Inderbir Singh’s Textbook of ANATOMY
Volume One
General Anatomy
Upper Limb
Lower Limb
6th Edition
Edited by Sudha Seshayyan
How this Book is Useful?

Features

• This edition has been prepared keeping in mind the twin factors, restructuring of medical curriculum and knowledge expansion.
• Many of the chapters have been completely revised, rewritten and rearranged in a new format for a different learning approach of Anatomy.
• Embryological and histological details have been added to give the reader a comprehensive picture.
• Each chapter begins with Specific Learning Objectives (SLOs) to highlight important concepts in the chapter.
• Newer features like Multiple Choice Questions and Clinical Problem-solving have been appended to each chapter for self-assessment.
• New sections on General Anatomy and Genetics have been added to make the fundamental knowledge stronger.
• Clinical conditions relevant to each chapter have been discussed under Clinical Correlation wherever necessary to emphasise their anatomical basis.
• Histology and Embryology have been added for the first time for comprehensive learning.
• To facilitate easy understanding, Surface Marking and Steps of Dissection have been added for the first time.
• The chapter on Cross-sectional and Surface Anatomy is completely updated to make students abreast with newer trends.
• Additional features like Added Information and Clinical Correlation in every chapter have been included to cater to the needs of postgraduate students and bright undergraduates too.
• Enriched with easy-to-reproduce nearly 1500 four-colour diagrams to make learning enjoyable and retainable.
• Many new relevant flowcharts and tables have been added for a quick grasp of the subject.
• Useful appendices have been given at the end of all volumes for better understanding of the subject.
Preface

Castles of all medical wisdom are anchored to the knowledge of anatomy. Both the learning and the teaching of anatomy have undergone masterly changes. Though the limits of human anatomy appear to be confined to the boundaries of the human body, newer frontiers have constantly appeared due to two primary factors—one, expanding basic medical and clinical research and two, larger understanding of hitherto unexplained areas.

The preparation of a textbook on Anatomy should have the scope to adequately accommodate the growing changes. At the same time, it also cannot become disproportionately large, considering the time span within which an average undergraduate medical student would have to acquire this knowledge.

This edition of Inderbir Singh’s Textbook of Anatomy has been prepared keeping the twin factors of the restructuring of medical curriculum and the knowledge expansion in mind. Many of the chapters have been completely revised and rewritten. Clinical Correlation has been clearly laid out. Embryological and Histological details have been added so as to give the reader a comprehensive picture. Newer features like Multiple Choice Questions and Clinical Problem-solving have been appended to each chapter in order to provide the reader with the opportunity of self-assessment.

A student entering the medical curriculum is faced with a completely new atmosphere. In an attempt to familiarize the student not only with Anatomy but also with the nuances of the medical world, new sections on General Anatomy and Genetics have been added. Professor Inderbir Singh’s eye for details and meticulous writing style have always been popular amongst generations of medical students. Though many areas of the book have been revisited, the basic spirit and nature of the book have been retained. Additional features like Added Information and Clinical Correlation in any chapter will be of much help not only to the undergraduate students but also to the postgraduates.

At this juncture, I would like to place on record my appreciation and gratitude to Dr Hannah Sugirthabai Rajila Rajendran, Professor, Department of Anatomy, Chettinad Hospital and Research Institute, Kanchipuram District, Tamil Nadu, India; Dr M Nirmaladevi, Associate Professor, PSGIMS & R, Coimbatore, Tamil Nadu, India and Dr J Sreevidya, Assistant Professor-cum-Civil Surgeon, Madras Medical College, Chennai, Tamil Nadu, India for their painstaking editorial assistance. I would like to thank Dr Indumathi S, Professor and HOD, Department of Anatomy, Chettinad Hospital and Research Institute, Dr T Anitha, Dr Elamathi Bose and Dr Bhuvaneswari, Assistant Professors of Anatomy, Madras Medical College, Chennai for their help during the preparation and review of the manuscripts and formulation of chapters.

I would be failing in my duty if I do not acknowledge the contributions of Dr Lakshmi, Dr Kanagavalli, Dr Arrchana, Assistant Professors, Department of Anatomy, Madras Medical College, Chennai and Dr Dharni, Assistant Professor, Villupuram Government Medical College, Villupuram, Tamil Nadu, India towards the completion of this edition. Shri RAC Mathews, Shri Ranganath and Shri Sashikumar were instrumental in providing the necessary assistance, and Shri E Senthilkumar provided some of the illustrations for the book and I would like to extend my thanks to each of them.

Special thanks to Shri Jitendar P. Vij (Group Chairman) and Mr Ankit Vij (Group President), Jaypee Brothers Medical Publishers (P) Ltd., without whom this edition would not have seen the light of the day. I am extremely thankful to them for reposing their confidence in me and providing the opportunity to revise Inderbir Singh’s Textbook of Anatomy. Dr Sakshi Arora (Director, Content and Strategy) has been the driving force behind all efforts and deserves a very special thanks. She has provided insights and innovative ideas which have gone a long way in consolidating this book to best meet the needs of the taught and the teacher alike. We are thankful to her entire Development and Content Strategy team consisting of Ms Nitasha Arora (Project Manager), Ms Ankita Singh, Ms Sonal Jain, Ms Neelam Kakariya, Mr Prashant Soni (Editorial), and Mr Prabhat Ranjan, Mr Neeraj Choudhary, Mr Bunty Kashyap, Mr Phool Kumar, Mr Puneet Kumar, Mr Vikas Kumar, Mr Sanjeev Kumar and Mr Sandeep Kumar (Designers and Operators) for their constant technical support throughout the project.

This book is the combined effort of a number of people who have contributed in myriad ways and it may not be humanly possible to list down the many; however, I take this opportunity to extend my thanks to all of them.

Sudha Seshayyan
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Chapter 11

Bones of Upper Limb

Frequently Asked Questions

- Write notes on (a) Upper end of Humerus, (b) Olecranon of ulna, (c) Radial tuberosity, and (d) Surgical neck of humerus
- Describe the lower end of humerus.
- Describe the ulna.
- Write notes on: (a) Scaphoid, (b) Hamate, (c) Capitate, (d) Lunate, (e) Lower end of radius, and (f) Upper end of ulna.
- Discuss the features of clavicle. Add a note on its applied importance.
- Discuss the following: (a) Spine of scapula, (b) Acromion, (c) Glenoid cavity, and (d) Coracoacromial arch.

The evolution of human kind with consecutive adoption of upright posture and bipedal mode of locomotion has resulted in changes not only in the bones of lower limb, but also in the bones of upper limb. The upper limb is made free from locomotion and weight-bearing. Further, the presence of clavicle as a strut facilitates free movement of the upper limb.

The other significant change in human beings is the progressive separation of the thumb from the other fingers enabling the hand to be used for prehension and other skilled movements. To enable these movements, the forearm is endowed with good range of supination and pronation, the shoulder joint is freely mobile and is further facilitated by the mobility at the pectoral girdle.

The upper limb is connected to the trunk by the pectoral girdle (also called the shoulder girdle) which is composed of scapula and clavicle on each side. These two bones support the shoulder region. Scapula is connected to the trunk only by muscles; clavicle acts as a prop for scapula (Fig. 11.1).

CLAVICLE

Another name: Collar bone

The clavicle (Latin, clavicula=a small key) is a long bone that connects the upper limb to the trunk. It has a shaft and two ends. It is situated at the anterosuperior aspect of
the thorax, and articulates with the sternum and the first rib medially and the scapula laterally. The medial end of
the bone which articulates with the sternum is called the sternal end and the lateral end which articulates with the
acromion of the scapula is called the acromial end. The bone is readily palpable from end to end; the skin moves
over it freely. Its medial part is convex forwards and lateral part concave forwards. The most important feature of
clavicle is that in the normal anatomical position, the bone is placed almost horizontally. Lying so, it serves to prevent
the shoulder from falling forwards.

**Side Determination**

- The medial end is much thicker than the shaft and is easily distinguished from the lateral end that is flattened.
- The medial part is convex forwards and the lateral part concave forwards.
- The inferior aspect has a shallow groove on the shaft and a rough area near its medial end.

With the aforementioned information, the side of the given clavicle can be determined.

For purposes of description, it is convenient to divide the clavicle into the lateral one-third which is flattened and
the medial two-thirds which is cylindrical. The forward convexity of the medial part is in conformity with the
superior thoracic aperture and the forward concavity of the lateral part with the shape of the shoulder.

The lateral one-third is flattened from above downwards and has two surfaces, i.e., superior and inferior. These surfaces are separated by two borders: anterior and posterior. The anterior border is concave and shows a small thickened area called the deltoid tubercle (Fig. 11.2). The inferior surface (of the lateral one-third) shows a prominent thickening near the posterior border called the conoid tubercle (Fig. 11.3). Lateral to the tubercle is a rough ridge that runs obliquely up to the lateral end of the bone, and is called the trapezoid line.

The medial two-thirds is variably described as cylindrical or prismatic. It has four surfaces: (1) anterior, (2) posterior, (3) superior, and (4) inferior. These surfaces are not clearly marked off from each other. The large rough area presents on the inferior aspect of the bone near the medial end and forms part of the inferior surface. The middle-third of the inferior aspect shows a longitudinal groove, the depth of which varies considerably from bone to bone. This is the groove for subclavius (sometimes called the subclavian groove). In well-formed bones, a rough, depressed area can be seen medial to this groove. This is the impression for costoclavicular ligament.
Chapter 11  Bones of Upper Limb

The lateral or acromial end of the clavicle bears a smooth facet for articulation with the acromion of the scapula to form the acromioclavicular joint. The medial or sternal end articulates with the manubrium sterni and also with the first costal cartilage. The articular area is smooth and extends onto the inferior surface of the bone for a short distance. The uppermost part of the sternal surface is rough for ligamentous attachments.

The clavicle can easily be felt in the living person as it lies just deep to the skin in its entire extent. The sternal end of the bone forms a prominent bulge that extends above the upper border of the manubrium sterni.

**Special Features of Clavicle**

- Though it is a long bone, it differs from other long bones because:
  - It is the only long bone which lies horizontally.
  - It does not possess a medullary cavity.
  - It is the only long bone which ossifies in membrane.
  - It is the only long bone which ossifies from two primary centres.
- It is the first bone to ossify and the last bone to complete ossification.

- It is subcutaneous in position and may be pierced by a cutaneous nerve (intermediate supraclavicular nerve).

**Attachments of Various Structures (Figs 11.4 and 11.5)**

**Muscular Insertions**

- The subclavius is inserted into the groove on the inferior surface of the shaft.
- The trapezius is inserted into the posterior border of the lateral one-third of the shaft.

**Muscular Origins**

- The clavicular head of the pectoralis major muscle arises from the anterior surface of the medial half of the shaft.
- The clavicular head of the sternocleidomastoid muscle arises from the medial part of the upper surface of the medial 2/3rds of the shaft.
- The lateral part of sternohyoid arises from the lower part of the posterior surface just near the sternal end.
- The deltoid arises from the anterior border of the lateral one-third of the shaft.
Section-2 Upper Limb

Ossification

The clavicle is the first bone in the body to start ossifying. The greater part of the clavicle is formed by intramembranous ossification. The sternal and acromial ends (Fig. 11.6) are preformed in cartilage. Two primary centres appear in the shaft during the 5th–6th weeks of foetal life and soon fuse with each other. The sternal end ossifies from a secondary centre that appears between 15 and 20 years of age, and fuses with the shaft by the age of 25 years. An additional centre may appear in the acromion.

SCAPULA

Other names: Shoulder blade, Blade bone

The scapula (Latin.scapule=shoulder blade, also meaning a spade) is a triangular plate of bone lying over the upper ribs in the back. It partly covers the 2nd to the 7th ribs. The bone gives attachments to muscles, forms the socket of the shoulder joint and enhances movements of the upper limb. It articulates with the clavicle and the humerus. The bone has a body and a spine. The body has two surfaces, three angles and three borders.

Clinical Correlation

- The sternal end of clavicle is the growing end.
- The nutrient artery to clavicle arises from the clavicular branch of the acromioclavicular artery.
- Fractures of the clavicle: Most of the fractures of the clavicle are caused by indirect violence. The bone is most commonly fractured at the junction of its middle and lateral one-thirds, as it is the weakest point of the bone. In this fracture, the outer fragment is pulled downwards by the weight of the upper limb and medially by the pectoralis major. The inner segment is pulled upwards by the sternocleidomastoid. Less commonly, the clavicle can be fractured near its lateral end. The slender and thin clavicle of a neonate may be fractured during birth, as the foetus passes through the birth canal. In neonates and young children, fracture of the bone is often incomplete, leading to what is called a ‘greenstick fracture.’ One part of the bone may be broken but the other side is bent. The bone resembles the bent branch of a tender sapling (green stick) which is not disconnected but is merely hanging sharp.
- Failure of fusion of ossification centres: When the two ossification centres of the bone do not fuse, the medial and lateral parts of the bone remain separate. This is a congenital deformity and should not be mistaken for a fracture. This condition is usually bilateral.

Added Information

- The clavicle, though readily palpable, is not strictly subcutaneous. It is subplatysmal. The thin elastic sheet of platysma intervenes between the skin and the clavicle. It is the platysma that allows the skin to move freely over the clavicle. Platysma is superficial to the supraclavicular nerves which descend in front of the bone.
- The bone is so named because it rotates like a key would do within the keyhole of a lock, during movements of the shoulder.
- The anterior aspect of the bone has a linear strip that is devoid of any muscular attachment. This strip lies between the attachments of sternocleidomastoid and trapezius above and the pectoralis major and deltoid below.
- Due to the varying features of the medial and lateral parts of the bone, the medial two-thirds are regarded a long bone and the lateral third a flat bone.
- The epiphysis of the secondary centre of the clavicle is the last of the epiphysis of the long bones of the body to fuse.
- Variations in the sizes of the bones of the two sides are common. The right clavicle is usually shorter, though stronger.
- Animals which use the forelimbs (equivalent to the upper limbs) for support and locomotion do not need a clavicle; so, in such animals (examples like dogs, oxen and horses), the clavicle is absent or rudimentary. In animals which use the forelimb for grasping, climbing and flying (examples like primates, rodents and bats), the bone is well developed.
- The clavicle, as a strut (a strut is a crane-like rigid support), holds the scapula in position; and thus, in turn, holds the upper limb laterally, backward and a little upward. As a result, the limb, in normal anatomical position, hangs behind the line of gravity and by its weight, maintains the erect posture. In fractures and deformities of the clavicle, the shoulders fall forward and medially, causing abnormalities of posture.
- The strut also keeps the upper limb away from the trunk, thus allowing free movements. The same strut action also helps the ribs getting elevated during deep inspiration.
- As one of the boundaries of the cervicoaxillary canal, the clavicle affords protection to the neurovascular bundle of the upper limb.
- The bone helps in transmission of shocks to the trunk from the upper limb.
- Structurally, the clavicle consists of spongy bone enclosed in a shell of compact bone.
The body has anterior (or costal) and posterior (or dorsal) surfaces. The anterior surface is smooth, but the upper part of the posterior surface gives off a large projection called the spine which stretches through the posterior surface from the medial to the lateral aspect.

At its lateral angle, the bone is enlarged and bears a large shallow oval depression called the glenoid cavity which articulates with the head of the humerus.

The side to which a given scapula belongs can be determined from the points given above.

**Orientation of the Scapula**

The scapula is applied to the posterosuperior aspect of the thorax which itself is barrel shaped. So, the inferior part of the bone is posterior when compared to the superior part. The inferior angle, therefore, is behind the plane of the glenoid cavity. The lateral border runs downwards, medially and posteriorly. The glenoid cavity faces laterally, little upwards and forwards.

**Body**

As already mentioned, the body of scapula has two surfaces, three borders and three angles.

The two surfaces are— (1) the Costal and, (2) the Dorsal surfaces. The costal surface (Fig. 11.7) lies against the posterolateral part of the chest wall. It is somewhat concave from above downwards. It is marked by longitudinal ridges. Since it gives attachment to the subscapularis muscle, the costal surface (except for a thick bar-like portion near the lateral border) is also called the subscapular fossa.

The dorsal surface (Fig. 11.8) is slightly arched from above downwards and has longitudinal corrugations near the lateral border. It gives off a large projection called the spine of scapula. The area above the spine, along with the upper surface of the spine forms the supraspinous fossa. The area below the spine, along with the lower surface of the spine forms the infraspinous fossa. The supraspinous and infraspinous fossae communicate with each other through the spinoglenoid notch that lies on the lateral side of the spine. The dorsal surface is otherwise called the dorsum scapulae.

The body of scapula has three angles— (1) superior, (2) inferior, and (3) lateral angles. The superior angle is at the junction of the superior and the medial borders. It is thin and acute. The inferior angle is at the junction of the medial and the lateral borders. It is thick and rounded. The lateral angle is at the junction of the superior and the lateral borders and is large and truncated. Since it bears the glenoid fossa, it is also called the glenoid angle.

There are three borders, namely (1) medial, (2) lateral, and (3) superior borders.

The superior border passes laterally and downwards from the superior angle to the lateral angle. Since there is no strain on this border and it does not give attachment to any bulky muscle, it is thin and sharp. At the lateral end, it is separated from the glenoid cavity by the root of the coracoid process. A deep suprascapular notch (also called the scapular notch) is seen close to the lateral end of the superior border. The medial border, otherwise called the vertebral border, extends from the superior to the inferior angle. It is arched and thicker than the superior border, because it gives attachments to muscles.
Section-2 Upper Limb

The *lateral border*, otherwise called the *axillary border*, runs from the lateral to the inferior angle. The part of the body adjoining the lateral border is thickened to form a longitudinal bar of bone, called the *strengthening bar*.

**Glenoid Cavity**

The *glenoid cavity* (Greek.glene=shallow) is a shallow articular socket for the head of humerus present at the lateral angle of the scapula. Its anterior margin is grooved by the subscapularis tendon and so the glenoid gets a pear shape. Just below the cavity, the lateral border shows a rough raised area called the *infra-\text{glenoid tubercle}*. Immediately above the glenoid cavity is a rough area called the *supra-\text{glenoid tubercle}*. The region of the glenoid cavity is often regarded as the head of the scapula. The slightly constricted area immediately medial to it constitutes the *neck*.

**Processes of the Scapula**

The scapula is usually described to have *three processes*. These are (1) the spinous process (often plainly called the spine), (2) the acromion process (or simply the acromion), and (3) the coracoid process.

- The *spinous process* is a large triangular projection from the posterior surface of the body. The apex of the triangle is at the medial end, and the base is laterally placed and forms the lateral border of the spine. The anterior border of the spine is attached to the dorsal surface; the posterior border is free and is greatly thickened to form the *crest of the spine*. The medial end of the spine (apex) lies near the medial border of the scapula and is often referred to as the *root of the spine*. The lateral border is free, broad and forms the medial boundary of the *spinoglenoid notch* (Fig. 11.9) (also called the *great scapular notch*). The crest is broad and flat; it has upper and lower lips with the intervening area being subcutaneous. The spine, as already noted, divides the dorsal surface into supraspinous and infraspinous fossae.
- The *acromion* (Greek.akros=point, omos=shoulder, acromios=point of the shoulder) is continuous with the lateral end of the spine and is, in fact, a projection of the latter. It forms a projection that is directed forwards and partly overhangs the glenoid cavity. It has lateral and medial borders which meet anteriorly at the tip of the acromion. The lateral border meets the crest of the spine at a sharp angle (usually a right angle) as termed the *acromial angle*. The medial border shows the presence of a small oval facet for articulation with the lateral end of the clavicle. The acromion also has upper and lower surfaces; the lateral border of the spine fades into the lower surface. The upper surface faces posterosuperiorly and is subcutaneous.
- The *coracoid process* (Greek.korax, korone=crow) is shaped like a bent finger. The root of this process is attached to the body of the scapula just above the glenoid cavity. The lower part of the root is marked by the *supraglenoid tubercle*. The tip portion which is also called the horizontal part is directed forwards, laterally and a little downwards.

**Attachments of Various Structures**

**Muscular Insertions**

- The *trapezius* is inserted into the upper border of the crest of the spine, and into the medial border of the acromion
- The *serratus anterior* is inserted into the *costal surface* along the *medial border* (Fig. 11.10)
  - The first digitation of the muscle is inserted from the superior angle to the root of the spine.
  - The next two or three digitations are inserted into a narrow line along the medial border.
  - The lower 4 or 5 digitations are inserted into a large triangular area over the inferior angle.

![Fig. 11.9: Right scapula-superior aspect](Image)
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![Diagram of the right scapula showing attachments seen from behind and from the front.](image)

**Fig. 11.10:** Right scapula showing attachments-seen from the front

**Fig. 11.11:** Right scapula showing attachments-seen from behind
Section-2  Upper Limb

- In the dorsal aspect of the medial border:
  - The levator scapulae (Fig. 11.11) is inserted into a narrow strip, extending from the superior angle to the level of the root of the spine.
  - The rhomboideus minor is inserted opposite the root of the spine.
  - The rhomboideus major is inserted from the root of the spine to the inferior angle.

Muscular Origins

- The short head of the biceps brachii arises from the lateral part of the tip of the coracoid process; and the long head from the supraglenoid tubercle.
- The coracobrachialis arises from the medial part of the tip of the coracoid process (Fig. 11.12).
- The long head of the triceps arises from the infraglenoid tubercle.
- The inferior belly of the omohyoid arises from the upper border near the suprascapular notch.
- The subscapularis arises from the whole of the costal surface, except for a small part near the neck.
- In the dorsal aspect of the lateral border: (Fig. 11.12)
  - The teres minor arises from the upper two-thirds of the rough strip.
  - The teres major arises from the lower one-third of the rough strip extending over the inferior angle.
  - The supraspinatus arises from the medial two-thirds of the supraspinous fossa, including the upper surface of the spine.
  - The infraspinatus arises from the greater part of the infraspinous fossa, except near the lateral border and a part near the neck.
  - The latissimus dorsi receives a small slip from the dorsal surface of the inferior angle.

Attachments of other Structures

- The capsule of the shoulder joint and the glenoidal labrum are attached to the margins of the glenoid cavity. In the upper part of glenoid cavity, the attachment of the capsule extends above the supraglenoid tubercle which makes the origin of the long head of the biceps intracapsular, i.e., within the capsule of the shoulder joint.
- The suprascapular ligament (also called the superior transverse ligament) bridges across the suprascapular notch and converts it into a foramen which transmits the suprascapular nerve. The suprascapular vessels lie above the ligament.
- The spinoglenoid notch is often converted into a foramen by the spinoglenoid ligament. The suprascapular nerve and artery enter the infraspinous fossa from the supraspinous fossa through the spinoglenoid notch or the foramen, if present.

Clinical Correlation

- The nutrient artery is a branch of the suprascapular artery.
- Vertebral levels: Different parts of the scapula correspond to different vertebral levels and these can be used as landmarks. The superior angle corresponds to T2 spine, the root of spine to T3 spine and the inferior angle to T7 spine.
- Triangle of auscultation: This is marked in relation to the scapula. The medial border of this triangle is the lateral border of trapezius, the lateral border is the lower part of the medial border of scapula and the inferior border is the upper line of latissimus dorsi.
- Various neurovascular structures are related to different parts of scapula. The suprascapular vessels and nerve are related to the superior border and the spinoglenoid area. The circumflex scapular branch of the subscapular artery turns around the lateral border between the two sets of fibres of teres minor and reaches the posterior aspect. The deep branch of the transverse cervical artery is related to the medial border.
- The suprascapular nerve can be entrapped at the suprascapular foramen or the spinoglenoid foramen.
- Fractures of the scapula (Fig. 11.13) are uncommon. They can occur in automobile accidents. Usual sites of fracture are:
  - Body of the scapula
  - Fracture through the neck
  - Fracture of the acromion process
  - Fracture of the coracoid process.
- Sprengel’s shoulder: (also called scapula elevata) is a condition in which the scapula is placed higher than normal.
- Winging of the scapula: (also called scapula alata) is a condition in which the medial border of the scapula is lifted off the chest wall. It is caused by paralysis of the serratus anterior muscle.
- Variations in the shape and size of scapula can occur.
- Non-union of epiphysis usually involves one of the acromial centres.
Chapter 11  Bones of Upper Limb

### Ossification

The scapula has one primary centre and seven secondary centres. The primary centre appears in the region of the body during the 8th week of foetal life. The spine is ossified by an extension from this centre. The greater part of the coracoid process is ossified from a secondary centre that appears in the first year. The remaining secondary centres, which appear about the age of puberty, are one for the subcoracoid area including the glenoid, two for the acromion, one for the medial border and one for the inferior angle. All the secondary centres fuse between the 18th and the 22nd years of age.

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**Added Information**

- The lower end of the scapula is felt easily and is used as a landmark.
- The meeting point of the apex of the spine and the medial border of scapula has a small triangular smooth area which is covered by the fibres of trapezius muscle.
- The same smooth triangle can be readily felt at the level of T3 spine and is used as a landmark.
- The acromial angle is also felt easily and used as a measuring point for chest dimensions.
- In some cases, the acromion is attached to the spine by cartilage or by a synovial joint (spinoacromial joint).
- Some authors define a primary centre for the coracoid process because of the appearance of such a centre before birth.
- The bony parts of scapula may get absorbed in old age with only the periosteum remaining.
- The crest of the spine is clinically referred to as the posterior border of the bone.
- The medial most point of attachment of deltoid fibres on the lower lip of the crest is prominent and is referred to as the deltoid tubercle.
- When the scapular body is in anatomical position, the medial border runs parallel and about 5 cm lateral to the thoracic vertebrae.
- The strengthening bar prevents buckling of the scapula.

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**Added Information contd...**

- The scapula forms the scapulothoracic joint with the thoracic wall. This is a physiological joint where movements occur between, on one side, the scapula and the associated muscles and, on the other, the thoracic wall. This is not an anatomical joint where movements occur between bony elements.
- The scapulothoracic joint is where the movements of scapular elevation-depression, scapular protraction-retraction and scapular rotation occur.
**HUMERUS**

**Other names:** Arm bone, Laughing bone, Funny bone

The humerus (Latin. humer=shoulder) is the bone of the arm and extends from the shoulder to the elbow. It is a long bone with a cylindrical central part **shaft**, and an enlarged **upper end** and **lower ends** (Figs 11.14 and 11.15).

**Side Determination**

- The upper end is marked by the presence of a large rounded head. The lower end is expanded
- The head is directed medially and so helps to decide the medial and lateral sides
- The anterior aspect of the upper end shows a prominent vertical groove called the **intertubercular sulcus**.

From the above-mentioned information, the side of a given humerus can be determined.

**Upper End (Fig. 11.16)**

The upper end has a hemispherical head, an ill-defined neck, two distinct tubercles and a deep groove between the tubercles.

The **head** is rounded (actually forms a third of a sphere) and has a smooth convex articular surface. It is directed medially, and also somewhat backwards and upwards. The articular surface articulates with the glenoid cavity of the scapula to form the shoulder joint. It may be noted that the articular area of the head is much greater than that of the glenoid cavity.

There are two distinct regions of the upper end of the humerus which are referred to as the **neck**. The junction of the head with the rest of the upper end is called the **anatomical neck** and is seen as a slightly constricted, narrow strip that encircles the head at the edge of the.
The two prominences in the upper end are called **the greater and lesser tubercles** (or tuberosities). These two tubercles are separated by the deep groove called the **intertubercular sulcus** (also called the bicipital groove) which is seen as a vertical furrow on the anterior aspect of the upper end. The **greater tubercle** is present on the lateral aspect of the upper end. Therefore, parts of it can be seen from both the anterior and posterior aspects. Three areas (or impressions) of muscular attachments are present on the tubercle. The uppermost of these is on the superior aspect, the lowest on the posterior aspect, and the middle is in between them. The **lesser tubercle** is on the anterior aspect of the bone medial to the intertubercular sulcus and lateral to the head. It has a smooth upper part and a rough lower part. The **intertubercular sulcus** lies between the two tubercles and passes down to the shaft. The anterior part of the greater tubercle continues down as the crest of the greater tubercle and forms the lateral lip of the sulcus. The medial part of the lesser tubercle continues down as the crest of the lesser tubercle and forms the medial lip of the sulcus.

**Shaft**

The **shaft** of the humerus has three borders and three surfaces.

The **three borders** are called the (1) anterior, (2) medial and (3) lateral borders. These are readily identified in the lower part of the bone. When traced upwards, the **anterior border** becomes continuous with the anterior margin of the greater tubercle (or crest of the greater tubercle, or lateral lip of the intertubercular sulcus). The **medial border** is indistinct, but can be traced to the lower end of the lesser tubercle and to its sharp lateral margin (crest of the lesser tubercle, or medial tip of the intertubercular sulcus). The lower part of the **lateral border** can be seen from the front, but its upper part runs upwards on the posterior aspect of the bone.

The three borders of shaft divide it into three surfaces, namely the anterolateral, anteromedial and posterior surfaces.

- The **anterolateral surface** lies between the anterior and lateral borders.
- The **anteromedial surface** lies between the anterior and medial borders.
- The **posterior surface** lies between the medial and lateral borders.

In the anterolateral surface, a V-shaped rough area called the **deltoid tuberosity** is present near the middle. The anterior limb of the tuberosity lies along the anterior border of the shaft while the posterior limb lies above the lower part of the radial groove. When the shaft is observed from behind, a broad and shallow groove called the **radial groove** (also called the spiral groove, since it appears to spiral around the shaft) running downwards and laterally across the upper parts of the posterior and anterolateral surfaces can be seen. The radial groove interrupts the lateral border of the shaft. The part of the lateral border below the groove is indistinct, but the part of the border above the groove can be traced to the posterior part of the greater tuberosity. The upper margin of the radial groove is formed by a roughened ridge that runs obliquely across the shaft. The lower end of the ridge is continuous with the posterior limb of the deltoid tuberosity. The shaft between the radial groove and the lower end of the bone widens out below and is smooth.

**Lower End**

The lower end of the humerus is irregular in shape, and is sometimes referred to as the **condyle**. It is flattened from backwards, expanded from side to side and bent slightly forwards. It has articular and non-articular parts. As the lower end expands both medially and laterally, the prominences made out of such expansions form the **medial** and the **lateral epicondyles**. The medial epicondyle is the larger and more projecting of the two. The middle portion of the distal edge of the bone can be seen to be pulley-shaped and is called the **troclea**. It articulates with the upper end (trochlear notch) of the ulna. Lateral to the troclea is the rounded convex projection called the **capitulum** (Latin.capitulum=small head) that articulates with the head of radius. The capitulum can be seen on the anterior and inferior aspects of the bone but does not extend posteriorly. The bone above the troclea is thinned out and so depressions can be seen both on the anterior and posterior aspects. Two depressions are
Section-2  Upper Limb
seen on the anterior aspect; the medial one above the trochea is larger and is called the coronoid fossa and the lateral one above the capitulum is smaller and is called the radial fossa (parts of the coronoid process of ulna and the head of radius lie in these depressions respectively when the elbow is fully flexed). The posterior depression is the olecranon fossa. It lodges the olecranon process of the ulna when the elbow is fully extended. The medial margin of the trochea projects downwards much below the level of the capitulum, and of the epicondyles.

The lowest parts of the medial and lateral borders of the humerus form sharp ridges called the medial and lateral supracondylar ridges. Their lower ends terminate in the medial and lateral epicondyles. The posterior aspect of the medial epicondyle is smooth and has a shallow sulcus. The posterior aspect of the lateral epicondyle is smooth and subcutaneous and, therefore, is felt easily.

Attachments of Various Structures

Muscular Insertions

(Figs 11.17 and 11.18)

- The supraspinatus is inserted into the upper impression on the greater tubercle.
- The infraspinatus is inserted into the middle impression on the greater tubercle.
- The teres minor is inserted into the lower impression on the greater tubercle.
- The subscapularis is inserted into the lesser tubercle.
- The pectoralis major is inserted into the lateral tip of the intertubercular sulcus.
- The latissimus dorsi is inserted into the floor of the intertubercular sulcus.
- The teres major is inserted into the medial tip of the intertubercular sulcus.

Fig. 11.17: Right humerus showing attachments-seen from the front

Fig. 11.18: Right humerus showing attachments-seen from behind
Muscular Origins

- The **brachialis** arises from the lower halves of the anteromedial and anterolateral surfaces of the shaft. Part of the area of origin extends onto the posterior aspect.
- The **pronator teres** (humeral head) arises from the anteromedial surface, near the lower end of the medial supracondylar ridge.
- The **brachioradialis** arises from the upper two-thirds of the lateral supracondylar ridge.
- The **extensor carpi radialis longus** arises from the lower one-third of the lateral supracondylar ridge.
- The **superficial flexor muscles** of the forearm arise from the anterior aspect of the **medial epicondyle**. This origin is called the **common flexor origin**.
- The **common extensor origin** for the superficial extensor muscles of the forearm is located on the anterior aspect of the **lateral condyle**.
- The lateral head of the **triceps** arises from the oblique ridge on the upper part of the posterior surface, just above the radial groove. The medial head of the muscle arises from the posterior surface below the radial groove. The upper end of the area of origin extends onto the anteromedial aspect of the shaft.
- The **anconeus** arises from the posterior surface of the lateral epicondyle (Fig. 11.18).

Attachments of Other Structures

- The **capsular ligament of the shoulder joint** is attached to the anatomical neck.
  On the medial side, the line of attachment dips down by about a centimetre to include a small area of the shaft within the joint cavity. The line of attachment of the capsule is interrupted at the intertubercular sulcus to provide an aperture through which the tendon of the long head of the biceps leaves the joint cavity.
- The **capsular ligament of the elbow joint** is attached to the lower end of the bone.
  - Anteriorly the line of attachment reaches the upper limits of the radial fossa and the coronoid fossa.
  - Posteriorly the line reaches the upper limit of the olecranon fossa.
  These fossae therefore lie within the joint cavity.
- The medial and lateral epicondyles give attachment to the **ulnar** and **radial collateral ligaments** respectively.

Important Relations

- The intertubercular sulcus lodges the tendon of the long head of the biceps brachii. The ascending branch of the anterior circumflex humeral artery also lies in this sulcus.
- The surgical neck of the bone is related to the axillary nerve and to the anterior and posterior circumflex humeral vessels.
- The radial nerve and the profunda brachii vessels lie in the radial groove between the attachments of the lateral and medial heads of the triceps.
- The ulnar nerve crosses behind the medial epicondyle, lying on a shallow sulcus.

Clinical Correlation

- The upper end is the growing end and the nutrient foramen is directed to the elbow.
- The main nutrient artery is a branch of the brachial artery; a branch of the profunda brachii artery may also enter the bone.
- **Fractures of the humerus (Fig. 11.19).** Fractures of humerus are comparatively common and can occur at almost any level.
- Among the various sites, fracture of shaft of humerus can occur through the surgical neck, through the middle of its shaft and/or just above the lower end (supracondylar fracture). Since the surgical neck is weaker than more proximal and distal regions of the bone, fracture is common in the surgical neck.
- Other fractures that can be seen are through the greater tuberosity, condyles (usually lateral) or through an epicondyle (usually medial).
- In children, the most common fracture is **supracondylar**. Fractures through the neck are common in old women. Fracture through the middle of the shaft usually occurs in adults.
- Avulsion fracture of the greater tubercle is seen in the older age group. The muscles attached to the humerus cause a medial rotation.
- **Nerves that can be damaged:**
  - Humerus is related to several nerves and these may be damaged in fracture.
  - Fracture through the surgical neck of the humerus can damage the axillary nerve (the posterior circumflex humeral artery may also be damaged, but such damage is usually rare).
  - Fracture through the middle of the shaft can damage the radial nerve (which lies in the radial groove).
  - In supracondylar fracture, the median nerve can be injured, and there is danger of damage to the brachial artery as well.
  - The ulnar nerve can be damaged in a fracture of the medial epicondyle.
- **Non-union**
  Humerus has a poor blood supply at the junction of its upper and middle-thirds. Fractures at this site may, therefore, heal poorly, resulting in delayed union or in non-union.
Section-2 Upper Limb

**Ossification**

A single primary centre appears in the shaft during the 8th foetal week. The greater part of the bone is formed from this centre.

Secondary centres at the upper end appear as follows:
- **Head**: Early in the first year
- **Greater tubercle**: Second year
- **Lesser tubercle**: Fifth year

These three parts fuse with each other in the sixth year to form a single epiphysis for the upper end that fuses with the shaft around 18 to 20 years of age.

Secondary centres at the lower end appear as follows:
- **Capitulum**: First year
- **Medial part of the trochlea**: Ninth or tenth year
- **Lateral epicondyle**: Twelfth year

These fuse to form a single epiphysis which fuses with the shaft around 15 years of age.

A separate centre appears in the medial epicondyle around the fifth year, and fuses with the shaft around the twentieth year.

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**Added Information**

- The humerus is often dubbed as the ‘laughing bone’ due to the similarity in the pronunciation of its name and the English word ‘humorous’. However, the epithet is justified by the tickling sensation one feels when the medial epicondyle of the humerus is tapped due to the stimulation of the ulnar nerve passing behind it.
- The greater and lesser tubercles are separated from the head by the anatomical neck, from the body by the surgical neck and from each other by the intertubercular sulcus.
- The greater tubercle projects laterally beyond the acromion and, therefore, gives the roundness to shoulder.

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**RADIUS**

*Other names*: Rod bone, Wheel bone

The radius (Latin. radion=rod, ray) is the lateral of the two bones of the forearm. It extends from the elbow to the wrist. Since it does not overlap the humerus, it is shorter than the ulna. It is a long bone with a shaft and two ends.

**Side Determination**

- The upper end bears a disc-shaped head, while the lower end is much enlarged.
- The shaft is convex laterally and has a sharp medial border.
- The lower end is smooth anteriorly but has numerous ridges and grooves on its posterior aspect.

From the above given information, the side of a given radius can be made out (Figs 11.20 and 11.21).

**Upper End**

The upper end of the bone consists of a head, a neck and a tuberosity. The head is disc-shaped. Its upper surface is concave and articulates with the capitulum of the humerus. The circumference of the head (representing the edge of the disc) is also smooth and articular. The medial part of this edge articulates with a notch on the ulna to form the superior radioulnar joint. The remaining part of the edge is encircled by the annular ligament which holds it against the notch but still allows it to rotate freely. The region just below the head is constricted to form the neck. It is smooth with a few vascular foramina. Just below the medial part of the neck, there is an elevation called the radial tuberosity. The tuberosity is rough in its posterior part and is smooth anteriorly.
Shaft

The shaft of the radius is round near the neck but becomes triangular in section lower down. It has three borders (anterior, posterior and interosseous) and three surfaces (anterior, posterior and lateral) (Fig. 11.22).

The interosseous or medial border is the prominent sharp ridge that extends from below the radial tuberosity to the medial side of the lower end of the bone. Near the lower end, this border forms the posterior margin of a small triangular area.

The anterior border begins at the anterior aspect of the radial tuberosity and runs downwards and laterally across the anterior aspect of the shaft. This part of the anterior border is called the anterior oblique line. It then runs downwards and forms the lateral boundary of the smooth anterior surface of the lower part of the shaft. The upper part of the posterior border runs downwards and laterally from the posterior part of the tuberosity. The lower part of the posterior border runs downwards along the middle of the posterior aspect of the shaft to the lower end.

The anterior surface lies between the interosseous and the anterior borders; the posterior surface between the interosseous and the posterior borders and the lateral surface between the anterior and the posterior borders. The anterior surface is smooth and continues inferiorly as the anterior surface of the lower end. The posterior surface is comparatively flatter and merges with the lateral surface in the inferior aspect. The lateral surface is indistinct.
inferiorly but expands into a wide triangular area in the upper part of the bone as it extends onto the anterior and posterior aspects. It also shows a rough area near the middle and most convex part of the shaft.

**Lower End**

The lower end of the radius has anterior, lateral and posterior surfaces which are continuous with the corresponding surfaces of the shaft. In addition, it has a medial surface and an inferior surface. The lateral surface is prolonged downwards as a projection called the *styloid process*. The medial aspect of the lower end has an articular area called the *ulnar notch* which articulates with the lower end of the ulna to form the *inferior radioulnar joint*. Just above the notch, there is a triangular area bounded posteriorly by the interosseous border (Fig. 11.23).

The posterior aspect of the lower end is marked by a number of vertical grooves separated by ridges. The most prominent ridge, called the *dorsal tubercle* (or Lister’s tubercle or dorsal radial tubercle), is placed roughly midway between the medial and lateral aspects of the lower end. Immediately medial to the tubercle is a narrow oblique groove, and still more medially, is a wide shallow groove. The area lateral to the dorsal tubercle also shows two grooves separated by a ridge.

The inferior surface of the lower end is concave and articular. It extends onto the medial surface of the styloid process and takes part in the formation of the wrist joint. It is subdivided into a medial quadrangular area that articulates with the lunate bone and a lateral triangular area that articulates with the scaphoid bone (Fig. 11.24).

**Attachments of Various Structures (Fig. 11.25)**

**Muscular Insertions**

- The *biceps brachii* is inserted into the rough posterior part of the radial tuberosity.
- The *supinator* is inserted into the upper part of the lateral surface. The area of insertion extends onto the anterior and posterior aspects of the shaft.
- The *pronator teres* is inserted into the rough area on the middle of the lateral surface at the point of maximum convexity of the shaft.
- The *brachioradialis* is inserted into the lowest part of the lateral surface just above the styloid process.
- 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.
Muscular Origins (Fig. 11.26)
- The flexor digitorum superficialis (radial head) arises from the upper part of the anterior border (oblique line).
- The flexor pollicis longus arises from the upper two-thirds of the anterior surface.
- The abductor pollicis longus arises from the upper part of the posterior surface.
- The extensor pollicis brevis arises from a small area on the posterior surface below the area for the abductor pollicis longus.

Attachments of Other Structures
The radial dorsal tubercle receives a slip from the extensor retinaculum and is grooved medially by the tendon of extensor pollicis longus. The groove lateral to the tubercle contains the tendons of extensor carpi radialis longus laterally and extensor carpi radialis brevis medially. Medially the dorsal surface is grooved by the tendons of extensor indicis and posterior interosseous nerve (Fig. 11.27).

Ossification
A primary centre appears in the shaft during the 8th week of foetal life. A secondary centre appears in the lower end in the first or second year and joins the shaft around 18 years of age. Another secondary centre appears in the...
head of the radius during the 4th or 5th year and fuses with the shaft around the 16th year. Occasionally, the radial tuberosity may ossify from a separate centre which appears around puberty.

**Clinical Correlation**

- The growing end is the lower end. The nutrient artery which is directed to the elbow is a branch of the anterior interosseous artery.
- **Fractures of the Radius (Fig. 11.28)**
  Since radius is the weight-bearing bone, it is more prone to fractures and injuries.
  The radius may be fractured through the middle of its shaft (either alone or along with the shaft of the ulna). It may also be fractured either through the upper end (or head) or through the lower end. Fracture of the lower end is called **Colles' fracture**. This fracture is very common in older persons, specially women. Usually, the lower fragment is displaced backwards and laterally resulting in what has been called a ‘dinner-fork’ deformity. The radial styloid process which normally lies distal to the ulnar styloid process becomes proximal. Complications of this fracture include injury to or compression of the median nerve, rupture of the tendon of the extensor pollicis longus and subluxation of the inferior radioulnar joint. Occasionally, fracture of the lower end of the radius is associated with forward displacement (as against backward displacement in Colles' fracture). This is called **Smith's fracture** or **Barton's fracture** or reversed Colles' fracture.

**ULNA**

**Another name:** Elbow bone

The ulna (Latin. ulna=elbow, Greek. olene=elbow) is the medial of the two forearm bones and is longer than the lateral radius. It extends from the elbow to the wrist and also overlaps the humerus. It is subcutaneous and can be felt in its whole length at the back of the forearm. It is a long bone with a shaft, the upper and the lower ends. It is important to note that the head of the bone is in the lower end.

**Side Determination**

- The upper end is large and irregular, while the lower end is small.
- The anterior aspect of the upper end has a large **trochlear notch**.
- The lateral margin of the shaft is sharp and thin, while the medial side is rounded.

From the above-mentioned facts, the side of a given ulna can be determined (Figs 11.29 and 11.30).

**Upper End**

The **upper end** of the ulna is large and consists of two prominent projections called the **olecranon process** and the **coronoid process**. These two processes enclose a concavity, thereby giving the bone a spanner-like appearance. When seen from behind, the olecranon process appears to be a direct upward continuation of the shaft and forms the uppermost part of the ulna. It can be easily felt in the living subject and forms what is called the 'point of elbow'. The coronoid process projects forwards from the anterior aspect of the ulna just below the olecranon. The concavity enclosed is the **trochlear notch** and is formed by the anterior aspect of the olecranon process and the superior aspect of the coronoid process. It takes part in the formation of the elbow joint and articulates with the trochlea of the humerus. The upper and lower parts of the notch may be partially separated from each other by a non-articular area. The trochlear notch is also divisible into medial and lateral areas corresponding to the medial and lateral flanges of the trochlea of the humerus.

In addition to its anterior surface, which forms the upper part of the trochlear notch, the **olecranon process** (Greek. olene=ulna, kranion=head) has superior, posterior, medial and lateral surfaces. When viewed from the lateral side, the uppermost part of the olecranon is seen projecting forwards beyond the rest of the process. The superior surface tapers in front. The posterior surface is smooth and subcutaneous and extends to the shaft as a triangle. The medial and lateral surfaces are rough.
The **coronoid process** (Greek. korone=crow, also Greek. coronae=garland or crown, crow-beak appearance or crown-like appearance) has an upper surface that forms the lower part of the trochlear notch. In addition, it has anterior, medial and lateral surfaces. The anterior surface is triangular. Its lower part shows a rough projection called the **tuberosity** of the ulna. The medial margin of the anterior surface is sharp and shows a small tubercle at its upper end.

The upper part of the lateral surface of the coronoid process shows a concave articular facet called the **radial notch**. The radial notch articulates with the head of the radius forming the superior radioulnar joint. A depression is seen just below the radial notch. The posterior border of this depression is formed by a ridge called the **supinator crest**.

**Shaft**

The shaft of the ulna is predominantly triangular in section and tapers to a slender rounded part. However, it again widens in the lower portion. The shaft has a sharp lateral or interosseous border, and less prominent anterior and posterior borders. It has anterior, posterior and medial surfaces.

The prominent lateral edge of the shaft is the **interosseous border**. In the upper part, it is continuous with the supinator crest; in the middle, it forms a prominent ridge on the lateral aspect of the shaft and in the lower part, it is indistinct and ends on the lateral side of the head. The **anterior border** begins at the tuberosity of the ulna and runs downwards. Near its lower end, it curves backwards to end in front of the styloid process. The **posterior border** begins at the apex of the triangular area on the posterior aspect of the olecranon process and ends at the styloid process (Figs 11.31 and 11.32).

The **anterior surface** lies between the interosseous and anterior borders. Its lower part shows an oblique ridge that runs downwards and medially from the interosseous border. The **medial surface** lies between the anterior and posterior borders. The **posterior surface** is bounded by the interosseous and posterior borders. It is marked by two lines that divide it into three areas. The upper end of
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these lines runs obliquely downwards and medially across the upper part of the surface. It starts at the posterior end of the radial notch and terminates by joining the posterior border. The part of the posterior surface above the oblique line is triangular. The part below the oblique line is subdivided into medial and lateral parts by a vertical ridge.

Lower End
The lower end of the ulna consists of a disc-like head and a styloid process. The head is rounded and has a circular inferior surface. This surface is separated from the cavity of the wrist joint by an articular disc which comes in apposition with the triquetral bone. Hence, the ulna bone does not take part directly in the formation of the wrist joint. The head has another convex articular surface on its lateral side. This surface articulates with the ulnar notch of the radius to form the inferior radioulnar joint. The styloid process (Latin. stylus = pen or stick) is a small downward projection that lies on the posteromedial aspect of the head. Between the styloid process and the head, the posterior aspect is marked by a vertical groove. It is of importance to note that the tip of the styloid process of the ulna lies at a higher level than the styloid process of the radius when articulated.

Attachments of Various Structures

Muscular Insertions
- The brachialis is inserted into the anterior surface of the coronoid process including the tuberosity.
- The triceps is inserted into the posterior part of the superior surface of the olecranon process.

Muscular Origins
- The flexor digitorum profundus arises from the upper three-fourths of the anterior and medial surfaces. The muscle also takes origin from the posterior border through an aponeurosis common to it, the flexor carpi ulnaris and the extensor carpi ulnaris (Fig. 11.33).
- The supinator arises from the supinator crest and from the triangular area in front of it.
- The flexor pollicis longus (occasional ulnar head) arises from the lateral border of the coronoid process.
- The flexor digitorum superficialis (ulnar head) arises from the tubercle at the upper end of the medial margin of the coronoid process.
- The pronator teres (ulnar head) arises from the medial margin of the coronoid process.
- The pronator quadratus arises from the oblique ridge on the lower part of the anterior surface of the shaft.
- The flexor carpi ulnaris (ulnar head) arises from the medial side of the olecranon process and from the upper two-thirds of the posterior border through an aponeurosis common to it, the extensor carpi ulnaris and the flexor digitorum profundus.
- The extensor carpi ulnaris (ulnar head) arises from the posterior border by an aponeurosis common to it, the flexor carpi ulnaris and the flexor digitorum profundus.
- The posterior surface of the ulna is divided into medial and lateral parts by a vertical ridge. The lateral part lies between the vertical ridge and the interosseous border. This part of the posterior surface may be divided into four parts:
The skeleton of the hand consists of the bones of the wrist, palm and fingers. The components, therefore, are the bones of the carpus, metacarpus and the phalanges (Fig. 11.35).

The term carpus (Greek.karpos=wrist) indicates a group of eight small bones in the region of the wrist. The skeleton of the palm is made up of five metacarpal bones. These are miniature ‘long’ bones. The skeleton of the fingers is made up of the phalanges. There are three phalanges (proximal, middle and distal) in each finger except the thumb which has only two phalanges (proximal and distal).

**Carpal Bones**

The bones of the carpus, usually referred to as the carpal bones, are arranged in two rows, namely proximal and distal.
Section-2  Upper Limb

Scaphoid Bone

Other names: os scaphoideum, navicular of the hand.

The scaphoid bone can be distinguished because of its distinctive boat-like shape as its name suggests (Greek. scaphé=boat). The proximal part of the bone is covered by a large, convex, articular surface of the radius. Distally and laterally, the palmar surface of the bone bears a projection called the tubercle. The medial surface of the scaphoid articulates with the lunate bone (proximally) and with the capitates (distally). The distal surface of the scaphoid articulates with the trapezium (laterally) and with the trapezoid bone (medially).

Lunate Bone

Other names: Os lunatum, Os intermedium, semilunar bone.

The lunate bone can be distinguished because it is shaped like a lunar crescent (Latin.luna=moon). Proximally, the bone has a convex articular facet that takes part in the formation of the wrist joint. The bone articulates laterally with the scaphoid; medially with the triquetral. Distally, it articulates with the capitate. Between the areas for the capitate and for the triquetral, the lunate may articulate with the hamate bone.

Triquetral Bone

Other names: Triquetrum, Os triangulare, cubital bone, pyramidal bone, three-cornered bone.

The triquetral bone (Latin.tri=three, quetrus=cornered) can be distinguished from other carpal bones by the fact that it is a small roughly cuboidal bone. It has palmar, dorsal, proximal, distal, medial and lateral surfaces. The distal part of its palmar surface articulates with the pisiform bone. The medial surface is directed as much proximally as...
medially. It bears a slightly convex surface that takes part in the formation of the wrist joint and comes into contact with the articular disc of the inferior radioulnar joint. Its lateral surface is directed distally and articulates with the hamate bone. The proximal surface is directed laterally and articulates with the lunate bone.

**Hamate Bone**

**Other names:** Os hamatum, hooked bone, unciform bone.

The hamate (Latin.hamus=hook, Latin.uncinatum=hooklike) is easy to recognise as it has a prominent hook-like process attached to the distal and medial parts of its palmar aspect. When viewed from the palmar aspect, the hamate is triangular in shape, the apex of the triangle being directed proximally. Proximally, the apex of the bone may articulate with the lunate bone. Distally, the hamate articulates with the fourth and fifth metacarpal bones. Medially and proximally, the hamate articulates with the triquetral bone. Laterally, the hamate bone articulates with the capitate bone.

**Carpal Tunnel (Fig. 11.37)**

The carpal bones are so arranged that the dorsal, medial and lateral surfaces of the carpus form one convex surface. On the other hand, the palmar surface is deeply concave with overhanging medial and lateral projections. This concavity called the carpal sulcus is converted into the carpal tunnel by a band of fascia called the flexor retinaculum. The flexor retinaculum is attached medially to the pisiform bone and the hook of the hamate; and laterally to the tubercle of the scaphoid and tubercle of the trapezium.

**METACARPAL BONES**

The hand has five metacarpal bones (Greek.meta=beyond, metacarpal=beyond carpal) (Fig. 11.38). They are numbered from lateral to medial side so that the bone related to the thumb is the first metacarpal, and that related to the little finger is the fifth. Each metacarpal is a miniature long bone having a shaft, a distal end and a proximal end. The distal end forms a rounded head. It bears a large convex articular surface for articulation with the scaphoid and trapezium. Medially, it articulates with the capitate bone.

**Trapezoid Bone**

**Other names:** Os multangulum minus, lesser multangular bone.

This bone (trapezoid=like a trapezium) can be distinguished from other carpal bones because of its small size and its irregular shape resembling that of a shoe. The trapezoid articulates distally with the base of the second metacarpal bone. Laterally, it articulates with the trapezium. Medially, it articulates with the capitate bone. Proximally, it articulates with the scaphoid bone.

**Capitate Bone**

**Other names:** Os capitatum, os magnum.

The capitate bone (Latin.caput=head) is easily recognised as it is the largest carpal bone, and bears a rounded head at one end. The capitate lies right in the middle of the carpus. Proximally, it articulates with the lunate bone, the rounded head fitting into a socket formed by the lunate and scaphoid bones. Distally, the capitate bone articulates mainly with the third metacarpal bone, but it also articulates with the second and fourth metacarpal bones. Laterally, it articulates with the scaphoid (proximally) and the trapezoid (distally). Medially, it articulates with the hamate bone.
articulation with the proximal phalanx of the corresponding digit. The shaft is triangular in cross-section and has medial, lateral and dorsal surfaces. The bases (or proximal ends) of the metacarpal bones are irregular in shape. They articulate with the distal row of carpal bones. The bases of the second and third, third and fourth, and fourth and fifth metacarpal bones also articulate with each other (Fig. 11.39).

The base of each of the metacarpal bones has certain characteristics that enable us to distinguish them from each other (Fig. 11.39).

**PHALANGES OF HAND**

*Other name:* Ossa digitorum manus

The arrangement of the phalanges of the hand and foot is similar. Each digit of the hand, except the thumb, has three phalanges: proximal, middle and distal (Fig. 11.40). The thumb has only two phalanges: proximal and distal. Each phalanx has a distal end or head, a proximal end or base, and an intervening shaft or body which tapers distally. The bases of the proximal phalanges carry concave, oval facets adapted to articulate with the metacarpal heads.

**Ossification of the Bones of Hand**

**Carpal Bones**

All the carpal bones are cartilaginous at birth. Each carpal bone has one centre which appears before birth. The ossification of the carpal bones starts after birth, which is as follows:

- **Capitate**: 2nd month
- **Hamate**: 3rd month (sometimes the capitate and hamate may start ossifying before birth)
heads and not in the bases. These appear at about two years of age and unite with the shaft between 16 and 18 years of age.

**Phalanges**

Each phalanx has a primary centre for the shaft and a secondary centre for its proximal end. The primary centre appears first in the distal phalanges (about the 8th week); next in the proximal phalanges (about the 10th week); and last in the middle phalanges (about the 12th foetal week). The secondary centres appear first in the proximal phalanges (2nd year) and later in the middle and distal phalanges (3rd or 4th year). They unite with the shafts between 16 and 18 years of age.

**Fractures of Bones of the Hand**

- The scaphoid bone is the most commonly fractured carpal bone. It often results from a fall on the palm when the hand is abducted, the fracture occurring across the narrow part called waist of the scaphoid. Pain occurs primarily on the lateral side of the wrist. Clinical examination shows tenderness over the anatomical snuff box. Owing to the poor blood supply to the proximal part of the scaphoid, union of the fractured parts may take at least 3 months. Avascular necrosis of the proximal fragment of the scaphoid (pathological death of bone resulting from inadequate blood supply) may occur and produce degenerative joint disease of the wrist.

- Fractures of other carpal bones are rare. Fracture or dislocation of lunate bone can cause carpal tunnel syndrome.

- The first metacarpal bone is usually fractured near its base. The fracture often involves the carpometacarpal joint.

**Metacarpals**

Each metacarpal has a primary centre for the shaft that appears in the 9th foetal week. The first metacarpal has a secondary centre for the base that appears in the 2nd or 3rd year and unites with the shaft at about 16 years. The other metacarpal bones have secondary centres in the heads and not in the bases. These appear at about two years of age and unite with the shaft between 16 and 18 years of age.

**Clinical Correlation**

- Triquetral: 3rd year
- Lunate: 4th year
- Scaphoid: 4th to 5th year
- Trapezium: 4th to 5th year
- Trapezoid: 4th to 5th year
- Pisiform: About 10th year

**Fractures of Bones of the Hand**

- The scaphoid bone is the most commonly fractured carpal bone. It often results from a fall on the palm when the hand is abducted, the fracture occurring across the narrow part called waist of the scaphoid. Pain occurs primarily on the lateral side of the wrist. Clinical examination shows tenderness over the anatomical snuff box. Owing to the poor blood supply to the proximal part of the scaphoid, union of the fractured parts may take at least 3 months. Avascular necrosis of the proximal fragment of the scaphoid (pathological death of bone resulting from inadequate blood supply) may occur and produce degenerative joint disease of the wrist.

- Fractures of other carpal bones are rare. Fracture or dislocation of lunate bone can cause carpal tunnel syndrome.

- The first metacarpal bone is usually fractured near its base. The fracture often involves the carpometacarpal joint.

- Other metacarpal bones and phalanges are fractured by direct injury:
  - A metacarpal bone may be fractured through the base, the shaft or the neck (i.e., just proximal to the head).
  - Phalanges may be fractured through the shaft or through either end.
Section-2 Upper Limb

Multiple Choice Questions

1. Conoid tubercle is found near the:
   a. Anterior border of the lateral third of the clavicle
   b. Posterior border of the lateral third of the clavicle
   c. Posterior border of the medial third of the clavicle
   d. Anterior border of the medial third of the clavicle

2. The strengthening bar of scapula is seen adjoining its:
   a. Axillary border
   b. Vertebral border
   c. Superior border
   d. Suprascapular notch

3. The functional joint where movements occur between the scapula and the thoracic wall is:
   a. Scapula humeral joint
   b. Scapulothoracic joint
   c. Thoracohumeral joint
   d. Scapulooclavicular joint

4. Dinner fork deformity results when:
   a. Fractured distal segment of radius is displaced backwards and laterally
   b. Fractured distal segment of radius is displaced forwards and laterally
   c. Fractured proximal segment of radius is displaced backwards and laterally
   d. Fractured distal segment of radius is displaced further distally

5. The carpal bone of the proximal row that does not take part in wrist joint is:
   a. Trapezius
   b. Trapezoid
   c. Capitate
   d. Pisiform

ANSWERS

1. b  2. a  3. b  4. a  5. d

Clinical Problem-solving

Case Study 1: One of your friends had a fall and sustained a fracture of his right humerus. As you visit him in the hospital, you are informed that he has a fracture in the upper part of the bone.

- By common occurrence, where do you expect the fracture to have occurred? Substantiate your answer.
- Do you think any nerve would have been damaged? If so, which nerve?
- What are the other nerves which may be involved if fracture had occurred in other parts of the bone?

Case Study 2: A 45-year-old woman fell on an outstretched upper limb with the palm bearing the impact. Her hand was abducted at the time of the impact. She complained of intense pain in the lateral aspect of her wrist.

- Which of the carpal bones do you expect to have had a fracture?
- What is the consequence of such a fracture?
- If a complication occurs, what other structure/part do you think would be affected?

(For solutions see Appendix).