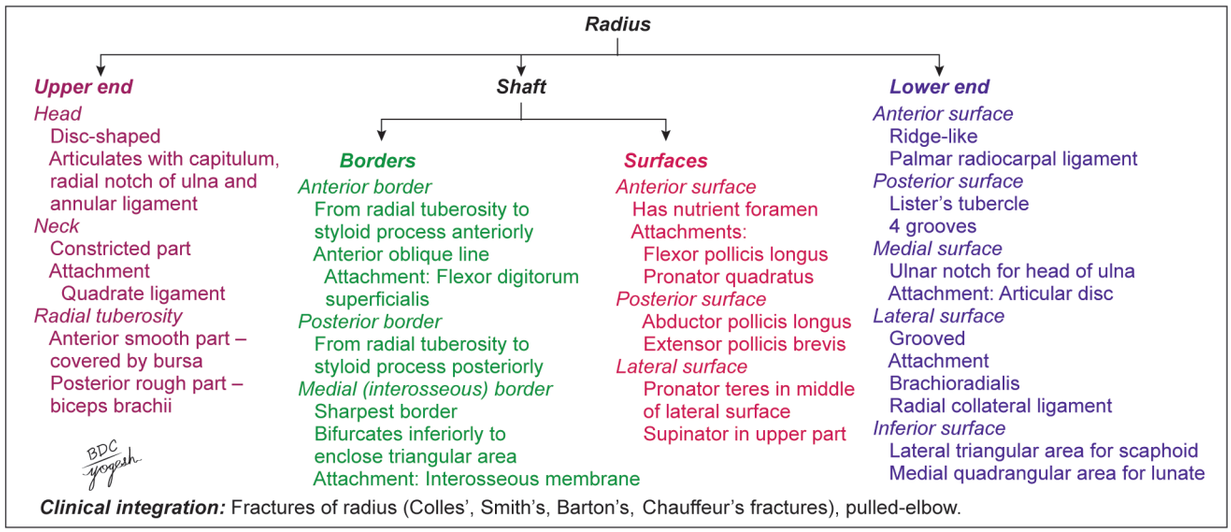


Figs 2.17a and b: Features of (a) anterior and (b) posterior views of radius

Plate 2.3: Radius and Ulna: (a) Features of right radius (anterior and posterior views), (b) features of right ulna (anterior and posterior views), (c) transverse section of radius and ulna (inferior view), (d) proximal end of right ulna (medial and lateral views)



Flowchart 2.4: Features of radius



Borders

1. **Anterior border:** It extends from the anterolateral part of the radial tuberosity to the styloid process. It is oblique in the upper half of the shaft and vertical in the lower half. The lowest part is sharp and crest-like. The oblique part is called the *anterior oblique line*.
2. **Posterior border:** It is clearly defined only in its middle one-third. Its upper oblique part is known as the *posterior oblique line*.
3. **Medial** or **interosseous border:** It is the sharpest border. It extends from the radial tuberosity above to the posterior margin of the ulnar notch below. The interosseous membrane is attached to its lower three-fourths. In its lower part, it forms the posterior margin of an elongated triangular area.

Surfaces

1. **Anterior surface:** It lies between the anterior and interosseous borders. A nutrient foramen opens in its upper part and is directed upwards. The nutrient artery is a branch of the anterior interosseous artery.
2. **Posterior surface:** It lies between the posterior and interosseous borders.
3. **Lateral surface:** It lies between the anterior and posterior borders. It shows a roughened area in its middle part.

Lower End

The lower end is expanded. It has five surfaces.

1. The anterior surface is in the form of a thick, prominent ridge. The *radial artery* is palpated against this surface.
2. The posterior surface presents four grooves for the extensor tendons. The dorsal tubercle of Lister lies lateral to an oblique groove.
3. The medial surface is occupied by the *ulnar notch* for the head of the ulna.
4. The lateral surface is prolonged downwards to form the styloid (Greek *pillar*) process.
5. The inferior surface bears a triangular area for the scaphoid bone and a medial quadrangular area for the lunate bone. This surface takes part in forming the wrist joint (*see* Fig. 10.24).

Attachments (Figs 2.18 and 2.19)

1. The quadrate ligament is attached to the medial part of the neck.
2. The biceps brachii is inserted into the rough posterior part of the radial tuberosity. The anterior part of the radial tuberosity is covered by a bursa.
3. The oblique cord is attached on the medial side just below the radial tuberosity.
4. The radial head of the flexor digitorum superficialis takes origin from the anterior oblique line.
5. The extensor retinaculum is attached to the lower part of the sharp anterior border.
6. The interosseous membrane is attached to the lower three-fourths of the interosseous border.
7. The flexor pollicis longus takes origin from the upper two-thirds of the anterior surface.
8. The pronator quadratus is inserted into the lower part of the anterior surface and into the triangular area on the medial side of the lower end. The radial artery is palpated for 'radial pulse', as it lies on the pronator quadratus, lateral to the tendon of flexor carpi radialis (*see* Fig. 9.4).
9. The abductor pollicis longus and the extensor pollicis brevis arise from the posterior surface.
10. The supinator is inserted into the upper part of the lateral surface.
11. The pronator teres is inserted into the middle of the lateral surface.
12. The brachioradialis is inserted into the lowest part of the lateral surface just above the styloid process.
13. The articular disc of the inferior radioulnar joint is attached to the lower border of the ulnar notch (*see* Fig. 10.25).
14. The articular capsule of the wrist joint is attached to the anterior and posterior margins of the inferior articular surface.

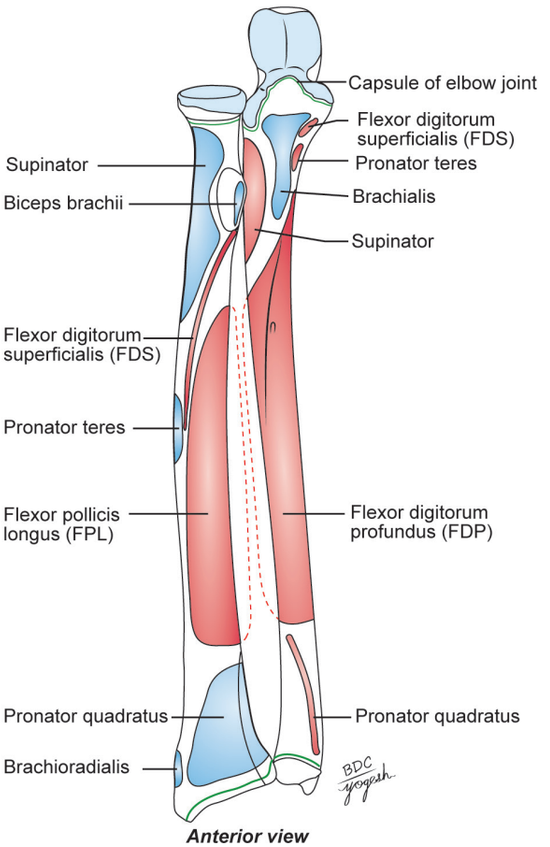


Fig. 2.18: Attachments of right radius and ulna: Anterior aspect

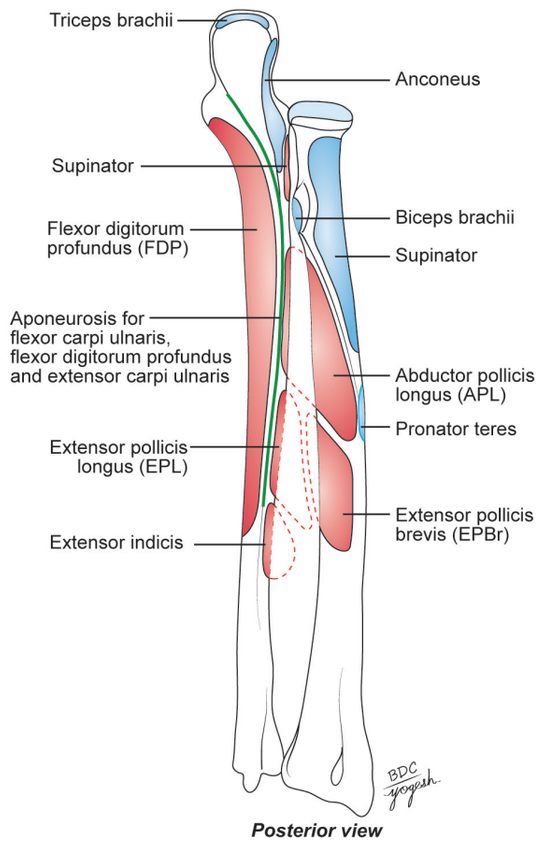


Fig. 2.19: Attachments of right radius and ulna: Posterior aspect

Structures related to the grooves are:

1st groove – between sharp (crest-like) lowest part of anterior border and styloid process gives passage to *abductor pollicis longus and extensor pollicis brevis.*

2nd groove – between styloid process and dorsal tubercle gives way to *extensor carpi radialis longus* and *extensor carpi radialis brevis* tendons.

3rd oblique groove – medial to dorsal tubercle gives passage to *extensor pollicis longus* tendon.

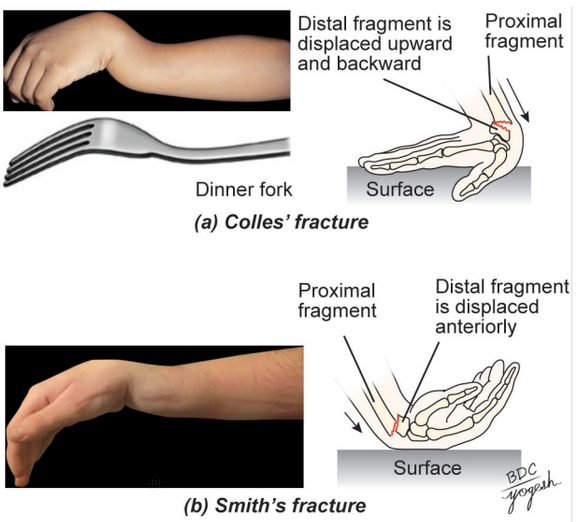
4th groove – on the medial aspect gives passage to tendons of *extensor digitorum, extensor indicis, posterior interosseous nerve* and *anterior interosseous artery.*

OSSIFICATION

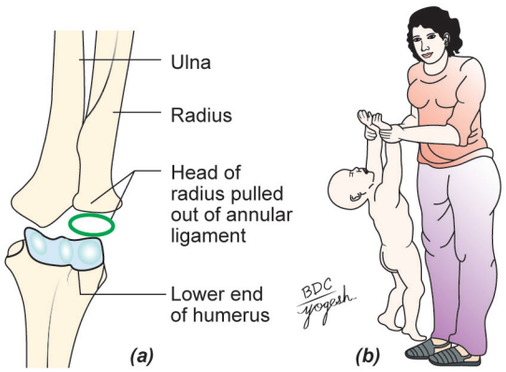
- The radius ossifies from one primary and two secondary centres as follows:
  1. One primary centre appears in 8th week of IUL – for shaft.
  2. One secondary centre appears in 1st year – for lower end and fuses with shaft by 17th–19th years.
  3. One secondary centre appears in 5th year – for upper end and fuses with shaft by 14th–17th years. Thus, lower end of radius is growing end.

CLINICAL ANATOMY

- *Colles' fracture*: The radius commonly gets fractured about 2 cm above its lower end, and it is called Colles' fracture (Fig. 2.20a). The distal fragment is displaced upwards and backwards, which creates the dinner-fork (bayonet-like) deformity.
- *Smith's fracture*: In this fracture, the distal fragment gets displaced anteriorly (reverse of Colles' fracture) (Fig. 2.20b).
- *Pulled elbow* (subluxation of head of radius): It occurs due to the sudden powerful jerk on the hand of a child with dislodgement of the head of the radius from the annular ligament (Figs 2.21a and b).



Figs 2.20a and b: (a) Colles' fracture with dinner fork deformity and (b) Smith's fracture



Figs 2.21a and b: (a) Position of bones and (b) pulled elbow

ULNA

The ulna is the medial bone of the forearm and is homologous with the fibula of the lower limb (Figs 2.22a and b, Flowchart 2.5).

Side Determination and Anatomical Position

For the side determination, hold the ulna vertically in such a way that:

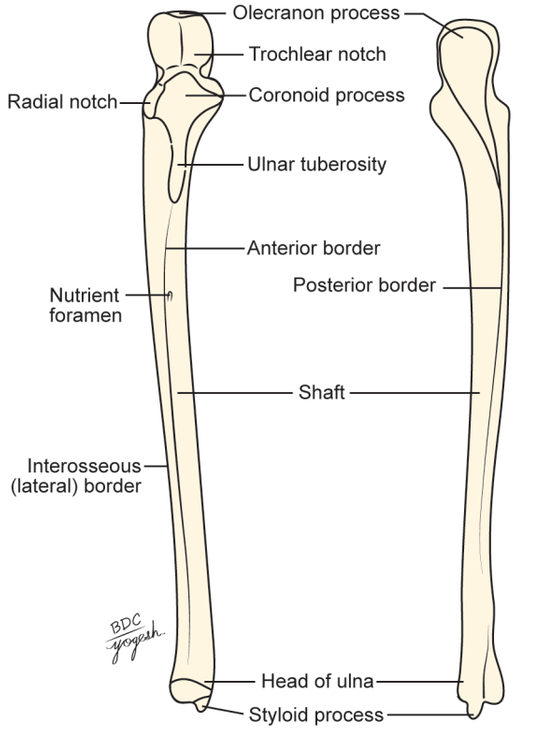
1. The upper end is hook-like, with its concavity directed forwards.
2. The lateral border of the shaft is sharp and crest-like.
3. Pointed styloid process lies posteromedial to the rounded head of ulna at its lower end.

Features

Upper End

The upper end presents the olecranon and coronoid processes, and the trochlear and radial notches (Plate 2.3, Fig. 2.22).

1. **Olecranon process:** It projects upwards from the shaft. It has superior, anterior, posterior, medial and lateral surfaces.
   - The *superior surface* in its posterior part shows a roughened area.
   - The *anterior surface* is articular; it forms the upper part of the trochlear notch.
   - The *posterior surface* forms a triangular subcutaneous area, which is separated from the skin by a *bursa.*
   - The *medial surface* is continuous inferiorly with the medial surface of the shaft.
   - The *lateral surface* is smooth, continues as posterior surface of shaft.
2. **Coronoid process** (Greek *like crow's beak*): It projects forwards from the shaft just below the olecranon process. It has four surfaces: superior, anterior, medial and lateral.
   - The *superior surface* forms the lower part of the trochlear notch.
   - The *anterior surface* is triangular and rough. Its lower corner forms the *ulnar tuberosity*.



Figs 2.22a and b: Features of (a) anterior surface and (b) posterior surface of ulna

   - The upper part of its *lateral surface* is marked by the *radial notch* for the head of the radius. The annular ligament is attached to the anterior and posterior margins of the notch. The lower part of the lateral surface forms a depressed area (supinator fossa) to accommodate the radial tuberosity. It is limited behind by a ridge called the *supinator crest*.
   - *Medial surface* is continuous with medial surface of the shaft.
3. **Trochlear notch:** It forms a C-shaped articular surface that articulates with the trochlea of the humerus to form the elbow joint.
4. **Radial notch:** It articulates with the head of the radius to form the superior radioulnar joint.

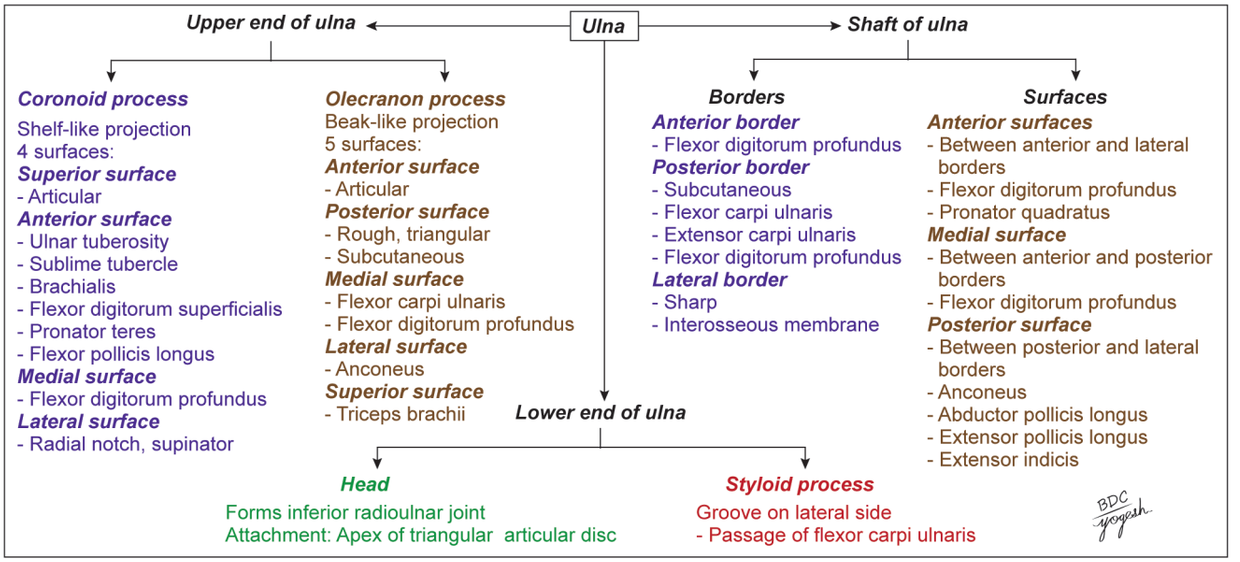
Shaft

The shaft has three borders and three surfaces (Plate 2.3c, Figs 2.22a and b).

Borders

1. **Interosseous** or **lateral border:** It is the sharpest in its middle two-fourths. Inferiorly, it is ill-defined. Superiorly, it is continuous with the supinator crest.
2. **Anterior border:** It is thick and rounded. It begins above on the medial side of the ulnar tuberosity and terminates at the medial side of the styloid process.
3. **Posterior border:** It is subcutaneous. It begins above, at the apex of the triangular subcutaneous area at the back of the olecranon process, and terminates at the base of the styloid process.

Flowchart 2.5: Features of ulna



Surfaces

1. **Anterior surface:** It lies between the anterior and interosseous borders. A nutrient foramen is present on the upper part of this surface. It is directed upwards. The nutrient artery is derived from the anterior interosseous artery.
2. **Medial surface:** It lies between the anterior and posterior borders.
3. **Posterior surface:** It lies between the posterior and interosseous lateral borders. It is subdivided into three areas by two lines. An oblique line divides it into upper and lower parts. The lower part is further divided by a vertical line into a medial and a lateral area.

Lower End

The lower end has head and a styloid process.

- **Head:** Laterally, it articulates with the ulnar notch of the radius to form the *inferior radioulnar joint*. Its inferior surface is smooth.
- **Styloid process:** It projects downwards from postero-medial side of lower end of the ulna. Posteriorly, between the head and the styloid process, there is a groove for the tendon of the extensor carpi ulnaris (Fig. 2.25b).

Attachments (Figs 2.18 and 2.19)

1. Triceps brachii is inserted into the rough posterior part of the superior surface of the olecranon process. The anterior part of the surface is covered by a bursa.
2. Anconeus is inserted into the lateral aspect of the olecranon process and the upper one-fourth of the posterior surface of the shaft.
3. Capsular ligament of the elbow joint is attached to the margins of the trochlear notch.
4. Annular ligament of the superior radioulnar joint is attached to the anterior and posterior margins of radial notch of ulna.
5. Anterior band and oblique band of ulnar collateral ligament are attached to medial margin of anterior surface of coronoid process.
6. Posterior band and oblique band of ulnar collateral ligament are attached to medial surface of olecranon process (*see* Fig. 10.12).
7. Brachialis is inserted into the anterior surface of the coronoid process, including the ulnar tuberosity.
8. Supinator arises from the supinator crest and from the triangular area in front of the crest.
9. Flexor digitorum superficialis (ulnar head) arises from a tubercle at the upper end of the medial margin of the coronoid process.
10. Pronator teres (ulnar head) arises from the medial margin of the coronoid process.
11. Oblique cord is attached to the ulnar tuberosity.
12. Interosseous membrane is attached to the interosseous border.
13. Flexor carpi ulnaris (ulnar head) arises from the medial surface of the olecranon process and from the posterior border.
14. Extensor carpi ulnaris arises from the posterior border.
15. Flexor digitorum profundus (Latin *deep*) arises from:
    a. Upper three-fourths of the anterior and medial surfaces of the shaft.
    b. Medial surfaces of the coronoid and olecranon processes.
    c. Posterior border of the shaft through an aponeurosis, which also gives origin to the flexor carpi ulnaris and the extensor carpi ulnaris.
16. Pronator quadratus takes origin from the oblique ridge on the lower part of the anterior surface.

17. The lateral part of the posterior surface gives origin from above downwards to the abductor pollicis longus, the extensor pollicis longus and the extensor indicis.
18. Ulnar collateral ligament of the wrist is attached to the styloid process.
19. Articular disc of the inferior radioulnar joint is attached by its apex to a small rough area just lateral to the styloid process (*see* Fig. 10.25).

OSSIFICATION

The ulna ossifies from one primary and two secondary centres as follows:

- The primary centre – For shaft appears during 8th week of intrauterine life.
- The secondary centre

  One for upper end (at olecranon process) appears during 11th year – fuses with shaft by the 16th year.

  One for lower end appears by 6th year and fuses with shaft by shaft by the 18th year.

  Thus, the lower end of ulna is the growing end.

CLINICAL ANATOMY

- The ulna is the stabilising bone of the forearm, with its trochlear notch gripping the lower end of the humerus. On this foundation, the radius can pronate and supinate for efficient working of the upper limb.
- The shaft of the ulna may fracture either alone or along with that of the radius. Cross-union between the radius and ulna must be prevented to preserve pronation and supination of the hand.
- *Nightstick fracture* is the fractured shaft of ulna without any other fracture. It occurs due to direct hit on shaft of ulna, may occur when watchman raises his arm against trauma.
- *Monteggia fracture* is the fracture of upper one-third of ulna with dislocation of the head of radius.
- *Hume fracture* is a fracture of olecranon with anterior dislocation of head of radius.
- *Madelung's deformity* is dorsal subluxation (displacement) of the lower end of the ulna, due to retarded growth of the lower end of the radius (Fig. 2.23).

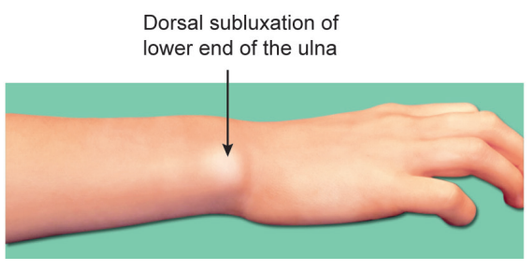


Fig. 2.23: Madelung's deformity

***Competency*:**
AN8.3 Identify and name various bones in articulated hand, specify the parts of metacarpals and phalanges and enumerate the peculiarities of pisiform.

CARPAL BONES

The carpus is (Greek *Karpos, wrist*) made up of 8 carpal bones, which are arranged in two rows (Figs 2.24 and 2.25a and b, Plate 2.4, Flowchart 2.6).

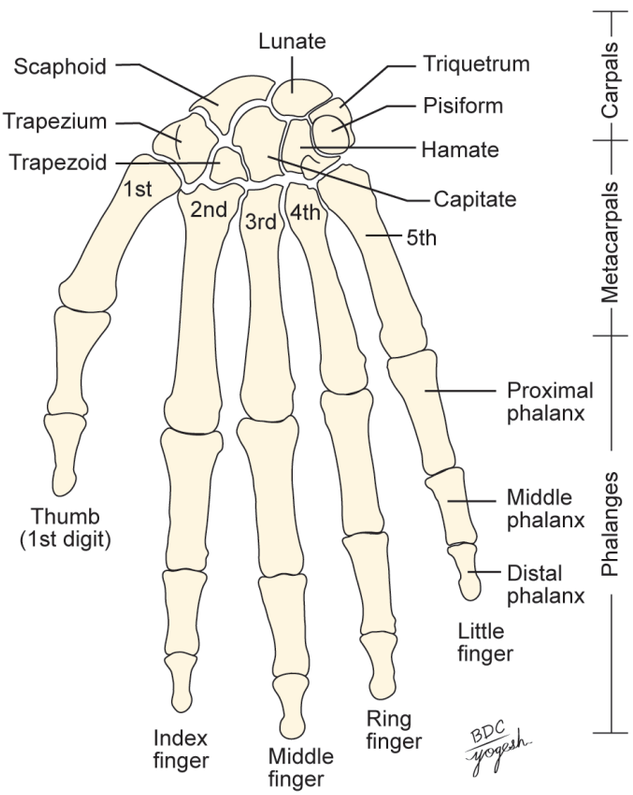
A. The proximal row (from lateral to medial side):
   1. Scaphoid (Greek *boat, wrist*)
   2. Lunate (Latin *moon-shaped*)
   3. Triquetral (Latin *three-cornered*)
   4. Pisiform (Greek *pea*).

B. The distal row (from lateral to medial):
   1. Trapezium (Greek *four-sided geometric figure*)
   2. Trapezoid (Greek *baby's shoe*)
   3. Capitate (Latin *head*)
   4. Hamate (Latin *hook*).

(*Mnemonic*: She looks too pretty, try to catch her).

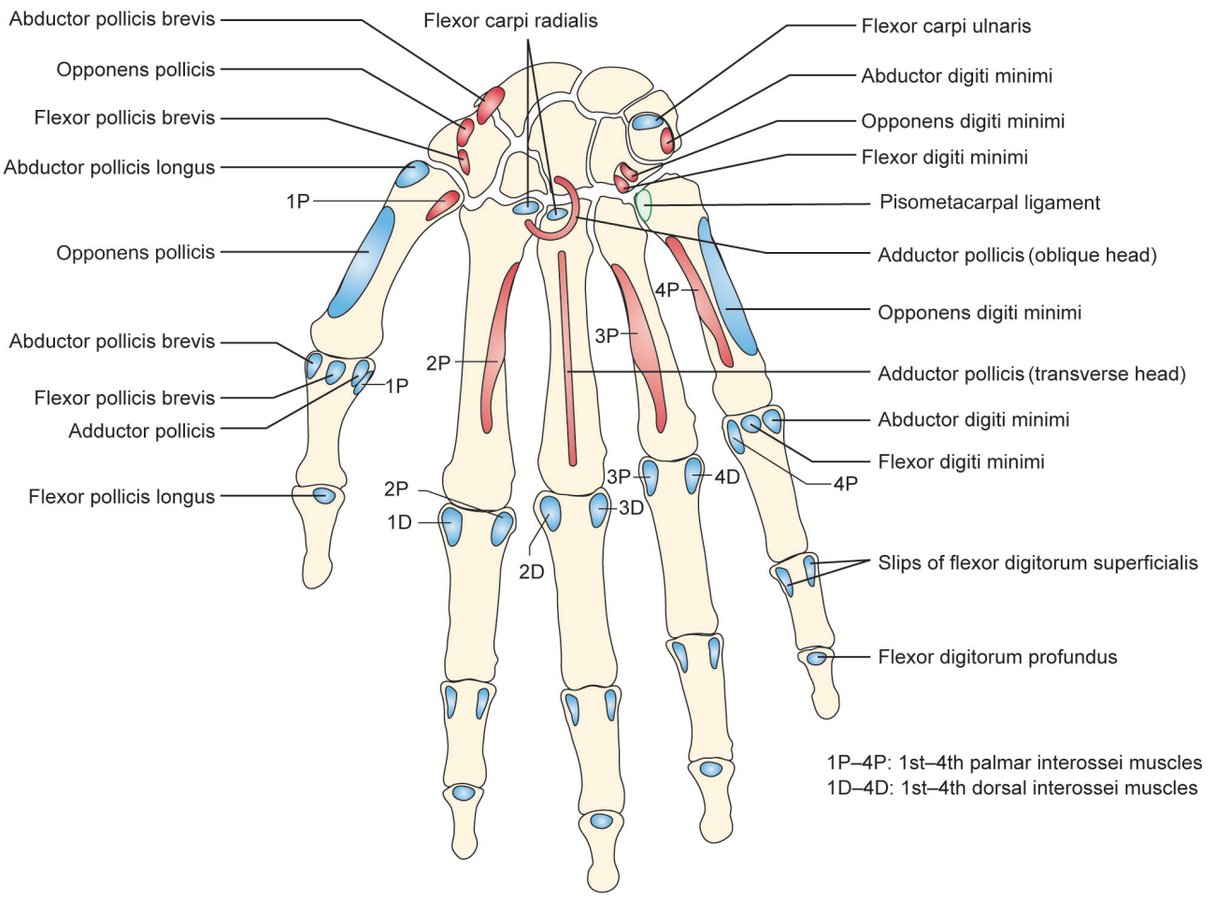
Identification

The individual carpal bones can be identified by their shape and the side can be determined based on their articular surfaces. For details, *refer* Table 2.1 (Figs 2.24 and 2.25 a and b, Plate 2.4).

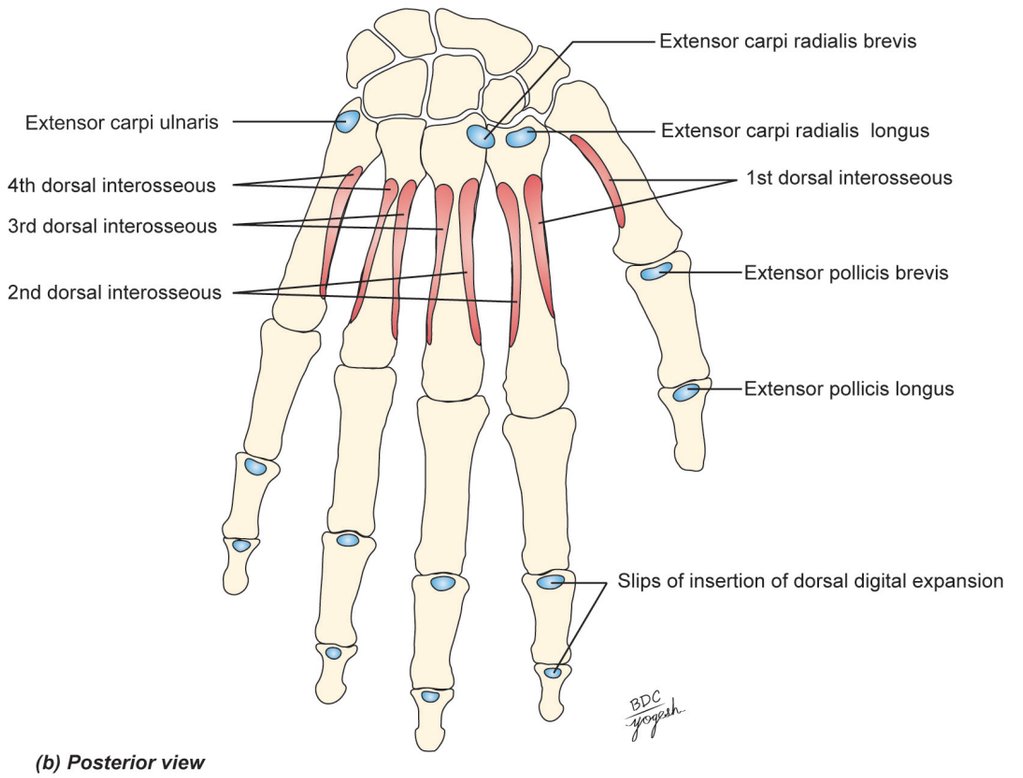


Anterior (palmar) view

Fig. 2.24: Skeleton of the right hand: Palmar aspect



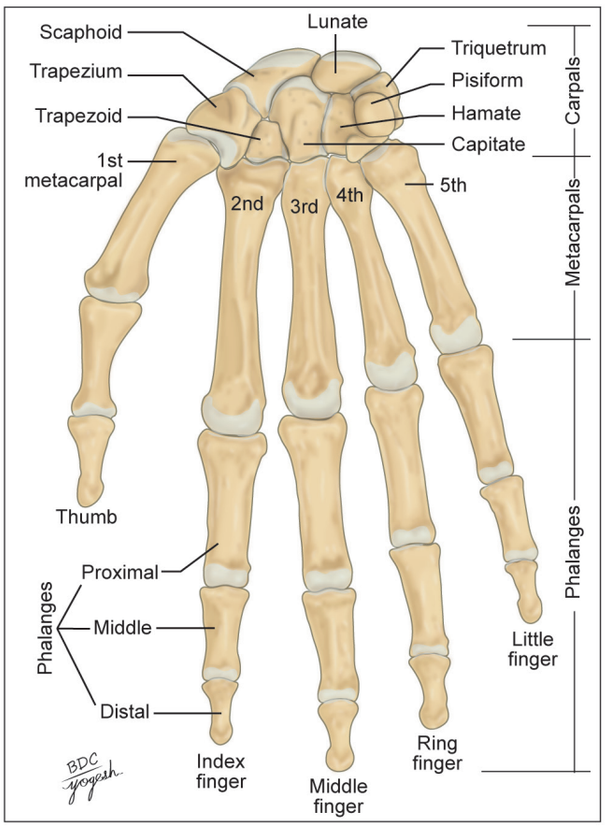
(a) Anterior view



(b) Posterior view

Figs 2.25a and b: Attachments on the skeleton of hand: (a) Anterior aspect and (b) posterior aspect

Plate 2.4: Bones of the hand



OSSIFICATION

The carpal bones ossify from secondary centres except for capitate and hamate, as follows:

Capitate – 2nd month of IUL

Hamate – 3rd month of IUL

Triquetrum – 3rd year

Lunate – 4th year

Scaphoid, trapezium, trapezoid – 5th year

Pisiform – 12th year (9–12 years).

Competency:

AN8.4 Describe scaphoid fracture and explain the anatomical basis of avascular necrosis.

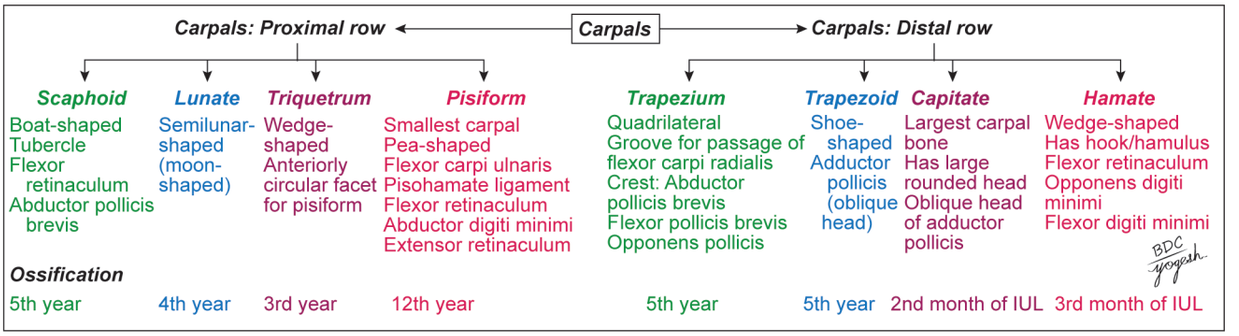
CLINICAL ANATOMY

- *Fracture of the scaphoid* is quite common in a fall on the outstretched hand. Normally, the scaphoid has two nutrient arteries from the radial artery, one entering the palmar surface and the other the dorsal surface. Occasionally (13% of cases), the proximal part of scaphoid receives supply from its distal part. In these cases, the fracture of proximal part of scaphoid may result in a lack of blood supply, and it may result in avascular necrosis or nonunion (Fig. 2.26).
- Anterior dislocation of the lunate may produce *carpal tunnel syndrome* like features (Figs 2.27a to c).

TABLE 2.1: Identification of the individual carpal bones (Figs 2.24 and 2.25 a and b, Plate 2.4)

Carpal bone	*Identification features*	*Attachments*
1. Scaphoid	Boat-shaped. Has tubercle on lateral part of its anterior surface. Has constricted neck.	Tubercle of scaphoid: Abductor pollicis Brevis. Flexor retinaculum.
2. Lunate	Moon-shaped. Small semilunar articular surface for the scaphoid is on the lateral side. Quadrilateral articular surface for the triquetral is on the medial side.	–
3. Triquetral	Pyramidal-shaped. Oval facet on the distal part of its anterior surface for articulation with pisiform.	–
4. Pisiform	Pea-shaped and smallest carpal bone Oval facet for the triquetral lies on the proximal part of the dorsal surface. Lateral surface is grooved by the ulnar nerve. Sesamoid bone in the tendon of flexor carpi ulnaris.	Insertion to flexor carpi ulnaris, and abductor digiti minimi. Flexor and extensor retinaculae
5. Trapezium	Quadrilateral in shape. Groove (for the tendon of the flexor carpi radialis) and crest on its anterior surface.	Crest: Origin to the abductor pollicis brevis, flexor pollicis brevis, opponens pollicis. Flexor retinaculum.
6. Trapezoid	Shoe-shaped. Posterior surface is larger than anterior.	Anterior surfaces: Some fibers of oblique head of adductor pollicis arise.
7. Capitate	Largest carpal bone. Rounded head on its proximal surface.	
8. Hamate	Wedge-shaped. Hook-like process projects from distal part of its anterior surface.	Hook: Flexor retinaculum, origin of flexor digiti minimi and opponens digiti minimi.

Flowchart 2.6: Features of carpals



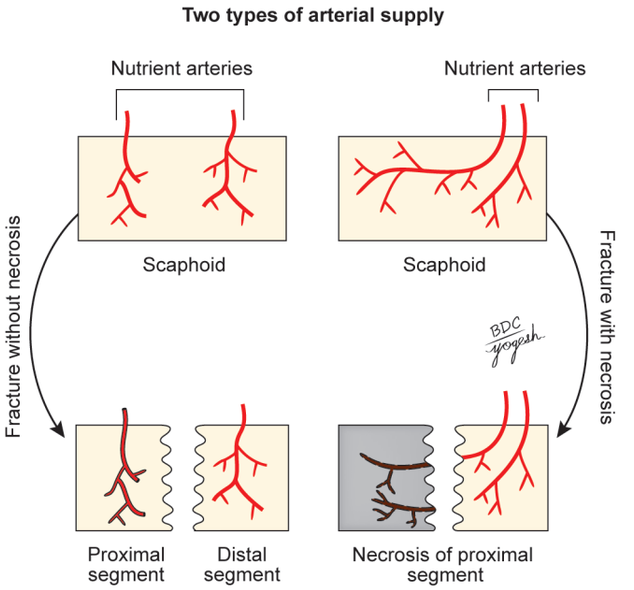
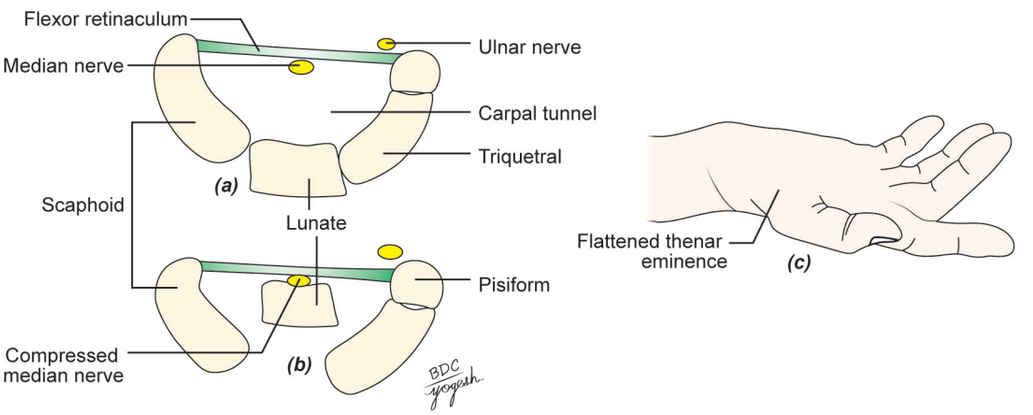


Fig. 2.26: Fracture of the scaphoid



Figs 2.27a to c: (a) Normal position of nerves, (b) dislocation of lunate leading to carpal tunnel syndrome and (c) ape-like deformity of the hand (flattened thenar eminence)

METACARPAL BONES

1. The metacarpal bones are 5 miniature long bones, which are numbered from lateral to the medial side (Figs 2.24 and 2.25 a and b, Plate 2.4).
2. Each bone has a head, shaft and base.
   a. The head is round and placed distally.
   b. The shaft is concave on the palmar surface. Its dorsal surface bears a flat triangular area in its distal part.
   c. The base lies proximally and smaller than the head.

The features and attachments of the individual metacarpals are given in Table 2.2.

TABLE 2.2: Features of the individual metacarpal bones

Metacarpal	*Identification features*	*Attachments*
1st	Shortest and stoutest of all metacarpals. Base has a concavoconvex articular surface for the trapezium. Head is less convex and broader than other metacarpals. The anterolateral surface is larger than the anteromedial.	*Base*: Insertion of abductor pollicis longus on the lateral side of its base, and origin of 1st palmar interossei *Shaft*: Insertion of opponens pollicis on its anterolateral surface, origin of lateral head of 1st dorsal interossei.
2nd	Its base is grooved. The medial edge of the groove is larger. The medial side of the base bears an articular strip, which is constricted in the middle.	*Base*: Insertion of flexor carpi radialis on its palmar surface, extensor carpi radialis longus on its dorsal surface, and origin of oblique head of the adductor pollicis from its palmar surface. *Shaft*: Origin of medial head of the 1st dorsal interosseous muscle.
3rd	Its base has a styloid process on its dorsolateral side. The lateral side of the base bears an articular strip, which is constricted in the middle. The medial side of the base has two small oval facets for the 4th metacarpal.	*Base*: Insertion of flexor carpi radialis on its palmar surface and extensor carpi radialis brevis on its dorsal surface, origin of oblique head of the adductor pollicis from its palmar surface. *Shaft*: Origin of transverse head of the adductor pollicis from the ridge on its palmar surface, origin of lateral head of 3rd dorsal interosseous muscle.
4th	Its base has two small oval facets on its lateral side for the 3rd metacarpal and a single facet on its medial side for the 5th metacarpal.	*Shaft*: Origin of 3rd palmar, 3rd dorsal and lateral head of the 4th dorsal interossei muscles. *Base*: Insertion of extensor carpi ulnaris.
5th	Its base has strip-like facet on the lateral side for the 4th metacarpal. The medial side of the base is non-articular and has a tubercle.	*Shaft*: Insertion of opponens digiti minimi. Origin of 4th palmar and medial head of 4th dorsal interossei muscle.

Note: The 1st metacarpal is rotated medially through 90°. Hence, its movements take place at right angles to those of other digits. Palmar surface is divided into larger anterolateral and smaller anteromedial areas by a ridge.

OSSIFICATION

- The shafts ossify from one primary centre each, which appears during the 9th week of development.
- A secondary centre for the head appears in the 2nd–5th metacarpals, and for the *base* in the 1st metacarpal. It appears during the 2nd–3rd year and fuses with the shaft at about 16–18 years (Fig. 2.28).

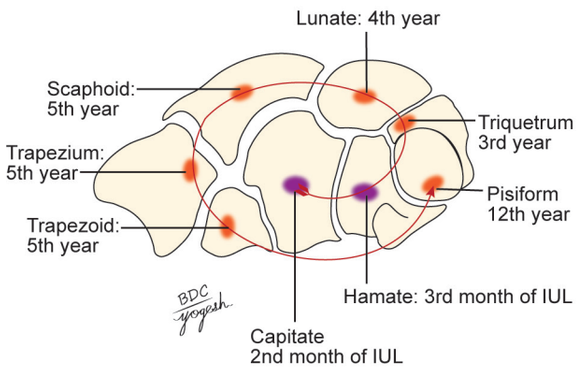


Fig. 2.28: Ossification of carpal bones

CLINICAL ANATOMY

- *Bennett's fracture* is a fracture of the base of the 1st metacarpal (Fig. 2.29).
- *Boxer's fracture*: It is a fracture of neck of metacarpals due to violent trauma, with anterior displacement of distal fragment. It commonly involves the 5th metacarpal (Fig. 2.30).
- Tubercular or syphilitic disease of the metacarpals or phalanges in a child is located in the middle of the diaphysis rather than in the metaphysis because the nutrient artery breaks up into a plexus immediately upon reaching the medullary cavity. In adults, however, the chances of infection are minimised because the nutrient artery is replaced (as the major source of supply) by periosteal vessels.
- ***Polydactyly:*** It is an abnormality of fingers or toes. There are extra digits which are not formed fully. These have poor muscular development and are useless. The extra digit is either medial or lateral to the hand or foot. It is inherited as a dominant characteristic (Fig. 2.31).

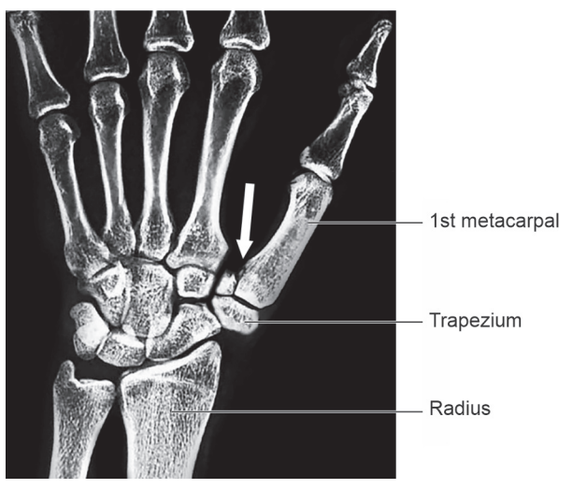


Fig. 2.29: Bennett's fracture



Fig. 2.30: Boxer's fracture

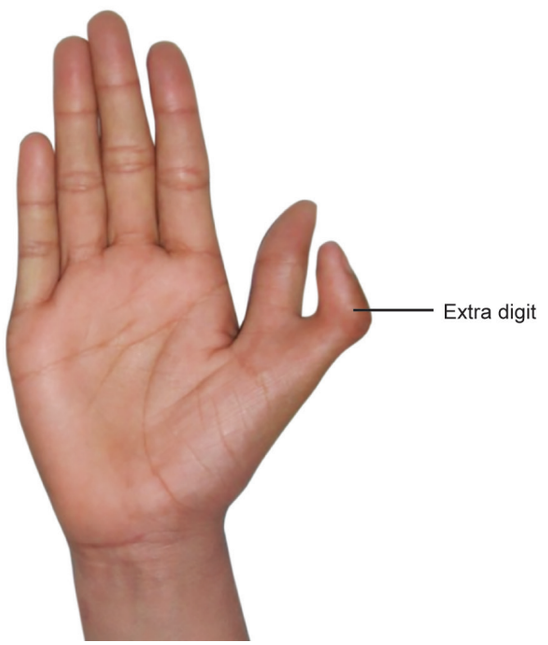


Fig. 2.31: Six digits (polydactyly)

PHALANGES

There are 14 phalanges in each hand, three for each finger and two for the thumb. Each phalanx has a base, a shaft and a head (Figs 2.24 and 2.25a and b, Plate 2.4).

Base

In the proximal phalanx, the base is marked by a concave oval facet for articulation with the head of the metacarpal bone. In the middle phalanx, or a distal phalanx, it is marked by two small concave facets separated by a smooth ridge.

Shaft

The shaft tapers towards the head. The dorsal surface is convex from side-to-side. The palmar surface is flattened from side-to-side, but is gently concave in its long axis.

Head

In the proximal and middle phalanges, the head has a pulley-shaped articular surface. In the distal phalanges, the head is non-articular and is marked anteriorly by a rough horseshoe-shaped tuberosity, which supports the sensitive pulp of the finger/tip.

Attachments

1. *Base of the distal phalanx:*
   a. Flexor digitorum profundus is inserted on the palmar surface.
   b. Two-sided slips of digital expansion fuse to be inserted on the dorsal surface. These also extend the insertion of lumbrical and interossei muscles.
2. *Middle phalanx:*
   a. Two slips of flexor digitorum superficialis are inserted on each side of the shaft.
   b. Extensor digitorum is inserted on the dorsal surface of the base through dorsal digital expansion.
3. *Proximal phalanx:*
   a. On each side of the base, parts of the *lumbricals* and interossei are inserted.
4. *Base of proximal phalanx of thumb:*
   a. Abductor pollicis brevis and flexor pollicis brevis are inserted on the lateral side.
   b. Adductor pollicis and the 1st palmar interosseous are inserted on the medial side.
   c. Extensor pollicis brevis is inserted on the dorsal surface.
5. *Base of distal phalanx of thumb:*
   a. Flexor pollicis longus is inserted on its palmar side.
   b. Extensor pollicis longus is inserted on its dorsal side.
6. *Base of proximal phalanx of little finger:* Abductor digiti minimi and flexor digiti minimi are inserted on its medial side.

OSSIFICATION

- The shaft of each phalanx ossifies from a primary centre which appears during the 8th week of development in the distal phalanx, 10th week in the proximal phalanx and 12th week in the middle phalanx.
- The secondary centre appears for the base during 2–4 years and fuses with the shaft during 16–18 years (Fig. 2.29).

CLINICAL ANATOMY

Fracture of distal phalanx of middle finger is commonest. It is treated by splinting the injured phalanx to the adjacent normal finger. This is called 'buddy splint' (Fig. 2.32).



Fig. 2.32: Buddy splint of the fingers

VIDEO

Video 1.2.1 Clavicle ▶ Introduction and general features ▶ Attachments
Video 1.2.2 Scapula ▶ General features and side determination ▶ Attachments, relations and joints of scapula ▶ Movements of shoulder girdle
Video 1.2.3 Humerus ▶ Introduction, general features and side identification ▶ Attachments and relations
Video 1.2.4 Radius ▶ Introduction, general features and side identification ▶ Attachments and relations ▶ Attachments of muscles
Video 1.2.5 Ulna ▶ General features and side identification ▶ Attachments and relations
Video 1.2.6 Hand ▶ General features ▶ Attachments and relations ▶ Extensor retinaculum

Facts to Remember

- Clavicle is the most commonly fractured bone in the body.
- Commonest site of fracture clavicle is the junction of its lateral 1/3rd and medial 2/3rd.
- The strongest ligament of the upper limb is coracoclavicular ligament.
- The commonest fracture of the humerus is supracondylar fracture.
- The most commonly injured nerve in supracondylar fracture of humerus is the median nerve.
- Axillary, radial and ulnar nerves are intimately related to humerus and are liable to be injured.
- The most common site of the fracture of radius is distal end of radius 2.5 cm proximal to the wrist.
- Radial pulse is felt close to the lower end of anterior surface of shaft of radius.
- The most commonly fractured carpal bone is scaphoid.
- The most commonly dislocated carpal bone is lunate.
- The largest carpal bone and the first carpal bone to ossify is capitate.
- Pisiform bone is a sesamoid bone in the tendon of flexor carpi ulnaris muscle.
- The first metacarpal is the shortest and stoutest metacarpal.
- Bennett' fracture – fracture of base of the 1st metacarpal.
- Boxer's fracture – fracture of neck of metacarpals, commonly involves 5th metacarpal.
- All metacarpals have epiphysis at their distal end or head, except the first metacarpal, which has epiphysis at its proximal end or base.
- The third metacarpal is the longest, and the axis of abduction and adduction passes through its centre.

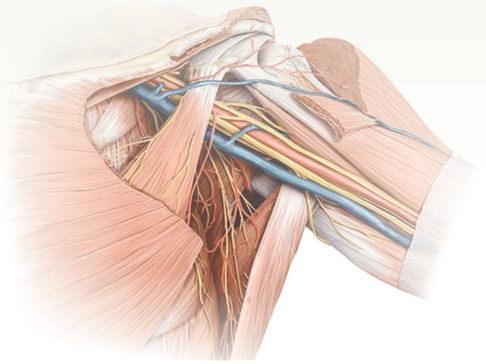
BDC's Anatomy *e*-book

Digital Content available with the BDC's Anatomy ebook:

1. Functions of the clavicle
2. Ossification of humerus, radius and ulna
3. Table e2.1: Ossification of humerus, radius and ulna
4. Importance of capsular attachments and epiphyseal lines
5. Table e2.2: Relation of capsular attachments and epiphyseal lines
6. Table e2.3: Differences between metacarpals and metatarsals
7. Features of the individual carpal bones
8. Sesamoid bones in upper limb
9. Further reading
10. Viva voce questions

Chapter

3



Pectoral Region

The pectoral region (Latin *pectus* = chest) lies on the front of the chest. It essentially consists of structures that connect the upper limb to the anterolateral chest wall. Breast lies in this region.

Competency:
AN13.6 Identify and demonstrate important bony landmarks of upper limb: Jugular notch, sternal angle, acromial angle, spine of the scapula, vertebral level of the medial end and inferior angle of the scapula.

SURFACE LANDMARKS

Surface landmarks are useful for clinical integration of the gross anatomy. The following features of the pectoral region can be seen or felt on the surface of body (Fig. 3.1).

1. **Clavicle:** It lies horizontally at the root of the neck, separating it from the front of the chest. The bone is subcutaneous, therefore, palpable throughout its length.
2. **Jugular notch** (interclavicular or suprasternal notch): It lies between the medial ends of the clavicles, at the superior border of the manubrium sterni.
3. **Sternal angle** (angle of Louis): It is felt as a transverse ridge about 5 cm below the jugular notch. Importance of sternal angle.
   - *Rib identification*: Second costal cartilage articulates on either side, opposite the sternal angle. It helps in counting ribs.
   - *Vertebral level*: Sternal angle lies at the level of lower border of the fourth thoracic vertebra.
4. **Epigastric fossa** (pit of the stomach): It is the depression in the infrasternal angle. The fossa overlies the xiphoid process and is bounded on each side by the seventh costal cartilage.
5. **Nipple:** It is markedly variable in position in females. In males and immature females, it usually lies in the fourth intercostal space just medial to the midclavicular line; or 10 cm from the midsternal line. Nipple is surrounded by a pigmented circular area called *areola*.

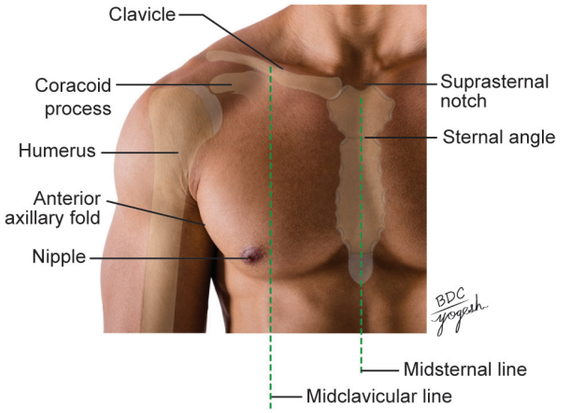


Fig. 3.1: Surface landmarks of pectoral region

6. **Infraclavicular fossa:** It is the junction of the clavicle. It is medially by the pectoralis major, laterally by the anterior fibres of the deltoid, and superiorly by the clavicle.
7. Coracoid process of scapula lies 2.5 cm below the clavicle in the infraclavicular fossa.
8. Acromion process of the scapula (*acron* = summit; *omos* = shoulder) lies subcutaneously forming the top of the shoulder.
9. **Axilla** (Latin armpit): It is a pyramidal space between the arm and chest.

Anatomical Lines

- The following anatomical lines are useful for clinical description of structures (Figs 3.1 and 3.2).
- *Midsternal line*: It is the middle line of sternum, and it passes through the midsagittal plane.
- *Parasternal line*: It lies along the lateral edge of sternum.
- *Midclavicular line*: It is an imaginary line passing through the middle of clavicle, tip of 9th costal cartilage and midinguinal point.
- *Anterior axillary line*: It lies along the anterior axillary fold.
- *Posterior axillary line*: It lies along the posterior axillary fold.
- *Midaxillary line*: It lies midway between anterior and posterior axillary folds.

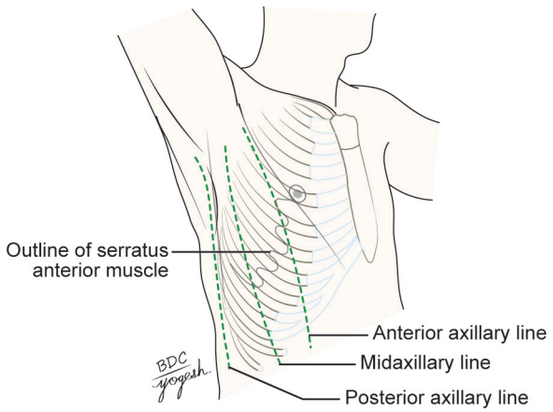


Fig. 3.2: Anatomic reference lines of lateral chest wall

DISSECTION

Mark the following points:

i. Centre of the suprasternal notch
ii. Xiphoid process
iii. 7 o'clock position at the margin of areola (left side), and 5 o'clock position at the margin of areola (right side)
iv. Lateral end of clavicle (Fig. 3.3).

Give an incision vertically down from the first point to the second, which joins the centre of the suprasternal notch to the xiphoid process in the midsagittal plane. From the lower end of this line, extend the incision upward and laterally till you reach to the third point on the areolar margin.

Encircle the areola and carry the incision upwards and laterally till the anterior axillary fold is reached.

Continue the line of incision downwards along the medial border of the upper arm till its junction of upper one-third and lower two-thirds. Extend this incision transversely across the arm.

Make another incision horizontally from the xiphoid process across the chest wall till the posterior axillary fold.

Lastly, give horizontal incision from the centre of suprasternal notch to the lateral (acromial) end of the clavicle.

Reflect the two flaps of skin towards the upper limb.

SUPERFICIAL FASCIA

The superficial fascia of the pectoral region contains moderate amount of fat.

Contents

1. Fat
2. Loose connective tissue
3. Cutaneous nerves
4. Cutaneous blood vessels
5. Platysma
6. Breast (mammary gland).

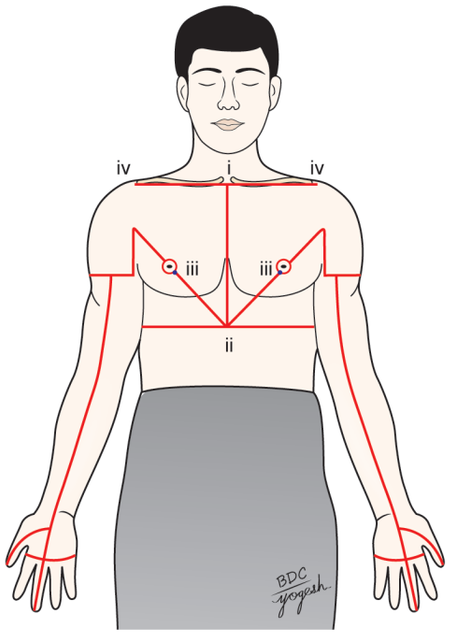


Fig. 3.3: Points and lines of incision

Cutaneous Nerves of the Pectoral Region

1. **Medial, intermediate and lateral supraclavicular nerves:** They are branches of the cervical plexus (C3, C4). They supply the skin over the upper half of the deltoid and from the clavicle down to the second rib.
2. **Second to sixth intercostal nerves:** The *anterior* and *lateral cutaneous* branches of the 2nd to 6th intercostal nerves supply the skin below the level of the second rib. The intercostobrachial nerve of T2 supplies the skin of the floor of the axilla and the upper half of the medial side of the arm (Fig. 3.4).

It is of interest to note that the area supplied by spinal nerves C3 and C4 directly meets the area supplied by spinal nerves T2 and T3. This is because of the fact that the intervening nerves (C5–C8 and T1) have been 'pulled away' to supply the upper limb (Fig. 3.5).

Cutaneous Vessels

The anterior cutaneous nerves are accompanied by the *perforating branches of the internal thoracic artery*. The 2nd, 3rd and 4th of these branches are large in females for supplying the breast. The lateral cutaneous nerves are accompanied by the *lateral cutaneous branches of the posterior intercostal arteries*.

Platysma

The platysma (Greek *broad*) is a thin, broad sheet of subcutaneous muscle. The fibres of the muscle arise from the deep fascia covering the pectoralis major; run upwards and medially, crossing the clavicle and the side of the neck, and are inserted into the base of the mandible and into skin over the posterior and lower part of the face. The platysma is supplied by a branch of the *facial nerve*. When the angle of the mouth is pulled down, the muscle contracts and wrinkles the skin of the neck. The platysma may protect the external jugular vein (which underlies the muscle) from external pressure.

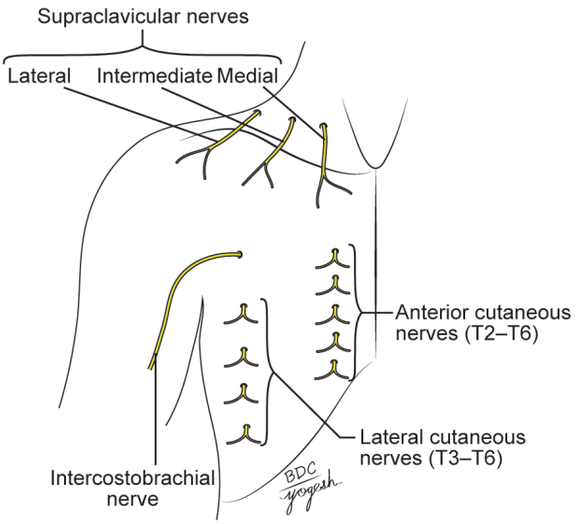


Fig. 3.4: Cutaneous nerves of the pectoral region

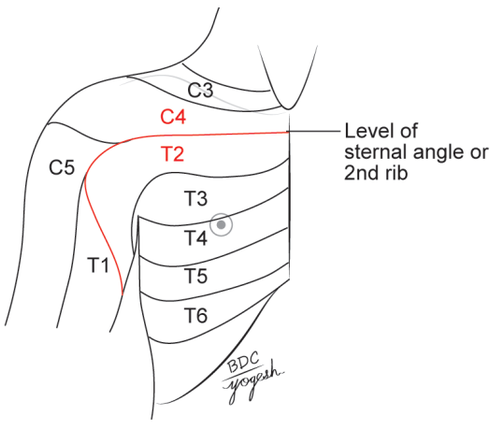


Fig. 3.5: Areas supplied by cutaneous nerves of the pectoral region

Competency:
AN9.2 Describe the location, extent, deep relations, structure, age changes, blood supply, lymphatic drainage, microanatomy and applied anatomy of breast.

MAMMARY GLAND/BREAST

Mammary gland is a modified sweat gland located in the superficial fascia of the pectoral region (Latin *mamma* = breast) (Plate 3.1, Flowchart 3.1).

The glandular tissue is found in both sexes, but is rudimentary in the male. It is well developed in the female after puberty. It forms an important accessory organ of the female reproductive system, and provides nutrition to the newborn in the form of milk.

Location

The breast lies in the superficial fascia of the pectoral region. A small extension of the superolateral part, called the *axillary tail of Spence*, passes through an opening in the deep fascia and lies in the axilla (Fig. 3.6). The opening is called *foramen of Langer*.

Shape

The shape of breast is variable. It may be hemispherical, conical, pyriform, pendulous or flat.

Extent of the Base

1. Vertically, it extends from the 2nd to the 6th ribs.
2. Horizontally, it extends from the lateral border of the sternum to the midaxillary line (Fig. 3.5).

Deep Relations

The deep surface of the breast is related to the following structures from superficial to deep (Figs 3.7 and 3.8).

1. Deep fascia (pectoral fascia) covering the pectoralis major.
2. Three muscles: *Pectoralis major, the serratus anterior and the external oblique muscle of the abdomen*.
3. **Retromammary space:** The breast is separated from the pectoral fascia by loose areolar tissue, called the *retromammary space*. Because of the presence of this loose tissue, the normal breast can be moved freely over the pectoralis major.

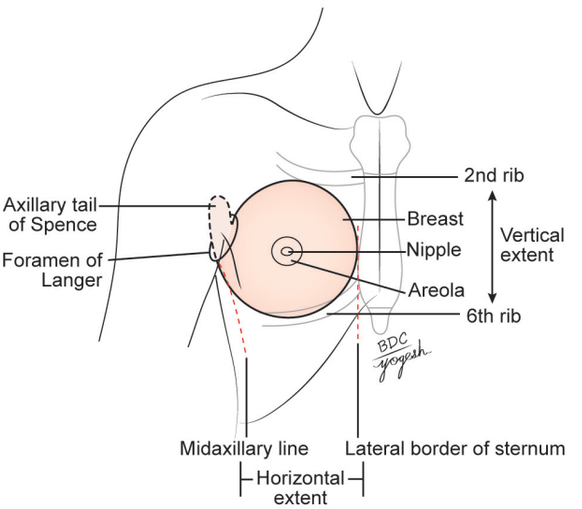


Fig. 3.6: Location and extent of right breast

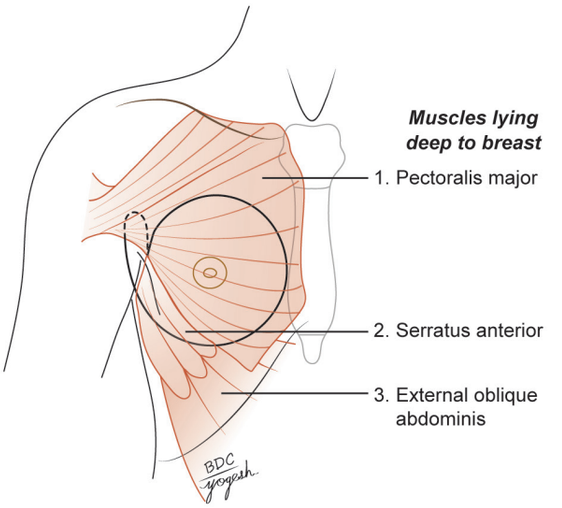
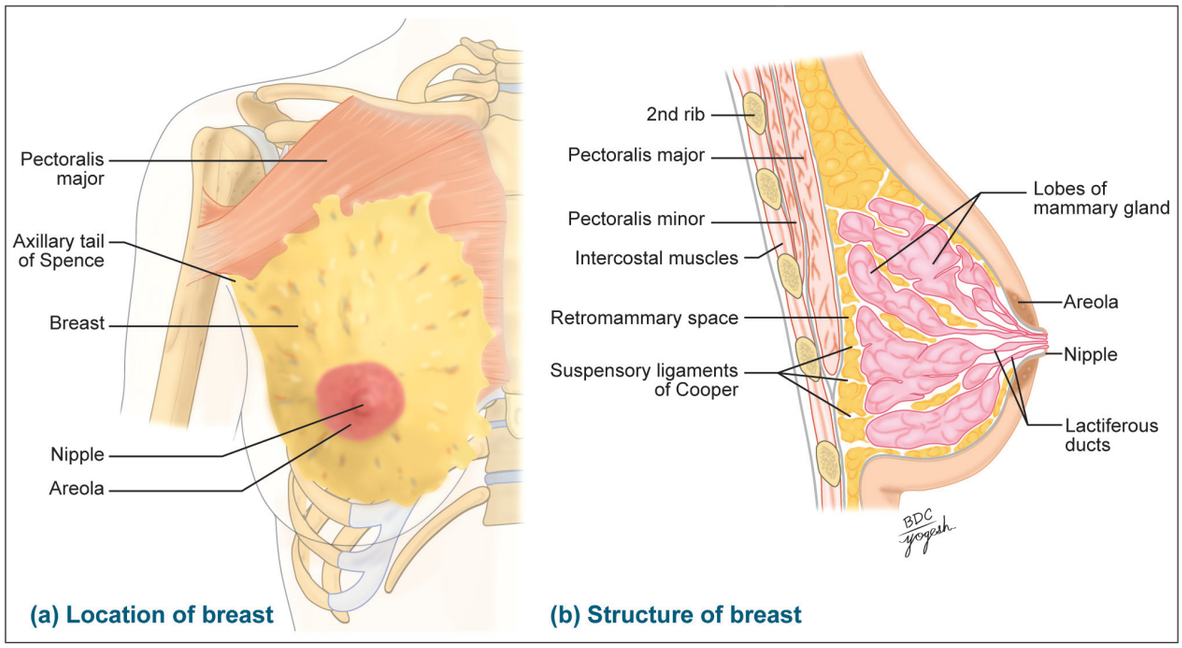
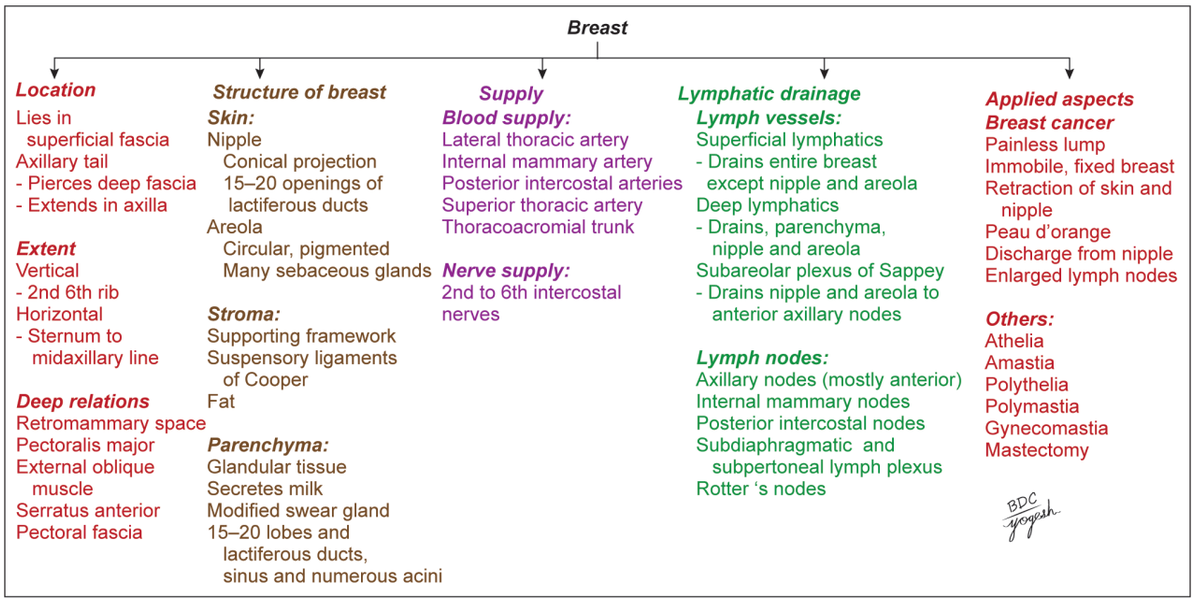


Fig. 3.7: Muscles lying deep to the breast

Plate 3.1: Female breast



Flowchart 3.1: Breast



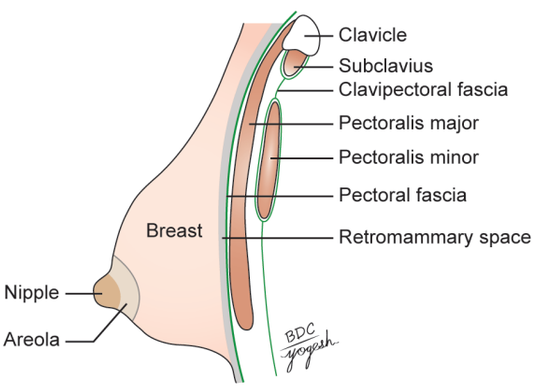


Fig. 3.8: Deep relations of breast

Structure of the Breast

The breast consists of the following three components:

1. Skin
2. Stroma
3. Parenchyma: Parenchyma is the mammary gland proper.

Skin

It covers the gland and presents the following features:

1. **Nipple:** A conical projection, called the *nipple*, is present just below the centre of the breast at the level of the 4th intercostal space, 10 cm from the midline. The nipple is pierced by 15 to 20 lactiferous ducts.

It contains circular and longitudinal smooth muscle fibres and a rich nerve supply. It can make the nipple stiff or flatten on stimulation.

2. **Areola:** The skin surrounding the base of the nipple is pigmented and forms a circular area called the *areola*. This region is rich in modified *sebaceous glands*, particularly at its outer margin. These become enlarged during pregnancy and lactation to form raised *tubercles of Montgomery*. Oily secretions of these glands lubricate the nipple and areola, and prevent them from cracking during lactation. The skin of the areola and nipple is devoid of hair and there is no fat subjacent to it. The color of areola becomes darker during pregnancy.

Stroma

It forms the supporting framework of the gland. It is partly fibrous and partly fatty.

The fibrous stroma forms septa, known as the *suspensory ligaments of Cooper*, which anchor the skin and gland to the pectoral fascia and maintain the normal shape of the breast (Figs 3.9a and b).

The fatty stroma forms the main bulk of the gland. It is distributed all over the breast except beneath the areola and nipple.

Parenchyma (Mammary Gland)

Mammary gland is a compound tubuloalveolar gland that secretes milk. It is a modified sweat gland and consists of 15 to 20 lobes. Each lobe is a cluster of alveoli and is drained by a *lactiferous duct*. The lactiferous ducts converge towards the nipple and open on it. Near its termination, each duct has a dilatation called a *lactiferous sinus* (Figs 3.9a and b).

Arterial Supply

The breast is highly vascular. It is supplied by branches of the following arteries (Fig. 3.10).

1. Internal thoracic (mammary) artery, a branch of the subclavian artery, through its perforating branches.
2. The lateral thoracic, superior thoracic and acromiothoracic (thoracoacromial) branches of the axillary artery.
3. Lateral branches of the posterior intercostal arteries.

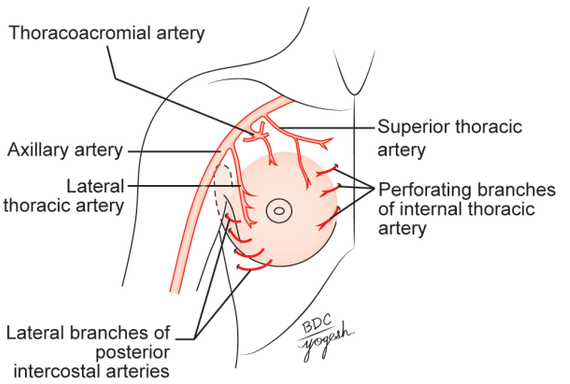


Fig. 3.10: Blood supply of breast

Venous Drainage

The veins follow the arteries. They first converge towards the base of the nipple, where they form an anastomotic venous circle, from where veins run in superficial and deep sets.

1. Superficial veins drain into the internal thoracic vein.
2. Deep veins drain into the axillary and posterior intercostal veins.

Nerve Supply

The breast is supplied by the anterior and lateral cutaneous branches of the 2nd to 6th intercostal nerves (4th to 6th intercostal nerves, as per 42nd Edn. Gray's Anatomy). The nerves convey sensory fibres to the skin and autonomic fibres to smooth muscle and to blood vessels. The nerves do not control the secretion of milk. Secretion is controlled by the hormone prolactin, secreted by the *pars anterior* of the *hypophysis cerebri*. The diagnosis and management of breast disease should be done carefully.

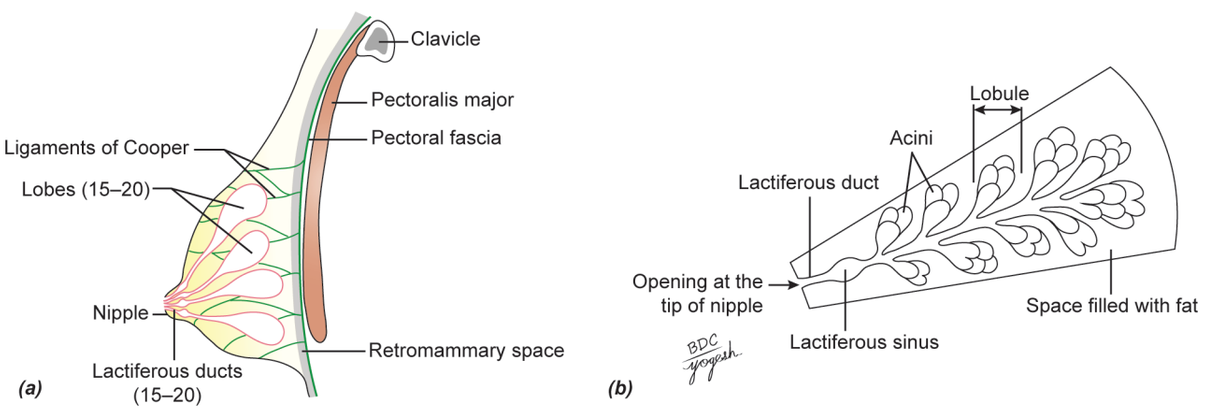
Competencies:

AN10.4 Describe the anatomical groups of axillary lymph nodes and specify their areas of drainage.

AN10.7 Describe axillary lymph nodes, areas of drainage and anatomical basis of their enlargement.

Lymphatic Drainage

Lymphatic drainage of the breast assumes great importance to the surgeon because carcinoma of the



Figs 3.9a and b: Structure of breast: (a) Sagittal section; (b) Structure of lobe

breast spreads mostly along lymphatics to the regional lymph nodes. The subject can be described under two heads—the lymph nodes and the lymphatic vessels.

Lymph Nodes

Lymph from the breast drains into the following lymph nodes (Fig. 3.11).

1. The axillary lymph nodes, chiefly the anterior (or pectoral) group. The posterior, lateral, central and apical groups of nodes also receive lymph from the breast either directly or indirectly.
2. The anterior thoracic (parasternal) nodes lie along the internal mammary (thoracic) vessels.
3. Some lymph from the breast also reaches the supraclavicular nodes, the cephalic (deltopectoral) node, the posterior intercostal nodes (lying in front of the heads of the ribs), the subdiaphragmatic and subperitoneal lymph plexuses.

Lymphatic Vessels

The lymphatic vessels draining breast are divided into two groups:

1. **Superficial lymphatics** drain the skin over the breast except for the nipple and areola. The lymphatics pass radially to the surrounding lymph nodes (axillary, anterior thoracic, supraclavicular and cephalic) (Fig. 3.11).
2. **Deep lymphatics** drain the parenchyma of the breast. They also drain the nipple and areola.

Important Points

1. About 75% of the lymph from the breast drains into the axillary nodes, 20% into the anterior thoracic nodes, and 5% into the posterior intercostal nodes. Among the axillary nodes, the lymphatics end mostly in the anterior group (closely related to the axillary tail) and partly in the posterior and apical groups. Lymph from the anterior and posterior groups passes to the central and lateral groups and through them to the apical group. Finally, it reaches the supraclavicular nodes.

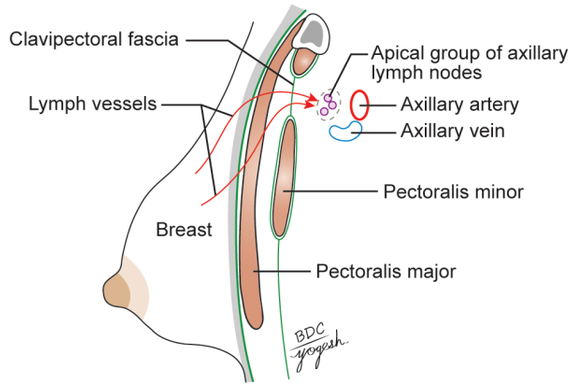


Fig. 3.12: Direct pathway of deep lymphatics of the breast through pectoralis major and clavipectoral fascia to apical group of axillary lymph nodes

2. **Subareolar plexus of Sappey:** It is a plexus of lymph vessels that is present deep to the areola. It drains into the anterior or pectoral group of lymph nodes.
3. The lymphatics from the deep surface of the gland pass through the pectoralis major muscle and the clavipectoral fascia to reach the apical nodes (Fig. 3.12).
4. Lymphatics from the lower and inner quadrants of the breast may communicate with the subdiaphragmatic and subperitoneal lymph plexuses after crossing the costal margin and then piercing the anterior abdominal wall through the upper part of the linea alba.
5. Anterior and central groups of nodes are commonly involved in carcinoma breast.

***Competency*:**
AN9.3 Describe development of breast, associated age changes and congenital anomalies.

Development of the Breast and Age Changes

Embryonic Development

1. The parenchyma (glandular tissue) of breast develops from ectoderm, whereas the fibrous stroma, suspensory ligaments, fat and myoepithelial cells develop from the surrounding mesoderm.

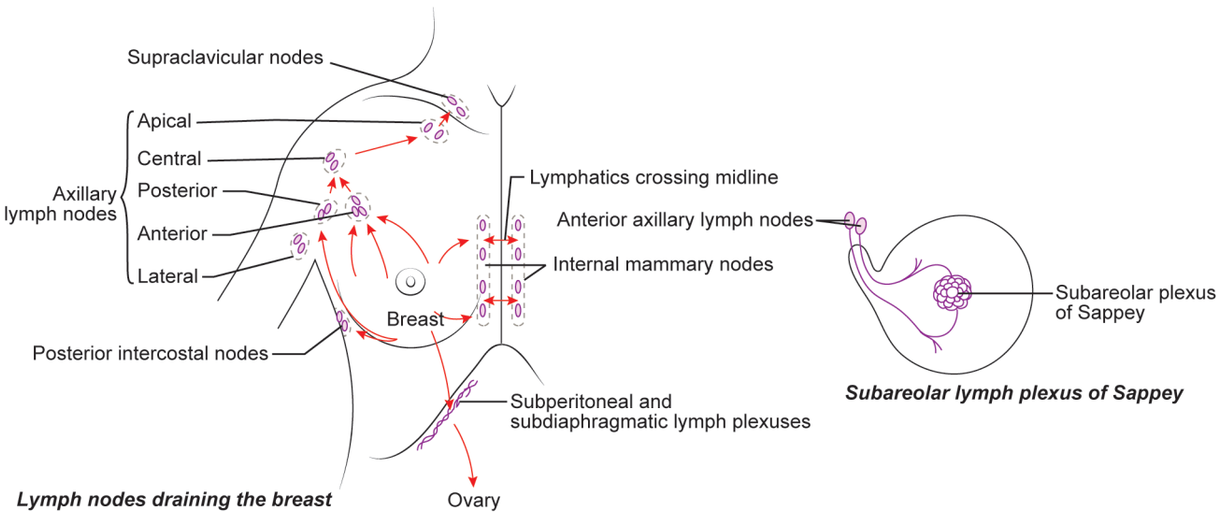


Fig. 3.11: Lymphatic drainage of right breast

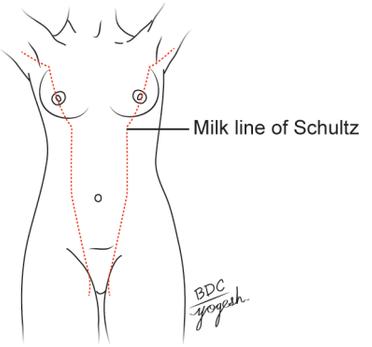


Fig. 3.13: Mammary ridge

2. An ectodermal thickening, called the *mammary ridge*, milk line or ***line of Schultz,*** forms parenchyma (Fig. 3.13). This ridge extends from the axilla to the groin. It appears during the 6th week of intrauterine life, but in human beings, it disappears over most of its extent, persisting only in the thoracic region.
3. The persisting part of the mammary ridge is converted into a mammary pit. Secondary buds (15–20) grow down from the floor of the pit. These buds divide and subdivide to form the lobes of the gland. The entire system is first solid but is later canalised. At birth or later, the nipple is everted at the site of the original pit.

Development at Puberty

1. At puberty, owing to the deposition of fat and connective tissue, female mammary glands enlarge rapidly. Under the influence of estrogen and progesterone, duct system grows.

Development during Pregnancy

1. During pregnancy, the glandular tissue rapidly develops and forms buds and alveoli.

Development Anomalies

a. Amastia – absence of the breast
b. Athelia – absence of nipple
c. Polymastia – supernumerary breasts
d. Polythelia – supernumerary nipples
e. Gynaecomastia – development of breasts in a male (occurs in Klinefelter's syndrome).

Histology of Breast

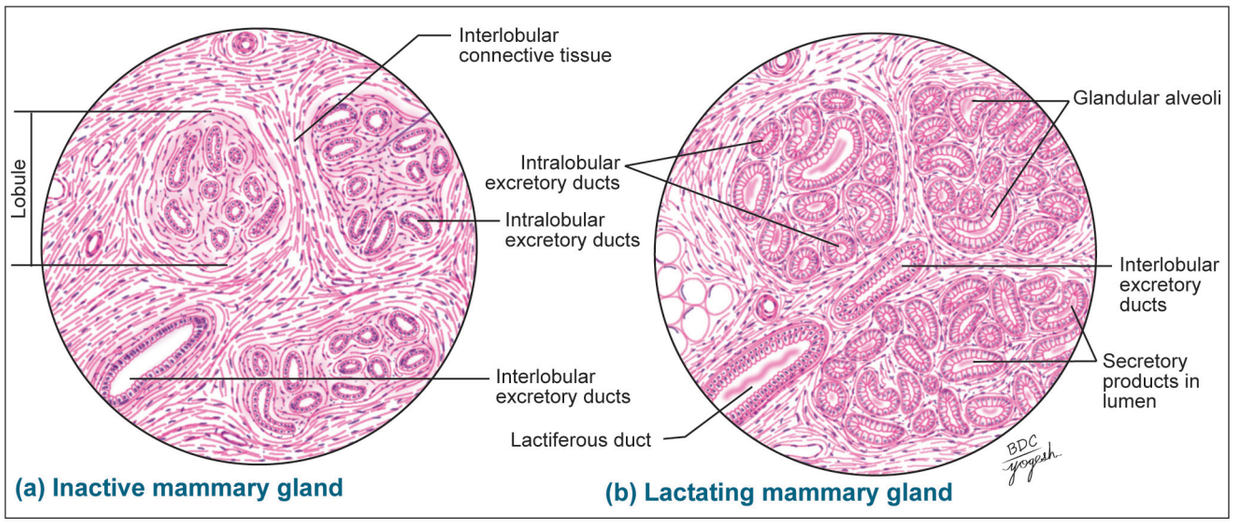
- Mammary gland is a *modified apocrine sweat gland*. It is composed of ducts, parenchyma and stroma (Plate 3.2).
- *Ducts*: Mammary gland has the following order of ducts:
  - *Lactiferous duct*: Lined by columnar epithelium (terminal part shows transformation from columnar to stratified squamous epithelium).
  - *Interlobular ducts*: Lined by cuboidal to low columnar epithelium.
  - *Intralobular ducts*: Lined by cuboidal epithelium.
  - *Alveolar ducts*: Lined by low cuboidal epithelium.
- Parenchyma
  - Each gland shows 15–20 lobes of compound tubuloalveolar gland.
  - ***Nonlactating inactive glands:*** Shows spherical masses or cords of alveolar cells.
  - ***Lactating active glands:*** Shows numerous branched ducts with clusters of alveoli that are lined by simple columnar epithelium.
- *Stroma*: Consists of interlobular, intralobar, and interlobar connective tissue.

CLINICAL ANATOMY

Breast cancer (carcinoma of breast): The upper and outer quadrants of breast are a frequent site of carcinoma (cancer). The first lymph node draining the tumour-bearing area is called 'sentinel node.'

- Incisions of breast for removal of carcinoma or drainage of abscess are usually made radially to avoid cutting the lactiferous ducts (Fig. 3.9).
- Cancer cells may infiltrate the suspensory ligaments. The breast then becomes fixed. Contraction of the ligaments can cause retraction or puckering (folding) of the skin.
- Infiltration of lactiferous ducts and their consequent fibrosis can cause *retraction of the nipple*.
- Obstruction of superficial lymph vessels by cancer cells may produce oedema of the skin giving rise to an appearance like that of the skin of an orange (***peau d'orange*** appearance) (Fig. 3.14).
- Because of communications of the superficial lymphatics of the breast across the midline, cancer may spread from one breast to the other.
- Because of communications of the lymph vessels with those in the abdomen, cancer of the breast may spread to the liver, and cancer cells may 'drop' into the pelvis producing secondaries (Fig. 3.11). Some cancer cells may deposit on the ovary and form a secondary tumor called ***Krukenberg's tumour***.
- Breast cancer may spread through venous channels to the vertebrae and to the brain.
- Carcinoma usually arises from epithelium of large ducts.
- Self-examination of breasts helps in early detection of breast cancers. It includes examination for symmetry of breasts and nipples, change in colour of skin, retraction of nipple, discharge from nipple on squeezing it, palpation with palm of hand for lump and to raise the arm to feel lymph nodes in axilla.
- **Mammogram** may reveal cancerous mass (Fig. 3.15).
- **Fine needle aspiration cytology** is safe and quick method of diagnosis of lesion of breast.
- Retracted nipple is a sign of tumour in the breast.
- Size of mammary gland can be increased by putting an implant inside the gland. The size can be reduced by breast reduction surgery.
- Cancer of the mammary glands is the most common cancer in females of all ages. It is more frequently seen in postmenopausal females due to lack of oestrogen hormones.
- *Mastectomy* is the medical term for the surgical removal of one or both breasts, partially or completely.
- *Radical mastectomy* is a surgical procedure involving the removal of breast, underlying pectoral muscles and lymph nodes of the axilla.

Plate 3.2: Histology of mammary gland



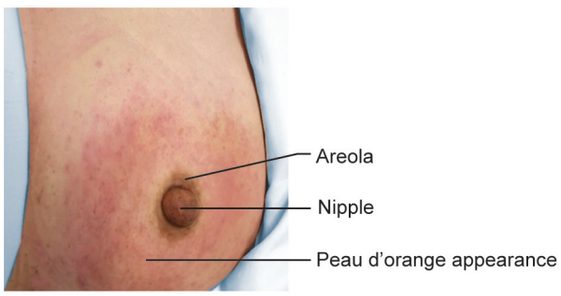


Fig. 3.14: Peau d'orange appearance



Fig. 3.15: Mammogram showing cancerous lesion

DEEP FASCIA

The deep fascia covering the pectoralis major muscle is called the pectoral fascia.

- *Extension*:
  - Superiorly: Attaches to the clavicle
  - Medially: Attaches to the sternum
  - Superolaterally: Continues as deep fascia over deltoid muscle
  - Inferolaterally: Turns to continue as axillary fascia.

Inferiorly: Continue as fascia covering the lower part of thoracic range.

Competency:
AN9.1 Describe attachment, nerve supply and action of pectoralis major and pectoralis minor and describe clavipectoral fascia.

MUSCLES OF THE PECTORAL REGION

Pectoral region has three muscles (Figs 3.16 to 3.18, Tables 3.1 and 3.2, Flowchart 3.2, Plates 3.3 and 3.4):

1. Pectoralis major
2. Pectoralis minor
3. Subclavius.

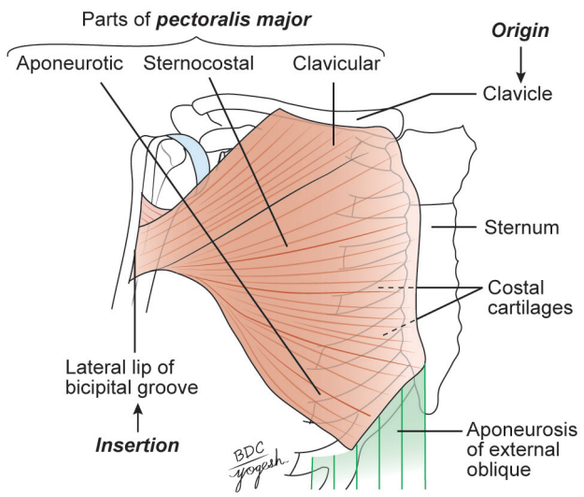


Fig. 3.16: Pectoralis major muscle

TABLE 3.1: Muscles of the pectoral region

Muscle	*Origin*	*Insertion*
Pectoralis major Thick, bulky, fan-shaped muscle	**Clavicular head:** Anterior surface of medial two-thirds of clavicle **Sternocostal head:** • Lateral half of anterior surface of manubrium and sternum up to 6th costal cartilage • 2nd to 6th costal cartilages, sternal end of 6th rib • Aponeurosis of the external oblique muscle of abdomen	It is inserted by a bilaminar tendon on the lateral lip of the bicipital groove in form of U-shaped bilaminar tendon The two laminae are continuous with each other inferiorly Its anterior lamina is thicker and shorter than the thinner and longer posterior lamina. Anterior lamina receives superficial clavicular and deep manubrial fibres; posterior lamina gets costal, sternal and aponeurotic fibres
Pectoralis minor	• 3, 4, 5 ribs near the costochondral junction • Intervening fascia covering external intercostal muscles	Medial border and upper surface of the coracoid process of scapula
Subclavius	First rib at the costochondral junction	Subclavian groove (on the inferior surface of middle-third of clavicle)

TABLE 3.2: Nerve supply and actions of muscles

Muscle	*Nerve supply*	*Actions*
Pectoralis major	Medial and lateral pectoral nerves	• As a whole the muscle: Adduction and medial rotation of the shoulder joint (arm) • Clavicular part: Flexion of the arm • Sternocostal part: Extension of flexed arm against resistance
Pectoralis minor	Medial and lateral pectoral nerves	• Draws the scapula forward (with serratus anterior) • Depresses the shoulder. Accessory muscle of respiration in forced inspiration
Subclavius	Nerve to subclavius (branch of upper trunk of brachial plexus)	Stabilises the clavicle during movements of the shoulder joint Forms a cushion for axillary vessels and brachial plexus

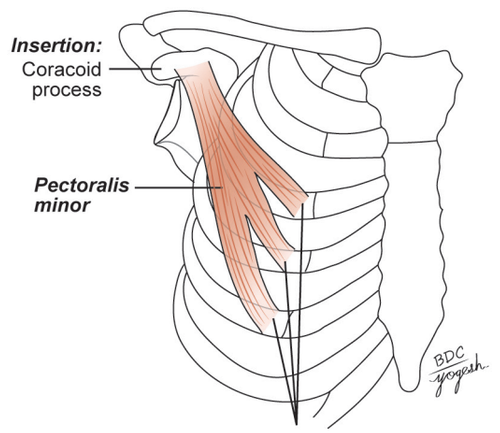


Fig. 3.17: Pectoralis minor muscle

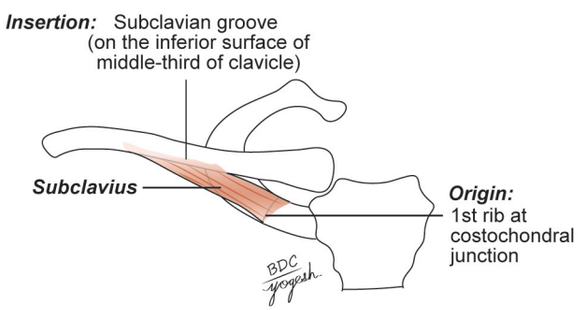


Fig. 3.18: Subclavius muscle

Pectoralis Major

Bilaminar Tendon of Pectoralis Major

The muscle is inserted by a U-shaped bilaminar tendon into the lateral lip of the intertubercular sulcus of the humerus. The two laminae are continuous with each other inferiorly.

Anterior lamina is thicker and shorter than the posterior. It receives two strata of muscle fibres: Superficial fibres arising from the clavicle and deep fibres arising from the manubrium (Plate 3.3b).

Posterior lamina is thinner and longer than the anterior lamina. It is formed by remaining sternal fibers, costal and aponeurotic fibres. Out of these, only the fibres from the sternum and aponeurosis are twisted around the lower border of the rest of the muscle. The twisted fibres form the anterior axillary fold.

The twisted fibres pass upwards and laterally to get inserted successively higher into the posterior lamina of the tendon. Fibres arising lowest are inserted the highest.

Clinical Testing

1. The clavicular head is made prominent by flexing the arm to a right angle. The sternocostal head can be tested by extending the flexed arm against resistance (Fig. 3.19a).
2. Sternocostal head is made prominent by abducting arm to 60° and then touching the opposite hip.

Plate 3.3: Pectoralis major muscle: (a) Gross features and parts of muscle, (b) bilaminar insertion

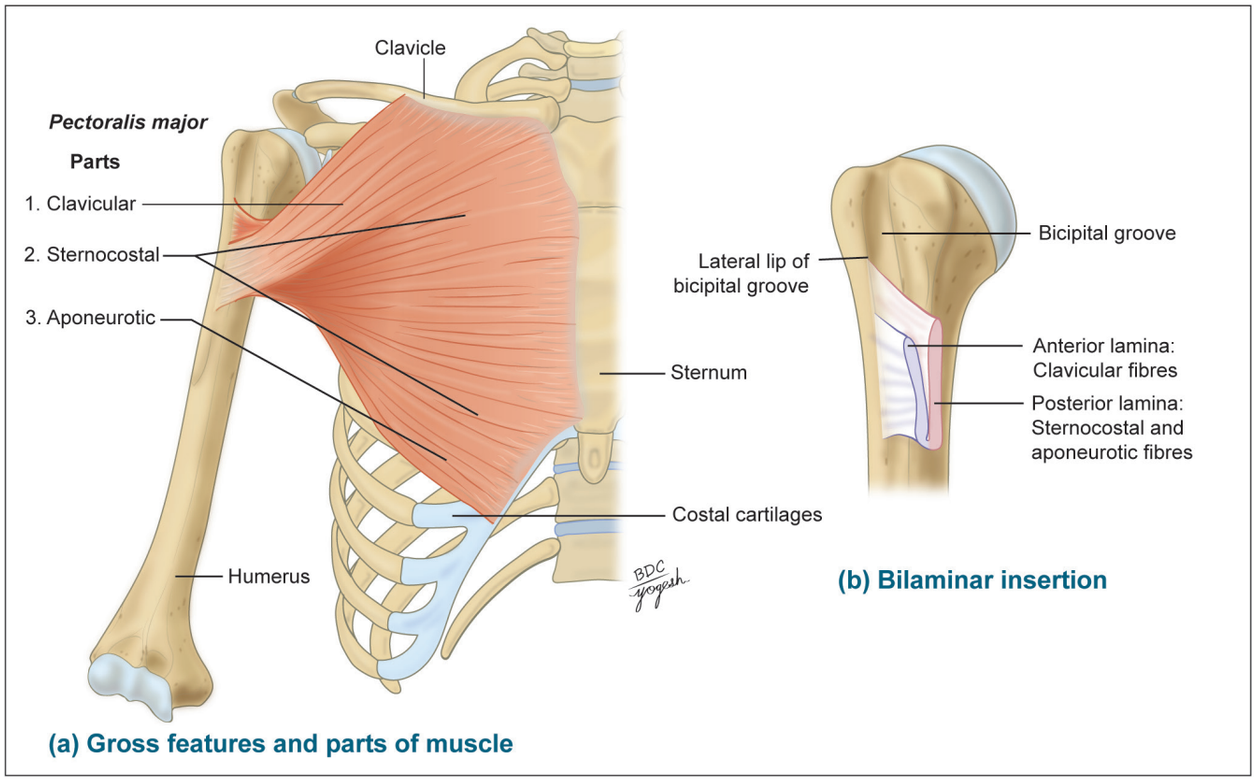
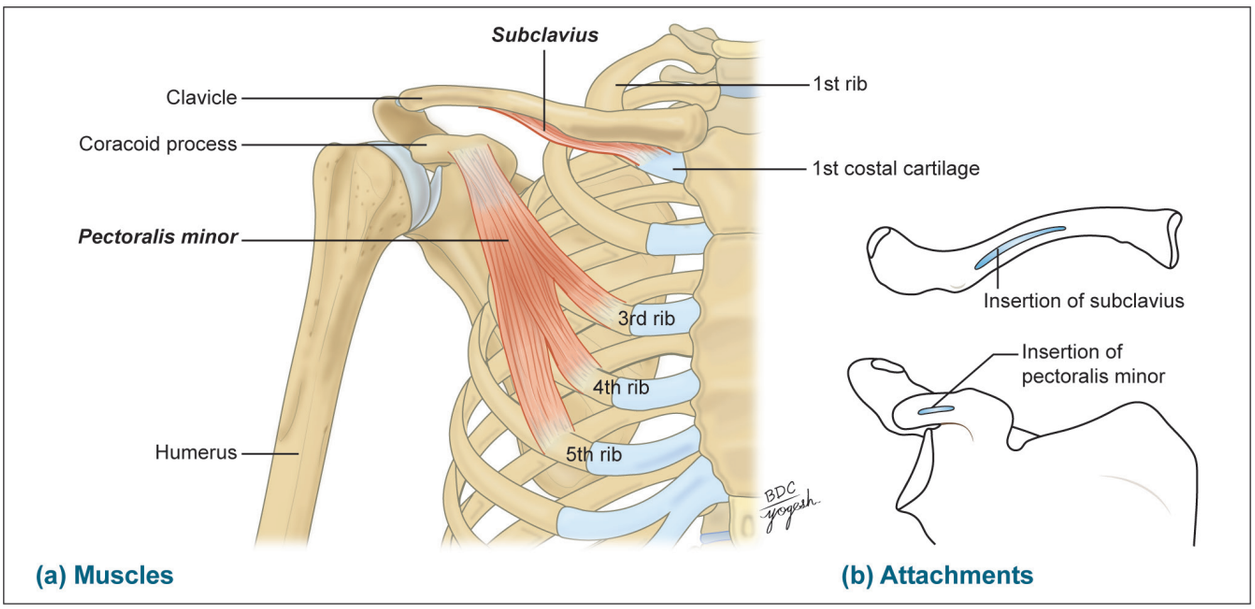


Plate 3.4: Pectoralis minor and subclavius muscles



3. Lifting a heavy rod makes clavicular part prominent (right arm). Depressing a heavy rod shows sternocostal part as prominent (left arm) (Fig. 3.19a).
4. Pressing the fists against each other makes the whole muscle prominent (Fig. 3.19b).

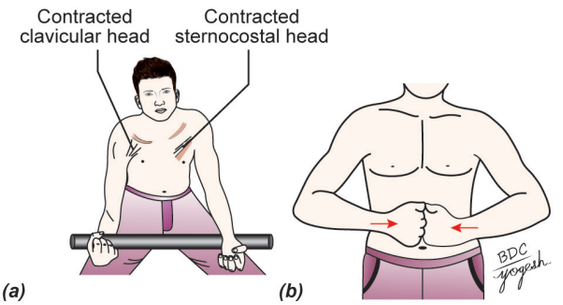
Clavipectoral Fascia

Clavipectoral fascia is a fibrous sheet situated deep to the clavicular portion of the pectoralis major muscle. It extends from the clavicle above to the axillary fascia below (Fig. 3.20, Flowchart 3.3). Its upper part splits to

Flowchart 3.2: Pectoral muscles and serratus anterior muscle

Muscles

	Origin	Insertion	Nerve supply	Actions
Pectoralis major Large bulky fan-shaped muscle	Clavicular head: Anterior surface of medial half of clavicle Sternocostal head: - Lateral half of anterior surface sternum upto 6th costal cartilage - 2nd to 6th costal cartilage - External oblique aponeurosis	Lateral lip of bicipital groove by bilaminar tendon: Anterior lamina Clavicular fibers Posterior lamina Sternocostal fibres (lowest fibres inserts highest)	Medial and lateral pectoral nerve	Adduction and medial rotation of arm - Clavicular head: Flexion of arm - Sternocostal head: Extension of flexed arm
Pectoralis minor	From 3rd, 4th, 5th ribs near costal cartilages	Coracoid process	Medial and lateral pectoral nerves	Protraction of scapula
Subclavius	First rib at costochondral junction	Subclavian groove	Nerve to subclavius	Protection of brachial plexus and subclavian vessels
Serratus anterior	8 digitation from lateral surface of upper 8 ribs and fascia covering intercostal muscles	Medial border of scapula (costal surface) 1st digitation: Superior angle Next 2–3 digitations: -Medial border Last 4–5 digitations: - At inferior angle	Long thoracic nerve (C5–7)	Stabilization of clavicle Pushing and punching (with pectoralis minor) Overhead abduction at shoulder (with trapezius)



Figs 3.19a and b: Clinical testing of pectoralis major: (a) Testing of clavicular and sternocostal heads and (b) testing of whole muscle

Flowchart 3.3: Clavipectoral fascia

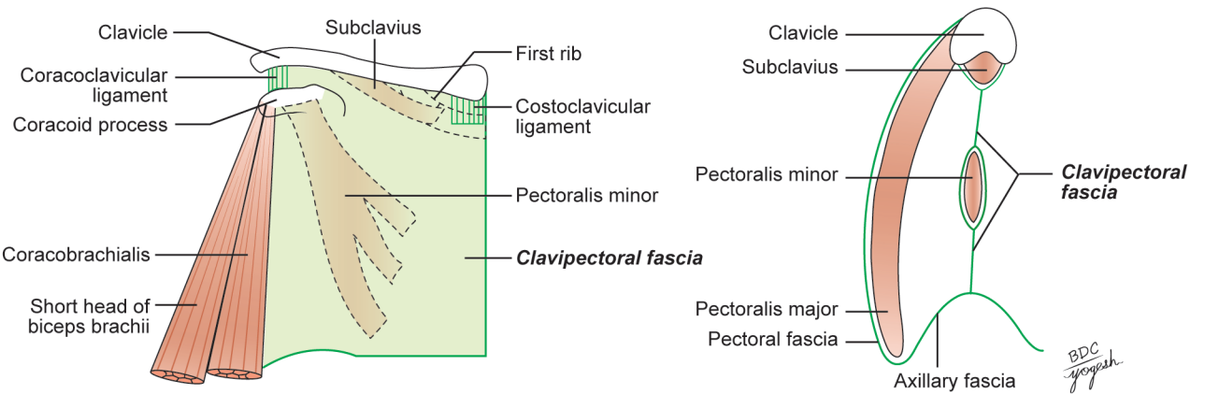
Clavipectoral fascia

Location	Attachments	Muscles enclosed	Structures piercing
Lies deep to pectoralis major muscle	Superior: Clavicle Medial: 1st rib and costoclavicular ligament Inferior: Forms suspensory ligament of axilla Laterally: Coracoid process	Subclavius Pectoralis minor	Lateral pectoral nerve Cephalic vein Thoracoacromial trunk Lymphatics

enclose the *subclavius muscle*. The posterior lamina is fused to the investing layer of the deep cervical fascia and to the *axillary sheath*. Inferiorly, the clavipectoral fascia splits to enclose the pectoralis minor muscle. Medially, it is attached to external intercostal muscle of upper intercostal spaces and laterally to coracoid process. Below this muscle, it continues as the *suspensory ligament*, which is attached to the dome of the axillary fascia and helps to maintain it.

The clavipectoral fascia is pierced by the following structures (Fig. 3.21):

1. Lateral pectoral nerve
2. Cephalic vein
3. Thoracoacromial artery
4. Lymphatics passing from the breast and pectoral region to the apical group of axillary lymph nodes.



Figs 3.20a and b: Clavipectoral fascia: (a) Attachments in anterior view and (b) attachments in sagittal section

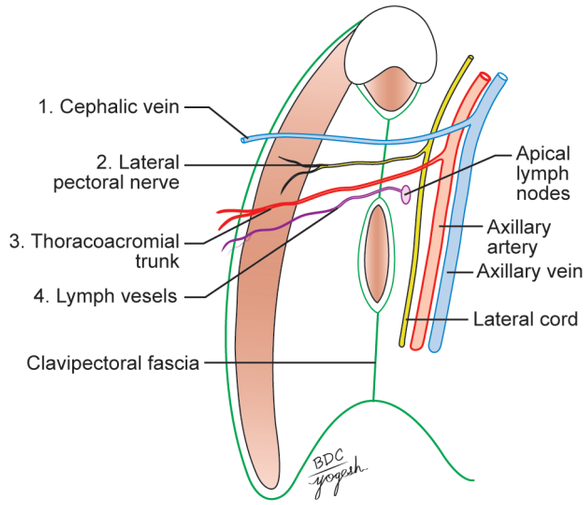


Fig. 3.21: Structures piercing clavipectoral fascia

***Competency*:**
AN10.11 Describe and demonstrate attachment, action and clinical anatomy of serratus anterior muscle.

Serratus Anterior

Serratus anterior muscle is not strictly muscle of the pectoral region, but it is convenient to consider it here (Latin, *serrate* = to saw) (Plate 3.5, Fig. 3.22). It is also called **boxer's muscle/swimmer's muscle** (Flowchart 3.2).

Origin

Serratus anterior muscle arises by eight digitations from the upper 8 ribs in the midaxillary plane and from the fascia covering the intervening intercostal muscles. The first digitation arises from the 1st and 2nd ribs, whereas all other digitations arise from their corresponding ribs.

Insertion

All 8 digitations pass backwards around the chest wall.

The muscle is inserted into the *costal surface* of the scapula along its medial border as follows (Figs 3.22a, b):

- 1st digitation at the superior angle
- 2nd and 3rd digitations along the entire medial border
- Remaining digitations on the triangular area at the costal surface of inferior angle of scapula.

Nerve Supply

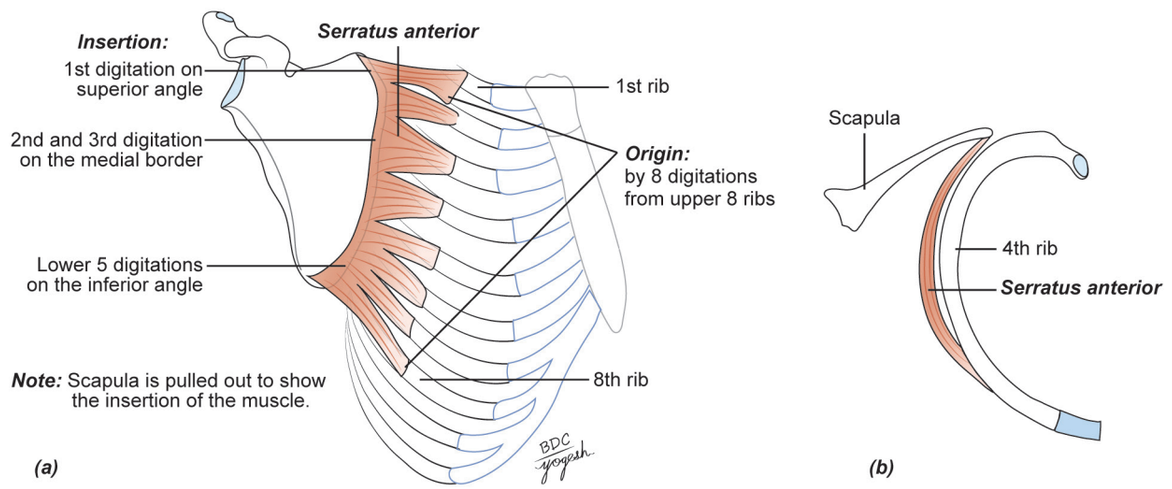
Long thoracic nerve (branch of C5, C6, C7 roots of brachial plexus) (Fig. 3.22a).

Actions

1. **Pushing and punching action (boxer's muscle):** Along with the pectoralis minor, the muscle pulls the scapula forwards around the chest wall to protract the upper limb.
2. **Overhead abduction of arm:** The fibres inserted into the inferior angle of the scapula pull it forwards and rotate the scapula so that the glenoid cavity is turned upwards. In this action, the serratus anterior is helped by the trapezius, which pulls the acromion process upwards and backwards.
3. Steadies the scapula during weight carrying.
4. Helps in forced inspiration.

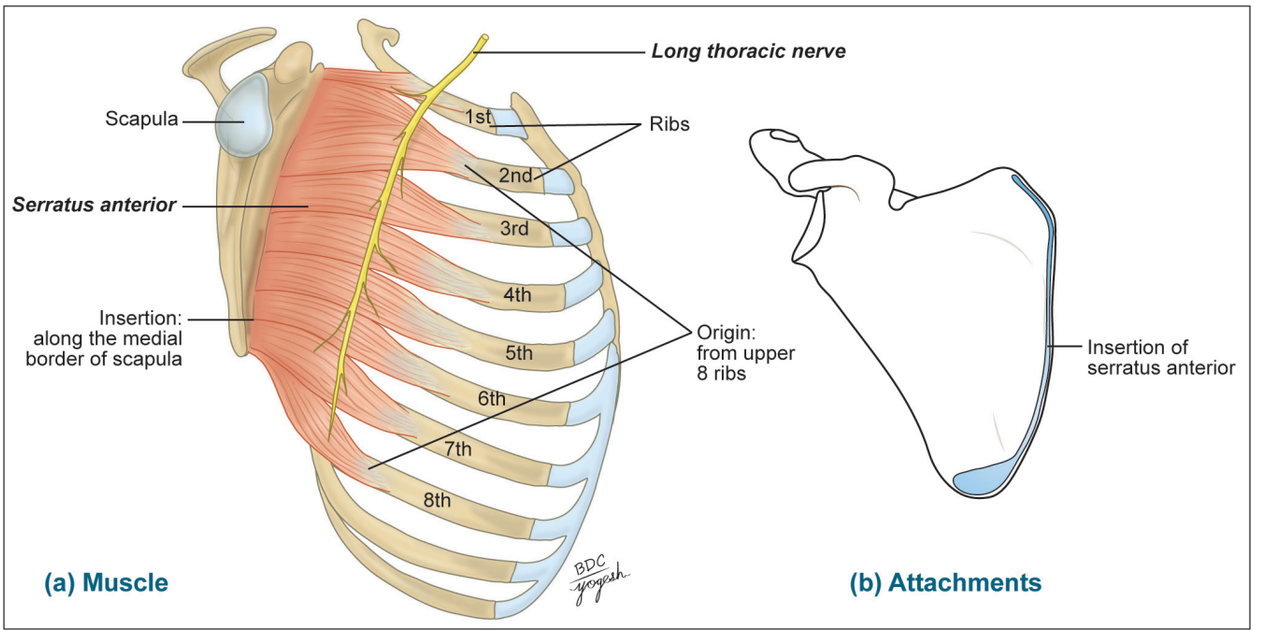
CLINICAL ANATOMY

1. **Winging of scapula:** Paralysis of the serratus anterior produces 'winging of scapula' in which the inferior angle and the medial border of the scapula are unduly prominent. It occurs due to injury to *long thoracic nerve*. The patient is unable to do any pushing action, nor can he raise his arm above the head. Any attempt to do these movements makes the inferior angle of the scapula still more prominent.



Figs 3.22a and b: Serratus anterior muscle: (a) Origin and insertion and (b) horizontal section through axilla showing relationship to the thoracic wall

Plate 3.5: Serratus anterior muscle and long thoracic nerve



2. **Clinical testing:** Forward pressure with the hands against a wall, or against resistance offered by the examiner, makes the medial border and the inferior angle of the scapula prominent (winging of scapula), if the serratus anterior is paralysed.

VIDEO

Video 1.3 Pectoral Region ▶ Mammary gland and muscles of pectoral region.

DISSECTION

Identify the extensive pectoralis major muscle in the pectoral region and the prominent deltoid muscle on the lateral aspect of the shoulder joint and upper arm.

Demarcate the deltopectoral groove by removing the deep fascia. Now identify the cephalic vein, a small artery and a few lymph nodes in the groove.

Clean the fascia over the pectoralis major muscle and look for its attachments. Divide the clavicular head of the muscle and reflect it laterally. Medial and lateral pectoral nerves will be seen supplying the muscle.

Make a vertical incision 5 to 6 cm from the lateral border of sternum and reflect its sternocostal head laterally.

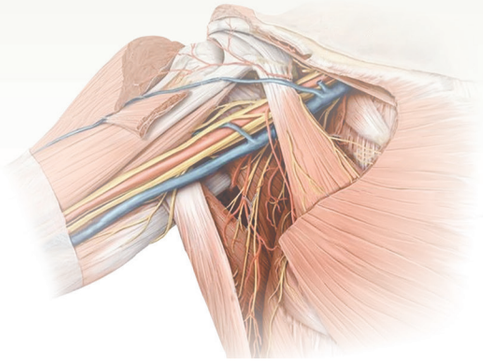
Identify the pectoralis minor muscle under the central part of the pectoralis major. Note clavipectoral fascia extending between pectoralis minor muscle and the clavicle bone.

Identify the structures piercing the clavipectoral fascia: These are cephalic vein, thoracoacromial artery and lateral pectoral nerve. If some fine vessels are also seen, these are the lymphatic channels.

Also, identify the serratus anterior muscle showing serrated digitations on the side of the chest wall.

Facts to Remember

- The mammary gland is a modified apocrine sweat gland. It lies in the superficial fascia.
- Most of the lymph from breast is drained into the anterior axillary lymph nodes.
- The subareolar plexus of Sappey is a plexus of lymph vessels deep to the areola, which drain into anterior axillary lymph nodes.
- Rotter's lymph nodes lie between pectoralis major and pectoralis minor (hence called interpectoral nodes).
- The upper and outer quadrants of the breast are the most common site of breast cancer.
- 75% of lymph from mammary gland drains into axillary; 20% into anterior thoracic and 5% into posterior intercostal lymph nodes.
- Pectoralis major is the largest muscle of the pectoral region.
- Pectoralis minor is the key muscle of the pectoral region, as it divides the axillary artery into three parts.



Chapter

4

Axilla

Competency:
AN10.1 Identify and describe boundaries and contents of axilla.

Axilla (Latin *armpit*) is a pyramidal space situated between the upper part of the arm and the chest wall (Figs 4.1a–c, Flowchart 4.1, Plate 4.1). It contains the brachial plexus, axillary vessels and axillary lymph nodes. It gives passage to the neurovascular structures from the root of the neck to the upper limb and vice versa.

DISSECTION

Place a rectangular wooden block under the neck and shoulder region of cadaver (Figs 4.1a–c). Ensure that the block supports the body firmly. Abduct the limb at right angles to the trunk, and strap the wrist firmly on block projecting towards your side. In continuation with earlier dissection, reflect the lower skin flap till the posterior axillary fold, made up by the subscapularis, teres major and latissimus dorsi muscles, is seen. Clean the fat and remove the lymph nodes and superficial veins to reach depth of the armpit. Identify two muscles arising from the tip of the coracoid process of scapula; out of these, the short head of biceps brachii muscle lies on the lateral side and the coracobrachialis on the medial side.

The pectoral muscles with the clavipectoral fascia form anterior boundary of the region.

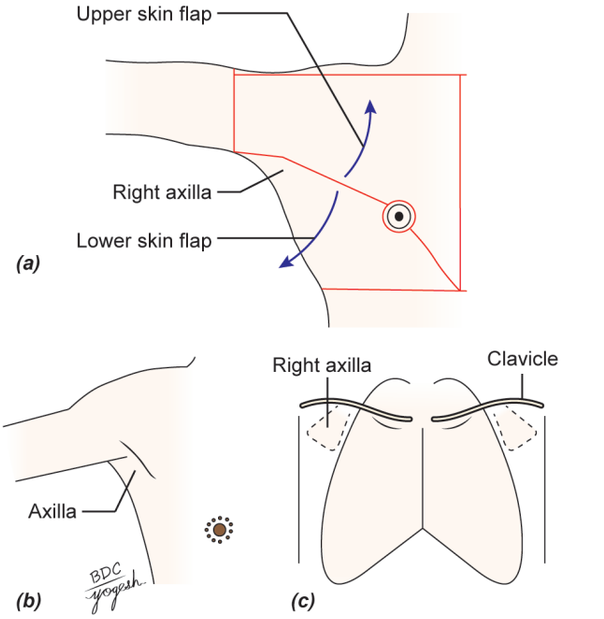
Look for upper three intercostal muscles and serratus anterior muscle, which make the medial wall of axilla.

Clean the fat in the axilla carefully and identify the branches of the axillary artery, the axillary lymph nodes and the brachial plexus (Table 4.1).

BOUNDARIES

It resembles a four-sided pyramid. It has the following boundaries (Figs 4.2 and 4.3a and b):

- Apex
- Base
- *Four walls*: Anterior, posterior, medial and lateral.



Figs 4.1a to c: (a) Dissection of axilla, (b) axilla in living body, and (c) relations to the skeleton

Flowchart 4.1: Axilla

Axilla
Armpit, pyramidal-shaped space

Boundaries

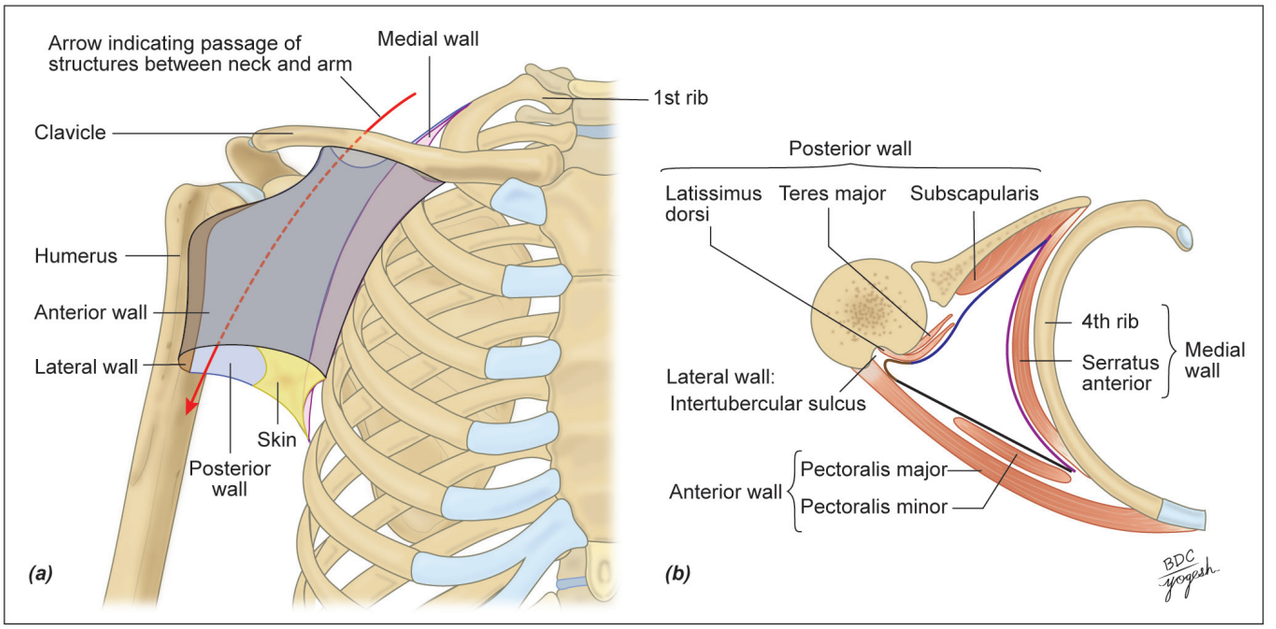
Apex (cervicoaxillary canal): Lies between clavicle, scapula and 1st rib
Base: Fascia and skin
Anterior wall: Pectoralis major, clavipectoral fascia, pectoralis minor
Posterior wall: Subscapularis, teres major, latissimus dorsi
Medial wall: Upper 4 ribs and intercostal muscles, serratus anterior
Lateral wall: Coracobrachialis, biceps brachii, bicipital groove

Content

1. Axillary artery and its branches
2. Axillary vein and its tributaries
3. Infraclavicular part of brachial plexus
4. Axillary lymph nodes
5. Axillary fat

The axilla is disposed obliquely in such a way that the apex is directed upwards and medially towards the root of the neck, and the base is directed downwards.

Plate 4.1: Axilla: (a) Location and (b) walls of axilla



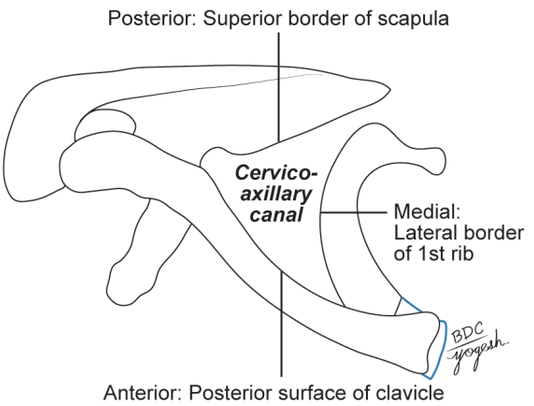
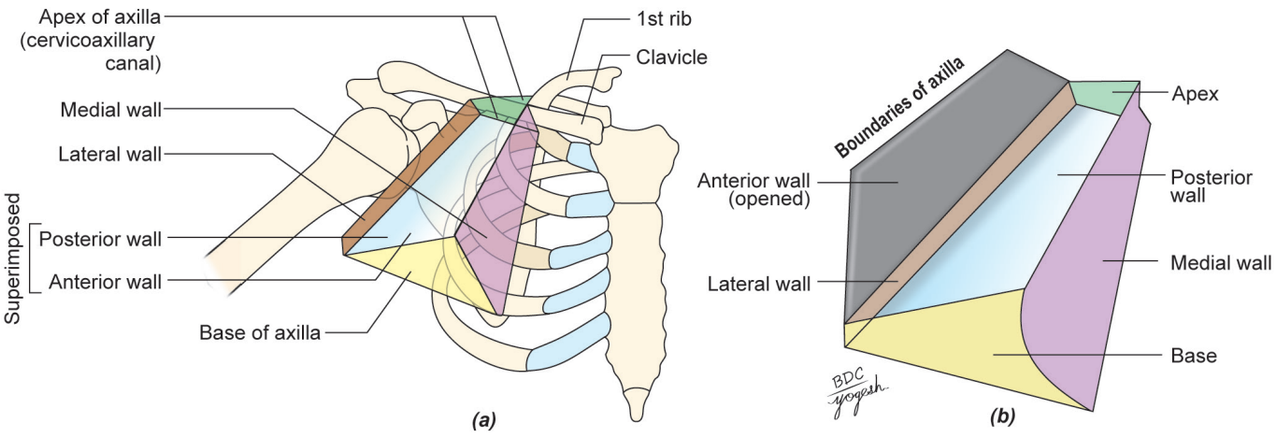


Fig. 4.2: Boundaries of apex of axilla or cervicoaxillary canal (superior view)



Figs 4.3a and b: (a) Walls of the axilla and (b) opened-up axilla

TABLE 4.1: Identification and locations of the structures in the axilla

Name of structure	*Identification*
Branches of axillary artery	
Superior thoracic artery	Runs along the superior border of pectoralis minor muscle.
Thoracoacromial trunk	Emerges at the superior border of pectoralis minor muscle. It pierces clavipectoral fascia and divides into four branches.
Lateral thoracic artery	Runs along the lateral border of pectoralis minor.
Subscapular artery	Runs along the lower border of subscapularis.
Anterior circumflex humeral artery	Passes in front of surgical neck of humerus.
Posterior circumflex humeral artery	Leaves axilla along with axillary nerve through quadrangular intermuscular space.
Axillary lymph nodes	
Anterior group	Lies along the lower border of the pectoralis minor along the lateral thoracic vessels.
Posterior group	Lies along the lower margin of the posterior wall of axilla along the subscapular vessels.
Lateral group	Lies posteromedial to the axillary vein.
Central group	Lies in the fat of the axilla.
Apical group	Lies behind and above the pectoralis minor, medial to the axillary vein.
Brachial plexus and its branches Cords	The 2nd part of the axillary artery is related laterally to the lateral cord, medially to the medial cord and posteriorly to the posterior cord.
Lateral pectoral nerve	Carefully reflect the pectoralis major upward to visualise the lateral pectoral nerve.
Musculocutaneous nerve	Musculocutaneous nerve pierces coracobrachialis muscle.
Median nerve	Lateral root of median nerve joins with medial root in front of 3rd part of axillary artery. Together, they form a 'Y'-shaped structure.
Medial pectoral nerve	Reflect pectoralis major laterally to visualise medial pectoral nerve, which pierces the pectoralis minor muscle.
Medial cutaneous nerve	Is a very thin nerve that runs on the medial side of axillary vein.
Medial cutaneous nerve of forearm	Is a thin nerve and runs downward between axillary artery and vein, anterior to the thicker ulnar nerve.
Axillary nerve	Lies posterolateral to the axillary artery and leaves the axilla through the quadrangular muscular space.
Radial nerve	Lies hidden behind the axillary artery.
Upper and lower subscapular nerves and nerve to latissimus dorsi	Run downwards posterior to the axillary artery and vein on the anterior surface of subscapularis muscle. Nerve to latissimus dorsi is larger and lies in between upper and lower subscapular nerves.
Long thoracic nerve	Passes on the lateral surface of serratus anterior muscle in midaxillary line.

Apex (Cervicoaxillary Canal)

It is directed upwards and medially towards the root of the neck (Fig. 4.2). It is truncated (not pointed) and corresponds to a triangular, oblique passage called the ***cervicoaxillary canal***. This canal is bounded:

- *Anteriorly*, by the posterior surface of clavicle.
- *Posteriorly*, by the superior border of the scapula and medial aspect of coracoid process.
- *Medially*, by the outer border of the first rib.

This canal gives passage to the axillary artery, axillary vein and brachial plexus in between the axilla and the neck.

Base or Floor

It is directed downwards. It is formed by skin, superficial and axillary fascia. Base of axilla extends from anterior to posterior axillary folds. Medially, it is continuous with the chest wall and laterally with the medial side of the arm. It is convex upwards.

Note: Axillary folds are folds of skin within which a margin of muscles is enclosed. *Anterior axillary fold* covers the lateral edge of pectoralis major muscle, and the *posterior axillary fold* covers the latissimus dorsi and teres major muscle.

Anterior Wall

It is formed by the following structures:

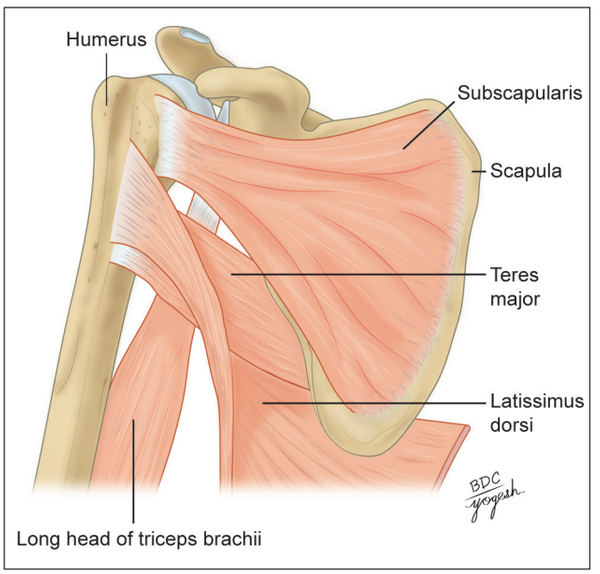
1. Pectoralis major in front (Fig. 4.4)
2. Clavipectoral fascia
3. Pectoralis minor.

Posterior Wall

It is formed by the following structures:

1. Subscapularis above (Plate 4.2)
2. Teres major
3. Latissimus dorsi below.

Plate 4.2: Muscles forming posterior wall of right axilla



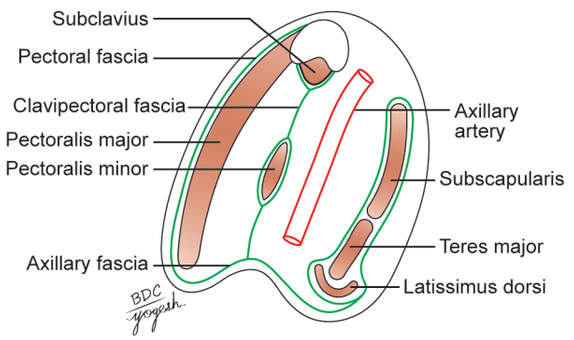


Fig. 4.4: Anterior and posterior walls and the base of the axilla with the axillary artery

Medial Wall

It is convex laterally and formed by the following structures:

1. Upper four ribs with their intercostal muscles.
2. Upper part of the serratus anterior muscle (Plates 4.1 and 4.3, Fig. 4.5).

Lateral Wall

It is very narrow because the anterior and posterior walls converge on it. It is formed by the following structures:

1. Upper part of the shaft of the humerus in the region of the bicipital groove.
2. Coracobrachialis and short head of the biceps brachii (Fig. 4.5).

CONTENTS OF AXILLA

1. Axillary artery and its branches (Plate 4.3, Figs 4.5 to 4.8)
2. Axillary vein and its tributaries
3. Infraclavicular part of the brachial plexus
4. Axillary lymph nodes
5. Long thoracic and intercostobrachial nerves

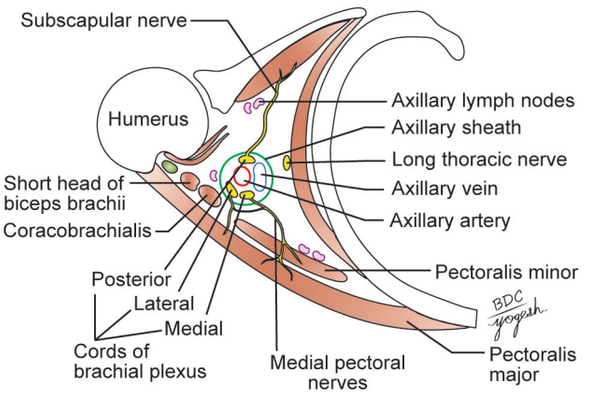


Fig. 4.5: Content of axilla (right)

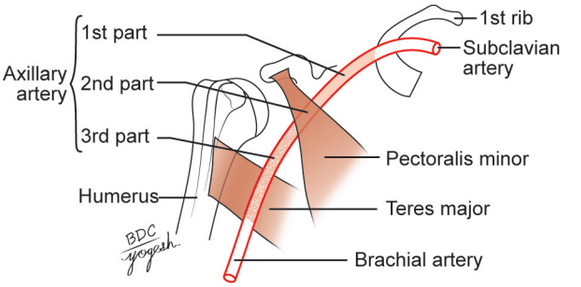


Fig. 4.6: The extent and parts of the axillary artery

6. Axillary tail of mammary gland
7. Axillary fat and areolar tissue in which the other contents are embedded.

CLINICAL ANATOMY

The axilla has abundant axillary hair. Infection of the hair follicles and sebaceous glands gives rise to boils, which are common in this area.

***Competency*:**
AN10.2 Identify, describe and demonstrate the origin, extent, course, parts, relations and branches of axillary artery and tributaries of vein.

AXILLARY ARTERY

Axillary artery is the continuation of the subclavian artery. It extends from the outer border of the 1st rib to the lower border of the teres major muscle, where it continues as the brachial artery. Its direction varies with the position of the arm.

Parts

Axillary artery is crossed anteriorly by pectoralis minor muscle. The crossing of pectoralis minor muscle divides the axillary artery into the following three parts (Fig. 4.6, Flowchart 4.2):

1. **First part**, superior or proximal to the muscle.
2. **Second part**, posterior or deep to the muscle.
3. **Third part**, inferior or distal to the muscle.

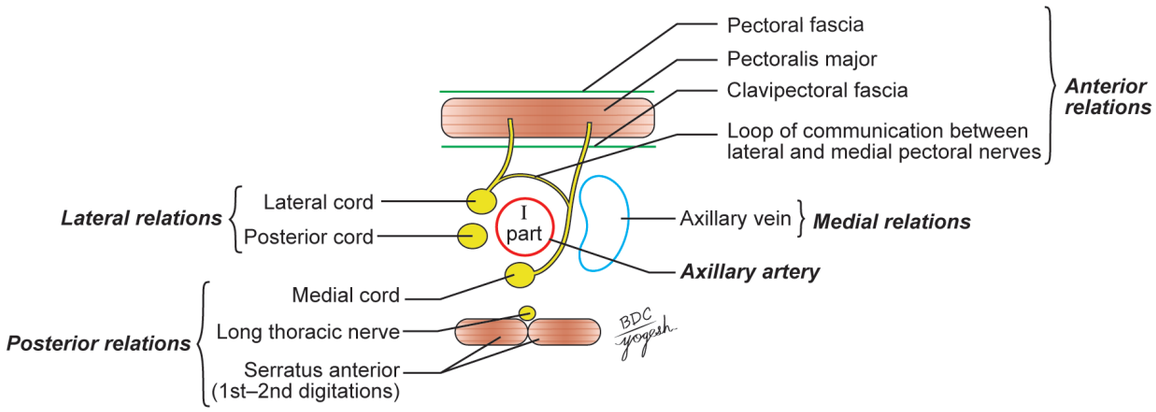


Fig. 4.7a: Diagrammatic relations of first part of axillary artery

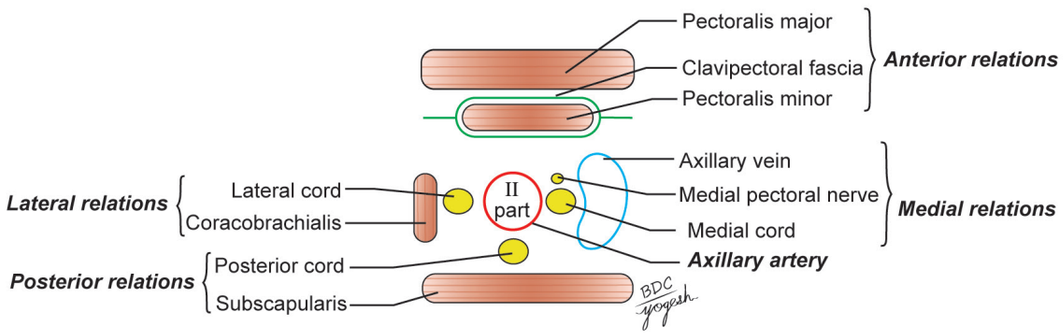


Fig. 4.7b: Diagrammatic relations of second part of axillary artery

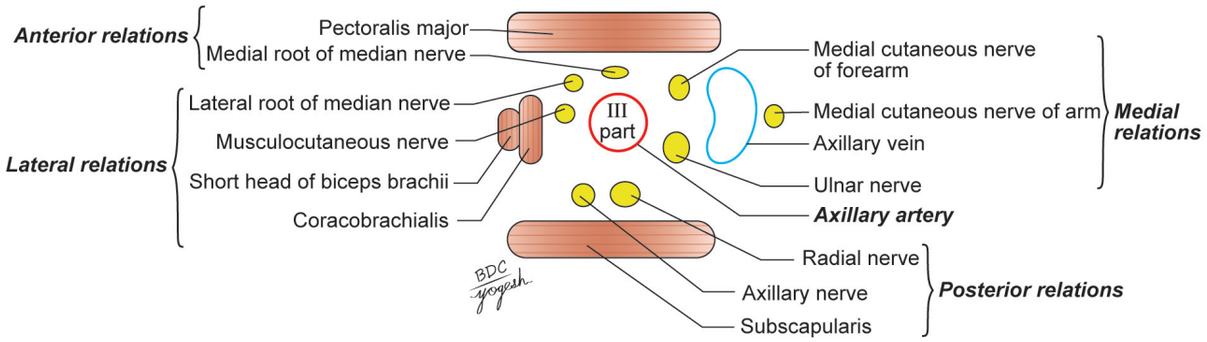


Fig. 4.7c: Diagrammatic relations of third part of axillary artery (proximal part)

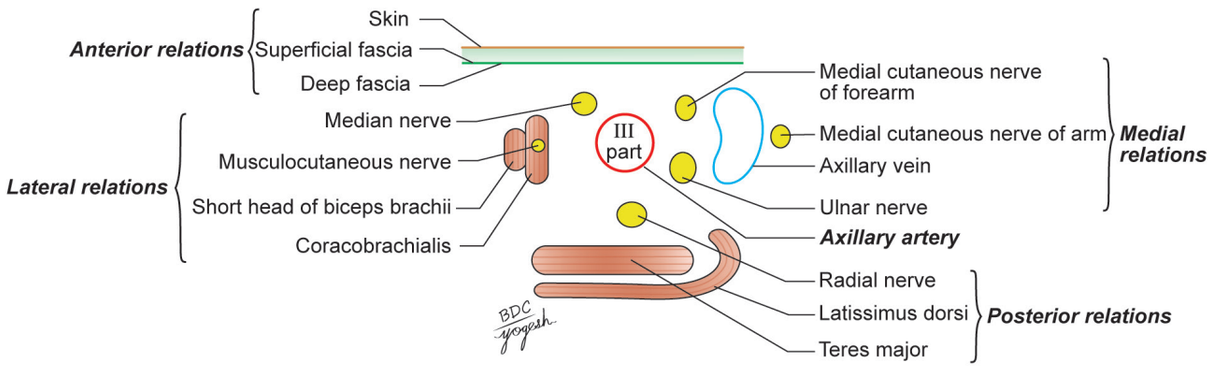
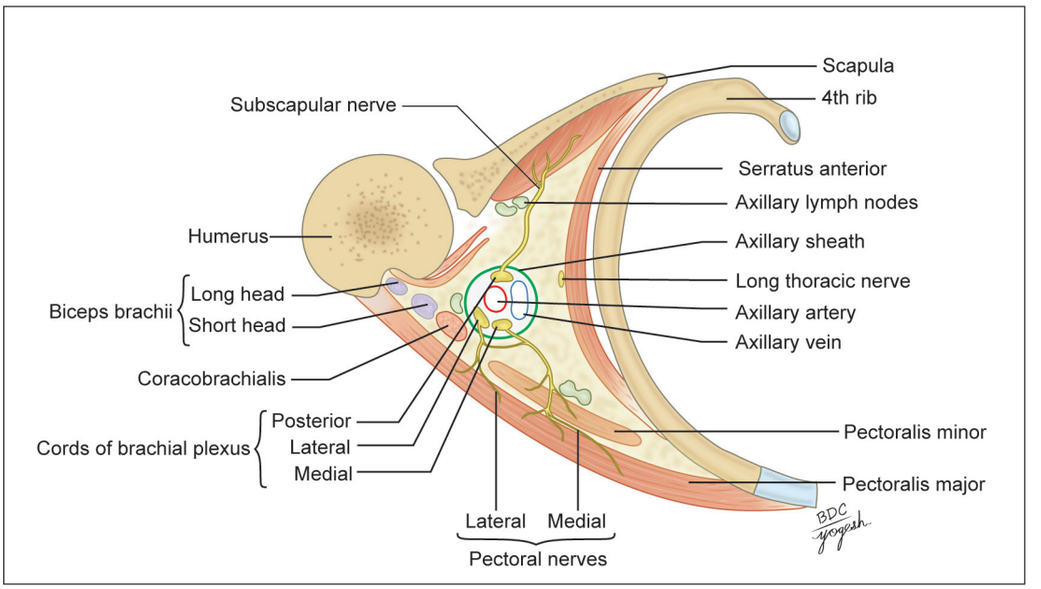


Fig. 4.7d: Diagrammatic relations of third part of axillary artery (distal part)

Plate 4.3: Content of right axilla



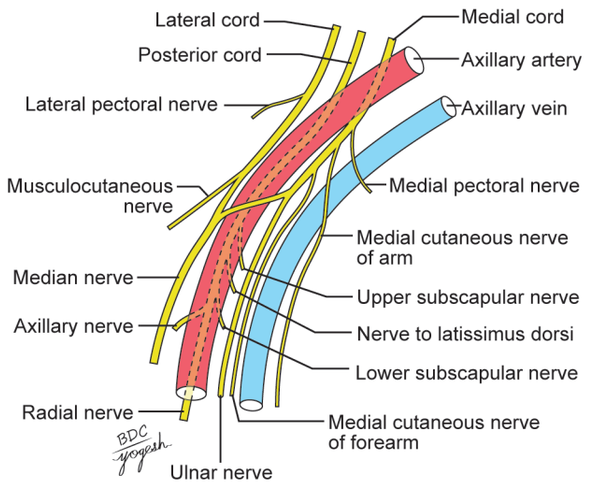
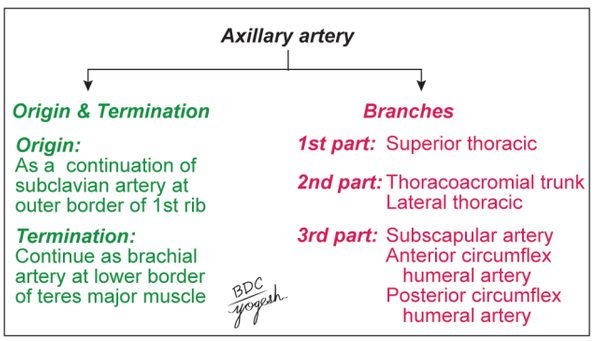


Fig. 4.8: Relation of the brachial plexus to the axillary artery

Flowchart 4.2: Axillary artery



RELATIONS OF AXILLARY ARTERY

The axillary artery is related to the corresponding walls of axilla and accompanied by the axillary vein on the medial side (Plate 4.4). The first part of the axillary artery is enclosed (together with the brachial plexus) in the axillary sheath, derived from the prevertebral layer of deep cervical fascia. The other specific relations of axillary artery are described as relation of 1st, 2nd and 3rd parts are given below.

Relations of 1st Part

Anterior

1. Skin
2. Superficial fascia, platysma and supraclavicular nerves
3. Deep fascia
4. Clavicular part of the pectoralis major (Fig. 4.7a)
5. Clavipectoral fascia
6. Loop of communication between the lateral and medial pectoral nerves.

Posterior

1. Medial cord of brachial plexus
2. Nerve to serratus anterior
3. 1st and 2nd digitations of the serratus anterior
4. 1st intercostal space.

Lateral

1. Lateral and posterior cords of the brachial plexus.

Medial

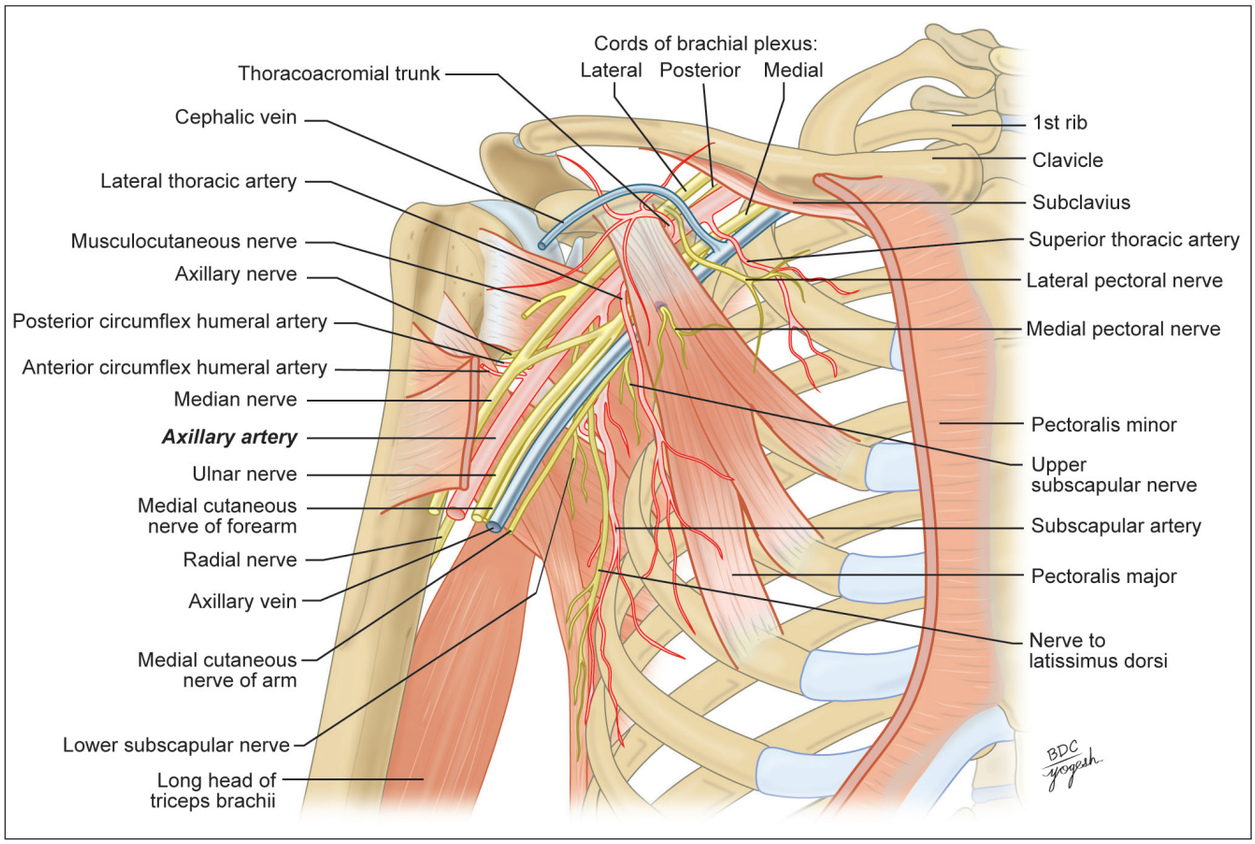
1. Axillary vein.

Relations of 2nd Part

Anterior

1. Skin
2. Superficial fascia
3. Deep fascia
4. Pectoralis major
5. Pectoralis minor (Fig. 4.7b).

Plate 4.4: Relations of contents of axilla



Posterior

1. Posterior cord of brachial plexus
2. Subscapularis.

Lateral

1. Lateral cord of brachial plexus (Fig. 4.8)
2. Coracobrachialis.

Medial

1. Medial cord of brachial plexus
2. Medial pectoral nerve
3. Axillary vein.

Relations of 3rd Part

Anterior

1. Skin
2. Superficial fascia
3. Deep fascia
4. Medial root of the median nerve
5. Pectoralis major (in the upper part only).

Posterior

1. Radial nerve (Plate 4.4)
2. Axillary nerve in the upper part
3. Subscapularis in the upper part
4. Tendons of the latissimus dorsi and the teres major in the lower part (Fig. 4.7d).

Lateral

1. Musculocutaneous nerve in the upper part (Fig. 4.8)
2. Lateral root of median nerve in the upper part
3. Trunk of median nerve in the lower part
4. Coracobrachialis.

Medial

1. Medial cutaneous nerve of the forearm
2. Ulnar nerve
3. Axillary vein
4. Medial cutaneous nerve of arm.

Branches

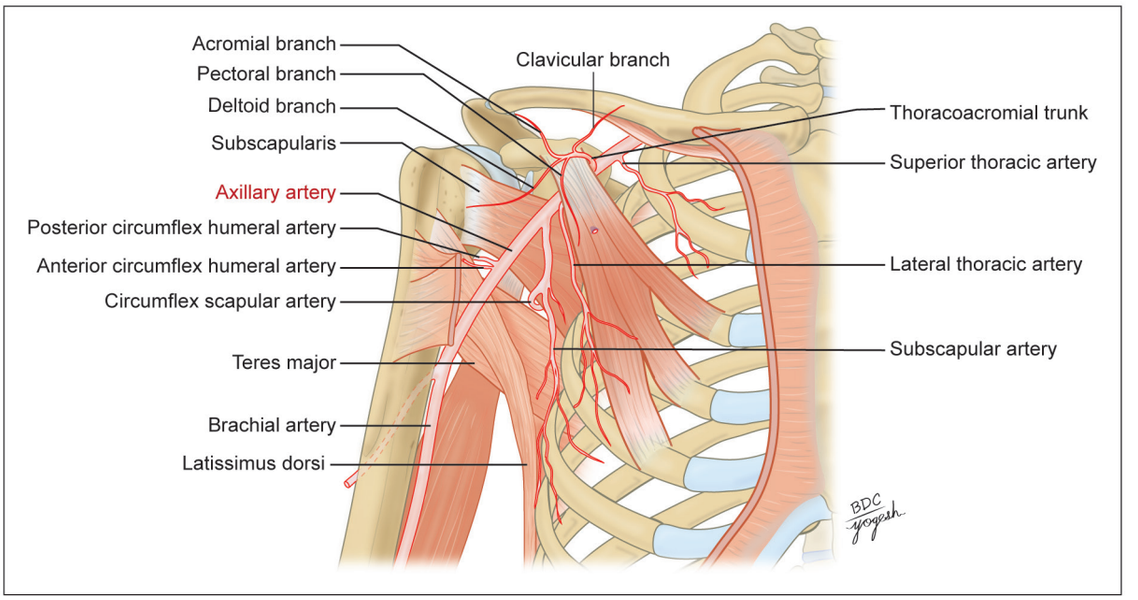
The axillary artery gives six branches, one from the 1st part, two from the 2nd part and three branches from the 3rd part (Plate 4.5, Fig. 4.9).

1st part:	Superior thoracic artery
2nd part:	Thoracoacromial trunk,
	Lateral thoracic artery
3rd part:	Subscapular artery
	Anterior circumflex humeral artery
	Posterior circumflex humeral artery.

Superior Thoracic Artery

It is a very small branch that arises from the 1st part of the axillary artery (near the subclavius). It runs along the superior border of pectoralis minor muscle. It supplies

Plate 4.5: Branches of axillary artery



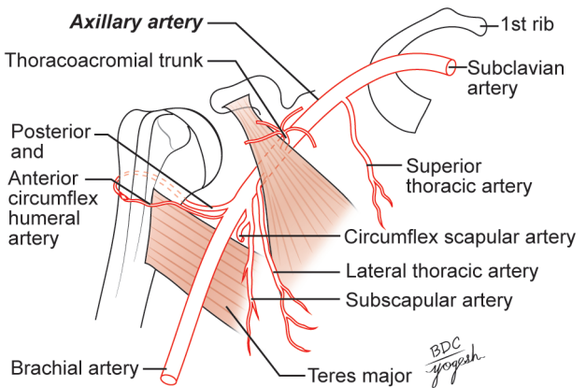


Fig. 4.9: The branches of the axillary artery

pectoralis major and minor muscles and the thoracic wall (Fig. 4.9).

Thoracoacromial (Acromiothoracic) Artery

It is a branch from the 2nd part of the axillary artery. It emerges at the upper border of the pectoralis minor, pierces the clavipectoral fascia and soon divides into the following four terminal radiating branches:

1. The *pectoral branch* passes between the pectoral muscles and supplies pectoral muscles and the breast.
2. The *deltoid branch* runs in the deltopectoral groove, along with the cephalic vein.
3. The *acromial branch* joins the anastomoses over the acromion process.
4. The *clavicular branch* runs superomedially deep to the pectoralis major and supplies the acromioclavicular joint and subclavius.

[*Mnemonic*: "ABCD": **A**cromial, **B**reast (pectoral), **C**lavicular, **D**eltoid).

Lateral Thoracic Artery

It is a branch of the 2nd part of the axillary artery. It emerges at, and runs along, the lower border of the pectoralis minor in close relation with the anterior group of axillary lymph nodes.

In females, the artery is large and gives off the lateral mammary branches to the breast.

Subscapular Artery

It is the largest branch of the axillary artery, arising from its 3rd part. It runs along the lower border of the subscapularis to terminate near the inferior angle of the scapula. It supplies the latissimus dorsi and the serratus anterior.

It gives off a large branch, the ***circumflex scapular artery***, which passes through the upper triangular intermuscular space and winds around the lateral border of the scapula between two slips of the teres minor to enter the infraspinous fossa. The subscapular artery and its branches give numerous branches that anastomoses around the scapula. It also gives ***thoracodorsal artery*** which runs inferiorly with the thoracodorsal nerve and supplies the latissimus dorsi.

Anterior Circumflex Humeral Artery

It is a small branch arising from the 3rd part of the axillary artery at the lower border of the subscapularis.

It passes laterally and anastomoses with the posterior circumflex humeral artery to form an arterial circle round the surgical neck of the humerus.

It gives off an *ascending branch*, which runs in the intertubercular sulcus, and supplies the head of the humerus and shoulder joint (Fig. 4.9).

Posterior Circumflex Humeral Artery

It is much larger than the anterior artery. It arises from the 3rd part of the axillary artery at the lower border

of the subscapularis. It runs backwards, accompanied by the axillary nerve, passes through the *quadrangular intermuscular* space and ends by anastomosing with the anterior circumflex humeral artery around the surgical neck of the humerus.

It supplies the shoulder joint, the deltoid and the muscles bounding the quadrangular space.

It gives off a *descending branch,* which anastomoses with the ascending branch of the *profunda brachii artery*.

CLINICAL ANATOMY

Axillary arterial pulsations can be felt against the lower part of the lateral wall of the axilla. In order to check bleeding from the distal part of the limb (in injuries, operations and amputations), the artery can be effectively compressed against the humerus in the lower part of the lateral wall of the axilla.

AXILLARY VEIN

The axillary vein is the continuation of the basilic vein at the lower border of the teres major muscle. It runs upward on the medial side of the axillary artery (Fig. 4.10). At the outer border of the first rib, it becomes the subclavian vein.

Tributaries

1. Brachial veins (formed by venae comitantes along radial and ulnar arteries).
2. Tributaries corresponding to the branches of axillary artery (except that of thoracoacromial trunk)
3. Cephalic vein.

Note: The axillary vein lies outside the axillary sheath, which permits the required expansion of the axillary vein during venous return. Veins accompanying branches of thoracoacromial artery drain directly into the cephalic vein. Lateral thoracic vein of upper limb is joined to superficial epigastric vein of lower limb by thoracoepigastric vein enabling blood to return to heart in blockage of inferior vena cava.

Old concept: The axillary vein is formed by union of basilic vein and brachial vein.

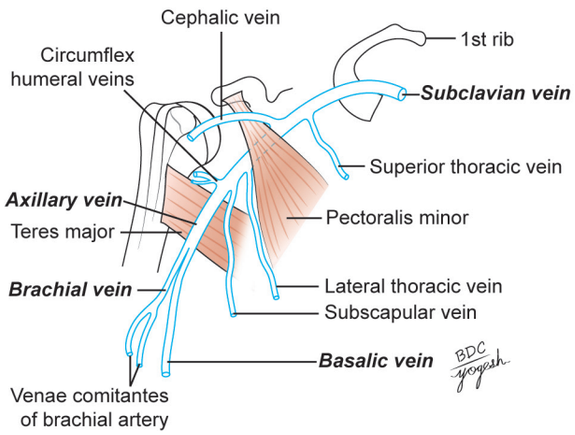


Fig. 4.10: Axillary vein: Formation and tributaries

Competencies:

AN10.4 Describe the anatomical groups of axillary lymph nodes and specify their areas of drainage.

AN10.7 Describe axillary lymph nodes, areas of drainage and anatomical basis of their enlargement.

AXILLARY LYMPH NODES

The axillary lymph nodes are scattered in the fibrofatty tissue of the axilla. They are divided into the following five groups:

1. ***Anterior (pectoral) group*** lies along the lateral thoracic vessels, i.e. along the lower border of the pectoralis minor. They receive lymph from the upper half of the anterior wall of the trunk, and from the major part of the breast (Flowchart 4.3, Fig. 4.11).
2. ***Posterior (scapular) group*** lies along the subscapular vessels on the posterior axillary fold. They receive lymph from the posterior wall of the upper half of the trunk and from the axillary tail of the breast.
3. ***Lateral group*** lies along the upper part of the humerus, medial to the axillary vein. They receive lymph from the upper limb.
4. ***Central group*** lies in the fat of the upper axilla. They receive lymph from the preceding groups and drain into the apical group. They receive some direct vessels from the floor of the axilla.
5. ***Apical or infraclavicular group*** lies deep to the clavipectoral fascia, along the axillary vessels. They receive lymph from the central group, from the upper part of the breast and from the thumb and its web. The lymphatics from the thumb accompany the cephalic vein. Anterior and central groups of nodes are often involved in carcinoma breast.

Flowchart 4.3: Axillary lymph nodes

Axillary lymph nodes

20–30 nodes | 5 groups

	Anterior	***Posterior***	***Lateral***	***Central***	***Apical***
Location	Along lateral thoracic vein and lateral border of pectoralis minor	Along posterior axillary fold, along subscapular vessels	Along, lateral wall of axilla	In the floor of axilla	Near apex of axilla
Area of drainage	Upper half of trunk, breast	Posterior body wall, scapular region	Upper limb except thumb	From anterior, posterior and lateral nodes	From central nodes and thumb

Clinical integration: Axillary lymphadenopathy, palpation of axillary nodes, axillary abscess.

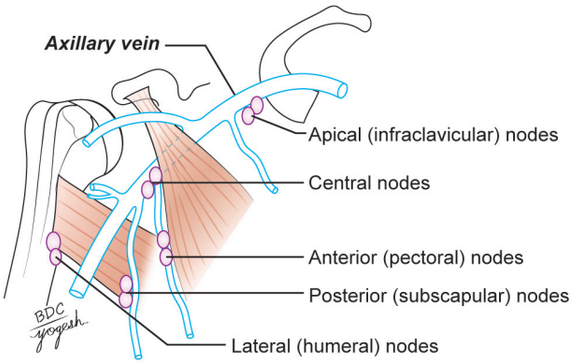


Fig. 4.11: The axillary lymph nodes

CLINICAL ANATOMY

- ***Axillary lymphadenopathy*:** The axillary lymph nodes drain lymph not only from the upper limb but also from the breast and the anterior and posterior body walls above the level of the umbilicus. Therefore, infections or malignant growths in any part of their territory of drainage give rise to *axillary lymphadenopathy* (enlargement of the lymph nodes) (Fig. 4.12).
- **Bimanual examination** of axillary lymph nodes is important in clinical practice. Left axillary nodes have to be palpated by right hand. Right axillary nodes have to be palpated by left hand. An axillary abscess should be incised through the floor of the axilla, midway between the anterior and posterior axillary folds and nearer to the medial wall in order to avoid injury to the main vessels running along the anterior, posterior and lateral walls.
- The axillary tail of Spence of the breast comes in contact with anterior group of axillary nodes. Therefore, cancer involving axillary tail of the breast may be misdiagnosed as an enlarged lymph node.
- The central group of nodes is in close relationship with intercostobrachial nerve. Hence, enlarged nodes may compress this nerve and cause pain along the inner border of arm.
- ***Axillary abscess*** may occur due to pus formation in the enlarged and infected axillary nodes. It can be drained by giving incision in the floor of axilla midway between anterior and posterior axillary walls, near the medial wall (to avoid injury to major vessels and nerves).

SPINAL NERVE

There are 31 pairs of spinal nerves. Each spinal nerve is formed by union of dorsal root and ventral root. *Dorsal root* is sensory and is characterised by the presence of *spinal* or *dorsal root ganglion* and enters the dorsal horn and posterior funiculus of spinal cord. *Ventral root* is motor and arises from anterior horn cells of spinal cord (Fig. 4.13). The motor and sensory fibres get united in the spinal nerve, which divides into short dorsal ramus and long ventral ramus. Dorsal ramus supplies muscles and skin of back, whereas the ventral ramus supplies anterolateral part of trunk and limb.

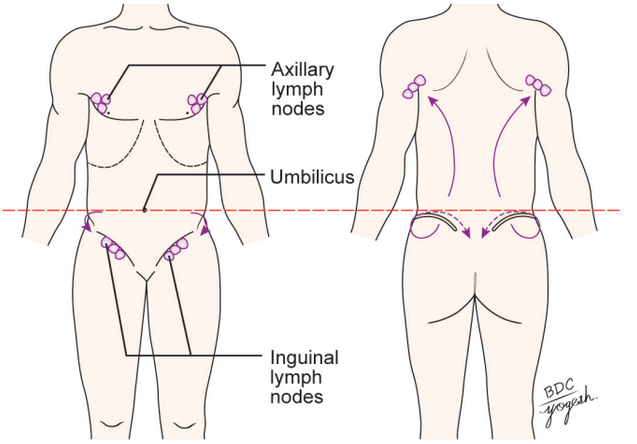


Fig. 4.12: Lymph above umbilicus drains into axillary lymph nodes while below umbilicus drains into inguinal group

Only the ventral primary rami form nerve plexuses. Brachial plexus is formed by ventral primary rami of C5–C8 and T1 segments of spinal cord.

Sympathetic fibres arising from lateral horn cells enter the ventral root and then the chain of sympathetic ganglion via grey rami communicantes. Postganglionic sympathetic fibres join spinal nerve through white rami communicantes.

Competencies:
AN10.3 Describe, identify and demonstrate formation, branches, relations, area of supply of branches, course and relations of terminal branches of brachial plexus.
AN10.5 Explain variations in formation of brachial plexus.

BRACHIAL PLEXUS

The brachial plexus is the nerve plexus that is derived from ventral (or anterior) primary rami of lower four cervical spinal nerves (C5–C8) and 1st thoracic spinal nerve (T1).

Components of Brachial Plexus

- Brachial plexus consists of the following components (Plate 4.4, Fig. 4.14, Flowchart 4.4):
  1. Roots: Ventral primary rami of C5–C8 and T1 nerves.
  2. Trunks: Three trunks derived from roots (upper, middle and lower).
  3. Divisions: Each trunk divides into anterior and posterior divisions.
  4. Cords: Divisions join to form three cords (medial, lateral and posterior).
  5. Branches: Various nerves arise from each cord.

[*Mnemonic*: "Ramu Tailor Drinks Cold Beer": **R**oots, **T**runks, **D**ivisions, **C**ords, **B**ranches]

- Relations of brachial plexus with clavicle: *Supraclavicular part* of brachial plexus includes roots and trunks, *retroclavicular part* includes divisions of trunks and *infraclavicular part* includes cords and their branches.

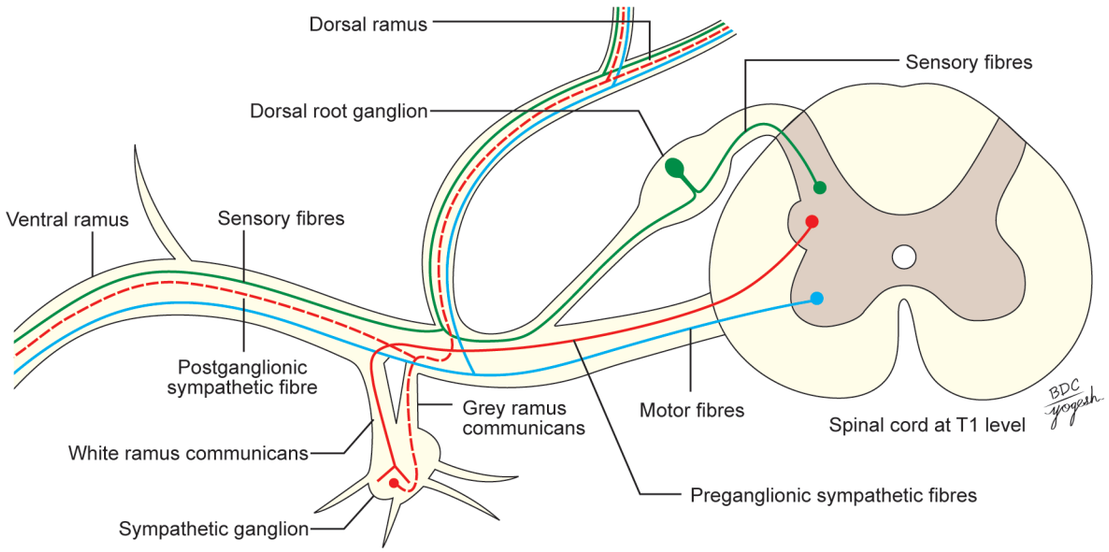


Fig. 4.13: Mixed fibres of a spinal nerve

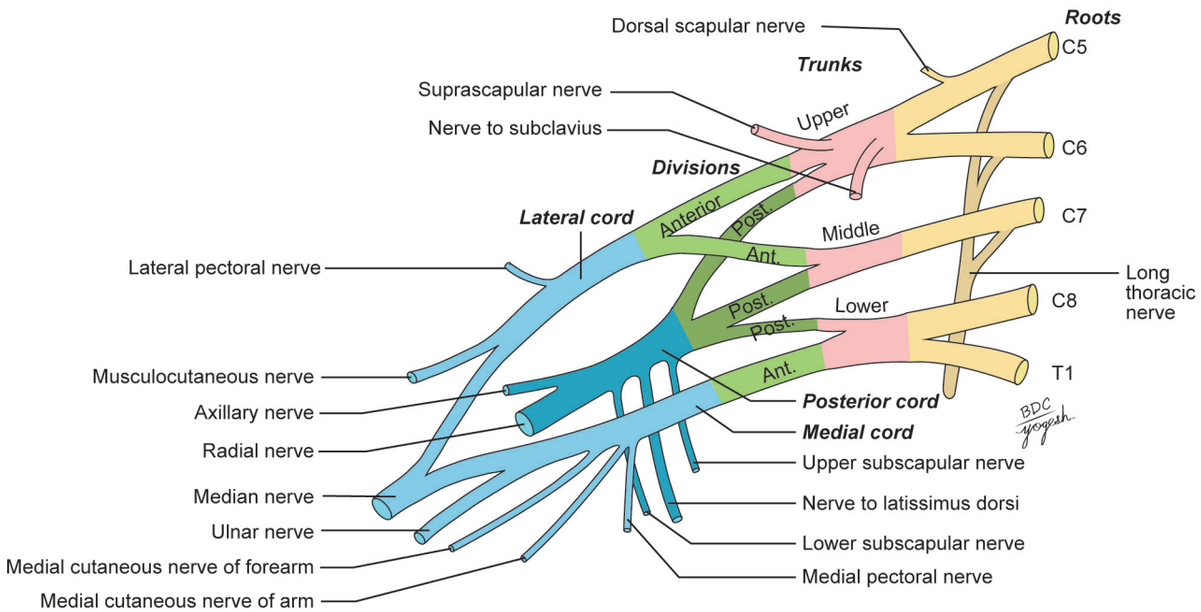


Fig. 4.14: The right brachial plexus

Flowchart 4.4: Brachial plexus

Brachial plexus

Roots
Ventral primary rami of C5–C8 and T1 spinal nerves
Branches:
Nerve to serratus anterior
Nerve to rhomboids

Trunks
Upper trunk:
formed by joining of C5, C6 roots
Branches:
Suprascapular nerve
Nerve to subclavius
Middle trunk:
Continuation of C7 root
Lower trunk:
Formed by joining of C8 and T1 roots

Divisions
Each trunk divides into anterior posterior divisions

Cords

Lateral cord
Union of anterior divisions of upper and middle trunk
Branches:
Lateral pectoral n.
Musculocutaneous n.
Lateral root of median n.

Medial cord
Continuation of anterior division of lower trunk
Branches:
Medial cutaneous nerve of arm
Medial cutaneous nerve of forearm
Medial pectoral n.
Ulnar n.
Medial root of median n.

Posterior cord
Union of posterior divisions of all trunks
Branches:
Upper subscapular n.
Thoracodorsal n.
Lower subscapular n.
Axillary n.
Radial n.

Roots

These are constituted by the ventral primary rami of spinal nerves C5–C8 and T1, with occasional contributions from the ventral primary rami of C4 and T2 (Fig. 4.14).

The origin of the plexus may shift by one segment, either upward or downward, resulting in a prefixed or postfixed plexus, respectively. In a *prefixed plexus*, the contribution by C4 is large, T1 is small and T2 is often absent.

In a *postfixed plexus*, the contribution by T1 is large, T2 is always present, C4 is absent and C5 is reduced in size.

Trunks

Roots of the brachial plexus join to form three trunks as follows:

1. *Upper trunk* formed by joining of C5 and C6 roots.
2. *Middle trunk* as a continuation of C7 root.
3. *Lower trunk* formed by joining C8 and T1 roots.

Trunks lie deep in the neck between scalenus anterior and scalenus medius muscles.

Divisions of the Trunks

Each trunk (three in number) divides into ventral and dorsal divisions (which ultimately supply the anterior and posterior aspects of the limb).

Cords and Branches

Divisions join to form three cords:

1. The *lateral cord* is formed by the union of ventral divisions of the upper and middle trunks (two divisions).
2. The *medial cord* is formed by the ventral division of the lower trunk (one division).
3. The *posterior cord* is formed by union of the dorsal divisions of all the three trunks (three divisions). These are named according to relation of cords to the 2nd part of axillary artery.

Branches

The root value of each branch is given in brackets.

Branches of the Roots

1. Nerve to serratus anterior (long thoracic nerve) (C5, C6, C7)
2. Nerve to rhomboids (dorsal scapular nerve) (C5)
3. Branches to longus colli and scaleni muscles (C5– C8) and branch to phrenic nerve (C4).

Branches of the Trunks

These arise only from the upper trunk:

1. Suprascapular nerve (C5, C6)
2. Nerve to subclavius (C5, C6).

Branches of the Cords

Branches of lateral cord

1. Lateral pectoral nerve (C5–C7)
2. Musculocutaneous nerve (C5–C7)
3. Lateral root of median nerve (C5–C7).

[*Mnemonic*: "**LML**"]

Branches of medial cord

1. Medial pectoral nerve (C8, T1)
2. Medial cutaneous nerve of arm (C8, T1)
3. Medial cutaneous nerve of forearm (C8, T1)
4. Ulnar nerve (C7, C8, T1)
5. Medial root of median nerve (C8, T1) (joins the lateral root to form the median nerve).

[*Mnemonic*: "**M4U**"]

Branches of posterior cord

1. Upper subscapular nerve (C5, C6)
2. Nerve to latissimus dorsi (C6–C8)
3. Lower subscapular nerve (C5, C6)
4. Axillary (circumflex) nerve (C5, C6)
5. Radial nerve (C5–C8, T1).

[*Mnemonic*: "**U**dit **N**ever **L**eave **A** **R**ainbow"]

In addition to the branches of the brachial plexus, the upper limb is also supplied near the trunk by the supraclavicular branches of the cervical plexus and by the intercostobrachial branch of the second intercostal nerve. Sympathetic nerves are distributed through the brachial plexus.

Kuntz's nerve is the communicating branch between T1 and T2 nerves, which carry sympathetic fibres from 3rd thoracic ganglion to the upper limb via T2 nerve.

Blood Supply of Brachial Plexus

Vertebral artery and thyrocervical trunk with its branches, the suprascapular and transverse cervical arteries, supply blood to the brachial plexus. These are the lifeline of this important plexus.

DISSECTION

After cleaning the branches of the axillary artery, proceed to clean the brachial plexus. It is formed by the ventral primary rami of the lower four cervicals (C5–C8) and the first thoracic (T1) nerves. The first and second parts of the axillary artery are related to the cords, and third part is related to the branches of the plexus.

Reflect upward carefully pectoralis major to visualise lateral pectoral nerve. Musculocutaneous nerve pierces coracobrachialis muscle. Lateral root of median nerve joins with medial root in front of 3rd part of axillary artery. Together, it forms a 'Y' shaped structure.

Reflect pectoralis major laterally to visualise medial pectoral nerve, which pierces the pectoralis minor muscle. The medial cutaneous nerve of arm is a very thin nerve that runs on medial side of axillary vein. The medial cutaneous nerve of forearm is a thin nerve and runs downward between axillary artery and vein, anterior to the thicker ulnar nerve.

Axillary nerve lies posterolateral to the axillary artery and leaves the axilla through the quadrangular muscular space. The radial nerve lies hidden behind the axillary artery. The upper and lower subscapular nerves and nerve to latissimus dorsi run downwards posterior to

the axillary artery and vein, on the anterior surface of subscapularis muscle. Nerve to latissimus dorsi is larger and lies in between upper and lower subscapular nerves.

Long thoracic nerve passes on the lateral surface of serratus anterior muscle in midaxillary line.

Competency:
AN10.6 Explain the anatomical basis of clinical features of Erb's palsy and Klumpke's paralysis.

CLINICAL ANATOMY

Global total brachial plexus birth palsy is the most severe type of paralysis.

Erb's Paralysis

Erb's paralysis or palsy is the paralysis of arm caused by injury to upper trunk of brachial plexus [Wilhelm Heinrich Erb, German Neurologist, 1840–1921].

Site of injury: One region of the upper trunk of the brachial plexus is called Erb's point (Fig. 4.15). Six nerves meet here. Injury to the upper trunk causes Erb's paralysis.

Nerve roots involved: Mainly C5 and partly C6.

Causes of injury: Undue separation of the head from the shoulder, which is commonly encountered in the following:

1. Birth injury/difficult childbirth (Fig. 4.16)
2. Fall on the shoulder
3. During anaesthesia.

Muscles paralysed: Mainly biceps brachii, deltoid, brachialis and brachioradialis. Partly supraspinatus, infraspinatus and supinator.

Deformity and position of the limb:

- *Arm*: Hangs by the side; it is adducted and medially rotated.
- *Forearm*: Extended and pronated. The deformity is known as '***policeman's tip hand***' or '***waiter's tip hand***' or '***porter's tip hand***' (Fig. 4.17).

Disability: The following movements are lost.

- Abduction and lateral rotation of the arm at shoulder joint.
- Flexion and supination of the forearm.
- Biceps and supinator jerks are lost.
- Sensations are lost over a small area over the lower part of the deltoid.

Klumpke's Paralysis

Klumpke's paralysis or palsy is the injury of the lower trunk of brachial plexus, causing paralysis of hand muscles.

Site of injury: Lower trunk of the brachial plexus.

Cause of injury: Undue abduction of the arm, as in clutching something with the hands after a fall from a height, or sometimes in birth injury (Fig. 4.18, Flowchart 4.5).

Nerve roots involved: Mainly T1 and partly C8.

Muscles paralysed:

- Intrinsic muscles of the hand (T1).
- Ulnar flexors of the wrist and fingers (C8).

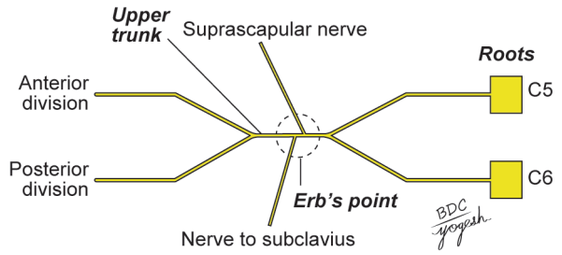


Fig. 4.15: Erb's point

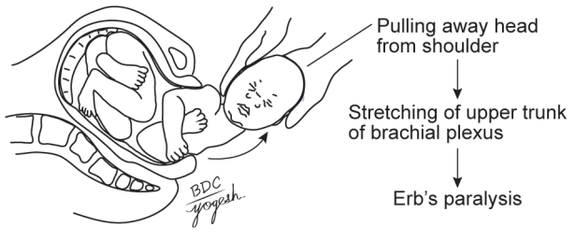


Fig. 4.16: Causes of injury in Erb's paralysis

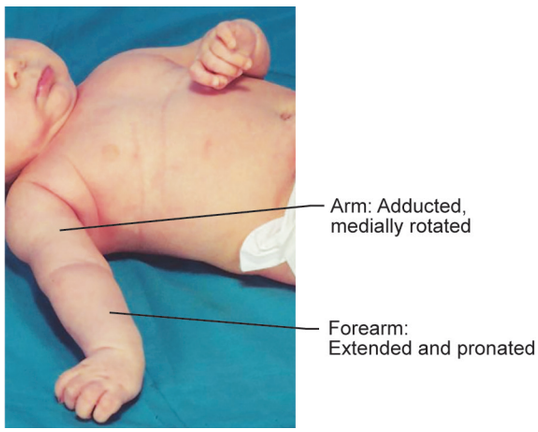


Fig. 4.17: Erb's paralysis of right arm

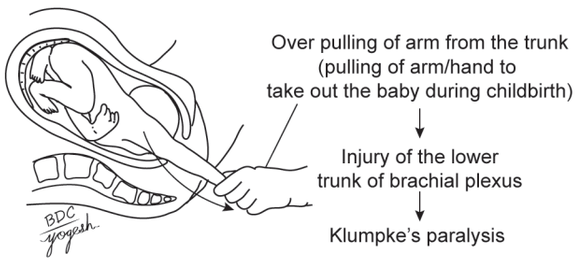


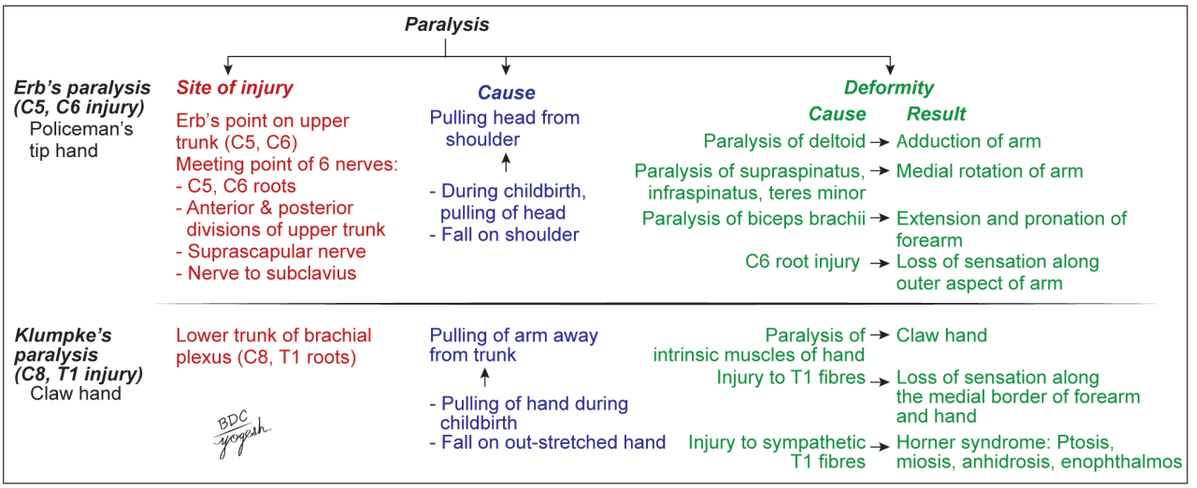
Fig. 4.18: Causes of injury in Klumpke's paralysis

Deformity and position of the hand: Claw hand due to the unopposed action of the long flexors and extensors of the fingers. In a claw hand, there is hyperextension at the metacarpophalangeal joints and flexion at the interphalangeal joints.

Disability:

- Complete claw hand (Fig. 4.19).
- Cutaneous anaesthesia and analgesia in a narrow zone along the ulnar border of the forearm and hand.
- *Horner's syndrome:* If T1 is injured proximal to white ramus communicantes to 1st thoracic sympathetic

Flowchart 4.5: Erb's and Klumpke's paralysis



ganglion, there is ptosis, miosis, anhydrosis, enophthalmos and loss of ciliospinal reflex—may be associated. This is because of injury to sympathetic fibres to the head and neck that leave the spinal cord through nerve T1 (Fig. 4.20).

- *Vasomotor changes:* The skin area with sensory loss is warmer due to arteriolar dilation. It is also drier due to the absence of sweating as there is loss of sympathetic activity.
- *Trophic changes:* Long-standing case of paralysis leads to dry and scaly skin. The nails crack easily with atrophy of the pulp of fingers.

Injury to the Nerve to Serratus Anterior (Nerve of Bell)

Causes:

1. Sudden pressure on the shoulder from above.
2. Carrying heavy loads on the shoulder.

Deformity: Winging of the scapula, i.e. excessive prominence of the medial border of the scapula.

Normally, the pull of the muscle keeps the medial border against the thoracic wall.

Disability:

- Loss of pushing and punching actions. During attempts at pushing, there occurs winging of the scapula.
- Overhead abduction of shoulder girdle is partly affected due to intact trapezius muscle.

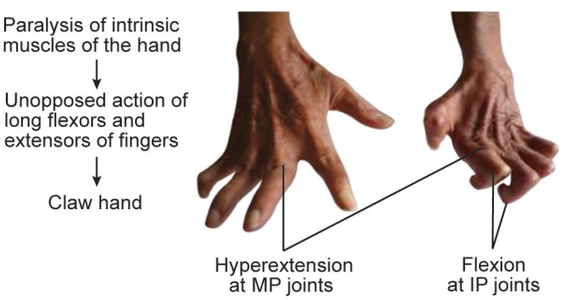


Fig. 4.19: Complete claw hand



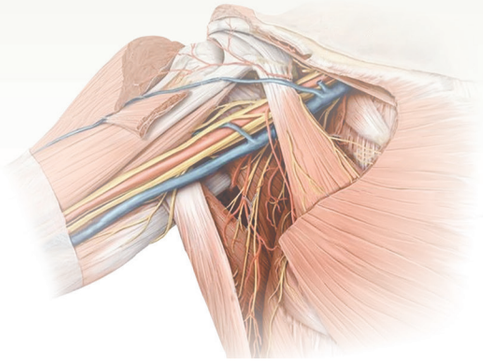
Fig. 4.20: Ptosis due to Horner's syndrome

Facts to Remember

- Apex of the axilla is known as *cervicoaxillary canal* and gives passage to axillary vessels and lower part of brachial plexus.
- Infraclavicular part of brachial plexus lies in the axilla.
- The fibre of sternoaponeurotic part of pectoralis major and latissimus dorsi twisted.
- Axillary sheath is derived from prevertebral fascia.
- Brachial plexus – ventral primary rami of C5–C8 and T1 – consists of roots, trunks, divisions, cords and branches.
- The radial nerve is the largest branch of the brachial plexus.
- *Horner's syndrome*, due to damaged sympathetic fibres from T1, shows ptosis, miosis, anhidrosis, enophthalmos and loss of ciliospinal reflex.
- Erb's paralysis – injury to the upper trunk – '*policeman's tip hand*' or '*waiter's tip hand*' or '*porter's tip hand*'
- Klumpke's paralysis – injury of the lower trunk – complete claw hand.

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1. Layout of axilla
2. Anastomoses and collateral circulation
3. Branches of brachial plexus
4. Sympathetic innervation of upper limb
5. Further reading
6. Viva voce questions



Chapter

5

Back

SURFACE LANDMARKS

1. ***Scapula* (*shoulder blade*):** It is placed on the postero-lateral aspect of the upper part of the thorax. It extends from the 2nd to 7th ribs. Although it is thickly covered by muscles, most of its outline can be felt in the living subject.
   a. The ***acromion*** process lies at the top of the shoulder.
   b. The ***crest of the spine*** of the scapula runs from the acromion process medially and slightly downwards to the medial border of the scapula.
   c. The *medial border* and the *inferior angle* of the scapula can also be palpated (Fig. 5.1).
2. The ***8th rib*** is just below the inferior angle of the scapula. The lower ribs can be identified on the back by counting down from the 8th rib.
3. The ***iliac crest*** is a curved bony ridge lying below the waist. The anterior end of the crest is the *anterior superior iliac spine*. The *posterior superior iliac spine* is felt in a shallow dimple above the buttock, about 5 cm from the median plane.
4. The ***sacrum*** lies between the right and left dimples mentioned above. Usually, three *sacral spines* are palpable in the median plane.
5. The ***coccyx*** lies between the two buttocks in the median plane.
6. The spine of the 7th cervical vertebra or *vertebra prominens* is readily felt at the root of the neck. Higher up on the back of the neck, the 2*nd cervical spine* can be felt about 5 cm below the *external occipital protuberance*. Other spines that can be recognised are T3 at the level of root of the spine of the scapula, L4 at the level of the highest point of the iliac crest and S2 at the level of the posterior superior iliac spine (Table 5.1).
7. The junction of the back of the head with that of the neck is indicated by the external occipital protuberance and the superior nuchal lines. The ***external occipital protuberance*** is a bony projection felt in the median plane on the back of the head at the upper end of the nuchal furrow (running vertically on the back of the neck).
8. The ***superior nuchal lines*** are indistinct curved ridges, which extend on either side from the protuberance to the mastoid process. The *nuchal furrow* extends to the external occipital protuberance above and to the spine of C7 below.

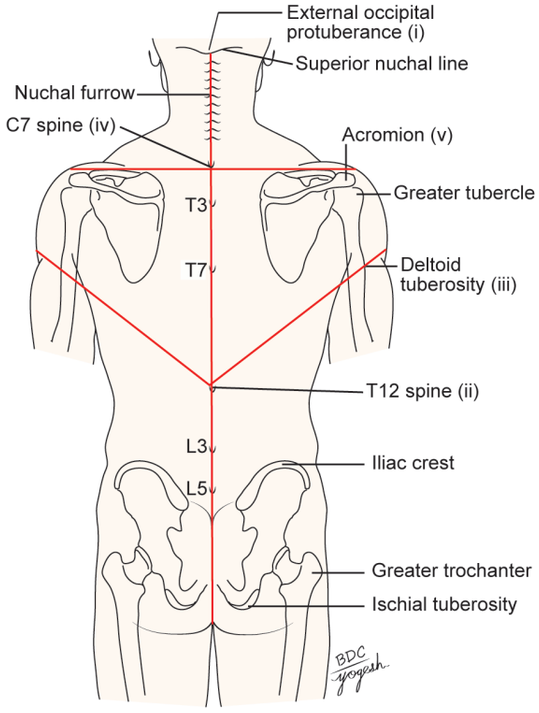


Fig. 5.1: Surface landmarks and lines of dissection

TABLE 5.1: Approximate levels of some spines on the back of the body

Vertebral spine	*Level*
C2	About 5 cm below the *external occipital protuberance*
C7	At the root of the neck
T2	Superior angle of the scapula
T3	Where crest of spine of the scapula meets its medial border
T7	Inferior angle of the scapula
L4	Highest point of iliac crests
S2	Posterior-superior iliac spine

SKIN AND FASCIAE OF THE BACK

Position

Humans mostly lie on their back. Therefore, the skin and fasciae of the back are adapted to sustain pressure of the body weight. Accordingly, the skin is thick and fixed to the underlying fasciae, the superficial fascia containing variable amount of fat is thick and strong and is connected to overlying skin by connective tissue, and the deep fascia is dense in texture. Hence, it is difficult to separate skin of back from underlying fascia.

Cutaneous Nerves

The cutaneous nerves of the back are derived from the *posterior primary rami* of the spinal nerves. Their distribution extends up to the posterior axillary lines.

1. The posterior primary rami of the spinal nerves C1, C7, C8, L4 and L5 do not give off any cutaneous branches. All twelve thoracic, L1–3 and five sacral nerves, however, give cutaneous branches.
2. Each posterior primary ramus divides into medial and lateral branches, both of which supply the erector spinae muscles, but only one of them, either medial or lateral, continues to become the cutaneous nerves.
3. In the upper half of the body (up to T6), the medial branches, and in the lower half of the body (below T6), the lateral branches of the posterior primary rami provide the cutaneous branches. Each cutaneous nerve divides into a smaller medial and a larger lateral branch before supplying the skin (Fig. 5.2).
4. The posterior primary rami supply the intrinsic muscles of the back and the skin covering them. The cutaneous distribution extends further laterally than the extensor muscles.
5. No posterior primary ramus *ever* supplies skin or muscles of a limb. The cutaneous branches of the posterior primary rami of nerves L1, 2, 3 and S1–3 are exceptions in this respect: They turn downwards unlike any other nerve and supply the skin of the gluteal region.

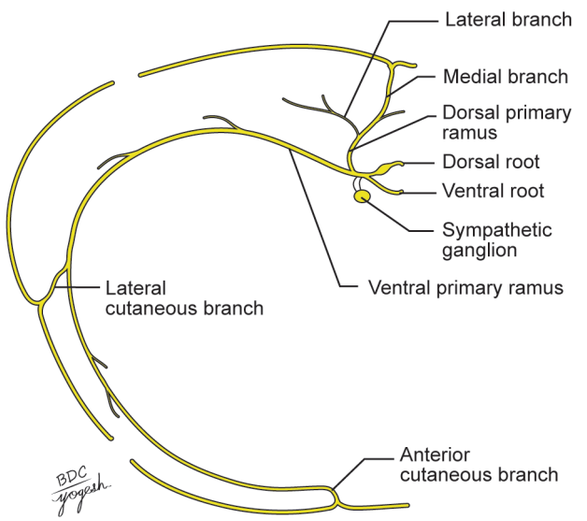


Fig. 5.2: Typical thoracic spinal nerve. The ventral or anterior primary ramus is the intercostal nerve

DISSECTION

Identify the external occipital protuberance (i) of the skull. Draw a line in the midline from the protuberance to the spine of the last thoracic (T12) vertebra (ii). Make incision along this line (Fig. 5.1). Extend the incision from its lower end to the deltoid tuberosity (iii) on the humerus which is present on lateral surface about the middle of the arm. Note that the arm is placed by the side of the trunk. Make another incision along a horizontal line from 7th cervical spine—vertebra prominens (iv) to the acromion process of scapula (v). Reflect the skin flap laterally.

Competency:
AN10.8 Describe, identify, and demonstrate the position, attachment, nerve supply, and actions of the trapezius and latissimus dorsi.

MUSCLES CONNECTING THE UPPER LIMB WITH THE VERTEBRAL COLUMN

Features

Muscles connecting the upper limb with the vertebral column are the posterior axio-appendicular muscles. These are grouped as follows (Figs 5.3a and b, Fig. 5.4, Flowchart 5.1, Plates 5.1 and 5.2):

1. Superficial layer
   - Trapezius
   - Latissimus dorsi
2. Deep layer
   - Levator scapulae
   - Rhomboid major
   - Rhomboid minor

The attachments of these muscles are given in Table 5.2, and their nerve supply and actions are shown in Table 5.3, Figs 5.3 to 5.6.

DISSECTION

Identify the attachments of trapezius muscle in the upper part of back; and that of latissimus dorsi in the lower part (Fig. 5.3b). Cut vertically through trapezius 5 cm lateral to the vertebral spines. Divide the muscle horizontally between the clavicle and spine of scapula; and reflect it laterally to identify the *accessory nerve* and its accompanying blood vessels, the *superficial branch of transverse cervical artery* and *vein*.

Look for the *suprascapular vessels* and *nerve*, deep to trapezius muscle, towards the scapular notch.

Cut through levator scapulae muscle midway between its two attachments and clean the dorsal scapular nerve (supplying the rhomboids) and accompanying blood vessels. Identify rhomboid minor from rhomboid major muscle.

Pull the medial or inner scapular border away from the chest wall for looking at the serratus anterior muscle.

Define attachments of latissimus dorsi muscle.

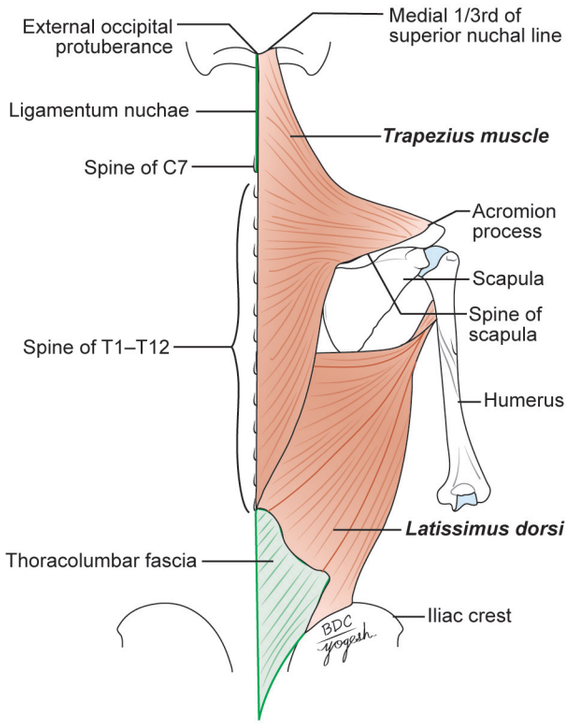


Fig. 5.3a: The trapezius muscle and latissimus dorsi

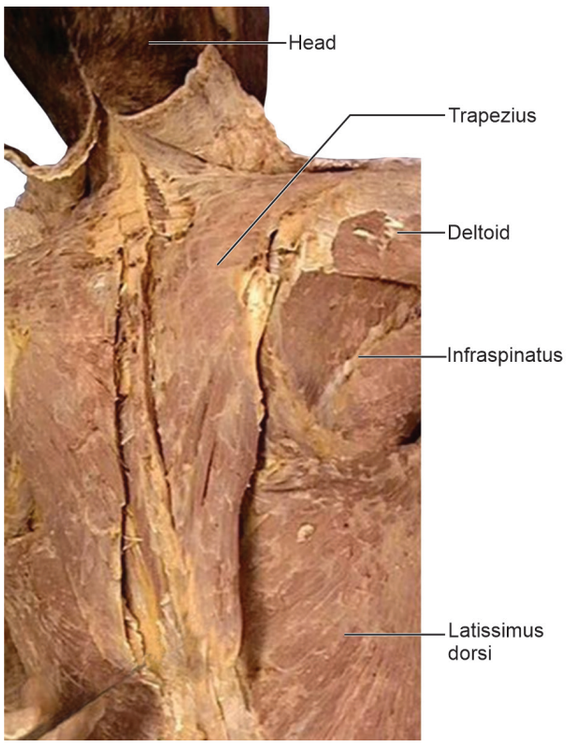


Fig. 5.3b: Dissection of the back showing superficial muscles

Flowchart 5.1: Muscles of back

Muscles of back

Muscle	Origin	Insertion	Innervation	Actions
Trapezius	External occipital protuberance Superior nuchal line Spines of C7–T12 vertebrae Ligamentum nuchae	Posterior border lateral third of clavicle Medial border of acromion Upper lip of crest of spine of scapula	Motor: Spinal part of XI cranial nerve Proprioceptive: C3, C4	Upper fibres: elevation of scapula Middle fibres: retraction of scapula Lower fibres: Overhead abduction of arm
Latissimus dorsi	Iliac crest Thoracolumbar fascia Spines of T7–T12 vertebrae Lower 3–4 ribs Inferior angle of scapula	Fibres twists upside down around lower border of teres major Inserts on floor bicipital groove	Thoracodorsal nerve (C6–C8)	Helps in swimming, rowing, climbing, pulling Adduction,extension, medial rotation of arm Violent expiration
Levator scapulae	Transverse processes of C1–C4 vertebrae	Medial border of scapula up to the root of spine	Dorsal scapular nerve (C5) C3, C4 fibres	Elevation of scapula
Rhomboid minor	Ligamentum nuchae and spine of C7 and T1	Root of spine	Dorsal scapular nerve (C5)	Retraction of scapula
Rhomboid major	Spines of T2–T5	Medial border of scapula below the root of spine	Dorsal scapular nerve (C5)	Retraction of scapula

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ADDITIONAL FEATURES OF MUSCLES OF THE BACK

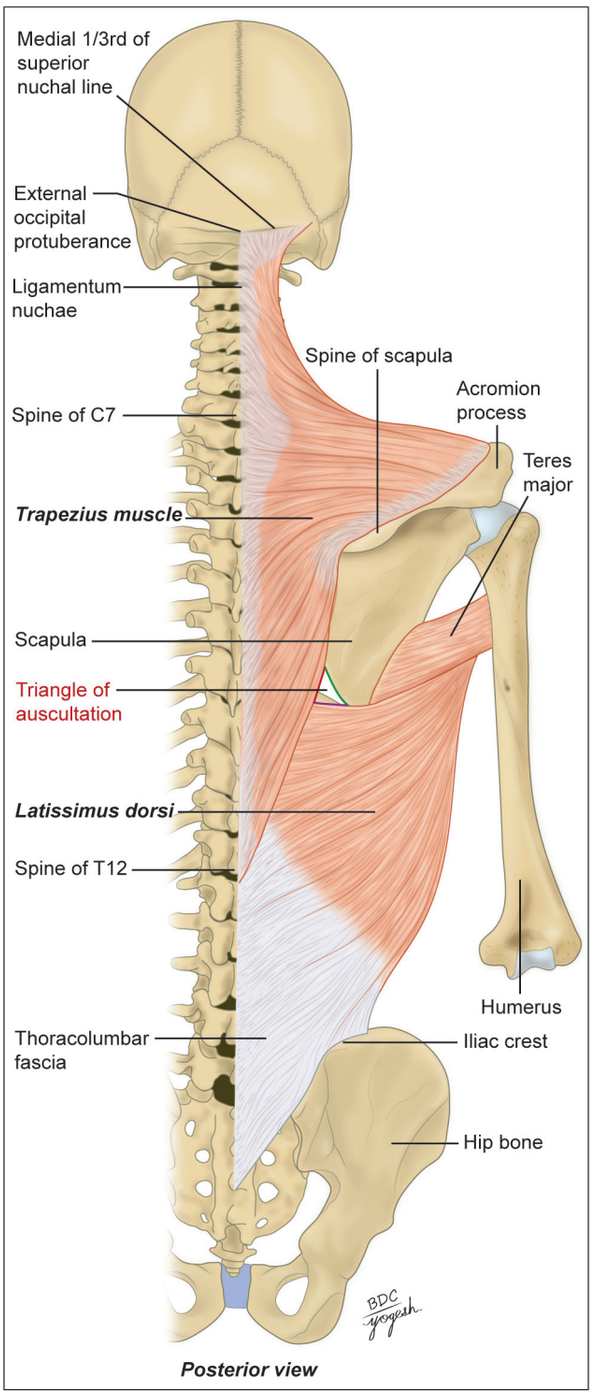
Trapezius

1. Developmentally, the trapezius is related to the sternocleidomastoid. Both of them develop from branchial arch mesoderm and are supplied by the spinal accessory nerve.
2. The principal action of the trapezius is to rotate the scapula during abduction of the arm beyond 90°.
3. The structures under cover of trapezius are shown in Plate 5.3 and Fig. 5.6 (for details, refer BDC's Anatomy eBook).
4. *Clinical testing*: Clinically, the muscle is tested by asking the patient to shrug their shoulder against resistance.

Latissimus Dorsi

1. This is the only muscle which connects the pelvic girdle and vertebral column to upper limb. It possesses extensive origin and narrow insertion.
2. The latissimus dorsi develops in the extensor compartment of the limb. Thereafter, it migrates to its wide attachment on the trunk, taking its nerve supply (thoracodorsal nerve) along with it (latus = wide). It is also called a ***swimmer's muscle***.

Plate 5.1: Latissimus dorsi and trapezius muscles.

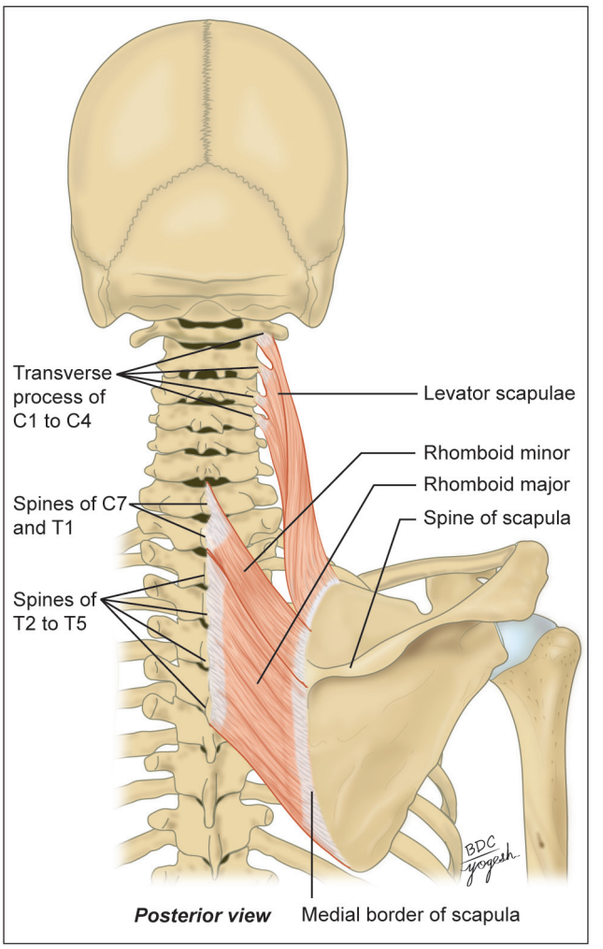


3. ***Clinical testing*:** The latissimus dorsi is tested clinically by feeling the contracting muscle in the posterior fold of the axilla after asking the patient to cough.

CLINICAL ANATOMY

- Musculocutaneous flap for breast reconstruction: In case of carcinoma of the breast, breast reconstruction surgery is required after mastectomy (removal of the breast). A musculocutaneous flap of latissimus dorsi with thoracodorsal nerve and thoracodorsal artery (branch of a subscapular artery) and venae comitantes may be used for breast reconstruction.
- *Cardiac support*: In patients with low cardiac output but not suitable for heart transplant, latissimus dorsi is wrapped around the heart, and this muscle is stimulated electrically using pacemaker along with heart. This procedure is called *cardiomyoplasty*.

Plate 5.2: Levator scapulae, rhomboid major and rhomboid minor muscles.



***Competency*:**
AN10.9 Describe the arterial anastomosis around the scapula and mention the boundaries of triangle of auscultation.

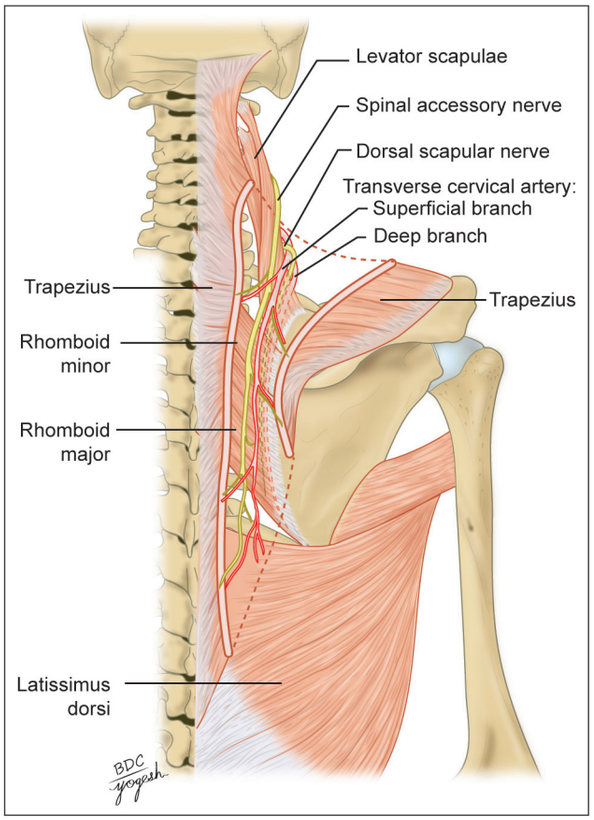
Triangle of Auscultation

Triangle of auscultation is a small triangular interval in the muscles of back (Fig. 5.7).

Boundaries

Medially — The lateral border of the trapezius
Laterally — The medial border of the scapula
Inferiorly — The upper border of the latissimus dorsi.
Floor of the triangle — It is formed by the 6th and 7th rib, and 6th intercostal space (ICS), and the rhomboid major.

Plate 5.3: Structures under cover of trapezius



This is the only part of the back which is not covered by big muscles. Respiratory sounds of apex of lower lobe heard through a stethoscope are better heard over this triangle on each side. On the left side, the cardiac orifice of the stomach lies deep to the triangle, and in days

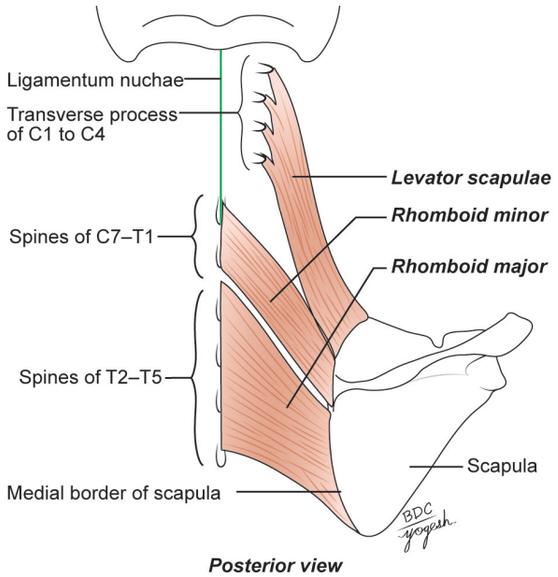


Fig. 5.4: The levator scapulae, the rhomboid minor and the rhomboid major muscles

before X-rays were discovered, the sounds of swallowed liquids were auscultated over this triangle to confirm the oesophageal tumour (Fig. 5.3a).

Lumbar Triangle of Petit

Lumbar triangle of Petit is another small triangle surrounded by muscles (Fig. 5.7).

Boundaries

Medially — The lateral border of the latissimus dorsi
Laterally — The posterior border of the external oblique muscle of the abdomen.

TABLE 5.2: Attachments of muscles connecting the upper limb to the vertebral column (Figs 5.3 a–b, and 5.4)

Muscle	*Origin*	*Insertion*
Trapezius The right and left muscles together form a trapezium that covers the upper half of the back.	• Medial one-third of superior nuchal line • External occipital protuberance • Ligamentum nuchae • C7 spine • T1–T12 spines • Corresponding supraspinous ligaments	• *Upper fibres* into the posterior border of lateral one-third of clavicle • *Middle fibres* into the medial margin of the acromion process and upper lip of the crest of spine of the scapula • *Lower fibres* on the deltoid tubercle at the junction of medial and middle third of spine of scapula
Latissimus dorsi It covers a large area of the lower back, and is overlapped by the trapezius.	• Posterior one-third of the outer lip of iliac crest • Posterior layer of thoracolumbar fascia (thus attaching the muscle to the lumbar and sacral spines) • Spines of T7–T12, lower four ribs • Inferior angle of the scapula	The muscle winds a round the lower border of the teres major and forms the posterior fold of the axilla. The tendon is twisted upside down and is inserted into floor of the intertubercular sulcus
Levator scapulae	• Transverse processes of C1, C2 • Posterior tubercles of the transverse processes of C3, C4	Superior angle and upper part of medial border (up to the root of spine) of the scapula
Rhomboid minor	• Lower part of ligamentum nuchae • Spines C7 and T1	Base of the triangular area at the root of the spine of the scapula
Rhomboid major	• Spines of T2–T5 • Supraspinous ligaments	Medial border of scapula below the root of the spine

TABLE 5.3: Nerve supply and actions of muscles connecting the upper limb to the vertebral column

Muscle	*Nerve supply*	*Actions*
Trapezius	• Spinal part of accessory nerve (XI) • Branches from C3, C4 (proprioceptive)	• *Upper fibres* act with levator scapulae and elevate the scapula, as in shrugging. Upper fibres of both sides extend the neck • *Middle fibres* act with rhomboids and retract the scapula • *Upper and lower fibres* act with serratus anterior and rotate the scapula forwards around the chest wall, thus playing an important role in abduction of the arm beyond 90° (Fig. 5.5) • Steadies the scapula
Latissimus dorsi	Thoracodorsal nerve (C6–C8) (nerve to latissimus dorsi)	• Adduction, extension and medial rotation of the shoulder, as in swimming, rowing, climbing, pulling, folding the arm behind the back and scratching the opposite scapula • Helps in violent expiratory efforts like coughing, sneezing, etc. • Essentially a ***climbing*** muscle • Hold inferior angle of the scapula in place
Levator scapulae	• A branch from dorsal scapular nerve (C5) • Branches from C3, C4	• Helps in elevation of scapula • Steadies the scapula during movements of the arm
Rhomboid minor	Dorsal scapular nerve (C5)	• Retraction of scapula
Rhomboid major	Dorsal scapular nerve (C5)	

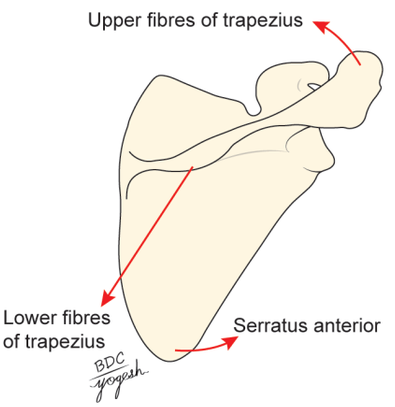


Fig. 5.5: Rotation of the scapula during abduction of the arm beyond 90°, brought about by the trapezius and the serratus anterior muscles

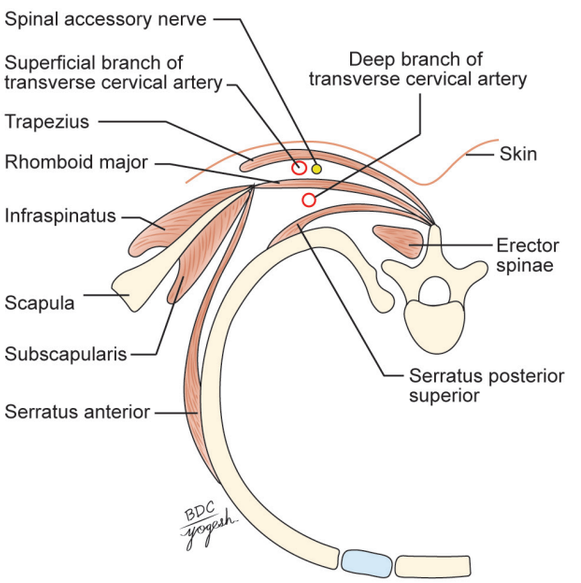


Fig. 5.6: Transverse section showing the arrangement of structures on the back

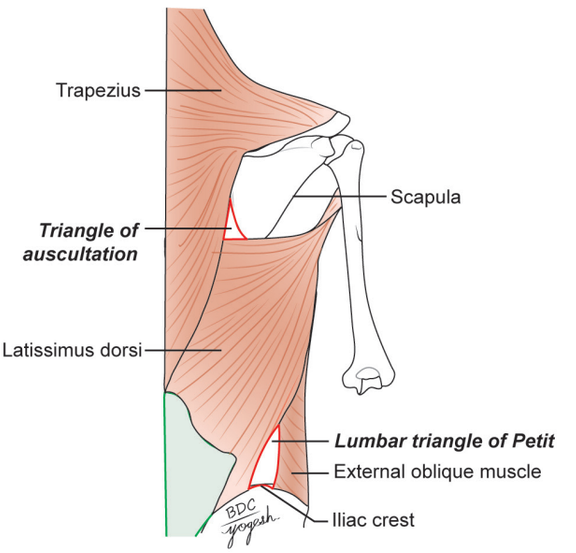


Fig. 5.7: The triangle of auscultation and lumbar triangle of Petit

Inferiorly — The iliac crest (which forms the base)
Floor of the triangle — It is formed by the internal oblique muscle of the anterior abdominal wall.

The occasional hernia at this site is called *lumbar hernia* (Fig. 5.4).

DISSECTION

After completing the dissection of the back, the limb with clavicle and scapula is detached from the trunk.

For detachment of the limb, muscles which need to be incised are trapezius, levator scapulae, rhomboid minor and major, serratus anterior, latissimus dorsi and sternocleidomastoid.

The sternoclavicular joint is opened to free clavicle from the sternum. Upper limb with clavicle and scapula is removed en bloc.

Facts to Remember

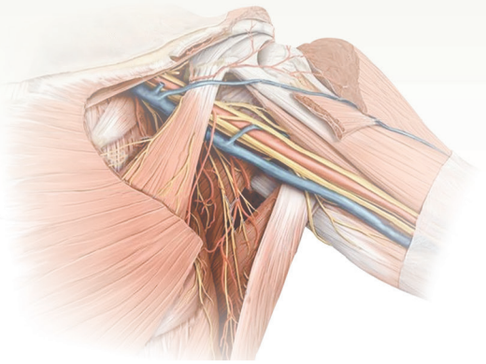
- The highest point of the iliac crests lies at the level of the L4 vertebral spine.
- The posterior-superior iliac spine lies at the level of the S2 vertebra.
- The posterior primary rami of the spinal nerves C1, C7, C8 and L4, L5 do not give off any cutaneous branches.
- Clinically, the trapezius is tested by asking the patient to shrug their shoulder against resistance.
- Trapezius is supplied by spinal root of XI nerve and C3–4 fibres.
- The latissimus dorsi and pectoralis major are *climbing muscles*.
- The dorsal scapular nerve supplies levator scapulae, rhomboid minor and rhomboid major.

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1. Structures under cover of the trapezius
2. Dorsal scapular nerve
3. Further reading
4. Viva voce questions

Chapter

6



Scapular Region

The shoulder or scapular region comprises structures closely related to and surrounding the shoulder joint. For a proper understanding of the region, revise some features of the scapula and the upper end of the humerus.

SURFACE LANDMARKS

1. a. The upper half of the humerus is covered on its anterior, lateral and posterior aspects by the *deltoid muscle*. This muscle is triangular and forms the rounded contour of the shoulder (Fig. 6.1).
   b. The *greater tubercle* of the humerus forms the most lateral bony point of the shoulder.
2. The *skin* covering the shoulder region is supplied by:
   a. The lateral supraclavicular nerve over the upper half of the deltoid.
   b. The upper lateral cutaneous nerve of the arm over the lower half of the deltoid.
   c. The dorsal rami of the upper thoracic nerves over the back, i.e. over the scapula.
3. The *superficial fascia* contains (in addition to some fat and cutaneous nerves) the inferolateral part of the platysma arising from the deltoid fascia.
4. The *deep fascia* covering the deltoid sends numerous septa between its fasciculi. The subscapularis, supraspinatus and infraspinatus fasciae provide origin to a part of the respective muscle.

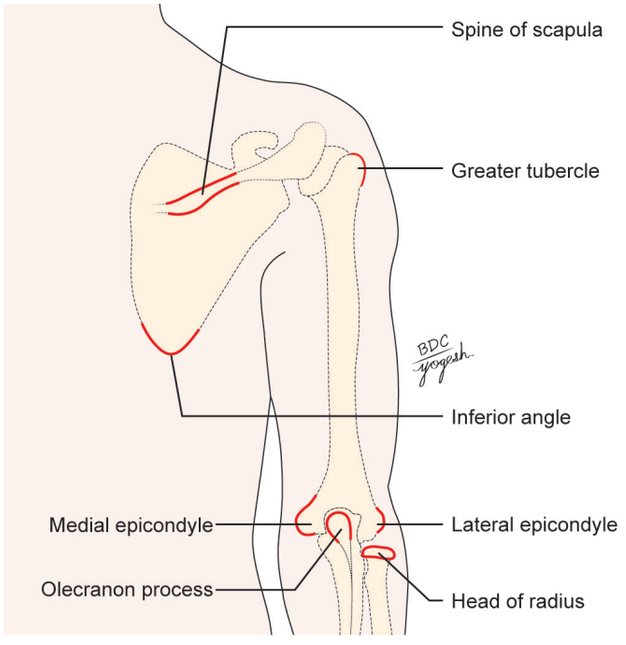


Fig. 6.1: Surface landmarks: Shoulder, arm and elbow regions

MUSCLES OF THE SCAPULAR REGION

Features

Muscles of scapular region are:

- Deltoid
- Supraspinatus
- Infraspinatus
- Teres minor
- Subscapularis
- Teres major

The deltoid is described below (Plate 6.1, Figs 6.2 to 6.4). The other muscles are described in Tables 6.1, 6.2, Plate 6.2, Figs 6.5 and 6.6.

***Competency*:**
AN10.10 Describe and identify the deltoid and rotator cuff muscles along with their nerve supply and clinical anatomy.

DELTOID (DELTA-LIKE OR TRIANGULAR)

Origin

1. The anterior border and adjoining surface of the lateral 1/3rd of the *clavicle* (Plate 6.1, Fig. 6.2, Flowchart 6.1).
2. The lateral border of the *acromion process* where four septa of origin are attached (Fig. 6.2).
3. Lower lip of the crest of the *spine* of the scapula.

The acromial part of deltoid is an example of a *multipennate muscle*. Many fibres arise from four septa of origin that are attached above to the acromion process. The fibres converge onto three septa of insertion, which are attached to the deltoid tuberosity (Fig. 6.2).

Plate 6.1: Deltoid muscle

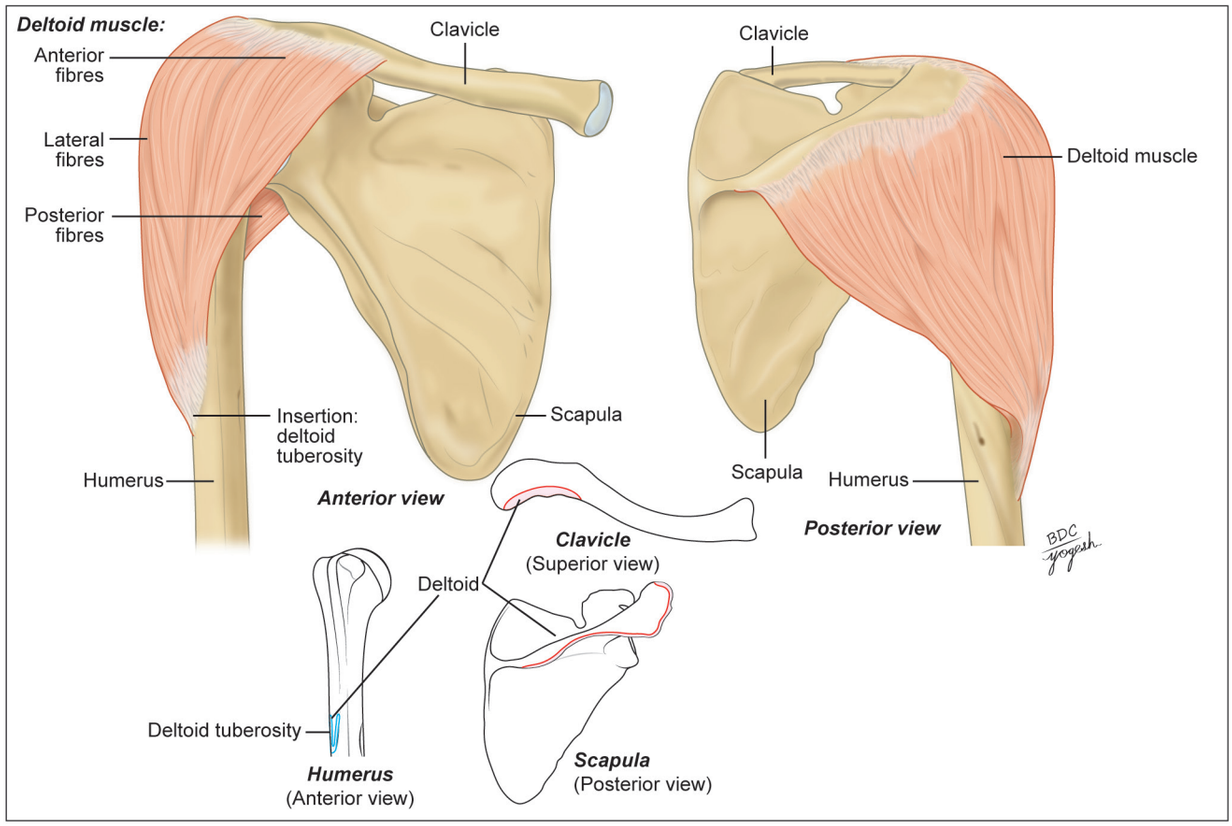


TABLE 6.1: Attachments of muscles of scapular region (except deltoid, Plate 6.2, Figs 6.5 and 6.6)

Muscle	*Origin*	*Insertion*
1. **Supraspinatus**	Medial 2/3rd of the supraspinous fossa of the scapula. The muscle passes as a tendon laterally beneath coracoacromial arch to blend with the capsule of shoulder joint. The tendon is separated from the arch by the subacromial bursa (Fig. 6.7).	Upper impression (facet) on the greater tubercle of the humerus
2. **Infraspinatus**	Medial 2/3rd of the infraspinous fossa of the scapula	Middle impression (facet) on the greater tubercle of the humerus
3. **Teres minor**	Upper 2/3rd of the dorsal surface of the lateral border of the scapula as 2 slips	Lowest impression (facet) on the greater tubercle of the humerus
4. **Subscapularis** (multipennate)	Medial 2/3rd of the subscapular fossa	Lesser tubercle of the humerus
5. **Teres major**	Lower 1/3rd of the dorsal surface of lateral border and inferior angle of the scapula	Medial lip of the bicipital groove of the humerus

TABLE 6.2: Nerve supply and actions of muscles of scapular region (except deltoid)

Muscle	*Nerve supply*	*Actions*
1. **Supraspinatus**	Suprascapular nerve (C5, C6)	Both supraspinatus and deltoid are involved in initiation of abduction and continuation of abduction (*Previous concept*: Supraspinatus acts as an abductor of the shoulder joint from 0°–15°)
2. **Infraspinatus**	Suprascapular nerve (C5, C6)	Lateral rotator of arm (*at shoulder joint*)
3. **Teres minor**	Axillary nerve (C5, C6)	Lateral rotator of arm (*at shoulder joint*)
4. **Subscapularis**	Upper and lower subscapular nerves (C5, C6)	Medial rotator and adductor of arm
5. **Teres major**	Lower subscapular nerve (C5, C6)	Medial rotator, adductor and extensor of arm

Flowchart 6.1: Muscles of scapular region

Muscles of scapular region

Muscle	*Origin (scapula)*	*Insertion (humerus)*	*Innervation*	*Actions*
Deltoid muscle	Anterior fibres: Anterior border of lateral 1/3 of clavicle Middle fibres: Acromion Posterior fibres: Lower lip of crest of spine of scapula	Deltoid tuberosity of humerus	Axillary nerve	Anterior fibres: Flexion and medial rotation of arm Middle fibres: Abduction (up to 90°) of arm Posterior fibres: Extension and lateral rotation of arm
Subscapularis	Medial 2/3 of subscapular fossa	Lesser tubercle	Upper and lower subscapular nerves	Medial rotations and adduction of arm
Supraspinatus	Supraspinous fossa	Greater tubercle	Suprascapular nerve	Initiation of abduction of arm
Infraspinatus	Infraspinous fossa	Greater tubercle	Suprascapular nerve	Lateral rotation of arm
Teres minor	Lateral border of scapula	Greater tubercle	Axillary nerve	Lateral rotation of arm

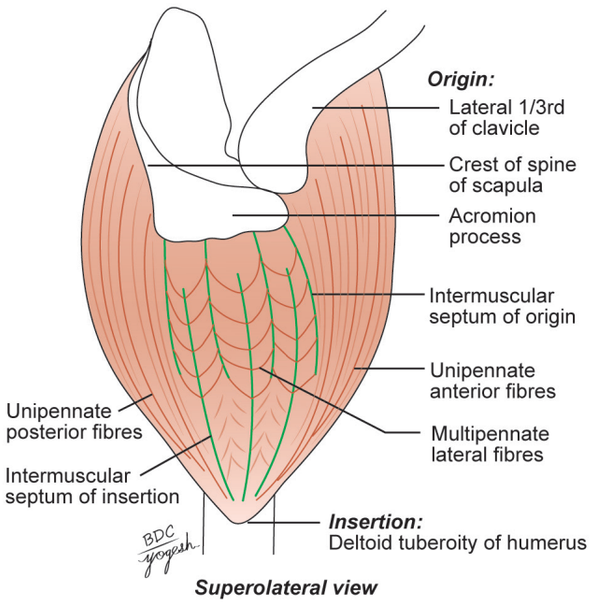


Fig. 6.2: The origin and insertion of the deltoid muscle

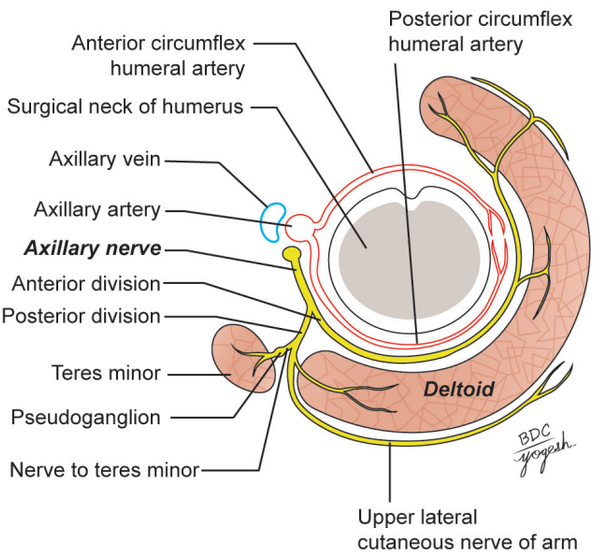
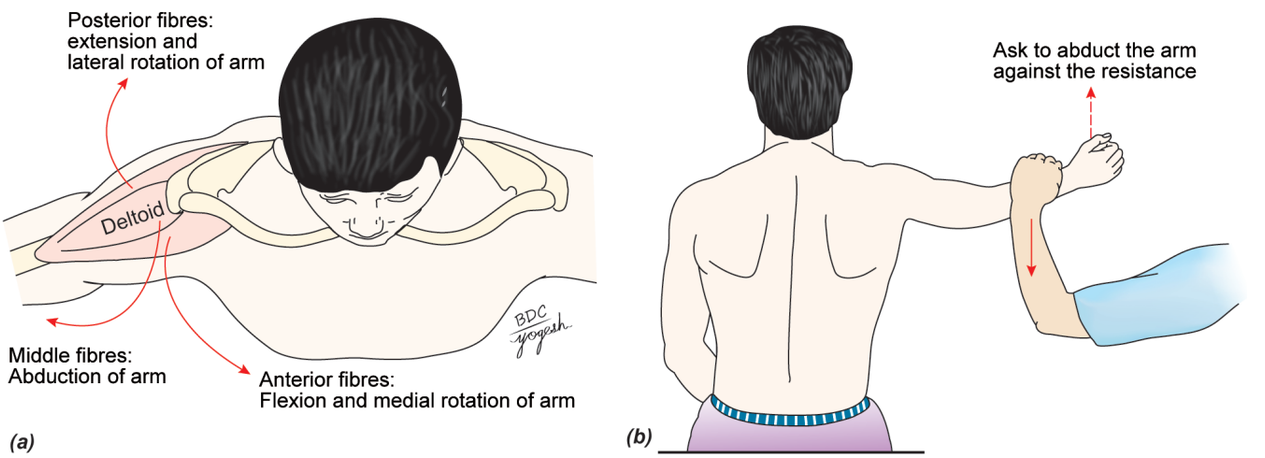
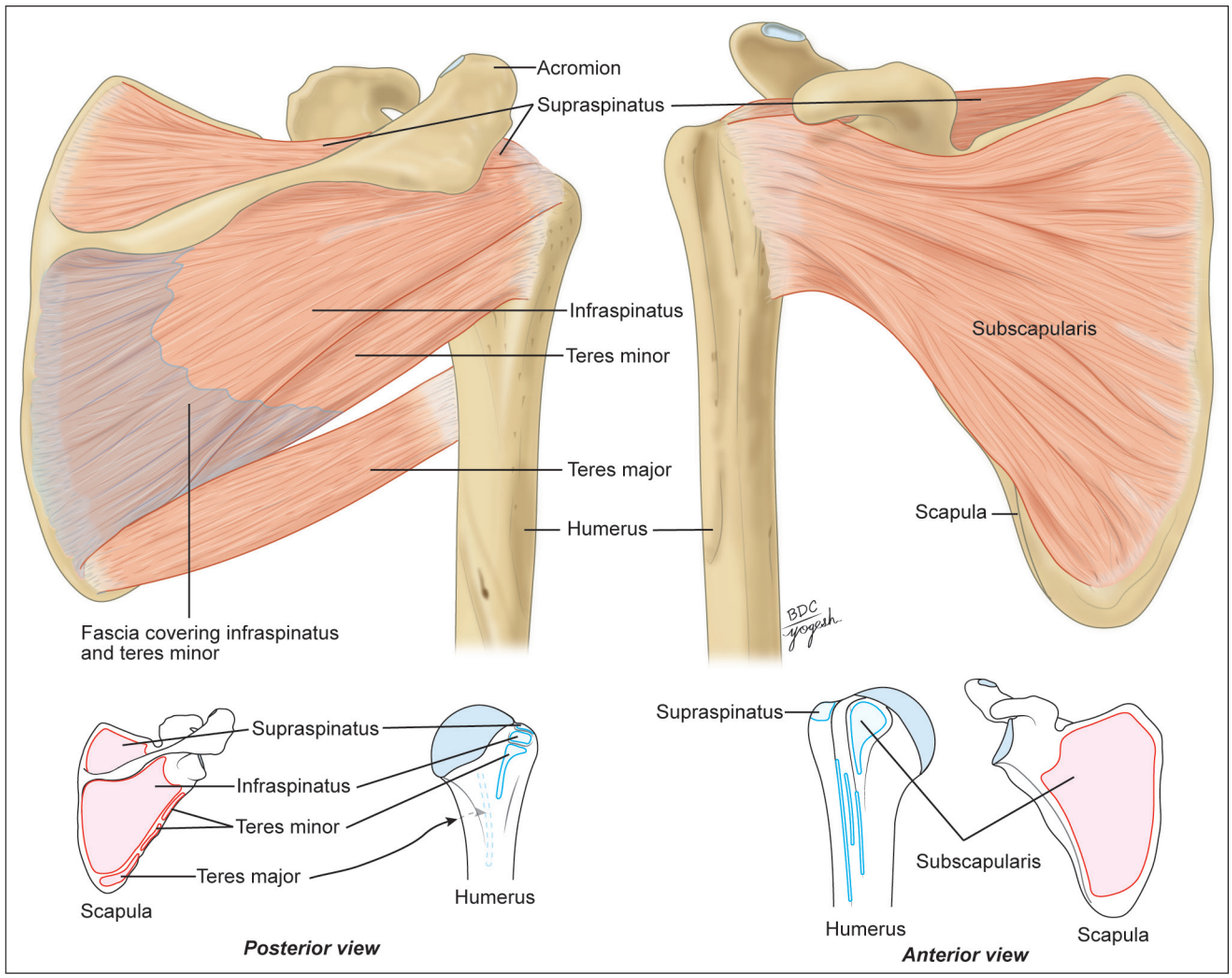


Fig. 6.3: Horizontal section of the deltoid region showing the axillary nerve and vessels around the surgical neck of humerus



Figs 6.4a and b: (a) Actions of deltoid muscle and (b) clinical testing of deltoid muscle

Plate 6.2: Supraspinatus, infraspinatus, teres minor, teres major and subscapularis muscles



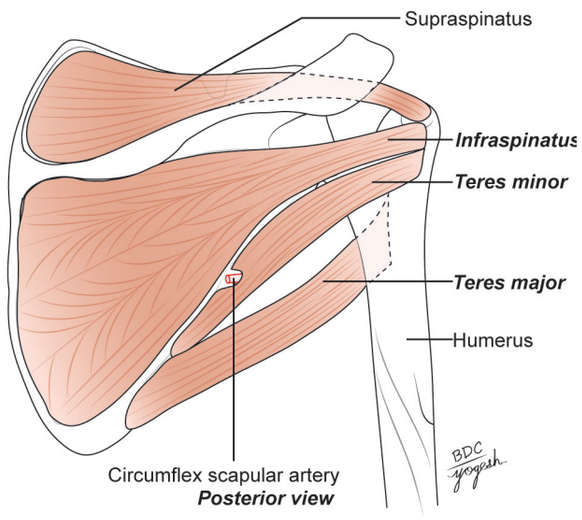


Fig. 6.5: The origins and insertions of the supraspinatus, infraspinatus and teres minor muscles of right side

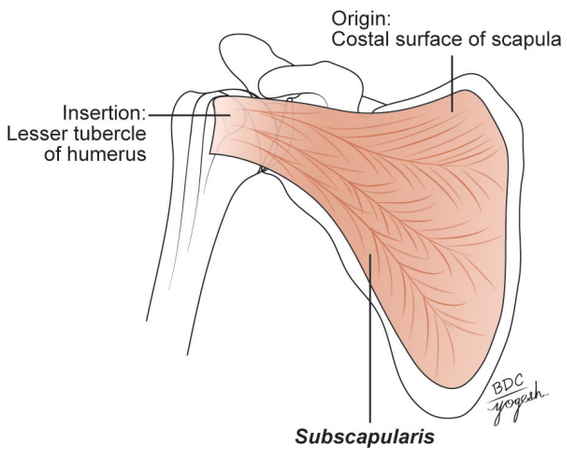


Fig. 6.6: The subscapularis muscle

Insertion

The V-shaped *deltoid tuberosity* of the humerus where three septa of insertion are attached.

Nerve Supply

Axillary nerve (C5, C6) (Fig. 6.3).

Actions

1. The *anterior fibres* are flexors and medial rotators of the arm (Fig. 6.4a).

2. The *multipennate acromial fibres* are powerful abductors of the arm at the shoulder joint from beginning to 90°. A multipennate arrangement allows a large number of muscle fibres to be packed into a relatively small volume. As the strength of contraction of a muscle is proportional to the number of muscle fibres present in it (and not on their length), a multipennate muscle is much stronger than other muscles having the same volume.
3. The *posterior fibres* are extensors and lateral rotators of the arm.

DISSECTION

Define the margins of the deltoid muscle covering the shoulder joint region. Reflect the part of the muscle arising from spine of scapula downwards. Separate the infraspinatus muscle from teres major and minor muscles, which run from the lateral scapular border towards humerus. Axillary nerve accompanied with posterior circumflex humeral vessels lies on the deep aspect of the deltoid muscle.

Competency:
AN10.13 Explain anatomical basis of injury to axillary nerve during intramuscular injections.

CLINICAL ANATOMY

- Intramuscular injections (COVID-19 vaccination) are often given into the deltoid. They should be given in the middle of the muscle to avoid injury to the axillary nerve (Fig. 6.7). If injection is given in upper part of deltoid, axillary nerve may be damaged.
- The deltoid muscle is tested by asking the patient to abduct the arm against resistance applied with one hand, and feeling for the contracting muscle with the other hand (Fig. 6.4b).

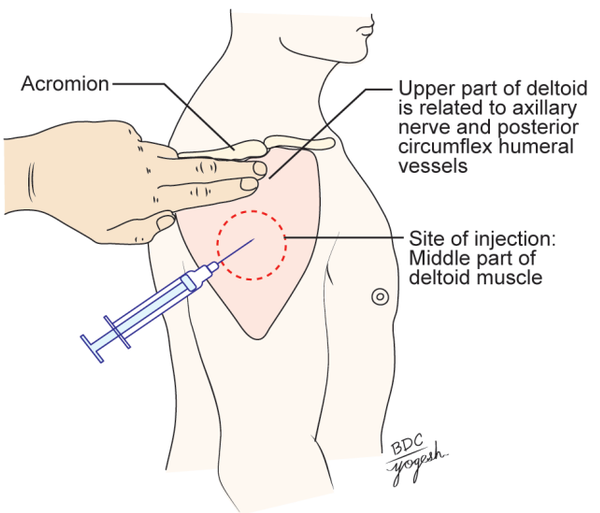


Fig. 6.7: Intramuscular injection in deltoid muscle

- The tendon of the supraspinatus may undergo degeneration. This can give rise to calcification and even spontaneous rupture of the tendon.
- In ***subacromial bursitis***, pressure over the deltoid below the acromion process with the arm by the side causes pain. However, when the arm is abducted, pressure over the same point causes no pain, because the bursa disappears under the acromion process (***Dawbarn's sign***). This is due to the fact that during abduction, the subacromial bursa passes beneath the coracoacromial arch causing pain to disappear. Subacromial or subdeltoid bursitis is usually secondary to inflammation of the supraspinatus tendon.

Competency:
AN10.10 Describe and identify the deltoid and rotator cuff muscles along with their nerve supply and clinical anatomy.

Musculotendinous Cuff of the Shoulder or Rotator Cuff

The musculotendinous cuff of the shoulder is a fibrous sheath formed by the four flattened tendons, which blend with the capsule of the shoulder joint and strengthen it. The muscles which form the cuff arise from the scapula and are inserted into the lesser and greater tubercles of the humerus. They are the subscapularis, the supraspinatus, the infraspinatus and the teres minor (Plate 6.3, Fig. 6.8). Their tendons, while crossing the shoulder joint, become flattened and blend with each other on one hand, and with the capsule of the joint on the other hand, before reaching their points of insertion.

The cuff gives strength to the capsule of the shoulder joint all around except inferiorly. This explains why dislocations of the humerus occur commonly in an anteroinferior direction. Thus, rotator cuff rests on tuberosities, fused to the capsule, strengthens the capsule and steadies head of humerus.

[*Mnemonic:* The **SITS** muscles: Clockwise from top: **S**upraspinatus, **I**nfraspinatus, **T**eres minor, **S**ubscapularis]

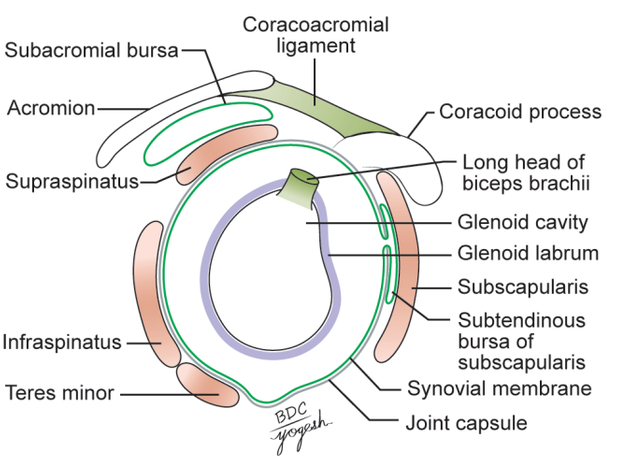
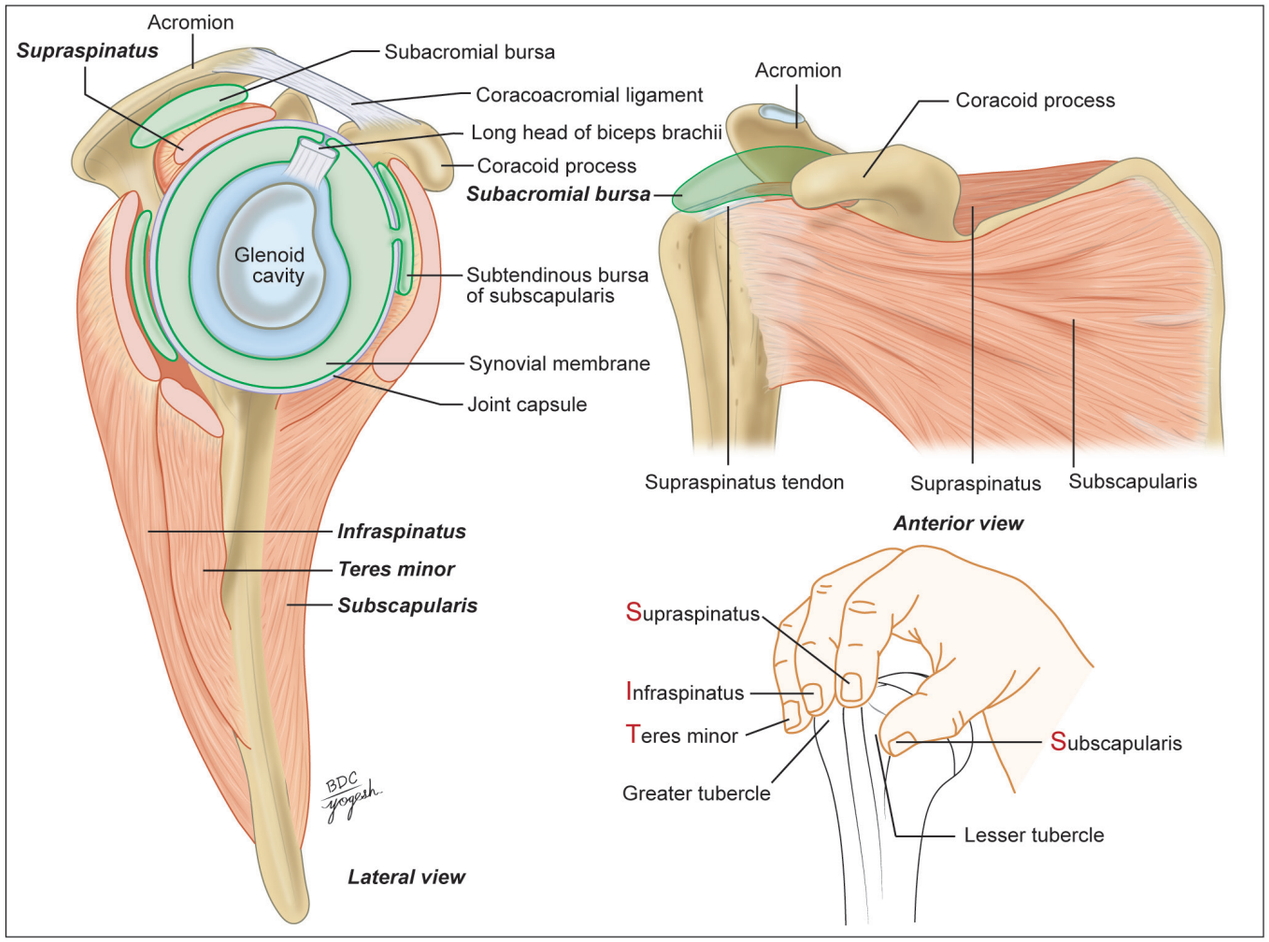


Fig. 6.8: Subacromial bursa with the musculotendinous cuff of the shoulder

Plate 6.3: Musculotendinous cuff of shoulder joint, subacromial bursa and insertion of muscles of rotator cuff muscles



Subacromial Bursa

The subacromial bursa is the largest bursa of the body, situated below the coracoacromial arch and the deltoid muscle. Below the bursa, there are the tendon of the supraspinatus and the greater tubercle of the humerus (Fig. 6.8).

The subacromial bursa is of great value in the abduction of the arm at the shoulder joint.

a. It protects the supraspinatus tendon against friction with the acromion process.
b. During overhead abduction, the greater tubercle of the humerus passes under the acromion process; this is facilitated by the presence of this bursa.

Supraspinatus Tendinitis

Painful arc syndrome/rotator cuff syndrome: Pain starts at about 60° and lasts till 120° of abduction as supraspinatus muscle gets impinged between coracoacromial arch and greater tubercle of humerus. Further abduction of shoulder occurs after lateral rotation of humerus, which takes greater tubercle of humerus away from the coracoacromial arch. Then supraspinatus tendon is no longer impinged, and thus, no more pain occurs.

INTERMUSCULAR SPACES

The long head of triceps brachii spans the length of the arm arising from infraglenoid tubercle of scapula to the olecranon process of ulna. It lies medial to humerus. Teres minor crosses posterior aspect of the shoulder joint and origin of the long head as it passes from its origin from scapula to the humerus. The muscle is replaced by subscapularis on the anterior aspect of shoulder joint. Teres major also crosses the long head as it runs to bicipital groove for its insertion.

Thus potential spaces are formed between lateral border of scapula, medial aspect of humerus, long head of triceps brachii, teres minor or subscapularis and teres major muscles.

In the upper part, there is a quadrangular space laterally and upper triangular space medially. In the lower part is the lower triangular space (Plate 6.4, Fig. 6.9, Flowchart 6.2).

Quadrangular Space

Boundaries

Superior

1. Subscapularis in front.

2. Capsule of the shoulder joint: This is the loose inferior part of the capsule of the shoulder joint. In anatomical position, the capsule lies in this space. The capsule gets taut as it is used up during abduction of the shoulder joint.
3. Inferior border of teres minor behind.

Inferior: Superior border of teres major.
Medial: Lateral border of long head of the triceps brachii.
Lateral: Surgical neck of the humerus.

Contents

1. Axillary nerve (Fig. 6.9)
2. Posterior circumflex humeral vessels.

Upper Triangular Space

Boundaries

Superior: Inferior border of teres minor.
Lateral: Medial border of long head of the triceps brachii.
Inferior: Superior border of teres major.

Contents

Circumflex scapular artery. It interrupts the origin of the teres minor and reaches the infraspinous fossa for anastomoses with the suprascapular artery and deep branch of transverse cervical artery.

Lower Triangular Space

It is diagonally opposite the upper triangular space.

Boundaries

Medial: Lateral border of long head of the triceps brachii.
Lateral: Medial border of humerus.
Superior: Lower border of teres major (Fig. 6.9).

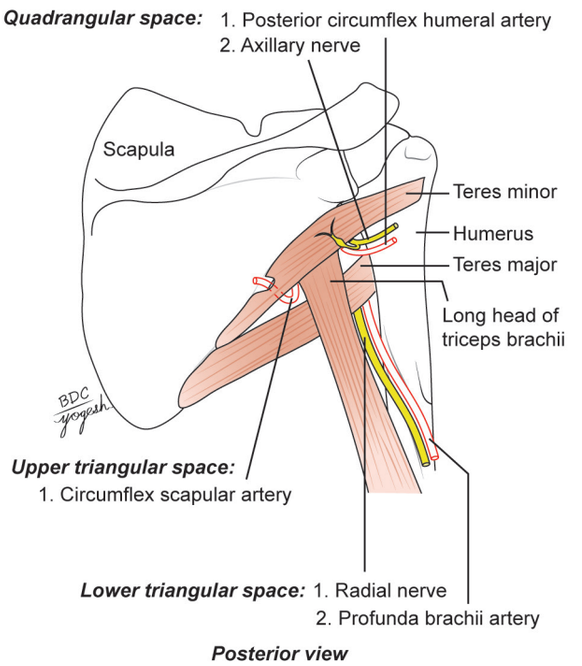
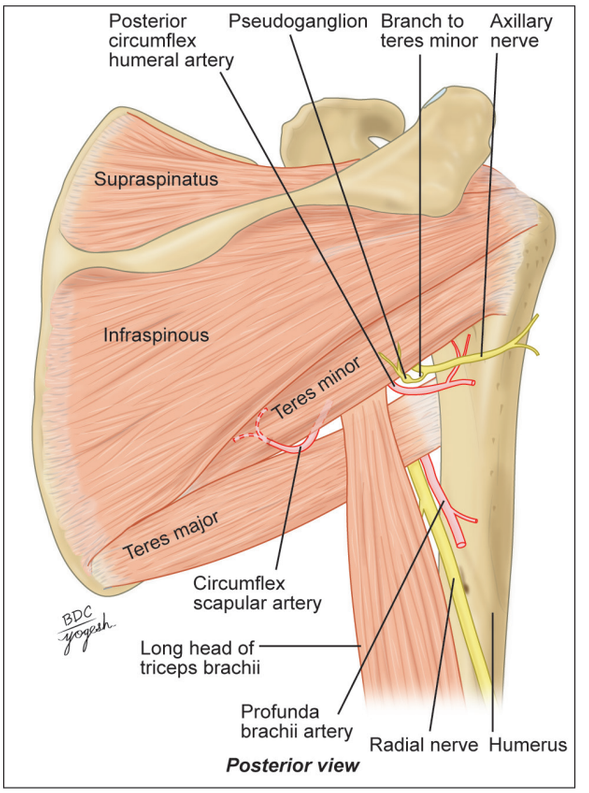


Fig. 6.9: The intermuscular spaces in the scapular region, including the quadrangular, upper triangular and lower triangular spaces

Plate 6.4: Intermuscular spaces in scapular region.



Contents

1. Radial nerve
2. Profunda brachii vessels.

DISSECTION

The quadrangular intermuscular space is a space in between the scapular muscles. The quadrangular space is bounded by teres minor above and teres major below; by the long head of triceps muscle medially and the surgical neck of humerus laterally. The axillary nerve accompanied with posterior circumflex humeral vessels lie in this space. Identify the nerve to the teres minor muscle (Fig. 6.9). Identify part of the capsule of the shoulder joint.

Another intermuscular space, the upper triangular space should be dissected. It is bounded by the teres minor muscle medially, long head of triceps laterally, and teres major muscle below.

Now the remaining 2/3rd of deltoid muscle can be reflected towards its insertion. Identify subscapularis muscle anteriorly.

Define the attachments of infraspinatus and cut muscle at the neck of scapula and reflect it on both sides.

Look for the structures covered with deltoid muscle.

Identify a lower triangular space, which is bounded above by the lower border of teres major muscle, medially by the long head of triceps brachii and laterally by the medial border of humerus. The radial nerve and profunda brachii vessels pass through the space.

Flowchart 6.2: Intermuscular spaces

Intermuscular spaces

	Quadrangular	Upper triangular	Lower triangular
Boundaries	Superior: Subscapularis, capsule of shoulder joint, teres minor Inferior: Teres major Medial: Triceps brachii Lateral: Humerus	Superior: Teres minor Inferior: Teres major Lateral: Triceps brachii	Superior: Teres major Medial: Triceps brachii Lateral: Humerus
Contents	1. Axillary nerve 2. Posterior circumflex humeral vessels	1. Circumflex scapular artery	1. Radial nerve 2. Profunda brachii vessels

Dissect and identify the arteries taking part in the anastomoses around scapula. These are suprascapular along upper border, deep branch of transverse cervical (dorsal scapular) along medial border and circumflex scapular along lateral border of scapula.

***Competency*:**
AN10.13 Explain anatomical basis of injury to axillary nerve during intramuscular injections.

AXILLARY OR CIRCUMFLEX NERVE

Axillary or circumflex nerve is an important nerve because it supplies the deltoid muscle, which is the main abductor of the arm. Surgically, it is important because it is commonly involved in dislocations of the shoulder and in fractures of the surgical neck of the humerus.

The axillary nerve is a smaller terminal branch of the posterior cord of the brachial plexus (C5, C6).

***Root value*:** Its root value is ventral rami of cervical 5, 6 segments of spinal cord.

Course

Axillary nerve courses through lower part of axilla into the quadrangular space, where it terminates by dividing into two branches (Fig. 6.3).

Relations and Branches

a. In the lower part of the axilla, the nerve runs downwards behind the third part of the axillary artery. Here, it lies on the subscapularis muscle. It is related medially to the radial nerve and laterally to the coracobrachialis. The nerve leaves the axilla by winding around the lower border of the subscapularis in close relation to the lowest part of the capsule of the shoulder joint, where it gives a branch to the capsule of the joint and enters the quadrangular space (Fig. 6.3).

b. The nerve then passes backwards through the quadrangular space. Here, it is accompanied by the posterior circumflex humeral vessels and has the following relations (Fig. 6.9).

Superiorly:
1. Subscapularis anteriorly or teres minor posteriorly.
2. Lowest part of the capsule of the shoulder joint.

Laterally: Surgical neck of humerus.

Inferiorly: Teres major.

Medially: Long head of the triceps brachii.

In the quadrangular space, the nerve divides into anterior and posterior branches (Fig. 6.3).

c. The ***anterior branch*** is accompanied by the posterior circumflex humeral vessels. It winds around the surgical neck of the humerus, deep to the deltoid muscle supplying the deltoid and the skin over its anteroinferior part.

d. The ***posterior branch*** supplies the teres minor and the posterior part of the deltoid. The nerve to the teres minor bears a ***pseudoganglion***, i.e. fibrous tissue and fat without any neurons (Fig. 6.3). The posterior branch then pierces the deep fascia at the lower part of the posterior border of the deltoid and continues as the upper lateral cutaneous nerve of the arm.

CLINICAL ANATOMY

- The axillary nerve may be damaged by dislocation of the shoulder or by the fracture of the surgical neck of the humerus. The effects produced are:
  a. Rounded contour of shoulder is lost; greater tubercle of humerus becomes prominent (Fig. 6.10).
  b. Deltoid is paralysed, with loss of the power of abduction up to 90° at the shoulder.
  c. There is sensory loss over the lower half of the deltoid in a badge-like area called regimental badge (Fig. 6.10).

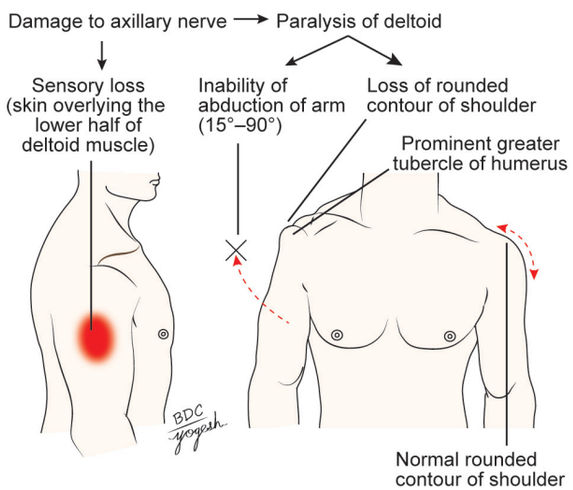


Fig. 6.10: Axillary nerve palsy

Competency:
AN10.9 Describe the arterial anastomosis around the scapula and mention the boundaries of triangle of auscultation.

ANASTOMOSES AROUND SCAPULA

Anastomoses Around the Body of the Scapula

It is formed by:

a. The *suprascapular artery*, a branch of the thyrocervical trunk (Fig. 6.11, Flowchart 6.3). It passes above suprascapular ligament and deep in to spinoglenoid ligament.
b. The *deep branch of the transverse cervical artery*, another branch of the thyrocervical trunk.
c. The *circumflex scapular artery*, a branch of the subscapular artery, which arises from the third part of the axillary artery.

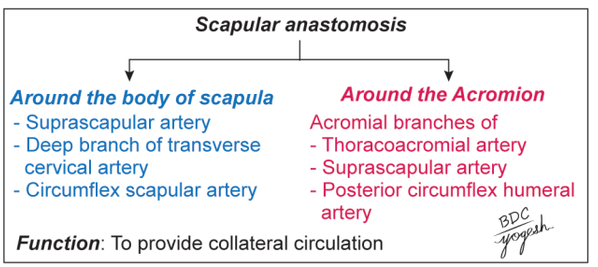
Note that it is the anastomosis between branches of the 1st part of the subclavian artery and the branches of the 3rd part of the axillary artery. These arteries also anastomose with intercostal arteries.

Anastomoses Over the Acromion Process

It is formed by (Flowchart 6.3):

a. The acromial branch of the *thoracoacromial artery* (2nd part of axillary).
b. The acromial branch of the *suprascapular artery* (1st part of subclavian).
c. The acromial branch of the *posterior circumflex humeral artery* (3rd part of axillary).

Flowchart 6.3: Scapular anastomosis



Note that this is the anastomosis between the first part of the subclavian artery and the branches of the second and third parts of the axillary artery (Fig. 6.11).

CLINICAL ANATOMY

The arterial anastomoses provide a collateral circulation through which blood can flow to the limb when the distal part of the subclavian artery, or the proximal part of the axillary artery is blocked (Fig. 6.11). Fracture of middle one-third of humerus causes injury to radial nerve as it lies in lower triangular space. This results in 'wrist drop'.

Facts to Remember

- Acromial fibres of the deltoid muscle are multipennate fibres.
- Muscles of rotator cuff (SITS): **S**upraspinatus, **I**nfraspinatus, **T**eres minor, **S**ubscapularis.
- Intramuscular injection should be given in the middle of the muscle as the upper part of the deltoid is related to the axillary nerve.
- Only circumflex scapular vessels pass through the upper triangular space.
- Branches of axillary nerve with accompanying blood vessels pass through the quadrangular intermuscular space.
- Radial nerve and profunda brachii vessels course through the lower triangular intermuscular space.
- Dawbarn's sign is seen in subacromial bursitis.

BDC's Anatomy *e*-book

1. Structures under cover of the deltoid
2. Forgotten muscle
3. Lift off test
4. Axillary nerve palsy
5. Further reading
6. Viva voce questions

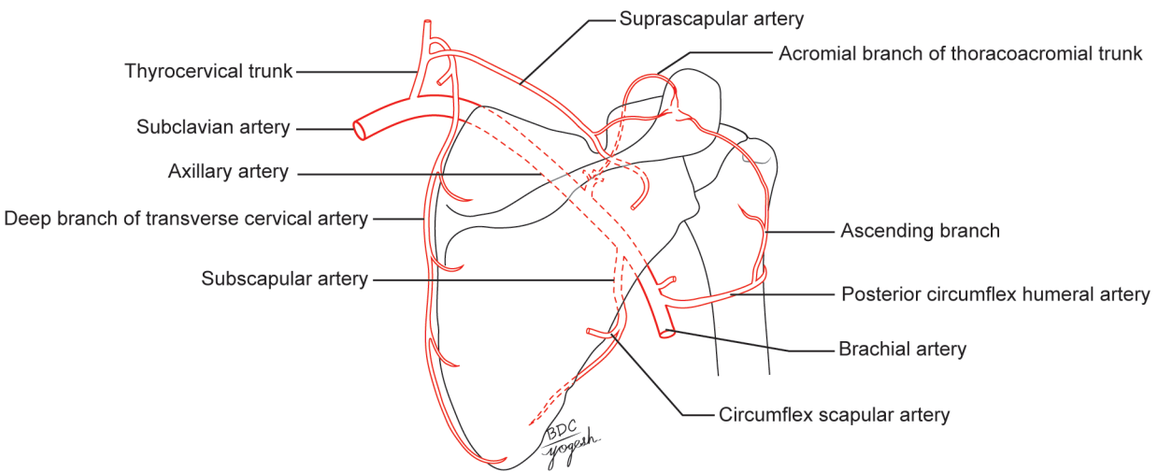
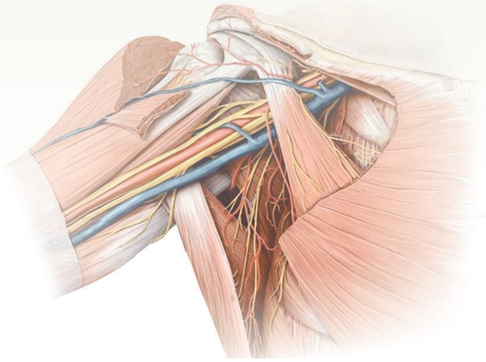


Fig. 6.11: Anastomoses around the scapula (dorsal aspect)



Chapter

7

Cutaneous Nerves, Superficial Veins and Lymphatic Drainage

The superficial fascia seen after the reflection of skin contains cutaneous nerves, cutaneous or superficial veins and lymphatics. The cutaneous nerves are the continuation of the spinal nerves and carry sympathetic fibres for supplying the sweat glands, arterioles in the dermis and arrector pilorum muscles in relation to the hair follicle. Thus, the effects of sympathetic on the skin are sudomotor (increase sweat secretion), vasomotor (narrow the arterioles of skin) and pilomotor (contract arrector pilorum muscle to make the hair erect or straight), respectively.

The cutaneous nerves also carry sensation of pain, touch, temperature and pressure. Superficial veins are seen along with the cutaneous nerves. These are utilised for giving intravenous transfusions, cardiac catheterisation and taking blood samples. Lymphatic vessels, though important, are not easily seen in ordinary dissection.

CUTANEOUS NERVES

Position

The skin of the upper limb is supplied by 15 sets of cutaneous nerves (Table 7.1). Out of these, only one set (supraclavicular) is derived from the cervical plexus, and another nerve (intercostobrachial) is derived from the 2nd intercostal nerve. The remaining 13 sets are derived from the brachial plexus through the musculocutaneous, median, ulnar, axillary and radial nerves. Some branches arise directly from the medial cord of the plexus.

Peculiarities of Cutaneous Nerves of Upper Limb

1. The areas of distribution of peripheral cutaneous nerves do not necessarily correspond with those of individual spinal segments (areas of the skin supplied by individual spinal segments are called dermatomes). This is so because each cutaneous nerve contains fibres from more than one ventral ramus (of a spinal nerve), and each ramus gives fibres to more than one cutaneous nerve.
2. Adjacent areas of skin supplied by different cutaneous nerves overlap each other to a considerable extent. Therefore, the area of sensory loss after damage to a nerve is much less than the area of distribution of the nerve. The anaesthetic area is surrounded by an area in which the sensations are somewhat altered.
3. In both the upper and lower limbs, the nerves of the anterior or flexor surface have a wider area of distribution than those supplying the posterior or extensor surface.

Cutaneous Nerves of Upper Limb

The individual cutaneous nerves, from above downwards, are described below with their root values. Figures 7.1a and b show the cutaneous nerves of the upper limb.

1. ***Supraclavicular nerves*** (C3, C4): These are branches of the cervical plexus. They pierce the deep fascia in the neck, descend superficial to the clavicle and supply:
   a. The skin of the pectoral region up to the level of the second rib.
   b. Skin covering the upper half of the deltoid.
2. ***Upper lateral cutaneous nerve of the arm*** (C5, C6): It is the continuation of the posterior branch of the axillary nerve. It supplies the skin covering the lower half of the deltoid.
3. ***Lower lateral cutaneous nerve of the arm*** (C5, C6): It is a branch of the radial nerve given off in the radial groove. It supplies the skin of the lower half of the lateral side of the arm.
4. ***Intercostobrachial nerve*** (T2): It is the lateral cutaneous branch of the 2nd intercostal nerve. It crosses the axilla and supplies the skin of the upper half of the medial and posterior parts of the arm. It lies amongst the central group of axillary lymph nodes.
5. ***Medial cutaneous nerve of the arm*** (T1, T2): It is the smallest branch of the medial cord of the brachial plexus.
6. ***Posterior cutaneous nerve of the arm*** (C5): It is a branch of the radial nerve given off in the axilla. It supplies the skin of the back of the arm from the insertion of the deltoid to the olecranon process.
7. ***Lateral cutaneous nerve of the forearm*** (C5, C6): It is the continuation of the musculocutaneous nerve.

TABLE 7.1: The cutaneous nerves (Fig. 7.1)

Region supplied	*Nerve(s)*	*Root value*	*Derived from*
Upper part of pectoral region and skin over upper part of deltoid	Supraclavicular	C3, C4	Cervical plexus
ARM			
1. Upper medial part	Intercostobrachial (Figs 7.1a and b)	T2	2nd intercostal
2. Lower medial part	Medial cutaneous nerve of arm	T1, T2	Medial cord
3. Upper lateral part (including skin over lower part of deltoid)	Upper lateral cutaneous nerve of arm	C5, C6	Axillary nerve
4. Lower lateral part	Lower lateral cutaneous nerve of arm	C5, C6	Radial nerve
5. Posterior aspect	Posterior cutaneous nerve of arm	C5	Radial nerve
FOREARM			
1. Medial side	Medial cutaneous nerve of forearm	C8, T1	Medial cord
2. Lateral side	Lateral cutaneous nerve of forearm	C5, C6	Musculocutaneous
3. Posterior side	Posterior cutaneous nerve of forearm	C6–C8	Radial nerve
PALM			
1. Lateral two-thirds	Palmar cutaneous branch of median	C6, C7	Median
2. Medial one-third	Palmar cutaneous branch of ulnar	C8	Ulnar
DORSUM OF HAND			
1. Medial half, including proximal and middle phalanges of medial 1½ digits	Dorsal branch of ulnar	C8	Ulnar
	Superficial terminal branch of radial	C6, C7	Radial
2. Lateral half, including proximal and middle phalanges of lateral 3½ digits			
DIGITS			
Palmar aspect and dorsal aspect of distal phalanges	Palmar digital branch of median	C7	Median
1. Lateral 3½ digits	Palmar digital branch of ulnar	C7, C8	Ulnar
2. Medial 1½ digits			

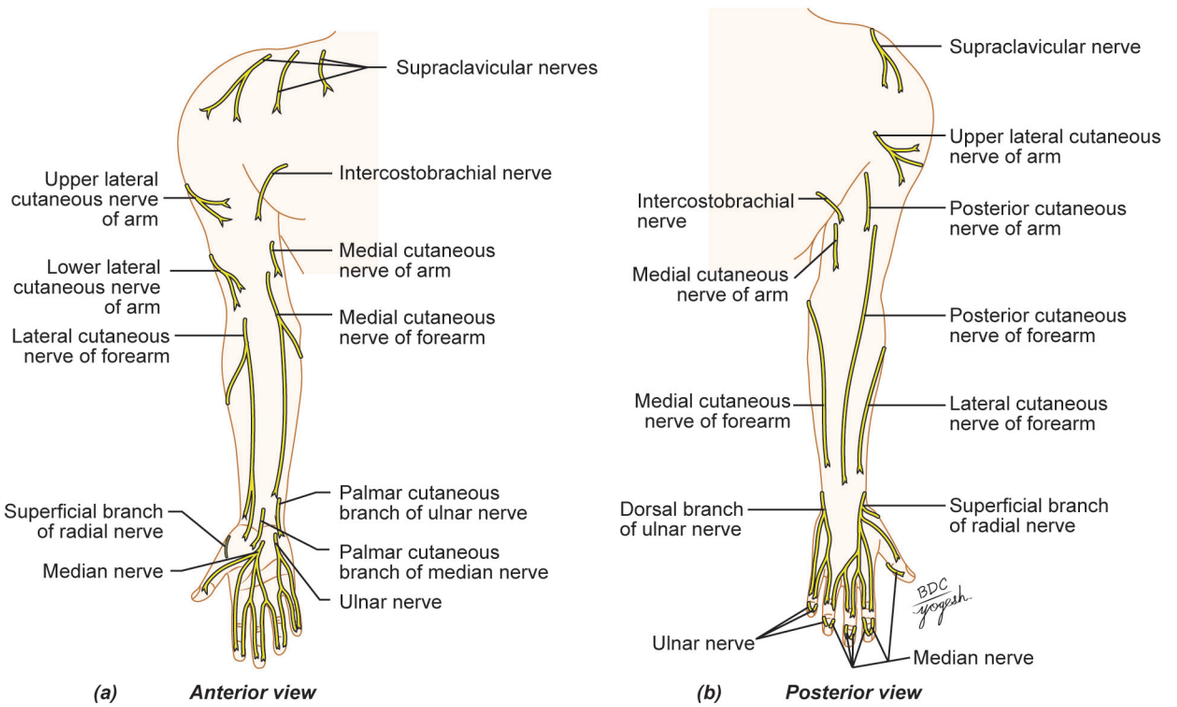


Fig. 7.1: The cutaneous nerves

It pierces the deep fascia just lateral to the tendon of the biceps 2–3 cm above the bend of the elbow and supplies the skin of the lateral side of the forearm, extending anteriorly to a small part of the ball of the thumb.

8. ***Medial cutaneous nerve of the forearm*** (C8, T1): It is a branch of the medial cord of the brachial plexus. It runs along the medial side of the axillary and brachial arteries and supplies the skin of the medial side of the forearm.

9. ***Posterior cutaneous nerve of the forearm*** (C6–C8): It arises from the radial nerve in the radial groove. It descends posterior to the lateral epicondyle and supplies the skin of the back of the forearm.
10. ***Median nerve*** gives off two sets of cutaneous branches in the hand.
    a. ***Palmar cutaneous branch*** (C6–C8): It arises a *short distance above the wrist*, lies *superficial to flexor retinaculum* and supplies skin over the lateral 2/3rd of the palm, including that over the thenar eminence (Fig. 7.1a).
    b. ***Palmar digital branches*** (C6–C8) are five in number and arise in the palm. The medial two branches are common palmar digital nerves; each divides near a digital cleft to form two *proper palmar digital nerves*. The lateral three branches are proper palmar digital nerves for the medial and lateral sides of the thumb and for the lateral side of the index finger. The various digital branches of the median nerve supply palmar skin of the lateral 3½ digits, the nail beds and skin on the dorsal aspect of the distal phalanges of the same digits (Fig. 7.1b).
11. ***Ulnar nerve*** gives off three sets of cutaneous nerves in hand.
    a. ***Palmar cutaneous branch*** (C7, C8): It arises in the middle of the forearm and descends, crossing *superficial to flexor retinaculum* and supplies skin of the medial 1/3rd of the palm.
    b. ***Palmar digital branches of the ulnar nerve*** (C7, C8) are two in number. They arise from the superficial terminal branch of the ulnar nerve just distal to the pisiform bone. The medial of the two branches is a proper palmar digital nerve for the medial side of the little finger. The lateral branch is a common palmar digital nerve which divides into two proper digital nerves for supply of adjacent sides of the ring and little fingers. Thus, it supplies skin of medial 1½ digits, their nail beds and skin on the dorsal aspects of distal phalanges of medial 1½ digits (Figs 7.1a and b).
    c. ***Dorsal branch of the ulnar nerve*** (C7, C8) arises about 6 cm above the wrist. It descends with the main trunk of the ulnar nerve almost to the pisiform bone. Here, it passes backwards to divide into three (sometimes two) dorsal digital nerves. Typically, the region of skin supplied by the dorsal branch covers the medial half of the back of the hand, and the skin on the dorsal aspect of the medial 1½ digits.
12. ***Superficial terminal branch of the radial nerve*** (C6–C8): It arises in front of the lateral epicondyle of the humerus. It descends through the upper 2/3rd of the forearm lateral to the radial artery, and then passes posteriorly about 7 cm above the wrist. While winding round the radius it pierces the deep fascia and divides into four or five small dorsal digital nerves. In all, the superficial terminal branch supplies the skin of the lateral half of the dorsum of the hand, and the dorsal surfaces of the lateral 3½ digits, including the thumb, except for the terminal portions supplied by the median nerve.

DISSECTION

Make one horizontal incision in the arm at its junction of upper 1/3rd and lower 2/3rd segments (*see* Fig. 3.3) and a vertical incision through the centre of arm and forearm till the wrist where another transverse incision is given.

Reflect the skin on either side on the front as well as on the back of the limb. Use this huge skin flap to cover the limb after the dissection.

Competency:
AN13.2 Describe dermatomes of upper limb.

DERMATOMES OF THE UPPER LIMB

Definition

- The area of skin supplied by one spinal segment is called a *dermatome*.
- A typical dermatome extends from the posterior median line to the anterior median line around the trunk. However, in the limbs, the dermatomes have migrated rather irregularly so that the original uniform pattern is disturbed.

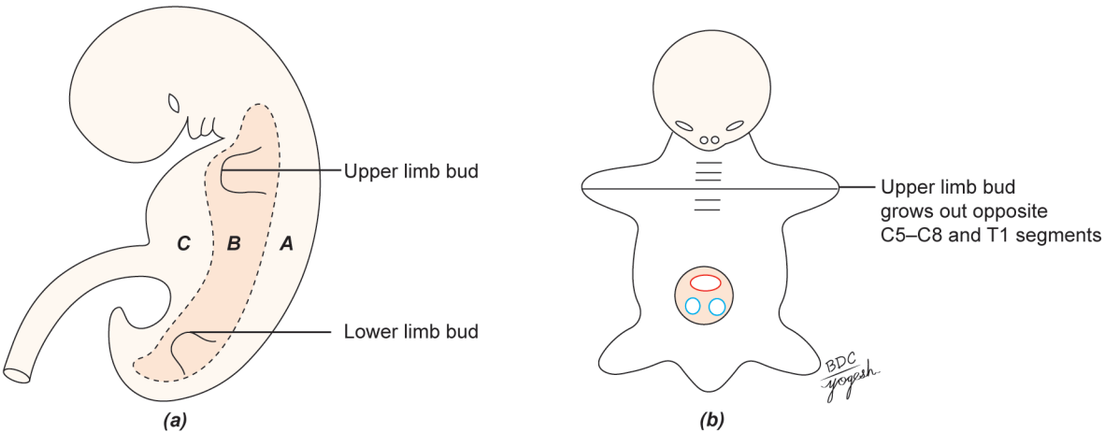
Embryological Basis

- The early human embryo shows regular segmentation of the body. Each segment is supplied by the corresponding segmental nerve. In an adult, all structures, including the skin, developed from one segment, are supplied by their original segmental nerve.
- The limb may be regarded as an extension of the body wall, and the segments from which they are derived can be deduced from the spinal nerves supplying them. The limb buds arise in the area of the body wall supplied by the lateral branches of anterior primary rami. The nerves to the limbs represent these branches (Figs 7.2 to 7.4).

Peculiarities of Dermatomes of Upper Limb

1. The cutaneous innervation of the upper limb is derived:
   a. Mainly from segments C5–C8 and T1 of the spinal cord, and
   b. Partly from the overlapping segments from above, additional segments are found only at the proximal end of the limb (Fig. 7.5).
2. Since the limb bud appears on the ventrolateral aspect of the body wall, it is invariably supplied by the anterior primary rami of the spinal nerves. Posterior primary rami do not supply the limb.

   It is possible that the ventral and dorsal divisions of the trunks of the brachial plexus represent the anterior and posterior branches of the lateral cutaneous nerves.
3. There is a varying degree of ***segmental overlap*** of adjoining dermatomes so that the area of sensory loss



Figs 7.2a and b: (a) The body wall is supplied by (A) the posterior primary rami, (B) the lateral branches of the anterior primary rami and (C) the anterior branches of the anterior primary rami of the spinal nerves. The limb buds develop from the area supplied by the lateral branches of the anterior primary rami and (b) the upper limb bud grows out opposite C5 – C8 and T1 segments of the spinal cord.

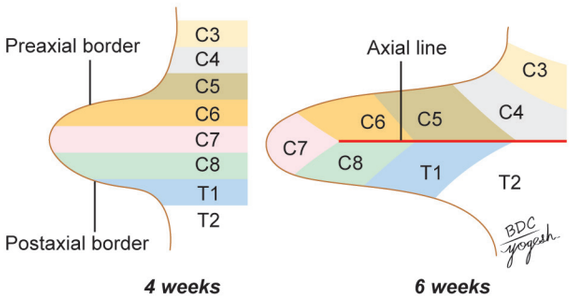


Fig. 7.3: Distribution of various segments in upper limb

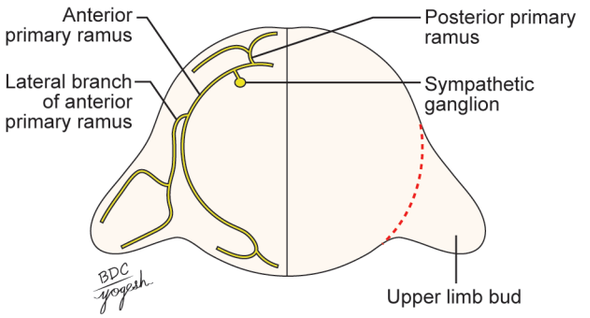


Fig. 7.4: The upper limb bud grows out from the part of the body wall supplied by the lateral cutaneous branches of the anterior primary rami of spinal nerves

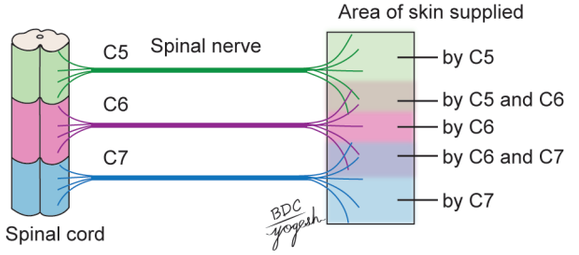


Fig. 7.5: Overlapping of the dermatomes

following damage to the cord or nerve roots is always less than the area of distribution of the dermatomes (Fig. 7.5).

4. Each limb bud has a cephalic and a caudal border, known as ***preaxial*** and ***postaxial borders***, respectively. In the upper limb, the thumb and radius lie along the preaxial border, and the little finger and ulna along the postaxial border.
5. The dermatomes of the upper limb are distributed in an orderly numerical sequence (Fig. 7.6).
   a. Along the preaxial border, by segments C3–C6 with overlapping of the dermatomes.
   b. The middle three digits (index, middle and ring fingers) and the adjoining area of the palm are supplied by segment C7.

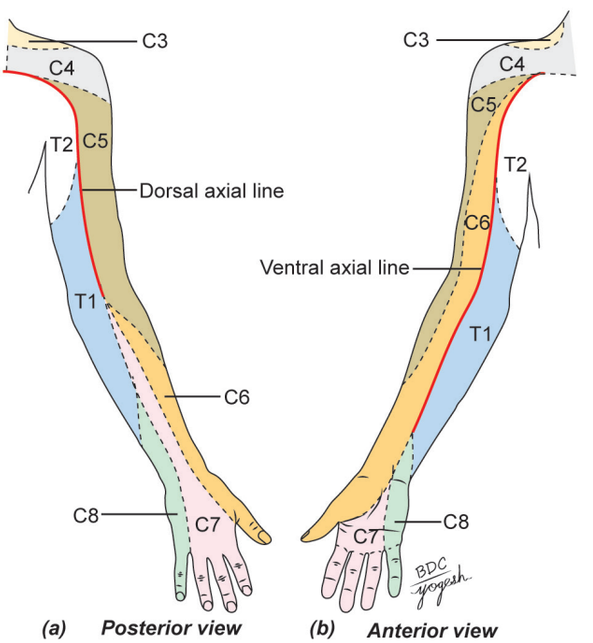


Fig. 7.6: Dermatomes of upper limb

c. The postaxial border is supplied (from below upwards) by segments C8, T1 and T2. There is overlapping of the dermatomes.

6. As the limb elongates, it rotates laterally and gets adducted and the central dermatome C7 gets pulled in such a way that these are represented only in the distal part of the limb and are buried proximally.

On the front of the limb, areas supplied by C5 and C6 segments adjoin the areas supplied by C8, T1 and T2 segments. There is a dividing line between them, known as the ***ventral axial line***, along which C7 is buried proximally. It reaches the skin just proximal to the wrist (Fig. 7.6).

On the back of the limb, C7 reaches the skin just proximal to the elbow. So the ***dorsal axial line*** ends more proximal to the ventral axial line. There is no overlapping across the ventral and dorsal axial lines (Fig. 7.6).

CLINICAL ANATOMY

- The area of sensory loss of the skin, following injuries of the spinal cord or of the nerve roots, conforms to the dermatomes. Therefore, the segmental level of the damage to the spinal cord can be determined by examining the dermatomes for touch, pain and temperature. Note that injury to a peripheral nerve produces sensory loss corresponding to the area of distribution of that nerve.
- The spinal segments do not lie opposite the corresponding vertebrae. In estimating the position of a spinal segment in relation to the surface of the body, it is important to remember that a vertebral spine is always *lower* than the corresponding spinal segment. As a rough guide, it may be stated that in the cervical region, there is a difference of one segment, e.g. the 5th cervical spine lies lower than the 5th cervical spinal segment. It overlies the 6th cervical spinal segment.

Spinal segments	*Spine of vertebra*
C1–C8	C1–C7
T1–T6	T1–T4
T7–T12	T5–T9
L1–L5	T10–T11
S1–S5 and Co1	T12–L1

Competency:
AN13.1 Describe and explain fascia of upper limb and compartments, veins of upper limb and its lymphatic drainage.

VEINS OF UPPER LIMB

The veins draining the upper limb are grouped as follows:

Superficial veins: These are located in the superficial fascia (Plate 7.1, Figs 7.8 and 7.9a–c). They include:

1. Dorsal venous arch
2. Cephalic vein
3. Basilic vein
4. Median cubital vein.

Deep veins: These are located deep in to the deep fascia. These include:

1. Venae comitantes that accompany the large arteries, such as radial, ulnar and brachial arteries.
2. Axillary vein.

SUPERFICIAL VEINS

Superficial veins of the upper limb assume importance in medical practice because these are most commonly used for intravenous injections and for withdrawing blood for testing.

General Features of Superficial Veins

1. Most of the superficial veins of the limb join together to form two large veins, cephalic (preaxial) and basilic (postaxial).
2. The superficial veins run away from pressure points. Therefore, they are absent in the palm (fist area), along the ulnar border of the forearm (supporting border) and in the back of the arm and trapezius region. This makes the course of the veins spiral from the dorsal to the ventral surface of the limb.
3. The preaxial vein is longer than the postaxial. In other words, the preaxial vein drains into the deep (axillary) vein more proximally (at the root of the limb) than the postaxial vein, which becomes deep in the middle of the arm.
4. The earlier a vein becomes deep the better, because the venous return is then assisted by muscular compression. The load of the preaxial (cephalic) vein is greatly relieved by the more efficient postaxial (basilic) vein through a short-circuiting channel (the median cubital vein situated in front of the elbow) and partly also by the deep veins through a perforator vein connecting the median cubital to the deep vein.
5. The superficial veins are accompanied by cutaneous nerves and superficial lymphatics and not by arteries. The superficial lymph nodes lie along the veins, and the deep lymph nodes along the arteries.
6. The superficial veins are best utilised for intravenous injections.

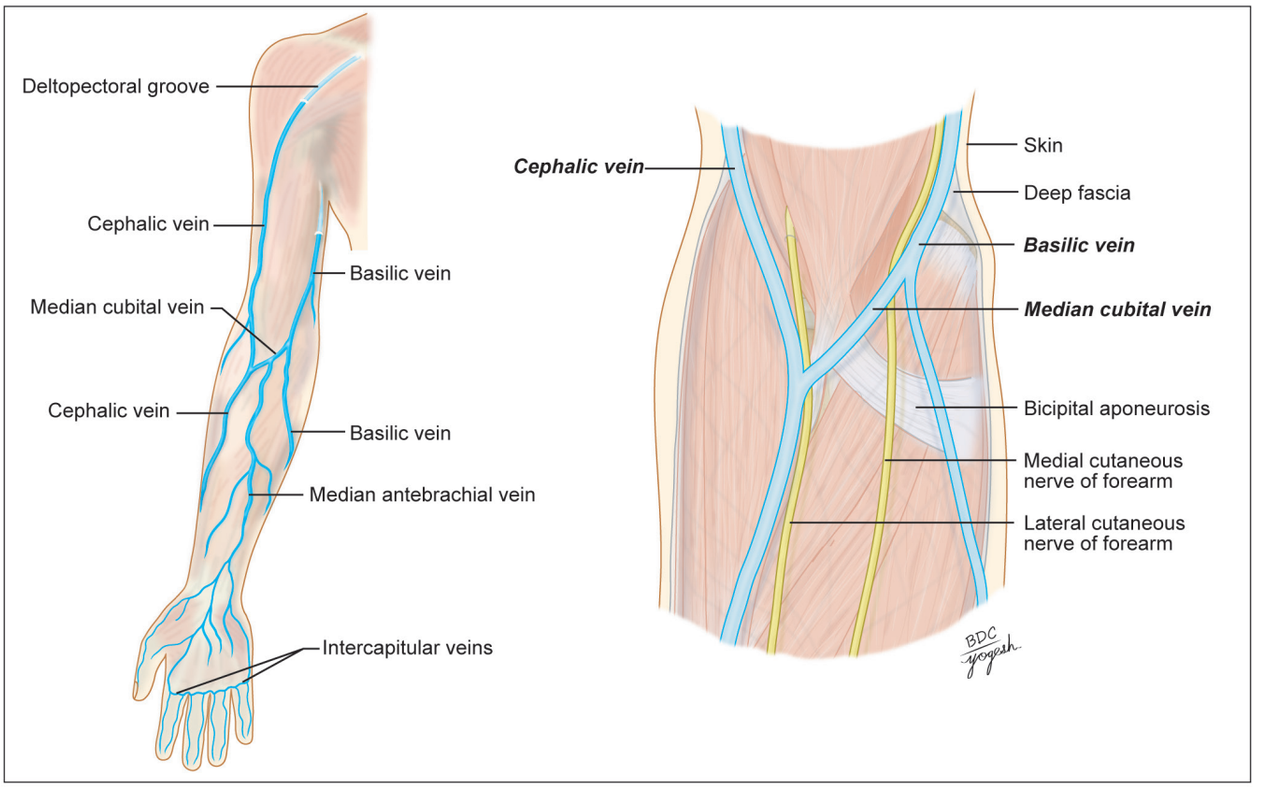
Dorsal Venous Arch

Dorsal venous arch lies on the dorsum of the hand (Fig. 7.7). Its afferents (tributaries) include:

1. Three dorsal metacarpal veins.
2. A dorsal digital vein from the medial side of the little finger.
3. A dorsal digital vein from the radial side of the index finger.
4. Two dorsal digital veins from the thumb.
5. Most of the blood from the palm courses through veins passing around the margins of the hand and also by perforating veins passing through the interosseous spaces.

Pressure on the palm during gripping fails to impede the venous return due to the mode of drainage of the palm into the dorsal venous arch.

Plate 7.1: Superficial veins of upper limb



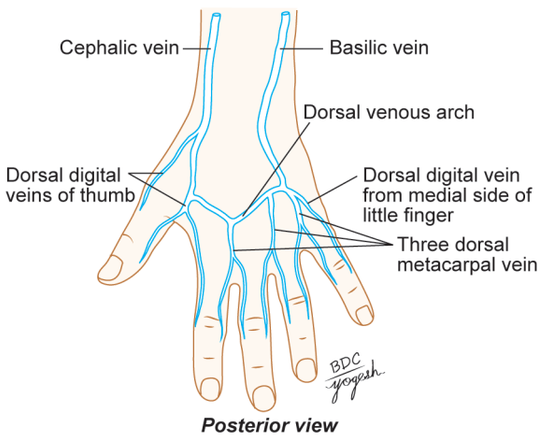


Fig. 7.7: Dorsal venous arch

The efferents of dorsal venous arch are the cephalic and basilic veins.

Cephalic Vein

Cephalic vein is the preaxial vein of the upper limb (cf. great saphenous vein of the lower limb). It begins from the lateral end of the dorsal venous arch.

It runs upwards:

1. Through the roof of the *anatomical snuffbox*.
2. Winds around the lateral border of the distal part of the forearm (Fig. 7.7).
3. Continues upwards in front of the elbow and along the lateral border of the biceps brachii.
4. Pierces the deep fascia at the lower border of the pectoralis major.
5. Runs in the deltopectoral groove up to the infraclavicular fossa.
6. It pierces the clavipectoral fascia and joins the axillary vein.

At the elbow, the greater part of its blood is drained into the basilic vein through the *median cubital vein* and partly also into the deep veins through the perforator vein.

It is accompanied by the lateral cutaneous nerve of the forearm and the terminal part of the radial nerve.

An *accessory cephalic vein* is sometimes present. It ends by joining the cephalic vein near the elbow.

Basilic Vein

Basilic vein is the postaxial vein of the upper limb (cf. short saphenous vein of the lower limb).

It begins from the medial end of the dorsal venous arch (Fig. 7.7).

It runs upwards:

1. Along the back of the medial border of the forearm,
2. Winds around this border near the elbow,
3. Continues upwards in front of the elbow (medial epicondyle) and along the medial margin of the biceps brachii up to the middle of the arm, where
   - It pierces the deep fascia, and
   - Runs along the medial side of the brachial artery up to the lower border of teres major where it becomes the axillary vein.

About 2.5 cm above the medial epicondyle of the humerus, it is joined by the median cubital vein.

It is accompanied by the posterior branch of the medial cutaneous nerve of the forearm and the terminal part of the dorsal branch of the ulnar nerve.

Median Cubital Vein

- Median cubital vein is a large communicating vein which shunts blood from the cephalic to the basilic vein (Fig. 7.8).
- It begins from the cephalic vein 2.5 cm below the bend of the elbow, runs obliquely upward and medially, and ends in the basilic vein 2.5 cm above the medial epicondyle. It is separated from the brachial artery by the bicipital aponeurosis.
- It may receive tributaries from the front of the forearm (median vein of the forearm) and is connected to the deep veins through a perforator vein, which pierces the bicipital aponeurosis. The perforator vein fixes the median cubital vein and thus makes it ideal for intravenous injections.

Median Vein of the Forearm

Median vein of the forearm begins from the palmar venous network and ends in any one of the veins in front of the elbow, mostly in median cubital vein.

DEEP VEINS

- Deep veins start as small venae comitantes running on each side of digital arteries. These continue proximally along superficial and deep palmar arches.
- Then, these course proximally to continue as venae comitantes of radial and ulnar arteries, which further join to form the brachial veins.
- Brachial veins lie on each side of brachial artery. These join the axillary vein at the lower border of teres major. Axillary vein is described in axilla (*see* Chapter 4).

Competency:
AN11.3 Describe the anatomical basis of venepuncture of cubital veins.

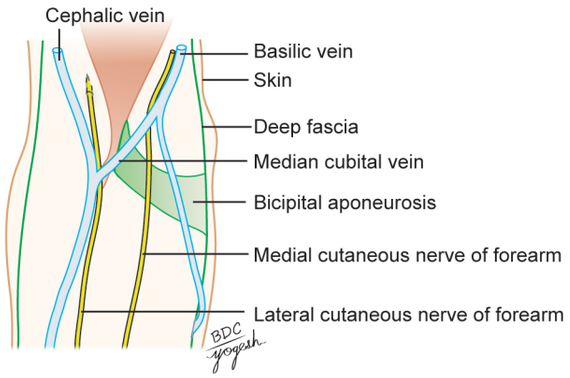


Fig. 7.8: Median cubital vein in the roof of cubital fossa

CLINICAL ANATOMY

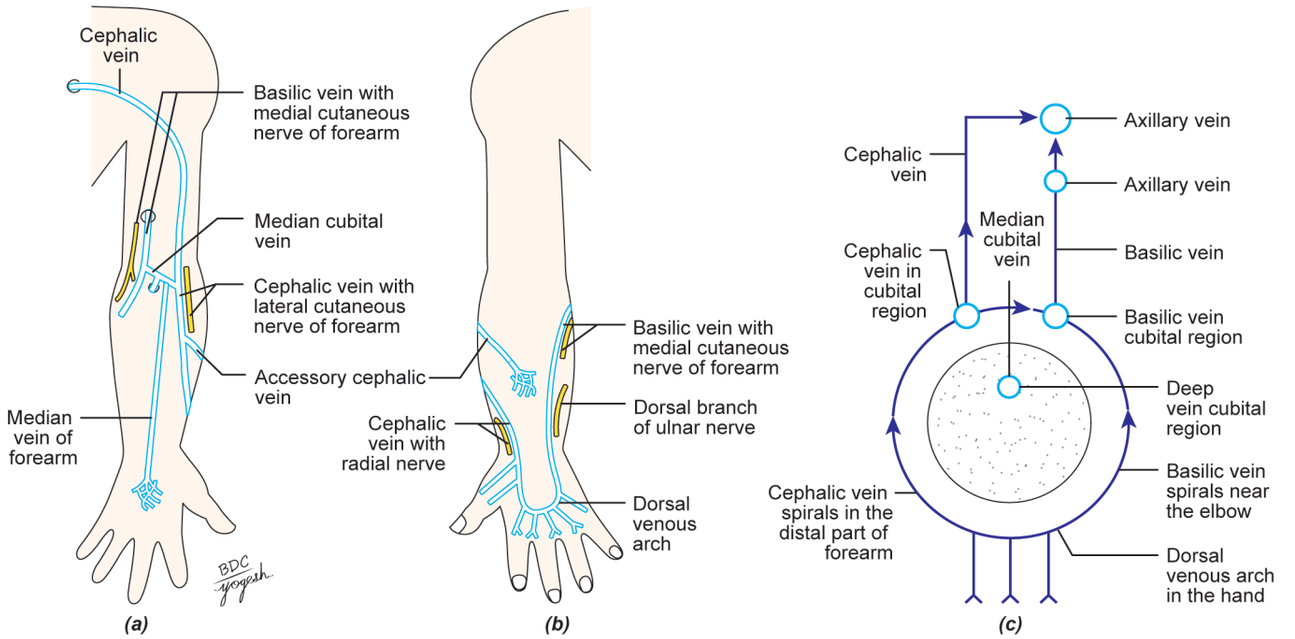
- ***Venepuncture in the cubital fossa*:** The median cubital vein is the vein of choice for intravenous injections, for withdrawing blood from donors, and for cardiac catheterisation, because it is fixed by the perforator and does not slip away during piercing. When the median cubital vein is absent, the basilic vein is preferred over the cephalic vein because the former is a more efficient channel (Figs 7.10 and 7.11).
- The cephalic vein frequently communicates with the external jugular vein by means of a small vein, which crosses in front of the clavicle. In operations for removal of the breast (in carcinoma), the axillary lymph nodes are also removed, and it sometimes becomes necessary to remove a segment of the axillary vein also. In these cases, the communication between the cephalic vein and the external jugular vein enlarges considerably and helps in draining blood from the upper limb (Fig. 7.12).
- In case of fracture of the clavicle, the rupture of the communicating channel may lead to formation of a large haematoma, i.e. collection of blood.
- Basilic vein is preferred for right cardiac catheterisation as this vein has large diameter and easily accessible. In cardiac catheterisation, a long rubber tube (called catheter) is inserted in the heart to check the heart disease to know the functioning of the cardiac muscles and valve.

LYMPH NODES AND LYMPHATIC DRAINAGE

- When circulating blood reaches the capillaries, part of its fluid content passes through them into the surrounding tissue as *tissue fluid.* Most of this tissue fluid re-enters the capillaries at their venous ends. Some of it is, however, returned to circulation through a separate set of *lymphatic vessels.* These vessels begin as lymphatic capillaries, which drain into larger vessels.
- Along the course of these lymph vessels, there are groups of *lymph nodes*.
- Lymph vessels are difficult to see and special techniques are required for their visualisation.
- Lymph nodes are small bean-like structures that are usually present in groups. These are not normally palpable in the living subject.
- However, they often become enlarged in disease, particularly by infection or malignancy in the area from which they receive lymph. They then become palpable, and examination of these nodes provides valuable information regarding the presence and spread of disease.

Lymph Nodes

1. ***Axillary lymph nodes:*** The main lymph nodes of the upper limb are the *axillary lymph nodes*. These comprise anterior, posterior, lateral, central and apical groups. These have been described in Chapter 4 (*see* page 51).



Figs 7.9a to c: The superficial veins of the upper limb: (a) On the front, (b) on the back of the limb, and (c) schematic representation



Fig. 7.10: Intravenous injection being given in the superficial vein of forearm

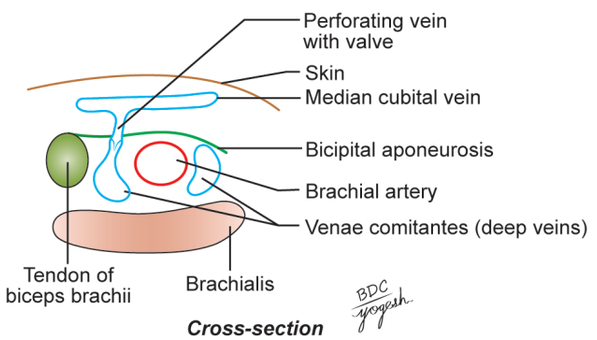


Fig. 7.11: Relations of median cubital vein

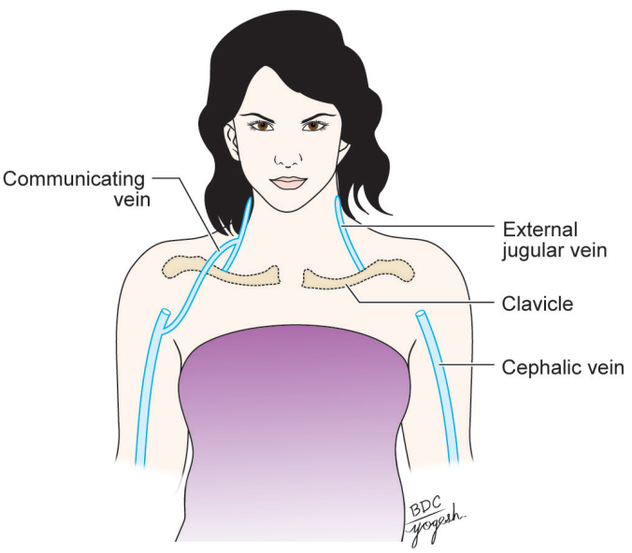


Fig. 7.12: A communicating vein helps in venous drainage from upper limb

2. ***Infraclavicular nodes*:** They lie in or on the clavipectoral fascia along the cephalic vein. They drain the upper part of the breast and the thumb with its web.
3. ***Deltopectoral node:*** They lie in the deltopectoral groove along the cephalic vein. It is a displaced node of the infraclavicular set and drains similar structures.
4. ***Superficial cubital or supratrochlear nodes*:** They lie just above the medial epicondyle along the basilic vein. They drain the ulnar side of the hand and forearm. These are the most distal superficial lymph nodes in the upper limb.
5. A few other deep lymph nodes lie in the following regions:
   a. Along the medial side of the brachial artery.
   b. At the bifurcation of the brachial artery (deep cubital lymph node).
   c. Occasionally along the arteries of the forearm.

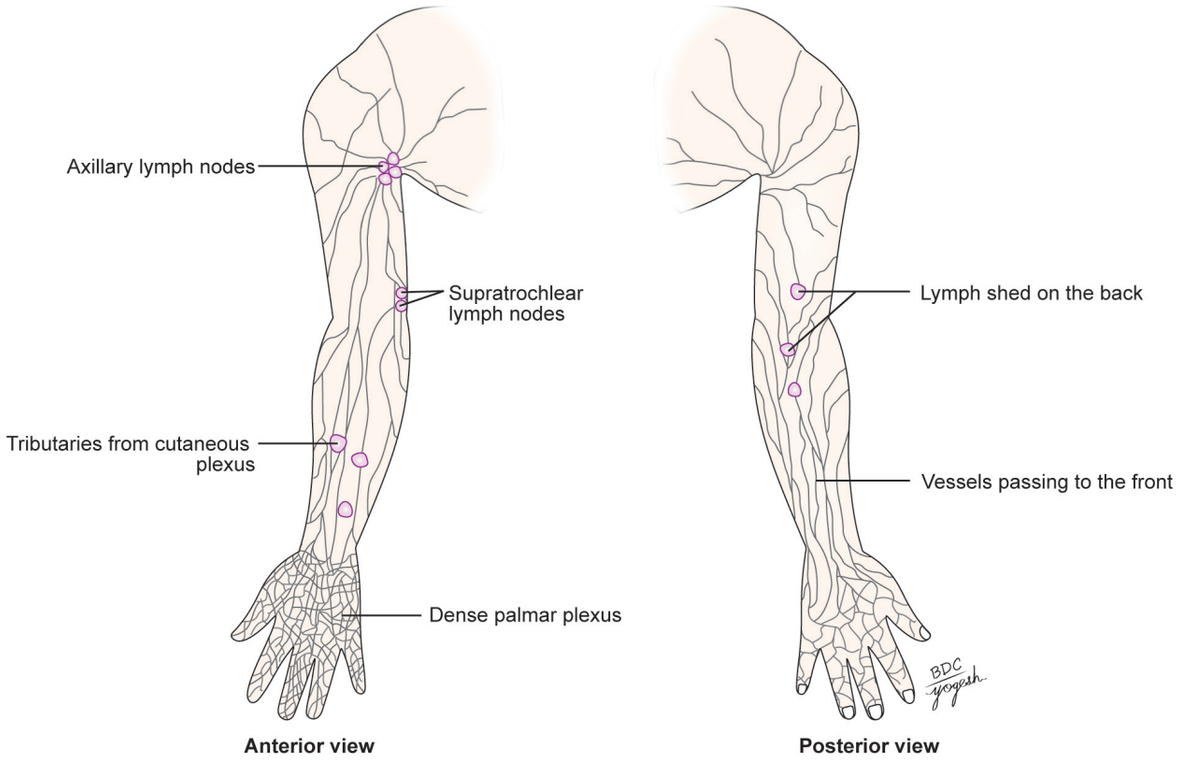


Fig. 7.13: The superficial lymphatics of the upper limb

Lymphatic Vessels

Superficial Lymphatics

Superficial lymphatics are much more numerous than the deep lymphatics. They collect lymph from the skin and subcutaneous tissues. Most of them ultimately drain into the axillary nodes, except for:

1. A few vessels from the medial side of the forearm, which drain into the superficial cubital nodes.
2. A few vessels from the lateral side of the forearm, which drain into the deltopectoral or infraclavicular nodes.

The dense *palmar plexus* drains mostly into the lymph vessels onto the dorsum of the hand, where these continue with the vessels of the forearm. Lymph vessels of the back of forearm and arm curve around their medial and lateral surfaces and ascend up to reach the floor of the axilla. Thus, there is a vertical area of *lymph shed* in the middle of back of forearm and arm (Fig. 7.13).

Deep Lymphatics

Deep lymphatics are much less numerous than the superficial lymphatics. They drain structures lying deep into the deep fascia. They run along the main blood vessels of the limb and end in the axillary nodes. Some of the lymph may pass through the deep lymph nodes present along the axillary vein, as mentioned above.

CLINICAL ANATOMY

- Inflammation of lymph vessels is known as ***lymphangitis***. In acute lymphangitis, the vessels may be seen through the skin as red, tender (painful to touch) streaks (Fig. 7.14).
- Inflammation of lymph nodes is called ***lymphadenitis***. It may be acute or chronic. The nodes enlarge and become palpable and painful (Fig. 7.15).
- Obstruction to lymph vessels can result in accumulation of tissue fluid in areas of drainage. This is called ***lymphoedema***. This may be caused by carcinoma because of surgical removal of lymph nodes (Fig. 7.16).
- Pain along the medial side of upper arm is due to pressure on the intercostobrachial nerve by enlarged central group of axillary lymph nodes.

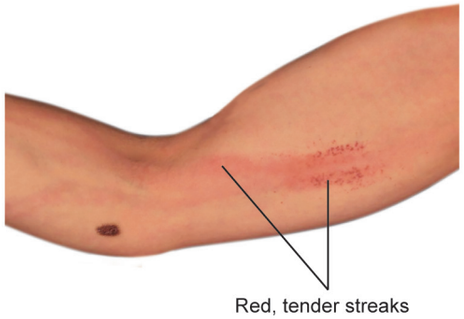


Fig. 7.14: Lymphangitis

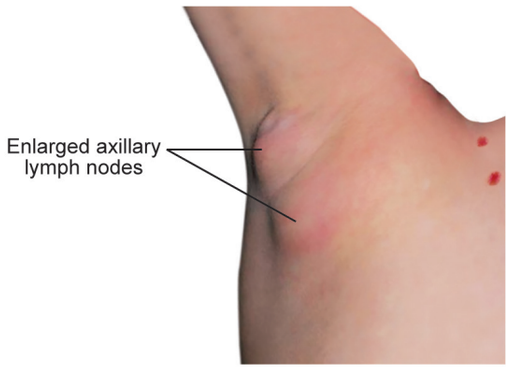
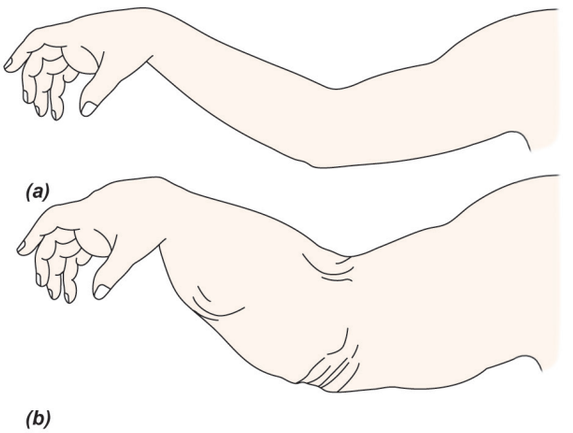


Fig. 7.15: Enlarged axillary lymph nodes



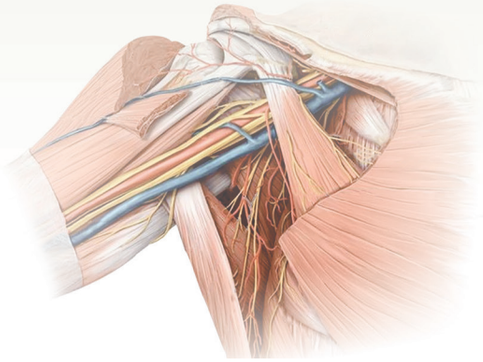
Figs 7.16a and b: (a) Normal upper limb and (b) lymphoedema due to removal of axillary lymph nodes in case of carcinoma of the breast

Facts to Remember

- Ventral axial line ends close to wrist joint, while dorsal axial line ends close to elbow joint.
- Dermatome is an area of skin supplied by single spinal segment through a pair of right and left spinal nerves through both its dorsal and ventral rami.
- There is no overlapping of the nerve supply across the axial lines.
- Intercostobrachial nerve (T2) is the lateral cutaneous branch of the 2nd intercostal nerve. It supplies the skin of the upper half of the medial and posterior parts of the arm.
- Cephalic vein begins in the 'anatomical snuffbox' and it is the longest superficial vein of the upper limb.
- The median cubital vein is the most commonly used vein for venipuncture. It is fixed due to perforators passing through the bicipital aponeurosis.
- The basilic vein is the most preferred vein for cardiac catheterisation.
- There is a vertical area of *lymph shed* in the middle of back of forearm and arm.

BDC's Anatomy *e*-book

1. Segment innervation of upper limb
2. Axial lines of upper limb
3. Common venous patterns in front of the elbow
4. Steps of venepuncture
5. Use of cephalic vein in haemodialysis
6. How is the lymph generated?
7. Further reading
8. Viva voce questions



Chapter

8

Arm

The arm extends from the shoulder joint to the elbow joint. The skeleton of the arm is a 'solo' bone, the humerus. Medial and lateral intermuscular septa divide the arm into an anterior or flexor compartment and a posterior or extensor compartment to give each compartment its individuality and freedom of action. Since the structures in the front of arm continue across the elbow joint into the cubital fossa, the cubital fossa is also included in this chapter.

The arm is called *brachium*, so most of the structures in this chapter are named accordingly, like brachialis, coracobrachialis and brachial artery.

SURFACE LANDMARKS

The following landmarks can be felt in the living subject.

1. ***Greater tubercle of the humerus:*** It can be felt just below the acromion process, deep to the deltoid, when the arm is by the side of the trunk (Fig. 8.1).
2. ***Shaft of the humerus:*** It is felt only indistinctly because it is surrounded by muscles in its upper half. In the lower half, the humerus is covered anteriorly by the biceps brachii and brachialis and posteriorly by the triceps brachii.
3. ***Medial epicondyle of the humerus:*** It is a prominent bony projection on the medial side of the elbow. It is best seen and felt in a mid-flexed elbow.
4. ***Lateral epicondyle of the humerus:*** It is less prominent than the medial. It can be felt in the upper part of the depression on the posterolateral aspect of the elbow in the extended position of the forearm.
5. ***Medial and lateral supracondylar ridges:*** These are better defined in the lower portions of the medial and lateral borders of the humerus. They can be felt in the lower one-fourth of the arm as upward continuations of the epicondyles.
6. ***Deltoid muscle:*** It forms the rounded contour of the shoulder. The apex of the muscle is attached to the deltoid tuberosity located in the middle of the anterolateral surface of the humerus.
7. ***Coracobrachialis muscle:*** It forms an inconspicuous rounded ridge in the upper part of the medial side of the arm. Pulsations of the brachial artery can be felt in the depression behind it.
8. ***Biceps brachii muscle:*** It forms a conspicuous elevation on the front of the arm. Upon flexing the elbow, the contracting muscle becomes still more prominent. The tendon of the biceps can be felt in front of the elbow. The tendon is a guide to the brachial artery, which lies on its medial side.
9. ***Brachial artery:*** It can be felt in front of the elbow joint just medial to the tendon of the biceps brachii. Brachial pulsations are used for recording the blood pressure.
10. ***Ulnar nerve:*** It can be rolled by the palpating finger behind the medial epicondyle of the humerus. During leprosy, this nerve becomes thick and enlarged.
11. The superficial cubital veins can be made more prominent by applying tight pressure a round the arm and then contracting the forearm muscles by clenching and releasing the fist a few times. The ***cephalic vein*** runs upwards along the lateral border of the biceps. The ***basilic vein*** can be seen along the

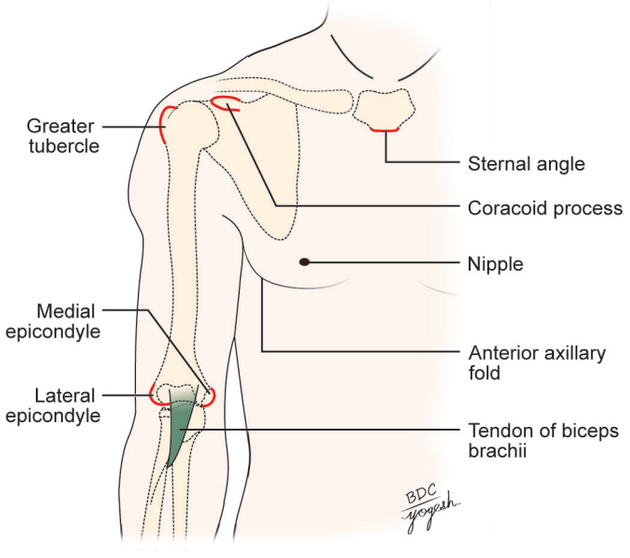


Fig. 8.1: Surface landmarks—front of upper arm

lower half of the medial border of the biceps. The cephalic and basilic veins are connected together in front of the elbow by the ***median cubital vein,*** which runs obliquely upwards and medially.

COMPARTMENTS OF THE ARM

The arm is divided into anterior and posterior compartments by extension of deep fascia, called the ***medial*** and ***lateral intermuscular septa*** (Fig. 8.2). These septa provide additional surface for the attachment of muscles. They also form planes along which nerves and blood vessels travel. The septa are well-defined only in the lower half of the arm and are attached to the medial and lateral borders and supracondylar ridges of the humerus.

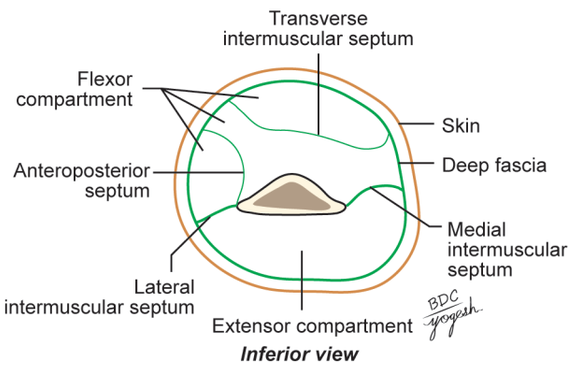


Fig. 8.2: Transverse section through the distal one-third of the arm, showing the intermuscular septa and the compartments

The medial septum is pierced by the ulnar nerve and the superior ulnar collateral artery; the lateral septum is pierced by the radial nerve and radial collateral artery or the anterior descending branch of the profunda brachii artery.

Two additional septa are present in the anterior compartment of the arm. The ***transverse septum*** separates the biceps from the brachialis and encloses the musculocutaneous nerve. The ***anteroposterior septum*** separates the brachialis from the muscles attached to the lateral supracondylar ridge; it encloses the radial nerve and the anterior descending branch of the profunda brachii artery.

Competency:
AN11.1 Describe and demonstrate muscle groups of upper arm with emphasis on biceps and triceps brachii.

ANTERIOR COMPARTMENT

The front or anterior compartment of the arm is homologous with flexor and medial compartments of the thigh. The flexor compartment of thigh lies posteriorly because the lower limb bud rotates medially.

MUSCLES

Muscles of the anterior compartment of the arm are the coracobrachialis, the biceps brachii and the brachialis (Fig. 8.3, Plates 8.1 and 8.2). They are described in Tables 8.1 and 8.2, Flowchart 8.1.

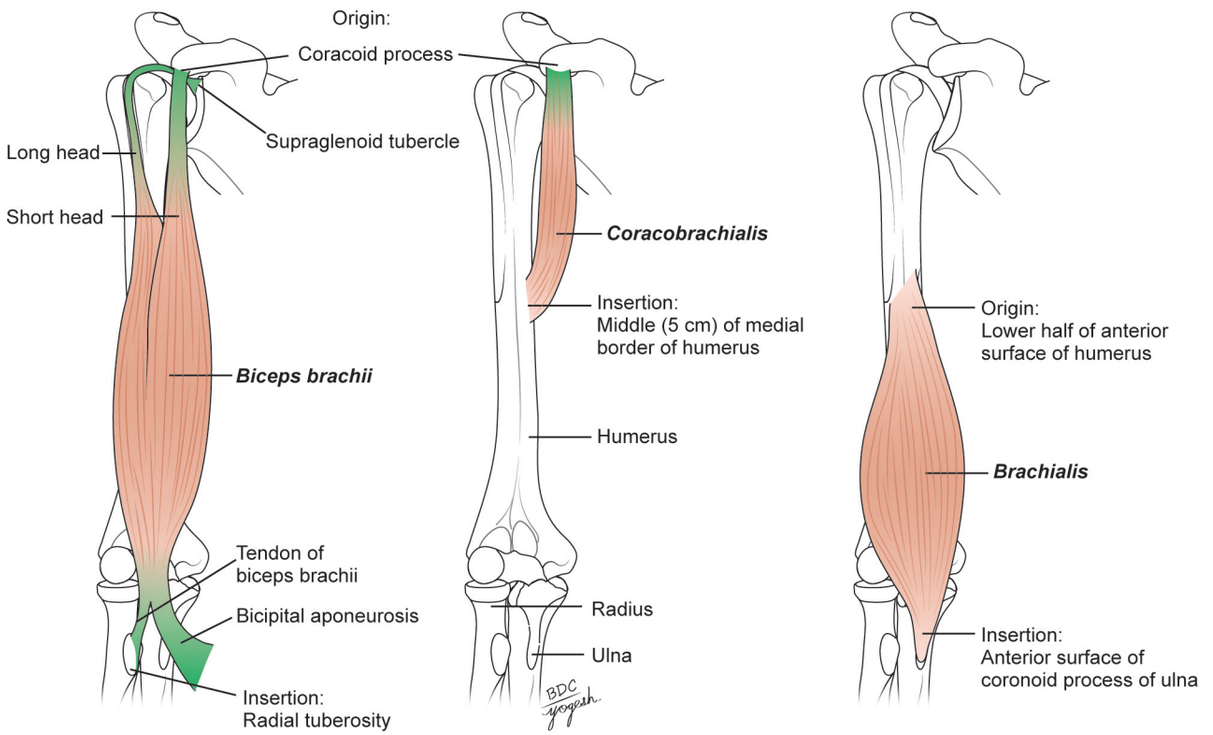


Fig. 8.3: Biceps brachii, coracobrachialis and brachialis muscles

Plate 8.1: Coracobrachialis, brachialis and biceps brachii muscles

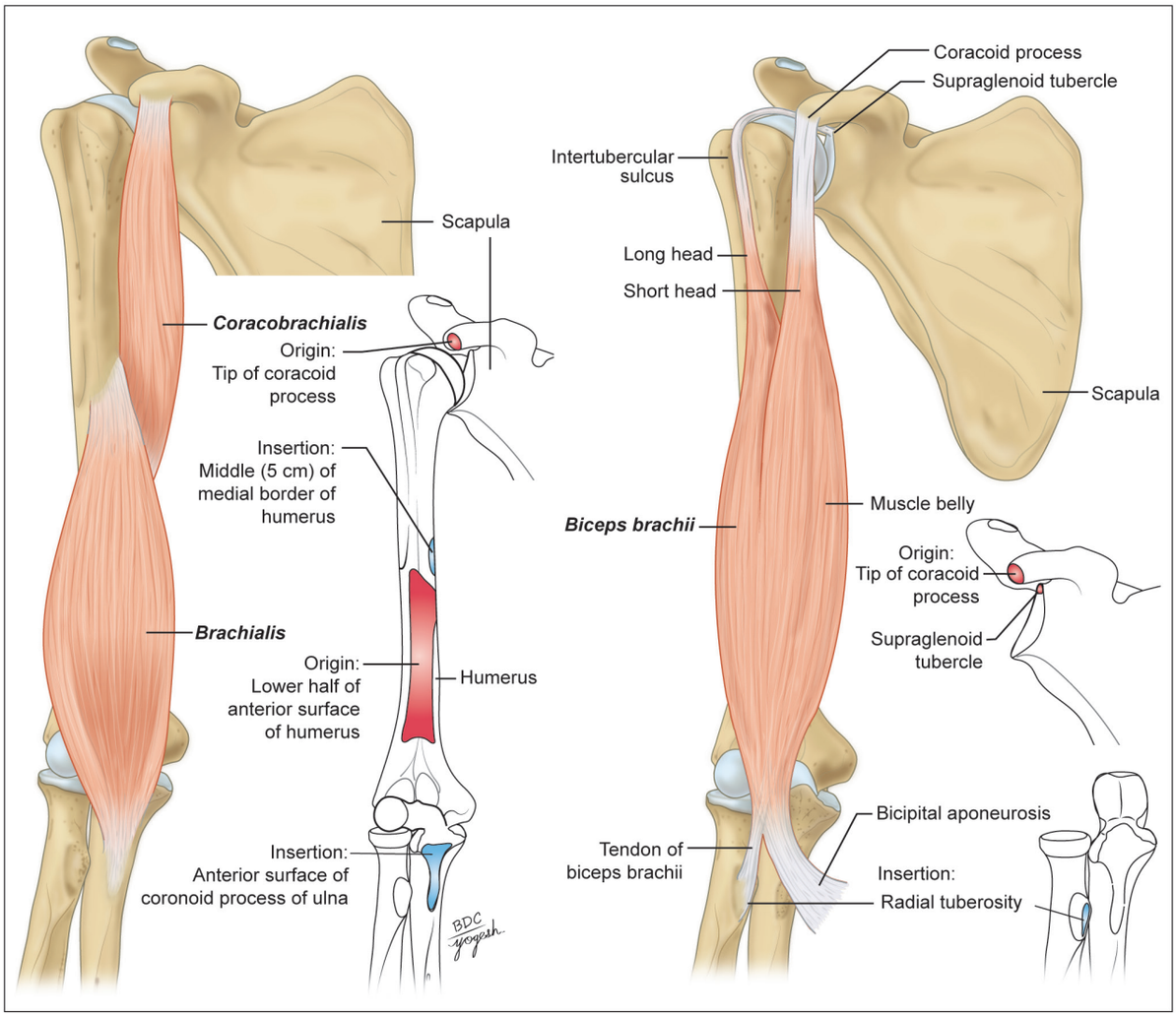
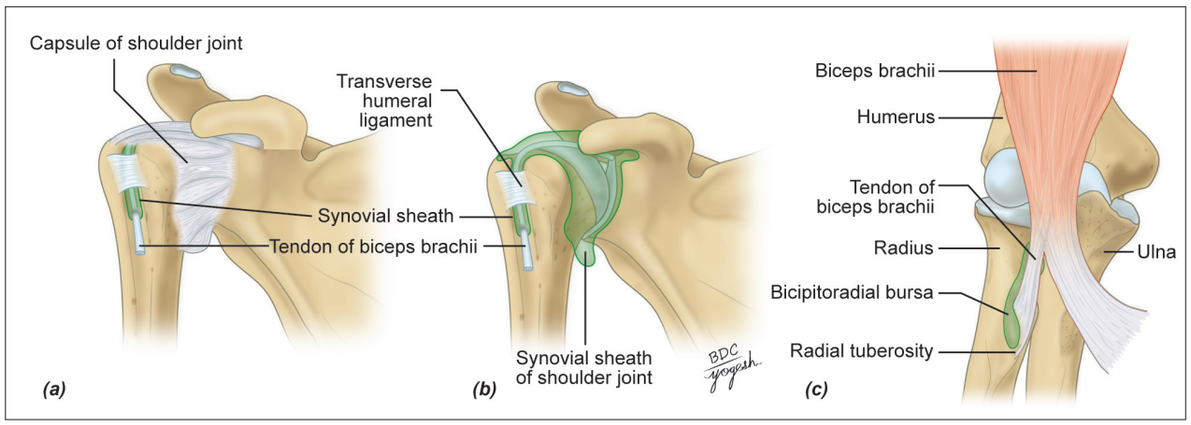


Plate 8.2: Origin of long head and insertion of biceps brachii



Morphological Importance of Coracobrachialis

Morphologically, the muscle is very important for the following reasons.

The coracobrachialis represents the ***medial compartment***, which is so well developed in the thigh.

In some animals, it is a ***tricipital muscle***. In humans, the upper two heads have fused and musculocutaneous nerve passes between the two, and the lowest third head has disappeared. Persistence of the lower head in humans is associated with the

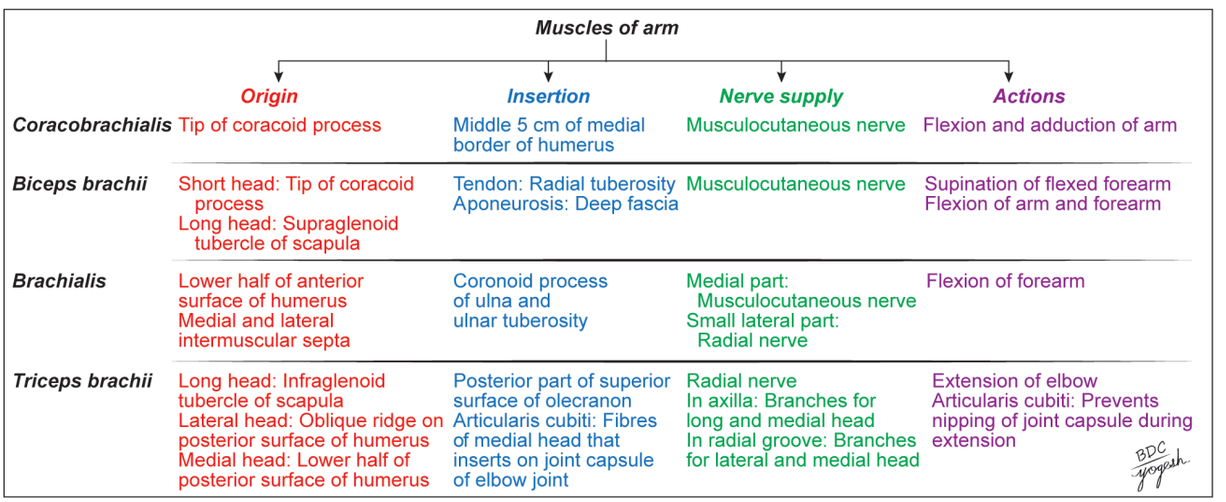
TABLE 8.1: Origin and insertion of muscles

Muscle	*Origin*	*Insertion*
1. **Coracobrachialis**	• The tip of the coracoid process with the short head of the biceps brachii	• The middle 5 cm of the medial border of the humerus
2. **Biceps brachii**	It has two heads of origin: 1. *Short head*: Arises with coracobrachialis from the tip of the coracoid process 2. *Long head:* Arises from the *supraglenoid tubercle* of the scapula and from the glenoidal labrum. The tendon is intracapsular (Plate 8.2a and b)	• Posterior rough part of the *radial tuberosity*. • The ***tendon*** is twisted; the anterior fibres become lateral and posterior fibres become medial. The tendon is separated from the anterior part of the tuberosity by a *bursa* (Plate 8.2c) • The tendon gives off an extension called the ***bicipital aponeurosis***, which extends to ulna and it separates median cubital vein from brachial artery
3. **Brachialis**	• Lower half of the front of the *humerus*, including both the anteromedial and anterolateral surfaces and the anterior border Superiorly, the origin embraces the insertion of the deltoid • Medial and lateral intermuscular septa	• Anterior surface of the *coronoid process* of the ulna and *ulnar tuberosity*

TABLE 8.2: Nerve supply and actions of muscles

Muscle	*Nerve supply*	*Actions*
1. **Coracobrachialis**	Musculocutaneous nerve	Flexes and adducts the arm at the shoulder joint
2. **Biceps brachii**	Musculocutaneous nerve	• It is strong supinator when the forearm is flexed • All screwing movements are done with it • It is a flexor of the elbow • The short head is a flexor of the arm • The long head prevents upwards displacement of the head of the humerus • It can be tested against resistance, as shown in Fig. 8.4
3. **Brachialis**	• Musculocutaneous nerve is motor • Radial nerve is proprioceptive	Flexes forearm at the elbow joint

Flowchart 8.1: Muscles of arm



presence of '*ligament of Struthers*', which is a fibrous band extending from the trochlear spine to the medial epicondyle of the humerus, to which the third head of the coracobrachialis is inserted, and from the lower part of which the pronator teres muscle takes origin. Beneath the ligament passes the median nerve or brachial artery or both.

CLINICAL ANATOMY

- ***Clinical testing of biceps brachii*:** Physician holds the patient's wrist firmly, not letting it move. Patient is requested to flex the elbow against the resistance offered by physician's hand. One can see and palpate hardening biceps brachii muscle (Fig. 8.4).

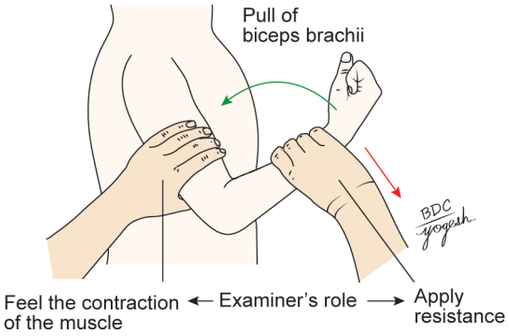


Fig. 8.4: Testing biceps brachii against resistance

***Competency*:**
AN11.2 Identify and describe origin, course, relations, branches (or tributaries), termination of important nerves and vessels in arm.

NERVES

Musculocutaneous Nerve

The musculocutaneous nerve is the main nerve of the front of the arm and continues below the elbow as the lateral cutaneous nerve of the forearm (Flowchart 8.2, Plate 8.3).

It is a branch of the lateral cord of the brachial plexus, arising at the lower border of the pectoralis minor in the axilla.

Root Value

The root value of musculocutaneous nerve is ventral rami of C5–C7 segments of spinal cord.

Origin, Course and Termination

Musculocutaneous nerve arises from the lateral cord of brachial plexus in the lower part of the axilla. It accompanies the third part of the axillary artery. It then enters the front of arm, where it pierces coracobrachialis muscle.

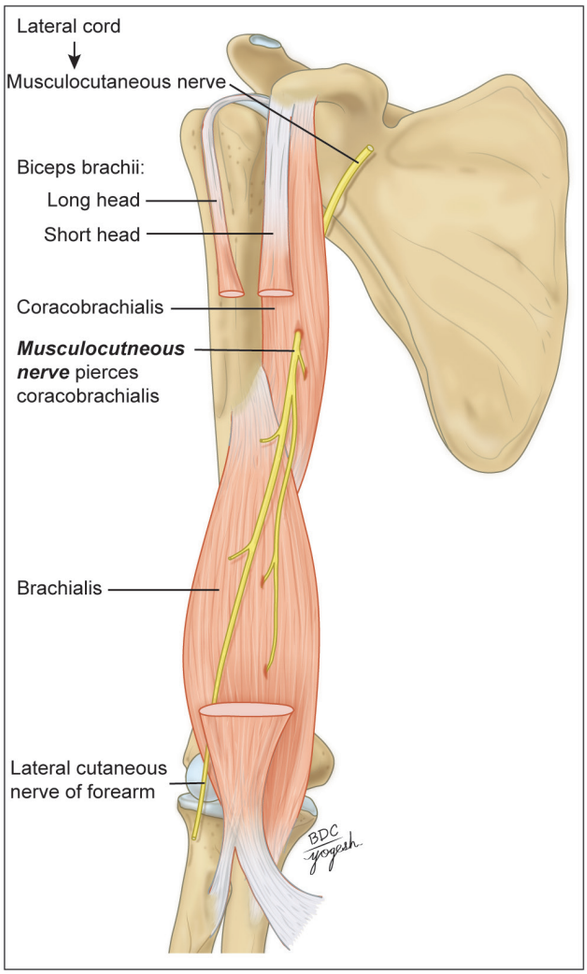
Musculocutaneous nerve runs downwards and laterally between biceps brachii and brachialis muscles to reach the lateral side of the tendon of biceps brachii. It terminates by continuing as the lateral cutaneous nerve of forearm 2 cm above the bend of the elbow (Plate 8.3).

Flowchart 8.2: Musculocutaneous nerve

Musculocutaneous nerve

Beginning and Termination	*Course*	*Branches (distribution)*
Branch of lateral cord of brachial plexus Root value: C5–C6 Continues as lateral cutaneous nerve of forearm	Arises in lower part of axilla lateral to axillary artery Pierces coracobrachialis Runs deep to biceps brachii and superficial to coracobrachialis and brachialis	Muscular for 1. Coracobrachialis 2. Biceps brachii 3. Brachialis Cutaneous 1. Lateral cutaneous nerve of forearm Articular for 1. Shoulder joint 2. Elbow joint

Plate 8.3: Musculocutaneous nerve



Relations

***In the lower part of the axilla*:** It accompanies the third part of the axillary artery and has the following relations:
Anteriorly: Pectoralis major
Posteriorly: Subscapularis
Medially: Axillary artery and lateral root of the median nerve
Laterally: Coracobrachialis.

Musculocutaneous nerve leaves the axilla and enters the front of the arm by piercing the coracobrachialis.

***In the arm*:** It runs downward and laterally between the biceps brachii and brachialis to reach the lateral side of the tendon of the biceps. It ends by piercing the fascia 2 cm above the bend of the forearm.

Branches and Distribution

A. ***Muscular branches*:** It supplies the following muscles of the front of the arm.
   1. Coracobrachialis
   2. Biceps brachii, long and short heads
   3. Brachialis (Plate 8.3, Fig. 8.5).

B. ***Cutaneous branches*:** Through the ***lateral cutaneous nerve of the forearm***, it supplies the skin of the

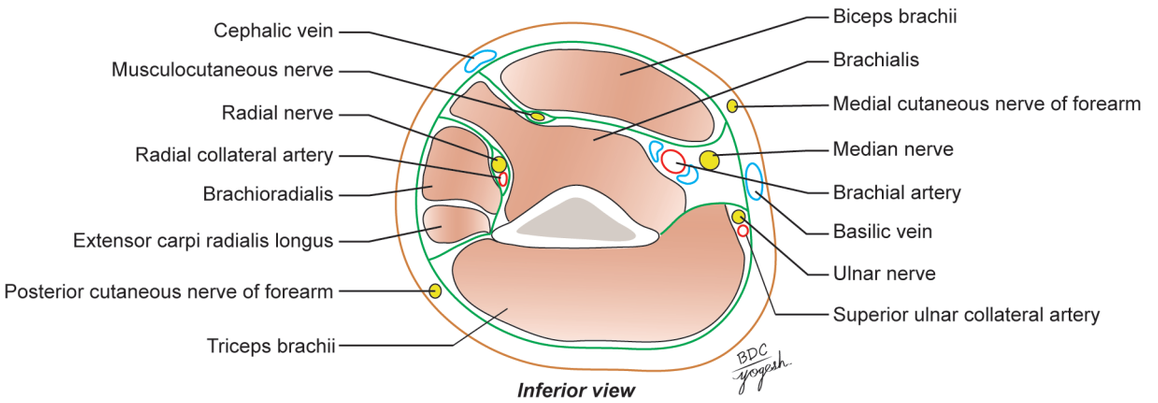


Fig. 8.5: Transverse section passing through the lower one-third of the arm

lateral side of the forearm from the elbow to the wrist, including the ball of the thumb.

C. ***Articular branches***
   1. The elbow joint through its branch to the brachialis.
   2. The shoulder joint through a separate branch which enters the humerus along with its nutrient artery.

D. ***Communicating branches*:** The musculocutaneous nerve, through lateral cutaneous nerve of forearm communicates with the neighbouring nerves, namely the superficial branch of the radial nerve, the posterior cutaneous nerve of the forearm and the palmar cutaneous branch of the median nerve.

CLINICAL ANATOMY

***Biceps reflex*:** Musculocutaneous nerve is tested by biceps reflex. Tap the tendon of biceps with forearm pronated and partially extended at the elbow. Normal reflex is jerk-like flexion of elbow joint (Fig. 8.6).

Median Nerve

Median nerve is closely related to the brachial artery throughout its course in the arm.

In the upper part, it is lateral to the artery; in the middle of the arm, it crosses the artery from lateral to the medial side and remains on the medial side of the artery right up to the elbow.

In the arm, the median nerve gives off a branch to the pronator teres just above the elbow and vascular branches to the brachial artery.

An articular branch to the elbow joint arises at the elbow.

Ulnar Nerve

Ulnar nerve runs on the medial side of the brachial artery up to the level of insertion of the coracobrachialis, where it pierces the medial intermuscular septum and enters the posterior compartment of the arm. It is accompanied by the superior ulnar collateral vessels.

At the elbow, it passes behind the medial epicondyle, where it can be palpated with a finger.

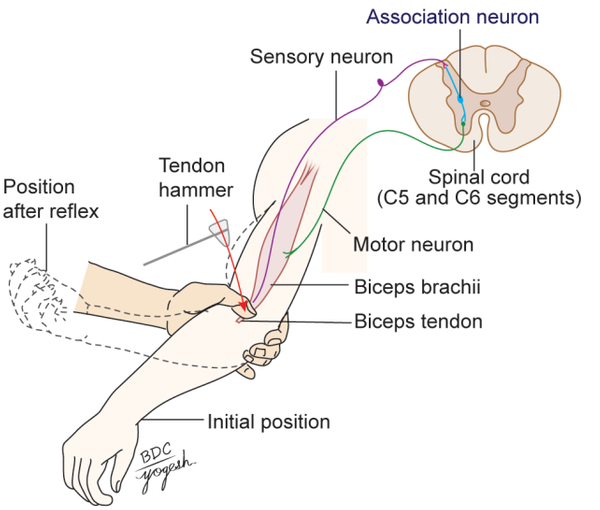


Fig. 8.6: Biceps tendon reflex

Radial Nerve

At the beginning of the brachial artery, the radial nerve lies posterior to the artery. Soon, the nerve leaves the artery by entering the radial (spiral) groove on the back of the arm, where it is accompanied by the profunda brachii artery.

In the lower part of the arm, the nerve appears again on the front of the arm, where it lies between the brachialis (medially) and the brachioradialis and extensor carpi radialis longus (laterally). Its branches will be discussed with the back of the arm.

DISSECTION

Make an incision in the middle of deep fascia of the upper arm right down up to the elbow joint. Reflect the flaps sideways.

The most prominent muscle seen is the biceps brachii. Deep to this, another muscle called brachialis is seen easily. In the fascial septum between the two muscles lies the musculocutaneous nerve (a branch of the lateral cord of brachial plexus). Trace the tendinous long head of biceps arising from the supraglenoid tubercle and the

short head arising from the tip of the coracoid process of scapula. Identify coracobrachialis muscle on the medial side of biceps brachii. This muscle is easily identified as it is pierced by musculocutaneous nerve. Clean the branches of the nerve supplying all the three muscles dissected.

BRACHIAL ARTERY

Features

Brachial artery is the continuation of the axillary artery (Plate 8.4, Flowchart 8.3). It extends from the lower border of the teres major muscle to a point in front of the elbow, at the level of the neck of the radius, just medial to the tendon of the biceps brachii.

Beginning, Course and Termination

Brachial artery begins at the lower border of teres major muscle as a continuation of axillary artery (Fig. 8.7). It runs downwards and laterally in the front of arm and crosses the elbow joint. It ends at the level of the neck of radius in the cubital fossa by dividing into its two terminal branches, the radial and ulnar arteries.

Relations

1. It runs downwards and laterally from the medial side of the arm to the front of the elbow.
2. It is superficial throughout its extent and is accompanied by two venae comitantes.
3. Anteriorly, in the middle of the arm, it is crossed by the median nerve from the lateral to the medial side; and in front of the elbow, it is covered by the bicipital aponeurosis and the median cubital vein (Fig. 8.8).
4. Posteriorly, it is related to:
   a. The triceps brachii
   b. The radial nerve and the profunda brachii artery.

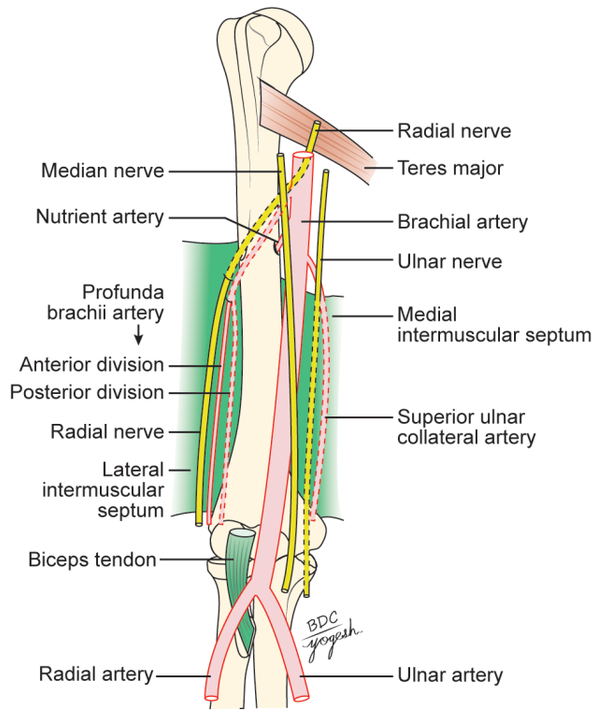
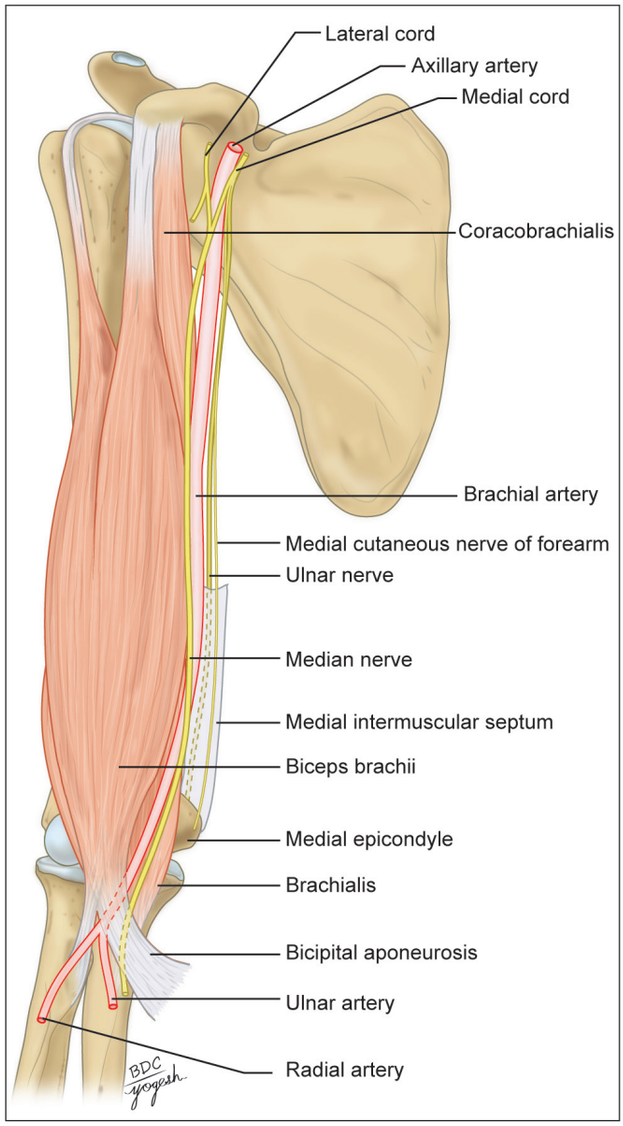
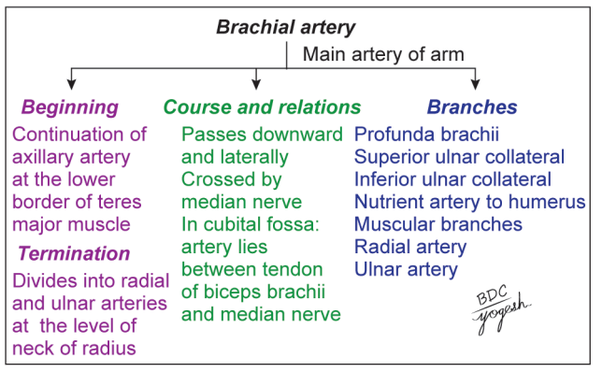


Fig. 8.7: The course and relations of the brachial artery

Plate 8.4: Relations of brachial artery



Flowchart 8.3: Brachial artery



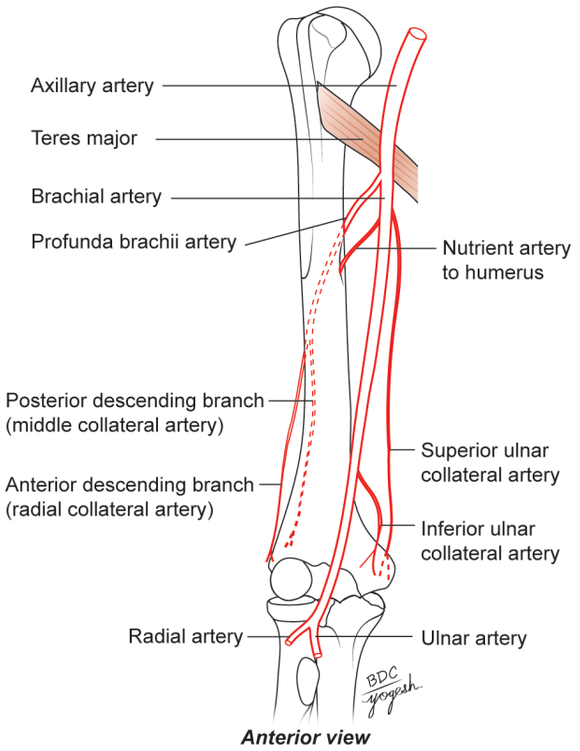


Fig. 8.8: Branches of brachial artery

5. Medially, in the upper part, it is related to the ulnar nerve and the basilic vein and in the lower part to the median nerve (Fig. 8.7).
6. Laterally, it is related to the coracobrachialis, the biceps brachii and the median nerve in its upper part, and to the tendon of the biceps brachii at the elbow.
7. At the elbow, the structures from the medial to the lateral side are:
   a. Median nerve
   b. Brachial artery
   c. Biceps brachii tendon
   d. Radial nerve on a deeper plane (*mnemonic*: MBBR).

Branches

1. Unnamed ***muscular branches***.
2. ***Profunda brachii artery:*** It arises just below the teres major and accompanies the radial nerve.
3. ***Superior ulnar collateral branch:*** It arises in the upper part of the arm and accompanies the ulnar nerve (Fig. 8.8).
4. A ***nutrient artery*** is given off to the humerus.
5. ***Inferior ulnar collateral*** (or supratrochlear) branch: It arises in the lower part and takes part in the anastomoses around the elbow joint.
6. The artery ends by dividing into two terminal branches, the ***radial*** and ***ulnar arteries***.

CLINICAL ANATOMY

- ***Brachial pulsations*** are felt or auscultated in front of the elbow just medial to the tendon of biceps for recording the blood pressure (Fig. 8.9). Figure 8.10 shows other palpable arteries.
- ***Compression of brachial artery:*** Although the brachial artery can be compressed anywhere along its course, it can be compressed most favourably in the middle of the arm, where it lies on the tendon of the coracobrachialis.
- Blood for blood gas analysis is collected from the brachial artery.

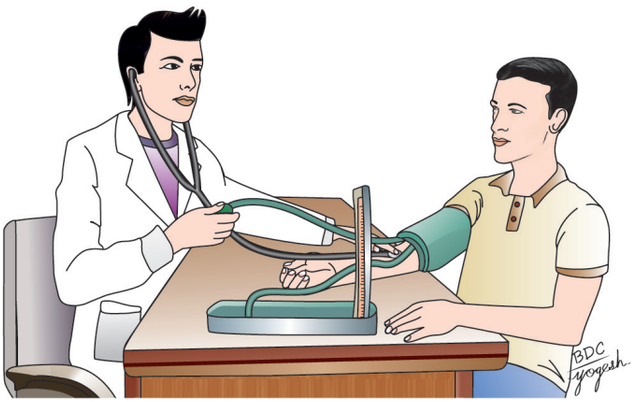


Fig. 8.9: Blood pressure being taken

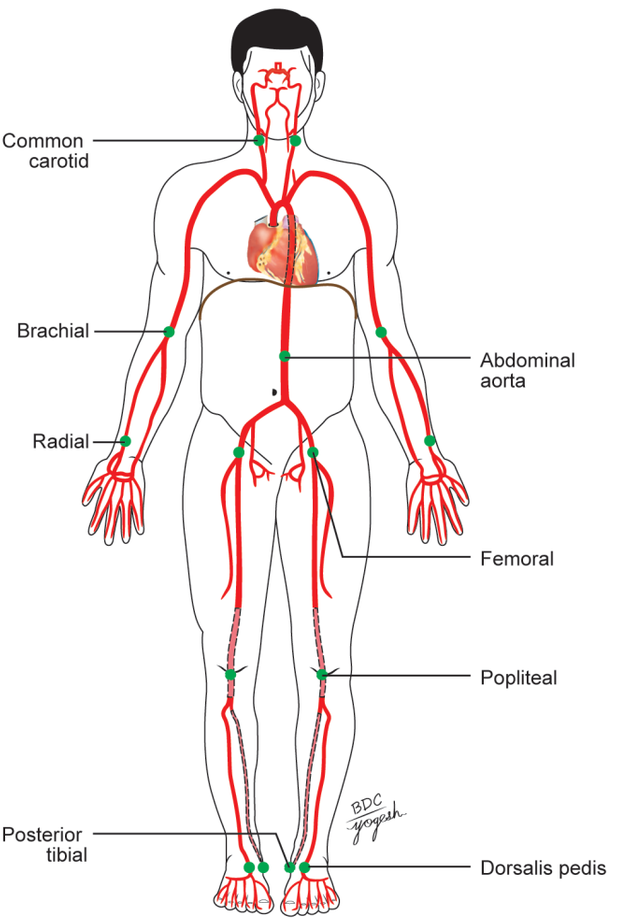


Fig. 8.10: Palpable arteries in the body

Competency:
AN11.6 Describe the anastomoses around the elbow joint.

ANASTOMOSES AROUND THE ELBOW JOINT

Anastomoses around the elbow joint link the brachial artery with the upper ends of the radial and ulnar arteries. They supply the ligaments and bones of the joint. The anastomoses can be subdivided into the following parts (Fig. 8.11):

A. *In front of the lateral epicondyle* of the humerus, the anterior descending (radial collateral) branch of the profunda brachii anastomoses with the radial recurrent branch of the radial artery (Figs 8.10a and b).
B. *Behind the lateral epicondyle* of the humerus, the posterior descending branch of the profunda brachii artery (middle collateral) anastomoses with the interosseous recurrent branch of the posterior interosseous artery.
C. *In front of the medial epicondyle* of the humerus, the inferior ulnar collateral branch of the brachial artery anastomoses with the anterior ulnar recurrent branch of the ulnar artery.
D. *Behind the medial epicondyle* of the humerus, the superior ulnar collateral branch of the brachial artery anastomoses with the posterior ulnar recurrent branch of the ulnar artery.

DISSECTION

Dissect the brachial artery as it lies on the medial side of the upper part of the arm medial to median nerve and lateral to ulnar nerve.

In the lower half of the upper arm, the brachial artery is seen lateral to the median nerve as the nerve crosses the brachial artery from lateral to medial side. Note that the median nerve and brachial artery are forming together a neurovascular bundle.

Ulnar nerve accompanied by the superior ulnar collateral branch of the brachial artery will be dissected later as it reaches the posterior (extensor) compartment of the upper arm after piercing the medial intermuscular septum.

Look for the radial nerve on the posterior aspect of artery before it enters the radial groove.

Clean the branches of brachial artery and identify other arteries which take part in the arterial anastomoses around the elbow joint.

Changes at the Level of Insertion of Coracobrachialis

1. *Bone*: The circular shaft of humerus becomes triangular below this level.
2. *Fascial septa*: The medial and lateral intermuscular septa become better defined from this level down (Fig. 8.7).
3. *Muscles*:
   a. Deltoid and coracobrachialis are inserted at this level (Fig. 8.3).

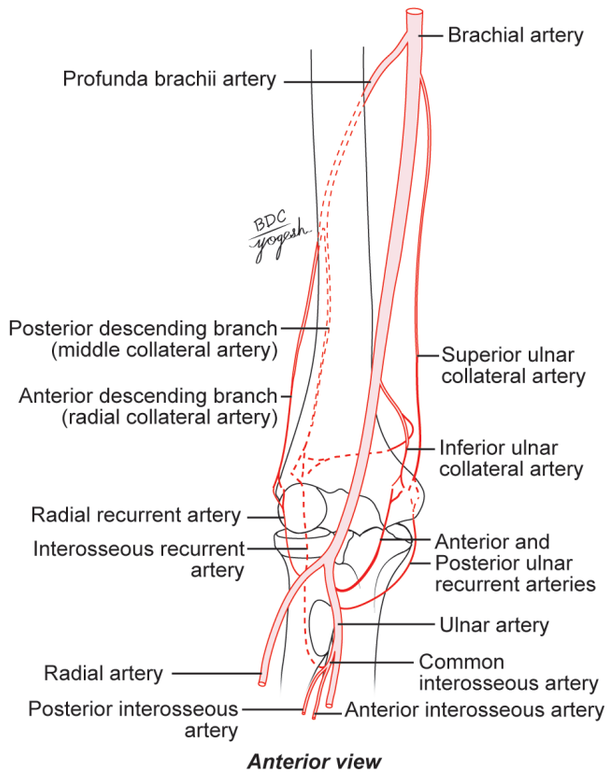
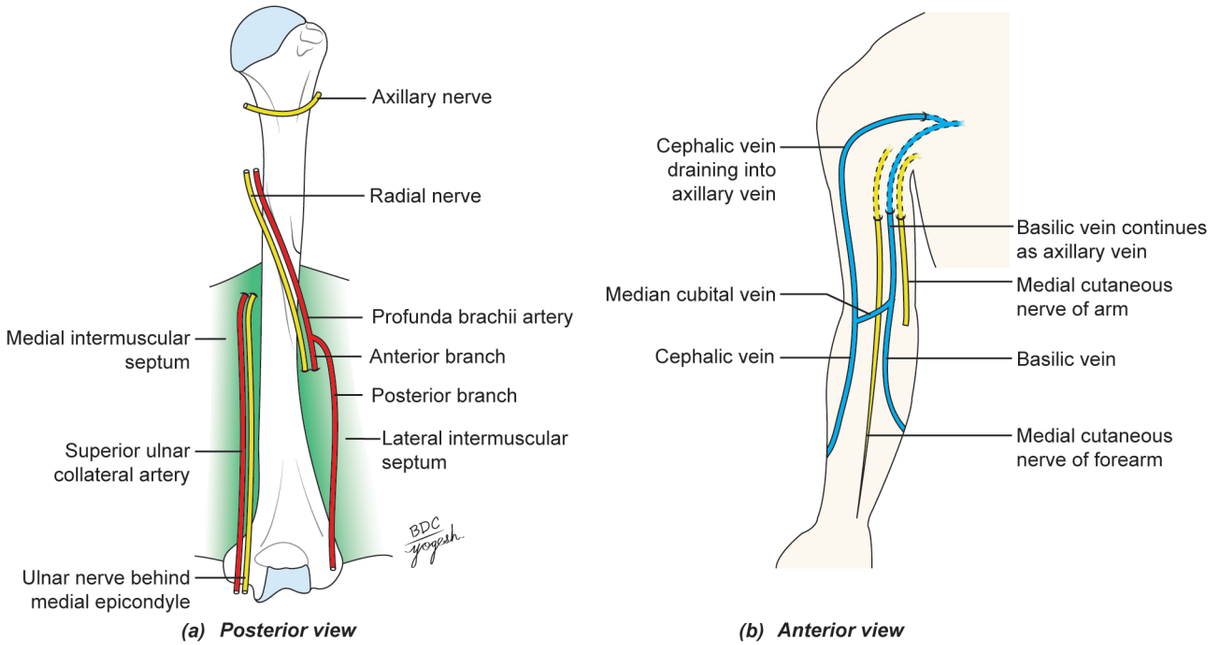


Fig. 8.11: Anastomosis around elbow

   b. Upper end of origin of brachialis.
   c. Upper end of origin of the medial head of triceps brachii.
4. *Arteries*:
   a. The brachial artery passes from the medial side of the arm to its anterior aspect.
   b. The profunda brachii artery runs in the spiral groove and divides into its anterior descending/radial collateral artery and posterior descending/middle collateral branches (Figs 8.7, 8.12a).
   c. The superior ulnar collateral artery originates from the brachial artery and pierces the medial intermuscular septum along with the ulnar nerve.
   d. The nutrient artery of the humerus enters the bone.
5. *Veins*:
   a. The basilic vein pierces the deep fascia (Fig. 8.12b).
   b. Two venae comitantes of the brachial artery may unite to form one brachial vein.
6. *Nerves*:
   a. The median nerve crosses the brachial artery from the lateral to the medial side (Fig. 8.7).
   b. The ulnar nerve pierces the medial intermuscular septum with the superior ulnar collateral artery and goes to the posterior compartment (Fig. 8.7).
   c. The radial nerve pierces the lateral intermuscular septum with the anterior descending (radial collateral) branch of the profunda brachii artery and passes from the posterior to the anterior compartment (Fig. 8.12a).



Figs 8.12a and b: Changes in positions of nerve, veins and arteries: (a) Back of arm and (b) front of arm and forearm

d. The medial cutaneous nerve of the arm pierces the deep fascia (Fig. 8.12b).
e. The medial cutaneous nerve of the forearm pierces the deep fascia (Fig. 8.12b).

Competency:
AN11.5 Identify and describe boundaries and contents of cubital fossa.

CUBITAL FOSSA

Features

Cubital (Latin *cubitus, elbow*) fossa is a triangular hollow situated on the front of the elbow. (It is homologous with the popliteal fossa of the lower limb situated on the back of the knee.) (Plate 8.5, Figs 8.13 to 8.17, Flowchart 8.4).

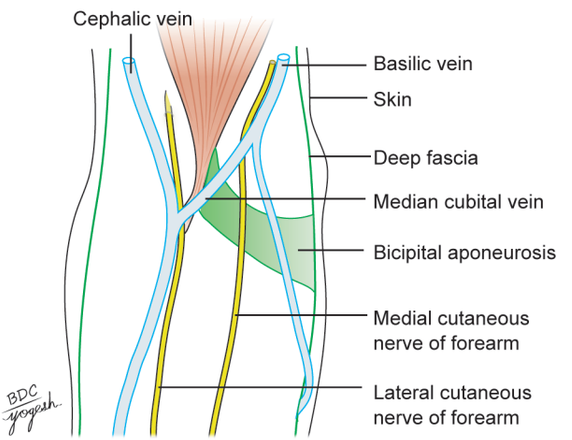


Fig. 8.14: Structures in the roof of the right cubital fossa

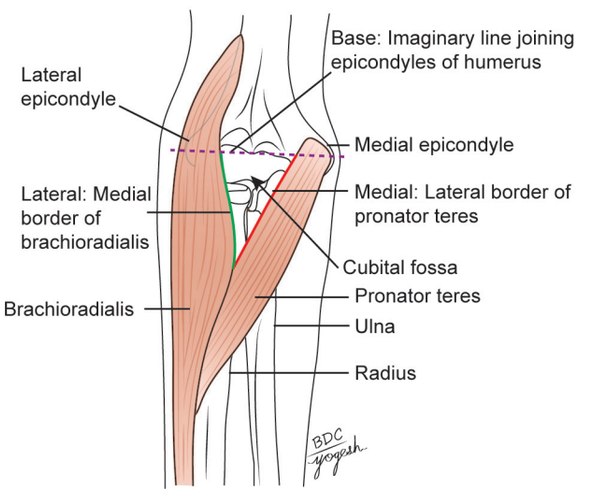
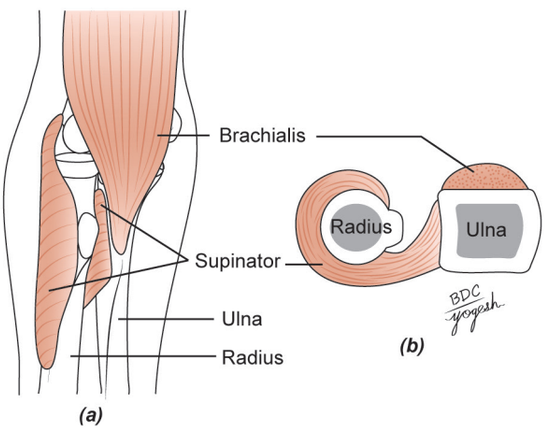


Fig. 8.13: Boundaries of the right cubital fossa



Figs 8.15a and b: The floor of the cubital fossa is formed by the brachialis and supinator muscles: (a) Surface view and (b) cross-sectional view

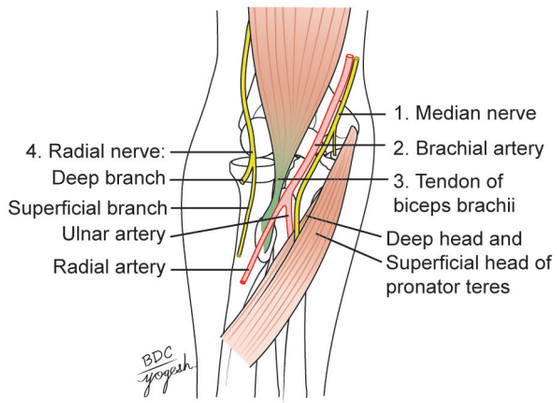
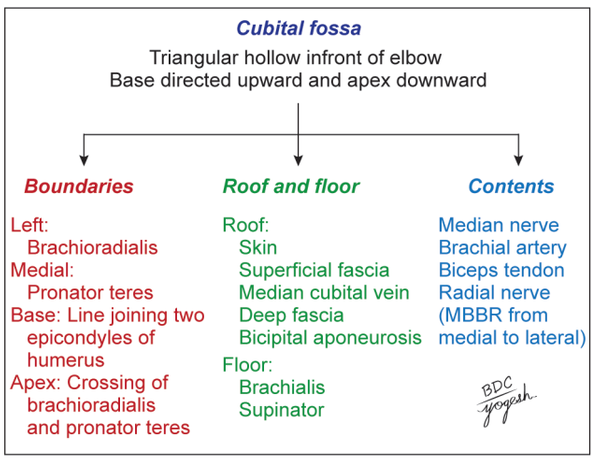


Fig. 8.16: Contents of right cubital fossa (schematic)

Flowchart 8.4: Cubital fossa



Boundaries

Laterally: Medial border of the brachioradialis (Plate 8.5, Fig. 8.13).

Medially: Lateral border of the pronator teres.

Base: It is directed upwards and is represented by an imaginary line joining the front of two epicondyles of the humerus.

Apex: It is directed downwards and is formed by the area where brachioradialis crosses the pronator teres muscle.

Roof

The roof of the cubital fossa (Plate 8.5, Fig. 8.14) is formed by:

a. Skin
b. Superficial fascia containing the median cubital vein joining the cephalic and basilic veins. The lateral cutaneous nerve of the forearm lies along with cephalic vein, and the medial cutaneous nerve of the forearm along with basilic vein.
c. Deep fascia
d. Bicipital aponeurosis.

Floor

It is formed by:

1. Brachialis (Plate 8.5, Figs 8.15a and b).
2. Supinator surrounding the upper part of radius.

Contents

The fossa is actually very narrow. The contents described are seen after retracting the boundaries. From medial to the lateral side, the contents are as follows:

1. ***Median nerve:*** It gives branches to flexor carpi radialis, palmaris longus and flexor digitorum superficialis and leaves the fossa by passing between the two heads of pronator teres (Fig. 8.17).
2. The termination of the ***brachial artery*** and the beginning of the ***radial*** and ***ulnar arteries*** lie in the fossa.

   The radial artery is smaller and more superficial than the ulnar artery. It gives off the *radial recurrent branch*. The *ulnar artery* goes deep to both heads of pronator teres and runs downwards and medially, being separated from the median nerve by the deep head of the pronator teres (Fig. 8.18).

   Ulnar artery gives off the *anterior ulnar recurrent*, the *posterior ulnar recurrent* and the *common interosseous* branches (Fig. 8.11).

   The common interosseous branch divides into the *anterior* and *posterior interosseous arteries*, and latter gives off the interosseous recurrent branch.
3. The tendon of the ***biceps brachii*** (Plate 8.5, Fig. 8.16).
4. ***Radial nerve:*** It descends down medial to lateral epicondyle to enter cubital fossa. In the fossa, it gives

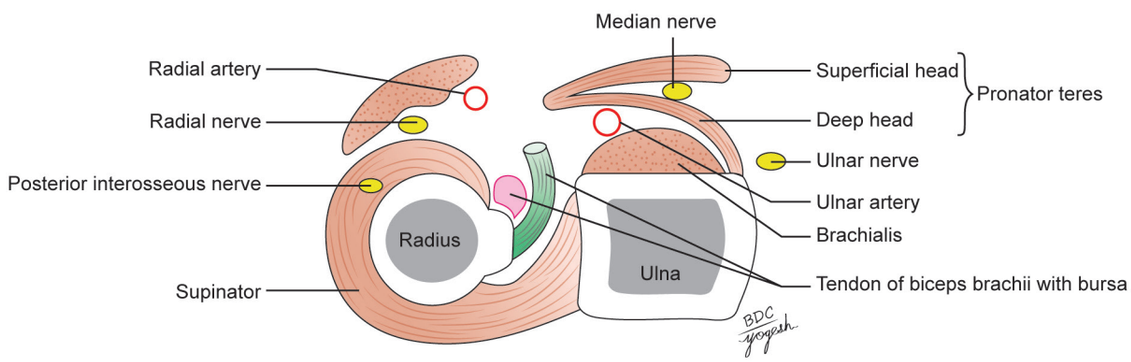
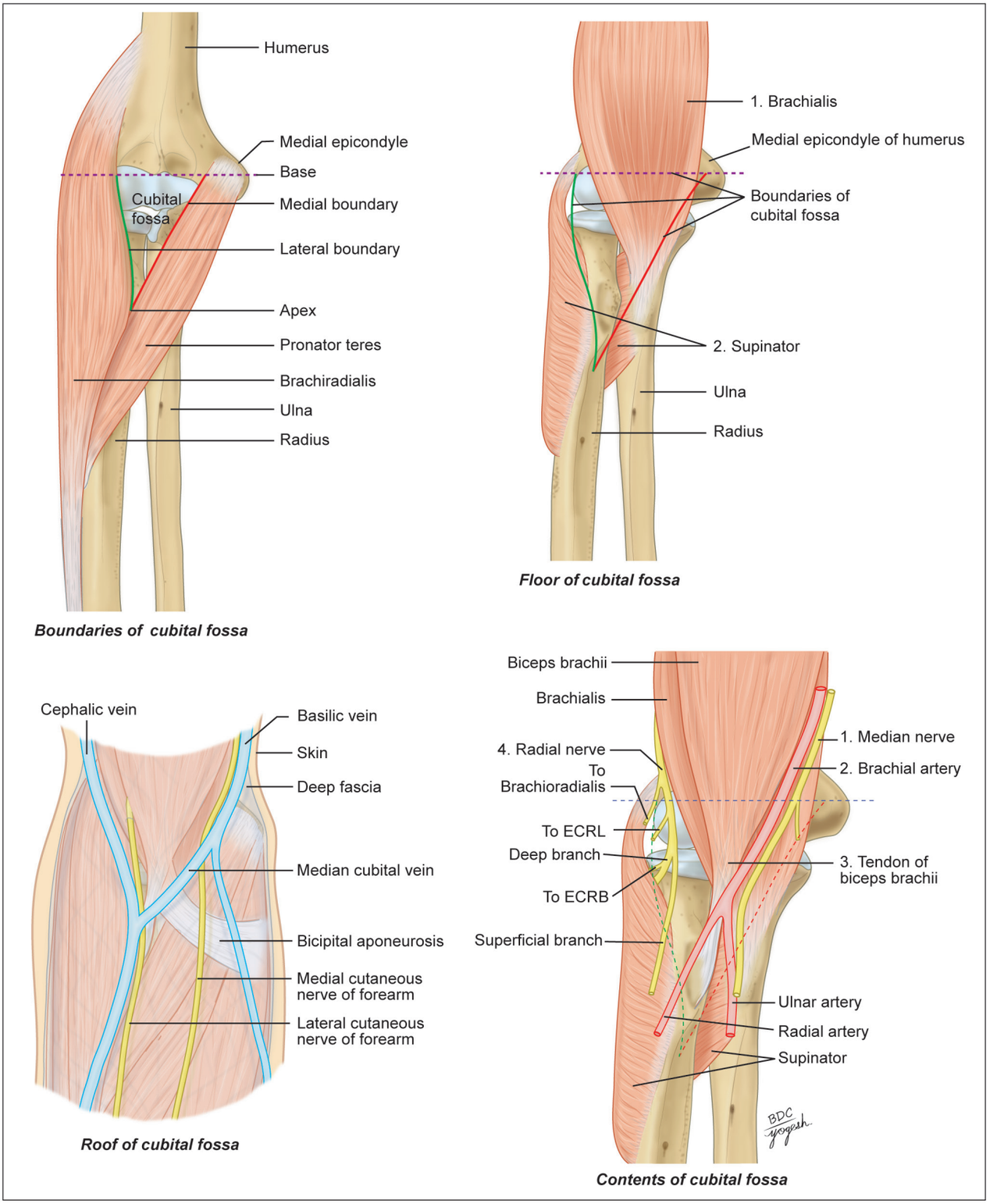


Fig. 8.17: Contents of the right cubital fossa seen in cross-section (anterior view)

Plate 8.5: Cubital fossa: Boundaries, floor, roof and contents



off the *posterior interosseous nerve* or deep branch of the radial nerve, which gives branches to extensor carpi radialis brevis and supinator. Then, it leaves the fossa by piercing the supinator muscle (Fig. 8.17).

The remaining *superficial branch* runs in the front of forearm for some distance.

[*Mnemonic*: **MBBR**: **M**edian nerve, **B**rachial artery, **B**iceps brachii tendon, **R**adial nerve]

CLINICAL ANATOMY

- The cubital region is important for the following reasons:
  a. ***Intravenous injections*:** The *median cubital vein* is often the vein of choice for intravenous injections. It is used for introducing cardiac catheters to get sample of blood from various chambers of heart.
  b. ***Blood pressure measurement:*** The blood pressure is universally recorded by auscultating the brachial artery in front of the elbow (Fig. 8.9).
- The anatomy of the cubital fossa is useful while dealing with fracture around the elbow, like the supracondylar fracture of the humerus.

DISSECTION

Identify the structures (*see* text) present in the roof of a shallow cubital fossa located on the front of the elbow. Separate the lateral and medial boundaries formed respectively by the brachioradialis and pronator teres muscles (Plate 8.5). Clean the contents:

1. Median nerve on the medial side of brachial artery.
2. Terminal part of brachial artery bifurcating into radial and ulnar arteries.
3. The tendon of biceps brachii muscle between the brachial artery and radial nerve.
4. The radial nerve on a deeper plane on the lateral side of biceps tendon.

Identify brachialis and supinator muscles, forming the floor of cubital fossa.

POSTERIOR COMPARTMENT

Features

The region contains the triceps muscle, the radial nerve and the profunda brachii artery. The nerve and artery run through the muscle. The ulnar nerve runs through the lower part of this compartment.

***Competency*:**
AN11.1 Describe and demonstrate muscle groups of upper arm with emphasis on biceps and triceps brachii.
Biceps has been described in Tables 8.1 and 8.2.

TRICEPS BRACHII MUSCLE

Origin

Triceps brachii muscle arises by the following three heads (Plate 8.6, Fig. 8.18):

1. ***Long head*:** It arises from the infraglenoid tubercle of the scapula; it is the longest of the three heads (Fig. 8.19).
2. ***Lateral head*:** It arises from an oblique ridge on the upper part of the posterior surface of the humerus, corresponding to the lateral lip of the radial (spiral) groove (Fig. 8.18).

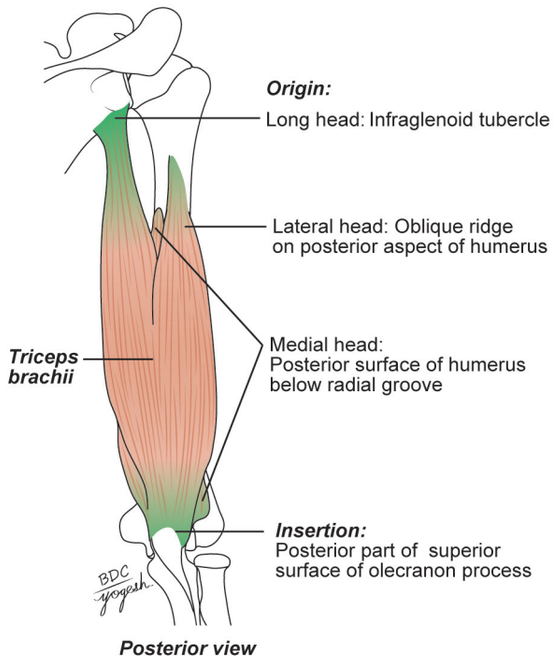


Fig. 8.18: The triceps brachii muscle

3. ***Medial head*:** It arises from a large triangular area on the posterior surface of the humerus below the radial groove, as well as from the medial and lateral intermuscular septa. At the level of the radial groove, the medial head is medial to the lateral head.

Insertion

The long and lateral heads converge and fuse to form a superficial flattened tendon, which covers the medial head and is inserted into the posterior part of the superior surface of the ***olecranon process*** (Plate 8.6, Fig. 8.18).

The medial head is inserted partly into the superficial tendon and partly into the olecranon process. Although the medial head is separated from the capsule of the elbow joint by a small bursa, a few of its fibres are inserted into this part of the capsule. This prevents nipping of the capsule during extension of the arm. These fibres are referred to as the ***articularis cubiti*** or as the ***subanconeus***.

Nerve Supply

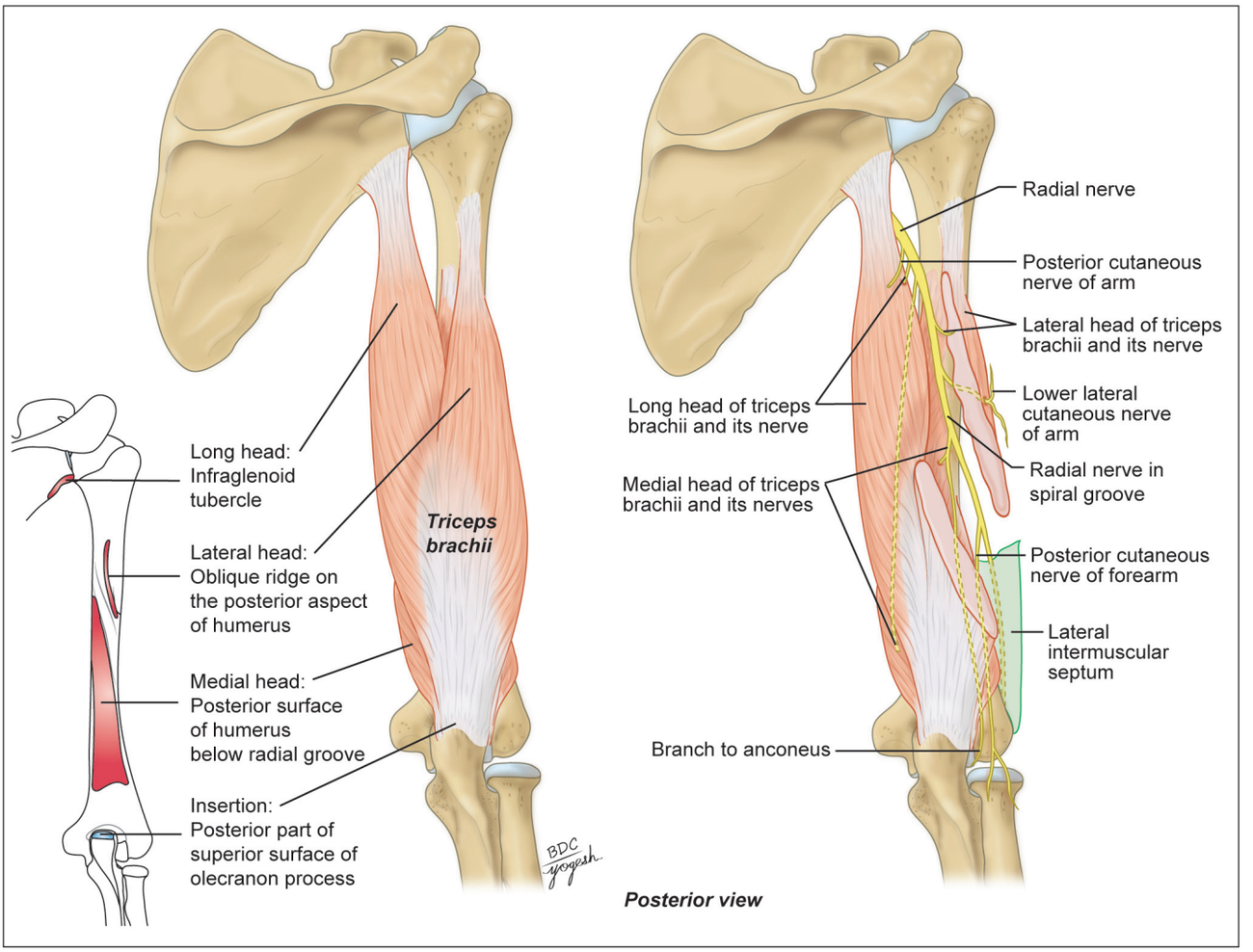
Each head receives a separate branch from the ***radial nerve*** (C7, C8). The branches arise in the axilla and in the radial groove.

Actions

The triceps is a powerful active ***extensor of the elbow***. The long head causes extension and adduction of arm at shoulder joint. It supports the head of the humerus in the abducted position of the arm. Gravity extends the elbow passively.

Electromyography has shown that the medial head of the triceps is active in all forms of extension, and the actions of the long and lateral heads are minimal, except when acting against resistance.

Plate 8.6: Triceps brachii muscle and radial nerve in the radial groove



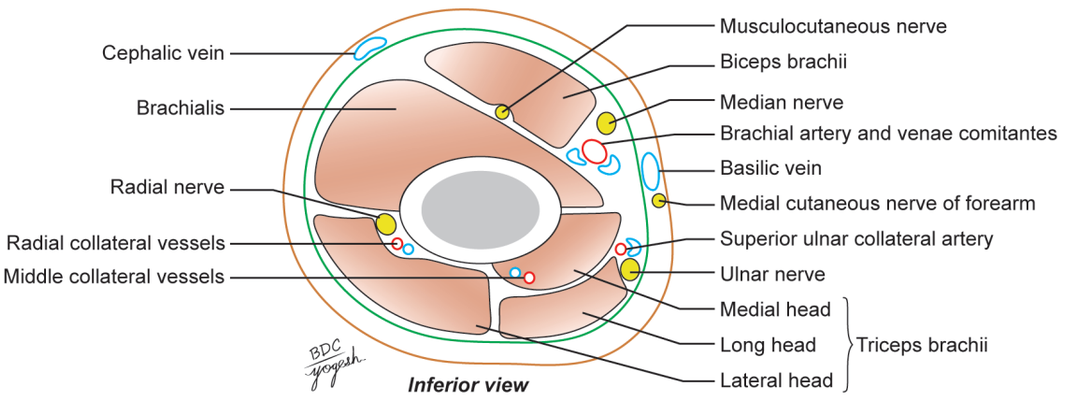


Fig. 8.19: Transverse section through the right arm a little below the insertion of the coracobrachialis and deltoid showing arrangement of three heads of the triceps and the radial nerve in the radial groove

CLINICAL ANATOMY

- In radial nerve injuries in the arm, the triceps brachii usually escapes complete paralysis because the two nerves supplying it, arising in the axilla.

- ***Clinical testing of triceps brachii*:** Physician holds the flexed forearm firmly. Patient is requested to extend his elbow against the resistance of the physician's hand. The contracting triceps brachii is felt (Fig. 8.20).

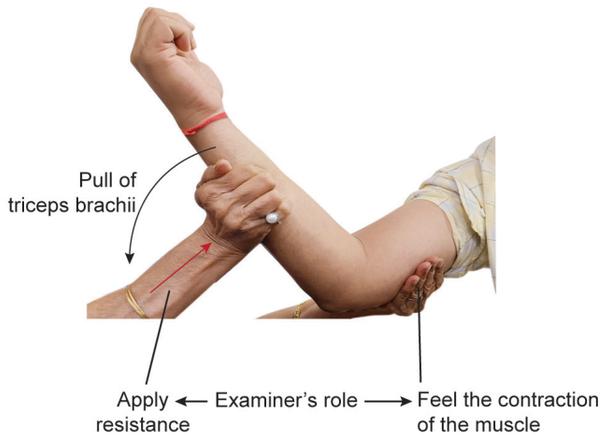
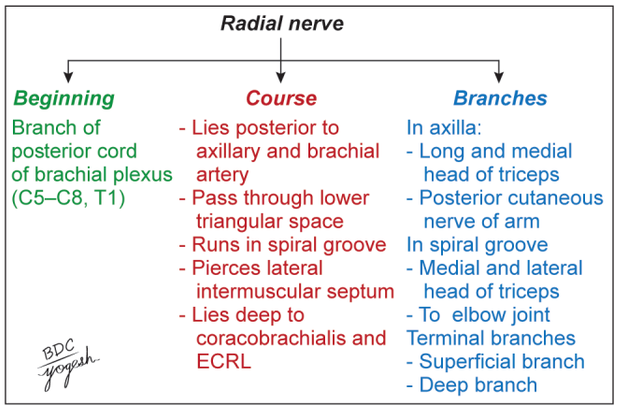


Fig. 8.20: Testing triceps brachii against resistance

Flowchart 8.5: Radial nerve



DISSECTION

Reflect the skin of back of arm to view the triceps brachii muscle. Define its attachments and separate the long head of the muscle from its lateral head.

Radial nerve will be seen passing between the long head of triceps and medial border of the humerus. Note the continuity of radial nerve up to axilla. Carefully cut through the lateral head of triceps to expose radial nerve along with profunda brachii vessels. Note that the radial nerve lies in the radial groove, on the back of humerus, passing between the lateral head of triceps above and its medial head below. In the lower part of arm, the radial nerve lies on the front of elbow just lateral to the brachialis, dividing into two terminal branches in the cubital fossa.

The ulnar nerve (which was seen in the anterior compartment of arm till its middle) pierces the medial intermuscular septum with its accompanying vessels, reaches the back of elbow and may easily be palpated on the back of medial epicondyle of humerus.

RADIAL NERVE OR MUSCULOSPIRAL NERVE

Radial nerve is the largest branch of the posterior cord of the brachial plexus with a root value of C5–C8 and T1 (Flowchart 8.5).

Origin, Course and Termination

1. Radial nerve is given off from the posterior cord in the lower part of axilla.
2. It runs behind third part of axillary artery.
3. In the arm, it lies behind the brachial artery (Fig. 8.7).
4. It enters the lower triangular space to reach the oblique radial sulcus on the back of humerus (Fig. 8.12a).
5. The nerve reaches the lateral side of arm 5 cm below deltoid tuberosity and pierces lateral intermuscular septum to enter the anterior compartment of arm on its lateral aspect (Fig. 8.12a).
6. It descends down the medial to the lateral epicondyle into cubital fossa.
7. Radial nerve terminates by dividing into a *superficial* and a *deep branch* (*posterior interosseous nerve*) just below the level of lateral epicondyle.

Relations

a. In the lower part of the axilla: Here, the radial nerve passes downwards and has the following relations:

Anteriorly: 3rd part of the axillary artery
Posteriorly: Subscapularis, latissimus dorsi and teres major
Laterally: Axillary nerve and coracobrachialis
Medially: Axillary vein.

b. **In the upper part of the arm:** The radial nerve continues behind the brachial artery and passes posterolaterally (with the profunda brachii vessels) through the lower triangular space, below the teres major and between the long head of the triceps brachii and the humerus. It then enters the radial groove with the profunda vessels.

c. **In the radial groove:** The nerve runs downwards and laterally between the lateral and medial heads of the triceps brachii, in contact with the humerus. At the lower end of the groove, 5 cm below the deltoid tuberosity, the nerve pierces the lateral intermuscular septum (Fig. 8.12a) and passes into the anterior compartment of the arm to reach the cubital fossa, where it ends by dividing into superficial and deep branches (Fig. 8.17).

Branches and Distribution

Various branches of radial nerve are shown in Fig. 8.21.

Muscular Branches

1. Before entering the spiral groove, radial nerve supplies the long and medial heads of the triceps brachii.
2. In the spiral groove, it supplies the lateral and medial heads of the triceps brachii and the anconeus.
3. Below the radial groove, on the front of the arm, it supplies the brachialis with proprioceptive fibres. The brachioradialis and extensor carpi radialis longus are supplied with motor fibres (Fig. 8.21).

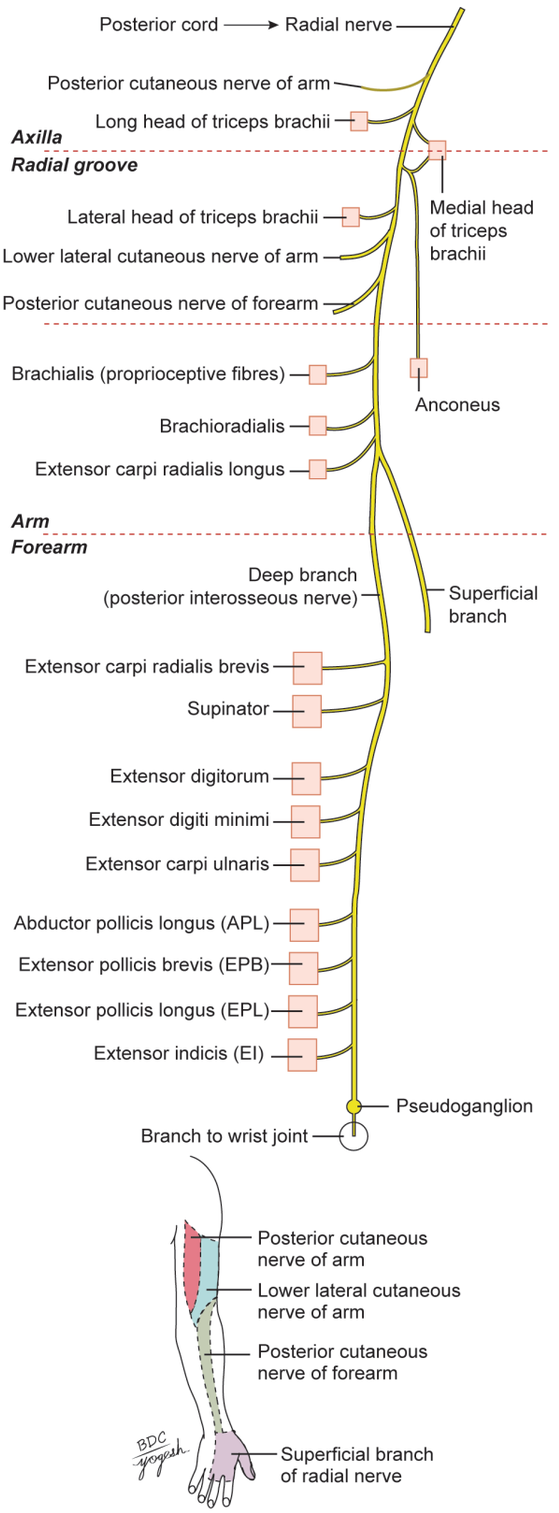


Fig. 8.21: Distribution of right radial nerve

Cutaneous Branches

1. In the axilla, radial nerve gives off the posterior cutaneous nerve of the arm, which supplies the skin on the back of the arm.
2. In the radial groove, the radial nerve gives off the lower lateral cutaneous nerves of the arm and the posterior cutaneous nerve of the forearm.

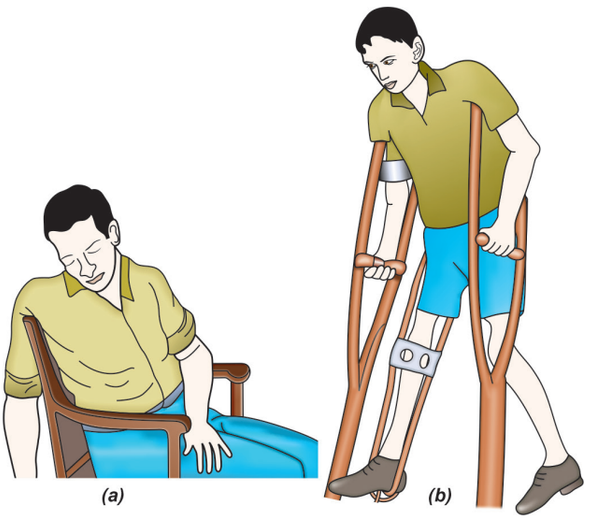
Articular Branches

The articular branches near the elbow supply the elbow joint.

Competencies:
AN11.4 Describe the anatomical basis of Saturday night paralysis.
AN12.13 Describe the anatomical basis of wrist drop.

CLINICAL ANATOMY

- ***Radial nerve injury:*** The radial nerve is very commonly damaged in the region of the radial (spiral) groove. The common causes of injury are as follows:
  a. Sleeping in an armchair with the limb hanging by the side of the chair (***Saturday night palsy***), or even the pressure of the crutch (***crutch paralysis***) (Figs 8.22a and b).
  b. Fractures of the shaft of the humerus. This results in the weakness and loss of power of extension at the wrist (wrist drop) (Fig. 8.23) and sensory loss over a narrow strip on the back of forearm, and on the lateral side of the dorsum of the hand (Fig. 8.24).
- *Wrist drop* is quite disabling because the patient cannot grip any object firmly in the hand without the synergistic action of the extensors.



Figs 8.22a and b: Injury to radial nerve: (a) Saturday night palsy and (b) crutch paralysis

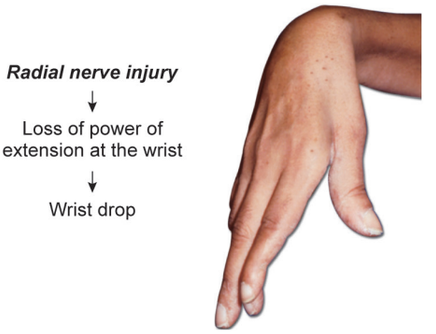


Fig. 8.23: Wrist drop

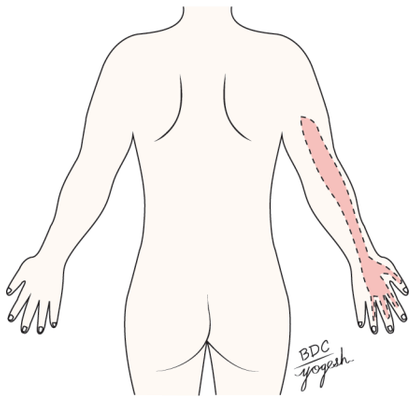


Fig. 8.24: Sensory loss over back of forearm and dorsum of hand

PROFUNDA BRACHII ARTERY

Profunda brachii artery is a large branch, arising just below the teres major. It accompanies the radial nerve through the radial groove, and before piercing the lateral intermuscular septum, it divides into the anterior and posterior descending branches, which take part in the anastomoses around the elbow joint (Fig. 8.8).

Branches

1. The ***anterior descending (radial collateral)*** artery is one of the terminal branches and represents the continuation of the profunda artery. It accompanies the radial nerve and ends by anastomosing with the radial recurrent artery in front of the lateral epicondyle of the humerus (Fig. 8.25).
2. The ***posterior descending (middle collateral)*** artery is the largest terminal branch, which descends in the substance of the medial head of the triceps. It ends by anastomosing with the interosseous recurrent artery behind the lateral epicondyle of the humerus (Fig. 8.25). It usually gives a branch which accompanies the nerve to the anconeus.

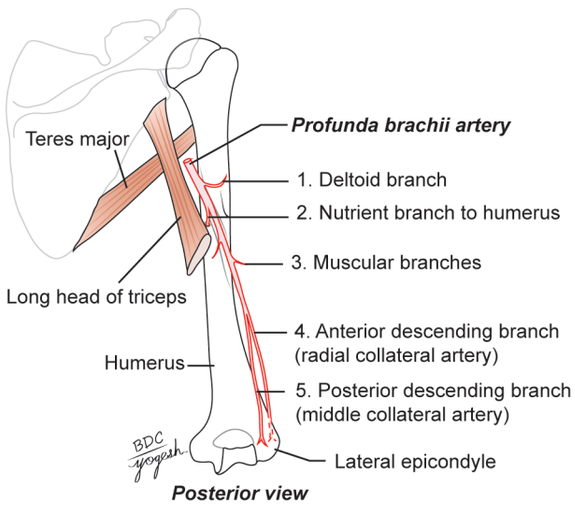


Fig. 8.25: Profunda brachii artery

3. The ***deltoid (ascending)*** branch ascends between the long and lateral heads of the triceps, and anastomoses with the descending branch of the posterior circumflex humeral artery.
4. The ***nutrient artery to the humerus*** is often present. It enters the bone in the radial groove just behind the deltoid tuberosity. However, it may be remembered that the main artery to the humerus is a branch of the brachial artery (Fig. 8.25).

VIDEO

Video 1.8 Arm Muscles of the arm, Brachial artery, Cubital fossa—boundaries and contents, Back of arm—triceps brachii, radial nerve.

Facts to Remember

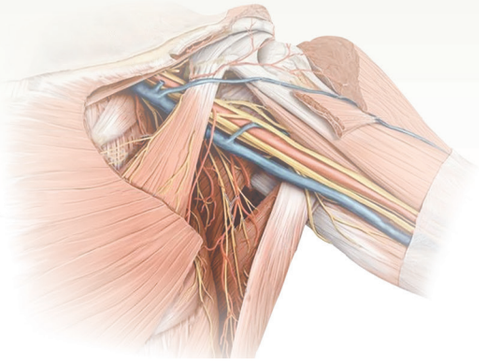
- The greater tubercle of humerus is the most lateral bony point of the shoulder.
- The coracobrachialis muscle is pierced by musculocutaneous nerve.
- Long head of biceps brachii muscle is intracapsular and extrasynovial at its origin.
- Biceps brachii is a strong supinator of the flexed elbow, besides being its flexor.
- The brachialis is the workhorse of the forearm flexion, whereas the medial head of the triceps is the workhorse of the forearm extension.
- Brachial pulse is commonly used for recording blood pressure.
- The median cubital vein is the most preferred vein for venepuncture.
- The ligament of Struthers is the fibrous band extending from the supracondylar spur to the medial epicondyle of the humerus.
- Medial root of median nerve crosses the axillary artery in front to join lateral root to form the median nerve.
- The order of structures from medial to lateral side in the cubital fossa (MBBR): median nerve, brachial artery, tendon of biceps brachii and radial nerve.
- Triceps brachii is the only active extensor of elbow joint. Gravity extends the joint passively.
- Radial groove gives passage to radial nerve and profunda brachii vessels.

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1. Bicipital aponeurosis
2. Biceps reflex
3. Recording of blood pressure
4. Musculocutaneous nerve palsy
5. Escape of triceps in radial nerve injuries
6. Further reading
7. Viva voce questions

Chapter

9



Forearm and Hand

The forearm extends between the elbow and the wrist joints. Radius and ulna form its skeleton. These two bones articulate at both ends to form superior and inferior radioulnar joints. Their shafts are kept at optimal distance by the interosseous membrane. Muscles accompanied by nerves and blood vessels are present both on the front and the back of the forearm.

Hand is the most distal part of the upper limb, meant for carrying out diverse activities. Numerous muscles, tendons, bursae, blood vessels and nerves are artistically placed and protected in this region.

SURFACE LANDMARKS OF FRONT OF FOREARM

1. ***Epicondyles of the humerus*:** The medial epicondyle is more prominent than the lateral (Fig. 9.1). The posterior surface of the medial epicondyle is crossed by the *ulnar nerve,* which can be rolled under the palpating finger. Pressure on the nerve produces tingling sensations on the medial side of the hand (*see* Fig. 8.12a).
2. ***Tendon of the biceps brachii:*** It can be felt in front of the elbow. It can be made prominent by flexing the elbow joint against resistance. Pulsations of the brachial artery can be felt just medial to the tendon (*see* Fig. 8.16).
3. ***Head of the radius:*** It can be palpated in a depression on the posterolateral aspect of the extended elbow, distal to the lateral epicondyle. Its rotation can be felt during pronation and supination of the forearm.
4. ***Styloid process of the radius:*** It projects 1 cm lower than the styloid process of the ulna (Fig. 9.1). It can be felt in the upper part of the anatomical snuffbox.
5. ***Head of the ulna:*** It forms a surface elevation on the medial part of the posterior surface of the wrist when the hand is pronated.
6. ***Styloid process of the ulna:*** It projects downwards from the posteromedial aspect of the lower end of the ulna. Its tip can be felt on the posteromedial aspect of the wrist, where it lies about 1 cm above the tip of the styloid process of the radius (Fig. 9.1).

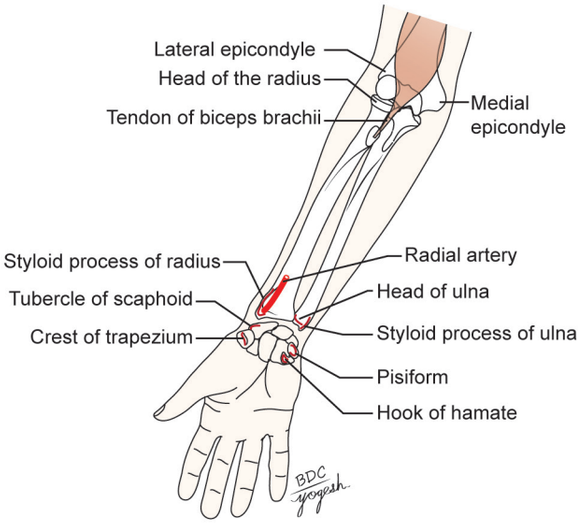


Fig. 9.1: Surface landmarks—front of forearm

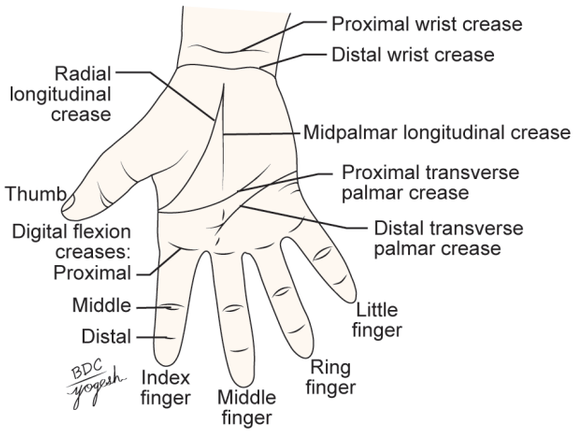


Fig. 9.2: Surface landmarks: Wrist and palm

7. ***Pisiform bone:*** It can be felt at the base of the hypothenar eminence (medially) where the tendon of the *flexor carpi ulnaris* terminates. It becomes visible and easily palpable at the medial end of the distal transverse crease (junction of forearm and hand) when the wrist is fully extended (Fig. 9.2).

8. ***Hook of the hamate:*** It lies one finger breadth below the pisiform bone, in line with the ulnar border of the ring finger. It can be felt only on deep palpation through the hypothenar muscles.
9. ***Tubercle of the scaphoid:*** It lies beneath the lateral part of the distal transverse crease in an extended wrist. It can be felt at the base of the thenar eminence in a depression just lateral to the tendon of the flexor carpi radialis (Fig. 9.1).
10. ***Tubercle (crest) of the trapezium:*** It may be felt on deep palpation inferolateral to the tubercle of the scaphoid.
11. The *brachioradialis* becomes prominent along the lateral border of the forearm when the elbow is flexed against resistance in the midprone position of the hand.
12. The *tendons of the flexor carpi radialis, palmaris longus* and *flexor carpi ulnaris* can be identified on the front of the wrist when the hand is flexed against resistance. The tendons lie in the order stated, from lateral to medial side (Fig. 9.3).
13. The pulsation of the *radial artery* can be felt in front of the lower end of the radius, just lateral to the tendon of the flexor carpi radialis.
14. The pulsations of the *ulnar artery* can be felt by careful palpation just lateral to the tendon of the flexor carpi ulnaris. Here, the ulnar nerve lies medial to the artery.
15. The *transverse creases* in front of the wrist are important landmarks. The proximal transverse crease lies at the level of the wrist joint, and distal crease corresponds to the proximal border of the flexor retinaculum.
16. The *median nerve* is very superficial in position at and above the wrist. It lies along the lateral edge of the tendon of the palmaris longus at the middle of the wrist.

Competency:
AN12.1 Describe and demonstrate important muscle groups of ventral forearm with attachments, nerve supply and actions.

MUSCLES OF FRONT OF FOREARM

The muscles of the front of the forearm may be divided into superficial and deep groups.

Components

The front of the forearm presents the following components for study.

1. Eight muscles: Five superficial and three deep.
2. Two arteries: Radial and ulnar.
3. Three nerves: Median, ulnar and radial.

These structures can be better understood by reviewing the long bones of the upper limb and having an articulated hand by the side.

SUPERFICIAL MUSCLES

There are five muscles in the superficial group (Plates 9.1 to 9.3, Figs 9.3 and 9.4):

1. Pronator teres
2. Flexor carpi radialis
3. Palmaris longus
4. Flexor carpi ulnaris
5. Flexor digitorum superficialis (Tables 9.1 and 9.2).

[*Mnemonic*: ***"Pretti Found Pamela for Fight":*** **P**ronator teres, **F**lexor carpi radialis, **P**almaris longus, **F**lexor carpi ulnaris, **F**lexor digitorum superficialis]

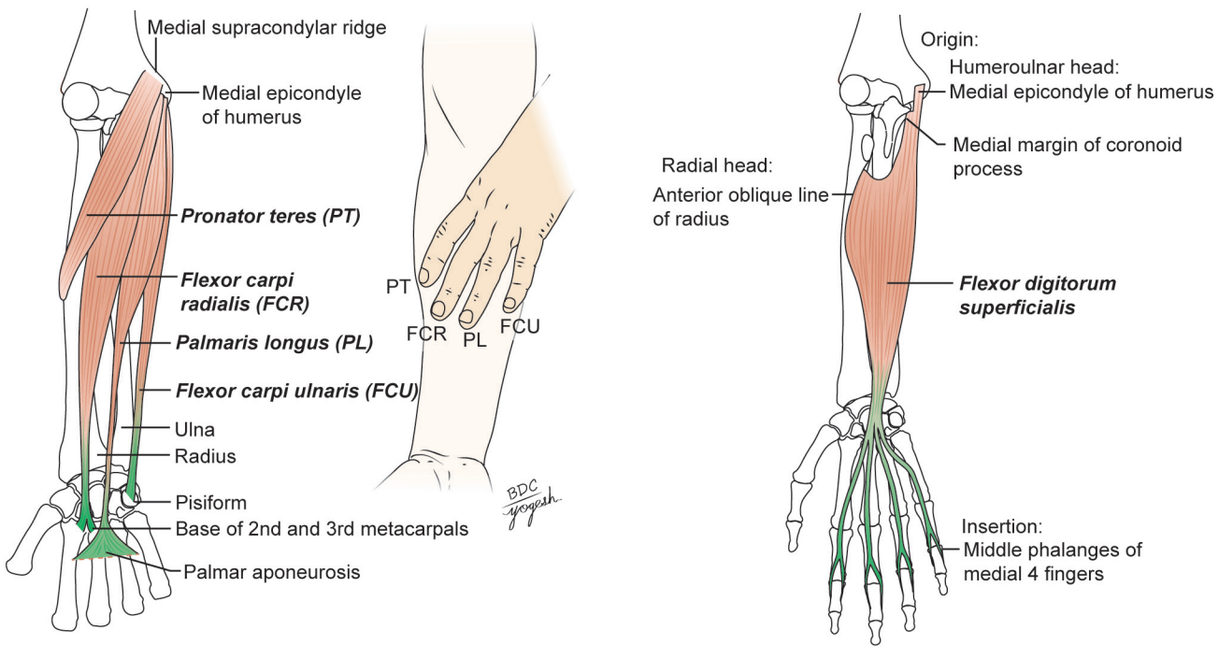


Fig. 9.3: The superficial muscles of the front of the right forearm

Plate 9.1: Pronator teres

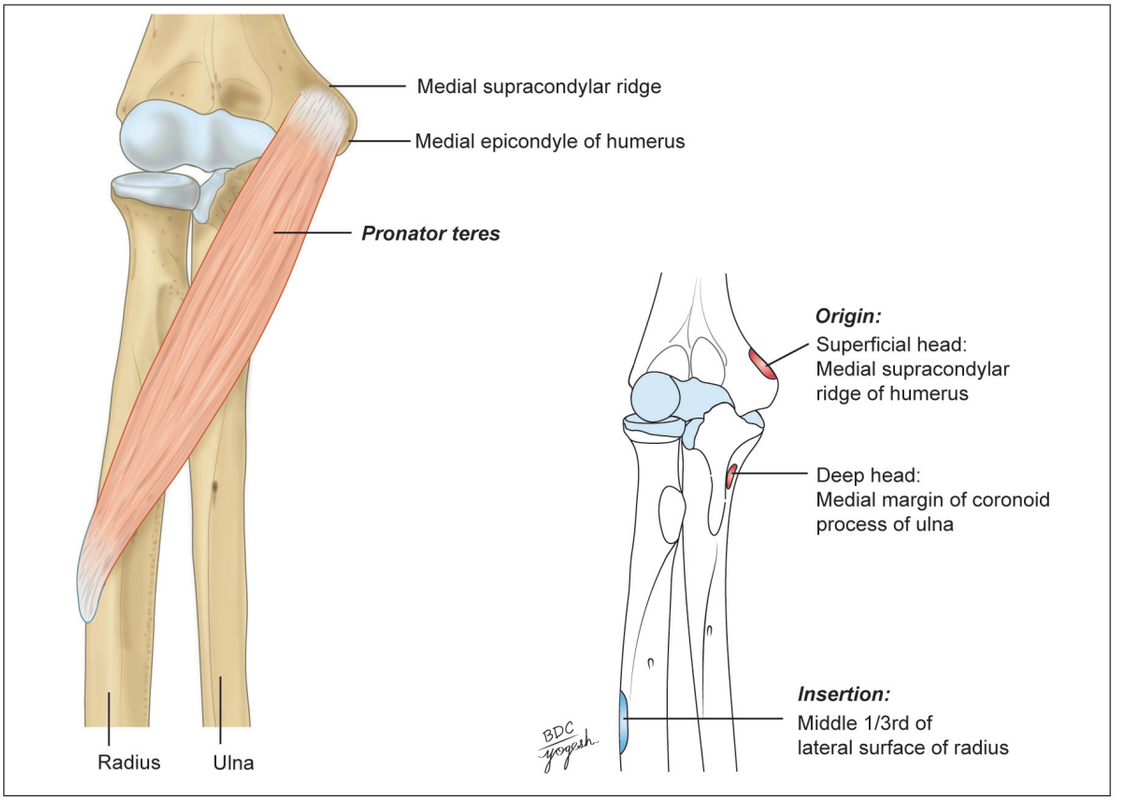


Plate 9.2: Flexor carpi radialis, palmaris longus and flexor carpi ulnaris

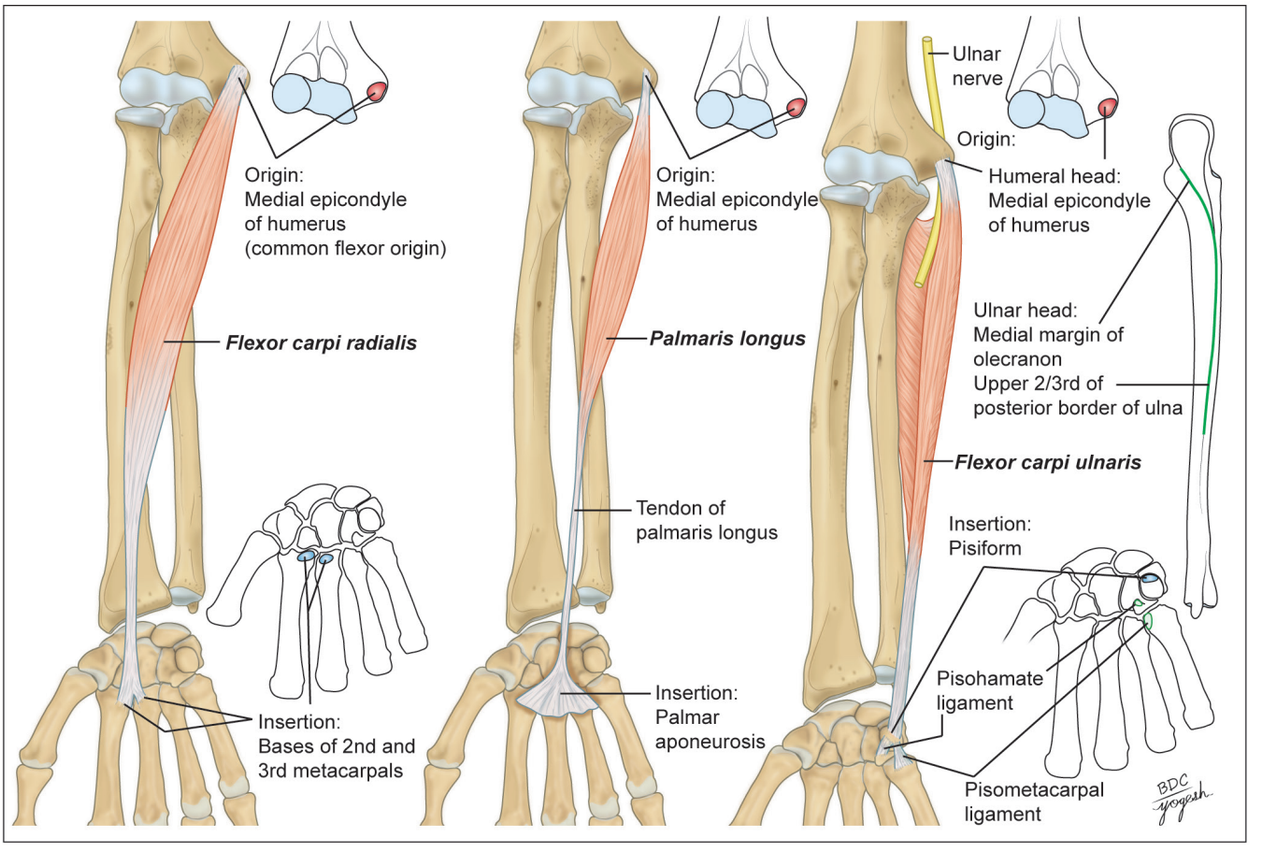
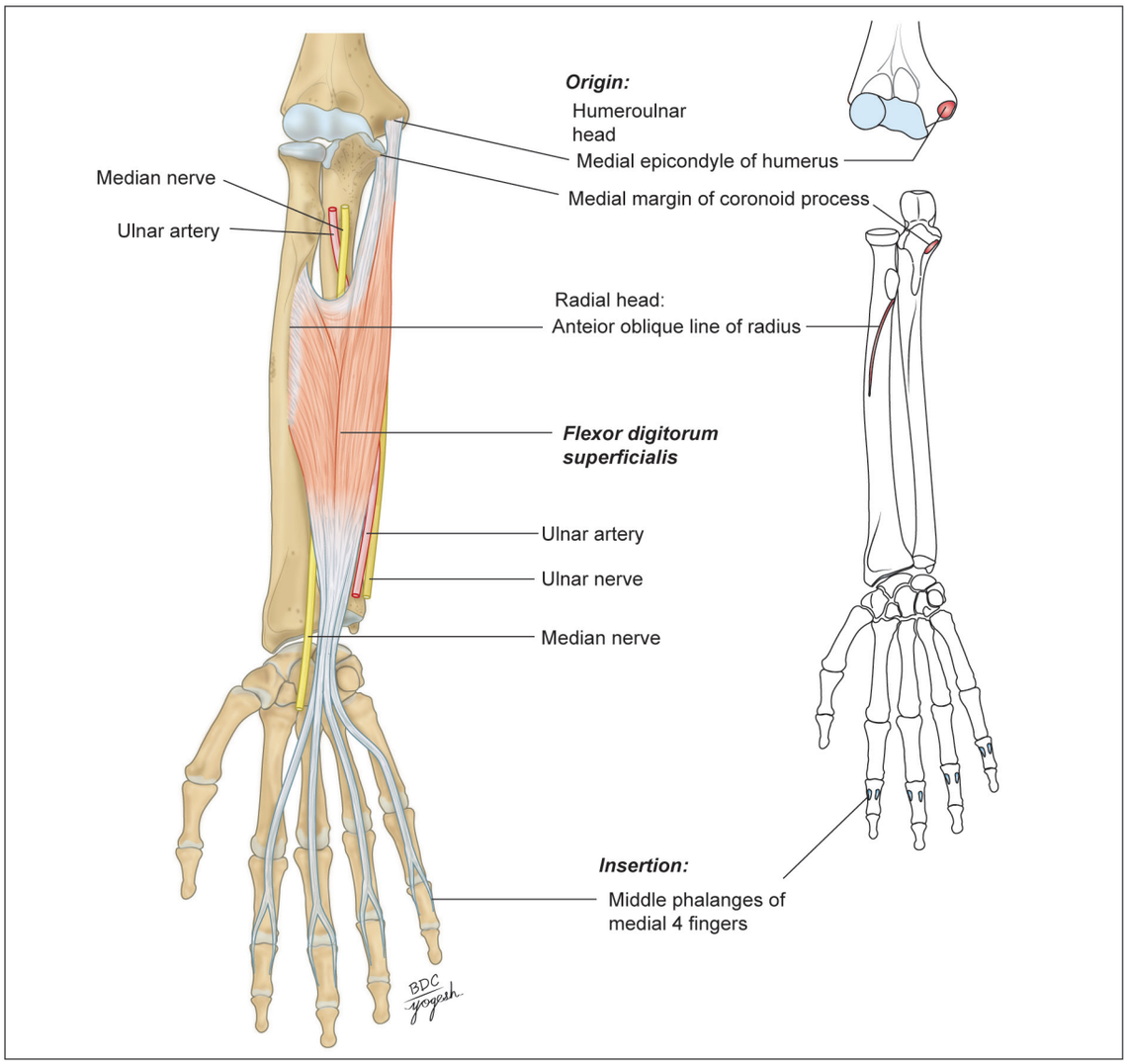


Plate 9.3: Flexor digitorum superficialis



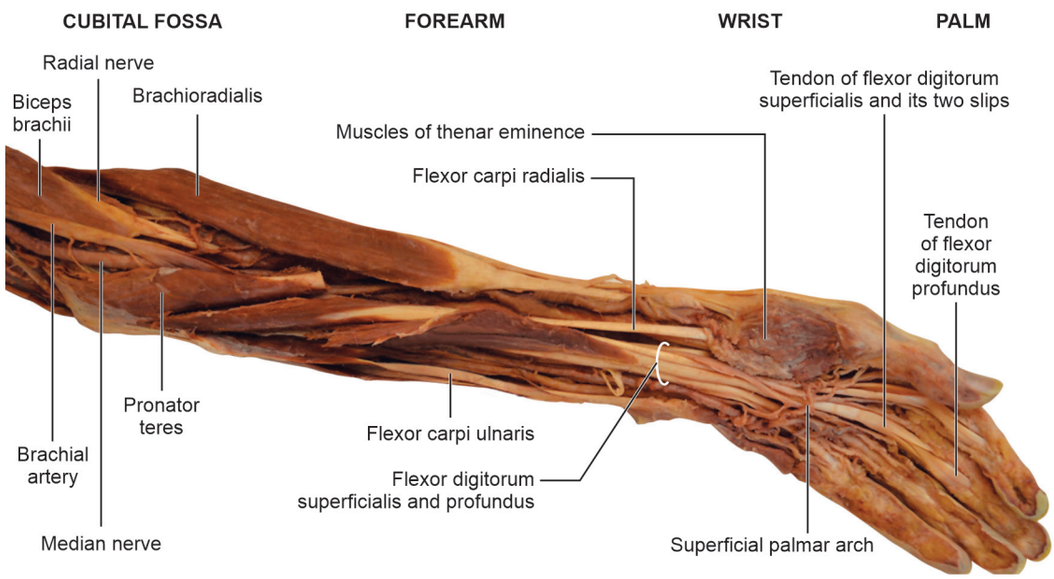


Fig. 9.4: Dissection of cubital fossa, front of the left forearm and palm

TABLE 9.1: Origin and insertion of the superficial muscles

Muscle	*Origin*	*Insertion*
1. **Pronator teres** (Fig.9.3)	Superficial head: Medial epicondyle of humerus Deep head: Medial margin of coronoid process of ulna	Middle of lateral aspect of shaft of radius
2. **Flexor carpi radialis**	Medial epicondyle of humerus	Bases of 2nd and 3rd metacarpal bones
3. **Palmaris longus**	Medial epicondyle of humerus	Flexor retinaculum and palmar aponeurosis
4. **Flexor digitorum superficialis** (Plate 9.3)		
• Humeroulnar head	Medial epicondyle of humerus; medial border of coronoid process of ulna	Muscle divides into 4 tendons. Each tendon divides into 2 slips, which are inserted on sides of **middle phalanx** of 2nd to 5th digits
• Radial head	Anterior oblique line of shaft of radius	
5. **Flexor carpi ulnaris**		
• Humeral head	Medial epicondyle of humerus	**Pisiform** bone; insertion prolonged to hook of the hamate and base of 5th metacarpal bone (Plate 9.2)
• Ulnar head	Medial aspect of olecranon process and posterior border of ulna	

TABLE 9.2: Nerve supply and actions of the superficial muscles

Muscle	*Nerve supply*	*Actions*
1. **Pronator teres**	Median nerve	Pronation of forearm
2. **Flexor carpi radialis**	Median nerve	Flexes and abducts hand at wrist joint
3. **Palmaris longus**	Median nerve	Flexes wrist joint
4. **Flexor digitorum superficialis**	Median nerve	Flexes middle phalanx of fingers and assists in flexing proximal phalanx and wrist joint
5. **Flexor carpi ulnaris**	Ulnar nerve	Flexes and adducts the hand at the wrist joint

Common Flexor Origin

All the superficial flexors of the forearm have a common origin from the front of the *medial epicondyle* of the humerus. This is called the common flexor origin (Plate 9.2).

Additional Features of Superficial Muscles

1. *Pronator teres:* Pronator teres comprise a big humeral and a smaller ulnar head. Between the two heads, the median nerve leaves the cubital fossa. Deep to the two heads exits ulnar artery from cubital fossa into the front of forearm. It forms medial boundary of the cubital fossa (Figs 9.3 and 9.4).
2. *Flexor carpi radialis:* It passes through a separate deep compartment of the flexor retinaculum. It is easily seen and is a guide to radial pulse, which lies lateral to the tendon (Fig. 9.4).
3. *Palmaris longus:* Palmaris longus (vestigial muscle) continues as palmar aponeurosis into the palm to protect the nerves and vessels there. Its tendon lies superficial to flexor retinaculum. It is known as "Fresher's nerve" as it looks like a nerve and may be cut by the fresher students.
4. *Flexor carpi ulnaris:* It is inserted into pisiform bone. Pisiform is a sesamoid bone in this tendon.
5. *Flexor digitorum superficialis:* Flexor digitorum superficialis comprises the humeroulnar and radial heads. The two heads of the muscle are joined by a fibrous arch. Median nerve and ulnar artery pass downwards deep to the fibrous arch (Plate 9.3). The part of muscle for middle ring and little fingers receive nerve supply from the median nerve in cubital fossa. Only the part for index finger receives nerve supply in middle of forearm.

DEEP MUSCLES

Deep muscles of the front of the forearm are (Tables 9.3 and 9.4, Plate 9.4, Fig. 9.5):

1. Flexor digitorum profundus
2. Flexor pollicis longus
3. Pronator quadratus.

Additional Points about the Flexor Digitorum Profundus

1. It is the most powerful and most bulky muscle of the forearm. It forms the muscular elevation seen and felt on the posterior surface of the forearm medial to the subcutaneous posterior border of the ulna (Fig. 9.5).
2. The main gripping power of the hand is provided by the flexor digitorum profundus.
3. The muscle is supplied by two different nerves. So, it is a ***hybrid muscle***.

Additional Points about the Flexor Pollicis Longus

1. The anterior interosseous nerve and vessels descend on the anterior surface of the interosseous membrane between the flexor digitorum profundus and the flexor pollicis longus.

TABLE 9.3: Origin and insertion of the deep muscles (Plate 9.4, Fig. 9.5)

Muscle	*Origin*	*Insertion*
1. **Flexor digitorum profundus** (composite or hybrid muscle)	• Upper 3/4th of the anterior and medial surface of the shaft of ulna • Upper 3/4th of the posterior border of ulna • Medial surface of the olecranon and coronoid processes of ulna • Adjoining part of the anterior surface of the interosseous membrane	• The muscle forms 4 tendons for the medial 4 digits, which enter the palm by passing deep to the flexor retinaculum in ulnar bursa and digital synovial sheaths • Opposite the proximal phalanx of the corresponding digit, the tendon perforates the tendon of the flexor digitorum superficialis (Plate 9.5) • Each tendon is inserted on the palmar surface of the base of the **distal phalanx** (Fig. 9.5)
2. **Flexor pollicis longus**	• Upper 3/4th of the anterior surface of the shaft of radius (Fig. 9.5) • Adjoining part of the anterior surface of the interosseous membrane	• The tendon enters the palm by passing deep to the flexor retinaculum • It is inserted into the palmar surface of the **distal phalanx** of the thumb
3. **Pronator quadratus**	Oblique ridge on the lower 1/4th of anterior surface of the shaft of ulna, and the area medial to it (Fig. 9.5)	• Superficial fibres into the lower 1/4th of the anterior surface and the anterior border of the radius • Deep fibres into the triangular area above the ulnar notch (*see* Fig. 2.18) of radius

TABLE 9.4: Nerve supply and actions of the deep muscles

Muscle	*Nerve supply*	*Actions*
1. **Flexor digitorum profundus**	• Medial half by ulnar nerve • Lateral half by anterior interosseous nerve (branch of median nerve)	• Flexor of distal phalanges after the flexor digitorum superficialis has flexed the middle phalanges • Secondarily, it flexes the other joints of the fingers and the wrist • It is the chief **gripping muscle**. It acts best when the wrist is extended
2. **Flexor pollicis longus**	Anterior interosseous nerve	• Flexes the distal phalanx of the thumb. Continued action may also flex the proximal joints crossed by the tendon
3. **Pronator quadratus**	Anterior interosseous nerve	• Superficial fibres pronate the forearm • Deep fibres bind the lower ends of radius and ulna

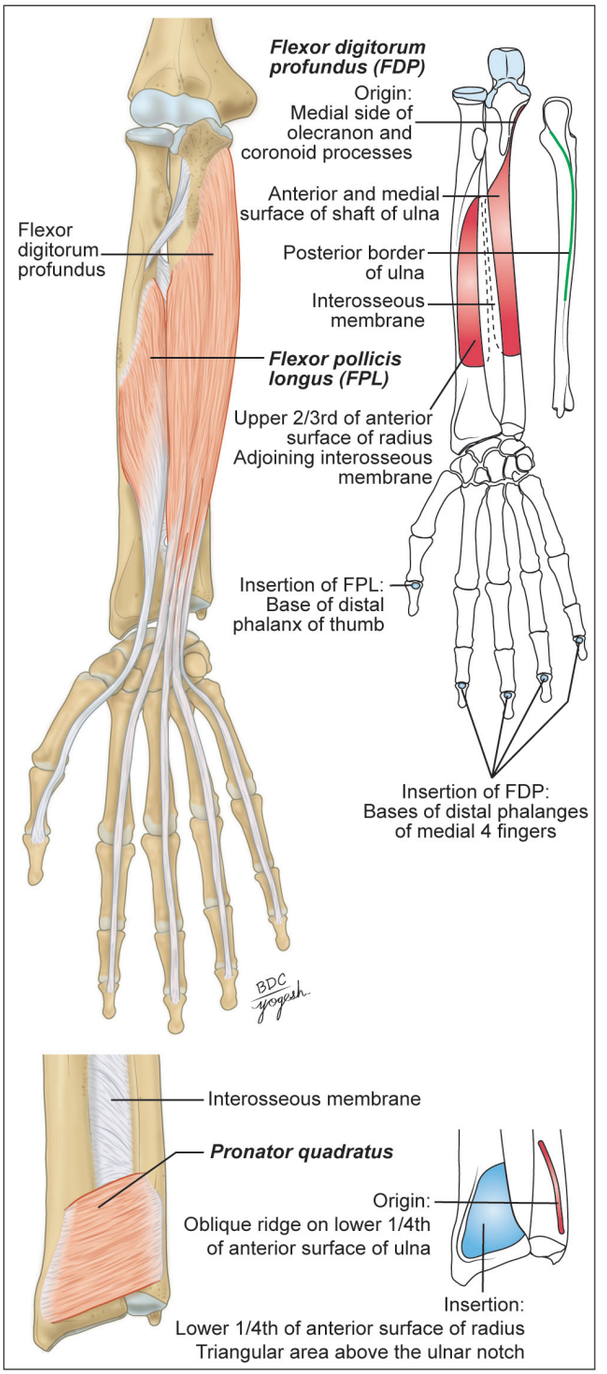
2. The tendon passes deep to the flexor retinaculum between the opponens pollicis and the oblique head of the adductor pollicis to enter the fibrous flexor sheath of the thumb. It lies in radial bursa (Fig. 9.6).

***Competency*:**
AN12.9 Identify and describe fibrous flexor sheaths, ulnar bursa, radial bursa and digital synovial sheaths.

Synovial Sheaths of Flexor Tendons

1. ***Ulnar bursa (Common flexor synovial sheath)*:** The long flexor tendons of the fingers (flexor digitorum superficialis and profundus) are enclosed in a common synovial sheath while passing deep to the flexor retinaculum (carpal tunnel). The sheath has a parietal layer lining the walls of the carpal tunnel and a visceral layer closely applied to the tendons (Plate 9.5, Fig. 9.6). From the arrangement of the sheath, it appears that the synovial sac has been invaginated by the tendons from its lateral side. The synovial sheath extends upwards for 5.0 or 7.5 cm into the forearm and downwards into the palm up to the middle of the shafts of the metacarpal bones. It is important to note that the lower medial end is continuous with the digital synovial sheath of the little finger.
2. ***Radial bursa (Synovial sheath of the tendon of flexor pollicis longus)*:** This sheath is separate. Superiorly, it is coextensive with the common sheath, and inferiorly it extends up to the distal phalanx of the thumb (Fig. 9.6).
3. ***Digital synovial sheaths*:** The sheaths enclose the flexor tendons in the fingers and line the fibrous flexor sheaths. The digital sheath of the little finger is continuous with the ulnar bursa and that of the thumb with the radial bursa. However, the digital sheaths of the index, middle and ring fingers are separate and independent (Fig. 9.7).

Plate 9.4: Deep muscles of front of forearm



Vincula Longa and Brevia

The vincula longa and brevia are synovial folds, which connect the tendons to the phalanges. They transmit vessels to the tendons (Plate 9.6). These are the remnants of mesotendon.

DISSECTION

The skin of the forearm has already been reflected on each side. Cut through the superficial and deep fasciae to expose the superficial muscles of the forearm.

Plate 9.5: Synovial sheaths of the flexor tendons of hand

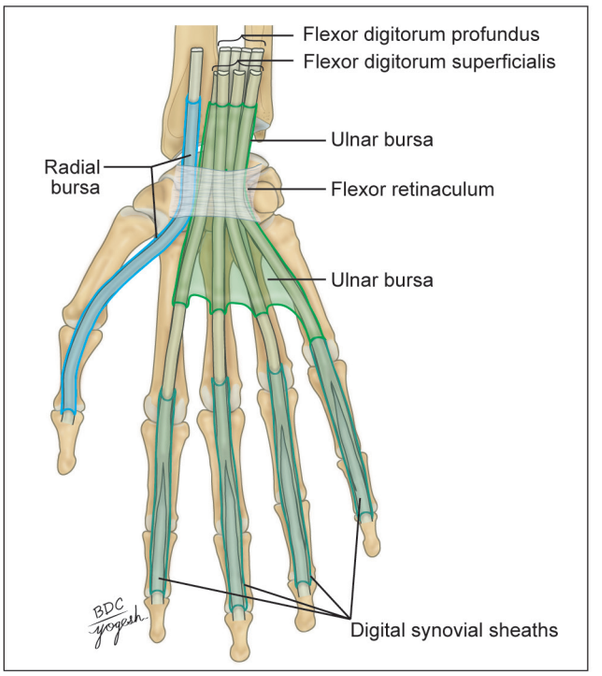
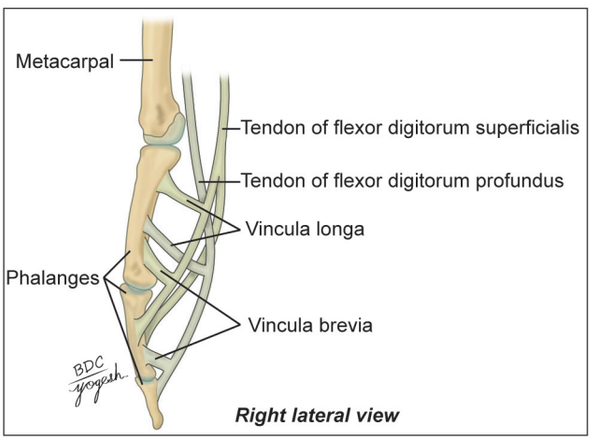


Plate 9.6: Vincula longa and brevia of the middle finger



Superficial muscles

Identify these five superficial muscles. These are from lateral to medial side, pronator teres getting inserted into middle of radius, flexor carpi radialis reaching till the wrist, palmaris longus continuing with palmar aponeurosis, flexor digitorum superficialis passing through the palm and most medially the flexor carpi ulnaris getting inserted into the pisiform bone (Fig. 9.3).

Deep muscles

Cut through the origin of superficial muscles of forearm at the level of medial epicondyle of humerus and reflect them distally. This will expose the three deep muscles, e.g. flexor pollicis longus, flexor digitorum profundus and pronator quadratus.

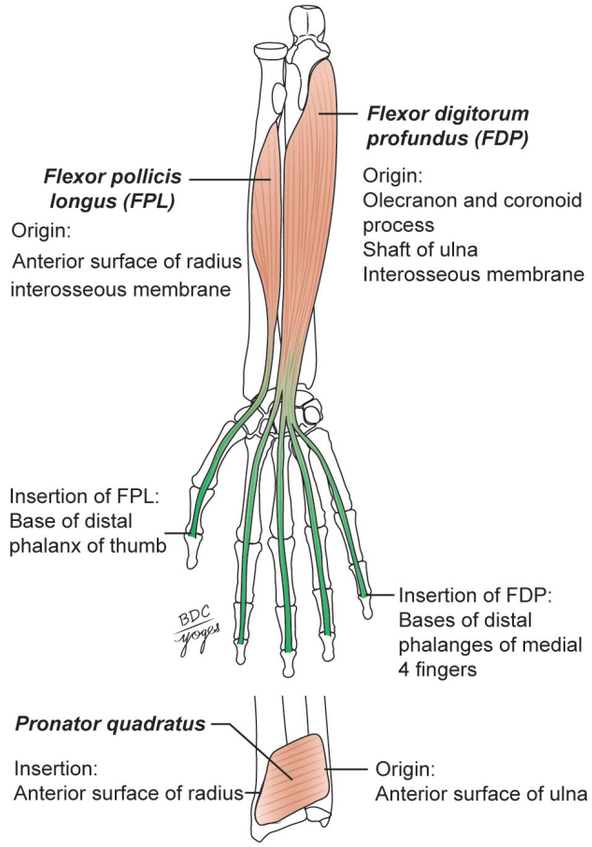


Fig. 9.5: Deep muscles of front of forearm

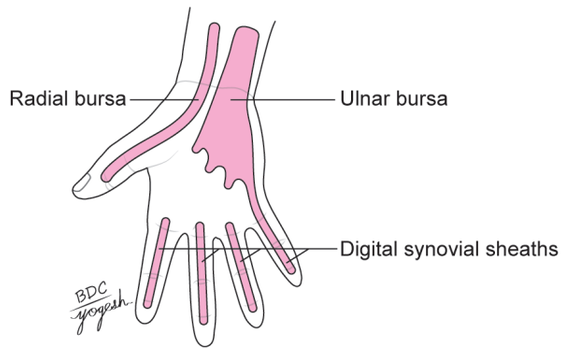


Fig. 9.6: The synovial sheaths of the flexor tendons, i.e. ulnar bursa, radial bursa and digital synovial sheaths

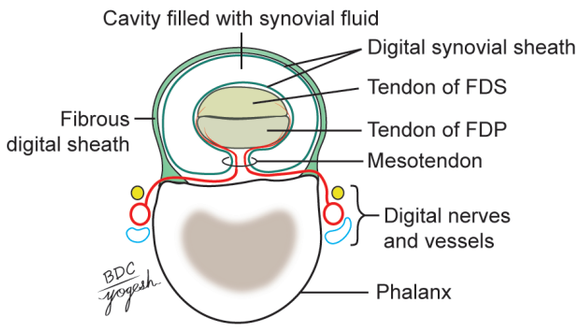


Fig. 9.7: Digital synovial sheath and mesotendon (cross-section of the digit)

***Competency*:**
AN12.2 Identify and describe origin, course, relations, branches (or tributaries), termination of important nerves and vessels of forearm.

ARTERIES OF FRONT OF FOREARM

Features

The most conspicuous arteries of the forearm are the radial and ulnar arteries (Plate 9.7). However, they mainly supply the hand through the deep and superficial palmar arches. The arterial supply of the forearm is chiefly derived from the common interosseous branch of the ulnar artery, which divides into anterior and posterior interosseous arteries. The posterior interosseous artery is reinforced in the upper part and replaced in the lower part by the anterior interosseous artery.

RADIAL ARTERY

Beginning, Course and Termination

Radial artery (Fig. 9.8) is the smaller terminal branch of the brachial artery in the cubital fossa. It runs downwards to the wrist with a lateral convexity. It leaves the forearm by turning posteriorly and entering the anatomical snuffbox. As compared to the ulnar artery, it is quite superficial throughout its whole course. The radial artery continues as deep palmar arch in the palm. Its distribution in the hand is described later. It is the most commonly palpated artery (Fig. 9.9, Flowchart 9.1).

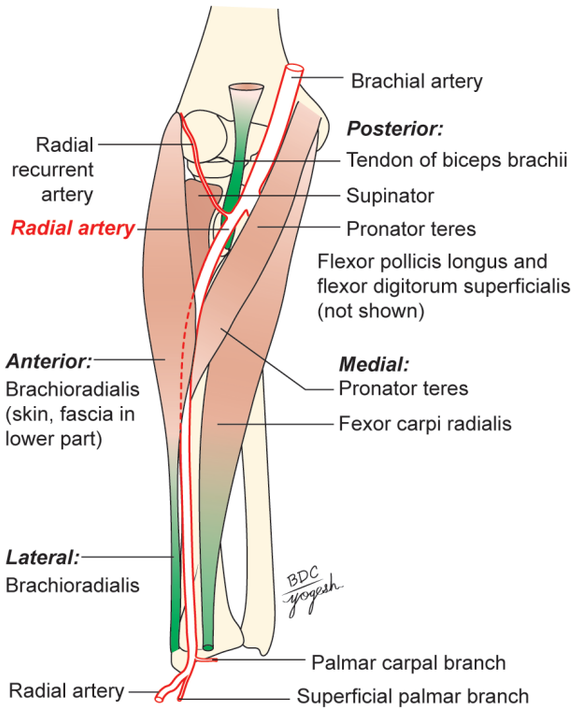
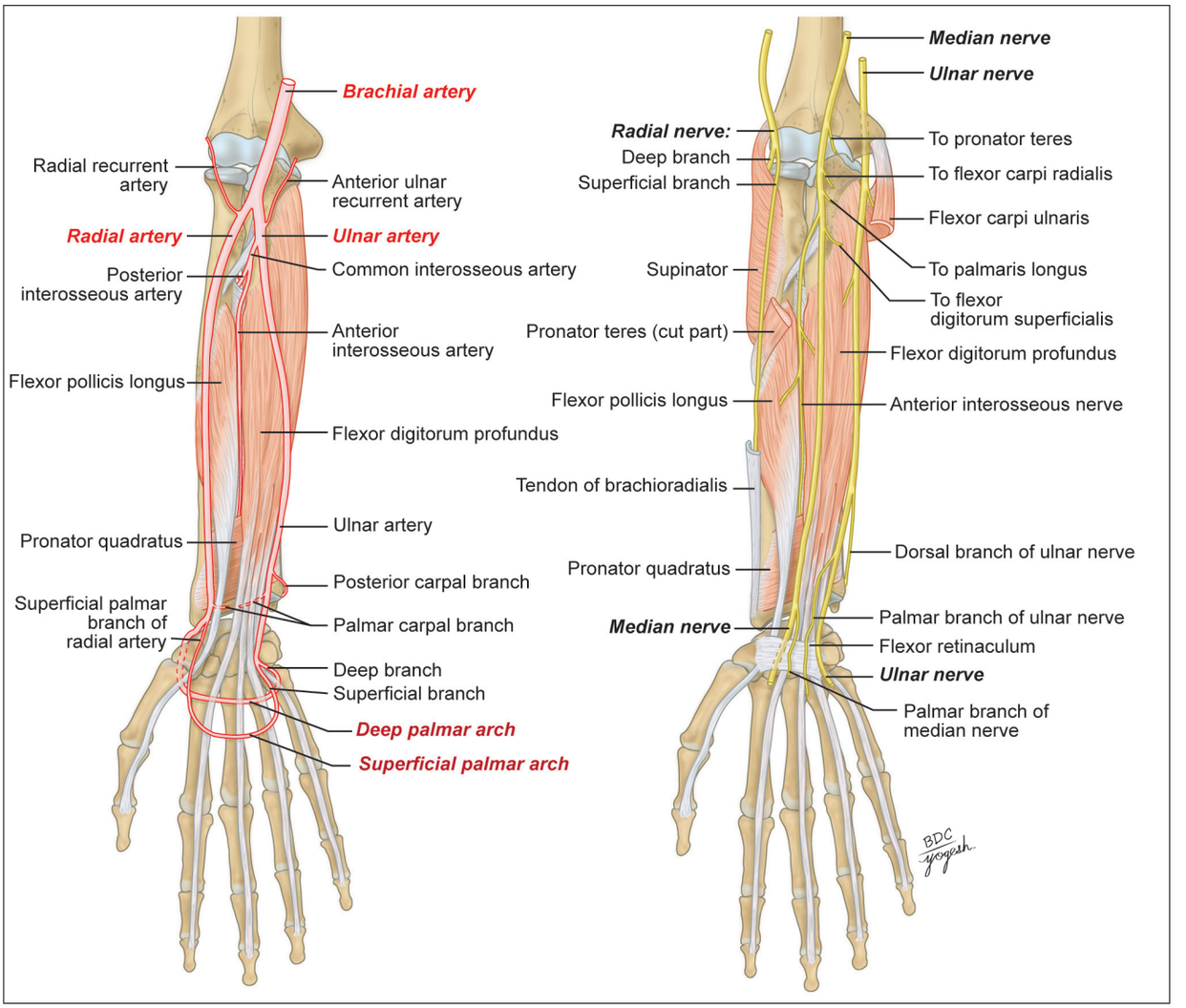
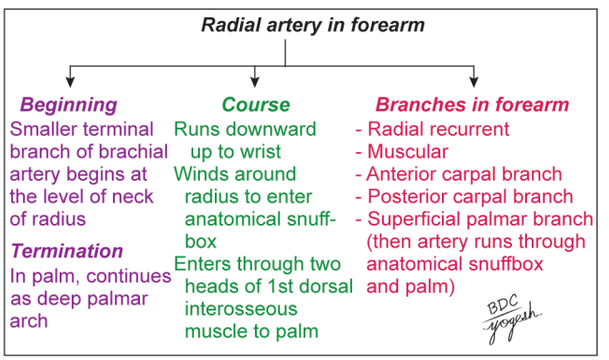


Fig. 9.8: Relations of radial artery

Plate 9.7: Blood vessels and nerves of front of the forearm



Flowchart 9.1: Radial artery in forearm



Relations

Anteriorly: It is overlapped by the brachioradialis in its upper part, but in the lower half, it is covered only by skin, superficial and deep fasciae.

Posteriorly: It is related to the tendon and muscles attached to anterior surface of radius, i.e. tendon of biceps brachii, supinator, flexor pollicis longus, radial head of flexor digitorum superficialis and pronator quadratus.

Medially: It is related to the pronator teres in the upper one-third and the tendon of the flexor carpi radialis in the lower two-thirds of its course (Figs 9.8 and 9.10).

Laterally: Brachioradialis in the whole extent and the radial nerve in the middle one-third.

The artery is accompanied by venae comitantes.

Branches in the Forearm

1. ***Radial recurrent artery:*** It arises just below the elbow, runs upwards deep to the brachioradialis and ends by anastomosing with the radial collateral artery (anterior branch of profunda brachii artery) in front of the lateral epicondyle of the humerus (*see* Fig. 8.11).
2. ***Muscular branches*** are given to the lateral muscles of the forearm.

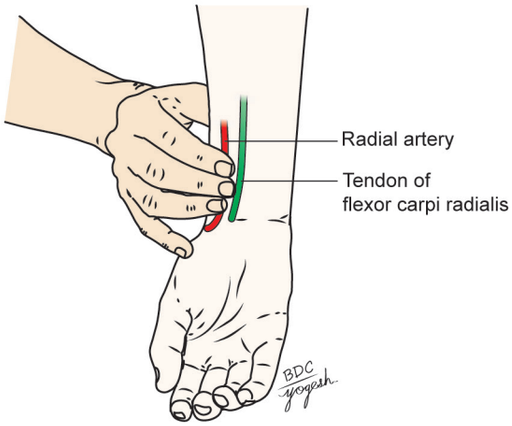


Fig. 9.9: Palpation of radial artery

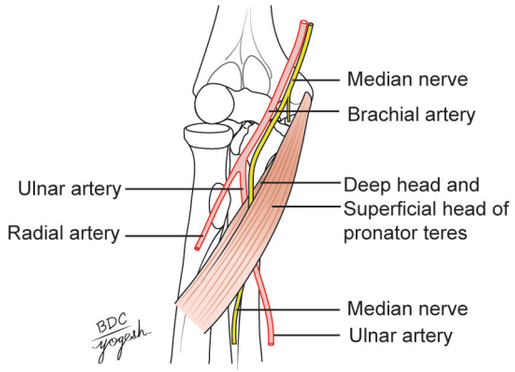


Fig. 9.10: Relations of the median nerve in right cubital fossa, and its entry into the forearm

3. ***Palmar/anterior carpal branch:*** It arises near the lower border of the pronator quadratus, runs medially deep to the flexor tendons and ends by anastomosing with the palmar carpal branch of the ulnar artery in front of the middle of the recurrent branch of the deep palmar arch, to form a cruciform anastomosis. The palmar carpal arch supplies bones and joints at the wrist.
4. ***Dorsal/posterior carpal branch:*** It forms dorsal carpal arch with branch of ulnar artery.
5. ***Superficial palmar branch:*** It arises just before the radial artery leaves the forearm by winding backwards. The branch passes through the thenar muscles and ends by joining the terminal part of the ulnar artery to complete the superficial palmar arch (Fig. 9.29).

ULNAR ARTERY

Beginning, Course and Termination

Ulnar artery is the larger terminal branch of the brachial artery and begins in the cubital fossa (Fig. 9.10). The artery runs obliquely downwards and medially in the upper one-third of the forearm, but in the lower 2/3rd of the forearm, its course is vertical (Plate 9.7, Flowchart 9.2). It enters the palm by passing superficial to the flexor retinaculum. In palm, ulnar artery terminates by dividing into superficial and deep branches. Its distribution in the hand is described later.

Relations

Anteriorly: In its upper half, the artery is deep and is covered by muscles arising from common flexor origin and median nerve. The lower half of the artery is superficial and is covered only by skin and fascia (Fig. 9.4).

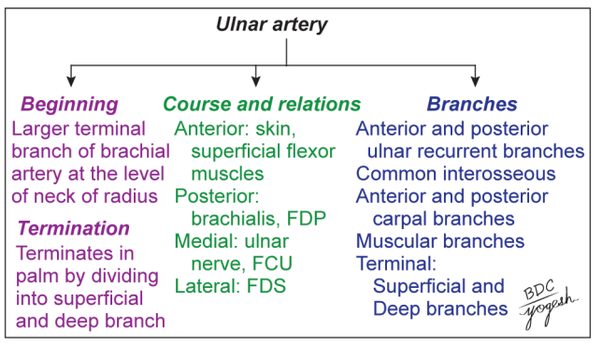
Posteriorly: It lies on brachialis and on the flexor digitorum profundus.

Medially: It is related to the ulnar nerve and to the flexor carpi ulnaris

Laterally: It is related to the flexor digitorum superficialis and median nerve.

The artery is accompanied by venae comitantes.

Flowchart 9.2: Ulnar artery



Branches

1. ***Anterior*** and ***posterior ulnar recurrent arteries:*** They anastomose around the elbow. The smaller anterior ulnar recurrent artery runs up and ends by anastomosing with the inferior ulnar collateral artery in front of the medial epicondyle. The larger posterior ulnar recurrent artery arises lower than the anterior and ends by anastomosing with the superior ulnar collateral artery behind the medial epicondyle (*see* Fig. 8.11).
2. ***Common interosseous artery*** (about 1 cm long): It arises just below the radial tuberosity. It passes backwards to reach the upper border of the interosseous membrane and end by dividing into the anterior and posterior interosseous arteries.

   The ***anterior interosseous artery*** is the deepest artery on the front of the forearm. It accompanies the anterior interosseous nerve. It descends on the surface of the interosseous membrane between the flexor digitorum profundus and the flexor pollicis longus (Plate 9.7). It pierces the interosseous membrane at the upper border of the pronator quadratus to enter the extensor compartment. The artery gives muscular branches to the deep muscles of the front of the forearm, nutrient branches to the radius and ulna and a *median artery*, which accompanies the median nerve.

   Near its origin, the ***posterior interosseous artery*** gives off the interosseous recurrent artery, which runs upwards, and ends by anastomosing with middle collateral artery (posterior branch of profunda brachii

artery) behind the lateral epicondyle. The posterior interosseous artery passes through a gap above the interosseous membrane to the back of forearm (Fig. 8.10).

3. ***Muscular branches*** supply the medial muscles of the forearm.

4, 5. ***Palmar*** and ***dorsal carpal branches:*** They take part in the anastomoses around the wrist joint. The palmar carpal branch helps to form the palmar carpal arch.

The dorsal carpal branch arises just above the pisiform bone, winds backwards deep to the tendons and ends in the dorsal carpal arch. This arch is formed medially by the dorsal carpal branch of the ulnar artery and laterally by the dorsal carpal branch of the radial artery.

DISSECTION

Having dissected the superficial and deep group of muscles of the forearm, identify the terminal branches of the brachial artery, e.g. ulnar and radial arteries and their branches.

Radial artery follows the direction of the brachial artery (Plate 9.7).

Ulnar artery passes obliquely deep to heads of pronator teres and then runs vertically till the wrist. Carefully look for common interosseous branch of ulnar artery and its anterior and posterior branches.

NERVES OF FRONT OF FOREARM

Nerves of the front of the forearm are the median, ulnar and radial nerves. The radial and ulnar nerves run along the margins of the forearm and are never crossed by the corresponding vessels, which gradually approach them. The ulnar artery, while approaching the ulnar nerve, gets crossed by the median nerve (Plate 9.7).

MEDIAN NERVE

Median nerve is the main nerve of the front of the forearm. It also supplies the muscles of thenar eminence (Plate 9.7, Fig. 9.12, Flowchart 9.3).

The median nerve controls coarse movements of the hand, as it supplies most of the long muscles of the front of the forearm. It is, therefore, called the '***labourer's nerve***'.

Course

Median nerve lies medial to brachial artery and enters the cubital fossa. It is the most medial content of cubital fossa (Fig. 9.10). Then it enters the forearm to lie between flexor digitorum superficialis and flexor digitorum profundus. It lies adherent to the back of superficialis muscle. Then it reaches down the region of wrist where it lies deep and lateral to palmaris longus tendon. Lastly, it passes deep to flexor retinaculum through carpal tunnel to enter the palm (Plate 9.7).

Relations

1. In the cubital fossa, median nerve lies medial to the brachial artery, behind the bicipital aponeurosis and in front of the brachialis.
2. The median nerve enters the forearm by passing between the two heads of the pronator teres. Here, it crosses the ulnar artery from which it is separated by the deep head of the pronator teres (Fig. 9.10).
3. Along with the ulnar artery, the median nerve passes beneath the fibrous arch of the flexor digitorum superficialis, and runs deep to this muscle on the surface of the flexor digitorum profundus. It is accompanied by the median artery, a branch of the anterior interosseous artery. About 5 cm above the flexor retinaculum (wrist), it becomes superficial and lies between the tendons of the flexor carpi radialis (laterally) and the flexor digitorum superficialis (medially). It is overlapped by the tendon of the palmaris longus.
4. The median nerve enters the palm by passing deep to the flexor retinaculum through the carpal tunnel.

Branches

1. ***Muscular branches*** to pronator teres in lower part of arm and in cubital fossa to flexor carpi radialis, palmaris longus and flexor digitorum superficialis (Fig. 9.11)

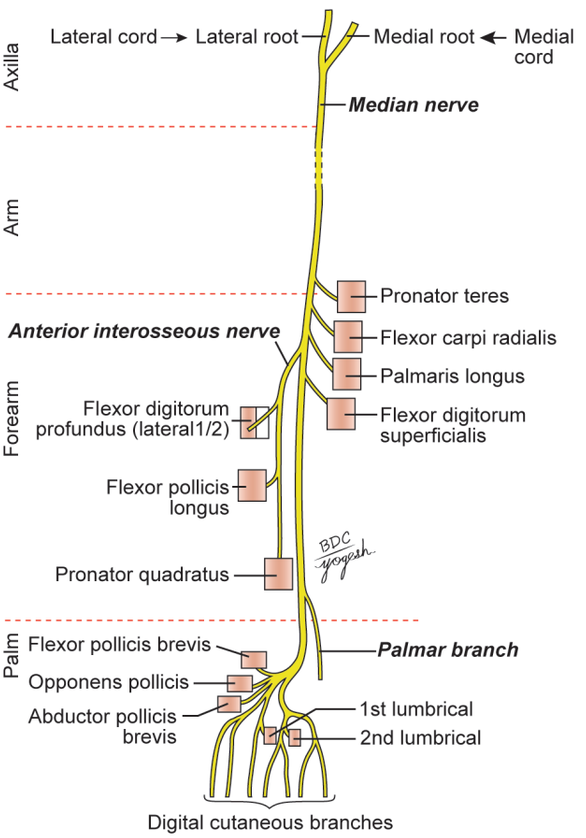
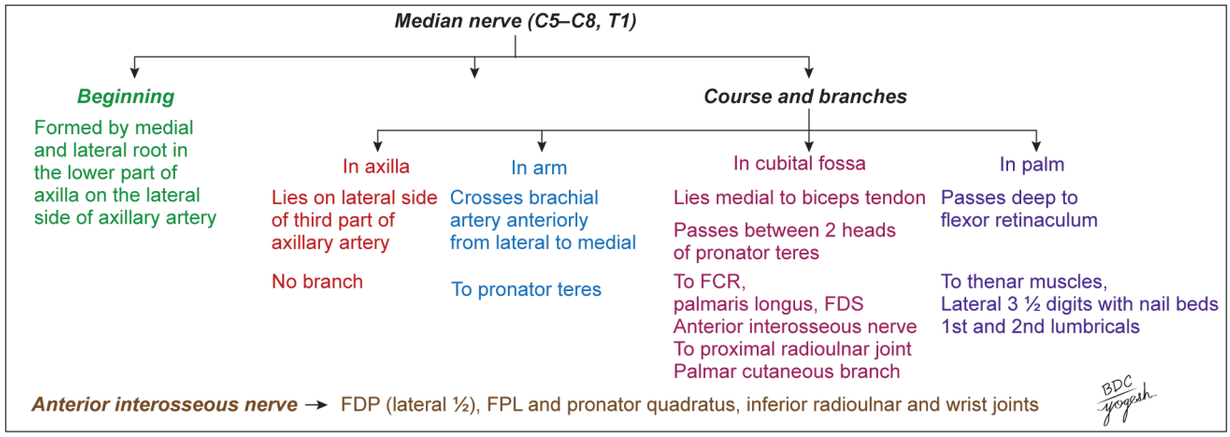


Fig. 9.11: Distribution of median nerve

Flowchart 9.3: Median nerve



2. ***Anterior interosseous branch*** is given off in the upper part of the forearm. It supplies the flexor pollicis longus, the lateral half of the flexor digitorum profundus and the pronator quadratus. The nerve also supplies the distal radioulnar and wrist joints.
3. ***Palmar cutaneous branch*** arises a short distance above the flexor retinaculum, lies superficial to it and supplies the lateral 2/3rd part of skin of palm over the thenar eminence and the central part of the palm (*see* Fig. 7.1a).
4. ***Articular branches*** are given to the elbow joint and to the proximal radioulnar joint.
5. ***Vascular branches*** supply the radial and ulnar arteries.
6. ***Communicating branch*** is given to the ulnar nerve.

ULNAR NERVE

The ulnar nerve is also known as the '***musician's nerve***' because it controls fine movements of the fingers. Its course in the palm will be considered in the later part of this chapter.

Course

Ulnar nerve is palpable as it lies behind medial epicondyle of humerus and is ***not*** a content of cubital fossa (Plate 9.7, Flowchart 9.4).

It enters the forearm by passing between two heads of flexor carpi ulnaris, i.e. cubital tunnel, to lie along the lateral border of flexor carpi ulnaris in the forearm.

In the last phase, it courses *superficial* to the flexor retinaculum, covered by its superficial slip or volar carpal ligament to enter the region of palm.

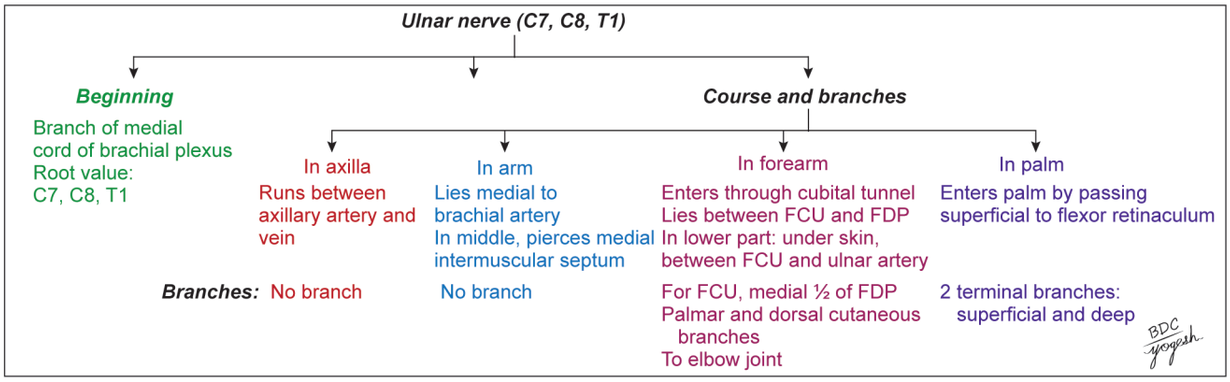
Relations

1. At the elbow, the ulnar nerve lies behind the medial epicondyle of the humerus (Plate 9.7). It enters the forearm by passing between the two heads of the flexor carpi ulnaris.
2. In the forearm, the ulnar nerve runs on the medial part of the flexor digitorum profundus muscle.
3. At the wrist, the ulnar neurovascular bundle lies between the flexor carpi ulnaris and the flexor digitorum profundus. The bundle enters the palm by passing superficial to the flexor retinaculum, lateral to the pisiform bone (Plate 9.7).

Branches

1. ***Muscular,*** to the flexor carpi ulnaris and the medial half of the flexor digitorum profundus.
2. ***Palmar cutaneous branch*** arises in the middle of the forearm and supplies the skin over the hypothenar eminence (*see* Fig. 7.1a) (medial 1/3rd of palm).

Flowchart 9.4: Ulnar nerve



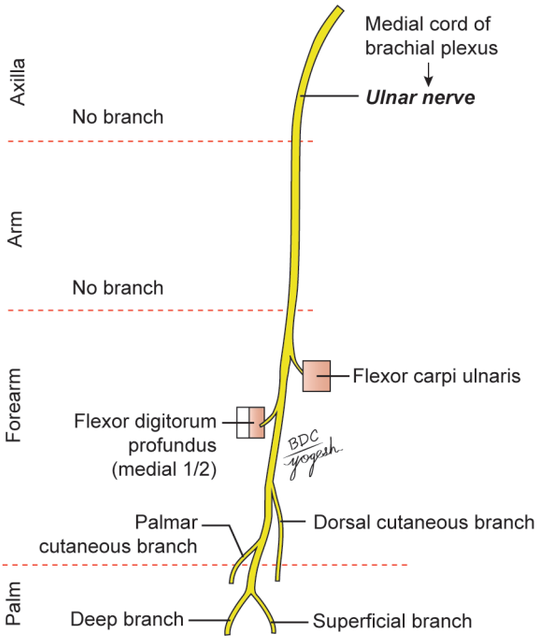


Fig. 9.12: Branches of ulnar nerve in forearm

3. ***Dorsal cutaneous branch*** arises 7.5 cm above the wrist, winds backwards and supplies the proximal parts of the medial 1½ digits and the adjoining area of the dorsum of the hand (*see* Fig. 7.1b).
4. ***Articular branches*** are given off to the elbow joint.

Its branches in the palm are shown in Fig. 9.33.

RADIAL NERVE

Course

The radial nerve divides into its two terminal branches in the cubital fossa just below the level of the lateral epicondyle of the humerus (Plate 9.7).

Branches

- The ***deep terminal branch*** (posterior interosseous nerve) soon enters the back of the forearm by passing through the supinator muscle. It will be studied further in back of forearm as posterior interosseous nerve.
- The ***superficial terminal branch*** (the main continuation of the nerve) runs down in front of the forearm. The superficial terminal branch of the radial nerve is closely related to the radial artery, only in the middle 1/3rd of the forearm. It is purely cutaneous.
- In the upper 1/3rd, it is widely separated from the artery, and in the lower 1/3rd it passes backwards under the tendon of the brachioradialis to reach the anatomical snuffbox from where it is distributed to the lateral half of the dorsum of the hand and to the proximal parts of the dorsal surfaces of the thumb, the index finger and lateral half of the middle finger (*see* Fig. 7.1b).
- Injury to this branch results in a small area of sensory loss over the root of the thumb.

DISSECTION

Median nerve is the chief nerve of the forearm. It enters the forearm by passing between two heads of pronator teres muscle. Its anterior interosseous branch is given off as it is leaving the cubital fossa. Identify median nerve *stuck* to the fascia on the deep surface of flexor digitorum superficialis muscle. Thus, the nerve lies deep to the flexor digitorum superficialis (Plate 9.3).

Dissect the anterior interosseous nerve as it lies on the interosseous membrane between flexor pollicis longus and flexor digitorum profundus muscles (Plate 9.7).

Identify the ulnar nerve situated behind the medial epicondyle. Trace it vertically down till the flexor retinaculum (Plate 9.7).

Trace the radial nerve and its two branches in the lateral part of the cubital fossa. Its deep branch is muscular and superficial branch is cutaneous (Plate 9.7).

PALMAR ASPECT OF WRIST AND HAND

Features

The human hand is designed:

1. For grasping,
2. For precise movements and
3. For serving as a tactile organ.

There is a big area in the motor cortex of brain for muscles of hand.

The skin of the palm is:

1. Thick for protection of underlying tissues.
2. Immobile because of its firm attachment to the underlying palmar aponeurosis.
3. Creased.

All of these characters increase the efficiency of the grip. The skin is supplied by spinal nerves C6–C8 (*see* Fig. 7.6a) through the median and ulnar nerves.

The superficial fascia of the palm is made up of dense fibrous bands, which bind the skin to the deep fascia (palmar aponeurosis) and divide the subcutaneous fat into small tight compartments, which serve as water-cushions during firm gripping. The fascia contains a subcutaneous muscle, the ***palmaris brevis***, which helps in improving the grip by steadying the skin on the ulnar side of the hand. The superficial metacarpal ligament, which stretches across the roots of the fingers over the digital vessels and nerves, is a part of this fascia.

The deep fascia is specialised to form:

1. The flexor retinaculum at the wrist.
2. The palmar aponeurosis in the palm.
3. The fibrous flexor sheaths in the fingers.

All three form a continuous structure, which holds the tendons in position and thus increases the efficiency of the grip.

DISSECTION

1. A horizontal incision at the distal crease of front of the wrist has already been made.
2. Make a vertical incision from the centre of the above incision through the palm to the centre of the middle finger (Fig. 9.13).
3. Make one horizontal incision along the distal palmar crease.
4. Make an oblique incision starting 3 cm distal to incision no. 2 and extend it till the tip of the distal phalanx of the thumb.

Thus the skin of the palm gets divided into three areas. Reflect the skin of lateral and medial flaps on their respective sides. The skin of the intermediate flap is reflected distally towards the distal palmar crease. Further the skin of middle finger is to be reflected on either side.

Superficial fascia and deep fascia

Remove the superficial fascia to clean the underlying deep fascia.

Deep fascia is modified to form the flexor retinaculum at wrist, palmar aponeurosis in the palm and fibrous flexor sheaths in the digits. Identify the structures on its superficial surface. Divide the flexor retinaculum between the thenar and hypothenar eminences, carefully preserving the underlying median nerve and long flexor tendons.

Identify long flexor tendons enveloped in their synovial sheaths, including the digital synovial sheaths.

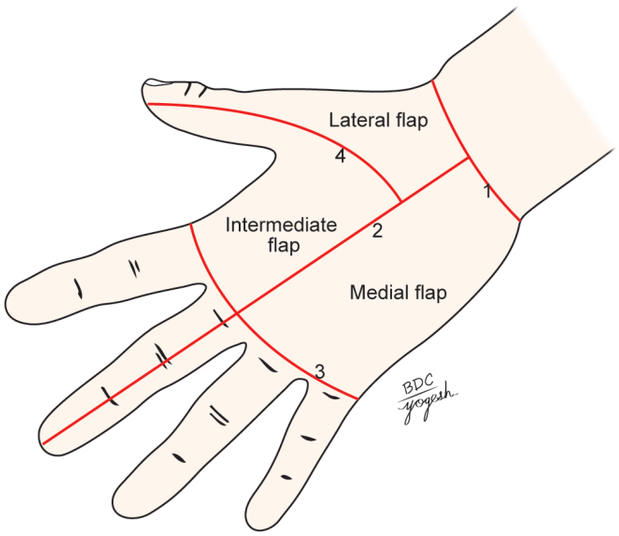


Fig. 9.13: Incisions of palm and digits (1–4)

***Competency*:**
AN12.3 Identify and describe flexor retinaculum with its attachments.

Flexor Retinaculum

Flexor retinaculum (Latin *to hold back*) is a strong fibrous band, which bridges the anterior concavity of the carpus and converts it into a tunnel, the *carpal tunnel* (Plates 9.8 and 9.9, Figs 9.14 and 9.15). The thenar and hypothenar muscles arise from the retinaculum.

Attachments

Medially, to:
1. Pisiform bone
2. Hook of the hamate.

Laterally, to:
1. Tubercle of the scaphoid, and
2. Crest of the trapezium.

On either side, the retinaculum has a slip:
1. The lateral *deep slip* is attached to the medial lip of the groove on the trapezium, which is thus converted into a tunnel for the tendon of the flexor carpi radialis.
2. The medial *superficial slip* (***volar carpal ligament***) is also attached to the pisiform bone. The ulnar vessels and nerves pass deep to this slip (Plate 9.9).

Relations

Structures passing superficial to the flexor retinaculum

These are:
1. The palmar cutaneous branch of the median nerve (Fig. 9.14)
2. The tendon of the palmaris longus
3. The palmar cutaneous branch of the ulnar nerve
4. The ulnar vessels
5. The ulnar nerve.

Structures passing deep to the flexor retinaculum

These are:
1. The median nerve (Fig. 9.14)
2. Four tendons of the flexor digitorum superficialis
3. Four tendons of the flexor digitorum profundus
4. The tendon of the flexor pollicis longus
5. The ulnar bursa
6. The radial bursa
7. The tendon of the flexor carpi radialis lies between the retinaculum and its deep slip in the groove on the trapezium (Fig. 9.15).

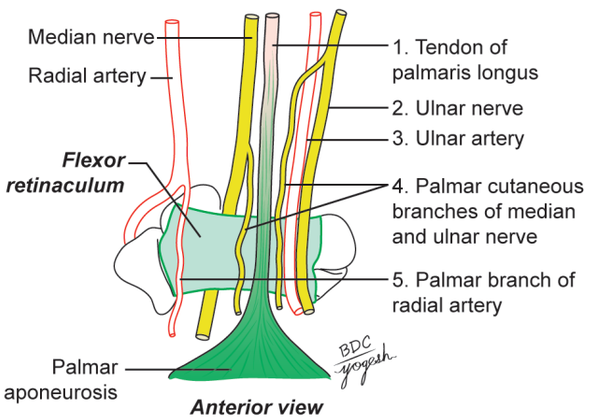


Fig. 9.14: Superficial relations of flexor retinaculum

Plate 9.8: Flexor retinaculum and its superficial relations

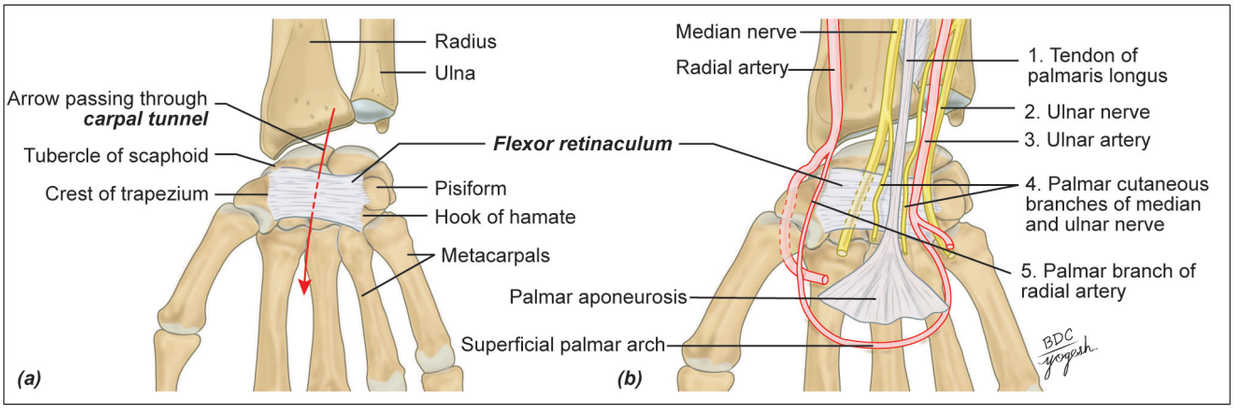
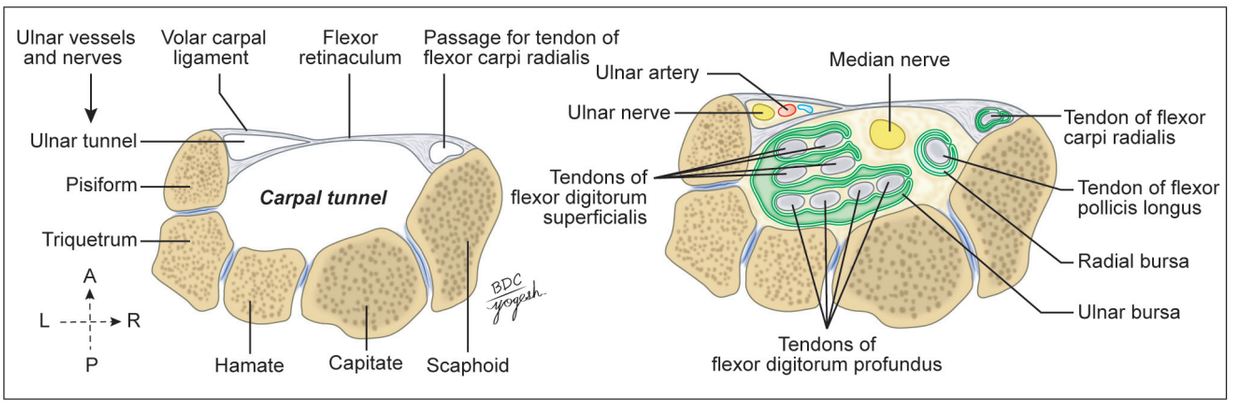


Plate 9.9: Carpal tunnel and structures passing through it



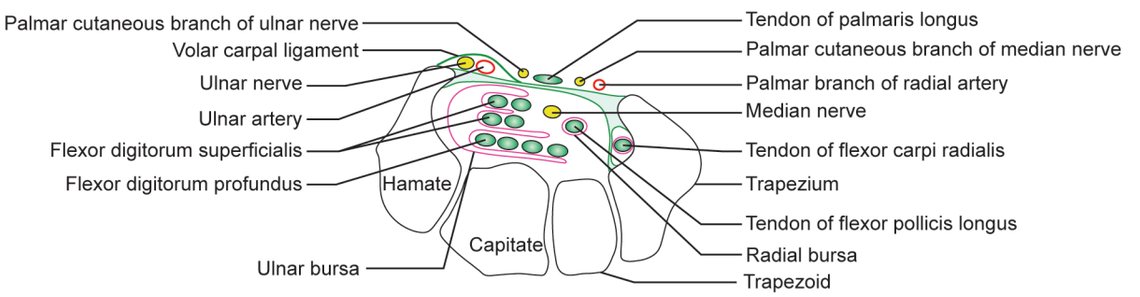


Fig. 9.15: Relations of flexor retinaculum (cross-section)

Palmar Aponeurosis

This term is often used for the entire deep fascia of the palm (Fig. 9.16). However, it is better to restrict this term to the central part of the deep fascia of the palm, which covers the superficial palmar arch, the long flexor tendons, the terminal part of the median nerve and the superficial branch of the ulnar nerve.

Features

Palmar aponeurosis is triangular in shape. It has apex, base and medial and lateral margins/borders.

1. The ***apex***, which is proximal, blends with the flexor retinaculum and is continuous with the tendon of the palmaris longus.
2. The ***base*** is directed distally. It divides into superficial and deep strata, superficial is attached to dermis. Deep strata divides into four slips opposite the heads of the metacarpals of the medial four digits. Each slip divides into two parts, which are continuous with the fibrous flexor sheaths. Extensions pass to the deep transverse metacarpal ligament, the capsule of the metacarpophalangeal joints and the sides of the base of the proximal phalanx. The digital vessels and nerves, and the tendons of the lumbricals emerge through the intervals between the slips.
3. From the ***lateral*** and ***medial margins*** of the palmar aponeurosis, the lateral and medial *palmar septa* pass backwards and divide the palm into compartments (Fig. 9.16).

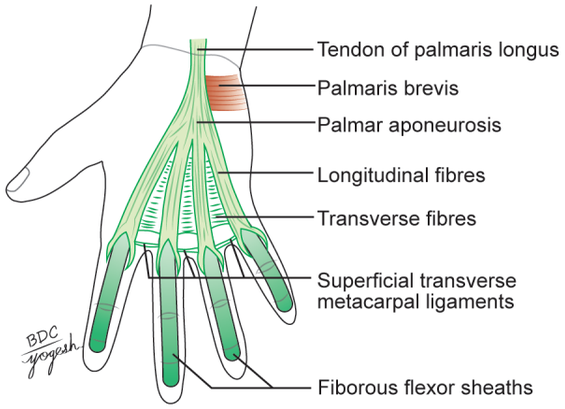


Fig. 9.16: The deep fascia of the hand forming the palmar aponeurosis and fibrous flexor sheaths

Functions

Palmar aponeurosis fixes the skin of the palm and thus improves the grip. It also protects the underlying tendons, vessels and nerves.

CLINICAL ANATOMY

***Dupuytren's contracture*:** This condition is due to inflammation involving the ulnar side of the palmar aponeurosis. There is thickening and contraction of the aponeurosis. As a result, the proximal phalanx and later the middle phalanx become flexed and cannot be straightened. The terminal phalanx remains unaffected. The ring finger is most commonly involved (Fig. 9.17).

Fibrous Flexor Sheaths of the Fingers

The fibrous flexor sheaths are made up of the deep fascia of the fingers. The fascia is thick and arched.

It is attached to the sides of the phalanges and across the base of the distal phalanx. Proximally, it is continuous with a slip of the palmar aponeurosis. In this way, a blind osseofascial tunnel is formed, which contains the long flexor tendons enclosed in the digital synovial sheath (Plate 9.10).

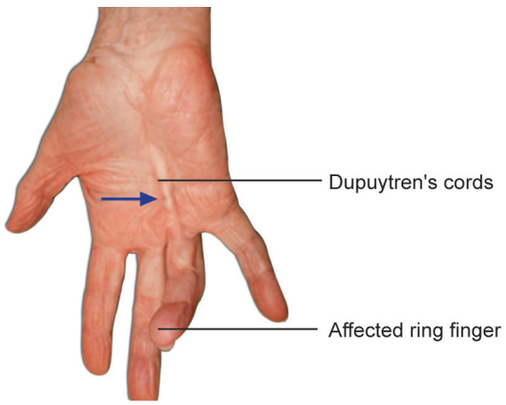
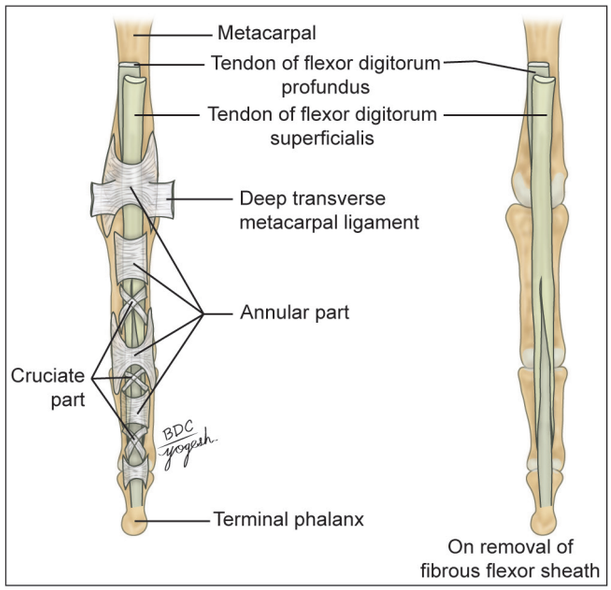


Fig. 9.17: Dupuytren's contracture

Plate 9.10: Fibrous flexor sheath of middle finger and its contents



Functions

The fibrous sheath is thick opposite the phalanges and thin opposite the joints to permit flexion. The sheath holds the tendons in position during flexion of the digits.

***Competency*:**
AN12.5 Identify and describe small muscles of hand. Also describe movements of thumb and muscles involved.

INTRINSIC MUSCLES OF HAND

Features

The intrinsic muscles of the hand serve the function of adjusting the hand during gripping and also for carrying out fine, skilled movements. Their attachments, nerve supply and actions are given in Tables 9.5 and 9.6.

There are 20 muscles in the hand. These are (Plates 9.11 to 9.14, Figs 9.18 to 9.20, Flowchart 9.5):

A. i. *Three muscles of thenar eminence* (Plate 9.11)
   1. Abductor pollicis brevis
   2. Flexor pollicis brevis
   3. Opponens pollicis

   ii. *One adductor of thumb:* Adductor pollicis (Plate 9.12).

B. Four hypothenar muscles (Plate 9.11, Fig. 9.16)
   1. Palmaris brevis (Fig. 9.16)
   2. Abductor digiti minimi
   3. Flexor digiti minimi
   4. Opponens digiti minimi

   Muscles (2) to (4) are muscles of hypothenar eminence.

C. Four lumbricals (Plate 9.13, Fig. 9.20)

D. Four palmar interossei (Plate 9.14)

E. Four dorsal interossei (Plate 9.14)

These muscles are described in Tables 9.5 and 9.6.

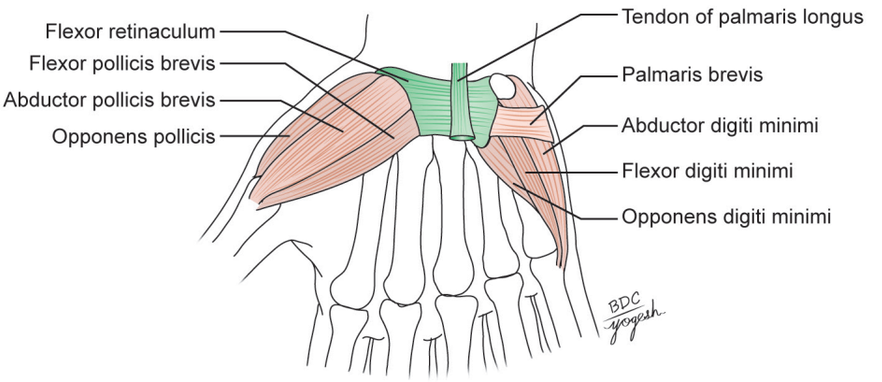


Fig. 9.18: Thenar and hypothenar muscles

TABLE 9.5: Origin and insertion of small muscles of the hand

Name	*Origin*	*Insertion*
Muscles of thenar eminence		
Abductor pollicis brevis	Tubercle of scaphoid Crest of trapezium Flexor retinaculum	Lateral side of base of proximal phalanx of thumb
Flexor pollicis brevis	Crest of trapezium Capitate bones Flexor retinaculum	Lateral side of base of proximal phalanx of thumb
Opponens pollicis	Crest of trapezium Flexor retinaculum	Lateral half of palmar surface of the shaft of metacarpal bone of thumb
Adductor of thumb		
Adductor pollicis	*Oblique head*: Capitate bone and bases of 2nd–3rd metacarpals *Transverse head*: Shaft of 3rd metacarpal	Medial side of base of proximal phalanx of thumb
Muscle of medial side of palm		
Palmaris brevis	Flexor retinaculum	Skin of palm on medial side
Muscles of hypothenar eminence		
Abductor digiti minimi	Pisiform bone	Medial side of base of proximal phalanx of little finger
Flexor digiti minimi	Hook of hamate Flexor retinaculum	Medial side of base of proximal phalanx of little finger
Opponens digiti minimi	Hook of hamate Flexor retinaculum	Medial border of 5th metacarpal bone
Lumbricals		
Lumbricals (4) Arise from 4 tendons of flexor digitorum profundus	1st: Lateral side of tendon of flexor digitorum profundus of index finger 2nd: Lateral side of same tendon of middle finger 3rd: Adjacent sides of same tendons of middle and ring fingers 4th: Adjacent sides of same tendons of ring and little fingers	Tendons cross the radial side of metacarpophalangeal joints and are inserted via *dorsal digital expansion* into dorsum of bases of distal phalanges of corresponding digits
Palmar interossei		
Palmar (4)	1st: Medial side of base of 1st metacarpal (MC) 2nd: Medial side of shaft of 2nd MC 3rd: Lateral side of shaft of 4th MC 4th: Lateral side of shaft of 5th MC	Medial side of base of proximal phalanx of thumb or 1st digit via *dorsal digital expansion* into dorsum of bases of distal phalanges of corresponding digits
Dorsal interossei		
Dorsal (4)	1st: Adjacent sides of shafts of 1st and 2nd MC 2nd: Adjacent sides of shafts of 2nd and 3rd MC 3rd: Adjacent sides of shafts of 3rd and 4th MC 4th: Adjacent sides of shafts of 4th and 5th MC	Via *dorsal digital expansion* into dorsum of bases of distal phalanges of corresponding digits

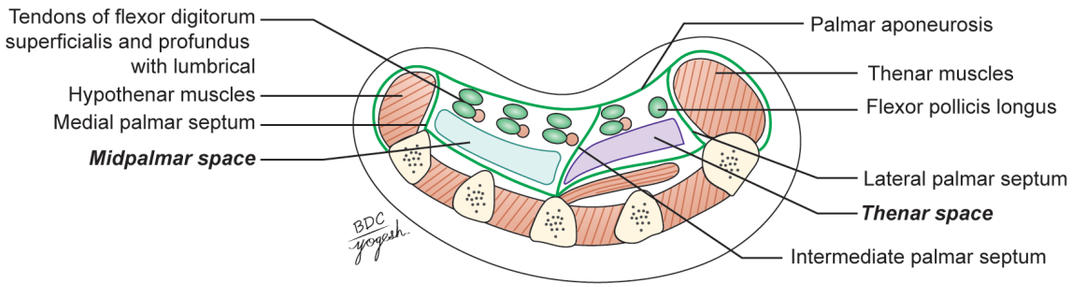
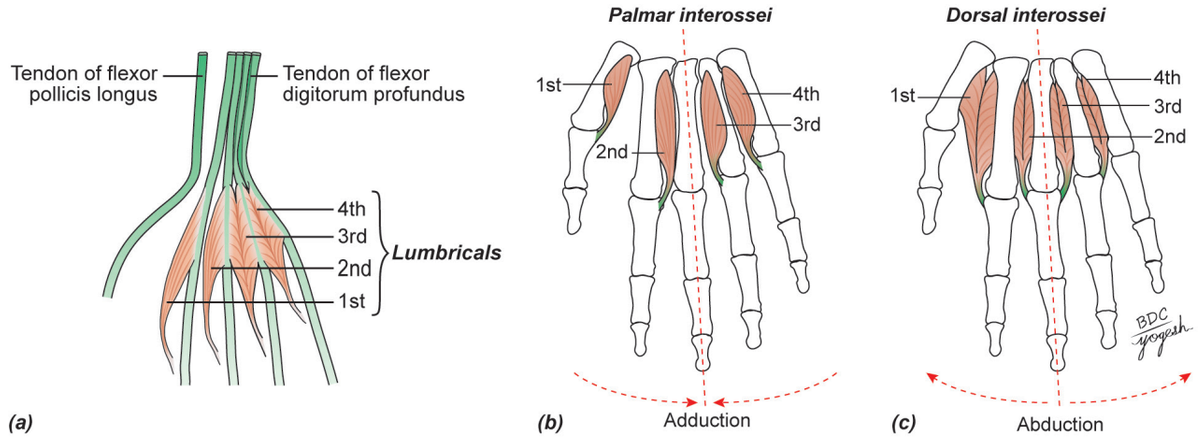


Fig. 9.19: Cross-section of hand (superior view)



Figs 9.20a to c: Lumbricals and interossei muscles

TABLE 9.6: Nerve supply and actions of small muscles of the hand

Muscle	*Nerve supply*	*Actions*
Muscles of thenar eminence		
Abductor pollicis brevis	Median nerve	Abduction of thumb
Flexor pollicis brevis	Median nerve	Flexes metacarpophalangeal joint of thumb
Opponens pollicis	Median nerve	Opposes thumb towards the fingers (pulls thumb medially and forward across palm)
Adductor of thumb		
Adductor pollicis	Deep branch of ulnar nerve, which ends in this muscle	Adduction of thumb
Muscle of medial side of palm		
Palmaris brevis	Superficial branch of ulnar nerve	Wrinkles skin to improve grip of palm
Muscles of hypothenar eminence		
Abductor digiti minimi	Deep branch of ulnar nerve	Abducts little finger
Flexor digiti minimi	Deep branch of ulnar nerve	Flexes little finger
Opponens digiti minimi	Deep branch of ulnar nerve	Pulls fifth metacarpal forward as in cupping the palm
Lumbricals		
Lumbricals (4)	1st and 2nd: Median nerve 3rd and 4th: Deep branch of ulnar nerve	Flex metacarpophalangeal joints extend interphalangeal joints of 2nd–5th digits (Fig. 9.21)
Palmar interossei		
Palmar (4)	Deep branch of ulnar nerve	Palmar interossei adduct fingers towards centre of third digit or middle finger (Fig. 9.22)
Dorsal interossei		
Dorsal (4)	Deep branch of ulnar nerve	Dorsal interossei abduct fingers from centre of 3rd digit. Both palmar and dorsal interossei flex the metacarpophalangeal joints and extend the interphalangeal joints (Fig. 9.22)

Plate 9.11: Thenar muscles and hypothenar muscles

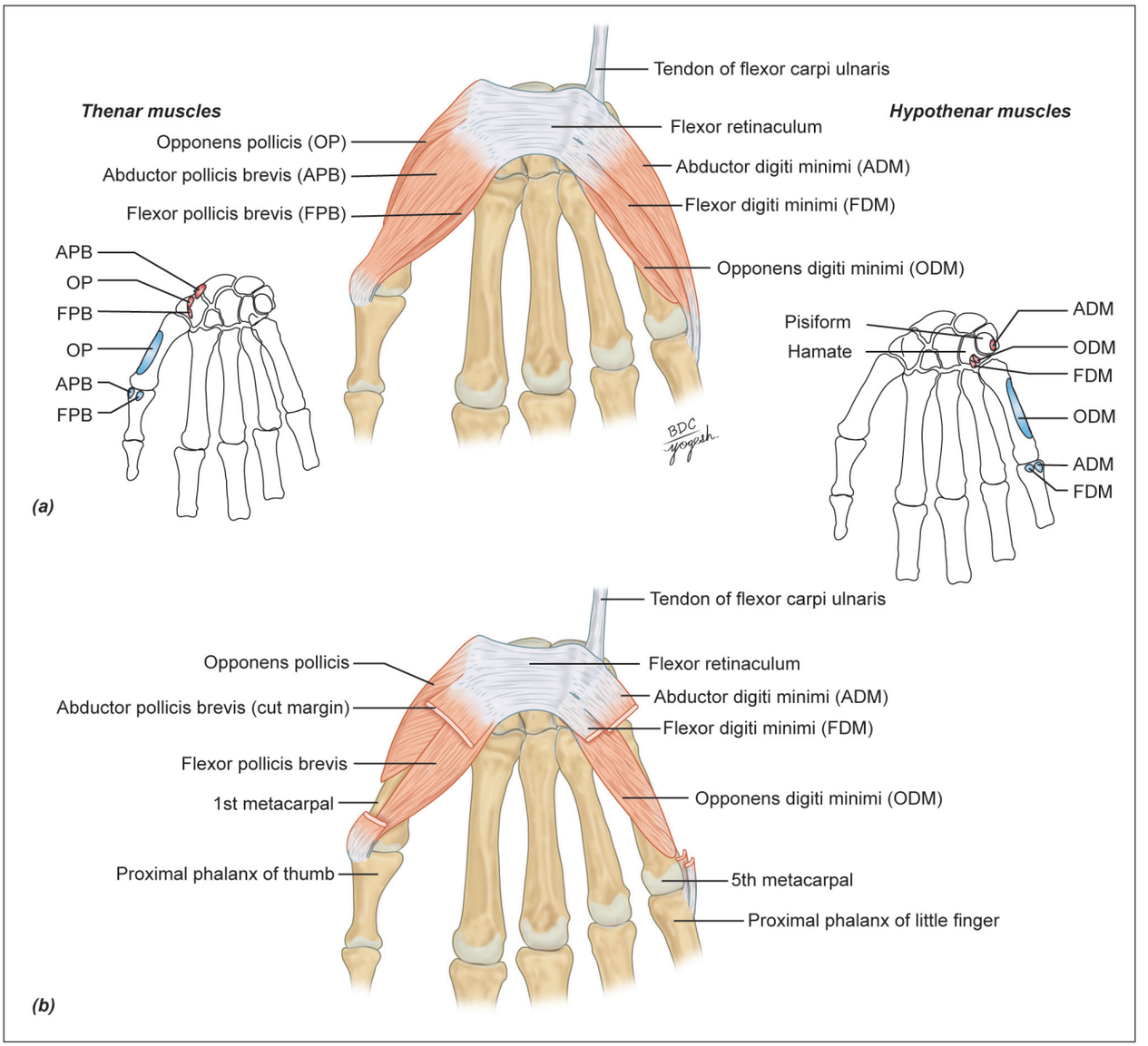
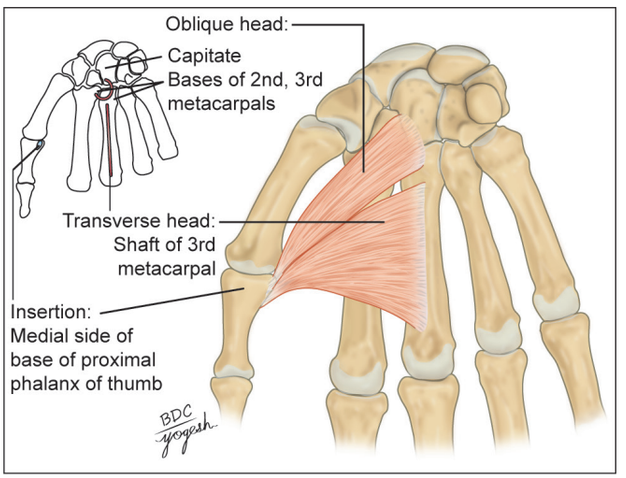


Plate 9.12: Adductor pollicis muscle



Actions of Thenar Muscles

In studying the actions of the thenar muscles, it must be remembered that the movements of the thumb take place in planes at right angles to those of the other digits because the thumb (1st metacarpal) is rotated medially through 90° (Fig. 9.23). Flexion and extension of the thumb take place in the plane of the palm, while abduction and adduction occur at right angles to the plane of palm.

Movement of the thumb across the palm to touch the other digits is known as 'opposition'. This movement is a combination of flexion and medial rotation.

Actions of Dorsal Interossei

All dorsal interossei cause abduction of the digits away from the line of the middle finger. This movement occurs in the plane of palm (Fig. 9.20) in contrast to the movement of thumb, where abduction occurs at

Plate 9.13: Lumbrical muscles and long flexor tendons of hand

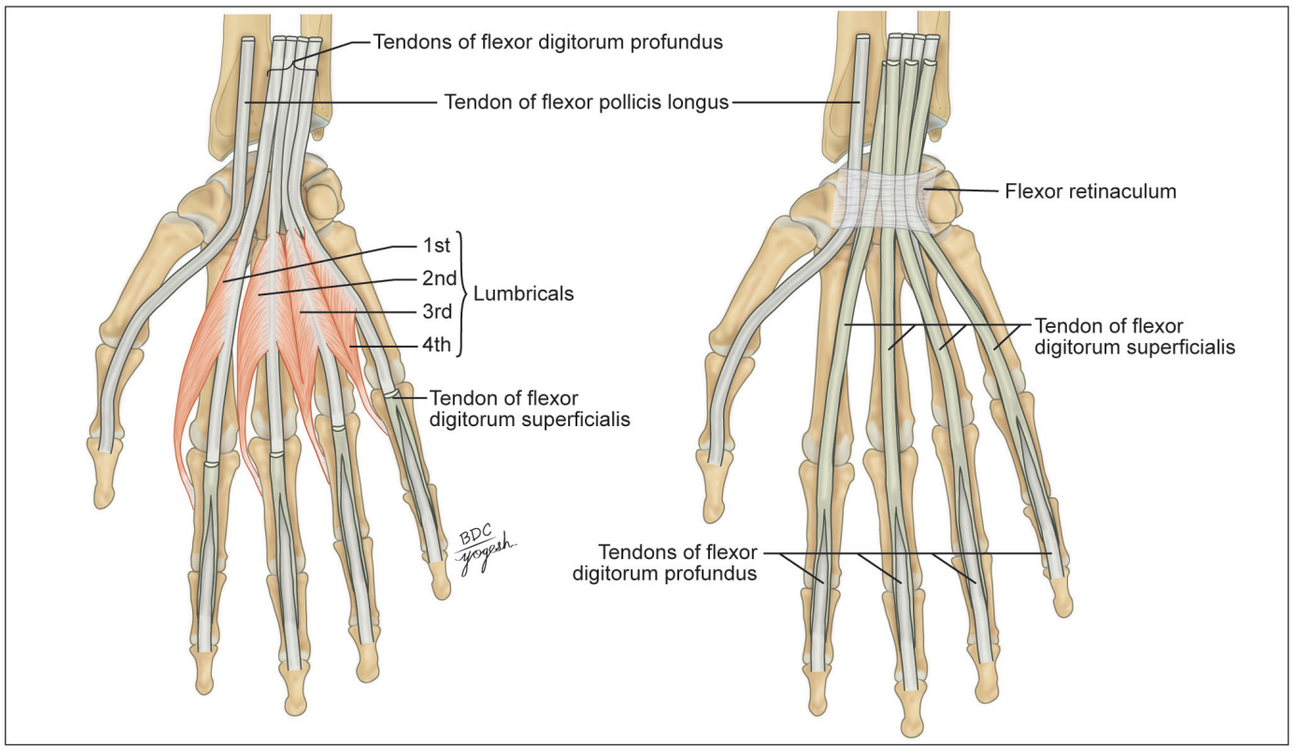
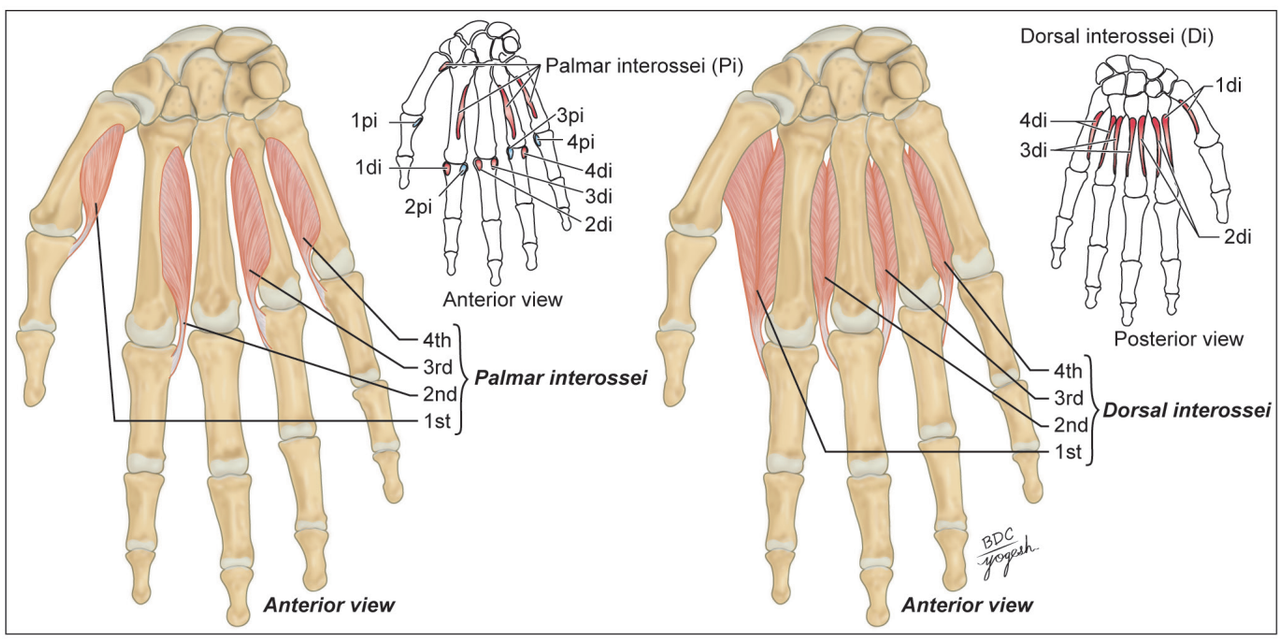


Plate 9.14: Palmar and dorsal interossei muscles of hand



right angles to the plane of palm (Fig. 9.20). Note that movement of the middle finger to either the medial or lateral side constitutes abduction. Also note that the 1st and 5th digits do not require dorsal interossei as they have their own abductors.

Testing of Some Intrinsic Muscles

1. ***Pen/pencil test*** *for abductor pollicis brevis:* Lay the hand flat on a table with the palm directed upwards. Ask the patient to touch with his thumb a pen/pencil held in front of the palm (Fig. 9.24).

Flowchart 9.5: Muscles of hand

Muscles of hand

Muscle	Origin	Insertion	Actions
Abductor pollicis brevis	Flexor retinaculum, tubercle of scaphoid, crest of trapezium	Base of proximal phalanx of thumb	Abduction of thumb
Flexor pollicis brevis	Superficial head: Flexor retinaculum Deep head: Crest of trapezium, capitate bone	Base of proximal phalanx of thumb	Flexion of thumb
Opponens pollicis	Flexor retinaculum, crest of trapezium	Lateral side of palmar surface of shaft of 1st metacarpal	Opposition of thumb (pulls thumb medially and forward)
Abductor digiti minimi	Pisiform	Base of proximal phalanx of little finger	Abduction of little finger
Flexor digiti minimi	Flexor retinaculum Hook of hamate	Base of proximal phalanx of little finger	Flexion of little finger
Opponens digiti minimi	Flexor retinaculum Hook of hamate	Medial surface of shaft of 5th metacarpal bone	Opposition of tip of the little finger and thumb
Lumbricals 4 small, worm-like muscles	From tendons of FDP 1st and 2nd - Unipennate 3rd and 4th - Bipennate	Crosses lateral to MP joint to insert on dorsal digital expansion	Flexion at MP joint Extension at proximal and distal IP joints
Palmar interossei 1 to 4 from lateral to medial Unipennate	Sides of metacarpals (Unipennate) 1st & 2nd: Medial side 3rd & 4th: Lateral side	Dorsal digital expansion 1st & 2nd: Medial side 3rd & 4th: Lateral side	Adduction of fingers
Dorsal interossei 1 to 4 from lateral to medial	Adjacent sides of metacarpals (Bipennate)	Dorsal digital expansion 1st and 2nd: Lateral side 3rd and 4th: Medial side	Abduction of fingers

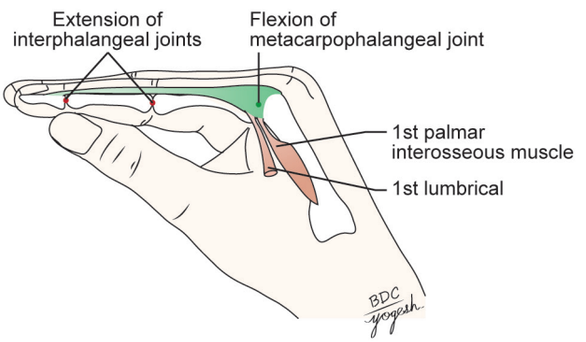


Fig. 9.21: Actions of lumbricals and interossei: lumbrical–interossei complex

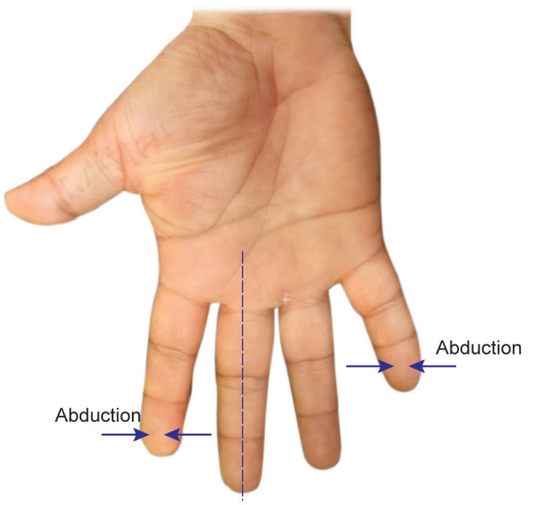


Fig. 9.22: The planes of movements of the fingers

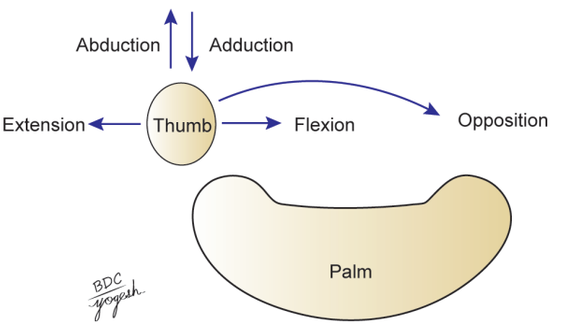


Fig. 9.23: The planes of movements of the thumb

2. *Test for opponens pollicis:* Ask the patient to touch the proximal phalanx of 2nd to 5th digits with the tip of thumb.
3. ***Interossei***
   a. ***Dorsal interossei*** are tested by asking the subject to spread out the fingers against resistance. As index finger is abducted, one feels 1st dorsal interosseous (Fig. 9.25).
   b. ***Palmar interossei*** and *adductor pollicis* are tested by placing a piece of paper between the fingers (Fig. 9.26), between thumb and index finger, and seeing how firmly it can be held (Fig. 9.27).

[*Mnemonic:* ***Interossei muscles: Actions of dorsal vs. palmar in hand "PAd and DAb":*** The **P**almar **Ad**duct and the **D**orsal **Ab**duct. Use your hand to dab with a pad.]

4. ***Froment's sign*** (**book test**) for the *adductor pollicis* muscle: When the patient is asked to grasp a book firmly between the thumb and other fingers of both hands, the terminal phalanx of the thumb on the



Fig. 9.24: Pen test for abductor pollicis brevis (median nerve)



Fig. 9.25: Testing first dorsal interosseous muscle of hand (median nerve)

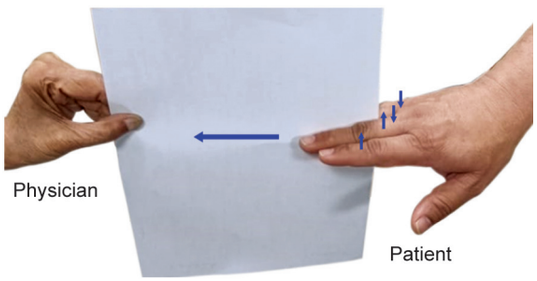


Fig. 9.26: Test for palmar interossei (ulnar nerve)

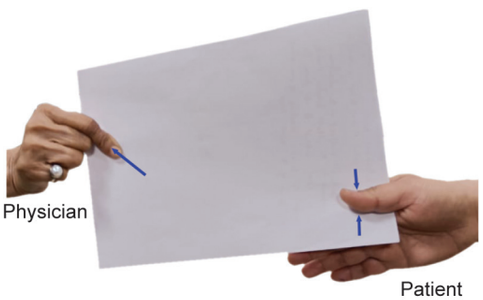


Fig. 9.27: Testing adductor pollicis (ulnar nerve)

paralysed side becomes flexed at the interphalangeal joint (by the flexor pollicis longus, which is supplied by the median nerve) (Fig. 9.28).

5. The *lumbricals* and *interossei* are tested by asking the subject to flex the fingers at the metacarpophalangeal joints against resistance.

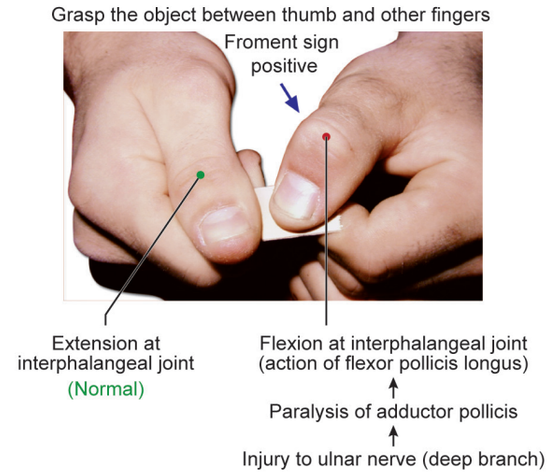


Fig. 9.28: Froment's test (ulnar nerve)

DISSECTION

Clean the thenar and hypothenar muscles. Carefully preserve the median nerve and superficial and deep branches of ulnar nerve, which supply these muscles.

Abductor pollicis brevis is the lateral muscle; flexor pollicis brevis is the medial one. Both these form the superficial lamina. The deeper lamina is constituted by opponens pollicis (Plate 9.11).

Cut through the abductor pollicis brevis and flexor pollicis brevis to expose the opponens pollicis. These three muscles constitute the muscles of thenar eminence.

Incise flexor pollicis brevis in its centre and reflect its two parts. This will reveal the tendon of flexor pollicis longus and adductor pollicis on a deeper plane. The three muscles of thenar eminence are supplied by thick recurrent branch of median nerve (Fig. 9.12).

On the medial side of hand, identify thin palmaris brevis muscle in the superficial fascia. It receives a twig from the superficial branch of ulnar nerve.

Hypothenar eminence is comprised by abductor digiti minimi medially, flexor digiti minimi just lateral to it. Deep to both these lies opponens digiti minimi. Identify these three muscles and trace their nerve supply from deep branch of ulnar nerve.

Between the two eminences of the palm, deep to palmar aponeurosis, identify the superficial palmar arch formed mainly by superficial branch of ulnar and superficial palmar branch of radial artery. Identify its common and proper digital branches.

Clean, dissect and preserve the branches of the median nerve and superficial division of ulnar nerve in the palm lying between the superficial palmar arch and long flexor tendons (Fig. 9.15).

Lying on a deeper plane are the tendons of flexor digitorum superficialis muscle. Dissect the peculiar mode of its insertion in relation to that of tendon of flexor digitorum profundus.

Cut through the tendons of flexor digitorum superficialis 5 cm above the wrist. Divide both ends of superficial

palmar arch. Reflect them distally towards the metacarpophalangeal joints.

Identify four tendons of flexor digitorum profundus diverging in the palm with four delicate muscles, the lumbricals, arising from them. Dissect the nerve supply to these lumbricals. The first and second are supplied from median and third and fourth from the deep branch of ulnar nerve (*see* Plate 9.15).

Divide the flexor digitorum profundus 5 cm above the wrist and reflect it towards the metacarpophalangeal joints. Trace one of its tendons to its insertion into the base of distal phalanx of one finger.

Competency:
AN12.7 Identify and describe course and branches of important blood vessels and nerves in hand.

ARTERIES OF HAND

Features

Arteries of the hand are the terminal parts of the ulnar and radial arteries. Branches of these arteries unite and form anastomotic channels called the superficial and deep palmar arches (Plate 9.15, Plate 9.6, Flowchart 9.6).

ULNAR ARTERY

It enters the palm by passing superficial to the flexor retinaculum but deep to the volar carpal ligament (Plate 9.15, Fig. 9.29). It ends by dividing into the *superficial palmar branch*, which is the main continuation of the artery, and the *deep palmar branch*. These branches take part in the formation of the superficial palmar arch and deep palmar arch, respectively.

The deep branch of the ulnar artery arises in front of the flexor retinaculum immediately beyond the pisiform bone. Soon, it passes between the flexor and abductor digiti minimi to join and complete the *deep palmar arch*.

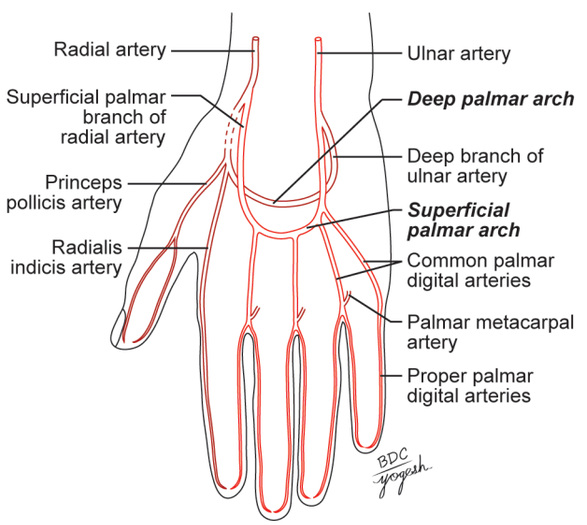


Fig. 9.29: The superficial and deep palmar arches

Flowchart 9.6: Palmar arterial arches

Palmar arterial arches

	Superficial palmar arch	***Deep palmar arch***
Formation	Continuation of superficial branch of ulnar artery	Continuation of radial artery
Completion	Completed by superficial palmar branch of radial artery	Completed by deep palmar branch of ulnar artery
Relations		
Superficial	Palmar aponeurosis	Long flexor tendons Lumbricals
Deep	Long flexor tendons Lumbricals	Interossei
Branches	3 common palmar digital arteries 1 proper digital artery Cutaneous branches	3 palmar metacarpal arteries 3 perforating branches Recurrent branch

BDC Yogesh

SUPERFICIAL PALMAR ARCH

The arch represents an important anastomosis between the ulnar and radial arteries. The convexity of the arch is directed towards the fingers, and its most distal point is situated at the level of the distal border of the fully extended thumb.

Formation

The superficial palmar arch is formed as the direct continuation of the superficial palmar branch ulnar artery beyond the flexor retinaculum. On the lateral side, the arch is completed by superficial palmar branch of radial artery (Plate 9.15, Fig. 9.29).

Relations

The superficial palmar arch lies deep to the palmaris brevis and the palmar aponeurosis. It crosses the palm over the flexor digiti minimi, the flexor tendons of the fingers, the lumbricals and the digital branches of the median nerve.

Branches

Superficial palmar arch gives off ***three common digital branches*** and ***one proper digital branch***, which supply the medial 3½ digits. The lateral three common digital branches are joined by the corresponding palmar metacarpal arteries from the deep palmar arch. It also gives ***cutaneous branches*** to the skin of palm.

CLINICAL ANATOMY

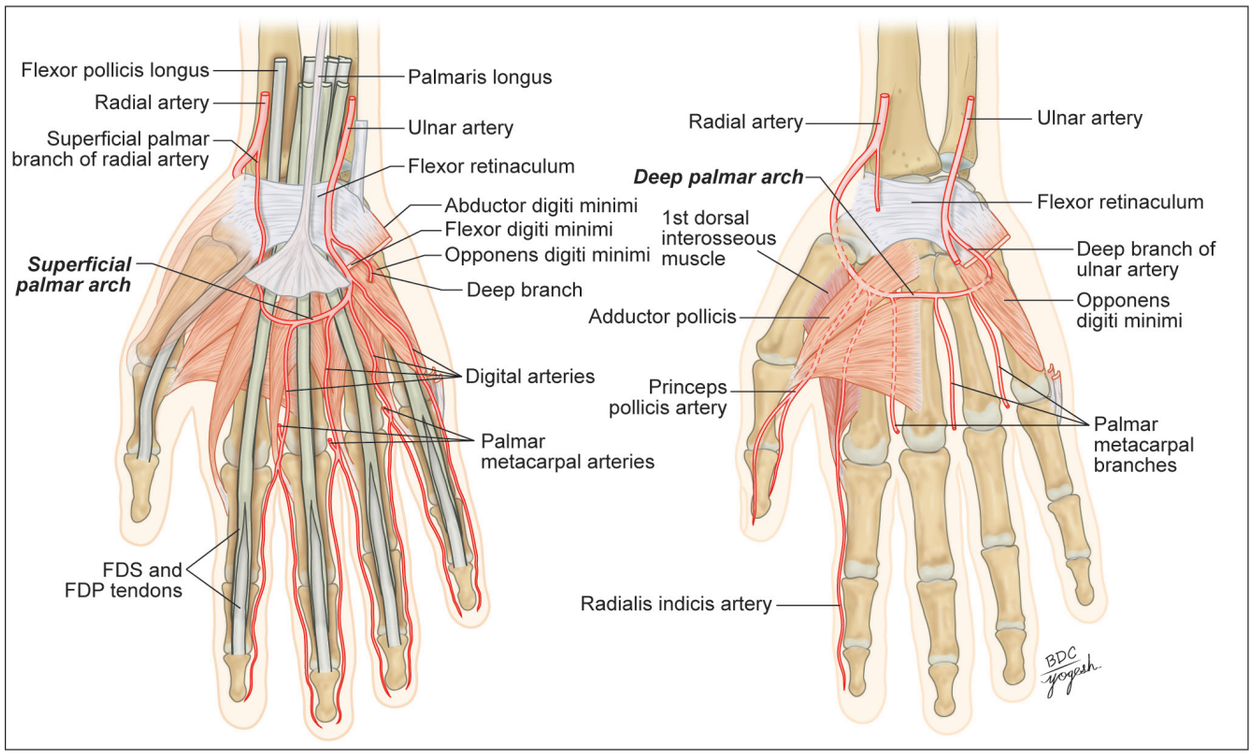
The radial artery is used for feeling the (arterial) pulse at the wrist. The pulsations can be felt well in this situation because of the presence of the flat radius with pronator quadratus muscle behind the artery (Fig. 9.10).

RADIAL ARTERY

Course

Radial artery runs obliquely downwards and backwards from the site of 'radial pulse' to reach the anatomical

Plate 9.15: Superficial and deep palmar arch



snuffbox. From there, it passes forwards to reach 1st interosseous space and then into the palm.

Relations

1. It leaves the forearm by winding backwards a around the wrist.
2. It passes through the "anatomical snuffbox" where it lies deep to the tendons of the abductor pollicis longus, the extensor pollicis brevis and the extensor pollicis longus and superficial to the lateral ligament of the wrist joint. It is also crossed by the digital branches of the radial nerve. The artery is superficial to the lateral ligament of the wrist joint, the scaphoid and the trapezium
3. It reaches the proximal end of the 1st interosseous space and passes between the two heads of the 1st dorsal interosseous muscle to reach the palm.
4. In the palm, the radial artery runs medially. At first, it lies deep to the oblique head of the adductor pollicis and then passes between the two heads of this muscle to form *deep palmar arch* (Fig. 9.29).

Branches

Dorsum of hand: On the dorsum of the hand, the radial artery gives off:

1. A branch to the lateral side of the dorsum of the thumb.
2. ***First dorsal metacarpal artery:*** This artery arises just before the radial artery passes into the interval between the two heads of the first dorsal interosseous muscle. It at once divides into two branches for the adjacent sides of the thumb and the index finger.

Palm: In the palm (deep to the oblique head of the adductor pollicis), the radial artery gives off:

1. The ***princeps pollicis artery***, which divides at the base of the proximal phalanx into two branches for the palmar surface of the thumb (Fig. 9.29).
2. The ***radialis indicis artery*** descends between the first dorsal interosseous muscle and the transverse head of the adductor pollicis to supply the lateral side of the index finger.

DEEP PALMAR ARCH

Deep palmar arch provides a channel connecting the radial and ulnar arteries in the palm (another channel is the superficial palmar arch). It is situated deep to the long flexor tendons.

Formation

The deep palmar arch is formed mainly by the terminal part of the radial artery and is completed medially at the base of the 5th metacarpal bone by the deep palmar branch of the ulnar artery (Fig. 9.29).

Relations

The arch lies on the proximal parts of the shafts of the metacarpals and on the interossei, under cover of the oblique head of the adductor pollicis, the flexor tendons of the fingers and the lumbricals. The deep branch of the ulnar nerve lies within the concavity of the arch.

Branches

1. From its convexity, i.e. from its distal side, the arch gives off ***three palmar metacarpal arteries***, which run distally in the 2nd, 3rd and 4th spaces, supply the medial four metacarpals and terminate at the finger clefts by joining the common digital branches of the superficial palmar arch (Fig. 9.29).
2. Dorsally, the arch gives off ***three*** (proximal) ***perforating digital arteries,*** which pass through the medial three interosseous spaces to anastomose with the dorsal metacarpal arteries. The digital perforating arteries connect the palmar digital branches of the superficial palmar arch with the dorsal metacarpal arteries.
3. ***Recurrent branch*** arises from the concavity of the arch, passes proximally to supply the carpal bones and joints, and ends in the palmar carpal arch.

DISSECTION

Deep to the lateral two tendons of flexor digitorum profundus muscle, note an obliquely placed muscle extending from two origins, i.e. from the shaft of the third metacarpal bone and the bases of 2nd and 3rd metacarpal bones and adjacent carpal bones to the base of proximal phalanx of the thumb. This is *adductor pollicis* (Plate 9.12). Reflect the adductor pollicis muscle from its origin towards its insertion. Identify the deeply placed interossei muscles.

Identify the radial artery entering the palm between two heads of first dorsal interosseous muscle and then between two heads of adductor pollicis muscle turning medially to join the deep branch of ulnar artery to complete the deep palmar arch (Fig. 9.29). Identify the deep branch of ulnar nerve lying in its concavity. Carefully preserve it, including its multiple branches. Deep branch of ulnar nerve ends by supplying the adductor pollicis muscle. It may supply deep head of flexor pollicis brevis also.

Lastly, define four small palmar interossei and four relatively bigger dorsal interossei muscles (Plates 9.13 and 9.14).

NERVES OF HAND

ULNAR NERVE

Ulnar nerve is the main nerve of the hand (like the lateral plantar nerve in the foot).

The ulnar nerve is also known as the ***'musician's nerve'*** because it controls fine movements of the fingers.

Course

The ulnar nerve lies superficial to the flexor retinaculum, covered only by the superficial slip of the retinaculum (volar carpal ligament). It terminates by dividing into a superficial and a deep branch.

Superficial branch is cutaneous. The deep branch passes through the muscles of the hypothenar eminence to lie in the concavity of the deep palmar arch to end in the adductor pollicis (Fig. 9.15).

Relations

1. The ulnar nerve enters the palm by passing superficial to the flexor retinaculum, where it lies between the pisiform bone and the ulnar vessels. Here, the nerve divides into its superficial and deep terminal branches (Plate 9.16).
2. The ***superficial terminal branch*** supplies the palmaris brevis and divides into two digital branches for the medial 1½ fingers (Plate 9.16).
3. The ***deep terminal branch*** accompanies the deep branch of the ulnar artery. It passes backwards between the abductor and flexor digiti minimi, and then between the opponens digiti minimi and the fifth metacarpal bone, lying on the hook of the hamate. Finally, it turns laterally within the concavity of the deep palmar arch. It ends by supplying the adductor pollicis muscle.

Branches

Superficial Terminal Branch

1. *Muscular branch*: To palmaris brevis.
2. *Cutaneous branches*: Two palmar digital nerves supply the medial 1½ fingers with their nail beds (Fig. 9.21).

The *medial branch* supplies the medial side of the little finger.

The *lateral branch* is a *common palmar digital nerve*. It divides into two proper palmar digital nerves for the adjoining sides of the ring and little fingers. The common palmar digital nerve communicates with the median nerve (Figs 9.30 and 9.31).

Deep Terminal Branch

1. *Muscular branches*:
   a. At its origin, the deep branch supplies three muscles of hypothenar eminence (Plate 9.16).
   b. As the nerve crosses the palm, it supplies the medial two lumbricals and eight interossei.
   c. The deep branch terminates by supplying the adductor pollicis and occasionally the deep head of the flexor pollicis brevis.
2. An *articular branch* supplies the wrist joint.

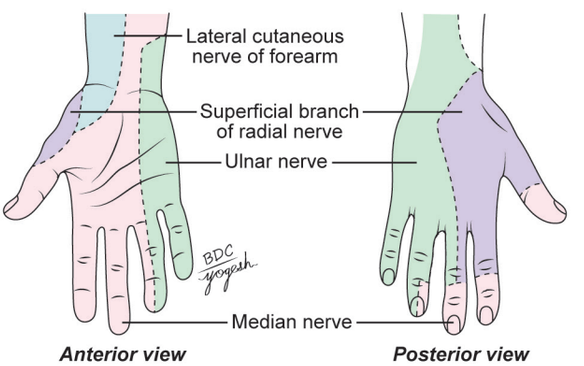


Fig. 9.30: Cutaneous innervation of palm and dorsum of hand

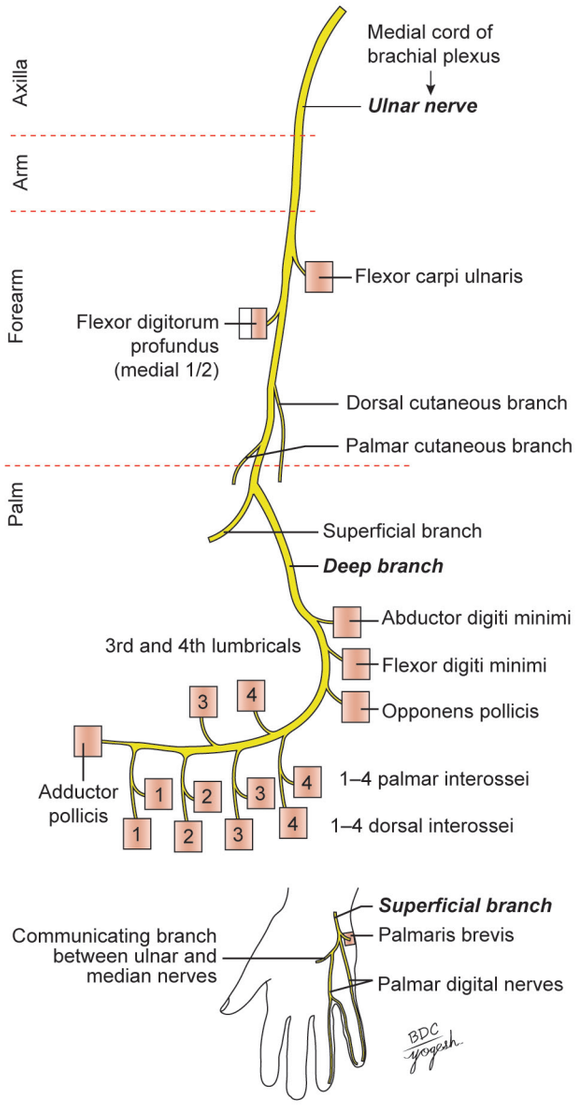


Fig. 9.31: Distribution of the branches of the ulnar nerve

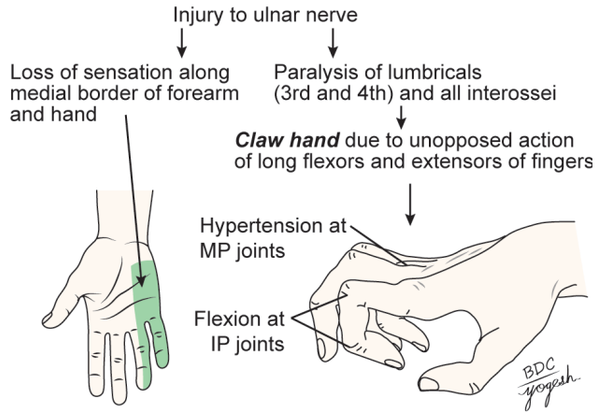


Fig. 9.32: Ulnar nerve injury (MP joint: Metacarpophalangeal joint, IP joint: Interphalangeal joint)

CLINICAL ANATOMY

Ulnar nerve injuries

- The ulnar nerve is commonly injured at the elbow, behind the medial epicondyle, or distal to elbow as it passes between two heads of flexor carpi ulnaris (cubital tunnel) or at the wrist in front of the flexor retinaculum.

Ulnar nerve injury at the elbow

- Flexor carpi ulnaris and the medial half of the flexor digitorum profundus get paralysed.
- Due to this paralysis, the medial border of the forearm becomes flattened. An attempt to produce flexion at the wrist results in abduction of the hand. The tendon of the flexor carpi ulnaris does not tighten on making a fist. Flexion of the terminal phalanges of the ring and little fingers is lost.
- The ulnar nerve controls fine movements of the fingers through its extensive motor distribution to the short muscles of the hand. There is ***ulnar claw hand*** as well (described below).

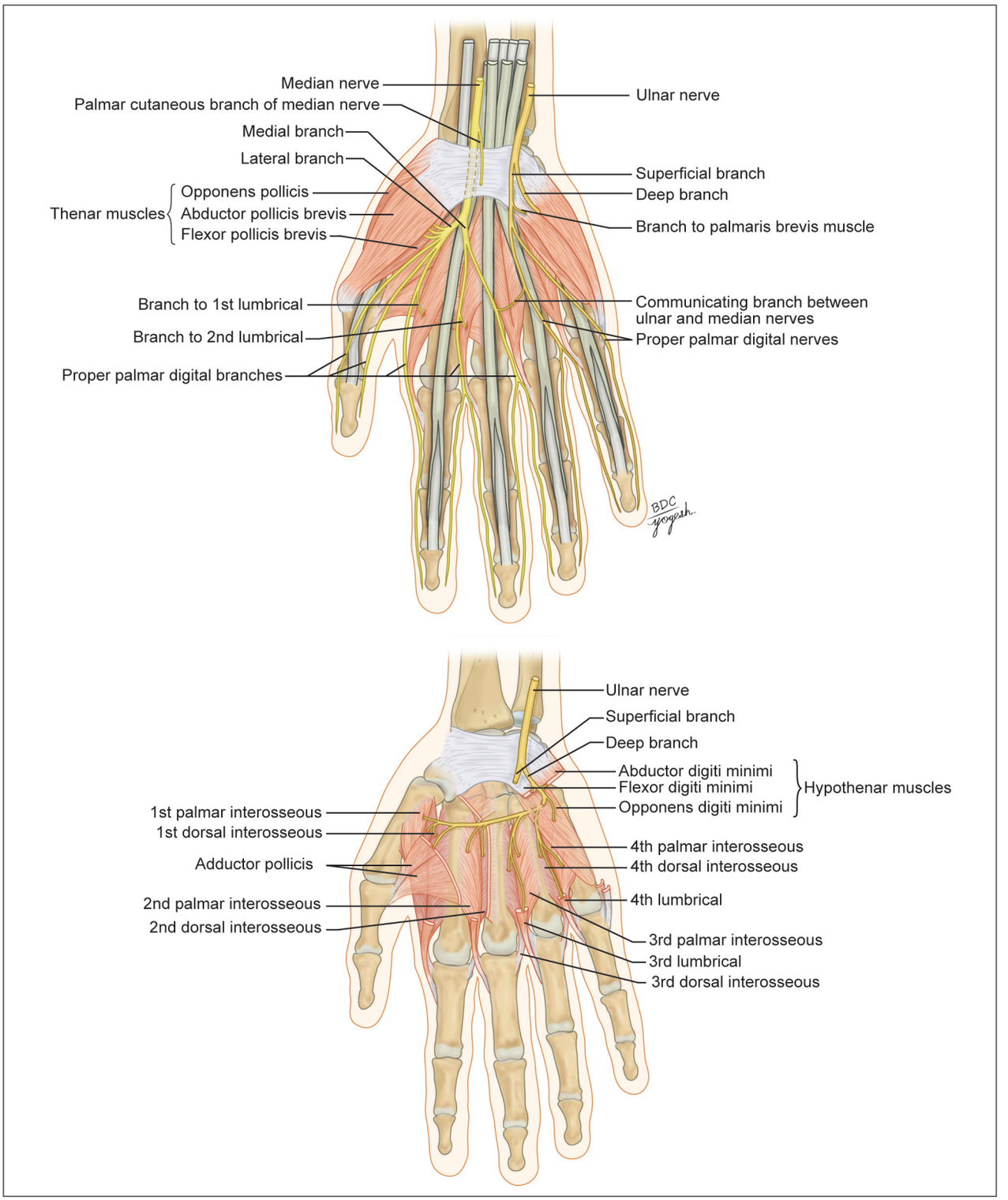
Ulnar nerve lesion at the wrist

- Produces '***ulnar claw hand' or 'Spinster claw deformity',*** which is characterised by the following signs:
  a. *Motor loss*: Hyperextension at the metacarpophalangeal joints and flexion at the interphalangeal joints, involving the ring and little fingers—more than the index and middle fingers (Fig. 9.32). The intermetacarpal spaces are hollowed out due to wasting of the interosseous muscles. Claw hand deformity is more obvious in wrist lesions as the profundus muscle is spared. This causes marked flexion of the terminal phalanges (***action of paradox***).
  b. *Sensory loss*: It is confined to the medial one-third of the palm and the palmar and dorsal surfaces of the medial 1½ fingers, including their nail beds (Figs 9.32).
  c. *Vasomotor changes:* The skin areas with sensory loss are warmer due to arteriolar dilatation; it is also dry due to the absence of sweating because of loss of sympathetic supply.
  d. *Trophic changes:* Long-standing cases of paralysis lead to dry and scaly skin. The nails crack easily with atrophy of the pulp of fingers.
  e. The patient is unable to spread out the fingers due to paralysis of the dorsal interossei. The power of adduction of the thumb and flexion of the ring and little fingers are lost. It should be noted that median nerve lesions are more disabling. In contrast, ulnar nerve lesions leave a relatively efficient hand.

MEDIAN NERVE

The median nerve is important because of its role in controlling the movements of the thumb, which are crucial in the mechanism of gripping by the hand (Plate 9.16).

Plate 9.16: Median and ulnar nerves in palm



The median nerve controls coarse movements of the hand, as it supplies most of the long muscles of the front of the forearm. It is, therefore, called the ***labourer's nerve***. It is also called '***eye of the hand***' as it is sensory to most of the hand.

Course

Median nerve lies deep to flexor retinaculum in the carpal tunnel and enters the palm (Plate 9.16) and terminates by dividing into lateral and medial divisions.

Relations

1. The median nerve enters the palm by passing deep to the flexor retinaculum, where it lies in the narrow space of the carpal tunnel in front of the ulnar bursa, enclosing the flexor tendons. Immediately below the retinaculum, the nerve divides into lateral and medial divisions (Plate 9.16).
2. The ***lateral division*** gives off a muscular branch to the ***thenar muscles*** and three digital branches for the lateral 1½ digits, including the thumb. The muscular branch curls upwards around the distal border of the retinaculum and supplies the thenar muscles.

   Out of the three digital branches, two supply the thumb and one the lateral side of the index finger. The digital branch to the index finger also supplies the ***1st lumbrical*** (Fig. 9.33).
3. The medial division divides into two common digital branches for the second and third interdigital clefts, supplying the adjoining sides of the index, middle and ring fingers. The lateral common digital branch also supplies the ***2nd lumbrical***.

Branches

In the hand, the median nerve supplies:

a. Five muscles, namely the abductor pollicis brevis, the flexor pollicis brevis, the opponens pollicis and the 1st and 2nd lumbrical muscles.
b. Palmar skin over the lateral 3½ digits with their nail beds.

Competencies:
AN12.4 Explain anatomical basis of carpal tunnel syndrome.
AN12.8 Describe anatomical basis of claw hand.

CLINICAL ANATOMY

Median nerve injuries above or at the level of the elbow

- When the median nerve is injured above the level of the elbow, as might happen in *supracondylar fracture of the humerus*, the following features are seen:
  1. The flexor pollicis longus and lateral half of flexor digitorum profundus are paralysed. The patient is unable to bend the terminal phalanx of the thumb and index finger when the proximal phalanx is held firmly by the clinician (to eliminate the action of the short flexors) (Fig. 9.34). Similarly, the terminal phalanx of the middle finger can be tested.
  2. The forearm is kept in a supine position due to paralysis of the pronators.
  3. The hand is adducted due to paralysis of the flexor carpi radialis, and flexion at the wrist is weak.
  4. Flexion at the interphalangeal joints of the index and middle fingers is lost so that the index and the middle (to a lesser extent) fingers tend to remain straight while making a fist. This is called ***pointing index finger***, occurs due to paralysis of long flexors of the digit (Fig. 9.35). When both index and middle fingers remain straight, the condition is called ***hand of benediction deformity***.
  5. ***Ape thumb*** or monkey-like thumb deformity is present due to paralysis of the thenar muscles (Fig. 9.36).
  6. The area of sensory loss corresponds to its distribution in the hand.
  7. Vasomotor and trophic changes: The skin on lateral 3½ digits is warm, dry and scaly. The nails get cracked easily (Fig. 9.37).
  8. ***Pen test*** done for abductor pollicis brevis (Fig. 9.24)

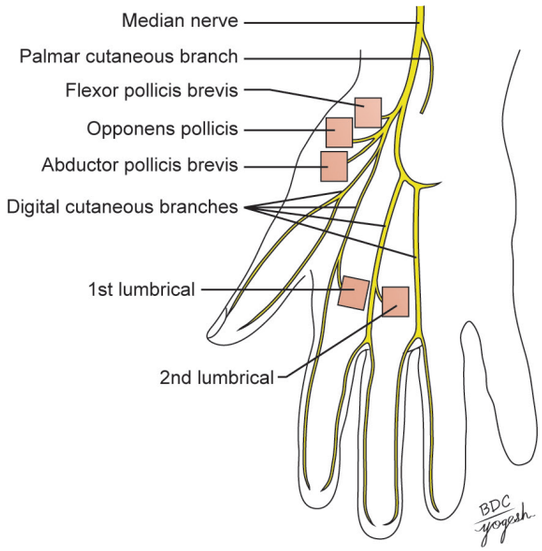


Fig. 9.33: Distribution of the median nerve in the hand

Carpal tunnel syndrome (CTS)

- Involvement of the median nerve in carpal tunnel at wrist has become a very common entity (Figs 9.15 and 9.38).
  1. This syndrome consists of motor, sensory, vasomotor and trophic symptoms in the hand caused by compression of the median nerve in the carpal tunnel. Examination reveals wasting of thenar eminence (ape-like hand), hypoaesthesia to light touch on the palmar aspect of lateral 3½ digits. However, the skin over the thenar eminence is *not affected* as the branch of median nerve supplying it arises in the forearm (Fig. 9.30).
  2. ***Froment's sign/book holding test***: The patient is unable to hold the book with thumbs and other fingers (Fig. 9.28).
  3. ***Paper holding test***: The patient is unable to hold paper between thumb and fingers. Both these tests are positive because of paralysis of thenar muscles.
  4. *Motor changes:* ***Ape thumb***/monkey-like thumb deformity (Fig. 9.39), loss of opposition of thumb. Index and middle fingers lag behind while making the fist due to paralysis of 1st and 2nd lumbrical muscles (Fig. 9.38).

5. *Sensory changes:* Loss of sensations on lateral 3½ digits, including the nail beds and distal phalanges on dorsum of hand (Fig. 9.38).
6. *Vasomotor changes:* The skin areas with sensory loss are warmer due to arteriolar dilatation; it is also drier due to absence of sweating due to loss of sympathetic supply.
7. *Trophic changes:* Long-standing cases of paralysis lead to dry and scaly skin. The nails crack easily with atrophy of the pulp of fingers (Fig. 9.38).

- CTS occurs both in males and females between the age of 25 and 70. They complain of intermittent attacks of pain in the distribution of the median nerve on one or both sides. The attacks frequently occur at night. Pain may be referred proximally to the forearm and arm. It is more common because of excessive work on the computer. ***Phalen's test*** (Fig. 9.39) is attempted for CTS.

Complete claw hand

- If both median and ulnar nerves are paralysed, the result is complete claw hand (Fig. 9.40).

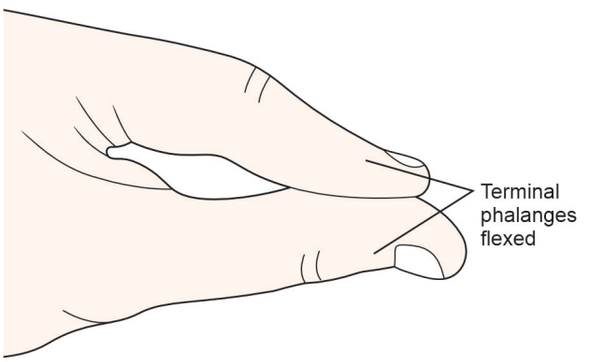


Fig. 9.34: Testing for anterior interosseous nerve



Fig. 9.35: Pointing index finger

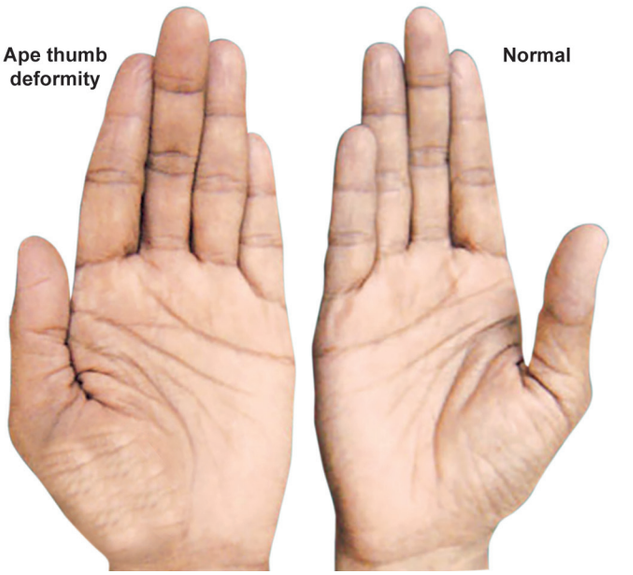


Fig. 9.36: Ape-like thumb deformity



Fig. 9.37: Vasomotor and trophic changes in left hand

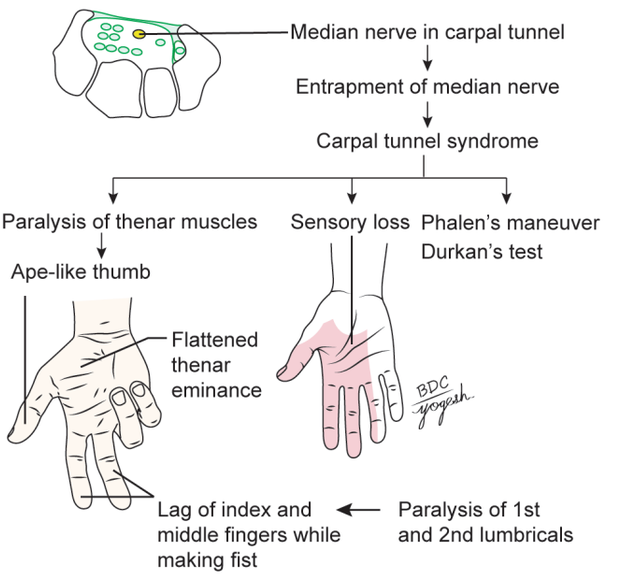


Fig. 9.38: Carpal tunnel syndrome or median nerve palsy

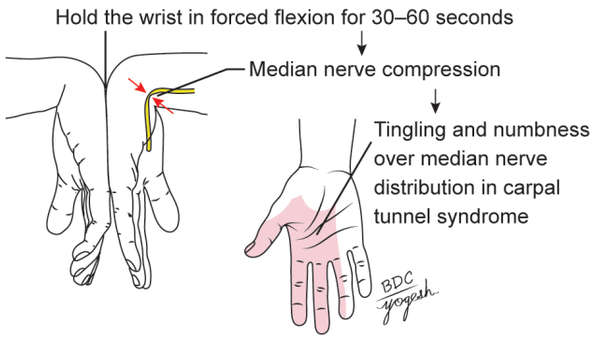


Fig. 9.39: Phalen's test: Acutely flexed wrist causes pain in carpal tunnel syndrome



Fig. 9.40: Complete claw hand

RADIAL NERVE

The part of the radial nerve seen in the hand is a continuation of the superficial terminal branch. It reaches the dorsum of the hand (after winding a round the anatomical snuffbox on the lateral side of the radius) and divides into 4 dorsal digital branches, which supply the skin of the digits as follows (Fig. 9.41):

1st: Lateral side of thumb
2nd: Medial side of thumb
3rd: Lateral side of index finger
4th: Contiguous sides of index and middle fingers
5th: Contiguous sides of middle and ring fingers.

Note that skin over the dorsum of the distal phalanges is supplied by the median nerve (not radial) (Fig. 9.41). Sensory loss is less because of the overlapping of nerves.

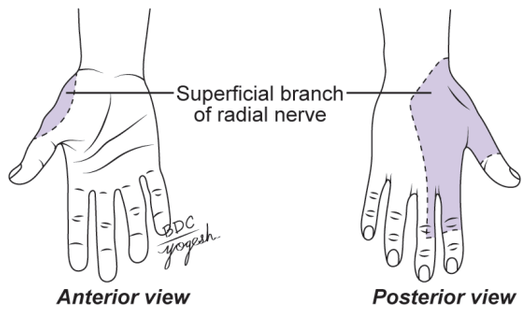


Fig. 9.41: Sensory loss in injury to superficial branch of radial nerve

***Competency*:**
AN12.10 Explain infection of fascial spaces of palm.

FASCIAL SPACES OF HAND

The spaces of the hand and their boundaries are clinically important. The arrangement of fasciae and the fascial septa in the hand is such that many spaces are formed. These spaces are of surgical importance because they may become infected and distended with pus. The important spaces are as follows (Plate 9.17, Fig. 9.42, Flowchart 9.7):

A. ***Palmar spaces***
   1. Pulp space of the fingers
   2. Midpalmar space
   3. Thenar space
B. ***Dorsal spaces***
   1. Dorsal subcutaneous space
   2. Dorsal subaponeurotic space
C. ***The forearm space of Parona.***

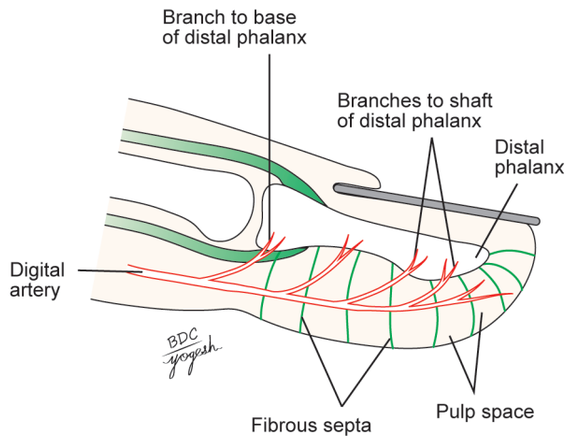


Fig. 9.42: The digital pulp space

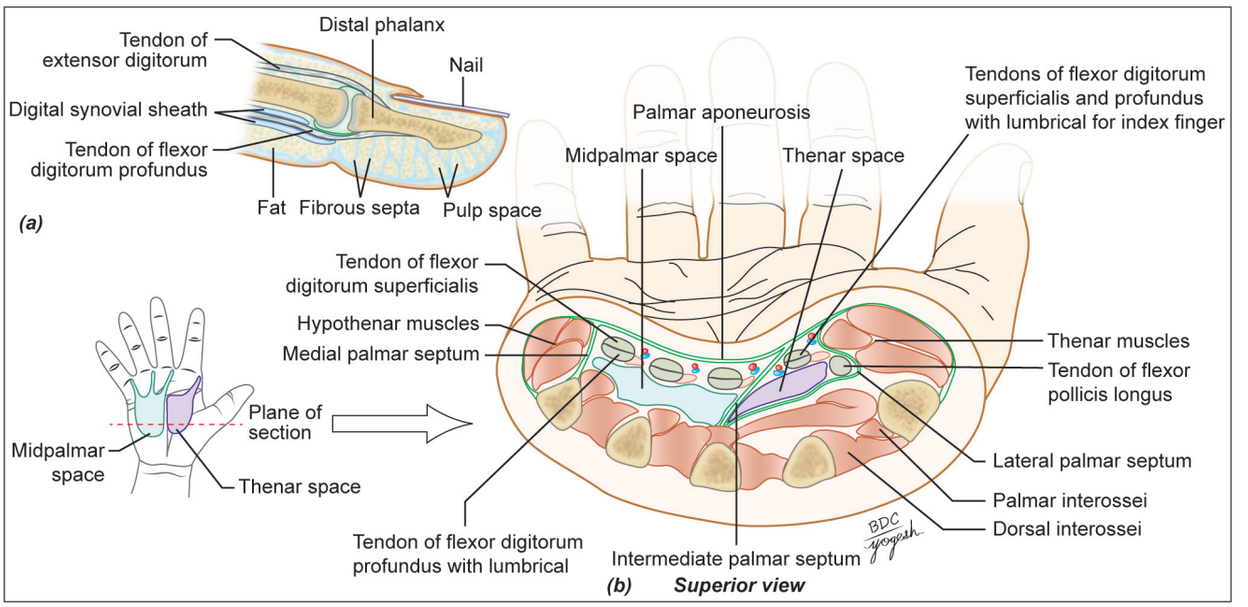
Flowchart 9.7: Midpalmar and thenar space

Midpalmar and thenar spaces

	Midpalmar space	*Thenar space*
Location	On medial side of hollow of palm	On lateral side of hollow of palm
Communication		
Proximal	Space of Parona	Space of Parona
Distal	Fascial sheaths of 3rd and 4th lumbricals	Fascial sheaths of 1st lumbrical
Drainage	Incision in 3rd or 4th webspace	Incision in 1st webspace

BDC yogesh

Plate 9.17: Thenar, hypothenar and pulp spaces of hand



Palmar Spaces

Pulp Space of the Fingers

The tips of the fingers and thumb contain subcutaneous fat arranged in tight compartments formed by fibrous septa, which pass from the skin to the periosteum of the terminal phalanx. Infection of this space is known as ***whitlow***. The rising tension in the space gives rise to severe throbbing pain.

Clinical significance

1. Infections in the pulp space (whitlow) can be drained by a lateral incision, which opens all compartments and avoids damage to the tactile tissue in front of the finger.
2. If neglected, a whitlow may lead to necrosis of the distal 4/5th of the terminal phalanx due to occlusion of the vessels by the tension. The proximal 1/5th (epiphysis) escapes because its artery does not traverse the fibrous septa (Fig. 9.42).

Midpalmar and Thenar Spaces

Midpalmar and thenar spaces are shown in Table 9.7, Fig. 9.19 and Plate 9.17.

TABLE 9.7: Midpalmar and thenar spaces (Fig. 9.19)

Features	*Midpalmar space*	*Thenar space*
1. Shape	Triangular	Triangular
2. Situation	Under the inner half of the hollow of the palm	Under the outer half of the hollow of the palm
3. *Extent*:		
Proximal	Distal margin of the flexor retinaculum	Distal margin of the flexor retinaculum
Distal	Distal palmar crease	Proximal transverse palmar crease
4. *Communications*:		
Proximal	Forearm space of Parona	Forearm space of Parona
Distal	Fascial sheaths of the 3rd and 4th lumbricals	Fascial sheath of the first lumbrical
5. *Boundaries*:		
Anterior	• Palmar aponeurosis • Flexor tendons of 3rd, 4th and 5th digits • 2nd, 3rd and 4th lumbricals	• Palmar aponeurosis • Short muscles of thumb • Flexor tendons of the index finger • First lumbrical
Posterior	Fascia covering interossei and metacarpals	Transverse head of adductor pollicis
Lateral	Intermediate palmar septum	• Tendon of flexor pollicis longus with radial bursa • Lateral palmar septum
Medial	Medial palmar septum	Intermediate palmar septum
6. Drainage	Incision in either the 3rd or 4th web space	Incision in the 1st web posteriorly

Dorsal Spaces

The *dorsal subcutaneous space* lies immediately deep to the loose skin of the dorsum of the hand. The *dorsal subaponeurotic space* lies between the metacarpal bones and the extensor tendons, which are united to one another by a thin aponeurosis.

Forearm Space of Parona

Forearm space of Parona is a rectangular space situated deep in the lower part of the forearm just above the wrist. It lies in front of the pronator quadratus and deep to the long flexor tendons.

Superiorly, the space extends up to the oblique origin of the flexor digitorum superficialis. Inferiorly, it extends up to the flexor retinaculum and communicates with the midpalmar space. The proximal part of the flexor synovial sheath protrudes into the forearm space.

Clinical significance

The forearm space may be infected through infections in the related synovial sheaths, especially of the ulnar bursa. Pus points at the margins of the distal part of the forearm where it may be drained by giving incision along the lateral margin of forearm.

SYNOVIAL SHEATHS

Many of the tendons entering the hand are surrounded by synovial sheaths. The extent of these sheaths is of surgical importance as they can be infected (Fig. 9.6).

Digital Synovial Sheaths

The synovial sheaths of the 2nd, 3rd and 4th digits are independent and terminate proximally at the levels of the heads of the metacarpals. The synovial sheath of the little finger is continuous proximally with the ulnar bursa and that of the thumb with the radial bursa. Therefore, infections of the little finger and thumb are more dangerous because they can spread into the palm and even up to 2.5 cm above the wrist (Fig. 9.6).

Ulnar Bursa

Infection of this bursa is usually secondary to the infection of the little finger, and this, in turn, may spread to the forearm space of the Parona. It results in an ***hourglass swelling*** (so-called because there is one swelling in the palm and another in the distal part of the forearm, the two being joined by a constriction in the region of the flexor retinaculum). It is also called ***compound palmar ganglion***.

Radial Bursa

Infection of the thumb may spread to the radial bursa.

CLINICAL ANATOMY

Surgical incisions

The surgical incisions of the hand are shown in Fig. 9.43.

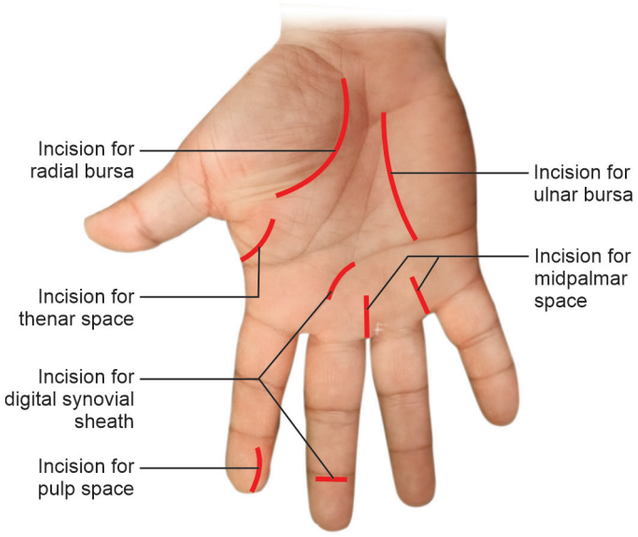


Fig. 9.43: Surgical incisions of the hand

BACK OF FOREARM AND HAND

This section deals mainly with the extensor retinaculum of the wrist, muscles of the back of the forearm, the deep terminal branch of the radial nerve and the posterior interosseous artery.

SURFACE LANDMARKS

1. ***Olecranon process*** of the ulna is the most prominent bony point on the back of a flexed elbow (Fig. 9.44). Normally, it forms a straight horizontal line with the two epicondyles of the humerus when the elbow is extended and a triangle when the elbow is flexed to a right angle. The relative position of the three bony points is disturbed when the elbow is dislocated.

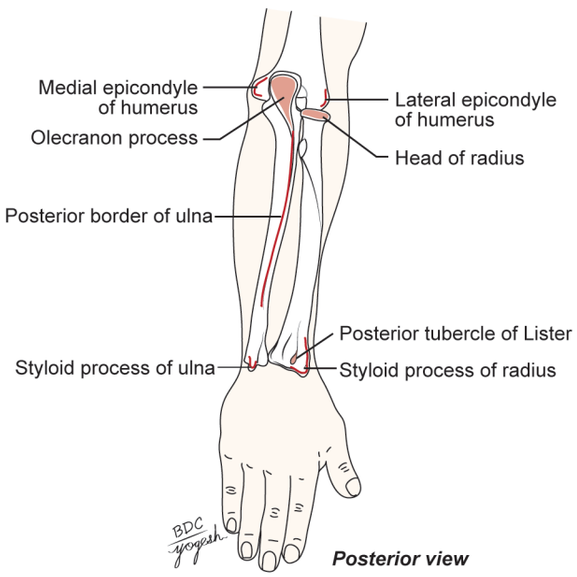


Fig. 9.44: Surface landmarks of the back of forearm

2. ***Head of the radius*** can be palpated in a depression on the posterolateral aspect of an extended elbow just below the lateral epicondyle of the humerus. Its rotation can be felt during pronation and supination of the forearm.
3. ***Posterior border of the ulna*** is subcutaneous in its entire length. It can be felt in a longitudinal groove on the back of the forearm when the elbow is flexed and the hand is supinated. The border ends distally in the ***styloid process of the ulna***.
4. ***Head of the ulna*** forms a surface elevation on the posteromedial aspect of the wrist in a pronated forearm.
5. ***Styloid process of the radius*** can be felt in the upper part of the anatomical snuffbox. It projects down 1 cm lower than the styloid process of the ulna. The relative position of the two styloid processes is disturbed in fractures at the wrist and is a clue to the proper realignment of fractured bones.
6. ***Dorsal tubercle of the radius*** (***Lister's tubercle***) can be palpated on the dorsal surface of the lower end of the radius in line with the cleft between the index and middle fingers. It is grooved on its medial side by the tendon of the extensor pollicis longus.
7. The heads of the metacarpals form the ***knuckles***.

DORSUM OF HAND

1. ***Skin:*** It is loose on the dorsum of hand. It can be pinched off from the underlying structures.
2. ***Superficial fascia:*** The fascia contains dorsal venous plexus, cutaneous nerves and dorsal carpal arch.
   a. ***Dorsal venous plexus or arch:*** The digital veins from adjacent sides of index, middle, ring and little fingers form 3 ***dorsal metacarpal veins*** (*see* Fig. 7.7). These join with each other on dorsum of hand. The lateral end of this arch is joined by one digital vein from index finger and two digital veins from thumb to form ***cephalic vein***. It runs proximally in the *anatomical snuffbox*, curves and a round the lateral border of wrist to come to front of forearm. In a similar manner, the medial end of the arch joins with one digital vein only from medial side of little finger to form ***basilic vein***. It also curves around the medial side of wrist to reach front of forearm. These metacarpal veins may unite in different ways to form a ***dorsal venous plexus***.
   b. ***Cutaneous nerves:*** These are *superficial branch of radial nerve* and *dorsal branch of ulnar nerve*. The nail beds and skin of distal phalanges of 3½ lateral nails are supplied by median nerve and 1½ medial nails by ulnar nerve.

      The superficial branch of radial nerve supplies lateral half of dorsum of hand with lateral 3½ digits except their nail beds. The dorsal branch of ulnar supplies medial half of dorsum of hand with medial 1 ½ digits without their nail beds.
   c. ***Dorsal carpal arch:*** It is formed by dorsal carpal branches of radial and ulnar arteries and lies close to the wrist joint. The arch gives three dorsal metacarpal arteries, which supply adjacent sides of index, middle, ring and little fingers. One digital artery goes to medial side of little finger. The arch also gives branches to the dorsum of hand.
3. ***Spaces on dorsum of hand:*** There are two spaces on the dorsum of hand:
   a. ***Dorsal subcutaneous space***, lying just subjacent to skin. Skin of dorsum of hand is loose can be pinched and lifted off.
   b. ***Dorsal subtendinous space*** lies deep to the extensor tendons, between the tendons and the metacarpal bones.
4. ***Deep fascia:*** The deep fascia is modified at the back of hand to form extensor retinaculum.

ANATOMICAL SNUFFBOX

The *anatomical snuffbox* (Fig. 9.45) is a triangular depression on the posterolateral side of the wrist. It is seen best when the thumb is extended.

Boundaries

- *Medial border* (*ulnar side*): Tendon of extensor pollicis longus
- *Lateral border* (*radial side*): Tendons of extensor pollicis brevis and abductor pollicis longus
- *Proximal border*: Styloid process of radius
- *Apex*: Approximation of medial and lateral borders
- *Floor*: Trapezium and scaphoid
- *Roof*: Skin, superficial branch of radial nerve, cephalic vein.

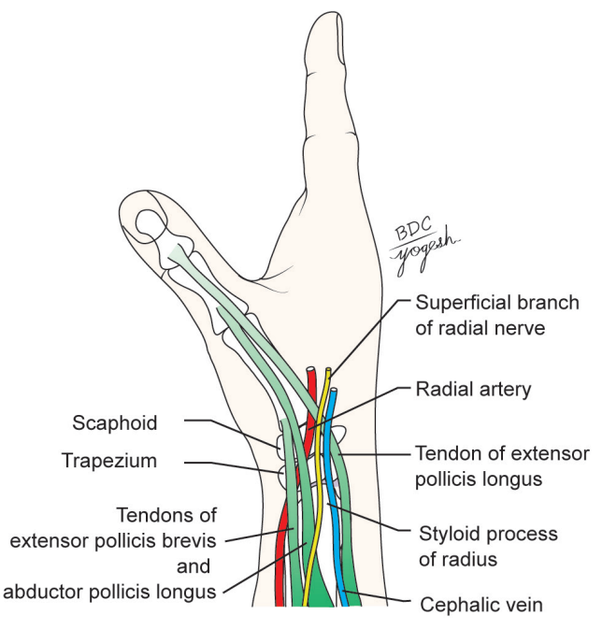


Fig. 9.45: Anatomical snuffbox

Contents

The radial artery is deep while the superficial branch of radial nerve and cephalic vein are superficial.

Clinical Significance

- The pulsations of radial artery can be felt in the anatomical snuff box.
- The tenderness in the anatomical box indicates fracture of scaphoid bone.
- The cephalic vein at the anatomical box can be used for giving intravenous fluids.

***Competency*:**
AN12.14 Identify and describe compartments deep to extensor retinaculum and describe the boundaries and contents of anatomical snuff box.

Extensor Retinaculum

The deep fascia on the back of the wrist is thickened to form the extensor retinaculum, which holds the extensor tendons in place. It is an oblique band directed downwards and medially. It is about 2 cm broad vertically (Plate 9.18, Fig. 9.46).

Attachments

Laterally: Lower part of the sharp *anterior* (crest-like) border of the radius.
Medially:
1. Triquetral
2. Pisiform.

Note: The extensor retinaculum is not attached to the ulna medially, as the distance between the radius and ulna varies with supination and pronation of the forearm.

Compartments

The retinaculum sends down septa, which are attached to the longitudinal ridges on the posterior surface of the lower end of radius. In this way, ***6 osseofascial compartments*** are formed on the back of the wrist. The structures passing through each compartment, from lateral to the medial side, are listed in Table 9.8 and Fig. 9.46.

Each compartment is lined by a synovial sheath, which is reflected in the contained tendons.

TABLE 9.8: Structures in various compartments under extensor retinaculum

Compartment	*Structure*
I	• Abductor pollicis longus • Extensor pollicis brevis
II	• Extensor carpi radialis longus • Extensor carpi radialis brevis
III	• Extensor pollicis longus
IV	• Extensor digitorum • Extensor indicis • Posterior interosseous nerve • Anterior interosseous artery
V	• Extensor digiti minimi
VI	• Extensor carpi ulnaris

DISSECTION

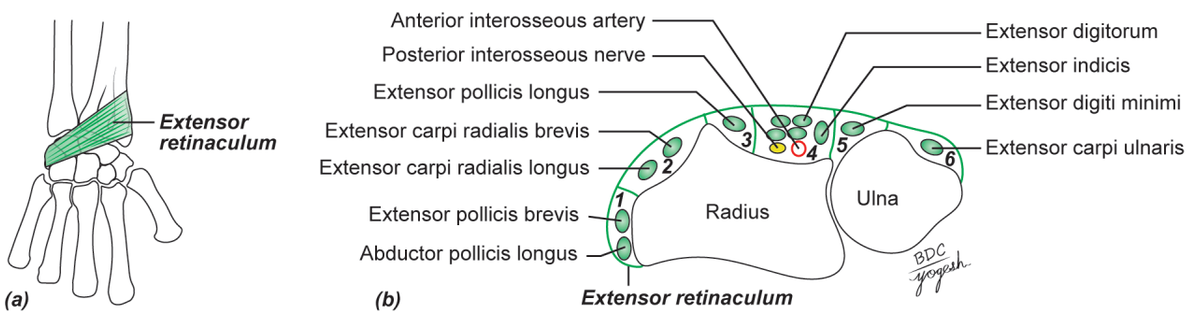
Make the incision in the centre of dorsum of hand. Reflect the skin of dorsum of hand till the respective borders. Reflect the skin of dorsum of middle finger on each side. Look for nerves on the back of forearm and hand. These are superficial branch of radial nerve and dorsal branch of ulnar nerve.

The dorsal venous network is the most prominent component of the superficial fascia of dorsum of hand. (Identify the beginning of cephalic and basilic veins by tying a tourniquet on the forearm and exercising the closed fist on oneself.)

The deep fascia at the back of wrist is thickened to form extensor retinaculum. Define its margins and attachments. Identify the structures traversing its six compartments.

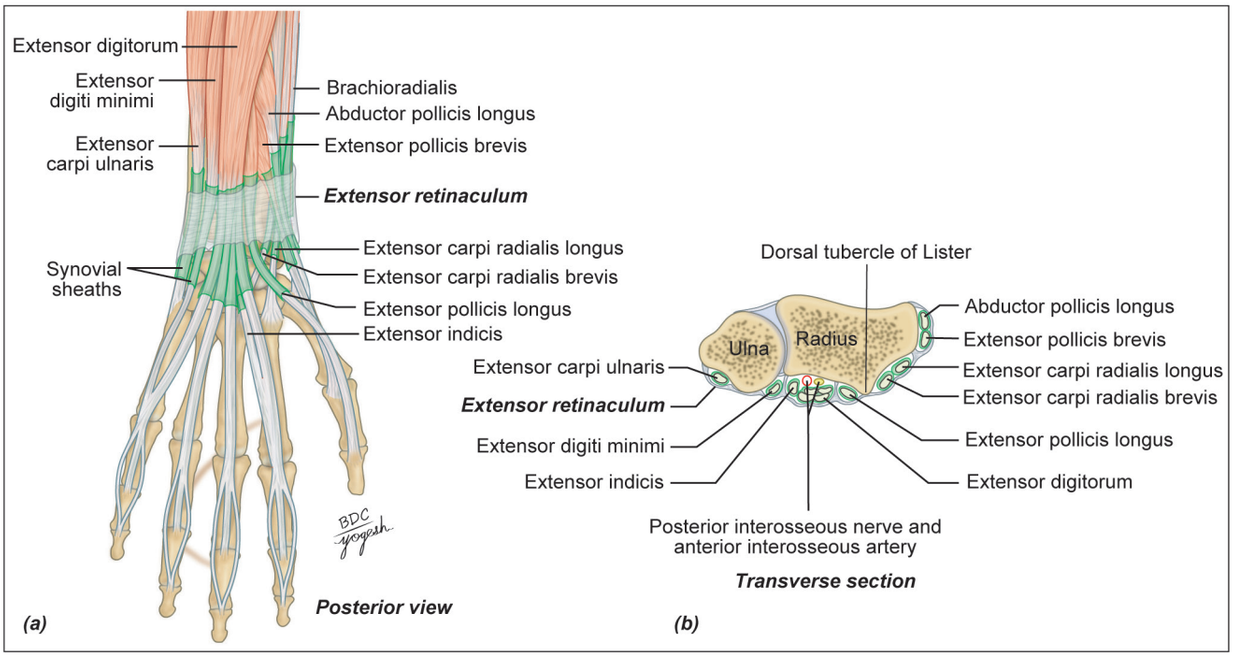
Clear the deep fascia over the back of forearm. Define the attachment of triceps brachii muscle on the olecranon process of ulna. Define the attachments of the seven superficial muscles of the back of the forearm.

Separate the anterolateral muscles, i.e. brachioradialis, extensor carpi radialis longus and brevis from the extensor digitorum lying in the centre and extensor digiti minimi and extensor carpi ulnaris situated on the medial aspect of the wrist (Plates 9.18 and 9.19). Anconeus is situated on the posterolateral aspect of the elbow joint. Dissect all these muscles and trace their nerve supply.



Figs 9.46a and b: (a) Attachments of extensor retinaculum, (b) transverse section passing just above the wrist showing structures passing through 1–6 compartments deep to the extensor retinaculum

Plate 9.18: Extensor retinaculum of forearm



Competency:
AN12.11 Identify, describe and demonstrate important muscle groups of dorsal forearm with attachments, nerve supply and actions.

MUSCLES OF BACK OF FOREARM

SUPERFICIAL MUSCLES

There are seven superficial muscles on the back of the forearm as follows (Plate 9.19, Figs 9.47 and 9.48):

1. Anconeus
2. Brachioradialis
3. Extensor carpi radialis longus
4. Extensor carpi radialis brevis
5. Extensor digitorum
6. Extensor digiti minimi
7. Extensor carpi ulnaris.

All the seven muscles cross the elbow joint. Most of them take origin (entirely or in part) from the tip of the lateral epicondyle of the humerus.

These muscles, with their nerve supply and actions, are described in Tables 9.9 and 9.10.

Additional Points

1. The extensor digitorum and extensor indicis pass through the same compartment of the extensor retinaculum, and have a common synovial sheath.
2. The four tendons of the extensor digitorum emerge from under cover of the extensor retinaculum and fan out over the dorsum of the hand. The tendon to the index finger is joined on its medial side by the tendon of the extensor indicis, and the tendon to the little finger is joined on its medial side by the two tendons of the extensor digiti minimi.

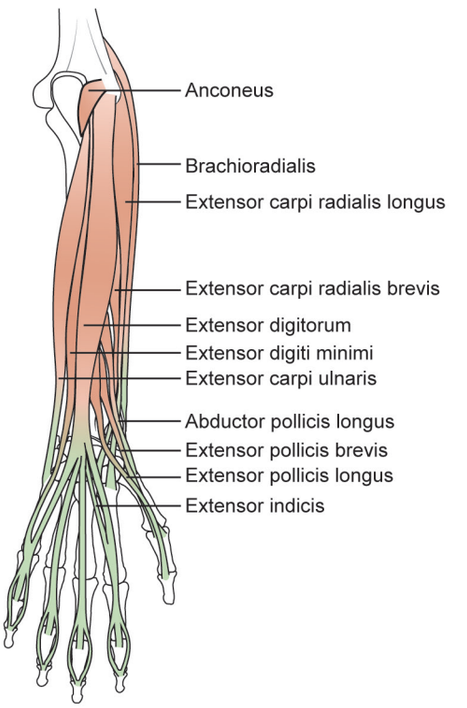
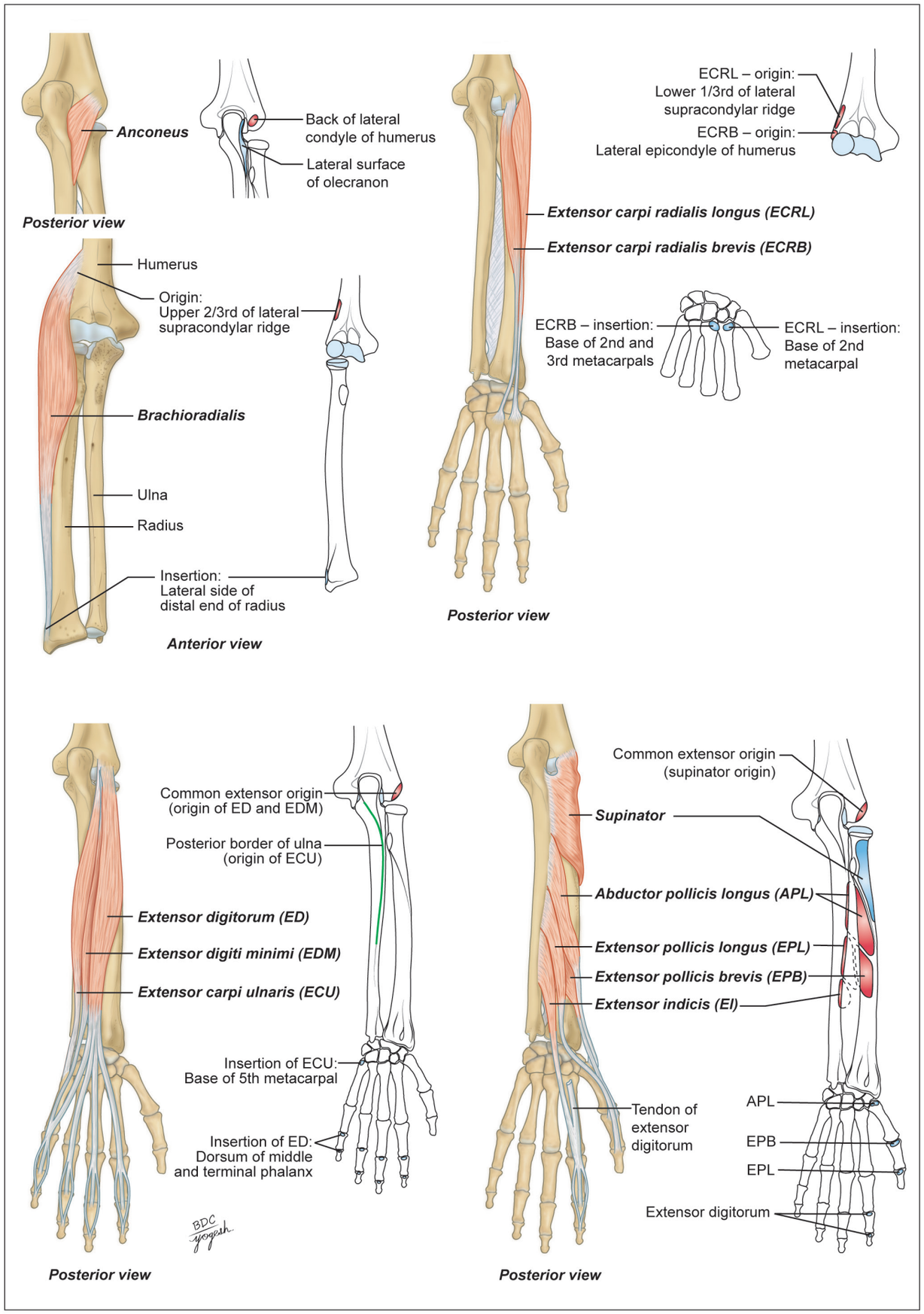


Fig. 9.47: Muscles of the back of forearm

3. On the dorsum of the hand, adjacent tendons are variably connected together by three intertendinous connections directed obliquely downwards and laterally. The medial connection is strong; the lateral connection is weakest and may be absent.

The four tendons and three intertendinous connections are embedded in deep fascia and together form the roof of the subtendinous (subaponeurotic) space on the dorsum of the hand.

Plate 9.19: Muscles of back of forearm



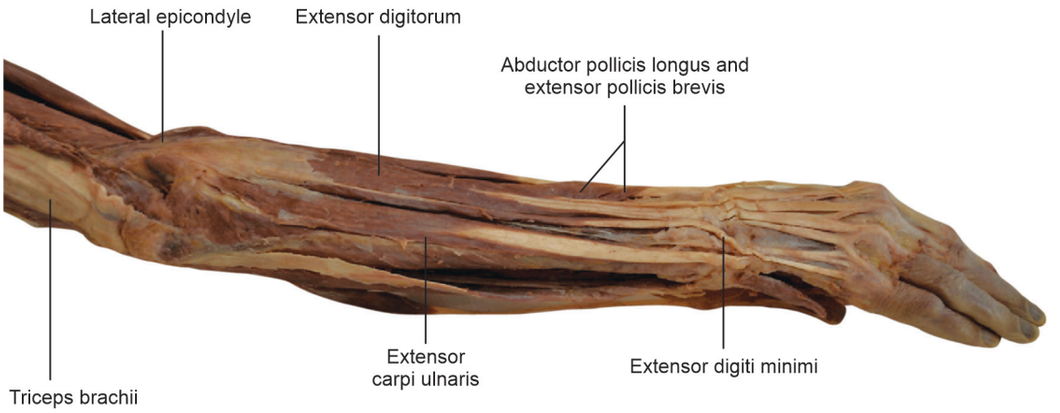


Fig. 9.48: Dissection of back of forearm

TABLE 9.9: Origin and insertion of superficial muscles of back of forearm (Plate 9.19, Figs 9.47 and 9.48)

Muscle	*Origin*	*Insertion*
1. **Anconeus**	Lateral epicondyle of humerus	Lateral surface of olecranon process and upper 1/4th of posterior surface of ulna
2. **Brachioradialis**	Upper 2/3rd of lateral supracondylar ridge of humerus	Lateral surface of radius just above the styloid process
3. **Extensor carpi radialis longus**	Lower 1/3rd of lateral supracondylar ridge of humerus	Posterior surface of base of 2nd metacarpal bone
4. **Extensor carpi radialis brevis**	Lateral epicondyle of humerus	Posterior surface of base of 3rd metacarpal
5. **Extensor digitorum**	Lateral epicondyle of humerus	Bases of middle and distal phalanges of the 2nd–5th digits
6. **Extensor digiti minimi**	Lateral epicondyle of humerus	Extensor expansion of little finger
7. **Extensor carpi ulnaris**	Lateral epicondyle of humerus	Base of 5th metacarpal bone

TABLE 9.10: Nerve supply and actions of superficial muscles of back of forearm

Muscle	*Nerve supply*	*Actions*
1. **Anconeus**	Radial nerve	Extends elbow joint
2. **Brachioradialis**	Radial nerve	Flexes forearm at elbow joint Brings forearm to the midprone position from supine or prone positions
3. **Extensor carpi radialis longus**	Radial nerve	Extends and abducts hand at wrist joint
4. **Extensor carpi radialis brevis**	Deep branch of radial nerve	Extends and abducts hand at wrist joint
5. **Extensor digitorum**	Deep branch of radial nerve	Extends fingers of hand
6. **Extensor digiti minimi**	Deep branch of radial nerve	Extends metacarpophalangeal joint of little finger
7. **Extensor carpi ulnaris**	Deep branch of radial nerve	Extends and adducts hand at wrist joint

DEEP MUSCLES

Features

These are as follows (Plate 9.19, Figs 9.47 and 9.48):

1. Supinator
2. Abductor pollicis longus
3. Extensor pollicis brevis
4. Extensor pollicis longus
5. Extensor indicis

In contrast to the superficial muscles, none of the deep muscles cross the elbow joint. These have been tabulated in Tables 9.11 and 9.12.

Competency:
AN12.15 Identify and describe extensor expansion formation.

Dorsal Digital Expansion/Extensor Expansion

The dorsal digital expansion (extensor expansion) is a small triangular aponeurosis (related to each tendon of the extensor digitorum) covering the dorsum of the proximal phalanx. Its base, which is proximal, covers the metacarpophalangeal (MP) joint. The main tendon of the extensor digitorum occupies the central part of the extension and is separated from the MP joint by a bursa.

TABLE 9.11: Origin and insertion of deep muscles of back of forearm (Plate 9.19, Figs 9.47 and 9.48)

Muscle	*Origin*	*Insertion*
1. **Supinator**	Lateral epicondyle of humerus Annular ligament of superior radioulnar joint Supinator crest of ulna and depression anterior to it	Neck and upper 1/3rd of lateral surface of shaft of radius
2. **Abductor pollicis longus**	Posterior surface of shafts of radius and ulna	Lateral side of base of 1st metacarpal bone
3. **Extensor pollicis brevis**	Posterior surface of shaft of radius and adjoining part of interosseous membrane	Base of proximal phalanx of thumb
4. **Extensor pollicis longus**	Posterior surface of shaft of ulna and adjoining part of interosseous membrane	Base of distal phalanx of thumb
5. **Extensor indicis**	Posterior surface of shaft of ulna and adjoining	Extensor expansion of index finger

TABLE 9.12: Nerve supply and actions of deep muscles of back of forearm

Muscle	*Nerve supply*	*Actions*
1. **Supinator**	Deep branch of radial nerve	Supination of forearm when elbow is extended
2. **Abductor pollicis longus**	Deep branch of radial nerve	Abducts and extends thumb
3. **Extensor pollicis brevis**	Deep branch of radial nerve	Extends metacarpophalangeal joint of thumb
4. **Extensor pollicis longus**	Deep branch of radial nerve	Extends distal phalanx of thumb
5. **Extensor indicis**	Deep branch of radial nerve	Extends metacarpophalangeal joint of index finger

The posterolateral corners of the extensor expansion are joined by tendons of the interossei and lumbrical muscles. The corners are attached to the deep transverse metacarpal ligament. The points of attachment of the interossei (proximal) and lumbrical (distal) are often called '***wing tendons***' (Fig. 9.49).

Near the proximal interphalangeal joint, the extensor tendon divides into a central slip and two collateral slips. The ***central slip*** is joined by some fibres from the margins of the expansion, crosses the proximal interphalangeal joint and is inserted on the dorsum of the base of the middle phalanx. The ***two collateral slips*** are joined by the remaining thick margin of the extensor expansion. They then join each other and are inserted on the dorsum of the base of the distal phalanx.

At the metacarpophalangeal and interphalangeal joints, the extensor expansion forms the dorsal part of the fibrous capsule of the joints.

The retinacular ligaments (link ligaments) extend from the side of the proximal phalanx and form its fibrous flexor sheath to the margins of the extensor expansion to reach the base of the distal phalanx.

Muscles Inserted on Dorsal Expansion

- *Index finger:* 1st dorsal interosseous, 2nd palmar interosseous, 1st lumbrical, extensor digitorum slip and extensor indicis (Fig. 9.49).
- *Middle finger:* 2nd and 3rd dorsal interossei, 2nd lumbrical, extensor digitorum slip.

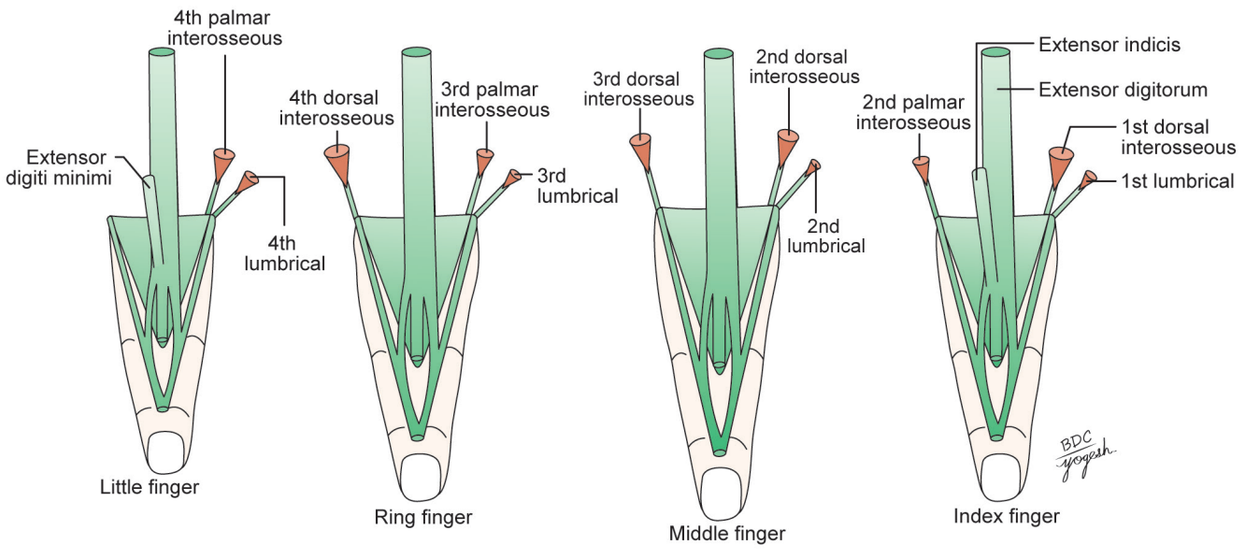


Fig. 9.49: The dorsal digital expansion of right little, ring, middle and index fingers. Note the insertions of the lumbricals and interossei into it

- *Ring finger:* 4th dorsal interosseous, 3rd palmar interosseous, 3rd lumbrical and extensor digitorum slip.
- *Little finger:* 4th palmar interosseous, 4th lumbrical, extensor digitorum slip and extensor digiti minimi.

Functions

1. Dorsal digital expansion is a functional unit that splits the action of muscles, combines the action of muscles and changes the direction of muscles.
2. It helps in flexion at MP joint, extension at IP joint by lumbricals, and also in isolated flexion of proximal and distal IP joints by extensor digitorum.

Clinical Aspects

- *Mallet finger* (baseball finger, cricketers finger or hammer finger): In Mallet finger, a forceful hit over the tip of finger causes sudden, strong flexion of the phalanx that results in avulsion of extensor digitorum tendon from terminal phalanx and inability to do the extension of terminal phalanx.
- *Busch fracture*: Avulsion of base of distal phalanx with tendon of extensor digitorum.

DISSECTION

Separate extensor carpi radials brevis from extensor digitorum and identify deeply placed supinator muscle.

Just distal to supinator is abductor pollicis longus. Other three muscles: Extensor pollicis longus, extensor pollicis brevis and extensor indicis are present distal to abductor pollicis longus. Identify them all.

Competency:
AN12.12 Identify and describe origin, course, relations, branches (or tributaries), termination of important nerves and vessels of back of forearm.

POSTERIOR INTEROSSEOUS NERVE

Features

It is the chief nerve of the back of the forearm. It is a branch of the radial nerve given off in the cubital fossa, just below the level of the lateral epicondyle of the humerus (Plate 9.20, Figs 9.50 and 9.51).

Course

It begins in cubital fossa. It passes through supinator muscle to reach back of forearm, where it descends downwards. It ends in a pseudoganglion in the 4th compartment of extensor retinaculum.

Relations

1. Posterior interosseous nerve leaves the cubital fossa and enters the back of the forearm by passing between the two planes of fibres of the supinator. Within the muscle, it winds backwards around the lateral side of the radius (Fig. 9.50).

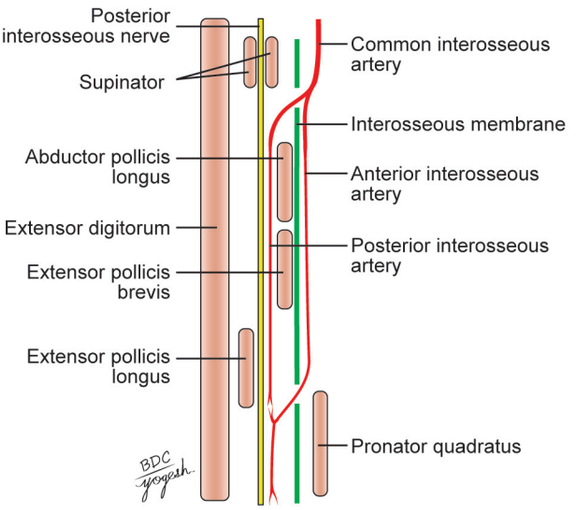


Fig. 9.50: Course and relations of the posterior interosseous nerve and the interosseous arteries

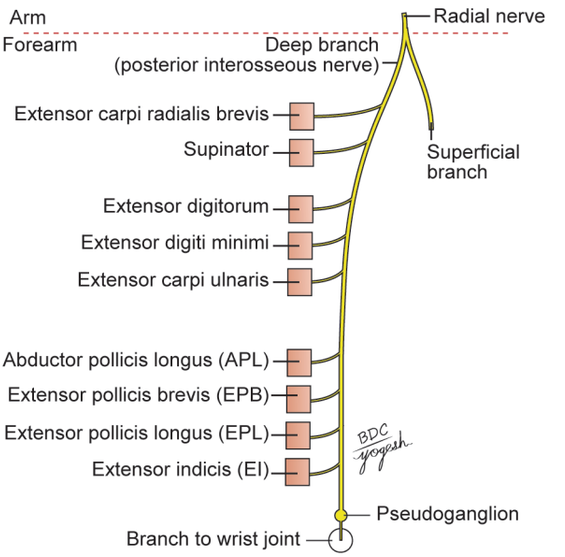


Fig. 9.51: Branches of the posterior interosseous nerve

2. It emerges from the supinator on the back of the forearm. Here, it lies between the superficial and deep muscles. At the lower border of the extensor pollicis brevis, it passes deep to the extensor pollicis longus. It then runs on the posterior surface of the interosseous membrane up to the wrist, where it enlarges into a *pseudoganglion* and ends by supplying the wrist and intercarpal joints.

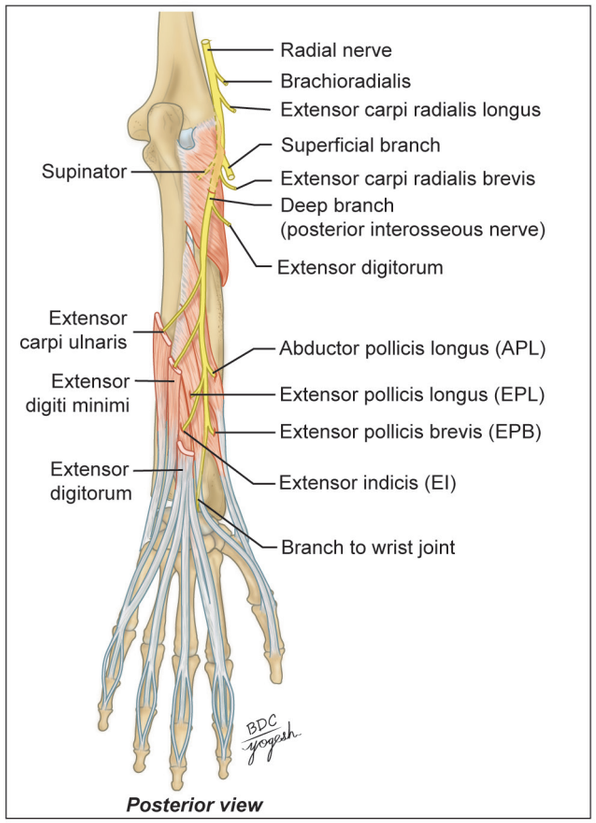
Branches

The posterior interosseous nerve gives muscular, articular and sensory branches (Fig. 9.51).

A. ***Muscular branches***

- Before piercing the supinator, branches are given to the extensor carpi radialis brevis and to the supinator.
- While passing through the supinator, another branch is given to the supinator.

Plate 9.20: Branches of radial nerve in forearm



- After emerging from the supinator, the nerve gives three short branches to:
  1. Extensor digitorum (Fig. 9.51)
  2. Extensor digiti minimi
  3. Extensor carpi ulnaris
- It also has two long branches:
  1. A lateral branch supplies the abductor pollicis longus and the extensor pollicis brevis.
  2. A medial branch supplies the extensor pollicis longus and the extensor indicis.

B. ***Articular branches:*** Articular branches are given to:
1. Wrist joint
2. Distal radioulnar joint
3. Intercarpal and intermetacarpal joints

C. ***Sensory branches:*** Sensory branches are given to the interosseous membrane, the radius and the ulna.

DISSECTION

The deep terminal branch of radial nerve/posterior interosseous nerve and posterior interosseous artery: Identify the posterior interosseous nerve at the distal border of exposed supinator muscle. Trace its branches to the various muscles.

Look for the radial nerve in the lower lateral part of front of arm between the brachioradialis, extensor carpi radialis longus laterally and brachialis muscle medially. Trace the two divisions of this nerve in the lateral part of the cubital fossa. The deep branch (posterior interosseous nerve) traverses between the two planes of supinator muscle and reaches the back of the forearm where it is already identified.

The nerve runs amongst the muscles of the back of the forearm, and ends at the level of the wrist in a pseudoganglion (Fig. 9.51).

This nerve is accompanied by posterior interosseous artery distal to the supinator muscle. This artery is supplemented by anterior interosseous artery in lower one-fourth of the forearm.

POSTERIOR INTEROSSEOUS ARTERY

Course

Posterior interosseous artery is the smaller terminal branch of the common interosseous, given off in the cubital fossa.

It enters the back of the forearm and lies in between the muscles there. It terminates by anastomosing with the anterior interosseous artery.

Relations

1. It is the smaller terminal branch of the common interosseous artery in the cubital fossa.
2. It enters the back of the forearm by passing between the oblique cord and the upper margin of the interosseous membrane (Fig. 9.50).
3. It appears on the back of the forearm in the interval between the supinator and the abductor pollicis longus and thereafter accompanies the posterior interosseous nerve. At the lower border of the extensor indicis, the artery becomes markedly reduced and ends by anastomosing with the anterior interosseous artery, which reaches the posterior compartment by piercing the interosseous membrane at the upper border of the pronator quadratus. Thus, in its lower 1/4th, the back of the forearm is supplied by the anterior interosseous artery.
4. The posterior interosseous artery gives off an ***interosseous recurrent branch,*** which runs upwards and takes part in the anastomosis on the back of the lateral epicondyle of the humerus (*see* Fig. 8.11).

VIDEO

Video 1.9.1 Forearm: Superficial and deep muscles of front of forearm, Nerves and blood vessels of forearm, Back of forearm.

Video 1.9.2 Palm: Flexor retinaculum, muscles of thenar and hypothenar eminence, Blood vessels and nerves of the palm, Ulnar artery, Ulnar nerve, Median nerve, Muscles and tendons in the palm.

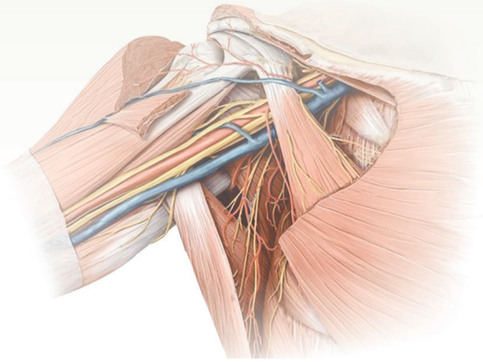
Facts to Remember

- Median nerve exits the cubital fossa by passing between two heads of pronator teres while ulnar artery passes deep to both the heads of pronator teres.

- Anterior interosseous branch of median nerve supplies 2½ muscles of front of the forearm, i.e. flexor pollicis longus, pronator quadratus and lateral half of flexor digitorum profundus.
- Flexor retinaculum has a superficial slip medially and a deep slip laterally. Deep to superficial slip course ulnar nerve and vessels and superficial to the deep slip passes the tendon of flexor carpi radialis.
- Thenar eminence *does not* include the adductor pollicis muscle. It comprises abductor pollicis brevis, flexor pollicis brevis and opponens pollicis.
- Median nerve supplies 5 muscles in the palm, three muscles of thenar eminence and 1st and 2nd lumbricals. It is called '*labourer's nerve*'. Median nerve is also the '*Eye of the hand or peripheral eye*'.
- Ulnar nerve is called '*Musician's nerve*'. It supplies 15 intrinsic muscles of the hand.
- There are 12 muscles on the back of forearm, two are smaller (supinator and anconeus) lying in upper 1/4th of the forearm, five are inserted close to the wrist (BR, APL, ECRL, ECRB and ECU); five get inserted into the phalanges (EPB, EPL, EI, ED and EDM). All are supplied by radial or posterior interosseous nerve. Injury to the nerve causes '*wrist drop*'.
- Lateral 3½ nail beds are supplied by median nerve and medial 1½ nail beds by ulnar nerve.

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1. Arches of hand
2. Kanavel's sign
3. Cleland and Grayson ligament
4. Handlebar neuropathy
5. Froment's sign
6. Movements of thumb
7. Muscles of posterior compartment of forearm
8. Dorsal digital expansion and mallet finger
9. Sectional anatomy of the forearm and palm
10. Nerves and vessels of forearm and palm
11. Further reading
12. Viva voce questions



Chapter

10

Joints of Upper Limb

Joints are sites where two or more bones or cartilages articulate. The bones of upper limb form the following joints:

1. Sternoclavicular joint
2. Acromioclavicular joint
3. Shoulder joint
4. Elbow joint
5. Radioulnar joints (superior, middle and inferior)
6. Wrist joint
7. Intercarpal joints
8. Carpometacarpal joints
9. Metacarpophalangeal joints
10. Interphalangeal joints (proximal and distal).

Shoulder joint is the most freely mobile joint. Shoulder joint gets excessive mobility at the cost of its own stability. The carrying angle in relation to elbow joint is to facilitate carrying objects like buckets without hitting the pelvis.

Supination and pronation are basic movements for the survival of human being. During pronation, the food is picked and by supination it is put at the right place—the mouth. The first carpometacarpal joint allows movements of opposition of thumb with the fingers for picking up or holding things.

SHOULDER GIRDLE

The shoulder girdle connects the upper limb to the axial skeleton. It consists of the clavicle and the scapula. Anteriorly, the clavicle reaches the sternum and articulates with it at the *sternoclavicular joint*. The clavicle and the scapula are united to each other at the *acromioclavicular joint*. The scapula is not connected to the axial skeleton directly, but is attached to it through muscles.

Competency:

AN13.4 Describe sternoclavicular joint, acromioclavicular joint, carpometacarpal joints and metacarpophalangeal joint.

STERNOCLAVICULAR JOINT

Features

Type

The sternoclavicular joint is a *synovial joint of saddle variety*. It is a *compound joint* as there are three elements taking part in it; namely the medial end of the clavicle, the clavicular notch of the manubrium sterni, and the upper surface of the first costal cartilage. It is a *complex joint* as its cavity is subdivided into two compartments—superomedial and inferolateral by an intra-articular disc (Fig. 10.1).

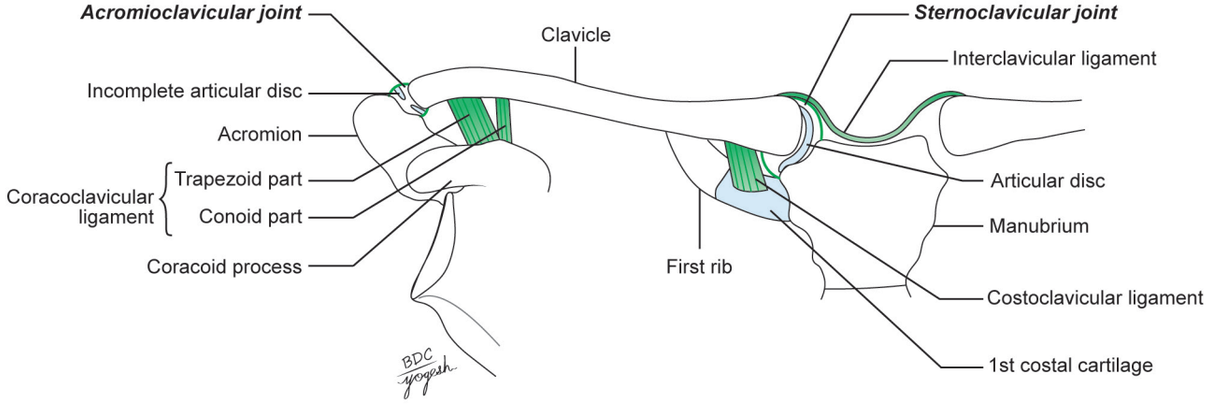


Fig. 10.1: The sternoclavicular and acromioclavicular joints

Articular Surfaces

The *articular surface* of the clavicle is covered with fibrocartilage (as the clavicle is a membrane bone). The surface is convex from above downwards and slightly concave from front to back. The sternal surface is smaller than the clavicular surface. It has a reciprocal convexity and concavity. Due to the concavo-convex shape of the articular surfaces, the joint can be classified as a saddle joint.

Ligaments

1. The *capsular ligament* is attached laterally to the margins of the clavicular articular surface and medially to the margins of the articular areas on the sternum and on the first costal cartilage.
2. The capsular ligament is strong anteriorly and posteriorly where it constitutes the ***anterior and posterior sternoclavicular ligaments***.
3. The ***interclavicular ligament*** passes between the sternal ends of the right and left clavicles, some of its fibres being attached to the upper border of the manubrium sterni (Plate 10.1, Fig. 10.1).
4. The ***costoclavicular ligament*** is attached above to the rough area on the inferior aspect of the medial end of the clavicle. Inferiorly, it is attached to the first costal cartilage and to the first rib. It consists of anterior and posterior laminae.

Note: The main bond of union at this joint is the ***articular disc***. The disc is attached laterally to the clavicle on a rough area above and posterior to the articular area for the sternum. Inferiorly, the disc is attached to the sternum and to the first costal cartilage at their junction. Anteriorly and posteriorly, the disc fuses with the capsule.

Blood Supply

Internal thoracic and suprascapular arteries.

Nerve Supply

Medial supraclavicular nerve.

Movements

Movements of the sternoclavicular joint are elevation/depression, protraction/retraction, and anterior and posterior rotation of the clavicle. The anterior and posterior rotation of clavicle is utilised in overhead movements of the shoulder girdle.

DISSECTION

Remove the subclavius muscle from 1st rib at its attachment with its costal cartilage. Identify the costoclavicular ligament. Define the sternoclavicular joint and clean the anterior and superior surfaces of the capsule of this joint. Cut carefully through the joint to expose the intra-articular disc positioned between the clavicle and the sternum. The fibrocartilagenous disc divides the joint cavity into superomedial and inferolateral compartments.

ACROMIOCLAVICULAR JOINT

Features

Type

The acromioclavicular joint is a *plane synovial joint*.

Articular Surfaces

It is formed by articulation of small facets present:

1. At the lateral end of the clavicle.
2. On the medial margin of the acromion process of the scapula.

The facets are covered with fibrocartilage. The cavity of the joint is subdivided by an articular disc, which may have perforation in it (Plate 10.1, Fig. 10.1).

Ligaments

1. The bones are held together by a *fibrous capsule* and by the articular disc.
2. The main bond of union between the scapula and the clavicle is the *coracoclavicular ligament* (Fig. 10.1). The ligament consists of two parts—conoid and trapezoid. The *trapezoid part* is attached below to the upper surface of the coracoid process and above to the trapezoid line on the inferior surface of the lateral part of the clavicle. The *conoid part* is attached, below to the root of the coracoid process just lateral to the scapular notch. It is attached above to the inferior surface of the clavicle on the conoid tubercle.

Blood Supply

Suprascapular and thoracoacromial arteries.

Nerve Supply

Lateral supraclavicular nerve.

Movements

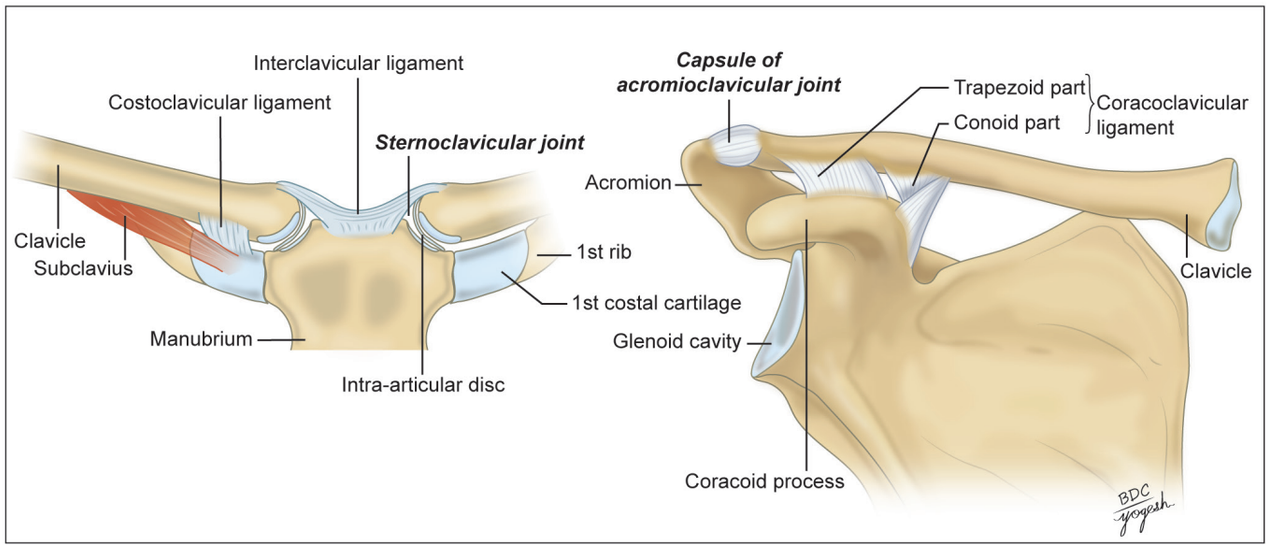
The movements of the acromioclavicular joints permit the movements of the shoulder joint specially the overhead abduction at shoulder.

Ligaments of the Scapula

1. ***Coracoacromial ligament*** (Fig. 10.1): It is a triangular ligament, the apex of which is attached to the tip of the acromion process, and the base to the lateral border of the coracoid process.

   The acromion process, the coracoacromial ligament, and the coracoid process together form the *coracoacromial arch*, which is known as the secondary socket of the joint and protects the head of the humerus.
2. ***Suprascapular ligament:*** It converts the scapular notch into a foramen. The suprascapular nerve passes below the ligament, and the suprascapular artery and vein above the ligament (Fig. 10.2).
3. ***Spinoglenoid ligament:*** It is a weak band that bridges the spinoglenoid notch. The suprascapular nerve and vessels pass beneath the arch to enter the infraspinous fossa (Fig. 10.2).

Plate 10.1: Sternoclavicular and acromioclavicular joints



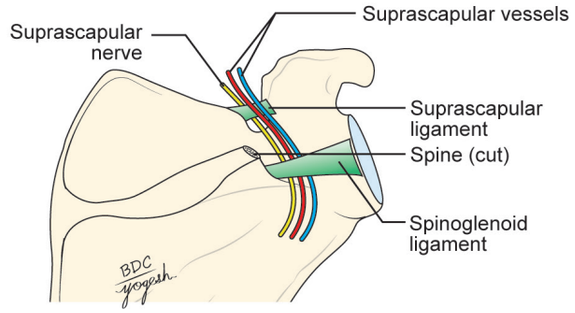


Fig. 10.2: The suprascapular and spinoglenoid ligaments

CLINICAL ANATOMY

- ***Dislocation of clavicle*:** The clavicle may be dislocated at either of its ends. At the medial end, it is usually dislocated forwards. Backward dislocation is rare as it is prevented by the costoclavicular ligament.

  The main bond of union between the clavicle and the manubrium is the articular disc. Apart from its attachment to the joint capsule, the disc is also attached above to the medial end of the clavicle, and below to the manubrium. This prevents the sternal end of the clavicle from tilting upwards when the weight of the arm depresses the acromial end (Fig. 10.1).

  The clavicle dislocates upwards at the acromioclavicular joint because the clavicle overrides the acromion process.
- ***Weight transmission*:** The weight of the limb is transmitted from the scapula to the clavicle through the coracoclavicular ligament, and from the clavicle to the sternum through the sternoclavicular joint. Some of the weight also passes to the first rib by the costoclavicular ligament. The clavicle usually fractures between these two ligaments (Fig. 10.1).

DISSECTION

Remove the muscles attached to the lateral end of clavicle and acromial process of scapula. Define the articular capsule surrounding the joint. Cut through the capsule to identify the intra-articular disc. Look for the strong coracoclavicular ligament.

***Competency*:**
AN10.12 Describe and demonstrate shoulder joint for—type, articular surfaces, capsule, synovial membrane, ligaments, relations, movements, muscles involved, blood supply, nerve supply and applied anatomy.

SHOULDER JOINT

Type

The shoulder joint is a synovial joint of ball and socket variety.

Articular Surface

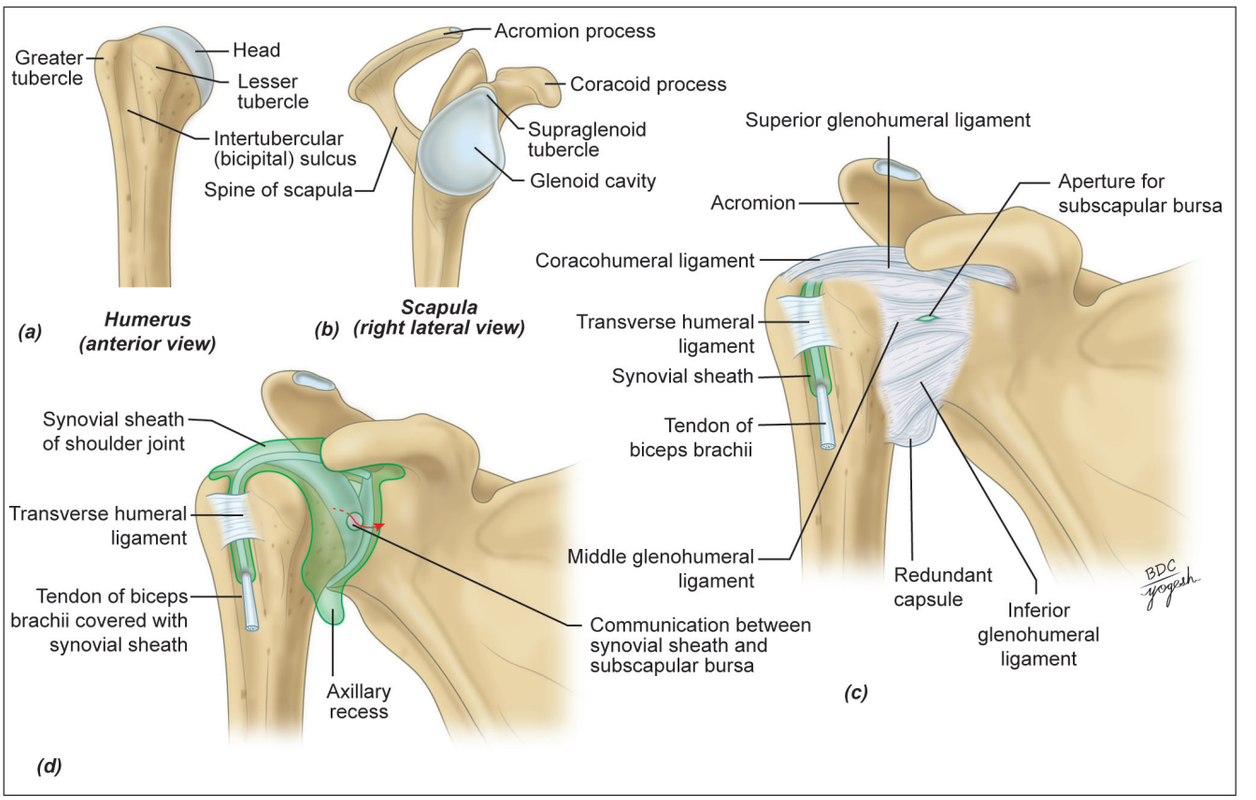
The joint is formed by articulation of the ***glenoid cavity of scapula*** and the ***head of the humerus*** (Plate 10.2, Fig. 10.3, Flowchart 10.1). Therefore, it is also known as the *glenohumeral articulation*. Structurally, it is a weak joint because the glenoid cavity is too small and shallow to hold the head of the humerus in place (the head is four times the size of the glenoid cavity). However, this arrangement permits great mobility.

Factors Maintaining Stability of Shoulder Joint

Stability of the joint is maintained by the following factors.

1. The coracoacromial arch or secondary socket for the head of the humerus.
2. The musculotendinous cuff of the shoulder formed by expansions from tendons of subscapularis (anteriorly);

Plate 10.2: Shoulder joint: Articular surfaces, ligaments and synovial membrane



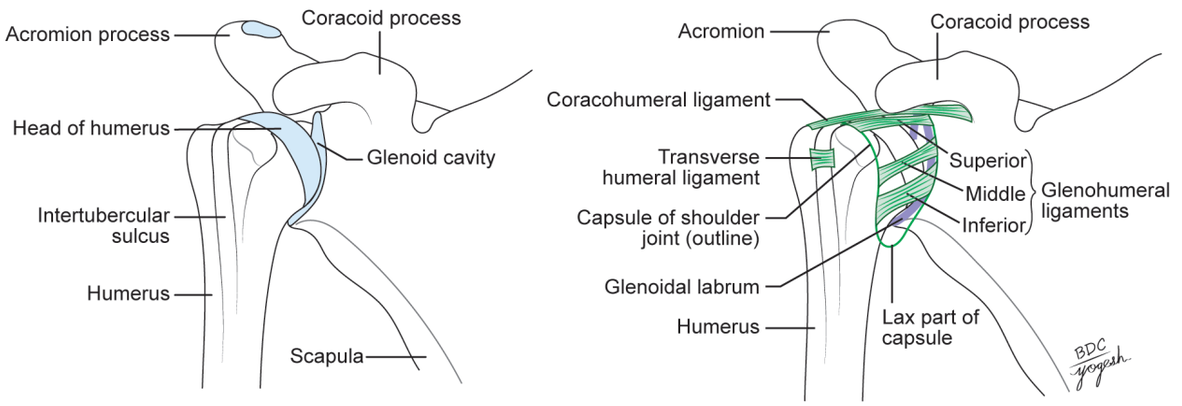


Fig. 10.3: Articular surfaces and ligaments of shoulder joint

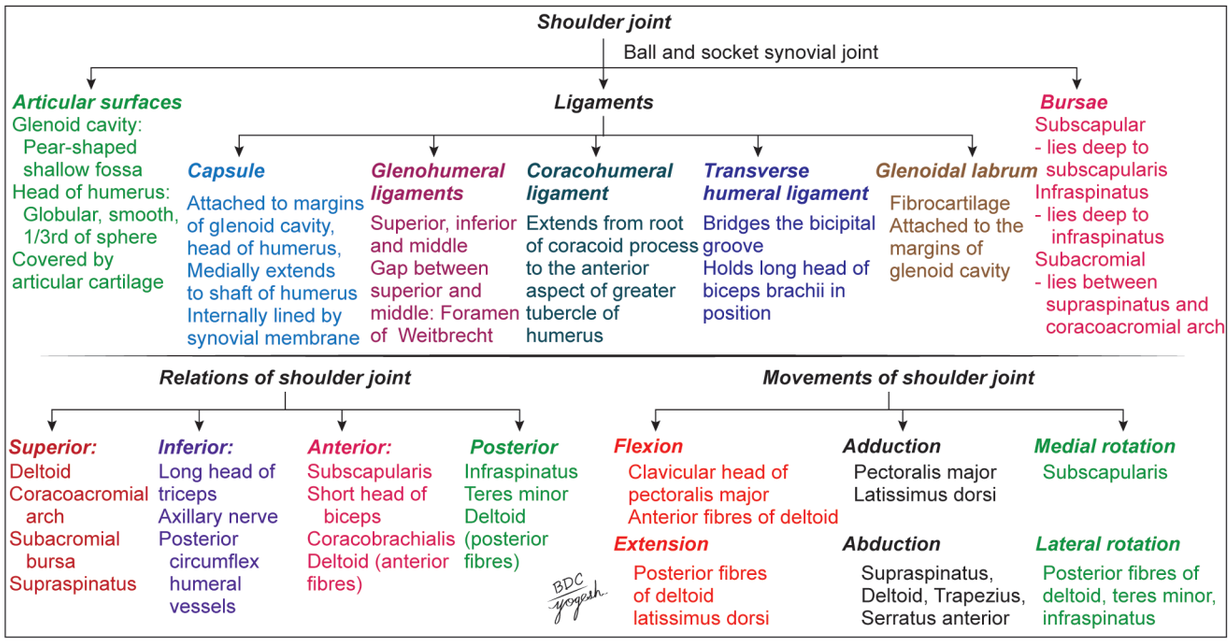
supraspinatus (above) and infraspinatus and teres minor (posteriorly).

3. The glenoidal labrum (Latin *lip*) helps in deepening the glenoid fossa.
4. Stability is also provided by the muscles attaching the humerus to the pectoral girdle, the long head of the biceps brachii, and the long head of the triceps brachii.
5. Atmospheric pressure also stabilises the joint.

Ligaments

1. ***Capsular ligament:*** It is very loose and permits free movements. It is least supported inferiorly where dislocations are common. Such a dislocation may damage the closely related axillary nerve.
   - Medially, the capsule is attached to the scapula beyond the supraglenoid tubercle and the margins of the labrum.
   - Laterally, it is attached to the anatomical neck of the humerus with the following exceptions.
     - Inferiorly, the attachment extends down to the surgical neck.
     - Superiorly, it is deficient for passage of the tendon of the long head of the biceps brachii (Plate 10.2).

Flowchart 10.1: Shoulder joint



- Anteriorly, the capsule is reinforced by supplemental bands called the superior, middle, and inferior glenohumeral ligaments (Fig. 10.3). The area between the superior and middle glenohumeral ligament is a point of weakness in the capsule (foramen of Weitbrecht) which is a common site of anterior dislocation of humeral head.
- The capsule is lined with *synovial membrane*. An extension of this membrane forms a tubular sheath for the tendon of the long head of the biceps brachii.

2. ***Coracohumeral ligament:*** It extends from the root of the coracoid process to the neck of the humerus opposite the greater tubercle. It gives strength to the capsule.
3. ***Transverse humeral ligament:*** It bridges the upper part of the bicipital groove of the humerus (between the greater and lesser tubercles). The tendon of the long head of the biceps brachii passes deep to the ligament.
4. ***Glenoidal labrum:*** It is a fibrocartilaginous rim which covers the margins of the glenoid cavity, thus increasing the depth of the cavity.

Bursae Related to the Joint

1. The *subacromial (subdeltoid) bursa* (Plate 10.3, Fig. 10.4).
2. The *subscapular bursa*—communicates with the joint cavity.
3. The *infraspinatus bursa*—may communicate with the joint cavity.

The subacromial and the subdeltoid bursae are commonly continuous with each other but may be

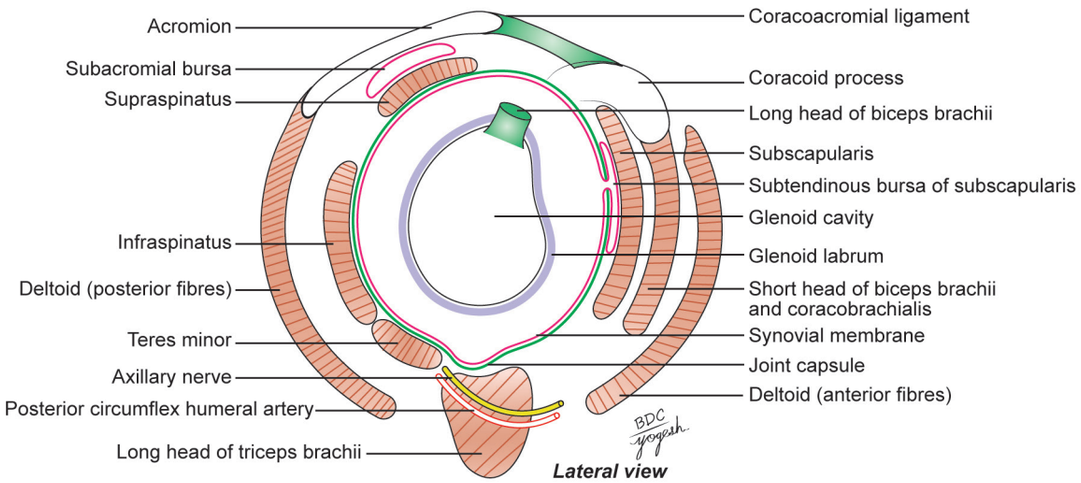
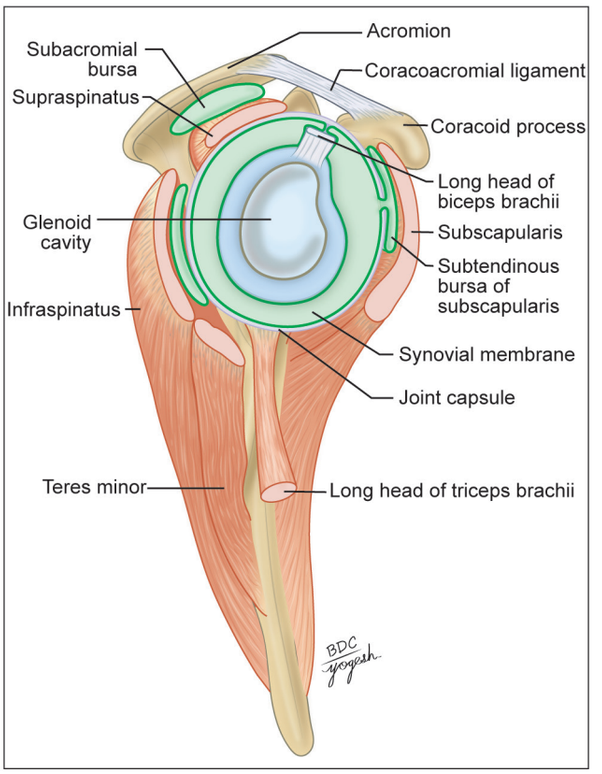


Fig. 10.4: Relations of shoulder joint (sagittal section)

Plate 10.3: Relations of shoulder joint



separate. Collectively they are called the subacromial bursa, which separates the acromion process and the coracoacromial ligaments from the supraspinatus tendon and permits smooth motion. Any failure of this mechanism can lead to inflammatory conditions of the supraspinatus tendon.

Relations

Superiorly:	Coracoacromial arch, subacromial bursa, supraspinatus and deltoid (Plate 10.3, Fig. 10.4).
Inferiorly:	Long head of the triceps brachii, axillary nerve and posterior circumflex humeral artery.
Anteriorly:	Subscapularis, coracobrachialis, short head of biceps brachii and deltoid.
Posteriorly:	Infraspinatus, teres minor and deltoid.
Within the joint:	Tendon of the long head of the biceps brachii.

Blood Supply

1. Anterior circumflex humeral vessels
2. Posterior circumflex humeral vessels
3. Suprascapular vessels
4. Subscapular vessels.

Nerve Supply

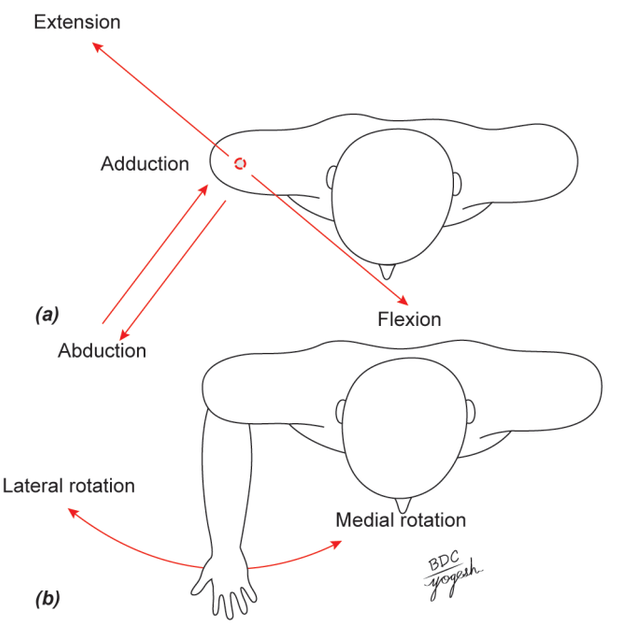
1. Axillary nerve
2. Musculocutaneous nerve
3. Suprascapular nerve.

Movements of Shoulder Joint

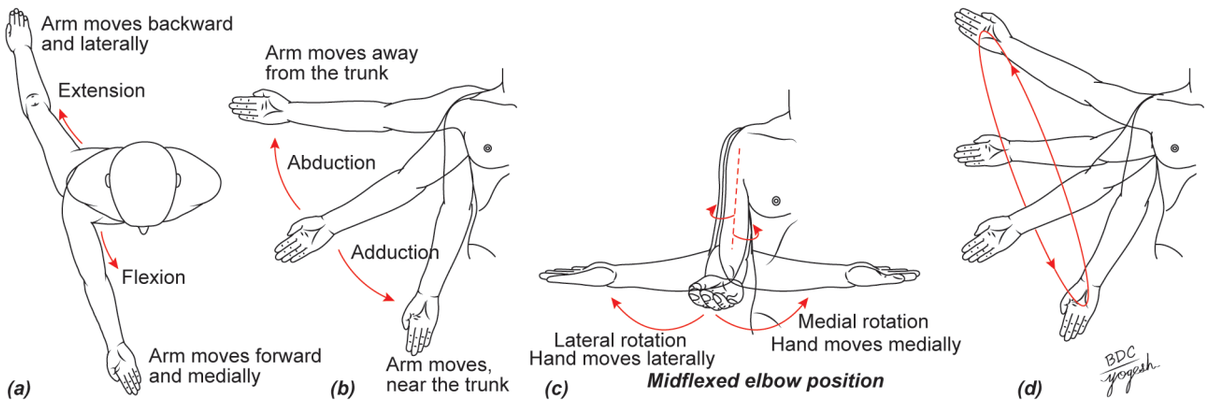
The shoulder joint enjoys great freedom of mobility at the cost of stability. The following movements take place at the shoulder joint (Figs 10.5 and 10.6):

1. ***Flexion and extension:*** During flexion, the arm moves forwards and medially, and during extension, the arm moves backwards and laterally. Thus, flexion and extension take place in a plane parallel to the surface of the glenoid cavity (Fig. 10.5).
2. ***Abduction and adduction*** take place at right angles to the plane of flexion and extension, i.e. approximately midway between the sagittal and coronal planes. In abduction, the arm moves anterolaterally away from the trunk. This movement is in the same plane as that of the body of the scapula (Fig. 10.5).
3. ***Medial and lateral rotations*** are best demonstrated with a mid-flexed elbow. In this position, the hand is moved medially across the chest either in front or behind the chest in medial rotation, and laterally in lateral rotation of the shoulder joint (Fig. 10.5).
4. ***Circumduction*** is a combination of different movements as a result of which the hand moves along a circle. The range of any movement depends on the availability of an area of free articular surface on the head of the humerus.
5. ***Scapulohumeral rhythm:*** In abduction of arm, two movements take place simultaneously as follows:
   a. Abduction of glenohumeral (shoulder) joint,
   b. Rotation of scapula. For every 2° abduction of shoulder joint, 1° rotation of scapula takes place. This is called scapulohumeral rhythm.

Muscles bringing about movements at shoulder joint are shown in Table 10.1.



Figs 10.5a and b: Planes of movements of the shoulder joint: (a) Flexion, extension, abduction, adduction and (b) medial and lateral rotations



Figs 10.6a to d: Movements of the shoulder joint: (a) Flexion and extension, (b) abduction and adduction, (c) medial rotation and lateral rotation, and (d) circumduction

TABLE 10.1: Muscles bringing about movements at the shoulder joint

Movements	*Main muscles*	*Accessory muscles*
1. Flexion	• Clavicular head of the pectoralis major • Anterior fibres of deltoid	• Coracobrachialis • Short head of biceps brachii
2. Extension	• Posterior fibres of deltoid • Latissimus dorsi	• Teres major • Long head of triceps brachii • Sternocostal head of the pectoralis major
3. Adduction	• Pectoralis major • Latissimus dorsi	• Teres major • Coracobrachialis • Short head of biceps brachii • Long head of triceps brachii
4. Abduction	• Both supraspinatus and deltoid muscles initiate abduction and are involved throughout the range of abduction from 0°–90°. • Serratus anterior 90°–180° • Upper and lower fibres of trapezius 90°–180°	—
5. Medial rotation	• Subscapularis	• Pectoralis major • Anterior fibres of deltoid • Latissimus dorsi • Teres major
6. Lateral rotation	• Posterior fibres of deltoid	• Infraspinatus • Teres minor
7. Circumduction	• Combination of most of the above muscles	

DISSECTION

Identify the muscles attached to the greater, and lesser tubercles of humerus. Deep to the acromion process look for the subacromial bursa.

Identify coracoid process, acromion process and triangular coracoacromial arch binding these two bones together.

Trace the supraspinatus muscle from supraspinous fossa of scapula to the greater tubercle of humerus. On its way, it is intimately fused to the capsule of the shoulder joint. In the same way, tendons of infraspinatus and teres minor also fuse with the posterior part of the capsule.

Inferiorly, trace the tendon of long head of triceps brachii from the infraglenoid tubercle of scapula.

Cut through the subscapularis muscle at the neck of scapula. It also gets fused with the anterior part of capsule of the shoulder joint as it passes to the lesser tubercle of humerus. Having studied the structures related to shoulder joint, the capsule of the joint is to be opened. A vertical incision is given in the posterior part of the capsule of the shoulder joint. The arm is rotated medially and laterally. This helps in head of humerus getting separated from the shallow glenoid cavity.

Inside the capsule, the shining tendon of long head of biceps brachii is visible as it traverses the intertubercular sulcus to reach the supraglenoid tubercle of scapula. This tendon also gets continuous with the labrum glenoidale attached to the rim of glenoid cavity.

CLINICAL ANATOMY

- ***Dislocation of shoulder joint:*** The shoulder joint is more prone to dislocation than any other joint. This is due to laxity of the capsule and the disproportionate area of the articular surfaces. Dislocation may be anterior or posterior. Anterior dislocation is more common and usually occurs when the arm is abducted. In this position, the head of the humerus presses against the lower unsupported part of the capsular ligament. Thus, almost always, the dislocation is primarily subglenoid. Dislocation endangers the axillary nerve, which is closely related to the lower part of the joint capsule (Fig. 10.7).
- ***Optimum attitude:*** In order to avoid ankylosis, many diseases of the shoulder joint are treated in an optimum position of the joint. In this position, the arm is abducted by 45°–90°.
- ***Aspiration of shoulder joint:*** The shoulder joint is most commonly approached (surgically) from the front. However, for aspiration, the needle may be introduced either anteriorly through the deltopectoral triangle (closer to the deltoid) or laterally just below the acromion process (Fig. 10.8).
- ***Frozen shoulder:*** This is a common occurrence. Pathologically, there is fibroelastic proliferation in the capsule that leads to formation of adhesions and consequent stiffness and pain on attempted movements. Clinically, the patient (usually 40–60 years of age) complains of progressively increasing pain in the shoulder, stiffness in the joint, and restriction of all movements, particularly external rotation, abduction, and medial rotation.
- The surrounding muscles show disuse atrophy. The disease is self-limiting and the patient may recover spontaneously in about two years and much earlier by physiotherapy.
- ***Calcific tendinitis of shoulder:*** It results from:
  a. inflammation and calcification of subacromial bursa —called calcific *scapulohumeral bursitis*
  b. calcified supraspinatus tendon causing *subacromial bursitis*.
- ***Glenoidal labrum tears:*** It occurs commonly in athletes with shoulder instability. It results in painful movements of the shoulder joint.

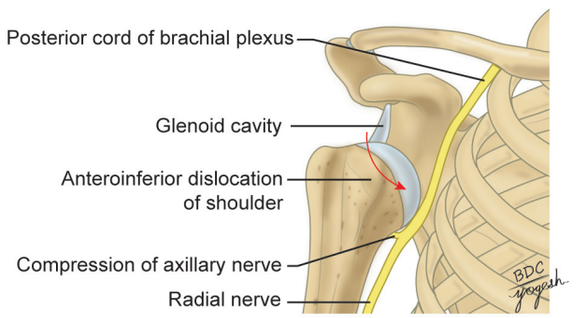


Fig. 10.7: Dislocation of shoulder joint (right, anterior view)

- ***Shoulder tip pain:*** Irritation of the peritoneum underlying diaphragm from any surrounding pathology causes referred pain in the shoulder. This is so because the phrenic nerve carrying impulses from peritoneum and the supraclavicular nerves (supplying the skin over the shoulder) both arise from spinal segments C3, C4 (Fig. 10.9).

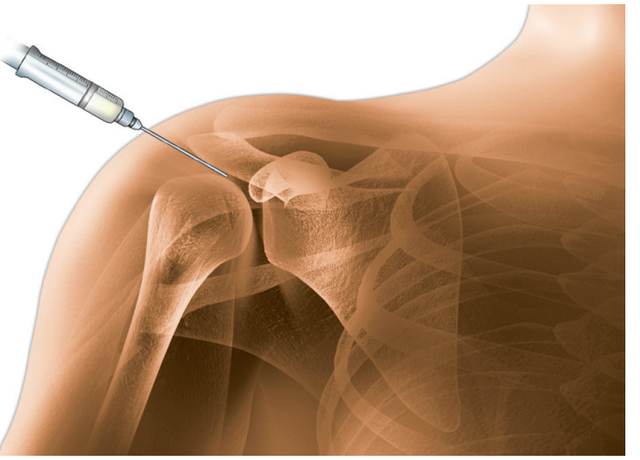


Fig. 10.8: Site of aspiration of shoulder joint

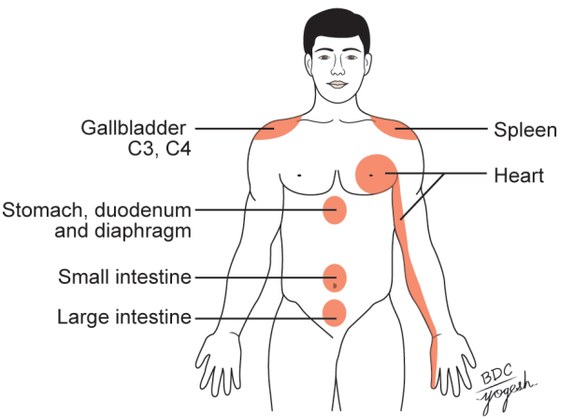


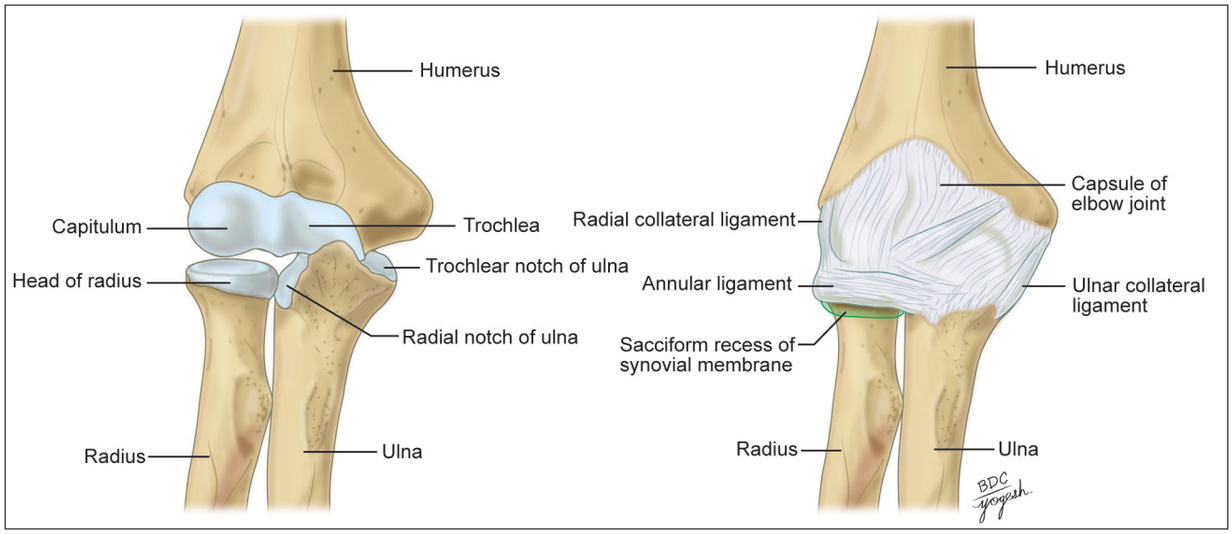
Fig. 10.9: Shoulder tip pain. Other sites of referred pain

Competency:
AN13.3 Identify and describe the type, articular surfaces, capsule, synovial membrane, ligaments, relations, movements, blood and nerve supply of elbow joint, proximal and distal radioulnar joints, wrist joint and first carpometacarpal joint.

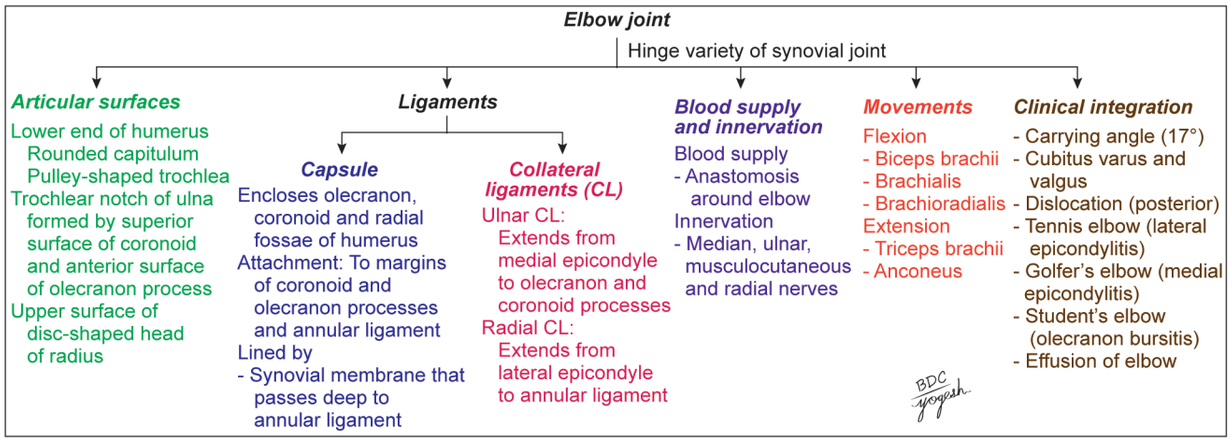
ELBOW JOINT

The elbow joint is a joint between the lower end of humerus and the upper ends of radius and ulna bones. Elbow joint is the term used for *humeroradial* and *humeroulnar joints*. The term elbow complex also includes the superior radioulnar joint also (Plate 10.4, Fig. 10.10, Flowchart 10.2).

Plate 10.4: Elbow joint: Articular surfaces and capsular ligament



Flowchart 10.2: Elbow joint



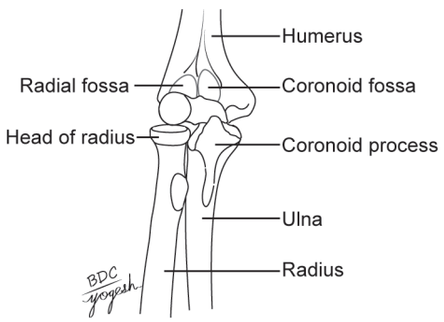


Fig. 10.10: Elbow joint: Articular surfaces

Type

The elbow joint is a *hinge* variety of synovial joint. It is also a *compound joint* as more than one bone participate in the joint formation (humerus, radius, and ulna).

Articular Surfaces

Upper

The ***capitulum and trochlea of the humerus***. The *coronoid fossa* lies just above the trochlea and is designed in a manner that the coronoid process of ulna fits into it in extreme flexion. Similarly, the *radial fossa* just above the capitulum allows for radial head fitting in the radial fossa in extreme flexion.

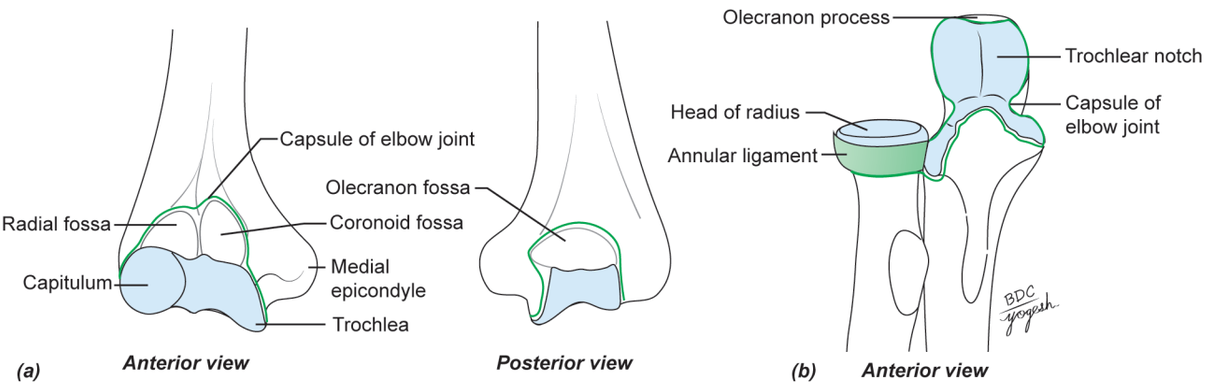
Lower

1. Upper surface of the ***head of the radius*** articulates with the capitulum.
2. ***Trochlear notch of the ulna*** articulates with the trochlea of the humerus.

The elbow joint is continuous with the superior radioulnar joint. The humeroradial, the humeroulnar, and the superior radioulnar joints are together known as ***cubital articulations***.

Ligaments

1. ***Capsular ligament:*** *Superiorly*, it is attached to the lower end of the humerus in such a way that the capitulum, the trochlea, the radial fossa, the coronoid fossa, and the olecranon fossa are intracapsular. *Inferomedially*, it is attached to the margin of the trochlear notch of the ulna except laterally; *inferolaterally*, it is attached to the

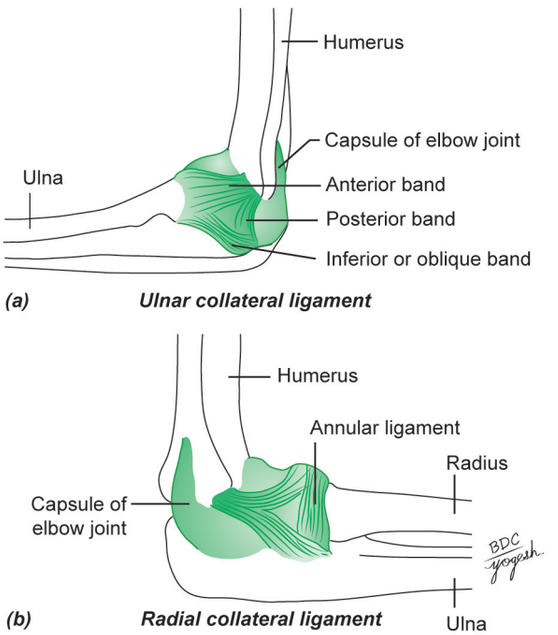


Figs 10.11a and b: Attachment of the capsular ligament

annular ligament of the superior radioulnar joint. The synovial membrane lines the capsule and the fossae, named above (Plate 10.4, Figs 10.11a and b).

The *anterior ligament* and the *posterior ligament* are thickenings of the capsule.

2. ***Ulnar collateral ligament*** is triangular in shape (Fig. 10.12a). Its apex is attached to the medial epicondyle of the humerus, and its base to the ulna. The ligament has thick anterior and posterior bands: These are attached below to the coronoid process and the olecranon process, respectively. Their lower ends are joined to each other by an oblique band which gives attachment to the thinner intermediate fibres of the ligament. The ligament is crossed by the *ulnar nerve* and it gives origin to the flexor digitorum superficialis.
3. ***Radial collateral or lateral ligament:*** It is a fan-shaped band extending from the lateral epicondyle to the annular ligament. It gives origin to the supinator and to the extensor carpi radialis brevis (Fig. 10.12b).



Figs 10.12a and b: (a) Ulnar collateral ligament, (b) radial collateral ligament

Relations

Anteriorly: Brachialis, median nerve, brachial artery, and tendon of biceps brachii (Fig. 10.13).

Posteriorly: Triceps brachii and anconeus.

Medially: Ulnar nerve, flexor carpi ulnaris and common flexors.

Laterally: Supinator, extensor carpi radialis brevis and other common extensors.

Bursae Related to Elbow Joint

- Elbow joint is supported with the following bursae (Fig. 10.14):
  1. ***Olecranon bursae:***
     a. *Subcutaneous olecranon bursa:* It lies between skin and posterior triangular surface of the olecranon.
     b. *Subtendinous olecranon bursa*: It lies between the tendon of triceps brachii and superior surface of olecranon process of ulna.
  2. ***Bicipitoradial bursa:*** It lies between the tendon of biceps brachii and anterior smooth part of radial tuberosity.

Blood Supply

From anastomoses around the elbow joint (*see* Fig. 8.11).

Nerve Supply

The joint receives branches from the following nerves:

1. Ulnar nerve
2. Median nerve
3. Radial nerve
4. Musculocutaneous nerve through its branch to the brachialis.

Movements

1. Flexion is brought about by:
   - Brachialis
   - Biceps brachii
   - Brachioradialis.

[*Mnemonics:* Busy Bees Buzz: **B**rachialis, **B**iceps brachii, **B**rachioradialis.]

2. Extension is produced by:
   - Triceps brachii
   - Anconeus.

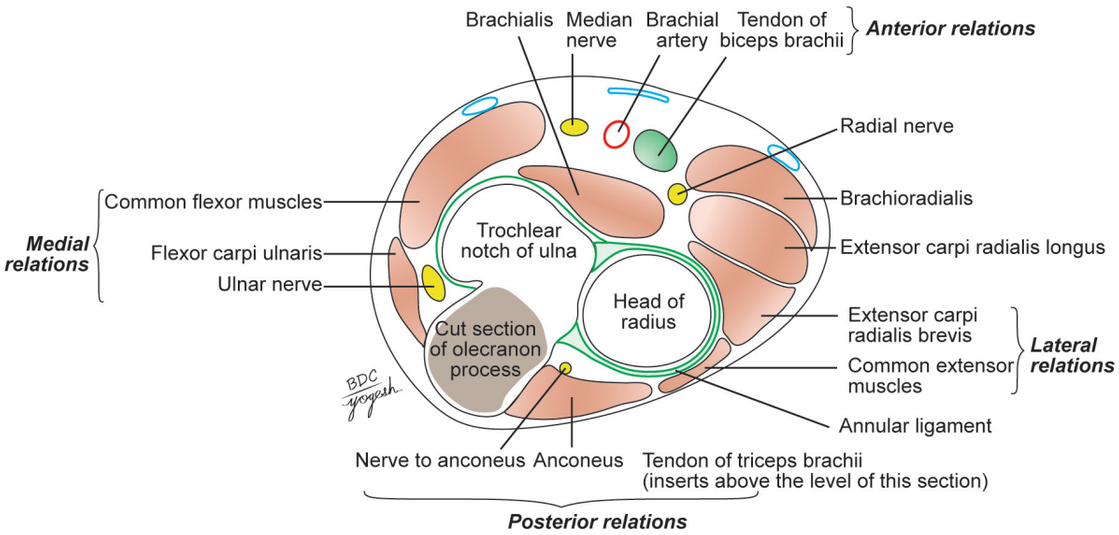


Fig. 10.13: Relations of elbow joint (superior view, section passing through the cavity of elbow joint)

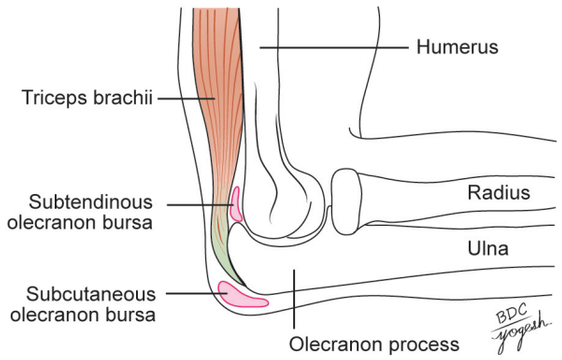


Fig. 10.14: Bursae related to elbow joint

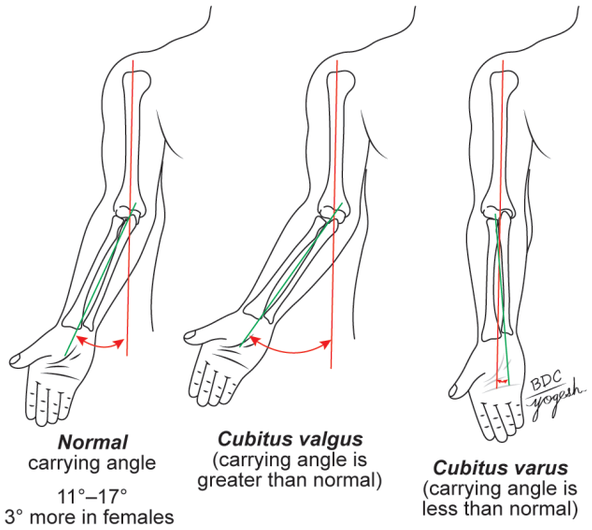


Fig. 10.15: Carrying angle, cubitus varus and cubitus valgus

Carrying Angle

Definition: In extended forearm, carrying angle is the angle of deviation of long axis of forearm from the long axis *of arm* (Fig. 10.15).

Anatomical basis: The transverse axis of the elbow joint is directed medially and downwards. Because of this, the extended forearm is not in straight line with the arm, but makes an angle of about 13° with it. This is known as the *carrying angle*.

The factors responsible for formation of the carrying angle are as follows:

1. The medial flange of the trochlea is 6 mm deeper than the lateral flange.
2. The superior articular surface of the coronoid process of the ulna is placed oblique to the long axis of the bone.

Normal carrying angle is 11°–17°. Carrying angle varies from individual to individual. It is 3° more in females than in males.

The carrying angle disappears in full flexion of the elbow, and also during pronation of the forearm. The forearm comes in line with the arm in the midprone position, and this is the position in which the hand is mostly used. This arrangement of gradually increasing carrying angle during extension of the elbow increases the precision with which the hand (and objects held in it) can be controlled.

DISSECTION

Cut through the muscles arising from the lateral and medial epicondyles of humerus and reflect them distally, if not already done. Also cut through biceps brachii, brachialis, and triceps brachii 3 cm proximal to the elbow joint and reflect them distally. Remove all the muscles fused with the fibrous capsule of the elbow joint and define its attachments.

CLINICAL ANATOMY

- ***Elbow effusion:*** Distension of the elbow joint by an effusion occurs posteriorly because here the capsule is weak and the covering deep fascia is thin. Aspiration is done posteriorly on any side of the olecranon process (Fig. 10.16).
- ***Dislocation* of the elbow** is usually posterior, and is often associated with fracture of the coronoid process. The triangular relationship between the olecranon process and the two humeral epicondyles is lost.
- ***Pulled elbow*:** *Subluxation* of the head of the radius (pulled elbow) occurs in children when the forearm is suddenly pulled in pronation. The head of the radius slips out from the annular ligament (*see* Fig. 2.21).
- ***Tennis elbow*** usually occurs in tennis players. It affects individuals whose work profile involves repetitive wrist extension against resistance and twisting activities (Fig. 10.17). This is possibly due to:
  1. Sprain of radial collateral ligament.
  2. Tearing of fibres of the extensor carpi radialis brevis.
  3. Recent researches have pointed out that it is more of a degenerative condition rather than inflammatory condition.
- ***Student's (miner's) elbow*** is characterised by effusion into the bursa over the subcutaneous posterior surface of the olecranon process. Students during lectures support their head (for sleeping) with their hands with flexed elbows. The bursa on the olecranon process gets inflamed (Fig. 10.18).
- ***Golfer's elbow*** is the microtrauma of medial epicondyle of humerus, occurs commonly in golf players. The common flexor origin undergoes repetitive strain and results in a painful condition on the medial side of the elbow (Fig. 10.19).
- ***Cubitus valgus and varus:*** If carrying angle (normal is 11°–17°) is more, the condition is *cubitus valgus*, ulnar nerve may get stretched leading to weakness of intrinsic muscles of hand. If the angle is less, it is called *cubitus varus* (Fig. 10.20).
- *Under* ***optimal position*** *of the elbow*: Generally elbow flexion between 30° and 40° is sufficient to perform common activities of daily living such as eating, combing, dressing, etc. Because of this flexion or extension after a fracture/trauma are able to accomplish these personal tasks without much problems.

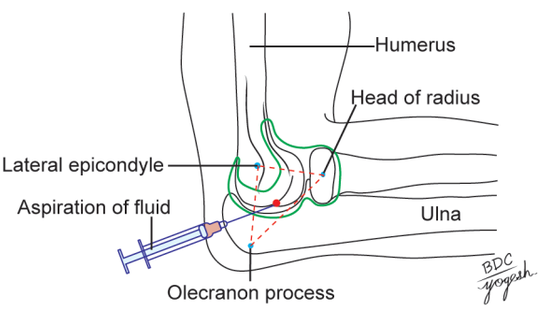


Fig. 10.16: Aspiration of elbow joint

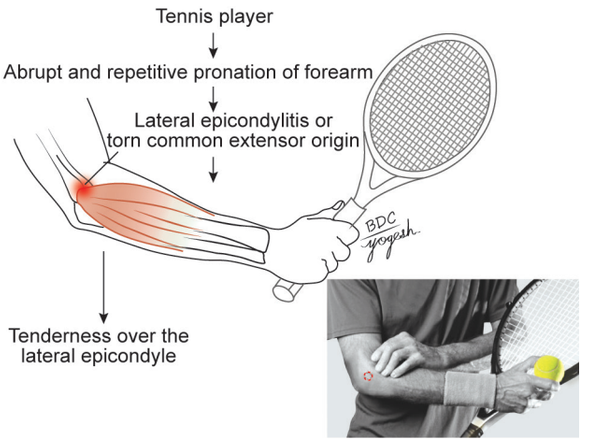


Fig. 10.17: Tennis elbow

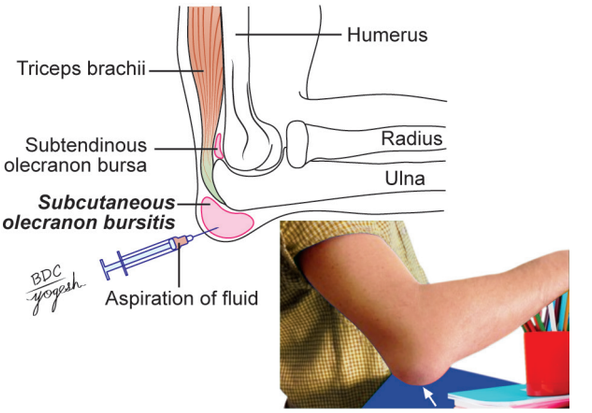


Fig. 10.18: Student's elbow

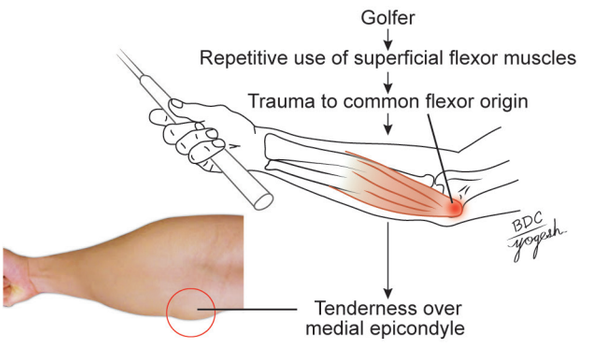


Fig. 10.19: Golfer's elbow

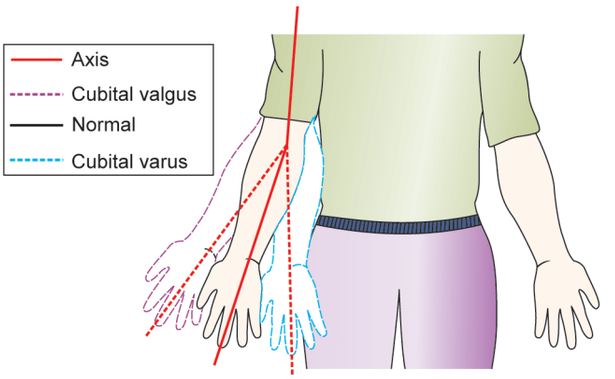


Fig. 10.20: Normal, cubitus valgus, and cubitus varus

RADIOULNAR JOINTS

Features

Radius and ulna articulate with each other at three junctions as follows (Plate 10.5, Flowchart 10.3):

1. *Superior radioulnar joint* (Table 10.2).
2. *Middle radioulnar joint* – formed by interosseous membrane.
3. *Inferior radioulnar joint* (Table 10.2).

INTEROSSEOUS MEMBRANE

The interosseous membrane connects the shafts of the radius and ulna. It is attached to the interosseous borders of these bones. The fibres of the membrane run downwards and medially from the radius to ulna (Plate 10.5, Fig. 10.21).

The two bones are also connected by the ***oblique cord*** which extends from the tuberosity of the ulna to the tuberosity of the radius. The direction of its fibres is opposite to that in the interosseous membrane. The oblique cord represents degenerated part of the flexor pollicis longus muscle.

Features

1. Superiorly, the interosseous membrane begins 2–3 cm below the radial tuberosity. Between the oblique cord and the interosseous membrane, there is a gap for passage of the posterior interosseous vessels to the back of the forearm.
2. Inferiorly, a little above its lower margin, there is an aperture for the passage of the anterior interosseous vessels to the back of the forearm.
3. The anterior surface is related to the flexor pollicis longus, the flexor digitorum profundus, the pronator quadratus, and to the anterior interosseous vessels and nerve.
4. The posterior surface is related to the supinator, the abductor pollicis longus, the extensor pollicis brevis, the extensor pollicis longus, the extensor indicis, the anterior interosseous artery, and the posterior interosseous nerve.

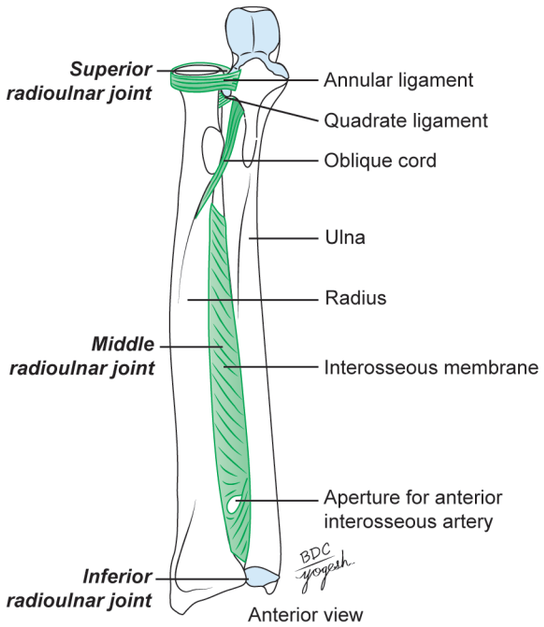


Fig. 10.21: Ligaments of radioulnar joints

Flowchart 10.3: Superior and inferior radioulnar joints

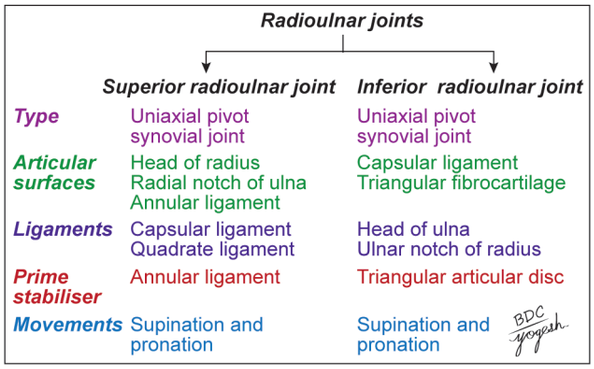
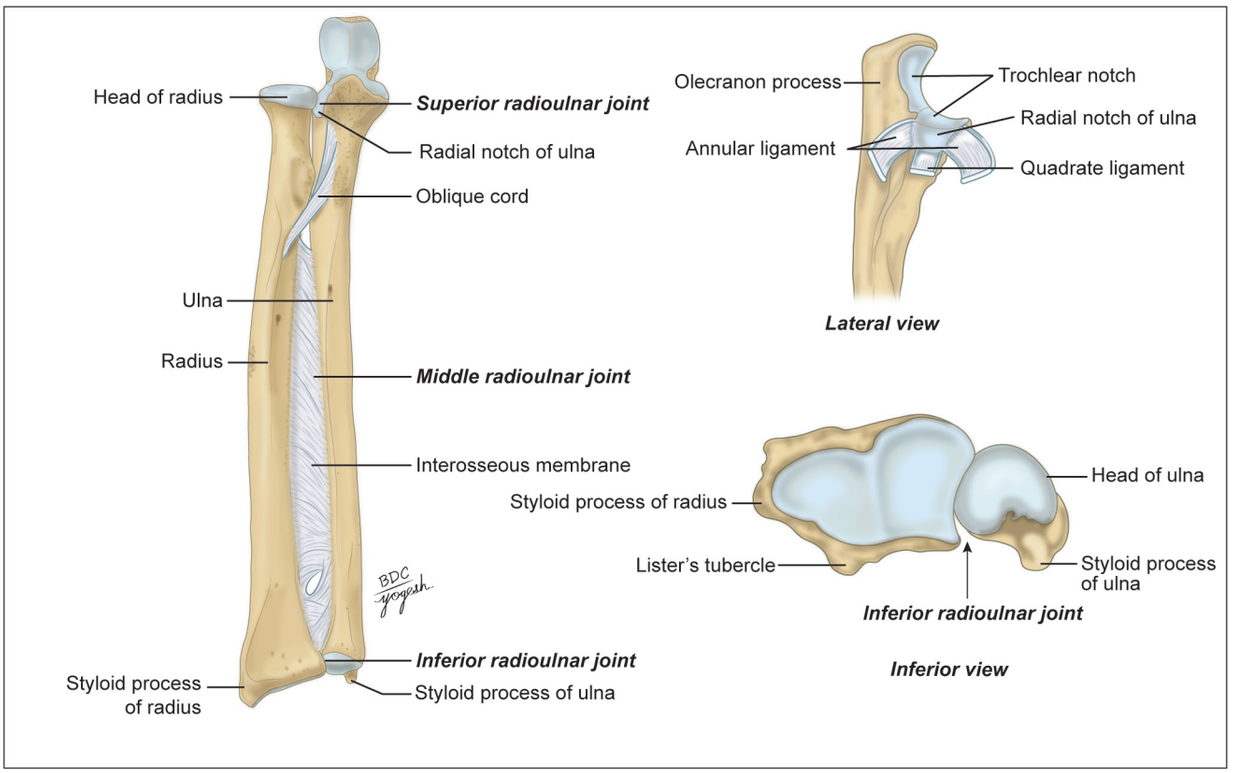


TABLE 10.2: Radioulnar joints (Fig. 10.19)

Features	*Superior radioulnar joint*	*Inferior radioulnar joint*
Type	Pivot type of synovial joint	Pivot type of synovial joint
Articular surfaces	• Circumference of head of radius • Osseofibrous ring, formed by the radial notch of the ulna and the annular ligament	• Head of ulna • Ulnar notch of radius
Ligaments	• The annular ligament forms four-fifths of the ring within which the head of the radius rotates. It is attached to the margins of the radial notch of the ulna, and is continuous with the capsule of the elbow joint above • The quadrate ligament extends from the neck of the radius to the lower margin of the radial notch of the ulna	• The capsule surrounds the joint. The weak upper part is evaginated by the synovial membrane to form a recess (recessus sacciformis) in front of the interosseous membrane • The apex of triangular fibrocartilaginous articular disc is attached to the base of the styloid process of the ulna, and the base to the lower margin of the ulnar notch of the radius (Fig. 10.20)
Blood supply	Anastomoses around the lateral side of the elbow joint	Anterior and posterior interosseous arteries
Nerve supply	Musculocutaneous, median, and radial nerves	Anterior and posterior interosseous nerves
Movements	Supination and pronation	Supination and pronation

Plate 10.5: Radioulnar joint



Functions

The interosseous membrane performs the following functions.

1. It binds the radius and ulna to each other.
2. It provides attachments to many muscles.
3. It transmits forces (including weight) applied to the radius (through the hand) to the ulna. This transmission is necessary as radius is the main bone taking part in the wrist joint, while the ulna is the main bone taking part in the elbow joint.
4. Separates the forearm into flexor and extensor compartments.

MIDDLE RADIOULNAR JOINT

Type: Syndesmosis, joined by interosseous membrane attached to interosseous borders of radius and ulna. It is attached to posterior border of medial surface at lower end of radius.

SUPINATION AND PRONATION

***Definition*:** Supination and pronation are rotatory movements of the forearm/hand around a vertical axis. In a semiflexed elbow, the palm is turned upwards in supination, and downwards in pronation (*kings pronate, beggars supinate*).

***Involved joints*:** The movements are permitted at the superior and inferior radioulnar joints. During pronation, head of radius spins within annular ligament. As radius with the hand comes medially across the lower part of ulna, the interosseous membrane is spiralised. During supination, the membrane is despiralised.

***Axis*:** The vertical axis of movement of the radius passes through the centre of the head of the radius above, and through the ulnar attachment of the articular disc below (Fig. 10.22). However, this axis is not stationary because the lower end of the ulna is not fixed: It moves backwards and laterally during pronation, and forwards and medially during supination. As a result of this movement, the axis (defined above) is displaced laterally in pronation, and medially in supination.

Muscles Responsible

1. Around 50° of supination and 50° of pronation are generally required to perform many of the routine activities, brought about by brachioradialis.
2. *Pronation is brought about* chiefly by the pronator quadratus. It is aided by the pronator teres when the movement is rapid and against resistance. Gravity also helps.
3. *Supination is brought about* by the supinator muscle and the biceps brachii. Slow supination, with elbow extended, is done by the supinator. Rapid supination with the elbow flexed, and when performed against resistance, is done mainly by the biceps brachii. Both the pronators and both the supinators are "inserted into radius". Even brachioradialis performing halfway pronation and supination is "inserted into radius".

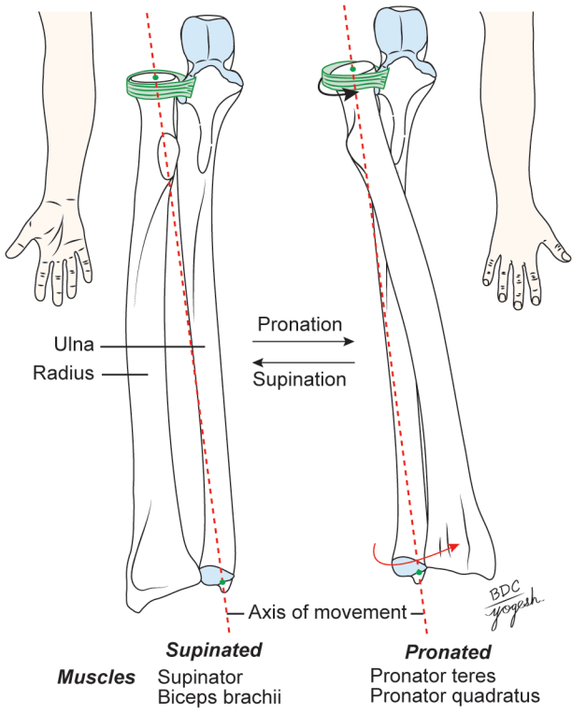


Fig. 10.22: Supination and pronation

Functional utility: Supination is more powerful than pronation because it is an antigravity movement. Supination movements are responsible for all screwing movements of the hand, e.g. as in tightening nuts and bolts. Morphologically, pronation and supination were evolved for picking up food and taking it to the mouth.

CLINICAL ANATOMY

Supination and pronation: During supination, the radius and ulna are parallel to each other. During pronation, radius crosses over the ulna (Fig. 10.22). In synostosis (fusion) of upper end of radius and ulna, pronation is not possible.

DISSECTION

Remove all the muscles covering the adjacent sides of radius, ulna and the intervening interosseous membrane. This will expose the superior and inferior radioulnar joints including the interosseous membrane. Cut through the annular ligament to see the superior radioulnar joint.

Clean and define the interosseous membrane. Lastly cut through the capsule of inferior radioulnar joint to locate the intra-articular fibrocartilaginous disc of the joint. Learn the movements of supination and pronation on dry bones and on yourself.

WRIST (RADIOCARPAL) JOINT

Wrist joint is a joint between lower end of radius and articular disc of inferior radioulnar joint proximally and three lateral bones of proximal row of carpus, i.e. scaphoid, lunate and triquetral distally (Plate 10.6, Flowchart 10.4).

Note: The pisiform does not play a role in the radiocarpal articulation. It is a sesamoid bone acting as a pulley for flexor carpi ulnaris.

Type

Wrist joint is a synovial joint of the ellipsoid variety (biaxial joint). It is *compound* synovial joint as more than two bones participate in the joint formation.

Articular Surfaces

Upper

1. Inferior surface of the lower end of the radius (Fig. 10.23).
2. Articular disc of the inferior radioulnar joint (Fig. 10.23).

Lower

1. Scaphoid
2. Lunate
3. Triquetral bones.

Ligaments (Fig. 10.24)

1. The ***articular capsule*** surrounds the joint. It is attached above to the lower ends of the radius and ulna, and below to the proximal row of carpal bones.
2. The ***palmar radiocarpal ligament*** is a broad band. It begins above from the anterior margin of the lower end of the radius and its styloid process, runs downwards and medially, and is attached below to the anterior surfaces of the scaphoid, the lunate, and triquetral bones.
3. The ***palmar ulnocarpal ligament*** is a rounded fasciculus. It begins above from the base of the styloid process of the ulna and the anterior margin of the articular disc, runs downwards and laterally, and is attached to the lunate and triquetral bones. Both the palmar carpal ligaments are considered to be intracapsular.
4. The ***dorsal radiocarpal ligament*** is weaker than the palmar ligaments. It begins above from the

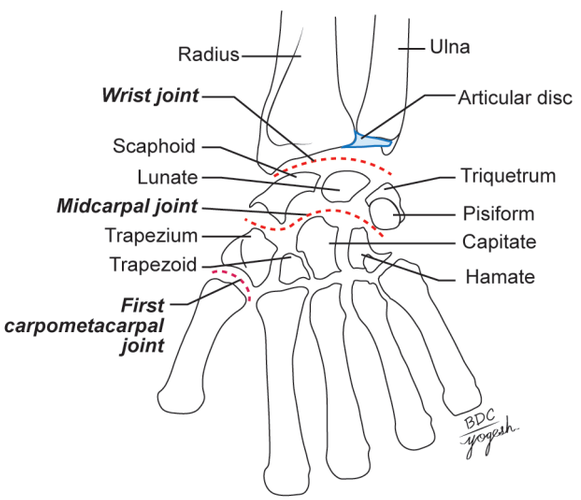
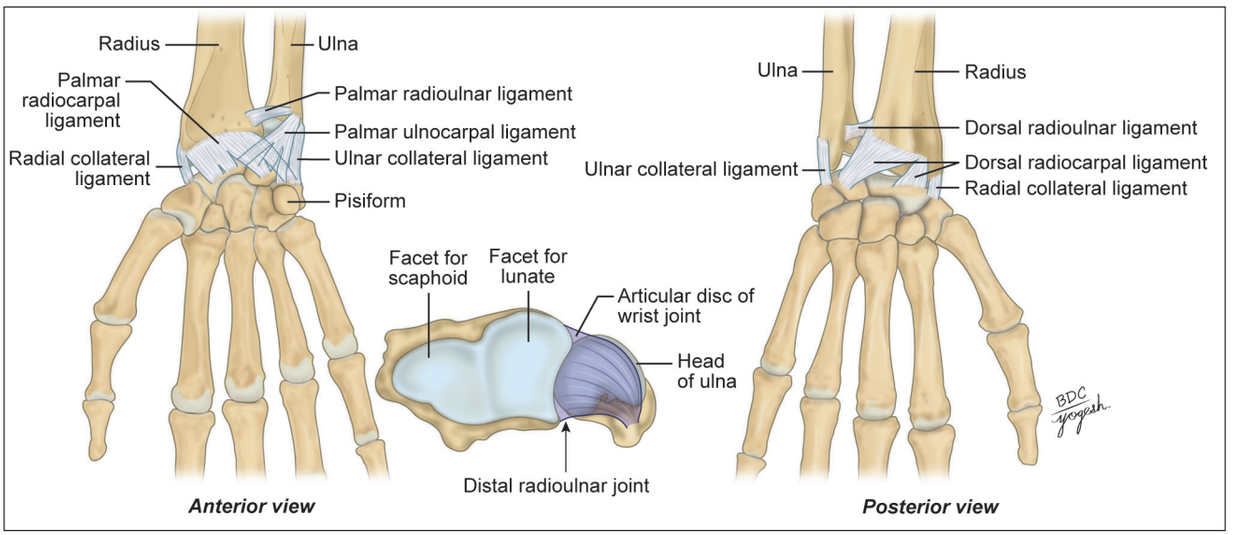
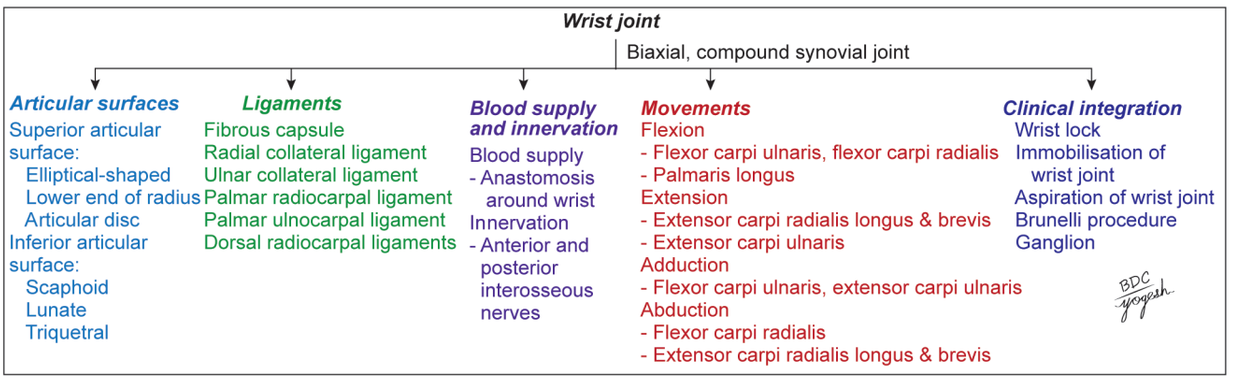


Fig. 10.23: Wrist, midcarpal and 1st carpometacarpal joints

Plate 10.6: Wrist joint: Articular surface and ligaments (Fig. 10.24)



Flowchart 10.4: Wrist joint



posterior margin of the lower end of the radius, runs downwards and medially, and is attached below to the dorsal surfaces of the scaphoid, lunate and triquetral bones (Plate 10.6).

5. The ***radial collateral ligament*** extends from the tip of the styloid process of the radius to the lateral side of the scaphoid bone. It is related to the radial artery.

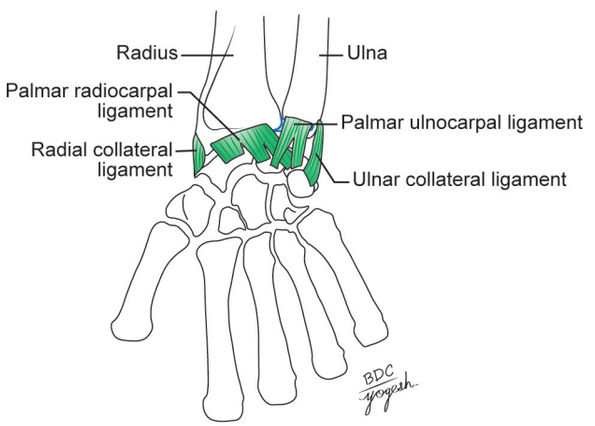


Fig. 10.24: Ligaments of wrist joint

6. The ***ulnar collateral ligament*** extends from the tip of the styloid process of the ulna to the triquetral and pisiform bones. Both the collateral ligaments are poorly developed.

Note: A protrusion of synovial membrane, called the ***recessus sacciformis***, lies in front of the styloid process of the ulna and in front of the articular disc. It is bounded inferiorly by a small meniscus projecting inwards from the ulnar collateral ligament between the styloid process and the triquetral bone.

Relations

Anterior: Long flexor tendons with their synovial sheaths, and median nerve (Fig. 10.25).

Posterior: Extensor tendons of the wrist and fingers with their synovial sheaths (Fig. 10.25).

Lateral: Radial artery (Fig. 10.25).

Blood Supply

Anterior and posterior carpal arches.

Nerve Supply

Anterior and posterior interosseous nerves.

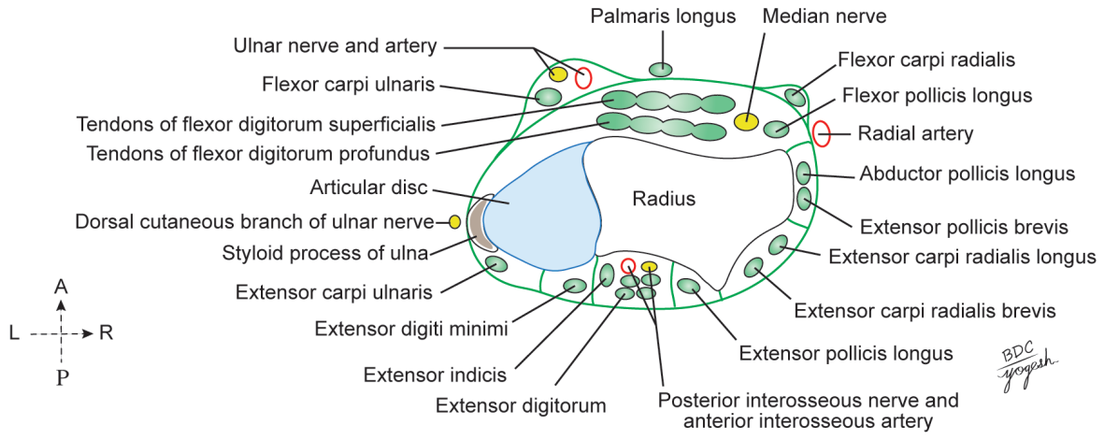


Fig. 10.25: Relations of wrist joint: transverse section passing through the wrist joint

Movements

The wrist joint has the following movements (Fig. 10.26):

1. *Flexion:* It takes place more at the midcarpal than at the wrist joint. The main flexors are:
   - Flexor carpi radialis
   - Flexor carpi ulnaris
   - Palmaris longus.

   The movement is assisted by long flexors of the fingers and thumb (Figs 10.35a and b), and abductor pollicis longus.
2. *Extension:* It takes place mainly at the wrist joint. The main extensors are:
   - Extensor carpi radialis longus
   - Extensor carpi radialis brevis
   - Extensor carpi ulnaris.

   It is assisted by the extensors of the fingers and thumb.
3. *Abduction (radial deviation):* It occurs mainly at the midcarpal joint. The main abductors are:
   - Flexor carpi radialis
   - Extensor carpi radialis longus and extensor carpi radialis brevis
   - Abductor pollicis longus and extensor pollicis brevis.
4. *Adduction (ulnar deviation):* It occurs mainly at the wrist joint. The main adductors are:
   - Flexor carpi ulnaris
   - Extensor carpi ulnaris.
5. *Circumduction:* It is a combination of movements in sequence. All the muscles work in co-ordination. The range of flexion is more than that of extension. Similarly, the range of adduction is greater than abduction (due to the shorter styloid process of ulna).

Note: Movements at the radiocarpal joints are accompanied by movements at the midcarpal joint. The midcarpal joint is anatomically separate from radiocarpal joint.

The joint between the two rows of carpal bones does not have smooth joint line because of multiple small joints. However, it still behaves as a functional unit in all movements of the wrist joint.

In addition to the congruency and the shape of the articular surfaces of radius and carpal bones, the length of the ulna can also affect the amount of motion available at the wrist joint. In the ulnar negative variance, the distal end of ulna is shorter than the radius and vice versa in ulnar positive variance.

CLINICAL ANATOMY

- ***Rheumatoid arthritis***: It is a chronic autoimmune disease that mostly affects joints, causing pain, swelling, stiffness, and loss of function. The wrist joint, metacarpophalangeal joints, and interphalangeal joints are commonly involved in rheumatoid arthritis (Fig. 10.27).
- ***Ganglion***: The back of the wrist is the common site for a ganglion. It is a cystic swelling resulting from mucoid degeneration of synovial sheaths around the tendons (Fig. 10.28).
- ***Aspiration of wrist joint***: The wrist joint can be aspirated from the posterior surface between the tendons of the extensor pollicis longus and the extensor digitorum (Fig. 10.29).
- ***Optimum position:*** The joint is immobilised in optimum position of 30° dorsiflexion (extension).
- Because of the complex nature of the joint and the multiple articulations, any injury to the ligaments attached to the proximal or the distal row of carpal bones may cause subluxation of the carpals ventrally or dorsally, leading to painful condition of the wrist.

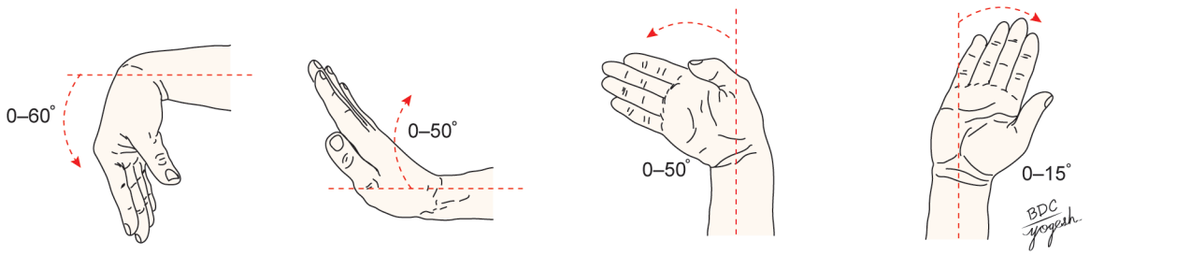
DISSECTION

Cut through the thenar and hypothenar muscles from their origins and reflect them distally.

Separate the flexor and extensor retinacula of the wrist from the bones.

Cut through flexor and extensor tendons (if not already done) and reflect them distally.

Define the capsular attachments and ligaments and relations of the wrist joint.



Flexion
Flexor carpi radialis
Flexor carpi ulnaris
Palmaris longus

Extension
Extensor carpi radialis longus
Extensor carpi radialis brevis
Extensor carpi ulnaris

Adduction
Flexor carpi ulnaris
Extensor carpi ulnaris

Abduction
Flexor carpi radialis
Extensor carpi radialis longus
Extensor carpi radialis brevis
Abductor pollicis longus
Extensor pollicis brevis

Fig. 10.26: Movements of wrist joint



Fig. 10.27: Rheumatoid arthritis leads to deformities of the tendons (Fig. 10.29).

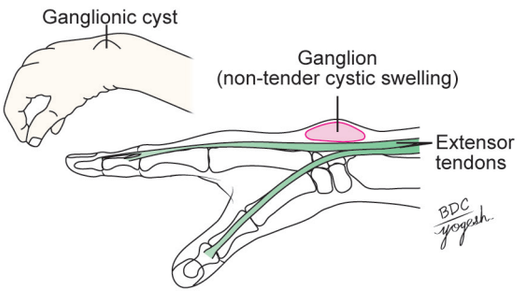


Fig. 10.28: Ganglion cyst at the back of wrist

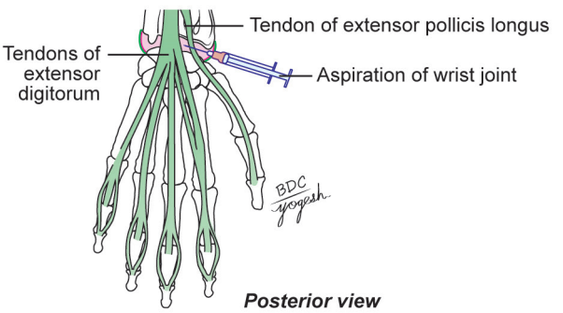


Fig. 10.29: Aspiration of the wrist joint

Competencies:
AN13.4 Describe sternoclavicular joint, acromioclavicular joint, carpometacarpal joints, and metacarpophalangeal joint.
AN12.6 Describe and demonstrate movements of thumb and muscles involved.

JOINTS OF HAND

INTERCARPAL, CARPOMETACARPAL AND INTERMETACARPAL JOINTS

There are three joint cavities among the intercarpal, carpometacarpal and intermetacarpal joints, which are:
1. Pisotriquetral,
2. First carpometacarpal, and
3. A common cavity for the rest of the joints. The common cavity may be described as the ***midcarpal (transverse intercarpal) joint*** between the proximal and distal rows of the carpus, which communicates with intercarpal joints superiorly, and with intercarpal, carpometacarpal and intermetacarpal joints inferiorly (Fig. 10.23).

The midcarpal joint permits movements between the two rows of the carpus as already described with the wrist joint.

FIRST CARPOMETACARPAL/ TRAPEZIO-METACARPAL JOINT (JOINT OF THUMB)

First carpometacarpal joint is only carpometacarpal joint which has a separate joint cavity. Movements at this joint are, therefore, much more free than at any other corresponding joint.

Type

Saddle variety of synovial joint (because the articular surfaces are concavo-convex).

Articular Surfaces

1. The distal surface of the ***trapezium***
2. The proximal surface of the ***base of the 1st metacarpal*** bone.

The articulating surface of trapezium is concave in the sagittal plane and convex in the frontal plane.

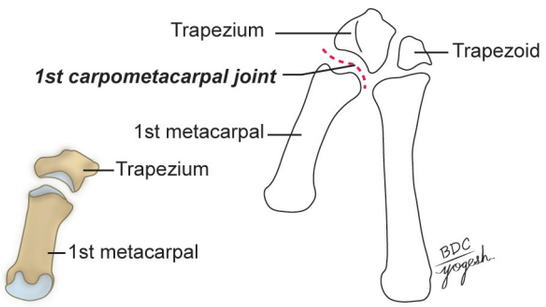


Fig. 10.30: First carpometacarpal (trapezio-metacarpal) joint

The concavo-convex nature of the articular surfaces permits a wide range of movements (Fig. 10.30).

Ligaments

1. Capsular ligament surrounds the joint. In general, it is thick but loose, and is thickest dorsally and laterally.
2. Lateral ligament is broad band which strengthens the capsule laterally.
3. The anterior ligament
4. The posterior ligaments are oblique bands running downwards and medially.

Relations

Anteriorly: The joint is covered by the muscles of the thenar eminence.
Posteriorly: Long and short extensors of the thumb.
Medially: First dorsal interosseous muscle, and the radial artery (passing from the dorsal to the palmar aspect of the hand through the interosseous space).
Laterally: Tendon of the abductor pollicis longus.

Blood Supply

Radial vessels.

Nerve Supply

1st digital branch of median nerve.

Movements

Flexion and extension of the thumb take place in the plane of the palm, and abduction and adduction at right angles to the plane of the palm. In opposition, the thumb crosses the palm and touches other fingers. Flexion is associated with medial rotation and extension with lateral rotation at the joint.

The following muscles bring about the movements (Fig. 10.31):

Flexion:	Flexor pollicis brevis Opponens pollicis
Extension:	Extensor pollicis brevis Extensor pollicis longus
Abduction:	Abductor pollicis brevis Abductor pollicis longus
Adduction:	Adductor pollicis
Opposition:	Opponens pollicis Flexor pollicis brevis
Circumduction:	Combination of different movements mentioned above

Note: The ***opposition*** is a sequential movement of abduction, flexion, adduction of the 1st metacarpal with simultaneous rotation. Opposition is unique to human beings and is one of the most important movements of the hand considering that this motion is used in almost all types of gripping actions. The adductor pollicis and the flexor pollicis longus exert pressure on the opposed fingers.

CLINICAL ANATOMY

- The 1st carpometacarpal joint can undergo degenerative changes with age which is a painful condition of the base of the thumb.
- The synovial lining of the tendons of extensor pollicis brevis and abductor pollicis longus can get inflamed due to repetitive strain and can lead to a painful condition called ***De Quervain's tenosynovitis***. Movement of the thumb can aggravate pain in this condition.

DISSECTION

Out of these, the most important joint with a separate joint cavity is the first carpometacarpal joint. This is the joint of the thumb and a wide variety of functionally useful movements take place here. Identify the distal surface of trapezium and base of first metacarpal bone.

Define the metacarpophalangeal and interphalangeal joints.

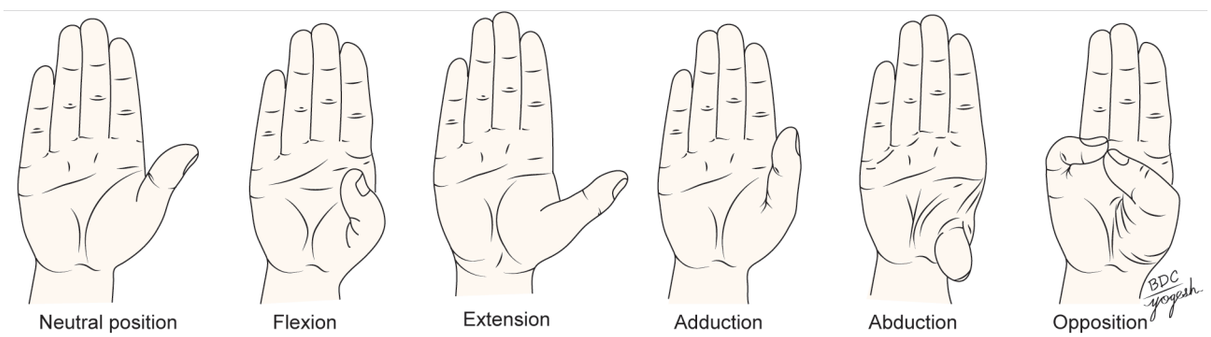


Fig. 10.31: Movements of the thumb

For their dissection, remove all the muscles and tendons from the anterior and posterior aspects of any two metacarpophalangeal joints. Define the articular capsule and ligaments. Do the same for proximal and distal interphalangeal joints of one of the fingers and define the ligaments.

METACARPOPHALANGEAL JOINTS

Type

Metacarpophalangeal joints are synovial joints of the ellipsoid variety.

Ligaments

Each joint has the following ligaments.

1. ***Capsular ligament:*** This is thick in front and thin behind.
2. ***Palmar ligament:*** This is a strong fibrocartilaginous plate (volar plate) which replaces the anterior part of the capsule. It is more firmly attached to the phalanx than to the metacarpal. The various palmar ligaments of the metacarpophalangeal joints are joined to one another by the deep transverse metacarpal ligament.
3. ***Medial and lateral collateral ligaments:*** These are oblique bands placed at the sides of the joint. Each runs downwards and forwards from the head of the metacarpal bone to the base of the phalanx. These are taut in flexion and relaxed in extension.

Movements at 1st Joint and Muscles Producing Them

Flexion:	Flexor pollicis longus and flexor pollicis brevis.
Extension:	Extensor pollicis longus and extensor pollicis brevis.
Abduction:	Abductor pollicis brevis.
Adduction:	Adductor pollicis.

Movements at 2nd to 5th Joints and Muscles Producing Them

Flexion:	Interossei and lumbricals
Extension:	Extensors of the fingers
Abduction:	Dorsal interossei
Adduction:	Palmar interossei
Circumduction:	Above muscles in sequence.

INTERPHALANGEAL JOINTS (PROXIMAL AND DISTAL)

Type

Hinge variety of synovial joints (Fig. 10.32).

Ligaments

Similar to the metacarpophalangeal joints, that is one palmar fibrocartilaginous ligament and two collateral bands running downwards and forwards.

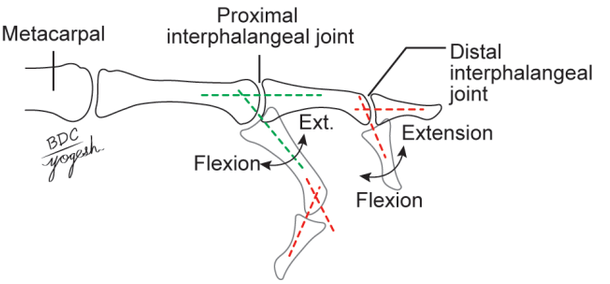


Fig. 10.32: Joints of the fingers

Movements at Interphalangeal Joint of Thumb

Flexion:	Flexor pollicis longus.
Extension:	Extensor pollicis longus.

Movements at 2nd to 5th Digits

Flexion:	Flexor digitorum superficialis at the proximal interphalangeal joint, and the flexor digitorum profundus at the distal joint.
Extension:	Interossei and lumbricals.

CLINICAL ANATOMY

***Position of immobilization of hand*:** The collateral ligaments of the metacarpophalangeal are full stretched only when the joint is fully flexed to 90°. The collateral ligaments of interphalangeal joint are stretched only when the joint is fully extended. In the immobilizing of the hand, contracture/shortening of the ligaments occurs within two weeks in the situation where the joints are immobilized with lax ligaments. Therefore, the hand should be mobilized with fully flexed metacarpophalangeal joints and fully extended interphalangeal joints.

Segmental Innervation of Movements of Upper Limb

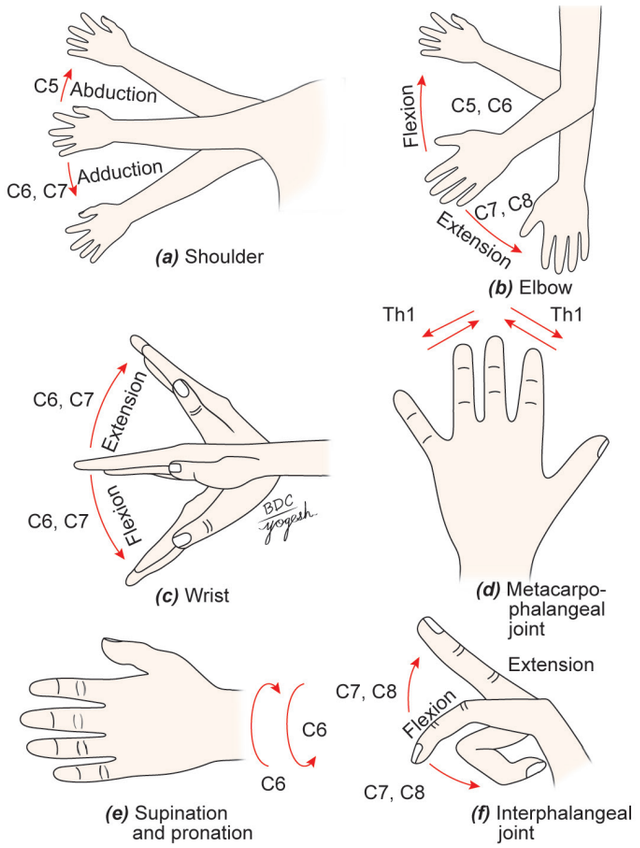
In Figure 10.33 shows the segments of the spinal cord responsible for movements of the various joints of the upper limb.

The proximal muscles of upper limb are supplied by proximal nerve roots forming brachial plexus and distal muscles by the distal or lower nerve roots. In shoulder, abduction is done by muscles supplied by C5 spinal segment and adduction by muscles innervated by C6, C7 spinal segments.

Elbow joint is flexed by C5, C6 and extended by C7, C8 innervated muscles. Supination is caused by muscle innervated by C6 spinal segment even pronation is done through C6 spinal segment.

Extension and flexion of wrist is done through C6, C7 spinal segments. Both the palmar and dorsal interossei are innervated by T1 spinal segment.

The interphalangeal joints also are flexed and extended by same spinal segments, i.e. C7, C8.



Figs 10.33a to f: Segmental innervation of movements of the upper limb

VIDEO

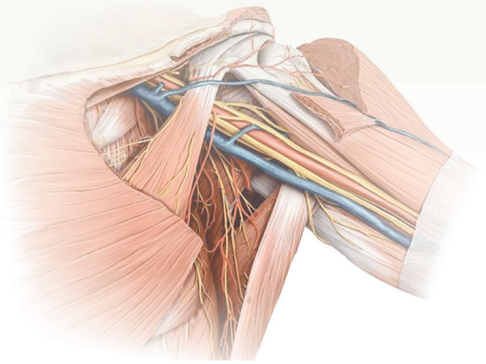
Video 1.10 Joints of Upper Limb.

Facts to Remember

- Sternoclavicular joint is a saddle variety of synovial joint. Its cavity is divided into two parts by an articular disc.
- Coracoclavicular ligament is the strongest ligament of the upper limb.
- Movements of shoulder girdle help the movements of shoulder joint during 90°–180° abduction.
- Shoulder joint is the most freely movable joint and most commonly dislocated joint in the body. It commonly undergoes recurrent dislocations.
- Shoulder joint commonly dislocates antero-inferiorly.
- Subacromial bursa is the largest synovial bursa of the body.
- Rotator cuff is the most important factor for maintaining the stability of the shoulder joint.
- Ulnar nerve lies behind medial epicondyle. It is not a content of the cubital fossa.
- Carrying angle separates the wrist from the hip joint while carrying buckets, etc.
- Biceps brachii is an important supinator of forearm when the elbow is flexed.
- Kings pronate, while beggars supinate.
- Movements of pronation and supination are not occurring at the elbow or wrist joints.
- First carpometacarpal joint is the most important joint as it permits the thumb to oppose the palm fingers for holding things.
- Ulnar nerve lies behind medial epicondyle, pressing the nerve cause tingling sensation. That is why the bone is named 'humerus'.
- Wrist joint complex = Radiocarpal joint + Mid carpal joint
- In midprone position, the bones of the forearm are most stable.
- Axis of movements of abduction and adduction of fingers is through the centre of the middle finger.

BDC's Anatomy *e*-book

1. Movements of the shoulder girdle
2. Mobility of shoulder joint
3. Analysis of the overhead movement of the shoulder
4. Dancing shoulder
5. Exclusion of shoulder joint disease
6. Anatomical basis of referred pain at shoulder tip
7. Classification of movements of the hand
8. Functional components of hand
9. Position of arthrodesis
10. Further reading
11. Viva voce questions



Chapter

11

Surface Marking and Radiological Anatomy of Upper Limb

Surface marking is the projection of the deeper structures on the surface. Its importance lies in various medical and surgical procedures. It is a useful guide for the location and palpation of organs and arteries, for the percussion, and the auscultation.

SURFACE MARKING

Bony landmarks have been shown in Fig. 11.1. The surface marking of important structures is given below.

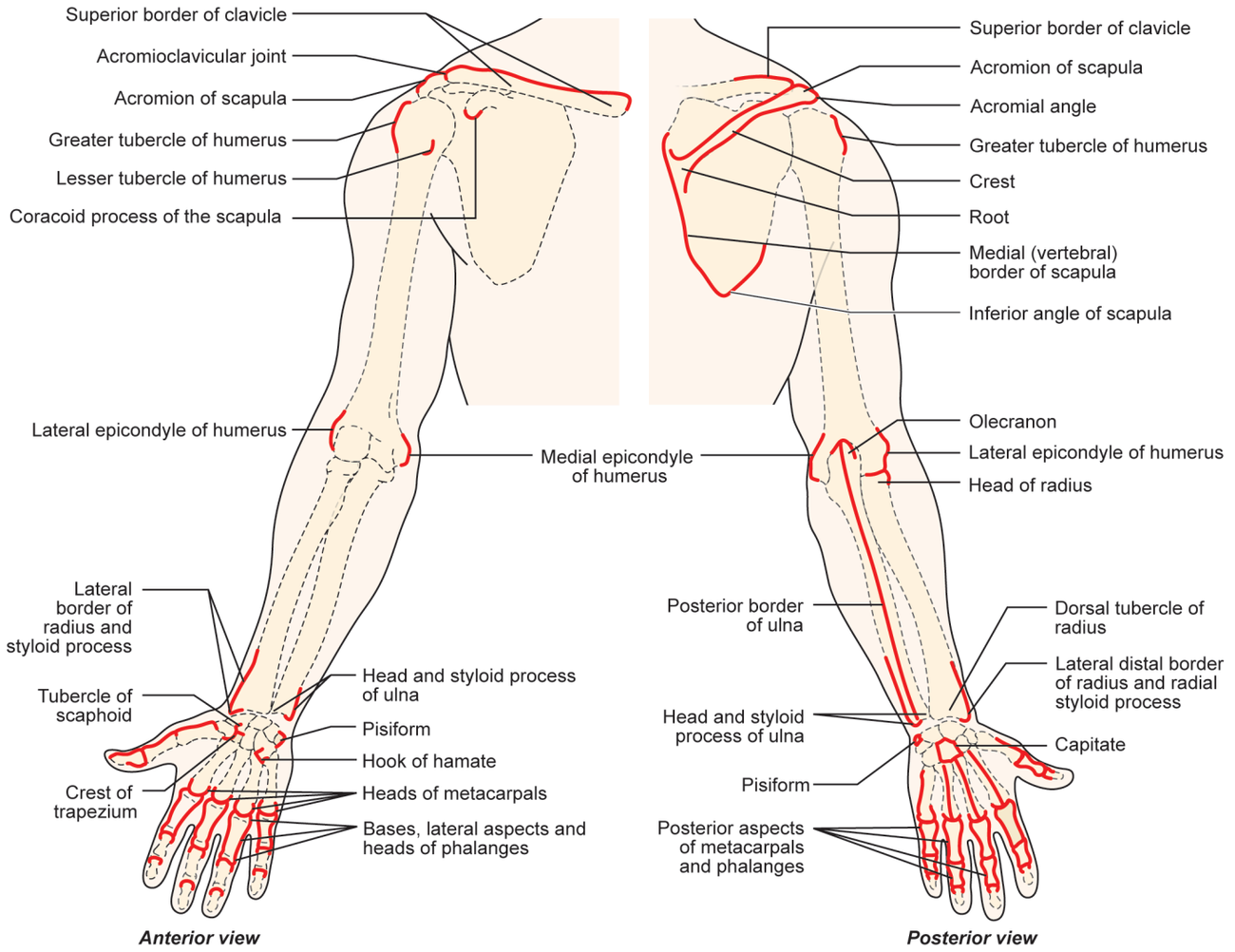


Fig. 11.1: Bony landmarks/palpable features of upper limb bones

MAMMARY GLAND

1. Point at margin of sternum opposite manubriosternal joint.
2. Point of the sternal end of 6th costal cartilage (Fig. 11.2).
3. Line along 6th costal cartilage.
4. Mid-axillary line.
5. Point at the pulsation of axillary artery deep to anterior axillary fold.
6. Line along anterior part of 2nd rib and its cartilage.

Draw a circle joining points 1, 2, 3, 4 with projection upwards towards point 5 and continue along 6 to reach back at point 1. Nipple is projection of 1 cm below the centre of this circle. Areola is circle of 1.5 cm around the nipple.

Competency:
AN13.7 Identify and demonstrate surface projection of—cephalic and basilic vein, palpation of brachial artery, radial artery; testing of muscles—trapezius, pectoralis major, serratus anterior, latissimus dorsi, deltoid, biceps brachii, brachioradialis.

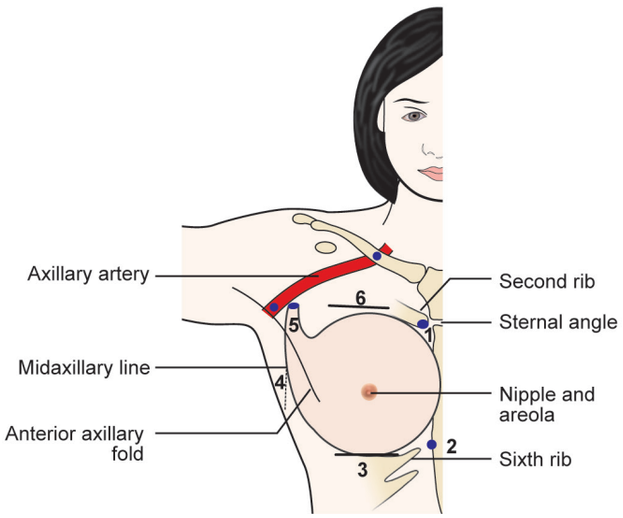


Fig. 11.2: Mammary gland

ARTERIES AND NERVES IN ARM

Axillary Artery

Hold the arm at right angles to the trunk and mark the following points:

- *Point 1*: Midpoint of the clavicle (Fig. 11.3).
- *Point 2*: On the lower part of axillary artery present in the groove behind coracobrachialis muscle posteromedial to biceps brachii in front of posterior axillary fold.

These points are joined by a broad curved line.

Clinical utility: Pulsation of this artery can be felt in the living.

Brachial Artery

- *Point 2:* Point on the lower part of axillary artery presents in the groove behind coracobrachialis muscle (posteromedial to biceps brachii) in front of the posterior axillary fold. Pulsation of the artery can be felt in living (Fig. 11.3).
- *Point 3:* At the level of the neck of the radius medial to the tendon of the biceps on the medial side of the upper part of the forearm.

Join points 3 and 4 by a line that runs downwards and slightly laterally to end in front of the elbow. At its termination, it bifurcates into radial and ulnar arteries.

Clinical utility: Surface anatomy of the brachial artery is important:

- To feel the pulsation of the brachial artery: Pulsation of brachial artery can be felt in the cubital fossa, medial to the tendon of biceps brachii.
- For auscultation of brachial artery during measurement of blood pressure.

Median Nerve

Mark the brachial artery. Mark median nerve lateral to the artery in upper half and medial to the artery in lower half. The nerve crosses the artery anteriorly in the middle of the arm (Fig. 11.3).

Musculocutaneous Nerve

Hold the arm at right angles to the trunk

- *Point A:* Just lateral to axillary artery 5 cm below coracoid process (Fig. 11.4).
- *Point B:* Lateral to tendon of biceps brachii muscle 2 cm above the bend of below. Here, it pierces deep

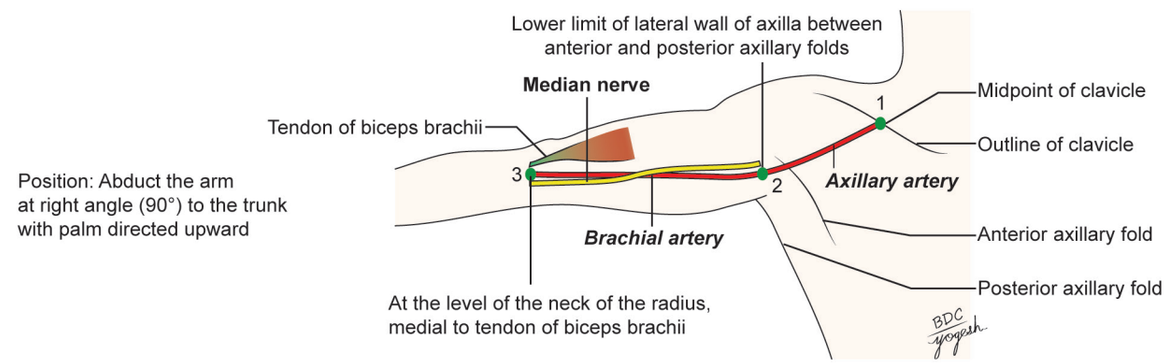


Fig. 11.3: Surface marking of axillary and brachial arteries and median nerve

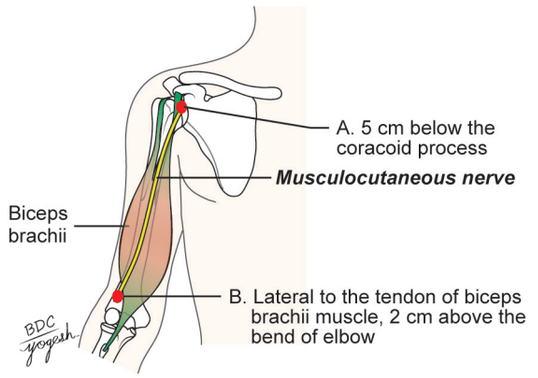


Fig. 11.4: Surface marking of musculocutaneous nerve

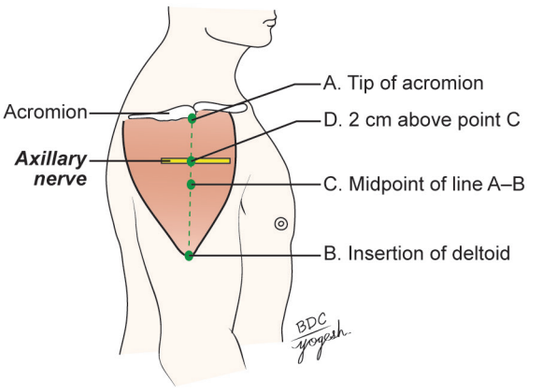


Fig. 11.6: Surface marking of axillary nerve

fascia and continues as the lateral cutaneous nerve of the forearm.

The musculocutaneous nerve lies lateral to axillary artery, crosses deep to the bulge formed by biceps brachii to reach the lateral side of tendon of biceps brachii.

Radial Nerve

Arm is kept on the side of trunk. Radial nerve is marked both on anterior and posterior aspects of the arm (Fig. 11.5).

- *Point A:* At the lateral wall of axilla at its lower limit.
- *Point B:* Junction of point of upper 1/3rd and lower 2/3rd of line joining deltoid tuberosity to lateral epicondyle of humerus.
- *Point C:* Infront of the elbow, just below the lateral epicondyle of humerus, where it divides into superficial and posterior interosseous (deep) branch. Join points A and B across back of arm and points B and C on front of arm.

Axillary Nerve

- *Point A:* At tip of acromion process of scapula (Fig. 11.6).
- *Point B:* At the insertion of deltoid muscle.
- Join points A and B.
- *Point C:* Midpoint of the line A–B.
- *Point D:* 2 cm above point C.

Draw a horizontal line of 3 cm along point D. This line represents the axillary nerve.

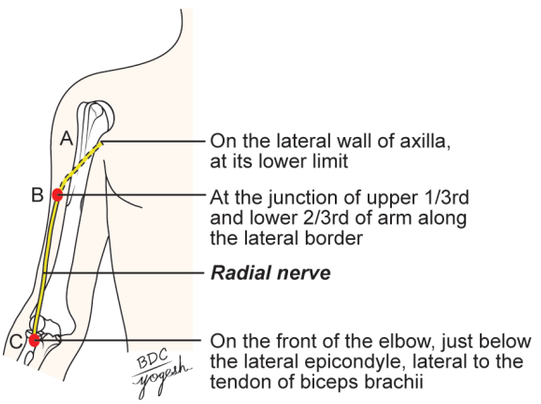


Fig. 11.5: Surface marking of radial nerve in arm

Ulnar Nerve

- *Point A:* On the posterior wall of axilla at its lower limit where pulsations of axillary artery are felt in the living (Fig. 11.7).
- *Point B:* At the middle of the medial border of the arm.
- *Point C:* Behind the base of the medial epicondyle of the humerus.

Join points A and B on anterior aspect of arm.
Join points B and C on posterior aspect of arm.

ARTERIES AND NERVES IN FOREARM AND HAND

Radial Artery

In the Forearm

Radial artery is marked by joining the following points:

- *Point A:* In front of the elbow at the level of the neck of the radius medial to the tendon of the biceps brachii (Fig. 11.8).
- *Point B:* At the wrist between the anterior border of the radius and the tendon of the flexor carpi radialis (Fig. 11.8).

Its course is curved with a gentle convexity to the lateral side.

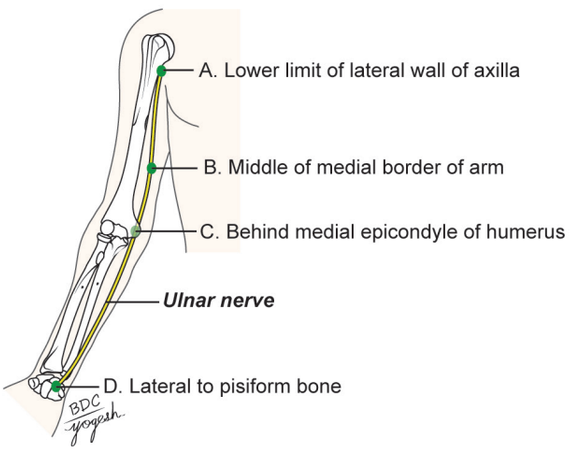


Fig. 11.7: Surface marking of ulnar nerve

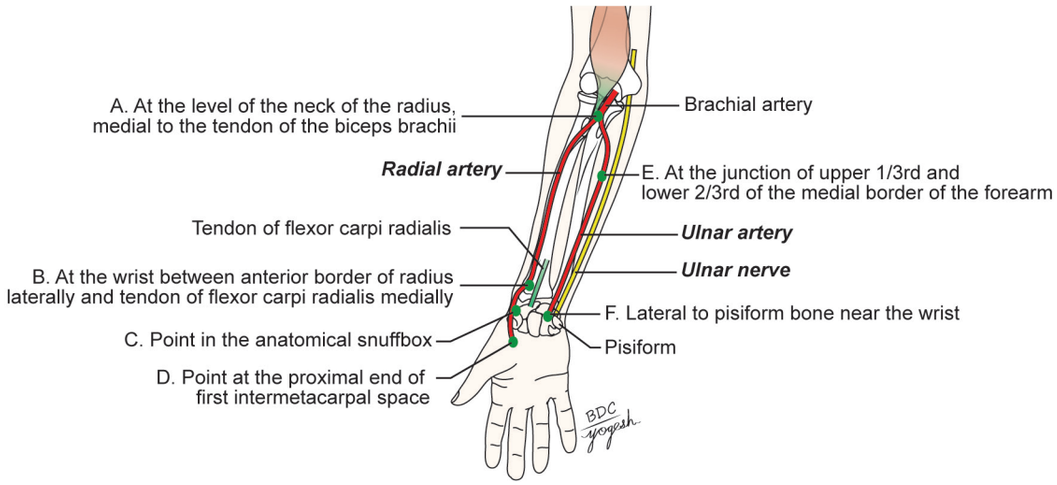


Fig. 11.8: Surface marking of radial and ulnar arteries

At the Wrist

Radial artery is marked by joining the following points (Fig. 11.8):

- *Point C:* Point in the anatomical snuffbox
- *Point D*: Point at the proximal end of the first intermetacarpal space.
- Joint point C and D with lateral convexity to mark the radial artery.
- *Clinical utility:*
  - Radial artery pulsation: Radial artery is palpated in the lower part of forearm against the anterior surface of lower end of radius lateral to the tendon of flexor carpi radialis.
  - Incision to dissect out radial artery for coronary artery bypass grafting (CABG): Radial artery is useful to bypass the blockage site of coronary artery.
  - Arterial blood sample: The radial artery may be used to draw arterial blood for blood gas analysis.

Ulnar Artery

Ulnar artery is marked by joining the following three points.

- *Point A:* In front of the elbow at the level of the neck of the radius medial to the tendon of the biceps brachii (Fig. 11.6).
- *Point E:* At the junction of the upper one-third and lower two-thirds of the medial border of the forearm (lateral to the ulnar nerve) (Fig. 11.6).
- *Point F:* Lateral to the pisiform bone (Fig. 11.6). Thus, the course of the ulnar artery is oblique in its upper 1/3rd, and vertical in its lower 2/3rd. The ulnar nerve lies just medial to the ulnar artery in the lower 2/3rd of its course. The ulnar artery continues in the palm as the superficial palmar arch (Fig. 11.8).

Superficial Palmar Arch

- *Point 1:* Just lateral to pisiform bone (Fig. 11.9).
- *Point 2:* Medial to hook of hamate.
- *Point 3:* Distal border of thenar eminence.

The convexity of arch is directed towards the finger.

Deep Palmar Arch

Deep palmar arch is formed as the direct continuation of the radial artery. It has a slight convexity towards the fingers.

- *Point 4:* At proximal part of 1st dorsal intermetacarpal space (Fig. 11.9).
- *Point 5:* Just distal to hook of hamate. It is marked by a slightly convex line, 4 cm long, just distal to the hook of the hamate bone.

The deep palmar arch lies 1.2 cm proximal to the superficial palmar arch across the metacarpals, immediately distal to their bases. The deep branch of ulnar nerve lies in its concavity.

Ulnar Nerve

Ulnar nerve is marked by joining the following two points.

- *Point C:* On the back of the base of the medial epicondyle of the humerus (Fig. 11.7).
- *Point D:* Lateral to the pisiform bone.

In the lower two-thirds of the forearm, the ulnar nerve lies medial to the ulnar artery (Fig. 11.7).

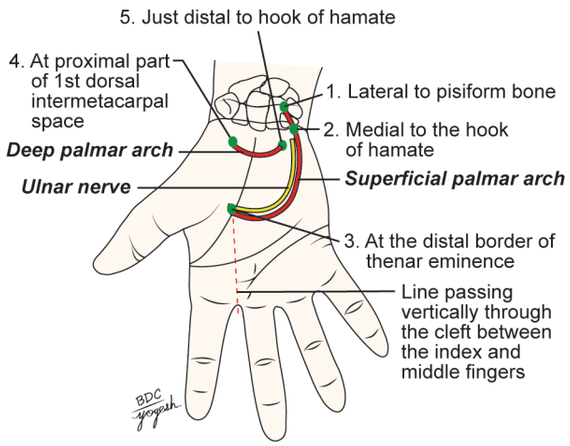


Fig. 11.9: Surface marking of superficial and deep palmar arches

In the Hand

Ulnar nerve lies superficial to the medial part of flexor retinaculum and medial to ulnar vessels where it divides into superficial and deep branches (Fig. 11.7).

The superficial branch supplies medial 1½ digits, including their nail beds. The deep branch passes backwards between pisiform and hook of hamate to lie in the concavity of the deep palmar arch.

Median Nerve

In the Forearm

Median nerve is marked by joining the following two points.

- *Point 1:* Medial to the brachial artery at the bend of the elbow (Fig. 11.10).
- *Point 2:* In front of the wrist (over the tendon of the palmaris longus) or 1 cm medial to the tendon of the flexor carpi radialis (Fig. 11.10).

In the Hand

Median nerve enters the palm by passing deep to flexor retinaculum, immediately below which it divides into lateral and medial branches. Lateral branch supplies the three muscles of thenar eminence and gives two branches to the thumb, and one to lateral side of index finger including 1st lumbrical muscle. Medial branch gives branches for the adjacent sides of index, middle, and ring fingers including 2nd lumbrical muscle. The lateral 3½ nail beds are also supplied.

Radial Nerve

In the Forearm

Superficial branch of radial nerve is marked by joining the following three points.

- *Point 1:* 1 cm lateral to the biceps tendon just below the level of the lateral epicondyle (Fig. 11.11).
- *Point 2:* At the junction of the upper two-thirds and lower one-third of the lateral border of the forearm just lateral to the radial artery.
- *Point 3:* At the anatomical snuffbox.

The nerve is vertical in its course between points *1* and *2*. At the second point, it inclines backwards to reach the snuffbox. The nerve is closely related to the lateral side of the radial artery only in the middle one-third of the forearm. The nerve turns towards the back of forearm. Then it lies in the anatomical snuffbox to descend on the back of hand.

Posterior Interosseous Nerve/Deep Branch of Radial Nerve

It is marked by joining the following three points.

- *Point 1:* 1 cm lateral to the biceps brachii tendon just below the level of the lateral epicondyle (Fig. 11.12).
- *Point 2:* At the junction of the upper 1/3rd and lower 2/3rd of a line joining the middle of the posterior aspect of the head of the radius to the dorsal tubercle at the lower end of the radius (Lister's tubercle).

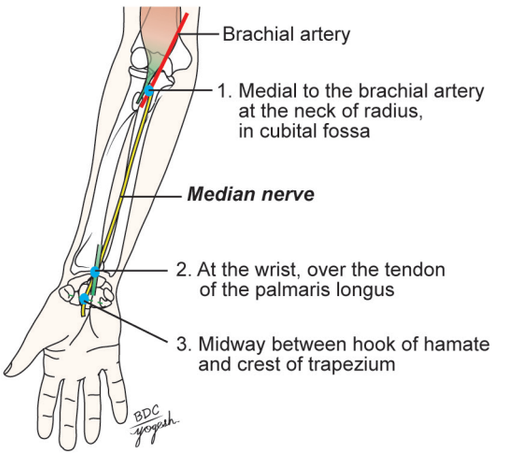


Fig. 11.10: Surface marking of median nerve in forearm and hand

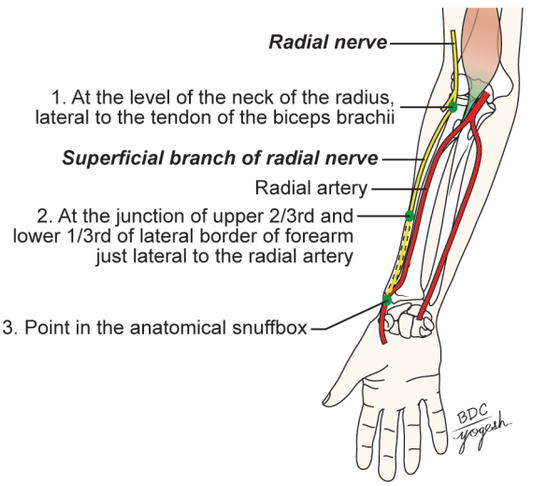


Fig. 11.11: Surface marking of superficial branch of radial nerve

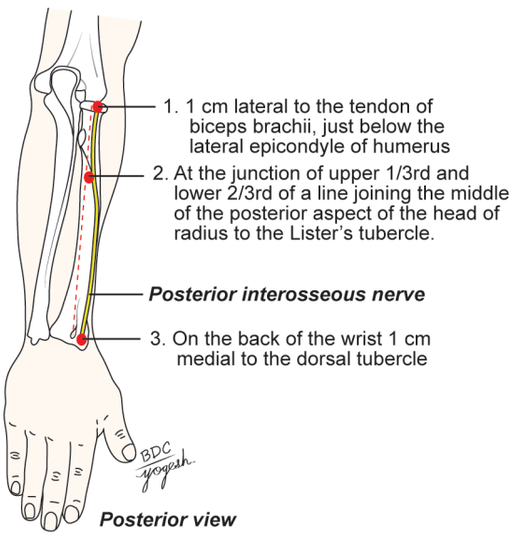


Fig. 11.12: Surface marking of posterior interosseous nerve

- *Point 3:* On the back of the wrist 1 cm medial to the dorsal tubercle.

Posterior interosseous nerve supplies the muscles of posterior aspect of the forearm.

JOINTS

Shoulder Joint

The anterior margin of the glenoid cavity corresponds to the lower half of the shoulder joint. It is marked by a line 3 cm long drawn downwards from a point just lateral to the tip of the coracoid process. The line is slightly concave laterally.

Elbow Joint

The joint line is situated 2 cm below the line joining the two epicondyles, and slopes downwards and medially.

This slope is responsible for the carrying angle.

Wrist Joint

The joint line is concave downwards and is marked by joining the styloid processes of the radius and ulna.

RETINACULA

Flexor Retinaculum

Flexor retinaculum is marked by joining the following four points.

1. Pisiform bone
2. Tubercle of the scaphoid bone
3. Hook of the hamate bone (Fig. 11.13)
4. Crest of the trapezium.

The upper border is obtained by joining the first and second points, and the lower border by joining the third and fourth points. The upper border is concave upwards, and the lower border is concave downwards.

Clinical utility: Flexor retinaculum and carpal bones together form carpal tunnel. It holds the long flexor tendons in place. Compression of median nerve in this tunnel causes carpal tunnel syndrome.

Extensor Retinaculum

Extensor retinaculum is an oblique band directed downwards and medially, and is about 2 cm broad (vertically) (Fig. 11.14). Laterally, it is attached to the lower salient part of the anterior border of the radius, and medially to the medial side of the carpus (pisiform and triquetral bones) and to the various ridges on the back of lower end of radius. It is not attached to ulna.

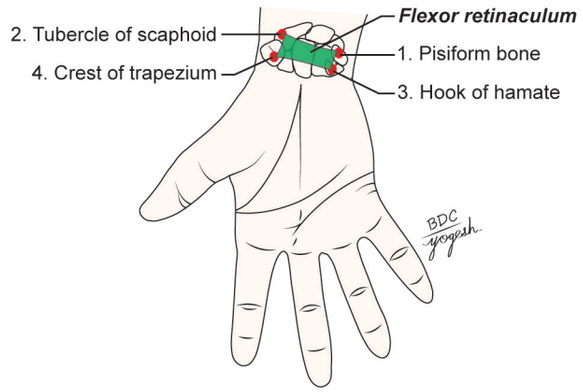


Fig. 11.13: Surface marking of flexor retinaculum of upper limb

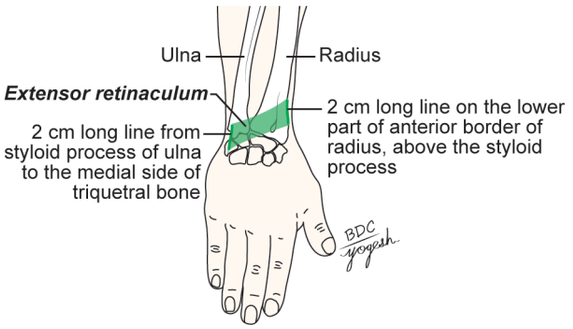


Fig. 11.14: Surface marking of extensor retinaculum of upper limb

Clinical utility: Extensor retinaculum holds the long extensor tendons and their synovial sheaths in place. It needs to be excised to release the pressure of inflamed synovial sheaths in De Quervain's tenosynovitis.

SYNOVIAL SHEATHS OF THE FLEXOR TENDONS

Common Flexor Synovial Sheath (Ulnar Bursa)

Above the flexor retinaculum (or lower transverse crease of the wrist), it extends into the forearm for about 2.5 cm. Here its medial border corresponds to the lateral edge of the tendon of the flexor carpi ulnaris, and its lateral border corresponds roughly to the tendon of the palmaris longus.

Ulnar bursa becomes narrower behind the flexor retinaculum and broadens out below it.

Most of it terminates at the level of the upper transverse crease of the palm, but the medial part is continued up to the distal transverse crease of the little finger.

Synovial Sheaths for the Tendon of Flexor Pollicis Longus (Radial Bursa)

Radial bursa is a narrow tube which is coextensive with the ulnar bursa in the forearm and wrist. Below the flexor retinaculum, it is continued into the thumb up to its distal crease.

Digital Synovial Sheaths

The synovial sheaths of the flexor tendons of the index, middle, and ring fingers extend from the necks of the metacarpal bones (corresponding roughly to the lower transverse crease of the palm) to the bases of the terminal phalanges.

Competency:
AN13.5 Identify the bones and joints of upper limb seen in anteroposterior and lateral view radiographs of shoulder region, arm, elbow, forearm, and hand.

RADIOLOGICAL ANATOMY OF UPPER LIMB

In the case of the limbs, plain radiography is mainly required. For complete information, it is always advisable to have anteroposterior (AP) as well as lateral

views; and as far as possible radiographs of the opposite limb should be available for comparison. The skeleton, owing to its high radiopacity, forms the most striking feature in plain skiagrams. In general, the following information can be obtained from plain skiagrams of the limbs.

1. *Fractures* are seen as breaks in the surface continuity of the bone. A fracture line is usually irregular and asymmetrical. An epiphyseal line of an incompletely ossified bone, seen as a gap, should not be mistaken for a fracture: It has regular margins and is bilaterally symmetrical. Supernumerary or accessory bones are also symmetrical.
2. *Dislocations* are seen as deranged or distorted relations between the articular bony surfaces forming a joint.
3. Below the age of 25 years, the age of a person can be determined from the knowledge of ossification of the bones.
4. Certain *deficiency diseases* like rickets and scurvy can be diagnosed.
5. *Infections* (osteomyelitis) and growths (osteoma, osteoclastoma, osteosarcoma, etc.) can be diagnosed. A localised rarefaction of a bone may indicate an infection.
6. *Congenital absence or fusion* of bones can be seen.

Reading Plain Skiagrams of Limbs

1. Identify the view of the picture, anteroposterior (AP) or lateral. Each view shows a specific shape and arrangement of the bones.
2. Identify the region and the side (right, left).
3. Identify all the bones and their different parts visible in the given radiogram. Normal overlapping and 'end-on' appearances of bones in different views should be carefully studied.
4. Study the normal relations of the bones forming joints. The articular cartilage is radiolucent and does not cast any shadow. The radiological 'joint space' indicates the size of the articular cartilages. Normally, the joint space is about 2–5 mm in adults.
5. Study the various epiphyses visible in young bones and try to determine the age of the person concerned.

Shoulder

A. The following are seen in an AP view of the shoulder (Fig. 11.15).
   1. The upper end of the humerus, including the head, greater and lesser tubercles and intertubercular sulcus.
   2. The scapula, including the glenoid cavity, coracoid (seen end-on), acromion process, its lateral, medial and superior borders, and the superior and inferior angles. The suprascapular notch may be seen.
   3. The clavicle, except for its medial end.
   4. Upper part of the thoracic cage, including the upper ribs.

B. Study the normal appearance of the following joints.
   1. *Shoulder joint:* The glenoid cavity articulates only with the lower half of the head of the humerus (when the arm is in the anatomical position). The upper part of the head lies beneath the acromion process. The greater tuberosity forms the lateral most bony point in the shoulder region.
   2. Acromioclavicular joint.

C. Note the epiphyses, if any, and determine the age with the help of ossifications described with individual bones.

Elbow

A. Identify the following bones in an AP and lateral views of the elbow (Figs 11.16a and b).
   1. The lower end of humerus, including the medial and lateral epicondyles, the medial and lateral supracondylar ridges, trochlea, the capitulum and the olecranon fossa.

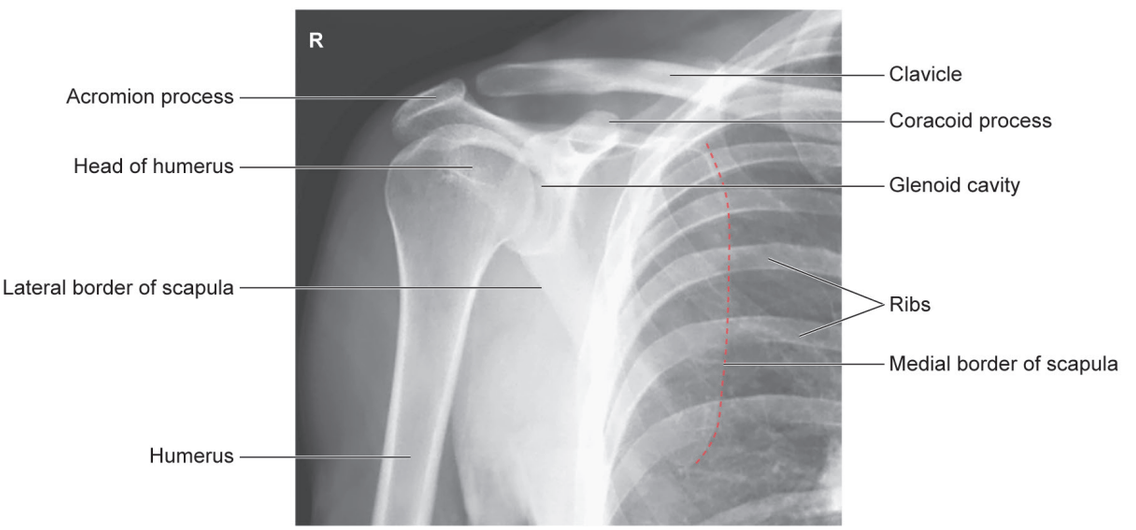
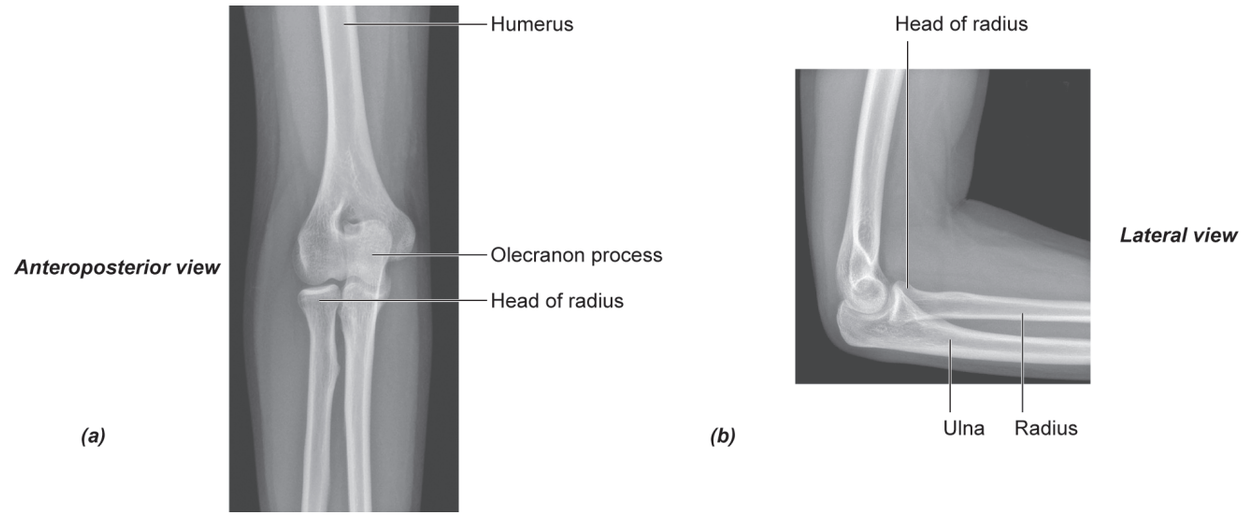


Fig. 11.15: Anteroposterior view of the shoulder joint



Figs 11.16a and b: Radiographs of elbow region: (a) AP view and (b) lateral view

2. The upper end of the ulna, including the olecranon and coronoid processes.
3. The upper end of the radius including its head, neck, and tuberosity.

B. Study the normal appearance of the following joints in AP view.
1. Elbow joint
2. Superior radioulnar joint

C. Note the olecranon and coronoid processes in a lateral view of the elbow (Figs 11.16a and b).

D. Note the epiphyses (if any) and determine the age with the help of ossifications described with individual bones.

Hand

A. Identify the following bones in an AP skiagram (Fig. 11.17).
1. The lower end of the radius with its styloid process.
2. The lower end of the ulna with its styloid process.
3. The eight carpal bones. Note the overlapping of the triquetral and pisiform bones; and of the trapezium with the trapezoid. Also, identify the tubercle of the scaphoid and the hook of the hamate.
4. The five metacarpal bones
5. The fourteen phalanges
6. The sesamoid bones present in relation to the thumb, and occasionally in relation to the other fingers.

B. Study the normal appearance of these joints.
1. The wrist joint
2. The inferior radioulnar joint
3. The intercarpal, carpometacarpal, metacarpophalangeal, and interphalangeal joints.

C. Note the following bones in a lateral skiagram.
1. Lunate
2. Scaphoid
3. Capitate
4. Trapezium

D. Note the epiphyses and other incomplete ossifications and determine the age with the help of ossifications described with individual bones.

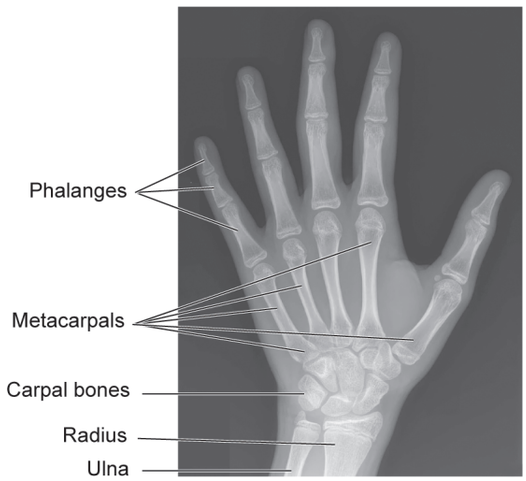
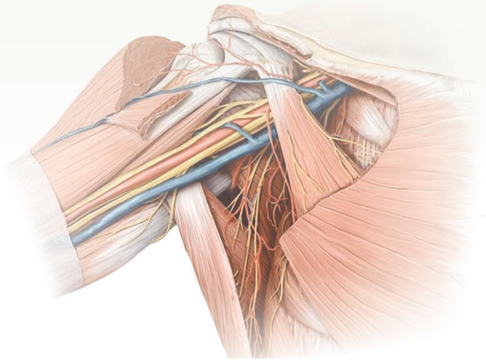


Fig. 11.17: Anteroposterior view of the hand

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1. Clinical testing of muscles of upper limb
2. Tracings of radiographs of upper limb
3. Clinical integration of radiographs of upper limb
4. Age determination using radiograph of hand
5. Comparison of upper and lower limbs
6. Further reading



Appendix

1

Major Nerves and Arteries of Upper Limb

MAJOR NERVES OF UPPER LIMB

The upper limb is supplied by major five nerves arising from the brachial plexus in addition to other smaller nerves:

1. Axillary nerve
2. Musculocutaneous nerve
3. Radial nerve
4. Median nerve
5. Ulnar nerve.

Most of the nerves course through different regions of the upper limb and have been described in parts in the respective regions. The course of the entire nerve, branches and clinical aspects has been described briefly in this annexure (Fig. A1.1a).

MUSCULOCUTANEOUS NERVE

Musculocutaneous nerve is so named as it supplies muscles of front of arm and skin of lateral side of forearm. This nerve rarely gets injured.

Root Value

Ventral rami of C5–C7 segments of spinal cord.

Course

Axilla and Arm

Musculocutaneous nerve is a branch of the lateral cord of brachial plexus, lies lateral to axillary and upper part of brachial artery. It supplies coracobrachialis, pierces the muscle to lie in the intermuscular septum between biceps brachii and brachialis muscles, both of which are supplied by this nerve (*see* Plate 8.3 and A1.1).

Forearm

About 2.5 cm above the crease of elbow, it becomes cutaneous by piercing the deep fascia. The nerve is called the lateral cutaneous nerve of forearm which supplies skin of lateral side of forearm both on the front and back.

Branches

Muscular: Coracobrachialis
Biceps brachii
Brachialis (large medial part) (Fig. A1.1)

Cutaneous: Lateral side of forearm (both on the front and the back).

Articular: Elbow joint.

Features of the musculocutaneous nerve injury are described in Fig. A1.2.

AXILLARY OR CIRCUMFLEX NERVE

Axillary nerve is called axillary as it runs through the upper part of axilla though it does not supply any structure there. It is called ***circumflex nerve*** as it courses around the surgical neck of humerus (*see* Fig. 6.3) to supply the prominent deltoid muscle.

Root Value

Ventral rami of C5, C6 segments of spinal cord.

Course

Axilla

Axillary or circumflex nerve is the smaller terminal branch of posterior cord seen in the axilla (*see* Fig. 4.14).

Quadrangular Space

The nerve passes backwards through the quadrangular space (bounded by subscapularis above, teres major below, long head of triceps brachii medially and surgical neck of humerus laterally) (*see* Fig. 6.9). Here it lies below the capsule of the shoulder joint.

Surgical Neck of Humerus

Then it passes behind the surgical neck of humerus where it divides into anterior and posterior divisions (Fig. A1.1).

Branches

The branches of axillary nerve are presented in Table A1.1.

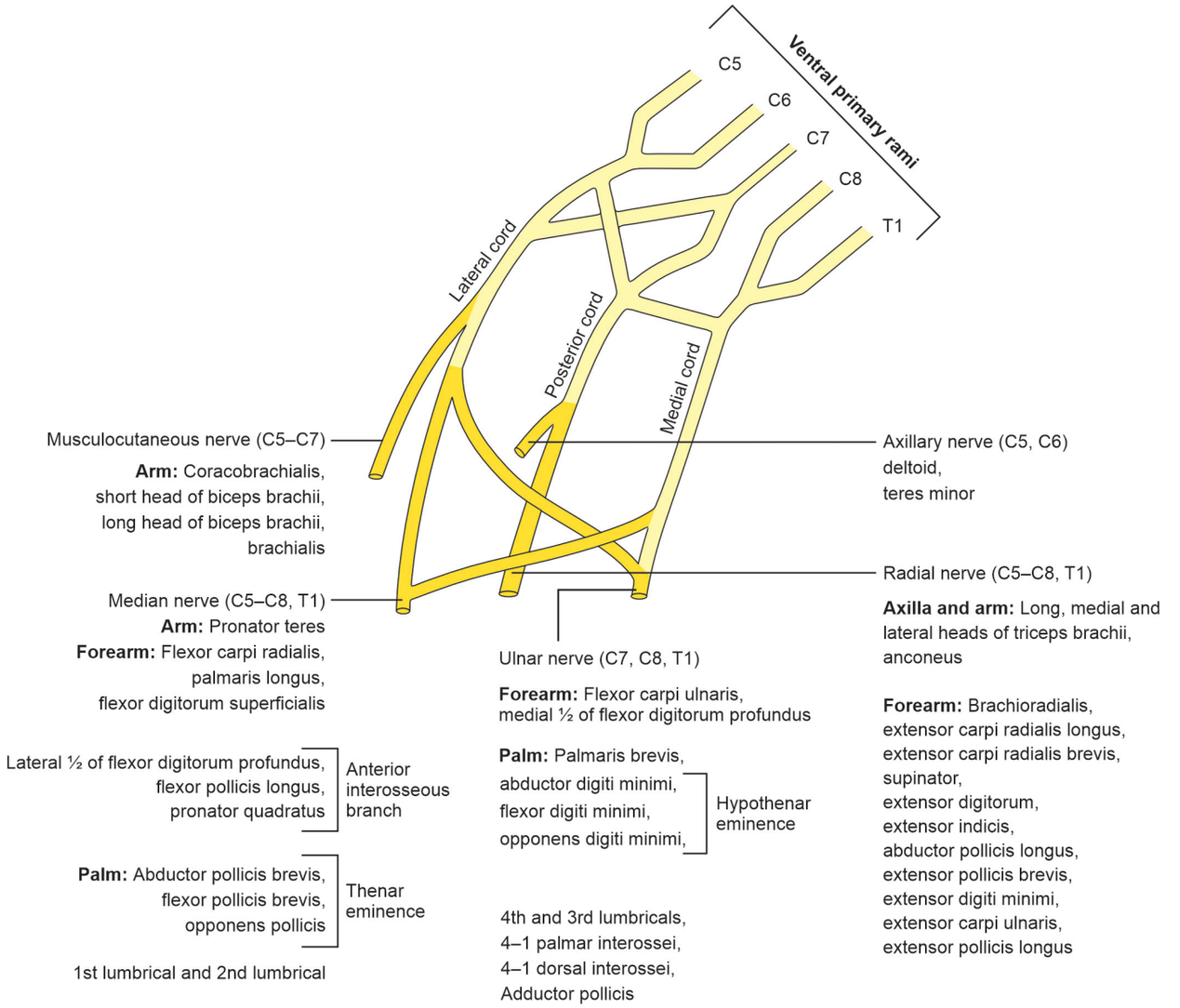


Fig. A1.1: Brachial plexus and muscular branches of the main nerves

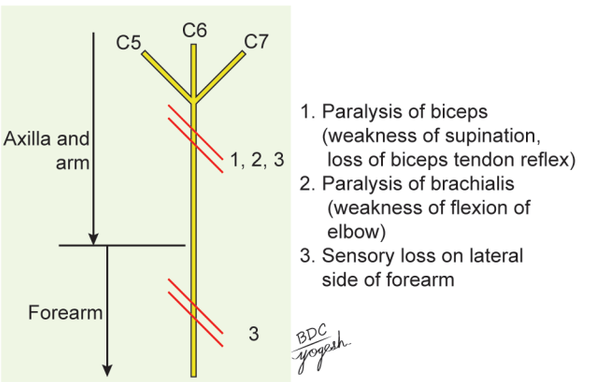


Fig. A1.2: Musculocutaneous nerve injury

TABLE A1.1: Branches of axillary nerve

	Trunk	*Anterior division*	*Posterior division*
Muscular	—	Deltoid (most part)	Deltoid (posterior part) and teres minor. The nerve to teres minor is characterised by the presence of a *pseudoganglion*
Cutaneous	—	—	Upper lateral cutaneous nerve of arm
Articular and vascular	Shoulder joint	—	To posterior circumflex humeral artery

CLINICAL ANATOMY

Axillary nerve injury:

Paralysis of deltoid (Weakness of abduction of arm up to 90° and loss of rounded contour of shoulder)

Sensory loss over lower half of deltoid—Regimental badge anaesthesia

RADIAL NERVE

Radial nerve is the thickest branch of brachial plexus.

Root Value

Ventral rami of C5–C8, T1 segments of spinal cord (*see* Fig. 4.14).

Course

Axilla

Radial nerve lies against the muscles forming the posterior wall of axilla, i.e. subscapularis, teres major distance in arm behind brachial artery. Then, it enters in the lower triangular space between teres major, long head of triceps brachii and shaft of humerus. It gives two muscular and one cutaneous branches in the axilla (Fig. A1.1).

Radial Groove

Radial nerve enters through the lower triangular space into the radial groove/sulcus, where it lies between the lateral and medial heads of triceps brachii along with profunda brachii vessels (*see* Plate 6.4). Long and lateral heads form the roof of the radial sulcus. It leaves the sulcus by piercing the lateral intermuscular septum. In the sulcus, it gives three muscular and two cutaneous branches.

Front of Arm

The radial nerve descends on the lower and lateral side of front of arm deep in the interval between brachialis on medial side and brachioradialis with extensor carpi radialis longus on the lateral side to reach capitulum of humerus.

Cubital Fossa

The nerve enters the lateral side of cubital fossa. There the radial nerve terminates by dividing into ***superficial and deep branches*** (*see* Fig. 8.16). The deep branch supplies extensor carpi radialis, brevis and supinator. Then, it courses between two heads of supinator to reach back of forearm.

Front of Forearm

The superficial branch leaves the cubital fossa to enter lateral side of front of forearm, accompanied by the radial vessels in its upper 2/3rd. At the junction of upper 2/3rd and lower 1/3rd, the superficial branch turns laterally to reach the posterolateral aspect of forearm.

Wrist and Dorsum of Hand

The superficial branch descends till the "anatomical snuffbox" to reach dorsum of hand, where it supplies skin of lateral half of dorsum of hand and lateral 3½ digits till distal interphalangeal joints (*see* Figs 7.1b and 9.45).

Back of Forearm and Wrist

The deep branch of radial nerve enters the back of forearm, where it supplies the muscles mentioned in Table A1.2. Lower down it passes through the 4th compartment under the extensor retinaculum to reach the back of wrist where it ends in a ***pseudoganglion***, branches of which supply the neighbouring joints (*see* Fig. 9.51).

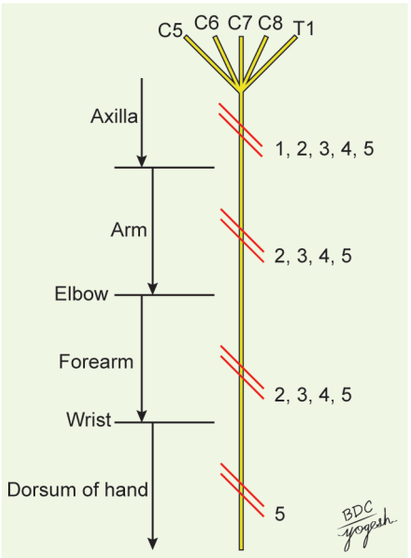
Branches of Radial Nerve

The branches of radial nerve are presented in Table A1.2.

Branches of deep division of radial nerve are shown in Table A1.3.

Branches of superficial division of radial nerve are shown in Table A1.4.

Features of the radial nerve injury are described in Fig. A1.3.



1. Paralysis of triceps brachii (loss of extension of elbow)*
2. Paralysis of extensor group of muscles in forearm (wrist drop)**
3. Paralysis of extensor pollicis longus (loss of extension at metacarpophalangeal and interphalangeal joints of thumb)
4. Paralysis of extensor digitorum, extensor indicis, and extensor digiti minimi (finger drop)***
5. Sensory loss (in lateral and posterior aspect of arm, posterior aspects, forearm, hand, and lateral 3½ fingers)

*When injured at arm, elbow extension is possible though it is weak as motor branches to long and medial head of triceps arise in the lower triangular space of axilla

**When injured at forearm, wrist drop may not be very pronounced as extensor carpi radialis longus is not involved

***Metacarpophalangeal joints cannot be extended but interphalangeal joints can be extended due to the action of lumbricals innervated by the median and ulnar nerves

Fig. A1.3: Radial nerve injury

TABLE A1.2: Branches of radial nerve

	Axilla	*Radial sulcus*	*Lateral side of arm*
Muscular	Long head of triceps brachii Medial head of triceps brachii	Lateral head of triceps brachii Medial head of triceps brachii Anconeus	Brachioradialis Extensor carpi radialis longus Lateral part of brachialis (proprioceptive)
Cutaneous	Posterior cutaneous nerve of arm	Posterior cutaneous nerve of forearm Lower lateral cutaneous nerve of arm	—
Vascular		To profunda brachii artery	—
Terminal	—	—	Superficial and deep or posterior interosseous branches

TABLE A1.3: Branches of deep division of radial nerve

	Cubital fossa	*Back of forearm*	*Wrist*
Muscular	Extensor carpi radialis brevis Supinator	Abductor pollicis longus Extensor pollicis brevis Extensor pollicis longus Extensor digitorum Extensor indicis Extensor digiti minimi Extensor carpi ulnaris	—
Articular	—	—	To inferior radioulnar, wrist and intercarpal joints

TABLE A1.4: Branches of superficial division of radial nerve

	Forearm	*Anatomical snuffbox and dorsum of hand*
Cutaneous and vascular	Lateral side of forearm and radial vessels	Skin over anatomical snuffbox, lateral half of dorsum of hand and lateral 3½ digits till their distal interphalangeal joints
Articular	—	To wrist joint, 1st carpometacarpal joint, metacarpophalangeal and interphalangeal joints of the thumb, index and middle fingers

MEDIAN NERVE

Median nerve is called median as it runs in the median plane of the forearm.

Root Value

Ventral rami of C5–C8, T1 segments of spinal cord.

Course

Axilla

Median nerve is formed by two roots, lateral root from lateral cord (C5–C7) and medial root from medial cord (C8, T1) of brachial plexus. Medial root crosses the axillary artery to join the lateral root. The median nerve runs on the lateral side of axillary artery (*see* Plate 8.4).

Arm

Median nerve continues to run on the lateral side of brachial artery till the middle of arm, where it crosses in front of the artery, passes anterior to elbow joint into the cubital fossa (*see* Plate 8.4 and A1.1).

Cubital Fossa

Median nerve lies most medial in the cubital fossa. It gives three branches to flexor muscles of the forearm. It leaves the fossa by passing between two heads of pronator teres (*see* Figs 8.16 and 8.17).

Forearm

Median nerve enters the forearm and lies in the centre of forearm. It lies deep to fibrous arch of flexor digitorum superficialis on the flexor digitorum profundus. Adheres to deep surface of flexor digitorum superficialis, leaves the muscle, along its lateral border (Plate 9.3). Lastly, it is placed deep and lateral to palmaris longus.

Flexor Retinaculum

Median nerve lies deep to flexor retinaculum to enter palm (*see* Plate 9.7).

Palm

Median nerve lies medial to the muscles of thenar eminence, which it supplies. It also gives cutaneous branches to lateral 3½ digits and their nail beds including skin of distal phalanges on their dorsal aspect.

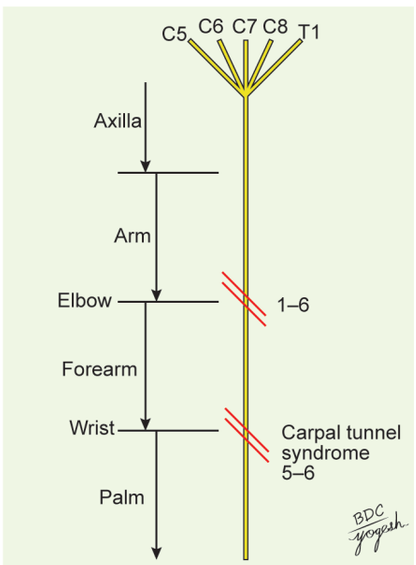
Branches of Median Nerve

The branches of median nerve are presented in Table A1.5.

Features of the median nerve injury are described in Fig. A1.4.

TABLE A1.5: Branches of median nerve

	Axilla and arm	*Cubital fossa*	*Forearm*	*Palm*
Muscular	Pronator teres in lower part of arm	Flexor carpi radialis Flexor digitorum superficialis Palmaris longus	Anterior interosseous which supplies: Lateral half of flexor digitorum profundus, pronator quadratus, and flexor pollicis longus	Recurrent branch for abductor pollicis brevis, flexor pollicis brevis, opponens pollicis. 1st and 2nd lumbricals from the digital nerves
Cutaneous	—	—	Palmar cutaneous branch for lateral 2/3rd of palm	Two digital branches to lateral and medial sides of thumb One to lateral side of index finger Two to adjacent sides of index and middle fingers Two to adjacent sides of middle and ring fingers. These branches also supply dorsal aspects of distal phalanges of lateral 3½ digits including nail beds (Fig. A1.2)
Articular and vascular	Gives sympathetic fibres to axillary and brachial arteries	Elbow joint	Gives sympathetic fibres to radial and ulnar arteries	Gives articular branches to joints of hand



1. Paralysis of all flexors of wrist except flexor carpi ulnaris and medial half of flexor digitorum profundus (weak flexion of wrist. The wrist deviates to ulnar side on flexion)
2. Paralysis of pronator teres and pronator quadratus (loss of pronation of forearm)
3. Paralysis of flexor digitorum superficialis and lateral half of flexor digitorum profundus and paralysis of 1st and 2nd lumbricals (when the patient is asked to close his hands and make a fist, he is able to close the ring and little finger as these have functioning flexor digitorum profundus, supplied by ulnar nerve. The middle finger also closes partially as FDPs are partially interlinked, but index finger remains open [pointing finger sign]).
4. Paralysis of flexor pollicis longus (loss of flexion at interphalangeal joint of thumb)
5. Paralysis of thenar muscles (loss of thenar eminence, Ape-like thumb)
6. Sensory, trophic and vasomotor changes over lateral 3½ fingers including their nails beds.

Fig. A1.4: Median nerve injury

ULNAR NERVE

Ulnar nerve is named so as it runs along the medial or ulnar side of the upper limb.

Root Value

Ventral rami of C8 and T1. It also gets fibres of C7 from the lateral root of median nerve (*see* Fig. 4.14).

Course

Axilla

Ulnar nerve lies in the axilla between the axillary vein and axillary artery on a deeper plane.

Arm

Ulnar nerve lies medial to brachial artery. Runs downwards with the brachial artery in its proximal part (*see* Fig. 8.7). At the middle of arm, it pierces the medial intermuscular septum to lie on its back and descends on the back of medial epicondyle of humerus where it can be palpated. Palpation causes tingling sensations (*see* Fig. 8.12a). That is why humerus is called 'funny bone'.

Forearm

Ulnar nerve enters the forearm by passing between two heads of flexor carpi ulnaris. There it lies on medial part

of flexor digitorum profundus. *Ulnar nerve is not a content of cubital fossa.*

It is accompanied by the ulnar artery in lower 2/3rd of forearm.

It gives two muscular and two cutaneous branches (Table A1.4 and Fig. A1.1).

Flexor Retinaculum

Finally, it lies on the medial part of flexor retinaculum to enter palm. At the distal border of retinaculum, the nerve divides into its superficial and deep branches.

Palm

Superficial branch supplies palmaris brevis and gives digital branches to medial 1½ digits including medial 1½ nail beds till the distal interphalangeal joints (Fig. A1.2).

Deep branch supplies most of the intrinsic muscles of the hand. At first, it supplies three muscles of hypothenar eminence. Running in the concavity of deep palmar arch, it gives branches to 3rd and 4th lumbricals from deep aspect; all dorsal and palmar interossei to end in adductor pollicis (Table A1.5). Since it supplies intrinsic muscles of hand responsible for finer movements, this nerve is called 'musician's nerve'.

Branches

The branches of ulnar nerve are presented in Table A1.6 and Fig. A1.1.

CLINICAL ANATOMY

- Features of the ulnar nerve injury are described in Fig. A1.5.
- ***Ulnar paradox*:** If ulnar nerve is injured at the elbow, the clawing of the fingers is less, because medial half of flexor digitorum profundus (flexor of proximal and distal interphalangeal joints) also gets paralysed. If ulnar nerve is injured at wrist, the clawing of the fingers is more as intact flexor digitorum profundus flexes the digits more. Thus, if lesion is proximal (near elbow), clawing is less. On the contrary, if lesion is distal (near wrist), clawing is more. This is called 'action of paradox'/ulnar paradox.
- ***Complete claw hand:*** If both ulnar and median nerves get paralysed, there is complete claw hand (*see* Fig. 9.40).
- Table A1.7 shows the comparison between injuries of median and ulnar nerves at the wrist.

SYMPATHETIC INNERVATION

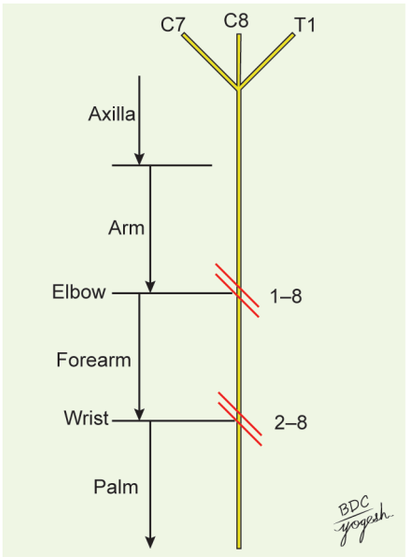
1. The sympathetic innervation of the upper limb is derived from the upper six thoracic segments of the spinal cord. The fibres arise from the lateral horn cells and come out with the ventral roots as preganglionic (white rami) fibres. These fibres ascend in the sympathetic chain to their appropriate ganglia for relay.
2. The postganglionic (grey rami) fibres emerge from the middle and inferior cervical and the first thoracic (stellate) sympathetic ganglia, and join the five roots (C5–C8, T1) of the brachial plexus.
3. The blood vessels to the skeletal muscles are dilated by the sympathetic activity. To the skin, however, these nerves are vasomotor, sudomotor and pilomotor.

TABLE A1.6: Branches of ulnar nerve

	Forearm	***Hand*** (*see* Fig. 9.31)
Muscular	Medial half of flexor digitorum profundus Flexor carpi ulnaris	Superficial branch—palmaris brevis Deep branch—muscles of hypothenar eminence, medial two lumbricals, 4–1 dorsal interossei and 4–1 palmar interossei and adductor pollicis. May supply deep head of flexor pollicis brevis (*see* Fig. 9.31)
Cutaneous/digital	Dorsal cutaneous branch for medial half of dorsum of hand. Palmar cutaneous branch for medial one-third of palm. Digital branches to medial 1½ fingers, nail beds and dorsal aspects of distal phalanges	—
Vascular/articular	Also supplies digital vessels and joints of medial side of hand	

TABLE A1.7: Comparison of injury of median and ulnar nerves at wrist

Injury to median nerve at wrist	***Injury to ulnar nerve at wrist***
Loss of thenar eminence	Loss of hypothenar eminence
Normal fist making by 4th, 5th digits	Clawing of 4th and 5th digits
Lagging behind of 2nd and 3rd digits in fist making	Slight clawing of 2nd and 3rd digits Gutters seen in palm
Sensory loss over lateral 3½ digits	Sensory loss over medial 1½ digits
Loss of pronation of forearm	Loss of adduction of 2nd, 4th and 5th digits
Loss of opposition of thumb	Loss of abduction of 2nd–4th digits



1. Paralysis of flexor carpi ulnaris and medial ½ of flexor digitorum profundus (flattening of medial border of forearm, loss of flexion at distal interphalangeal joints of 4th and 5th digits, weak flexion of the wrist*)
2. Paralysis of hypothenar muscles (loss of hypothenar eminence)
3. Paralysis of adductor pollicis (loss of adduction of thumb)
4. Paralysis of palmar interossei (loss of abduction of all fingers except little finger)
5. Paralysis of dorsal interossei (loss of adduction of 2nd, 4th and 5th digits)
6. Paralysis of interossei (slight clawing of 2nd and 3rd digits [intactness of median nerve supply to lateral ½ of flexor digitorum profundus])
7. Paralysis of 3rd and 4th lumbricals (marked clawing of 4th and 5th digits)
8. Sensory, trophic and vasomotor changes (Fig. A1.2)

* The wrist deviates to radial side due to lack of pull by paralysed flexor carpi ulnaris.

Fig. A1.5: Ulnar nerve injury

MAJOR ARTERIES OF UPPER LIMB

The upper limb is supplied by the axillary artery. The brief of the major arteries of the upper limb and their branches have been tabulated in Table A1.6. For the detailed course, relations and applied aspects of these arteries, refer corresponding chapters.

BDC's Anatomy *e*-book

1. Embryology of the upper limb
2. Clinical terms
3. Further reading
4. Viva voce questions

TABLE A1.6: Arteries of upper limb

Artery	*Origin, course and termination*	*Branches*
Axillary artery (*see* Figs 4.6 and A1.3)	Starts at the outer border of first rib as continuation of subclavian artery, runs through axilla and continues as brachial artery at the lower border of teres major muscle	*1st part*: Superior thoracic artery *2nd part*: Thoracoacromial trunk a. Pectoral b. Acromial c. Clavicular d. Deltoid branches Lateral thoracic artery 3rd part: Subscapular artery a. Circumflex scapular artery Anterior circumflex humeral artery a. Ascending branch Posterior circumflex humeral artery
Brachial artery (*see* Fig. 8.8)	Starts at the lower border of teres major as continuation of axillary artery. Runs on anterior aspect of arm and ends by dividing into radial and ulnar arteries at neck of radius in the cubital fossa	1. Profunda brachii artery a. Deltoid (ascending) branch b. Nutrient artery to humerus c. Numerous muscular branches d. Anterior descending (radial collateral) artery e. Posterior descending (middle collateral) artery 2. Superior ulnar collateral artery 3. Inferior ulnar collateral artery 4. Nutrient artery to humerus 5. Unnamed muscular arteries 6. Ulnar artery 7. Radial artery

(*Contd.*)

TABLE A1.6: Arteries of upper limb *(Contd.)*

Artery	*Origin, course and termination*	*Branches*
Radial artery (*see* Fig. 9.8):	Starts as smaller branch of brachial artery, lies on the lateral side of forearm, then in the anatomical snuffbox to reach the palm, where it continues as deep palmar arch	1. Muscular branches 2. Radial recurrent branch 3. Anterior (palmar) carpal branch 4. Posterior (dorsal) carpal branch 5. Superficial palmar branch – completes superficial palmar arch 6. First dorsal metacarpal artery 7. Arteria princeps pollicis 8. Arteria radialis indicis
Ulnar artery (*see* Plate 9.7)	Originates as the larger terminal branch of brachial artery at neck of radius. Courses first obliquely in upper one-third and then vertically in lower two-thirds of forearm. Lies superficial to flexor retinaculum and ends by dividing into superficial and deep branches	1. Anterior and posterior ulnar recurrent arteries 2. Common interosseous artery Anterior interosseous artery a. Muscular branches b. Nutrient arteries to radius and ulna c. Median artery (only 8% people) that runs with median nerve Posterior interosseous artery 3. Anterior and posterior ulnar carpal branches 4. Terminal branches – Superficial branch – continues as superficial palmar arch – Deep branch – completes deep palmar arch
Superficial palmar arch (*see* Plate 9.15)	Superficial palmar arch is the continuation of superficial branch of ulnar artery. It begins over the muscles of hypothenar eminence just below the flexor retinaculum. In palm, it runs laterally with downward convexity. It is completed by superficial palmar branch of radial artery	1–3. Three common palmar digital arteries for adjacent sides of medial 3½ digits 4. One proper digital artery for medial side of little finger 5. Cutaneous branches of the skin of palm
Deep palmar arch (*see* Plate 9.15)	Deep palmar arch is the continuation of radial artery after it emerges in the palm between transverse and oblique heads of adductor pollicis muscle. It is completed medially by deep palmar branch of ulnar artery at the base of 5th metacarpal bone	1–3. Three palmar metacarpal arteries 4–6. Three perforating arteries 7. Recurrent branch to superficial palmar arch

Right axilla

