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BONES, JOINTS AND MUSCLES OF THE UPPER AND LOWER LIMBS

STUDY GUIDE

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Martin, 2018

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ISBN 978-80-8187-049-1



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PREFACE

The main purpose of the study guide is to provide a basic educational material for the study of the bones, joints and muscles of the upper and lower limb.

The text is enriched by the figures of the dry human bones - photographs of the bony preparations used during the anatomy practicals in our Department of Anatomy. Figures of the joints, ligaments and muscles are retrieved from public domain of Gray's Anatomy of human Body (1918).

Although the study guide contains the photos and figures, it is necessary to use this study material in association with any human anatomy atlas (Sobotta's, Gray's, Gilroy's or Netter's atlas of human anatomy).

The study guide offers the possibility to test the obtained knowledge by a set of review questions at the last chapter.

We believe that the study guide will be useful resource used for the anatomy practicals and independent study as well.

Authors

INTRODUCTION

Differences between the upper and lower limbs depend on their distinct functions and loads in accord with their phylogenetic development.

The upper limb is smaller and shorter than lower limb; as well it is less firmly attached to axial skeleton and more mobile, particularly in the shoulder. It is adapted for mobility and fine movements of the finger and the hand important for the grasping objects and skilled movements.

The lower limb is specialized to the support of weight of the entire body; for the locomotion (the ability to move the body from one place to another) and for the adaptation to gravity and maintain balance. Consequently, it is designed for strength and stability; its bones tend to be more robust; the joints are more stable and firmly attached to axial skeleton. The muscles of the lower limb are larger and attached to larger bony areas; antigravity muscles are more developed in comparison with antigravity muscles of the upper limb.

Skeleton, joints and muscles of the upper limb and lower limb include:

- Appendicular skeleton with the bones of pectoral girdle and free upper limb, and the bones of pelvic girdle and free lower limb.
- Joints or articulations related to limbs and their classification based on the structure (fibrous, cartilaginous, synovial) and function; types of synovial joints in accordance with the shapes of the articulating surfaces of the bones that form each joint; ligaments and movements.
- Muscles related to limbs and their origin, insertion, function (action) and nerve supply.

SHORT INTRODUCTION TO SKELETON OF THE UPPER LIMB AND LOWER LIMB

Each limb (*membrum in Latin equivalent*) consists of two functional components:

- **the limb girdle – pectoral and pelvic**, attaches the limb to the axial skeleton. Pectoral girdle is formed by scapula and clavicle and joins the upper limb with axial skeleton via small sternoclavicular joint. Pelvic girdle is formed by hip bones, which articulate with each other at the pubic symphysis and both hip bones articulate with sacrum. Pelvic girdle connects the lower limb with vertebral column via large sacroiliac joint strengthened by strong sacroiliac ligaments. Pelvic girdle, with sacrum, forms a complete ring, massive and comparatively rigid in marked contrast to the light and mobile pectoral girdle which has no direct articulation with vertebral column.
- **bones of the free upper and lower limb** – are divided into three segments:
 - the bones of the **arm**, the **forearm** and the **hand** respectively in the upper limb;
 - the bones of the **thigh**, the **leg**, and the **foot** respectively in the lower limb.

PARTS OF THE UPPER LIMB	THE BONES OF THE APPENDICULAR SKELETON OF THE UPPER LIMB
Pectoral girdle	Scapula and clavicle
Arm (<i>brachium</i>)	Humerus
Forearm (<i>antebrachium</i>)	Ulna and radius
Hand (<i>manus</i>)	Carpal bones, metacarpal bones and phalanges
PARTS OF THE LOWER LIMB	THE BONES OF THE APPENDICULAR SKELETON OF THE LOWER LIMB
Pelvic girdle	Hip bone, <i>sacrum</i> * and <i>coccyx</i> *
Thigh (<i>femur</i>)	Femur
Leg (<i>crus</i>)	Tibia and fibula
Foot (<i>pes or pedis</i>)	Tarsal bones, metatarsal bones and phalanges

* *sacrum and coccyx are the bones of the axial skeleton*

Tab. 1

Parts and bones of the appendicular skeleton of the upper and lower limbs

SKELETON OF THE UPPER LIMB

Pectoral girdle attaches the upper limb to the trunk and is formed by **scapula** and **clavicle**. It serves as the attachment site for the muscles of the upper back, the chest, the neck and the arm.

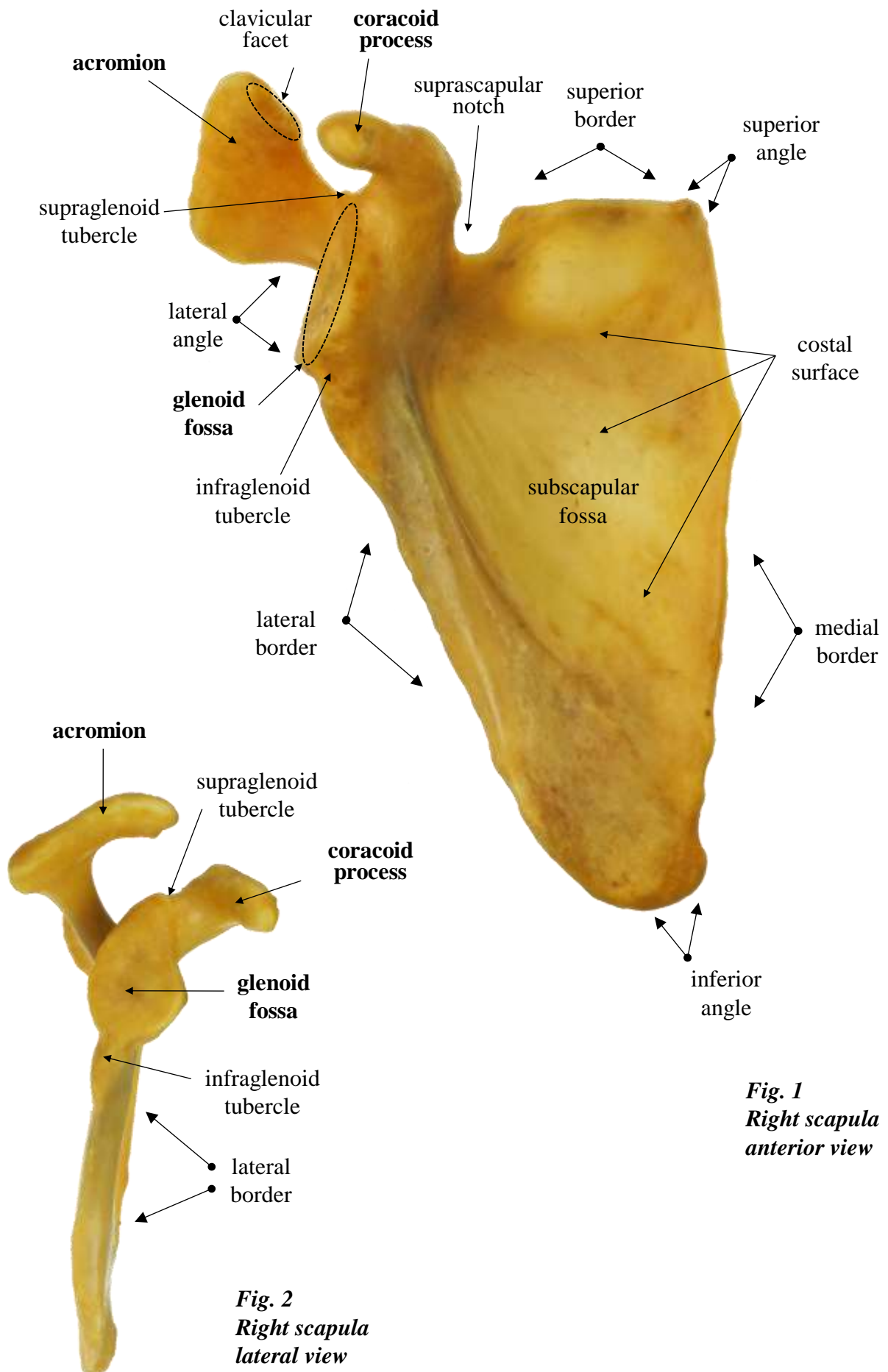
Humerus is the single bone of the arm and is located between the shoulder and elbow joints. **Ulna** and **radius** are the paired bones of the forearm which is between the elbow and wrist joints. Ulna is medial bone of the forearm. It runs parallel to radius, which is situated on the lateral (thumb) side of the forearm. The **hand** is located distal to the wrist and it consists of eight **carpal bones**, five **metacarpal bones**. The most distally, there are **phalanges** forming the fingers and the thumb.

SCAPULA

Scapula is a flat, triangular bone. It lies on the posterior thoracic wall at the level of the 2nd to the 7th ribs. Scapula articulates with clavicle at acromioclavicular joint and with humerus at glenohumeral (shoulder) joint. Scapula consists of:

- two **surfaces** – costal and posterior;
- three **angles** – superior, inferior and lateral;
- three **borders** – superior, medial and lateral.

Costal surface directs ventrally to the ribs. This slightly hollow (concave) surface forms **subscapular fossa** from which the *subscapularis muscle* originates. **Posterior surface** is subdivided by the **spine of the scapula** into small, superior – **supraspinous fossa** and much larger, inferior – **infraspinous fossa**. The fossae are occupied by origins of *supraspinatus* and *infraspinatus muscles*. The lateral end of scapular spine is free and flattened. It forms **acromion** that arches over glenohumeral joint and articulates with clavicle by **clavicular surface (facet)** at acromioclavicular joint. *Trapezius* and *deltoid muscles* are attached to acromion.



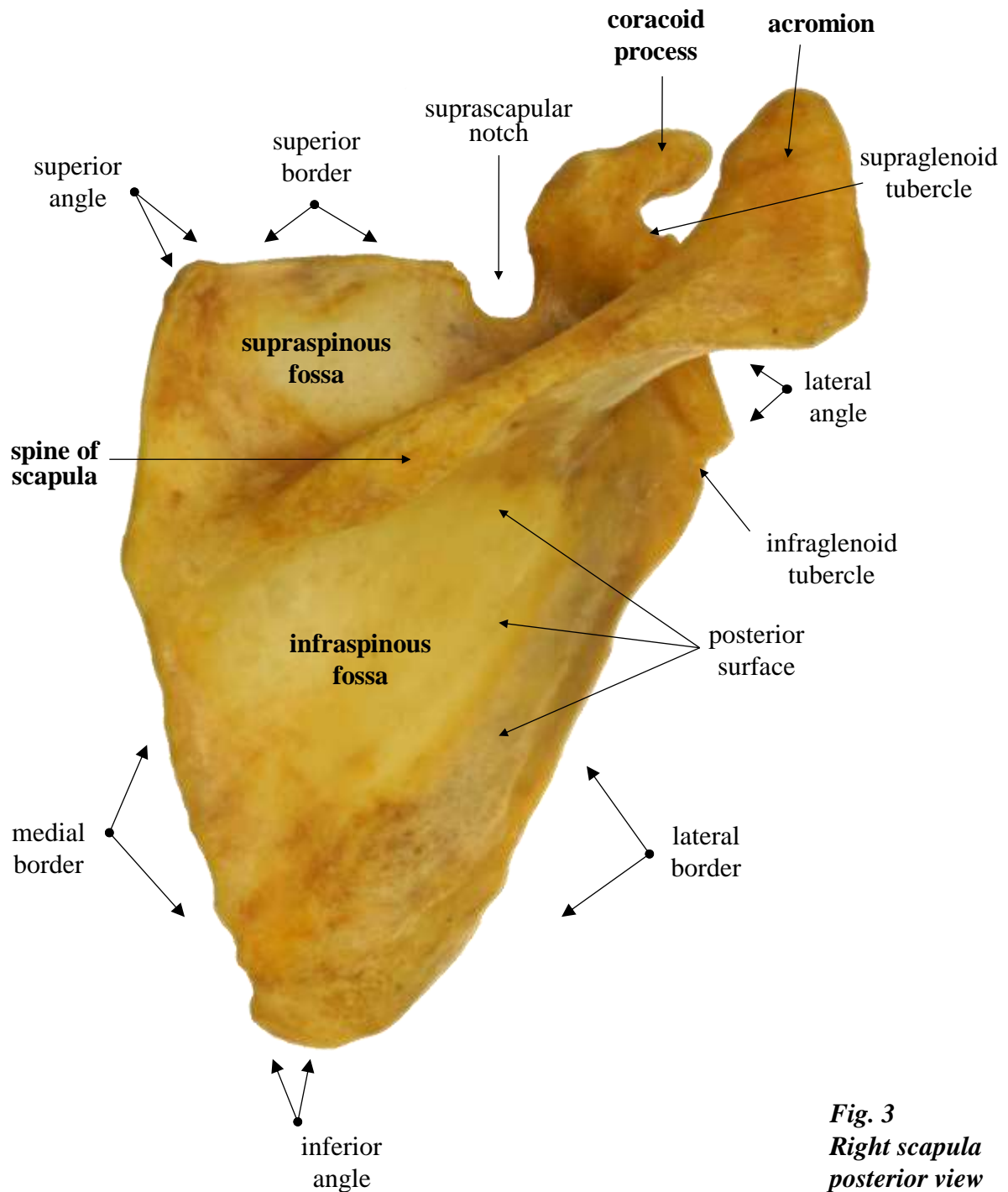


Fig. 3
Right scapula
posterior view

Superior angle is the site of *levator scapulae muscle attachment*. The thick, rough **inferior angle** projects at the level of the spine of the 7th thoracic vertebra and it is related to *teres major muscle*. **Lateral angle** is the thickest part of the scapula. It bears shallow articular surface – **glenoid fossa (glenoid cavity)**, which articulates with the head of the humerus to

form glenohumeral joint (shoulder joint). Glenoid fossa is elongated in vertical direction. There is **supraglenoid tubercle** above and **infraglenoid tubercle** below the glenoid fossa. The *long head of the biceps brachii* and *long head of the triceps brachii muscles*, respectively, originate from tubercles mentioned above.

Superior border extends on its lateral end into **coracoid process**. This structure projects anterolaterally and it lies under lateral end of clavicle. Coracoid process provides attachment for three muscles: *short head of biceps brachii*, *coracobrachialis* and *pectoralis minor*. Medial to the base of coracoid process there is **suprascapular notch**. In the living subject this notch is converted into foramen by the superior transverse ligament. Thinner **medial border** directs towards the vertebral column and in standard anatomical position is almost parallel to it. *Rhomboid minor*, *rhomboid major* and *serratus anterior muscles* are inserted to this border. **Lateral border** is thick and strong and provides attachment for *teres minor muscle*.

CLAVICLE

Clavicle is a slender S-shaped bone of the anterior part of pectoral girdle. It is oriented in horizontal plane and is palpable along its entire length in a living person. Its medial two thirds are convex forward and its lateral third is convex backward. The clavicle acts as a strut that holds the arm away from the trunk. It also transmits forces from the upper limb to the axial skeleton and provides attachment for the muscles. The clavicle has:

- **sternal (medial) end;**
- **shaft;**
- **acromial (lateral) end.**

Both clavicular ends bear articular facets for synovial joints with adjacent bones. **Sternal end** of clavicle is enlarged and more rounded whereas **acromial end** is flat. Sternal end connects clavicle to manubrium of sternum by **sternal surface (facet)** at sternoclavicular joint. Acromial end articulates with acromion of scapula by **acromial surface (facet)** at acromioclavicular joint. The **shaft (body)** is the middle portion of clavicle between two ends.

Fig. 4
Right clavicle
superior view

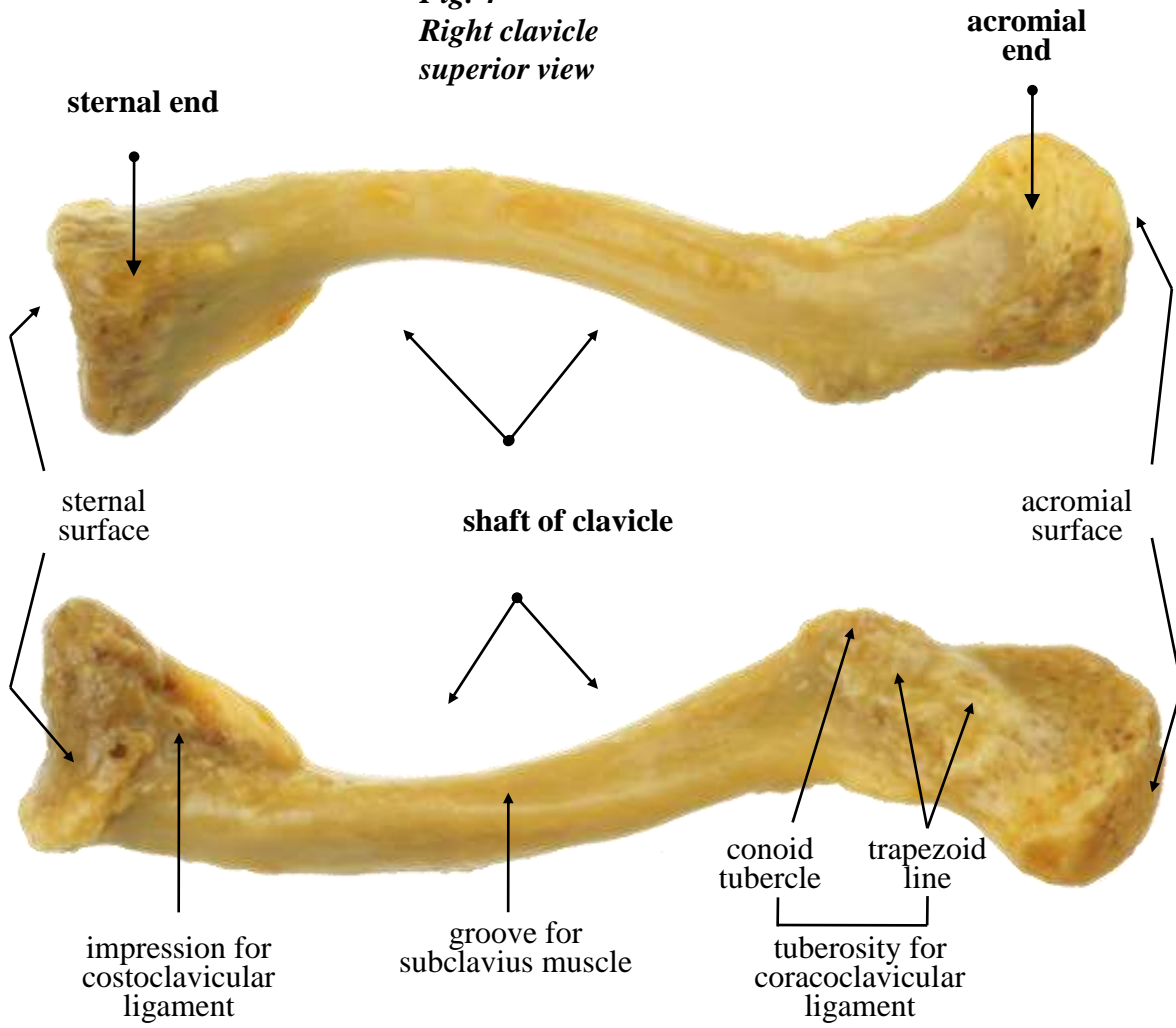


Fig. 5
Right clavicle
inferior view

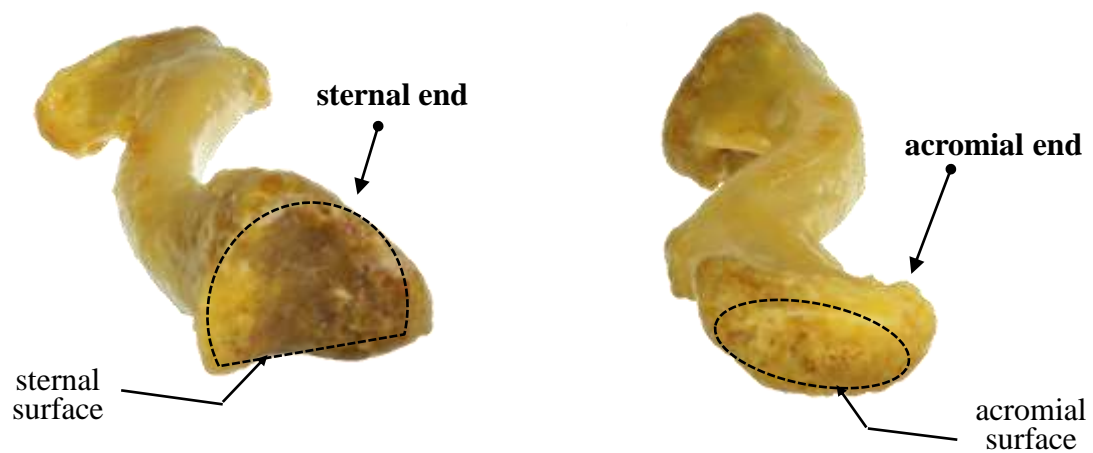


Fig. 6
Right clavicle
medial view

Fig. 7
Right clavicle
lateral view

Ligaments and muscle related to clavicle make its inferior surface more roughened than its superior surface.

Inferior surface shows:

- **impression for costoclavicular ligament** that lies on the medial end of clavicle; it provides attachment for costoclavicular ligament, which strengthens the sternoclavicular joint;
- **groove for subclavius muscle** that is situated on the midshaft;
- **tuberosity for coracoclavicular ligament** that lies on the lateral end on clavicle; it comprises:
 - **conoid tubercle**, which is located posteriorly and it is attachment site for conoid ligament;
 - **trapezoid line**, which runs laterally from the conoid tubercle and it is attachment site for trapezoid ligament.

Deltoid, pectoralis major and sternocleidomastoid muscles originate from clavicle. *Trapezius and subclavius muscles* are inserted to it.

Clinical column

Fractures of clavicle are common mainly in the middle third. The medial fragment may be dislocated by the upward pull of sternocleidomastoid muscle and the lateral one by the downward pull of the weight of the upper limb. Consequently the reposition of the fragments requires surgical intervention frequently.

HUMERUS

Humerus is the largest and the longest bone of the upper limb. It articulates proximally with scapula at the glenohumeral (shoulder) joint and distally with radius and ulna at the elbow joint. Humerus consists of:

- **proximal end;**
- **shaft (body);**
- **distal end.**

The **proximal end** of humerus extends into convex, spherical **head** projected medially and upwards. **Anatomical neck** of humerus provides attachment for articular capsule of the shoulder joint. It borders the head and separates it from greater and lesser tubercles. **Greater tubercle** is a prominent landmark on the proximal end of humerus. It directs laterally whereas **lesser tubercle** is anteromedial in position. **Intertubercular sulcus** separates both tubercles and contains tendon of long head of biceps brachii muscle (accordingly this sulcus is also called bicipital groove). The sulcus continues inferiorly on the proximal part of humeral shaft and it is bounded by **crest of the greater tubercle** and **crest of the lesser tubercle**. There are also called **lateral** and **medial lips of intertubercular sulcus**.

Tubercles and crests give attachment to some muscles. These are named successively in proximodistal direction:

- the greater tubercle and its crest serves as the site for insertion of *supraspinatus*, *infraspinatus*, *teres minor* and *pectoralis major* muscles;
- the lesser tubercle and its crest serves as the site for insertion of *subscapularis*, *teres major* and *latissimus dorsi* muscles.

Surgical neck is oriented in the horizontal plane between enlarged head and tubercles and the narrower shaft of humerus. The name of this region reflects a frequent site of the fractures of humerus – that's why it is region of the practical surgical importance.

The **shaft** of humerus (body) has three surfaces – anterolateral, anteromedial and posterior separated by anterior, lateral and medial borders. Anterolateral surface shows roughened **deltoid tuberosity** for the insertion of *deltoid muscle*. **Groove for radial nerve** is shallow groove (sulcus) on the posterior surface of the shaft. The spiral groove passes from the posterior surface of the humerus around the lateral border to reach the anterolateral surface. It contains radial nerve and deep brachial artery and veins. Distally the shaft becomes flattened anteroposteriorly and the lateral and medial borders are prolonged onto the **lateral supraepicondylar** (supracondylar) **ridge** and the **medial supraepicondylar** (supracondylar) **ridge**. *Brachialis muscle* and *medial* and *lateral heads of triceps brachii muscle* originate from the shaft of humerus and *coracobrachialis muscle* is inserted to it.

The **distal end** of humerus is the widest part of the bone and consists of:

- **condyles;**
- **epicondyles;**
- **fossae.**

Lateral and **medial condyles** of humerus bear surfaces for connection with two bones of the forearm. Lateral in position – the rounded **capitulum** articulates with radius. The pulley-shaped **trochlea**, for articulation with ulna, lies medial to the capitulum. Trochlea, unlike capitulum, extends onto the posterior surface of the humerus.

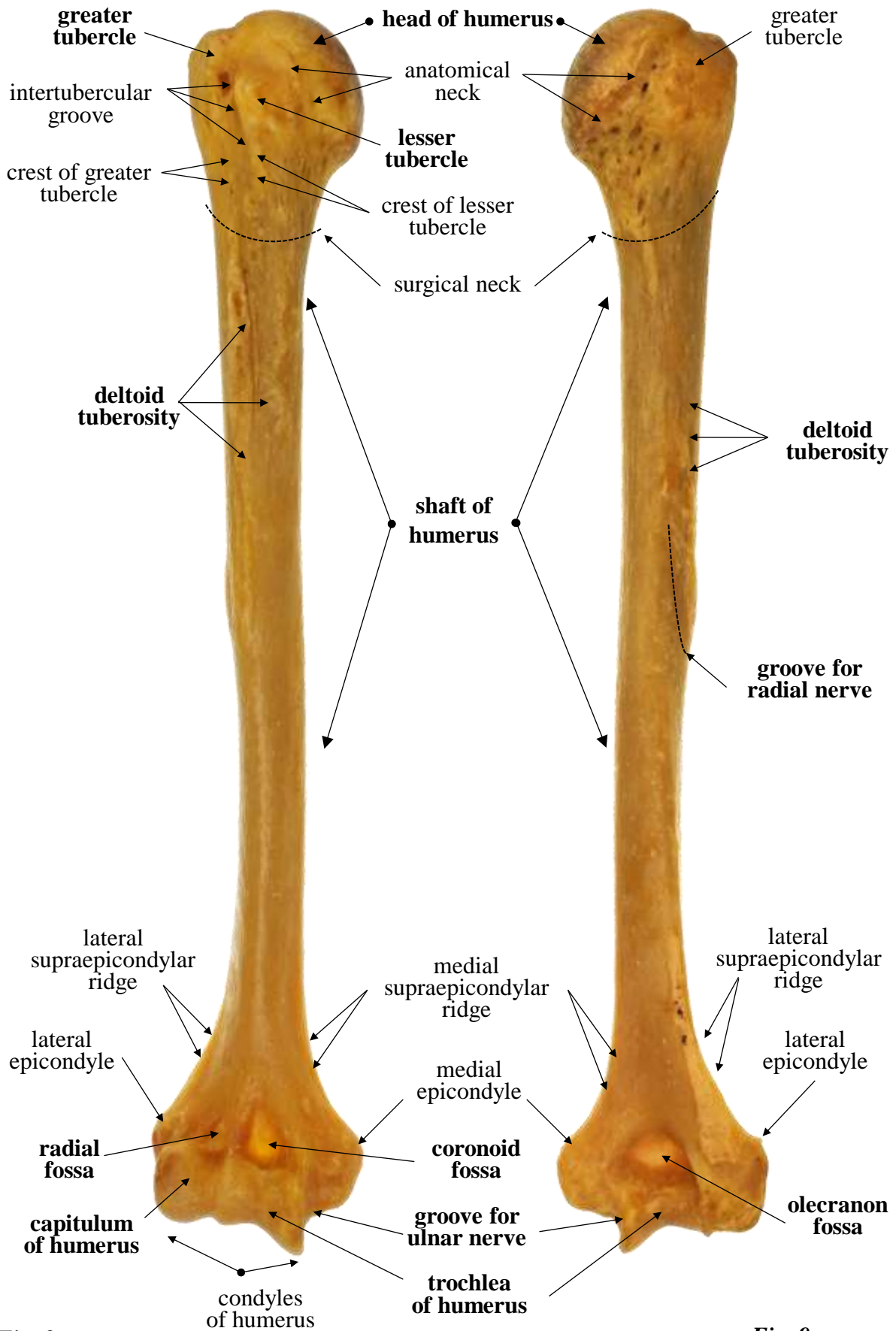
Epicondyles lie above the condyles and give attachment to the muscles of the forearm. Both epicondyles are subcutaneous and readily palpable. **Medial epicondyle** is more prominent and large than **lateral epicondyle**. Posterior surface of medial epicondyle bears **groove for ulnar nerve**. This groove contains ulnar nerve which can be felt as a cord and can be easily vulnerable to injury.

Three depressions are situated on the distal end of humerus. There are two on its anterior surface – **radial fossa** and **coronoid fossa** and one is situated posteriorly – **olecranon fossa**. **Radial fossa** is located just above capitulum. **Coronoid fossa** is adjacent to radial fossa and it is located just above trochlea. The largest **olecranon fossa** is located dorsally above trochlea. These three fossae accommodate projections from the bones in the forearm during movements of the elbow joint. Radial fossa receives the head of radius when the elbow is flexed. During the same movement, coronoid fossa receives coronoid process of ulna. Olecranon fossa receives olecranon process of ulna when the elbow is extended.

Lateral supraepicondylar ridge and lateral epicondyle provide attachment for all *muscles of the superficial layer in the posterior compartment of the forearm*, while the *muscles of the superficial and intermediate layers in the anterior compartment of the forearm* originate from medial epicondyle of humerus.

Clinical column

- Typically fracture around the surgical neck may injure associated neurovascular structures – the axillary nerve and the posterior circumflex humeral artery. It is important to test the function of axillary nerve before relocation of broken pieces.
- Fracture of middle part of the shaft could easily damage radial nerve and deep brachial artery, as they are tightly bound in groove for radial nerve.
- The most common site of ulnar nerve entrapment is related to the elbow region. Ulnar nerve runs in close proximity to medial epicondyle of humerus within the groove and it is bound in fibro-osseous tunnel (the cubital tunnel). In this location the nerve is vulnerable especially to compression at the elbow because it must travel through a narrow space with very little soft tissue protecting it. Degenerative changes in older patients may also develop within cubital tunnel and they result in impaired function of the ulnar nerve.



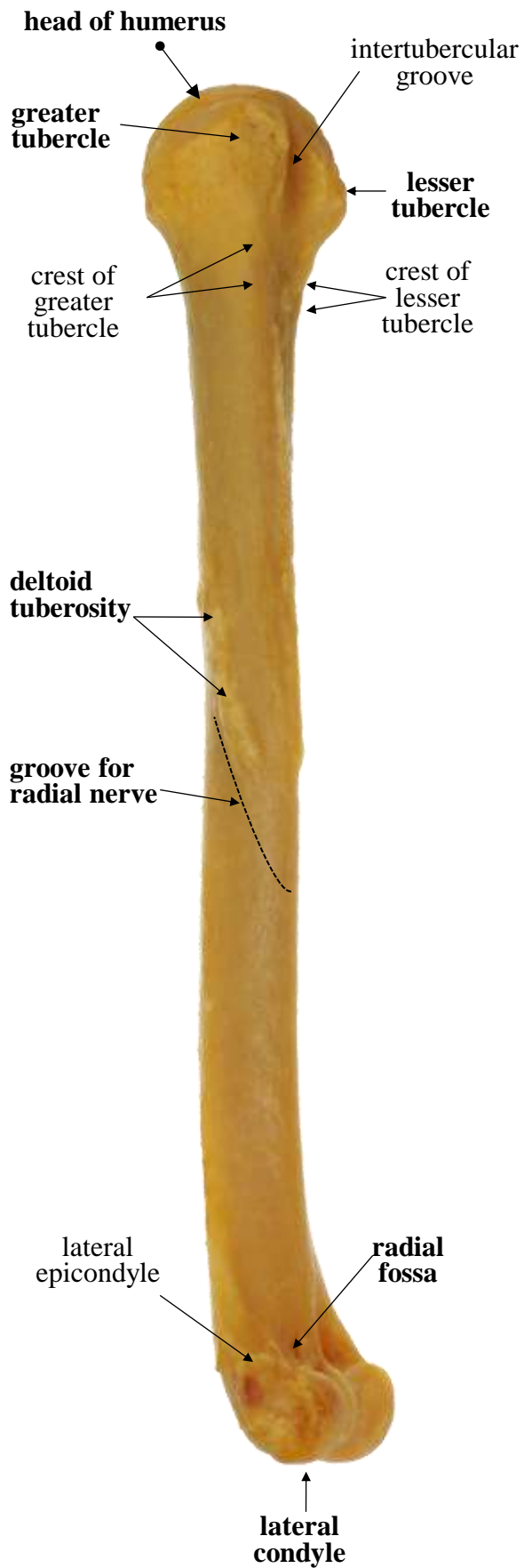


Fig. 10
Right humerus
lateral view

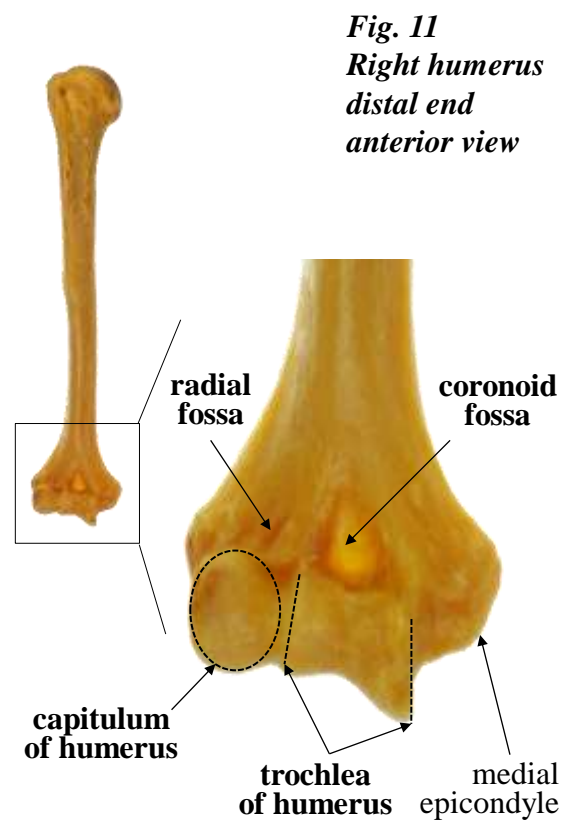


Fig. 11
Right humerus
distal end
anterior view

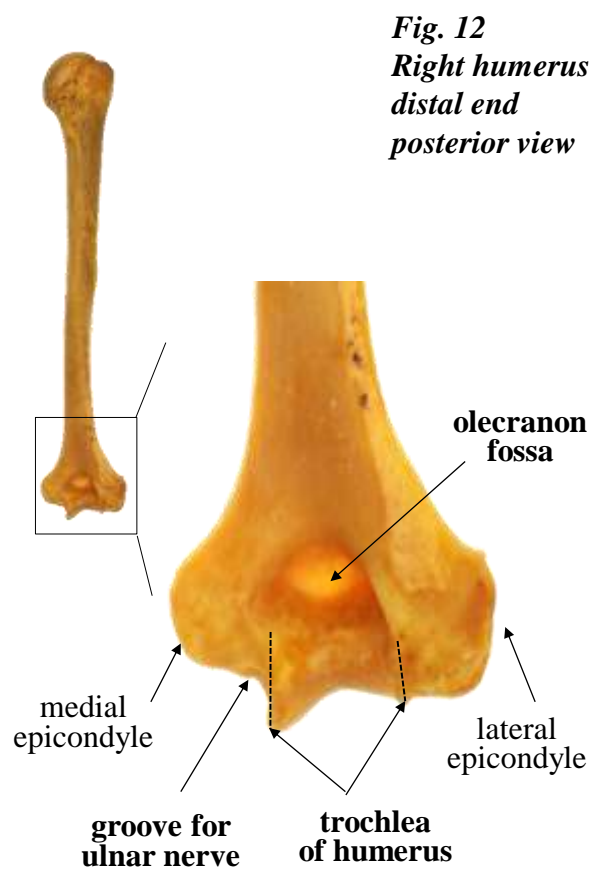


Fig. 12
Right humerus
distal end
posterior view

BONES OF THE FOREARM

The bones of the forearm are **radius** and **ulna**. For correct description, imagination and subsequently interpretation you should remember that all structures on radius and ulna are described in standard anatomical position of the human body. In this position the person is standing upright with face looking forward, lower limbs together or only slightly separated, **upper limbs hang vertically by the sides with palms facing forward – in supinatory position** (thumbs are pointed away from the body). In standard anatomical position radius and ulna **are parallel** and the **radius is positioned laterally**. The shafts of radius and ulna are connected by interosseous membrane.

RADIUS

Radius is the lateral bone of the forearm. It bears four articular surfaces (facets) – two are situated proximally and two distally. Its proximal end articulates with humerus at the elbow joint and with ulna at proximal radioulnar joint. Its distal end articulates with carpal bones at the wrist joint and with ulna at distal radioulnar joint.

Radius consists of:

- **proximal end;**
- **shaft (body);**
- **distal end.**

At the **proximal end** of radius is a small discoid-shaped **head** oriented in horizontal plane. The superior surface of discoid head is smooth and concave. It articulates with convex capitulum of humerus. **Articular circumference** of radial head articulates with radial notch of ulna. Below the head, the bone is narrowed to form a short **neck**. **Radial tuberosity** is projection which directs ventromedially. It lies just inferior to the neck. This rough projection gives the insertion to *biceps brachii muscle*.

The **shaft** of radius (body) is wider distally than proximally. It is triangular in cross-section with three borders – anterior, posterior and medial (interosseous). **Interosseous border** is sharp and directed medially for the attachment of interosseous membrane connecting the radius and ulna.

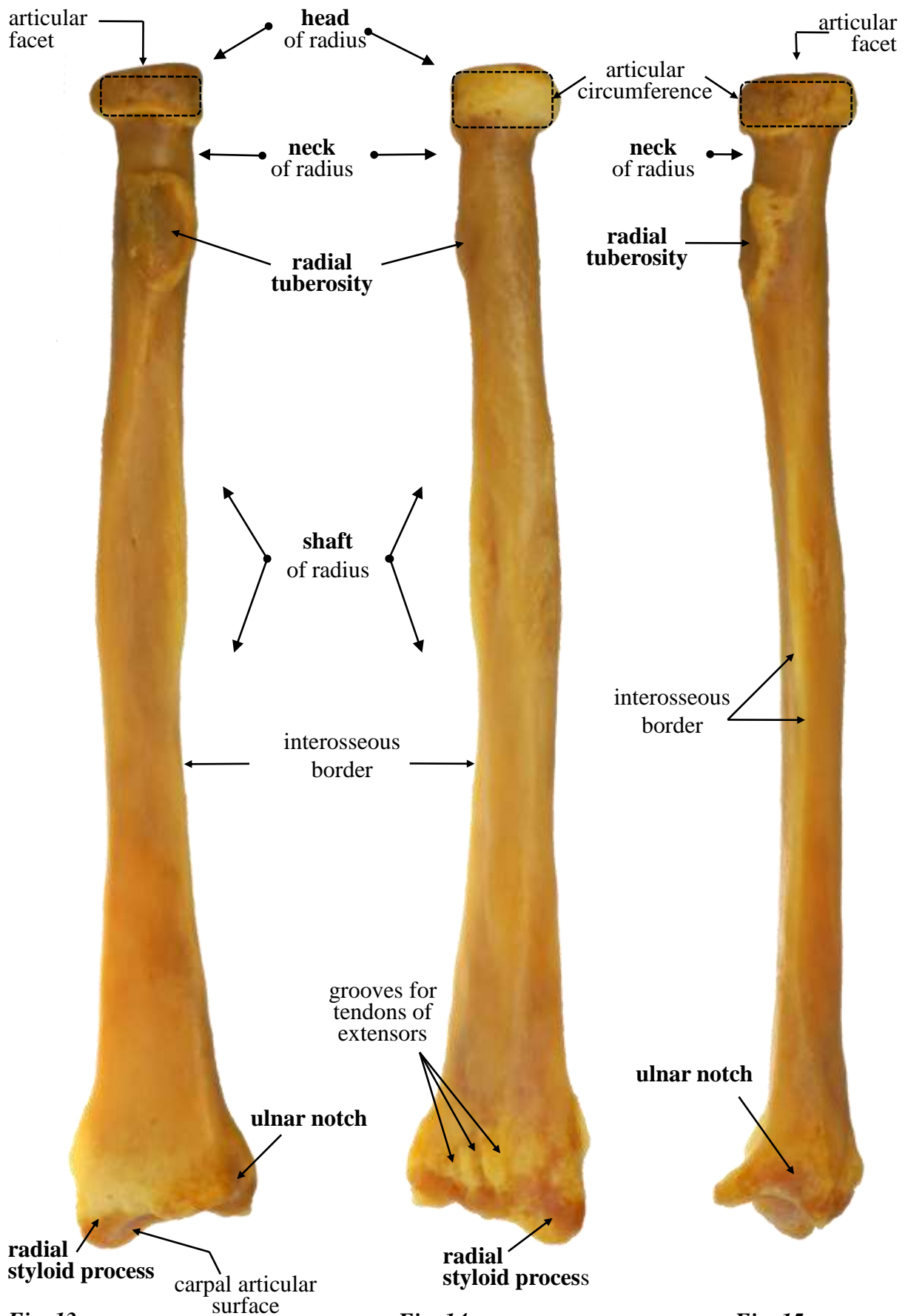


Fig. 13
Right radius
anterior view

Fig. 14
Right radius
posterior view

Fig. 15
Right radius
medial view

The **distal end** of radius is flattened anteroposteriorly. Its anterior aspect is smooth and concave, while the posterior is slightly convex and marked by distinct **grooves for tendons of extensors** of the wrist and fingers. The distal end extends from its lateral side as readily palpable **radial styloid process**. Its medial side forms a concavity – **ulnar notch** for articulation with the round head of ulna. Distally on radius, there is **carpal articular surface** which articulates with two carpal bones (scaphoid and lunate).

The muscles which originate from the radius are *flexor digitorum superficialis*, *flexor pollicis longus*, *abductor pollicis longus*, *extensor pollicis brevis*. The muscles which are inserted to the radius are *biceps brachii*, *pronator teres*, *pronator quadratus*, *supinator*, *brachioradialis*.

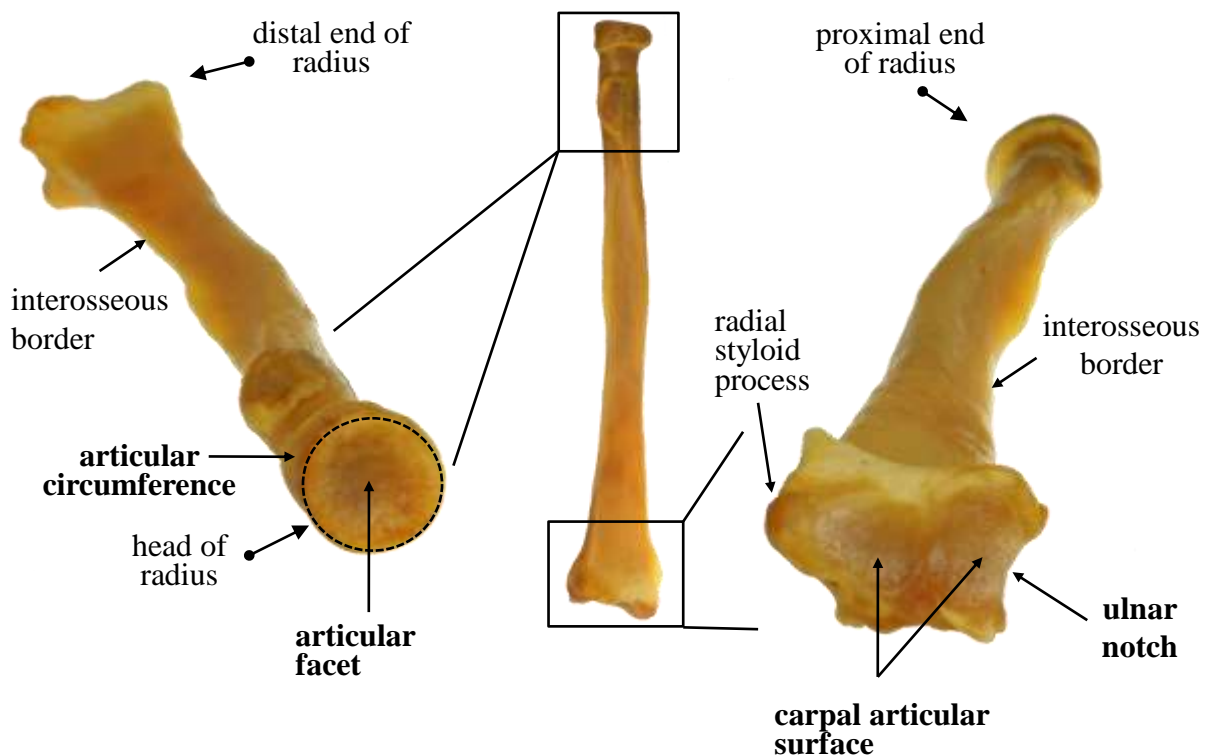


Fig. 16
Right radius
enlarged proximal end
superior view

Fig. 17
Right radius
enlarged distal end
inferior view

ULNA

Ulna is medial bone of the forearm. It is longer and proximally much larger than radius. Proximal end articulates with humerus at the elbow joint and with radius at proximal radioulnar joint. Distal end articulates with radius at distal radioulnar joint, but it is excluded from the wrist joint by the articular disc. Ulna consists of:

- **proximal end;**
- **shaft (body);**
- **distal end.**

The **proximal end** of ulna has two prominent projections – olecranon and coronoid process. **Olecranon** is a large projection which extends proximally from ulna. It is readily palpated as the tip of the elbow. Its superior surface is marked by roughened impression for the insertion of *triceps brachii* and *anconeus muscles*. Anterior surface of the proximal end forms concave **trochlear notch** for articulation with trochlea of humerus. Below trochlear notch, there is a triangular **coronoid process** which projects forwards. Its lateral surface is marked by **radial notch** for articulation with the head of radius. **Supinator crest** descends from radial notch obliquely to the posterior border. This crest serves as attachment for *supinator muscle*. **Ulnar tuberosity** is positioned distal to coronoid process and medial to radial notch. It gives insertion for *brachialis muscle*.

The **shaft** of ulna (body) has three borders. The sharp lateral **interosseous border** gives the attachment for interosseous membrane. The posterior border can be easily palpated along its whole length. Anterior border is rounded and covered by the muscles.

The **distal end** of the ulna narrows into small rounded **head** which bears smooth surface – **articular circumference** for the distal radioulnar joint. **Ulnar styloid process** projects from the head medially.

Muscles of the anterior compartment of the forearm which originate from the ulna are *pronator teres*, *flexor carpi ulnaris*, *flexor digitorum superficialis*, *flexor digitorum profundus*, *pronator quadratus*. Muscles of the posterior compartment which originate also from the ulna are *extensor carpi ulnaris*, *supinator*, *abductor pollicis longus*, *extensor pollicis longus*, *extensor indicis*.

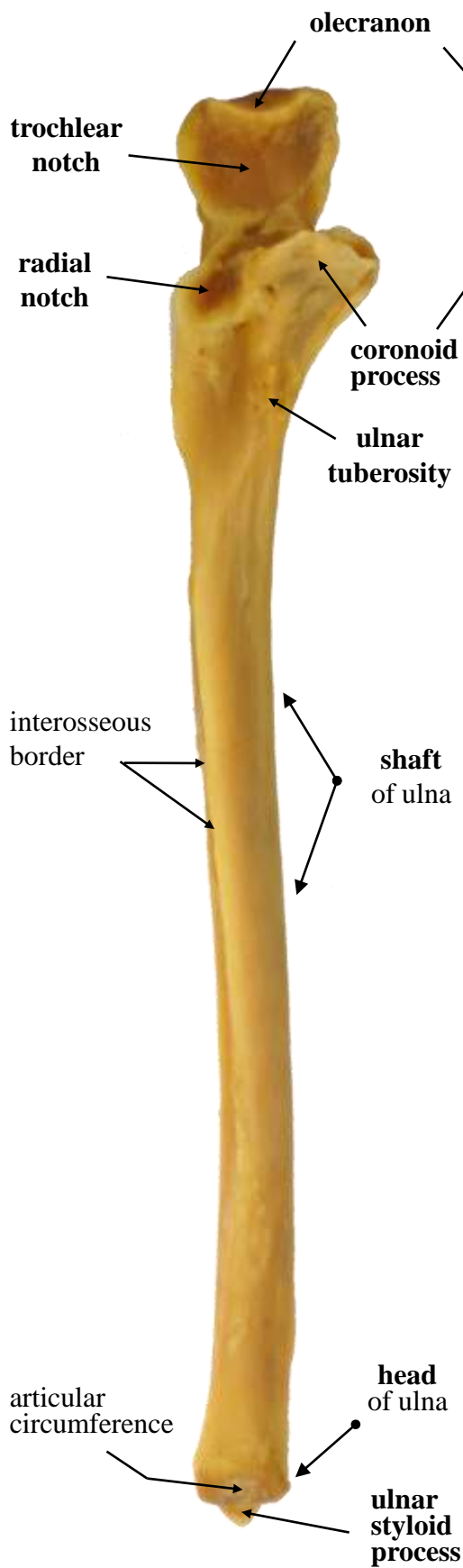


Fig. 18
Right ulna
anterior view

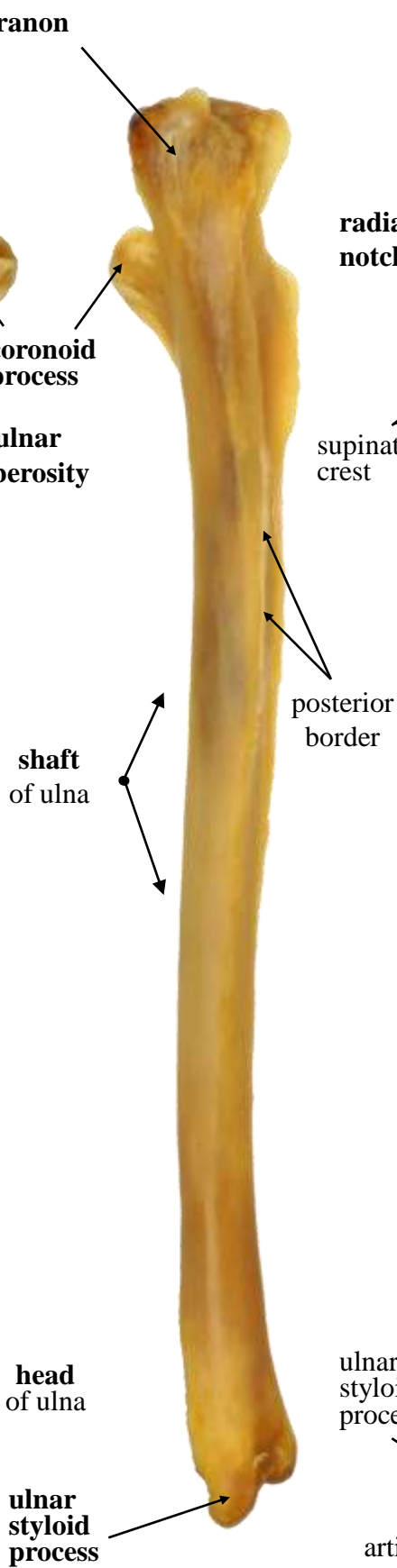


Fig. 19
Right ulna
posterior view

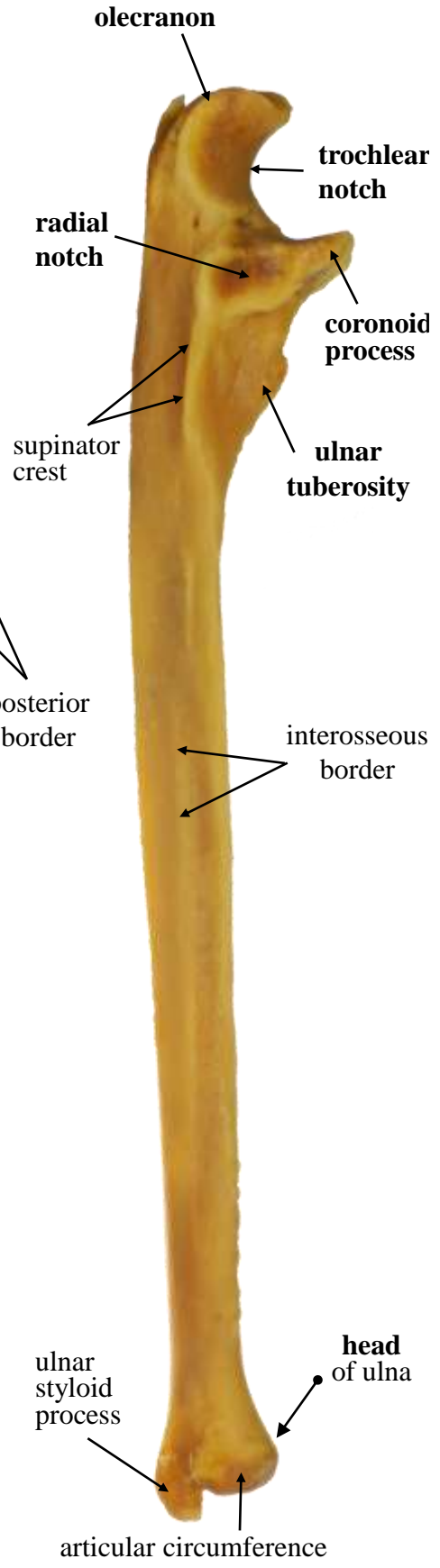


Fig. 20
Right ulna
lateral view

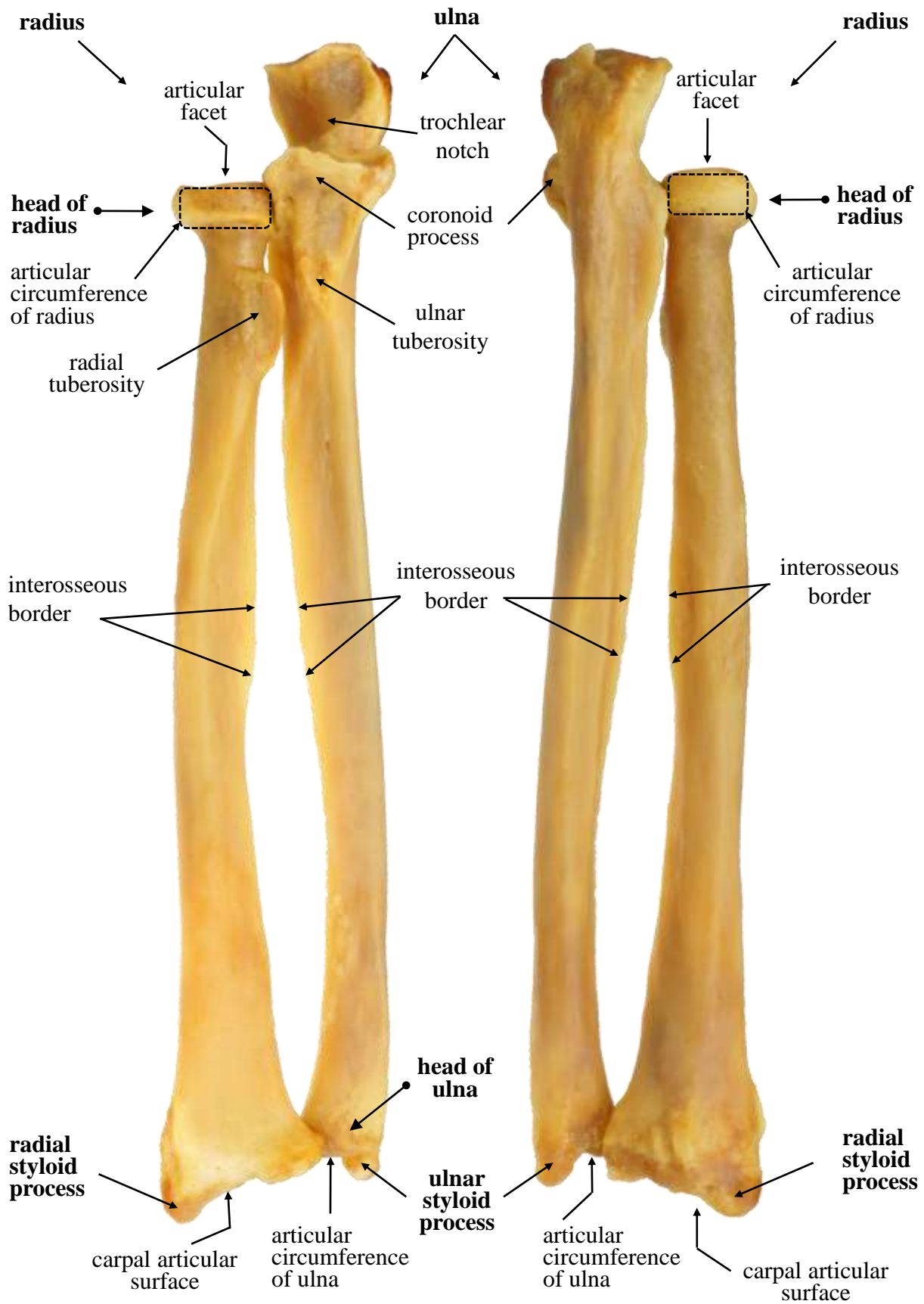


Fig. 21
Bones of right forearm
anterior view

Fig. 22
Bones of right forearm
posterior view

Clinical column

The forearm is a common site of the bone fractures. Ulna is more susceptible to the fracture due to trauma at elbow, radius is more susceptible to the fracture from falls on the hands. However radius and ulna are connected by the interosseous membrane and by proximal and distal radioulnar joints reinforced by the ligaments and muscles, so they act as one. The force of the trauma to one bone can be transmitted to the other, resulting in either fracture of both bones or more commonly a fracture of one bone with dislocation of the other.

Common fractures associated with the radius and ulna:

- *Colles fracture is the most common type of the fracture of the distal radial end. In this situation the structures situated distal to the fracture (the hand and fragment of radius) are dislocated backwards. It is usually caused by a fall onto an outstretched hand. Colles fracture is seen more frequently with advancing age and in women with osteoporosis. It also occurs as a result of the trauma during car or bike accidents or during skating, skiing.*
- *Monteggia's fracture is a fracture of the proximal portion of ulnar shaft with anterior dislocation of radial head at the elbow. It occurs as the result of a fall onto an outstretched hand with the forearm in hyperpronated position.*

BONES OF THE HAND

The skeleton of the hand comprises of three segments:

- ❖ **carpal (wrist) bones** – are situated **proximally**;
- ❖ **metacarpal bones**;
- ❖ **phalanges** – are situated **distally**.

CARPAL BONES

They are eight short, irregularly shaped carpal bones, which articulate with the forearm proximally and with the metacarpal bones distally. They are also intercarpal joints between individual carpal bones.

The bones are arranged in proximal and distal rows, each consisting of four bones (named from the lateral or radial to the medial or ulnar side):

- **proximal row** – scaphoid, lunate, triquetrum, pisiform;
- **distal row** – trapezium, trapezoid, capitate, hamate.

- **Scaphoid bone** is boat-shaped and the largest bone of the proximal row. Its palmar surface has a prominent tubercle for flexor retinaculum attachment.
- **Lunate bone** is half-moon shaped bone.
- **Triquetrum bone** is triangular bone, pyramidal in shape with an oval articular facet on its palmar surface for articulation with pisiform bone.
- **Pisiform bone** is small, pea-shaped bone with one articular facet on its dorsal surface.
- **Trapezium bone** is quadrangular in shape.
- **Trapezoid bone** is wedge-shaped bone and the smallest bone of the distal row.
- **Capitate bone** is the largest of all carpal bones. It is situated at the center of the wrist. It has the rounded head directed proximally into concavity formed by the scaphoid and lunate. It articulates with seven carpal bones.
- **Hamate bone** is hook-shaped. It has a curved hooklike process projected from its palmar surface anteriorly.

The carpal bones give insertion to *flexor carpi ulnaris m.* and they give origin to *thenar* and *hypothenar muscles*.

Eight carpal bones form the **carpus (wrist)** which is markedly anteriorly concave from side to side. This arrangement of bones creates **carpal arch**, which is elevated into two eminences (edges):

- **lateral eminence** (edge) is formed by the tubercles of scaphoid and trapezium;
- **medial eminence** (edge) is formed by the pisiform and the hook of hamate.

Strong fibrous band – the **flexor retinaculum** (transverse carpal ligament) is attached to both edges that forms a bridge. This bridge and carpal arch form **carpal tunnel** through which median nerve passes at the wrist and enters the hand. Carpal tunnel contains tendons of *flexor digitorum superficialis*, *flexor digitorum profundus*, *flexor pollicis longus muscles*. *Flexor carpi radialis muscle* passes directly through flexor retinaculum so it is not always designated as the structure of carpal tunnel.

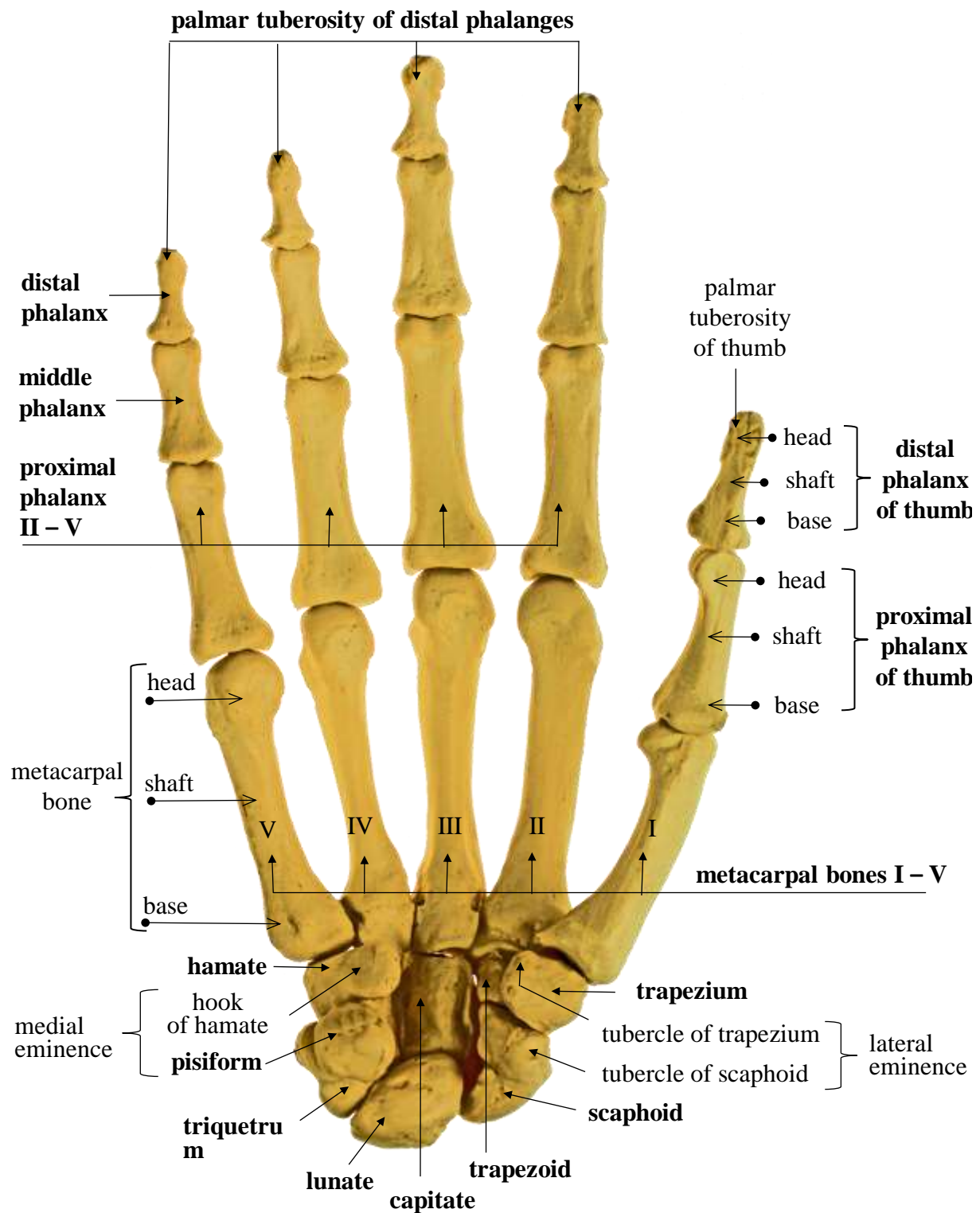


Fig. 23
Bones of right hand
palmar view

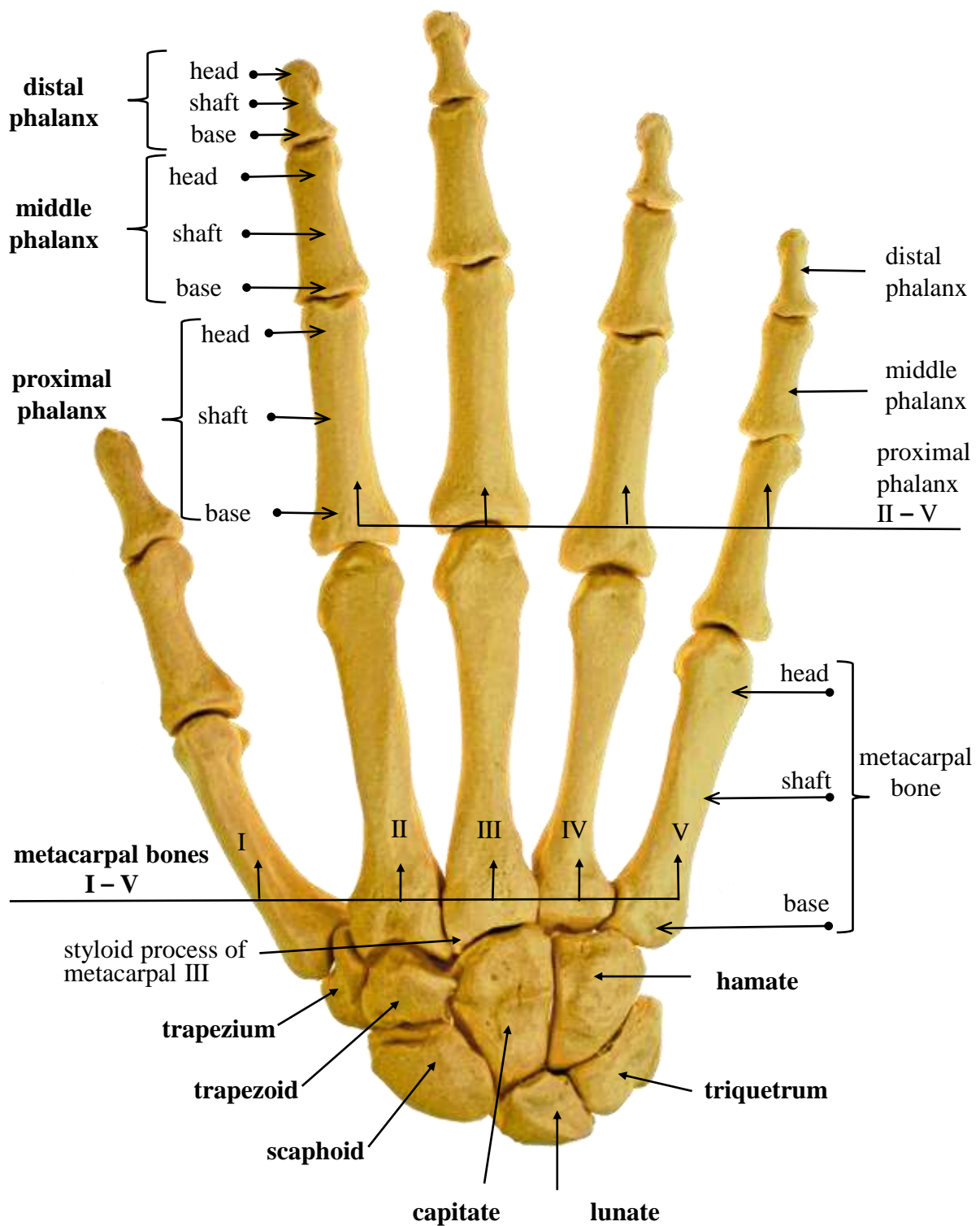


Fig. 24
Bones of right hand
dorsal view

Clinical column

- *Scaphoid bone is the most commonly injured carpal bone. Fracture of this bone is more than usually as a result of the falling on an outstretched hand.*
- *The carpal tunnel is an osteofibrous canal bounded on dorsal side by carpal bones and on the palmar side by thick connective tissue ligament. Because these boundaries are very rigid, tunnel has little capacity to widen. Increased pressure within the tunnel as a result of several risk factors causes carpal tunnel syndrome associated with compression of the median nerve at the wrist. Patients typically report pain (nocturnal), tingling, numbness in the distribution of the median nerve primarily in the thumb and index, middle and ring fingers, weakness in the hand and dropping things.*

METACARPAL BONES

Metacarpal bones together form **metacarpus**. They can be seen and felt through the skin on the back of the hand. Metacarpal bones are numbered from the thumb to the little finger. Each metacarpal bone is related to one digit. **Metacarpal I** is associated with the thumb and **metacarpals II – V** are associated with the index, middle, ring and little fingers, respectively. Each metacarpal bone is composed of three parts:

- **base** – enlarged proximal end;
- **shaft**, midportion – four medial metacarpals are gently concave on the palmar aspect and on their sides;
- **head** – at the distal end; the heads of four medial metacarpals are rounded distally and dorsally (at the back) and cylindrical on the palmar side.

The **bases** of metacarpal bones articulate proximally with the distal row of carpal bones. The **heads** of metacarpal bones, which form the knuckles, articulate distally with the bases of their corresponding proximal phalanges. Four medial metacarpal bones articulate by their bases with each other.

- **The first metacarpal** is shorter and thicker than the other metacarpals. It is rotated medially via 90° thus its dorsal surface faces laterally. Its base has a saddle-shaped facet for articulation with trapezium. It does not articulate with any other metacarpals. The configuration of the

thumb in carpometacarpal joint plays an important role in the mechanism of the opposition. Its head is wider than the other metacarpals.

- **The second metacarpal** is the longest with the largest base.
- **The third metacarpal** is slightly smaller than second one. It has a styloid process on the base which projects dorsally between capitate and trapezoid.
- **The fourth metacarpal** is shorter and more slender than the second and third metacarpal bones.
- **The fifth metacarpal** is the smallest with a tubercle on the medial side of the base, which is non-articular.

The muscles which originate from metacarpal bones are *adductor pollicis muscle*, *palmar* and *dorsal interossei muscles*. The muscles which insert to metacarpal bones are *flexor carpi ulnaris m.*, *flexor carpi radialis m.*, *extensor carpi radialis longus* and *brevis mm.*, *extensor carpi ulnaris m.*, *abductor pollicis longus m.*, *opponens pollicis m.*, *opponens digiti minimi m.*

PHALANGES

There are miniature long bones that form the fingers (digital bones). The thumb (pollex *in Latin terminology*) has only proximal and distal phalanx. The other digits (II – V) consist of proximal, middle and distal phalanges. Each phalanx has:

- **base** – proximal end;
 - **shaft**;
 - **head** – distal end.
-
- **Proximal phalanx** – its base with concave articular surface joins with the head of the metacarpal bone. Its head is pulley-shaped (two condyles separated by the groove) and joins with the base of the middle phalanx.
 - **Middle phalanx** – its base is marked by two small concavities separated by the ridge fitted to the shape of the head of the proximal phalanx. Its head is also pulley-shaped conforming to the base of the distal phalanx.
 - **Distal phalanx** – its head is nonarticular and is marked by a rough **palmar tuberosity** (for the insertion of flexor tendon).

The phalanges give insertion to numerous muscles (the flexors are inserted onto palmar side of the hand and extensors onto dorsal side of the hand):

PHALANX	INSERTION OF MUSCLE
Proximal phalanx of the thumb	<i>Flexor pollicis brevis</i> <i>Extensor pollicis brevis</i> via extensor hood <i>Adductor pollicis</i> <i>Abductor pollicis brevis</i>
Proximal phalanges of the II – V fingers	<i>Flexor digiti minimi</i> (onto little finger) <i>Abductor digiti minimi</i> (onto little finger) <i>Dorsal interossei</i> (onto II – IV fingers)
Middle phalanges	<i>Flexor digitorum superficialis</i> <i>Extensor digitorum</i> via extensor hoods <i>Extensor digiti minimi</i> via extensor hood of little finger <i>Extensor indicis</i> via extensor hood of index finger <i>Lumbricals</i> via extensor hoods <i>Dorsal interossei</i> (onto II – IV fingers) via extensor hoods <i>Palmar interossei</i> (onto II, IV and V fingers) via extensor hoods
Distal phalanx of the thumb	<i>Flexor pollicis longus</i> <i>Extensor pollicis longus</i> <i>Adductor pollicis</i> via extensor hood <i>Abductor pollicis brevis</i> via extensor hood
Distal phalanges of the II – V fingers	<i>Flexor digitorum profundus</i> <i>Extensor digitorum</i> via extensor hoods <i>Extensor digiti minimi</i> via extensor hood of little finger <i>Extensor indicis</i> via extensor hood of index finger <i>Lumbricals</i> via extensor hoods <i>Dorsal interossei</i> (onto II – IV fingers) via extensor hoods <i>Palmar interossei</i> (onto II, IV and V fingers) via extensor hoods

Tab. 2

Overview of the insertion of the muscles onto the phalanges of the hand

Clinical column

The injuries of metacarpals and phalanges are associated with car accidents, sport and work-related activities. There are two common fractures of metacarpals, which often need surgical treatment:

- fracture of the base of the first metacarpal bone – „Bennett’s fracture“ is intraarticular fracture caused by forced hyperabduction of the thumb. It is nearly always accompanied by instability and some degree of subluxation or dislocation of the carpometacarpal joint.
- fractures of the other metacarpals most often affect the fifth finger. They typically occur as a result of direct trauma, e.g. caused by a clenched fist striking a hard object. Boxers tend to have high incidence of fracture to metacarpals, hence the term „Boxers Fracture“.

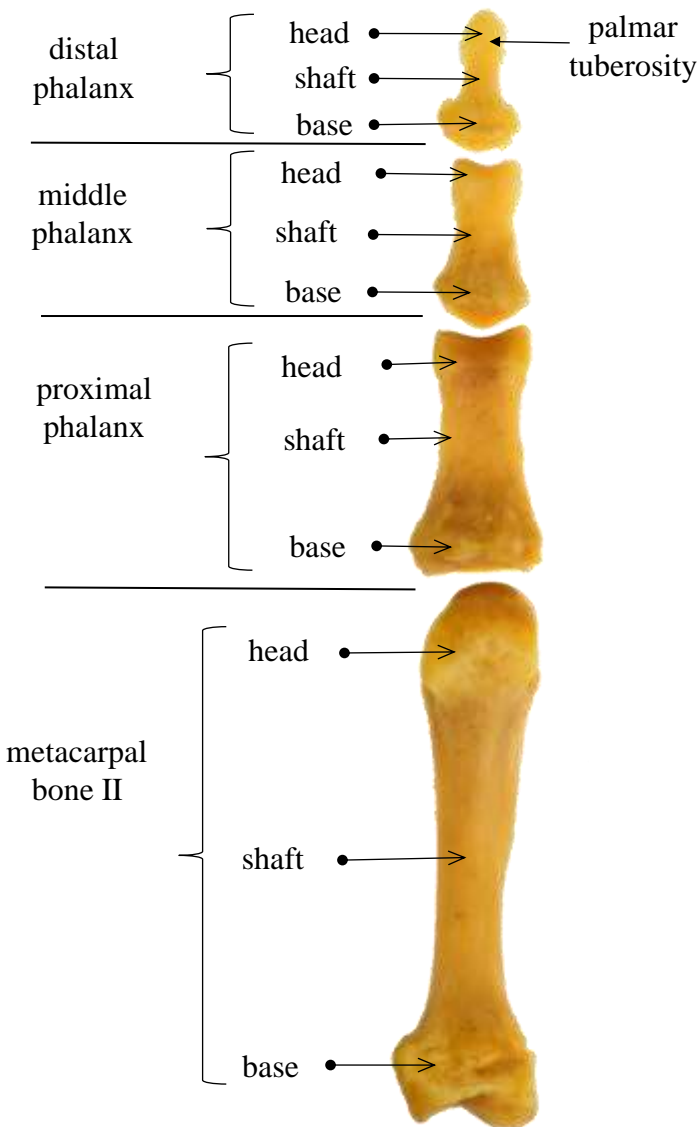


Fig. 25
2nd metacarpal and phalanges
palmar view

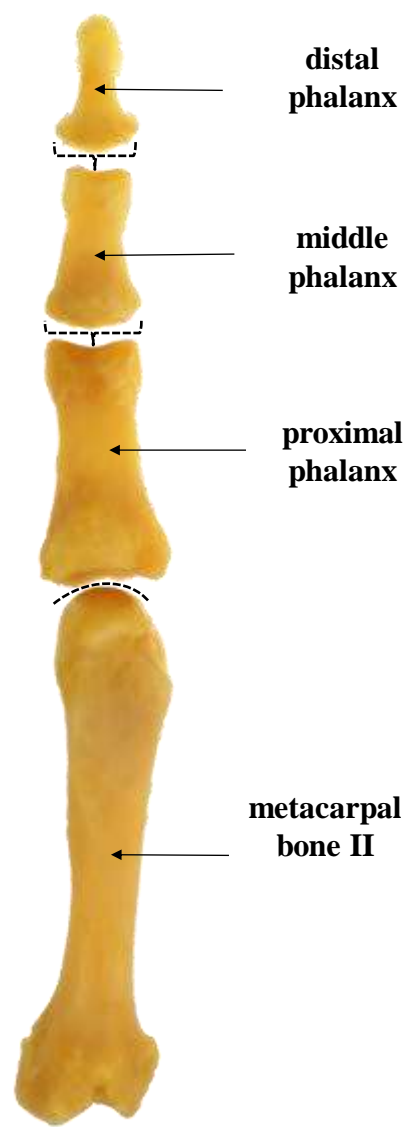


Fig. 26
2nd metacarpal and phalanges
dorsal view

SKELETON OF THE LOWER LIMB

Skeleton of the lower limb consists of **pelvic girdle** and the **bones of the free lower limb**: the bones of the **thigh**; the bones of the **leg**; and the bones of the **foot**.

Pelvic girdle attaches lower limb to the trunk. Two hip bones articulate with each other anteriorly at the pubic symphysis and posteriorly with the sacrum at the sacroiliac joints. Pelvic girdle with its joints forms a strong basin-shaped structure named the **pelvis**. The pelvis protects pelvic viscera and stabilizes the back.

Femur is the single long bone of the **thigh** which is located between the hip and the knee joints. **Tibia** and **fibula** are paired bones of the **leg** lying between the knee and the ankle joints. Tibia is the weightbearing bone of the leg. It is larger and stronger bone located on the medial side of the leg. Fibula is thin bone positioned laterally. The fibula does not take part in knee joint. The **foot** is located distal to the ankle joint. It is formed by seven **tarsal bones**, five **metatarsal bones** and the most distally **phalanges** forming the toes and the great toe.

HIP BONE

Hip bone (innominate bone) is a large, irregularly shaped bone. It is formed by the fusion of three parts:

- **ilium**
- **ischium**
- **pubis.**

During childhood, ilium, ischium and pubis are joined by hyaline cartilage and at the puberty these three parts fuse to form one hip bone.

Ilium forms superior, pubis anteroinferior and ischium posteroinferior portions of hip bone. All three parts meet in **acetabulum** which is directed laterally. Inferior to the acetabulum there is **obturator foramen** bounded by pubis and ischium. The posterior margin of hip bone is marked by **greater** and **lesser sciatic notches**, which are separated by a bony process – **ischial spine**. Inferior to lesser sciatic notch there is a large **ischial tuberosity**. The superior margin of hip bone is thickened forming **iliac crest**.

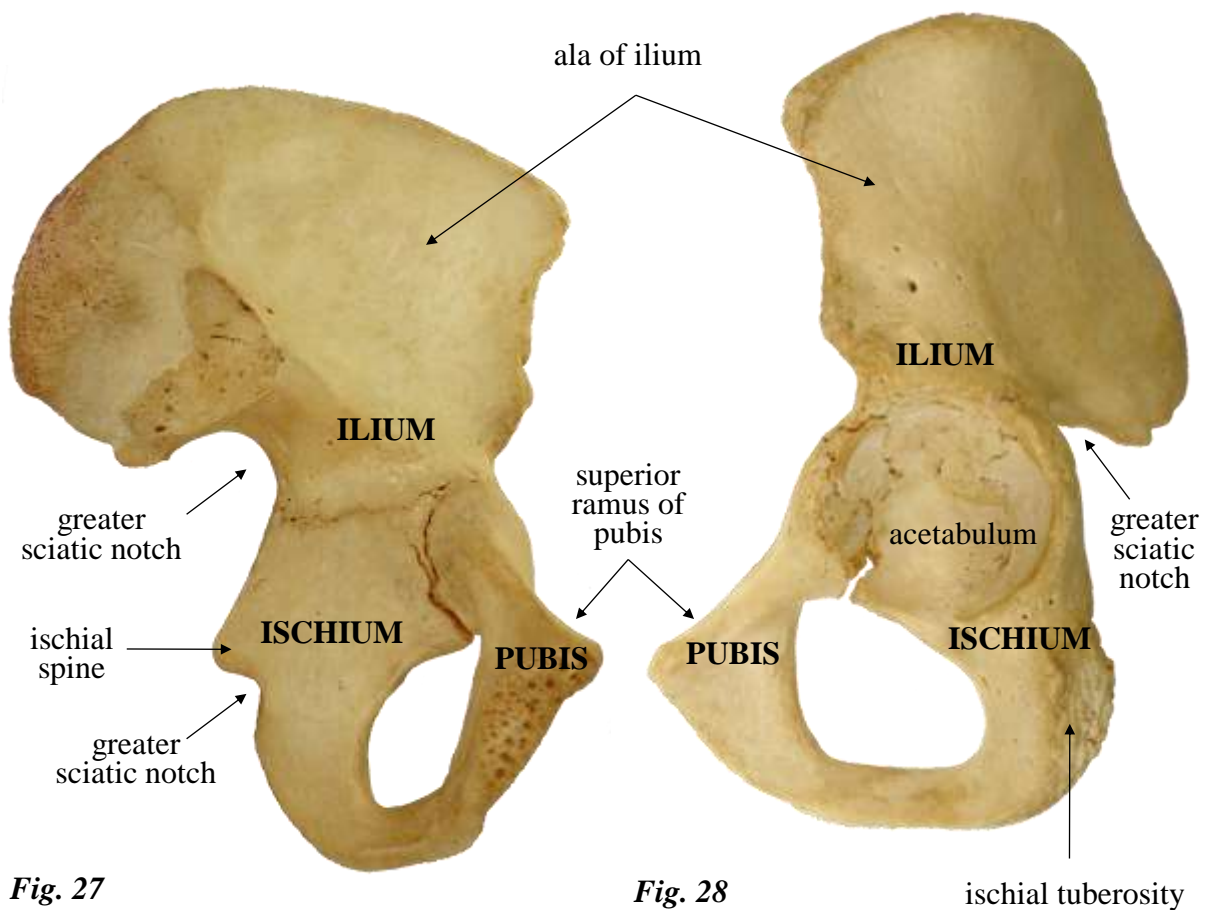


Fig. 27
Hip bone
of an adolescent
medial (internal) view

Fig. 28
Hip bone
of an adolescent
lateral (external) view

Acetabulum is a deep cup-shaped concavity on the lateral (external) side of hip bone. It is bounded by the prominent uneven acetabular margin. Acetabulum articulates with the head of femur to form the hip joint. Acetabulum consists of the articular and nonarticular surfaces.

- **Articular lunate surface** is broad, C-shaped area lined by the hyaline cartilage. It is interrupted inferiorly by **acetabular notch**. Acetabular notch is continuous with acetabular fossa.
- **Acetabular fossa** is **nonarticular surface**. It forms central shallow depression in the acetabulum surrounded by the articular lunate surface.

The large **obturator foramen** is closed by thin fibrous **obturator membrane** in the living body. **Obturator canal** remains open superiorly between the membrane and adjacent bone. It is a route through which the neurovascular structures pass between pelvic cavity and lower limb.

- **Ilium** is the widest and largest part of hip bone. It is composed of:
 - **body** of ilium – lower part of ilium forming the part of acetabulum;
 - **ala** of ilium (wing of ilium) – upper flattened fan-shaped part which includes iliac fossa, sacropelvic surface and gluteal surface.

Iliac fossa is shallow concave surface located on the medial (internal) surface of the ala of ilium. It gives origin to *iliacus muscle*. Iliac fossa is bordered inferiorly by the **arcuate line** forming a part of linea terminalis and pelvic inlet. This line continues anteriorly into **iliopubic eminence** where ilium fuses with pubis.

Sacropelvic surface of the ala of ilium consists of the ear-shaped **auricular surface** and **iliac tuberosity**. Auricular surface of ilium articulates with auricular surface of sacrum to form sacroiliac joint. Iliac tuberosity is roughened area behind the auricular surface for the attachment of strong sacroiliac ligaments.

External **gluteal surface** of the ala of ilium lies above the acetabulum and it faces posterolaterally. It is marked by three curved lines – **posterior, anterior and inferior gluteal lines**. This surface gives attachment to *gluteus maximus, medius and minimus muscles*.

The superior margin of the ala of ilium is thickened, forming **iliac crest**. It lies close to the surface and is easily palpable through the skin. Iliac crest runs between **anterior superior iliac spine** and **posterior superior iliac spine**. Below these spines there are corresponding **anterior inferior iliac spine** and **posterior inferior iliac spine**. The ilium is notched by **greater sciatic notch** which is situated between the posterior inferior iliac spine and ischial spine.

Iliac crest gives attachment to the *abdominal muscles (external oblique, internal oblique, transversus abdominis and quadratus lumborum)*; to the *extrinsic muscles of the back (latissimus dorsi)* and to some of the *intrinsic muscles of the back*. Anterior superior iliac spine gives origin to *sartorius* and *tensor fasciae latae muscles*; anterior inferior iliac spine gives origin to *rectus femoris muscle*.

- **Ischium** is composed of:
 - **body** of ischium – it projects superiorly and forms the part of acetabulum;
 - **ramus** of ischium – it is curved in acute angle and fused with inferior pubic ramus to complete the obturator foramen.

The posteroinferior aspect of ischium forms **ischial tuberosity**. It is an important site for the attachment of the muscles of the lower limb and supporting the body when sitting. It gives origin to some muscles of the gluteal region (*gemellus inferior, quadratus femoris*); to

hamstring part of *adductor magnus* and to the muscles of the posterior compartment of the thigh (*long head of biceps femoris*, *semitendinosus* and *semimebranosus*).

Dorsal surface of the ischium extends into thin and pointed eminence – **ischial spine**. It provides attachment for *gemellus superior muscle*. Above the ischial spine there is a large **greater sciatic notch**. Below the ischial spine there is a smaller **lesser sciatic notch**. Sacrospinous and sacrotuberous ligaments convert the notches to foramina through which neurovascular structures pass.

- **Pubis** is the most anterior portion of the hip bone. It consists of:
 - **body** – it forms the part of acetabulum and meets with ilium in iliopubic eminence;
 - **superior pubic ramus** – it extends from the body to the median plane;
 - **inferior pubic ramus** – it passes caudally from the superior pubic ramus; it joins with the ramus of ischium along obturator foramen (inferior pubic ramus and ramus of ischium are sometimes called as ischiopubic ramus).

Superior pubic ramus is marked by sharp upper ridge – **pecten pubis**. It ends into **pubic tubercle** ventrally. Pecten pubis forms a part of linea terminalis of hip bone and pelvic inlet. **Pubic crest** is situated medial to pubic tubercle and it extends to the medial edge of the bone. It is also a part of linea terminalis and pelvic inlet. Lower border of superior pubic ramus is marked by **obturator groove**.

Inferior pubic ramus is marked by the elongated **symphyseal surface** facing its counterpart. This surface is joined to the symphyseal surface of the opposite hip bone by the cartilaginous **pubic symphysis**. **Phallic crest** on the inferior pubic ramus provides attachment for crura of penis or crura of clitoris.

The ischiopubic ramus and the body of pubis are associated mainly with the muscles of medial femoral compartment of the thigh – *gracilis*, *pectineus*, *adductor longus*, *adductor brevis*, *adductor part of the adductor magnus*, *obturator externus* and with a single muscle of the gluteal region – *obturator internus*. The pubis and the ischium also give attachment to some of the abdominal muscles - *rectus abdominis*, *pyramidalis* and muscles of the *pelvic* and *urogenital diaphragm*.

Linea terminalis is a line extending from promontory of sacrum along arcuate line, pecten pubis, to the superior border of pubic symphysis. It marks the boundary between greater and lesser pelvis as well as the plane of the pelvic inlet.

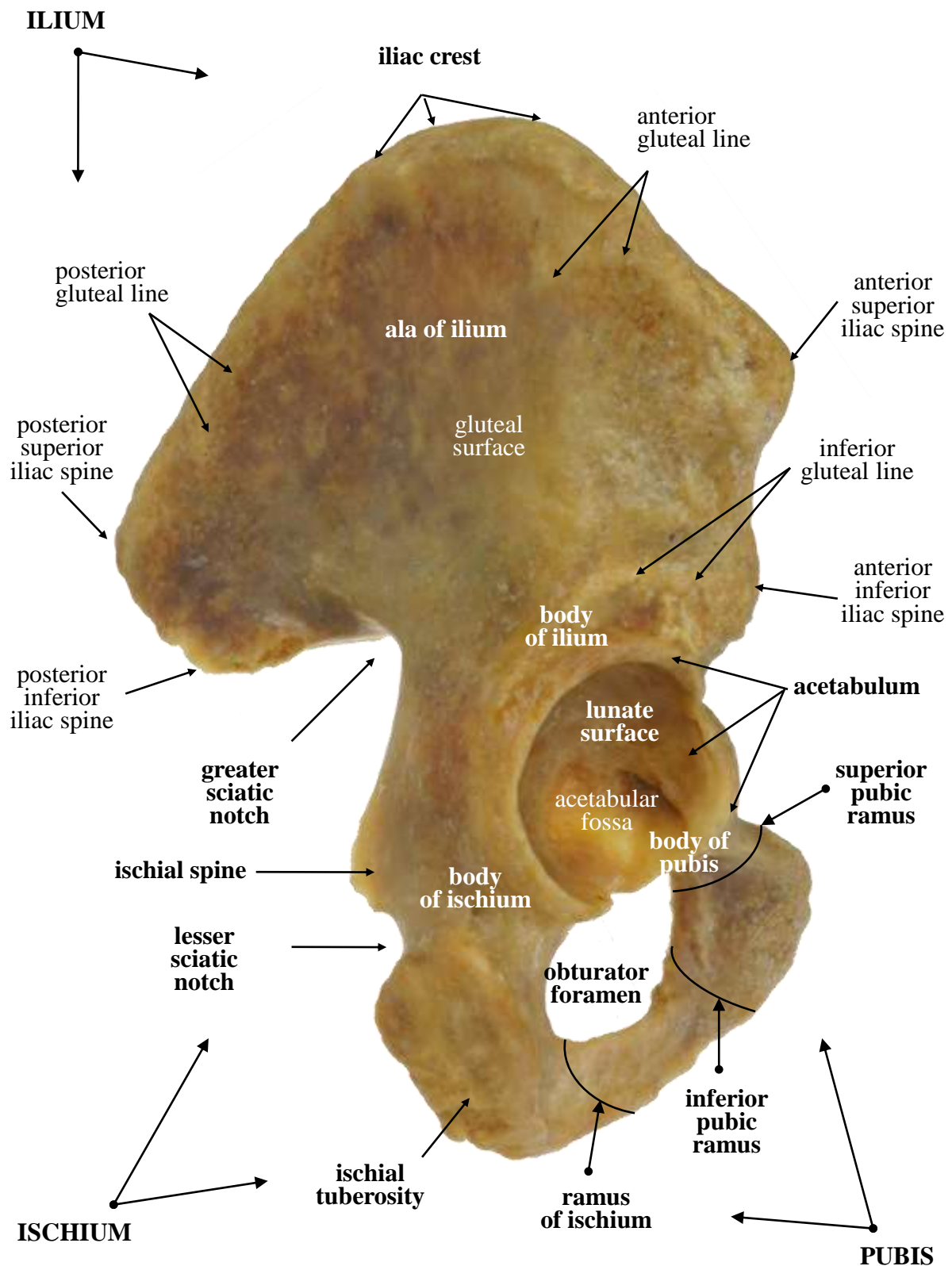


Fig. 29
Right hip bone
lateral (external) view

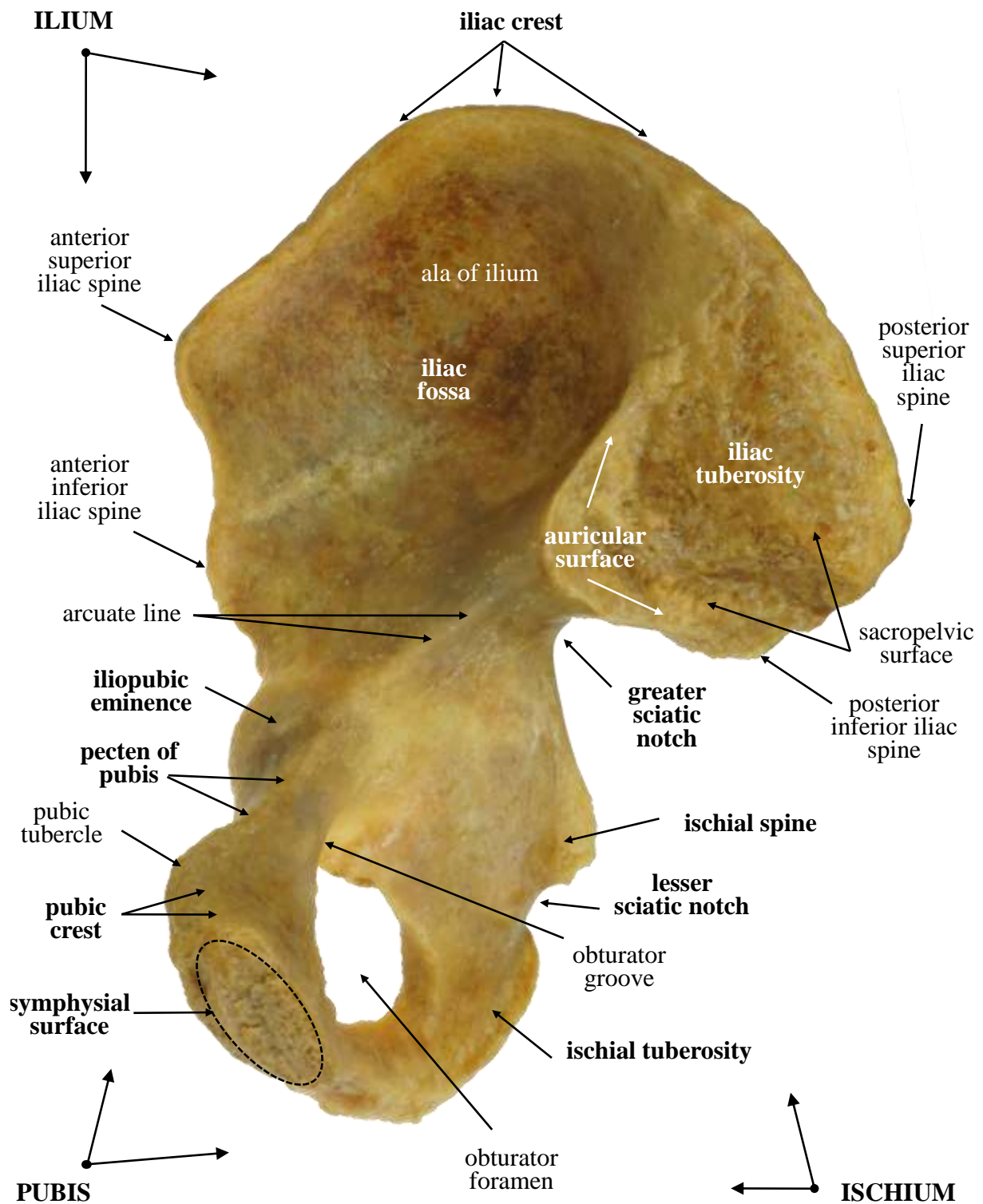


Fig. 30
Right hip bone
medial (internal) view

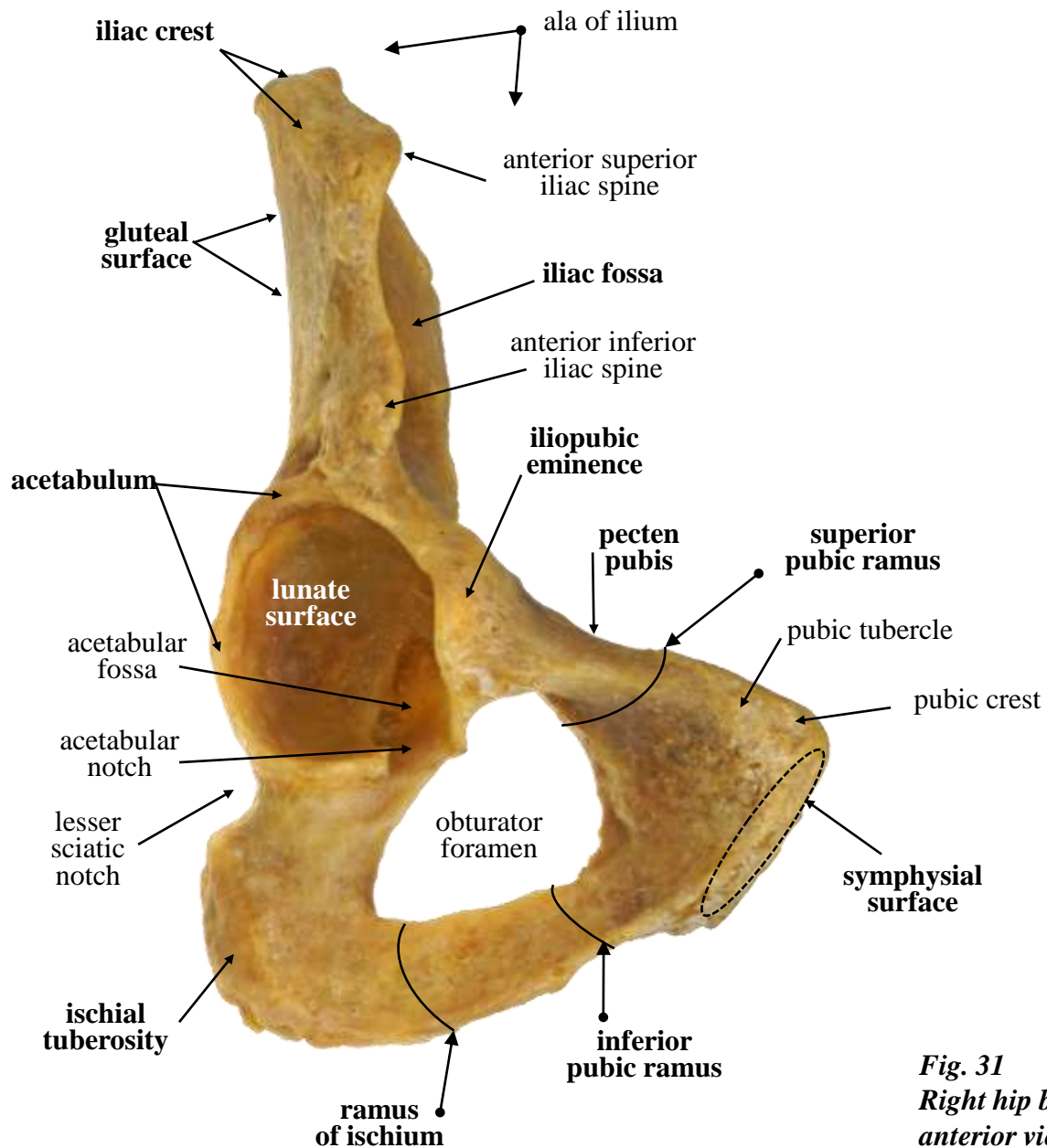


Fig. 31
Right hip bone
anterior view

Clinical column

- Anterior superior iliac spine (ASIS) is an important anatomical bony landmark which is easily palpable. It helps in the localisation of:
 - inguinal ligament which arises from ASIS and borders inguinal canal;
 - femoral artery which lies medial to the midpoint (halfway between the ASIS and pubic symphysis); the femoral artery can be palpated in this point;
 - base of appendix projected onto McBurney's point at line between ASIS and umbilicus;
 - ASIS is also the start point for the measurement of true leg length (between anterior superior iliac spine to the medial malleolus at the ankle joint).

- *The iliac crest is a readily accessible site for bone marrow biopsies (a bone marrow examination is performed to diagnose e.g. lymphoma, leukemia, metastasis to bone marrow).*
- *Pelvic fractures occur usually as a result of the high-energy injuries e.g. after a high speed road traffic accident, collisions of pedestrian vs. motor vehicle, fall from the height. These fractures include often injuries of soft tissue and neurovascular injuries with damage of urinary bladder, urethra or vaginal trauma associated with internal bleeding. The high-energy injuries frequently require urgent surgery and are typical for the younger people. Pelvic fractures caused by the low-energy injuries are typical for the older patients with osteoporotic bone after minor trauma. These are usually „stable“ injuries, not requiring surgery.*

FEMUR

Femur is the longest, largest and strongest bone in the human body. It articulates proximally with the hip bone at the hip joint and distally with tibia and patella at the knee joint. When a subject is in the standing position, femur transmits weight from hip bone to tibia. femur is covered with muscles, so that only its superior and inferior ends are palpable. Femur consists of:

- **proximal end;**
- **shaft;**
- **distal end.**

The **proximal end** of femur extends into large spherical **head** which is directed medially upwards and slightly forwards. It articulates with the articular lunate surface of hip bone. It bears nonarticular small depression, **fovea for ligament of head of femur (fovea capitis femoris)**. Inferolaterally angled the **neck** connects the head with the shaft.

Greater trochanter is a large, irregular and the most lateral palpable projection of the shaft. The medial surface of greater trochanter is marked by a deep depression, **trochanteric fossa**. Greater trochanter serves as a place for insertion of some muscles of the gluteal region, such as *gluteus medius*, *gluteus minimus* and *piriformis*. The trochanteric fossa gives insertion to *obturator internus* and *obturator externus muscles*, *gemellus superior* and *gemellus inferior muscles*.

Lesser trochanter is smaller than greater trochanter. It is situated on the posterior aspect of femur projecting medially from the junction of the neck and shaft. It serves as a place for insertion of *iliopsoas muscle*. **Intertrochanteric line** and **intertrochanteric crest** separate the shaft of femur from the neck. Intertrochanteric line lies on the anterior aspect of femur and extends from greater trochanter to lesser trochanter. Intertrochanteric crest lies on the posterior aspect of femur and it also extends between two trochanters. The *quadratus femoris muscle* inserts to the intertrochanteric crest.

The **shaft** of the femur (body) descends obliquely inferomedially, so the distal end of femur is therefore closer to the midline than the proximal end. The shaft is also slightly convex forwards. Its anterior surface provides attachment for *vastus intermedius muscle*. Its posterior surface bears rough double line – **linea aspera**. It gives origin to the *vastus medialis* and *vastus lateralis muscles*, *short head of the biceps femoris*, as well as it gives insertion to adductors – *brevis, longus* and *magnus*. **Linea aspera** is formed by the **lateral lip** and the **medial lip**:

- proximally, towards lesser trochanter, the medial lip of linea aspera continues as **pectineal line / spiral line** (attachment site for *pectineus muscle*), while the lateral lip continues towards greater trochanter as the **gluteal tuberosity** (attachment site for *gluteus maximus muscle*);
- distally, linea aspera divides into the **medial** and the **lateral supracondylar lines** which continue towards the medial and the lateral condyles of femur. Supracondylar lines border triangular area – **popliteal surface**. The medial supracondylar line terminates at a prominent tubercle – **adductor tubercle** which provides attachment for the *adductor magnus muscle*.

Distal end of femur is formed by:

- **condyles**;
- **epicondyles**.

Rounded projections – the **medial** and the **lateral condyles** form a part of the knee joint. The anterior **patellar surface** of the condyles articulates with patella, while the inferior and posterior surfaces articulate with menisci and tibial condyles. The lateral condyle is more prominent and is broader. The condyles are separated posteriorly by a deep notch – **intercondylar fossa** where the cruciate ligaments of the knee joint are hidden. Above the fossa there is **intercondylar line**. The **medial** and the **lateral epicondyles** are eminences above the condyles. Posterosuperior to the medial epicondyle there is **adductor tubercle**. Epicondyles give attachment to the collateral ligaments of knee joint. Distal end of femur gives origin to *medial* and *lateral heads of gastrocnemius muscle*, *plantaris* and *popliteus muscles*.

Clinical column

- *The angle between the long axis of femoral shaft and long axis of the neck and the head is about 125° in adults, smaller in female. This angle allows greater mobility of the femur at the hip joint.*
- *Fractures of femoral neck are common in older patients as a result of low-energy injury in the presence of the osteoporotic bone. They are more prevalent in women. In younger patients they tend to occur as a result of high-energy accidents. If this fractures is intracapsular it can damage blood circulation of the head and neck and causes avascular necrosis of the femoral head. The treatment options include non-operative management, internal fixation or total hip replacement.*
- *Fractures of femoral shaft are usually associated in adults with the high-energy injury (e.g. motor vehicle accidents). In younger children there are usually due to falls. These fractures are accompanied frequently by damage to the surrounding soft tissues – muscles and neurovascular structures. They can often occur as a spiral fracture, which causes leg shortening.*

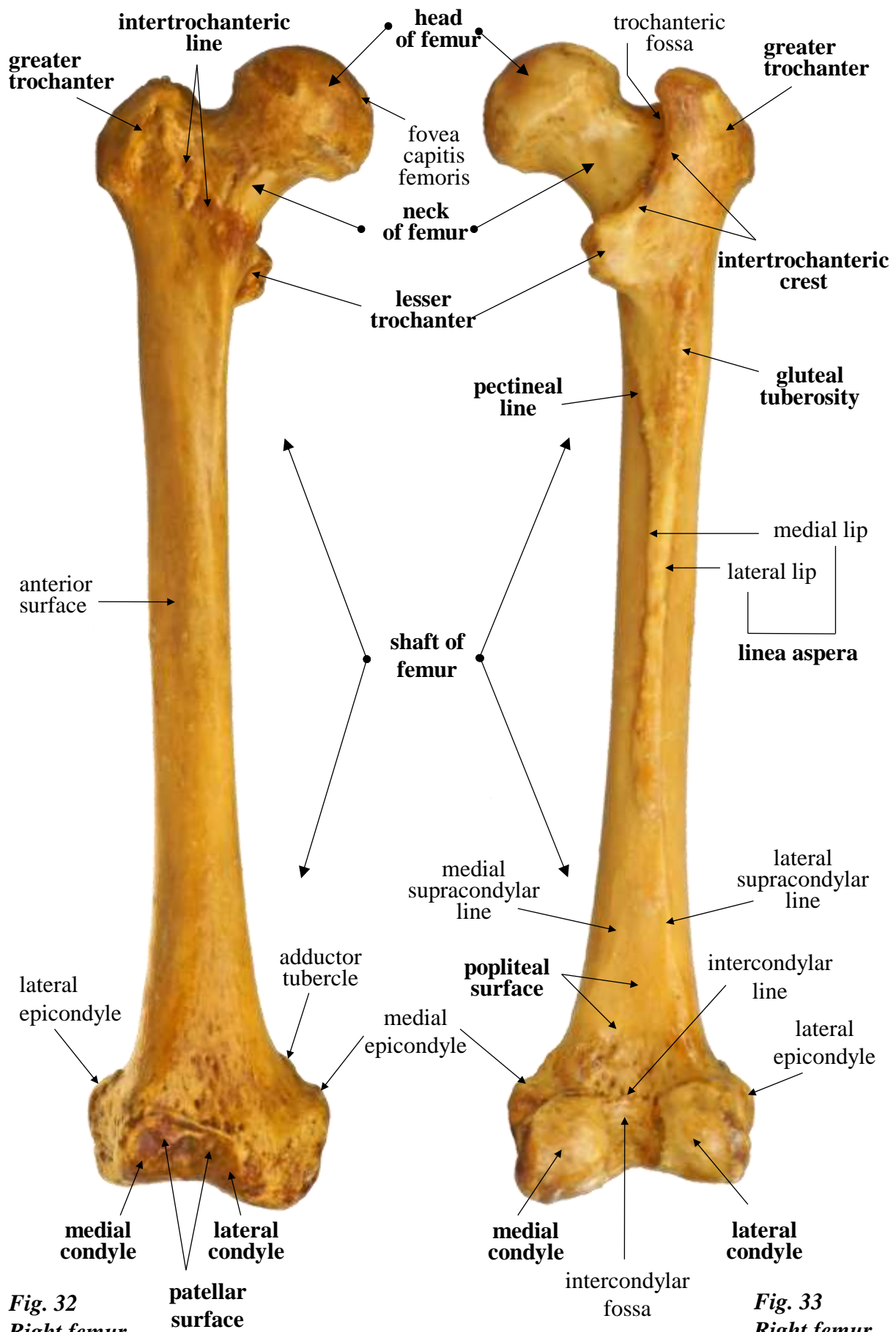
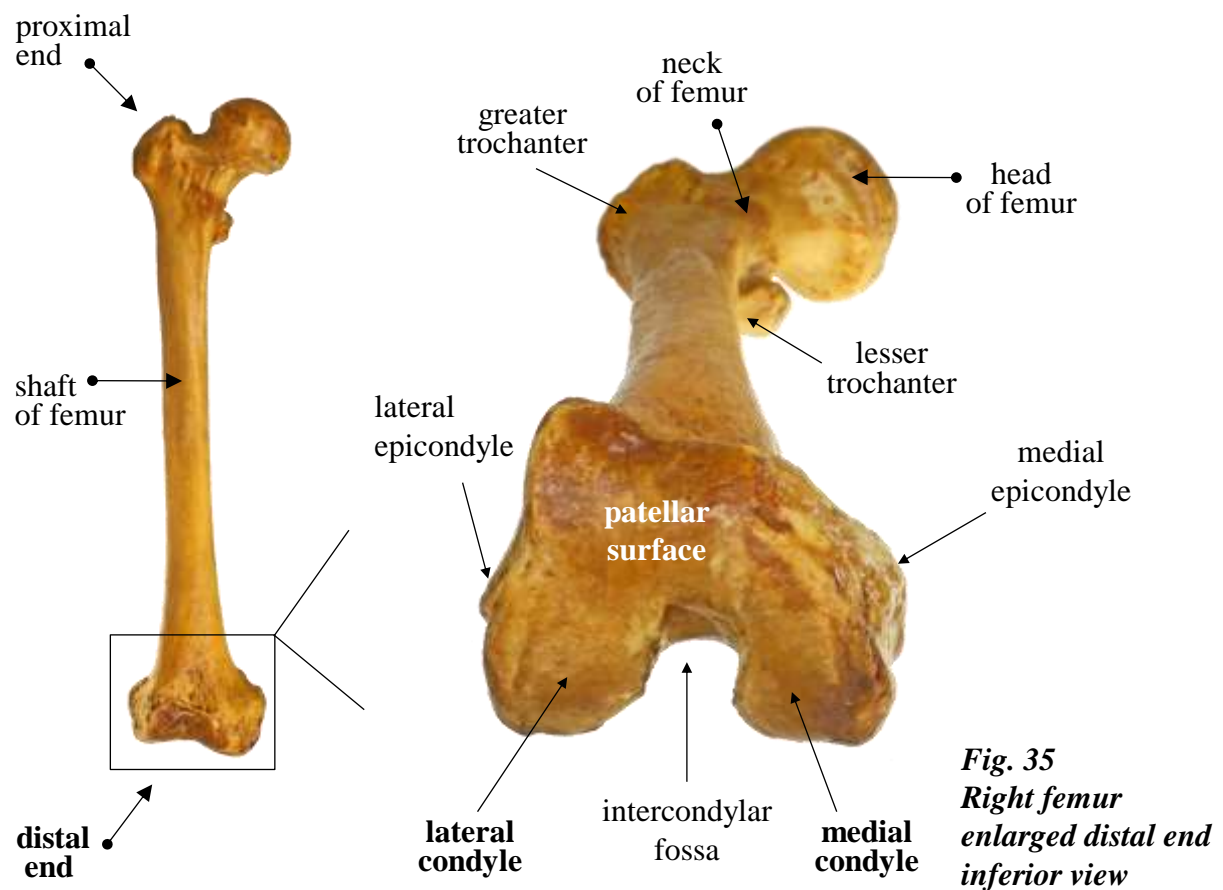
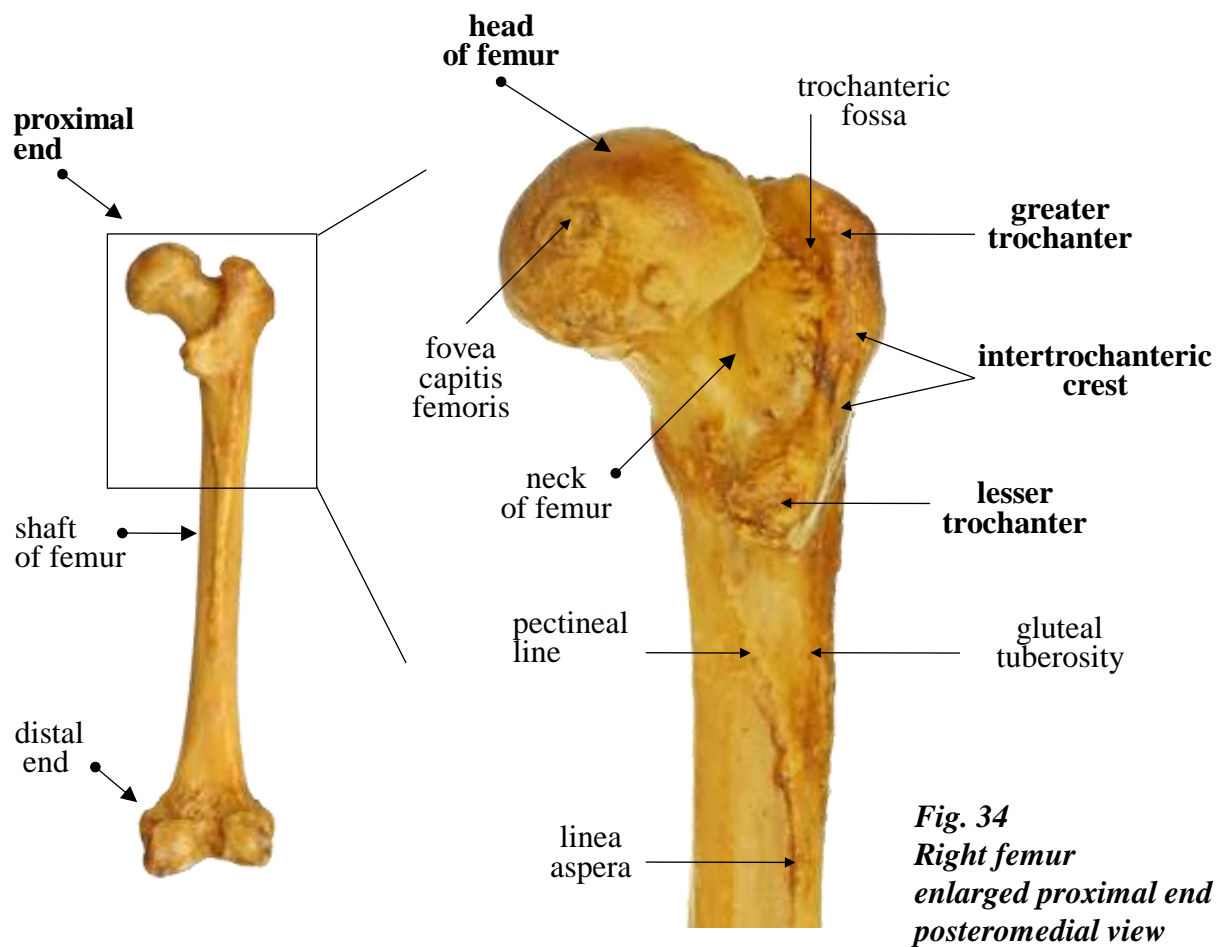


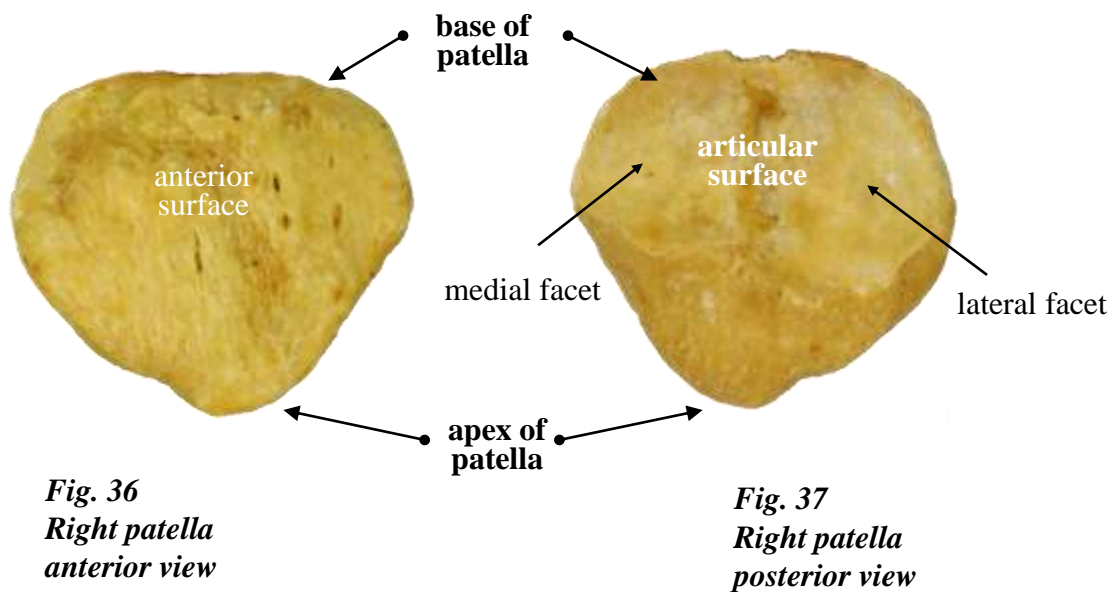
Fig. 32
Right femur
anterior view

Fig. 33
Right femur
posterior view



PATELLA

Patella (kneecap) is the largest **sesamoid** bone which is embedded within the patellar ligament (it is a tendon of the quadriceps femoris muscle). Its superior broad border is called **base of patella** and inferior pointed border – **apex of patella**. **Anterior surface** of patella is rough. Its posterior **articular surface** is subdivided into the **medial** and the **lateral facets**. The lateral facet is larger because articulates with the larger lateral condyle of the femur.



BONES OF THE LEG

Tibia and fibula are the bones of the leg. Tibia is the larger bone and is much stronger than fibula so it transmits the body's weight from femur to the foot. Tibia contributes to the knee and the ankle joints. Fibula participates only in the ankle joint, but it is important for the stability of this joint. The shafts of the tibia and the fibula are connected by a dense interosseous membrane.

Generally: the leg (crus**) is a part of the lower limb between the knee and the ankle joints includes calf* (sura**).*

** in English terminology with their ** Latin equivalents*

TIBIA

Tibia is located on the medial side of the leg, nearly parallel to fibula and it is the second longest bone in the human skeleton. The tibia consists of:

- **proximal end;**
- **shaft (body);**
- **distal end.**

At the **proximal end**, tibia is widened into thick **medial** and **lateral condyles**. They are attached to the top of tibial shaft. Tibial condyles bear the **superior articular surfaces** which are slightly concave. The medial condyle is larger than the lateral and its superior articular surface is oval-shaped for articulation with the medial condyle of femur. The surface on the lateral condyle is nearly circular in shape for articulation with the lateral condyle of femur.

Between the superior articular surfaces there is a bony prominence – **intercondylar eminence** elevated on either side by the **medial** and **lateral intercondylar tubercles**. Tubercles separate rough depressions – **anterior** and **posterior intercondylar areas**. They provide attachment for the cruciate ligaments and menisci of the knee joint. Inferior to the condyles and on the anterior aspect of tibia there is an oval elevation – **tibial tuberosity**. It is easily palpable approximately 5 cm below the apex of patella. Tibial tuberosity gives attachment to the patellar ligament that is a continuation of quadriceps femoris tendon below patella. Posterolaterally on the inferior aspect of the lateral condyle there is a flat, circular facet – **fibular articular surface** (facet) for connection with the head of the fibula.

Proximal end of tibia gives insertion to *sartorius*, *gracilis*, *semitendinosus* and *semimembranosus muscles* and to *iliotibial tract*.

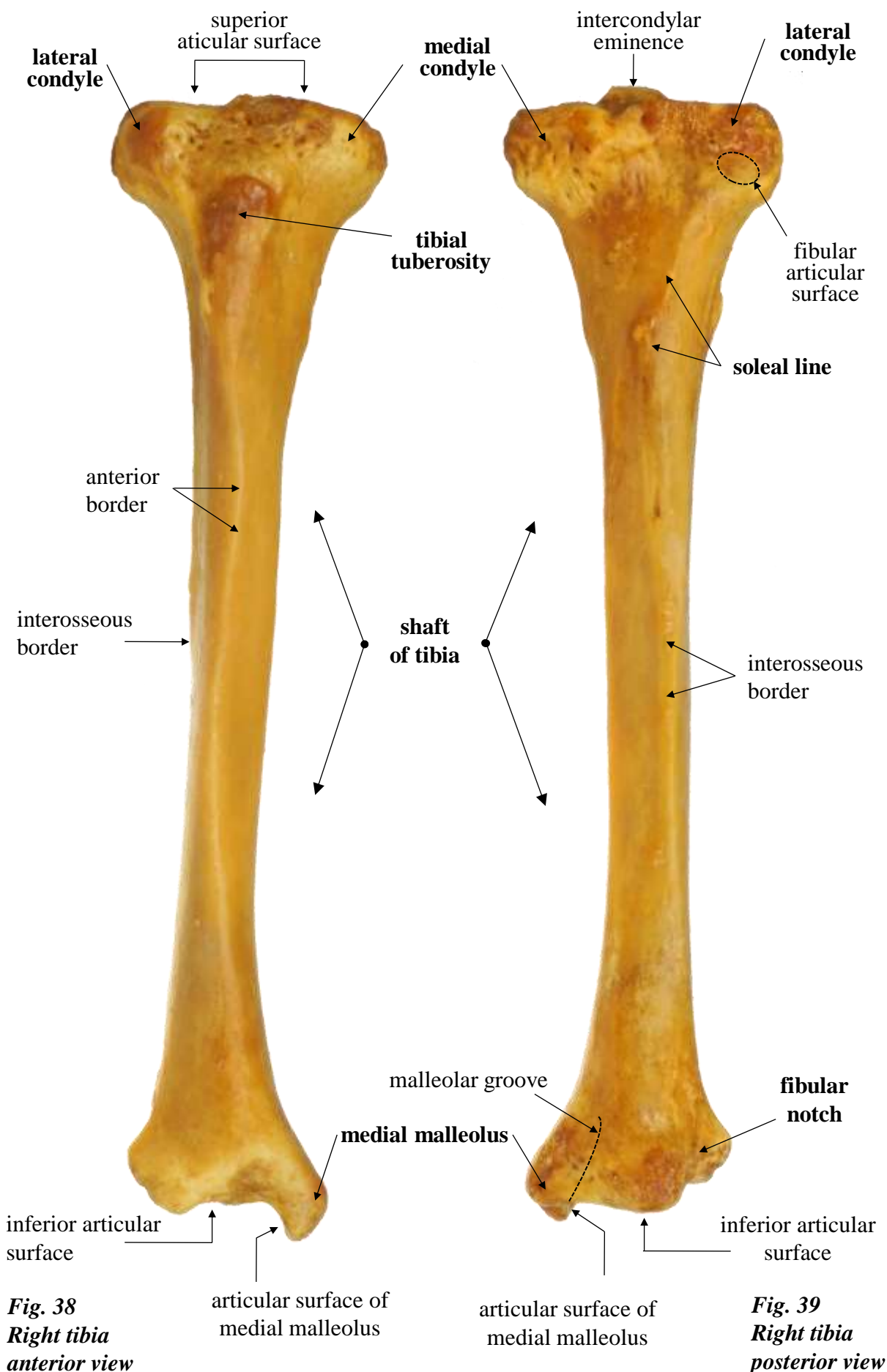
The **shaft** of tibia (body) is strong and triangular in cross-section. It is the thinnest at the junction of middle and distal thirds. It has three **borders** – **anterior**, **interosseous** (lateral), **medial** and three **surfaces** – **posterior**, **medial**, **lateral**.

Anterior border is the sharpest, subcutaneous and also easily palpable. It goes from tibial tuberosity to the anterior aspect of the medial malleolus. Here, the periosteal covering of the tibia is susceptible to damage, presenting clinically as bruising. The **interosseous border** faces the fibula and gives attachment to the crural interosseous membrane. **Posterior tibial surface** bears an oblique bony ridge – **soleal line**. It runs inferomedially. Soleal line gives origin

to *soleus muscle* and it marks the distal limit for insertion of *popliteus muscle*. **Medial tibial surface** is broad and subcutaneous so it is readily palpable on the anteromedial side of the leg;

The shaft of the tibia gives attachment to some muscles of the anterior compartment of the leg – *tibialis anterior* and *extensor digitorum longus muscles*, also of posterior compartment of the leg – *tibialis posterior* and *flexor digitorum longus muscles*.

The **distal end** of tibia projects inferiorly and medially to a strong pyramidal process – **medial malleolus**. It is convex, subcutaneous and easily palpable. It bears the **articular surface (facet) of medial malleolus** for articulation with talus at the ankle joint. Medial malleolus does not extend as far distally as the lateral malleolus. On the posterior aspect of the medial malleolus there is a small **malleolar groove of the tibia** (for passage of the tendon of tibialis posterior muscle). Laterally, on the distal end, there is the **fibular notch** for articulation with the fibula. Inferiorly, nearly in the horizontal plane, there is **inferior articular surface of tibia** for articulation with trochlea of talus.



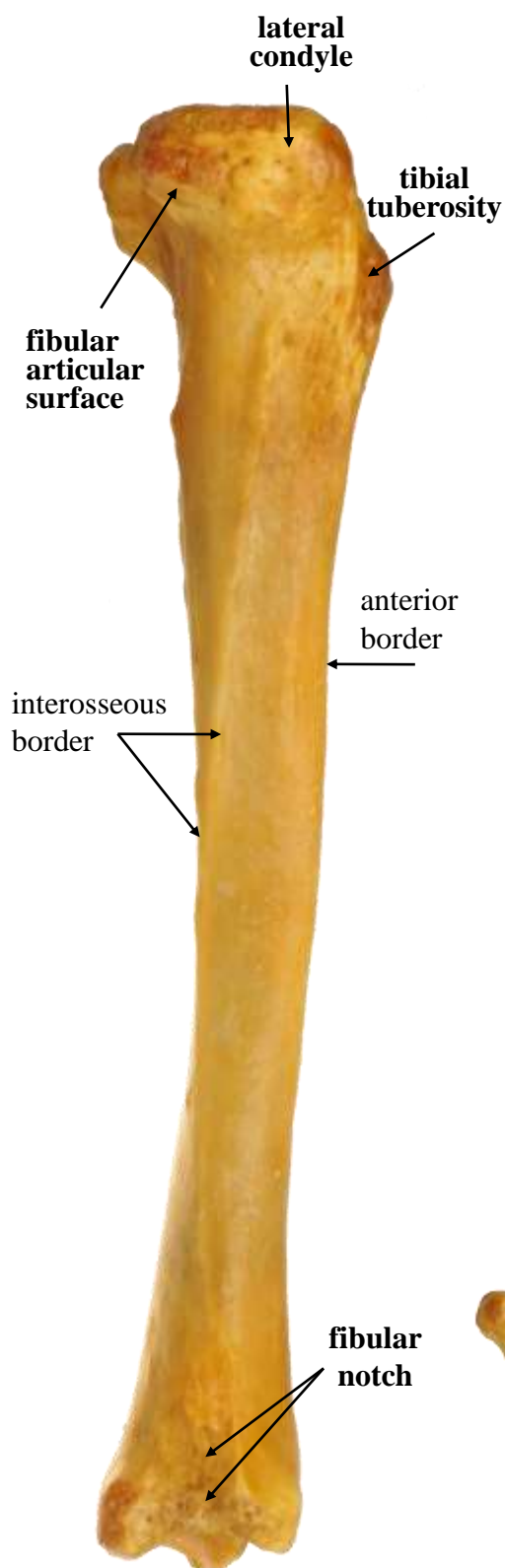


Fig. 40
Right tibia
lateral view

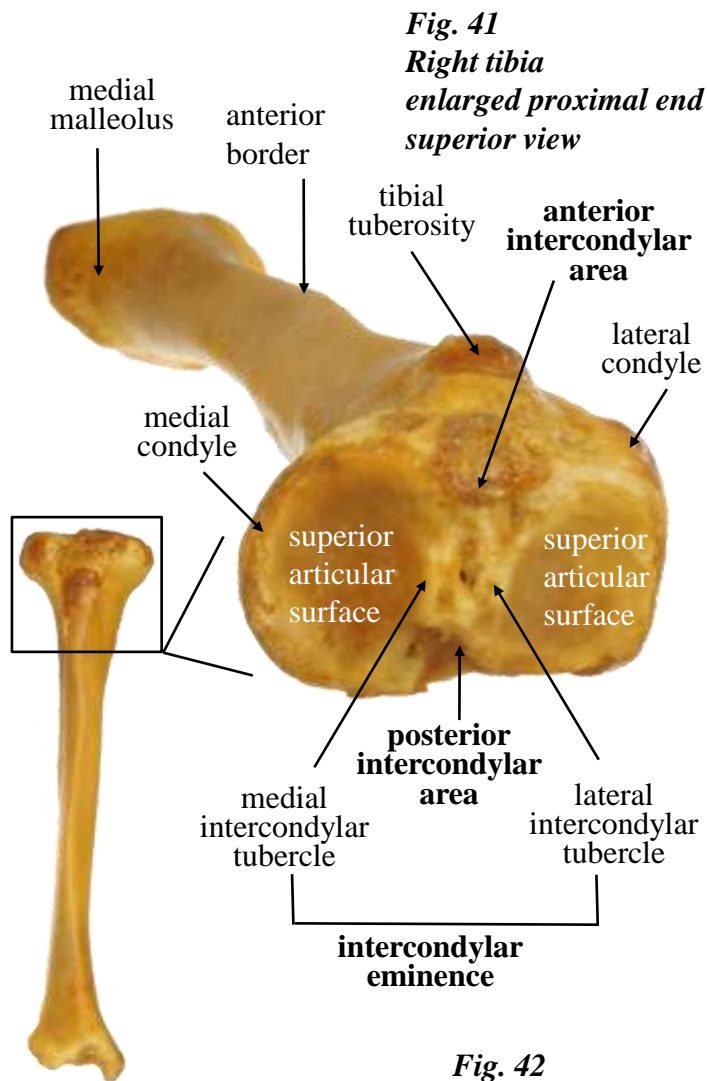


Fig. 41
Right tibia
enlarged proximal end
superior view

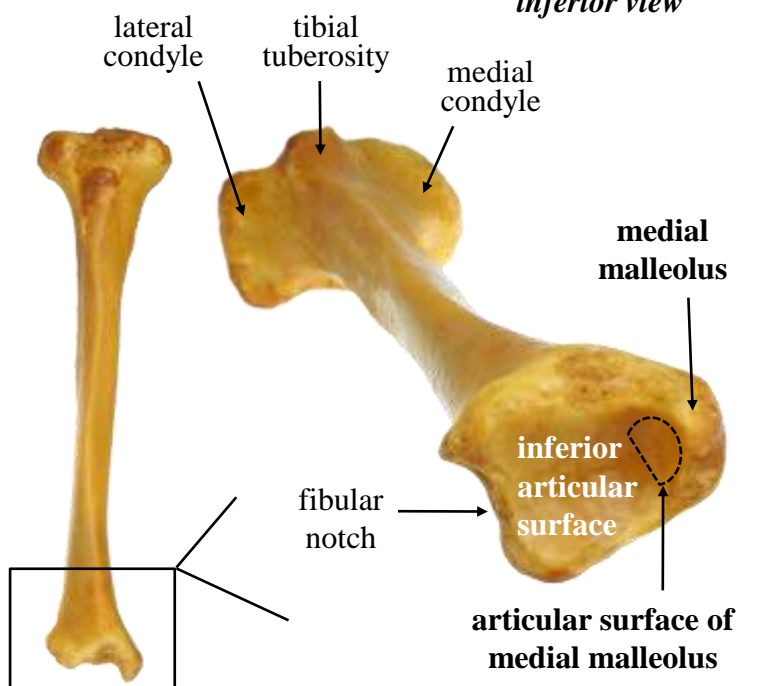


Fig. 42
Right tibia
enlarged distal end
inferior view

FIBULA

Fibula is the slender lateral bone of the leg. Its main function is to act as an attachment for the muscles and it forms a part of the ankle joint. Fibula articulates with tibia proximally and with talus distally. Proximal and distal ends of the bone are palpable. Its middle portion is covered by the muscles. Fibula consists of:

- **proximal end;**
- **shaft (body);**
- **distal end.**

The **proximal end** is enlarged into the **head of fibula**. Its superomedial surface bears a circular **articular surface (facet)** for joint with a corresponding surface on the lateral condyle of tibia. The head projects proximally into **apex of head**.

The head of fibula serves as a place for the insertion of *biceps femoris muscle* and also for the origin of *soleus* and *fibularis (peroneus*) longus muscles*. (*The term "peroneal" is synonymous with *fibular*).

The **neck** of fibula separates the enlarged head from the shaft. Like tibia, the **shaft** of fibula (body) is marked by the surfaces and borders. The interosseous border is medial in position. It faces tibia and gives attachment to the part of the interosseous membrane. The shaft of fibula gives origin to some muscles of the anterior compartment of the leg – *extensor digitorum longus*, *extensor hallucis longus* and *fibularis tertius*, to muscle of the lateral compartment of the leg – *fibularis (peroneus) brevis* and to some muscles of the posterior compartment of the leg – *flexor hallucis longus* and *tibialis posterior*.

The **distal end of the fibula** forms the **lateral malleolus**. It is expanded distal portion of fibula which can be palpable at the ankle on the lateral side of the leg. It is more prominent and extends more distally than the medial malleolus. Its medial surface bears the **articular surface (facet) of lateral malleolus** for articulation with trochlea of talus. The lateral malleolus bears the **malleolar fossa** and shallow **malleolar groove of the fibula** (for tendons of *fibularis longus* and *fibularis brevis muscles*).

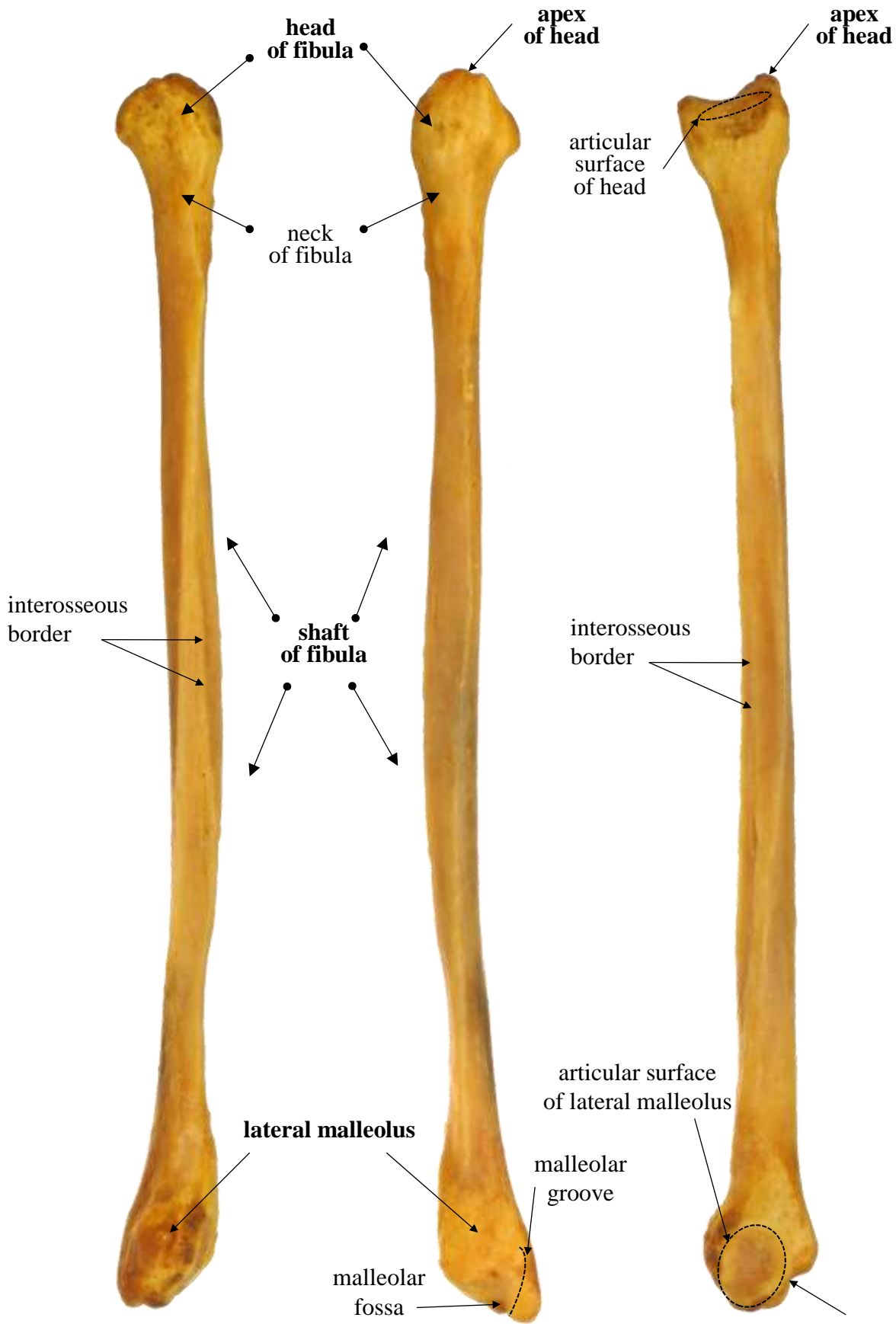


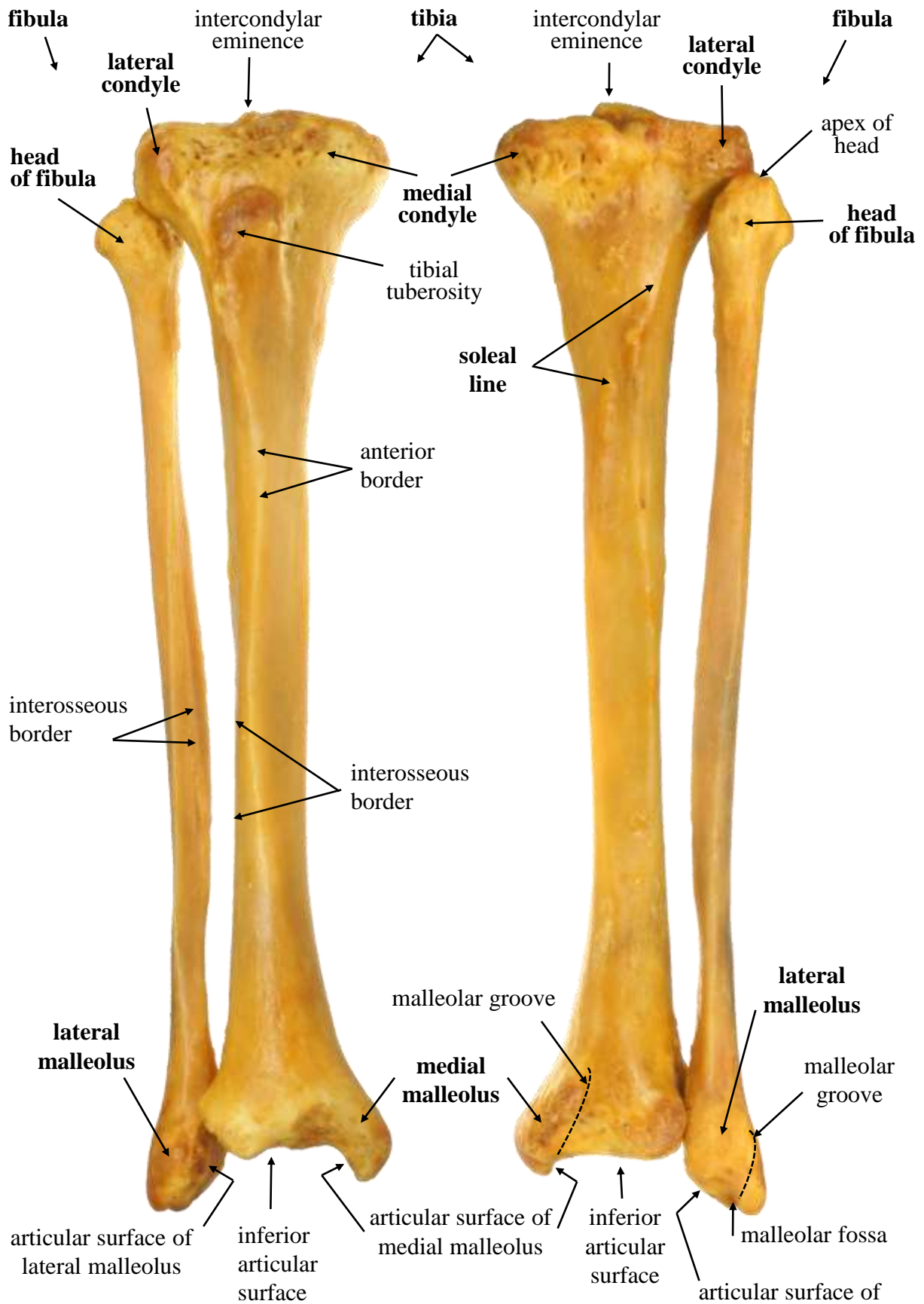
Fig. 43
Right fibula
anterior view

Fig. 44
Right fibula
posterior view

Fig. 45
Right fibula
medial view

Clinical column

- *Tibia and fibula may be fractured individually and in that case the unbroken bone holds the other with a little displacement. The both bones are interconnected by strong interosseous membrane that stabilizes the joints of the crural bones and trasmits the force from one to the other. Thus if the tibia is broken it is important to inspect the fibula at another level.*
- *Tibia is fractured more frequently than the other long bone. Its position just beneath the skin causes a high incidence of the open fractures (with the dislocation of the fragments) and infected fractures.*
 - *The fractures of its condyles may be associated with damage of the ligaments of knee joint.*
 - *The fractures of tibia are common at the narrowest part of its shaft which has the poorest blood supply. They are often caused by high-energy injuries (motor vehicle or motorcycle crash). These fractures may damage the nutrient artery that predisposes the patient to nonunion of the bone fragments (the most people have only one nutrient tibial artery).*
 - *„Boot-top“ fracture is commonly seen among skiers. It results from a highspeed forward fall, which angles the leg over the boot rigidly fixed to the ski. It requires surgery intervention and more often the long-time rehabilitation.*
- *Fracture of the neck of fibula or pressing of the firmly attached plaster bandage in this location may damage common fibular nerve which is fixed to the periost.*
- *The ankle fractures include the break of one or more bones that form the ankle and they are often associated with a damage of related ligaments. They are caused by twisting, tripping or falling of the ankle. The ankle may be twisted inwards (may caused fracture of the medial malleolus and it tears ligaments on the lateral ankle side) or outwards (as well as forced external rotation) that causes a fracture of the lateral malleolus.*



BONES OF THE FOOT

The skeleton of the foot comprises of three segments:

- ❖ **tarsal bones** – are situated **proximally**;
- ❖ **metatarsal bones**;
- ❖ **phalanges** – are situated **distally**.

The division of the bones of the foot into three segments is analogous to the hand but there are different features of the arrangement, size, shape between the bones of the hand and the foot depending on their special function. The bones of the foot provide mechanical support for the soft tissues helping the foot with stand the weight of the body. Thus the bones of the foot are more solid and robust and joints between them are less movable. The carpus forms only 1/6 and the phalanges 1/2 of the length of the hand however the tarsus forms the posterior half of the foot and the metatarsals and phalanges the anterior half of the foot. The carpus continues in the line with the forearm however the tarsus is placed at right angles to the leg. The first metacarpal bone, associated with the thumb, is located on the plane anterior to the other so allows its opposite position. The first metatarsal bone, associated with the great toe, lies parallel with the other metatarsals, and its mobility is limited. The phalanges of the foot are smaller and have limited degree of mobility in comparison with the phalanges of the hand.

TARSAL BONES

There are seven short, irregularly shaped tarsal bones, which are collectively known as tarsus. Tarsal bones form the skeletal framework for the ankle joint but only talus articulates with tibia and fibula. Distally, tarsal bones form articulations with the metatarsal bones. Individual tarsal bones are connected by intertarsal joints.

The tarsal bones are arranged in **three groups** (rows): proximal, intermediate and distal.

- ❖ **Proximal group** consists of two large tarsal bones, **talus** which is positioned medially and **calcaneus** which is situated on the lateral side of the foot (the side of the fifth, little toe);

- ❖ **Intermediate group** consists of the only **navicular bone**. It is located more on the medial side of the foot between talus and three cuneiform bones;
- ❖ **Distal group** consists of **lateral, intermediate and medial cuneiform bones** and **cuboid bone** (it is situated on the lateral side of the foot).

TALUS

Talus, ankle bone, is located above the calcaneus. It is the most superior of the tarsal bones. Talus articulates superiorly with tibia and fibula at the ankle joint (talocrural joint). Inferiorly, talus articulates with calcaneus and anteriorly with navicular bone. The talus consists of:

- **body;**
- **neck;**
- **head.**

The **body** of talus forms a posterior portion of talus. It has superior cylindrical projection named **trochlea** of talus. Trochlea articulates with the bones of the leg by its three surfaces at the ankle joint. **Superior surface (facet)** of trochlea articulates with the distal end of tibia. **Medial malleolar surface (facet)** of trochlea articulates with the medial malleolus of tibia. This surface is nearly parallel to the sagittal plane. **Lateral malleolar surface (facet)** of trochlea articulates with the lateral malleolus of fibula. This surface is larger and projects more inferiorly than the medial surface because the lateral malleolus is larger and projects more inferiorly than the medial malleolus.

Trochlea is wider anteriorly than posteriorly so it fits more closely between tibia and fibula in dorsiflexion of the foot. Consequently, the stability of the ankle joint depends on the position of the foot. Thus dorsiflexed foot is more fixed than plantarflexed (e.g. when standing on the toes).

The body of talus extends in two processes. The **lateral process** is a bony projection below the lateral malleolar surface. The **posterior process** is a broad process directed backwards. It bears the **medial and lateral tubercles** which border the **groove for the tendon of the flexor hallucis longus muscle** (this tendon runs from the leg into the sole of the foot).

The **neck** of talus lies anterior (distal) to the body and it is slightly narrow.

The rounded **head** of talus is directed anteriorly (distally) and bears convex distal **navicular articular surface** for articulation with navicular bone.

Inferior surface of the talus bears small articular surfaces, the **anterior, middle and posterior calcaneal surfaces (facets)**. They articulate with corresponding surfaces on calcaneus. The middle and posterior calcaneal surfaces are separated by a deep groove –**sulcus tali**. Sulcus tali and analogous sulcus on the calcaneus, the calcaneal sulcus form a large tunnel (gap) – **tarsal sinus**. It runs obliquely forward and opens laterally. Tarsal sinus contains a strong interosseous talocalcaneal ligament.

Talus has no muscular attachments.

Fig. 48
Right talus
anterior view

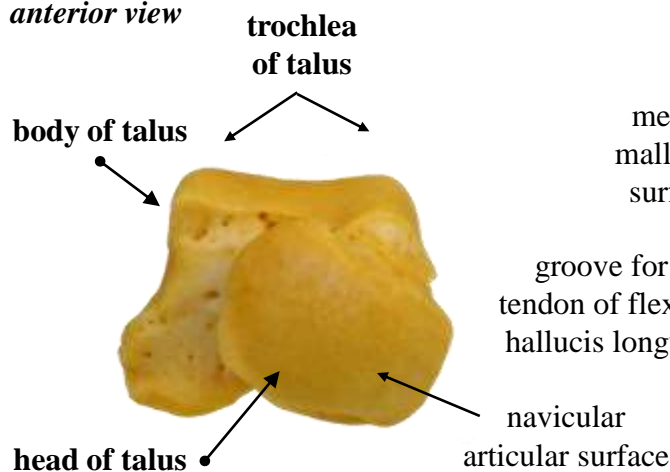
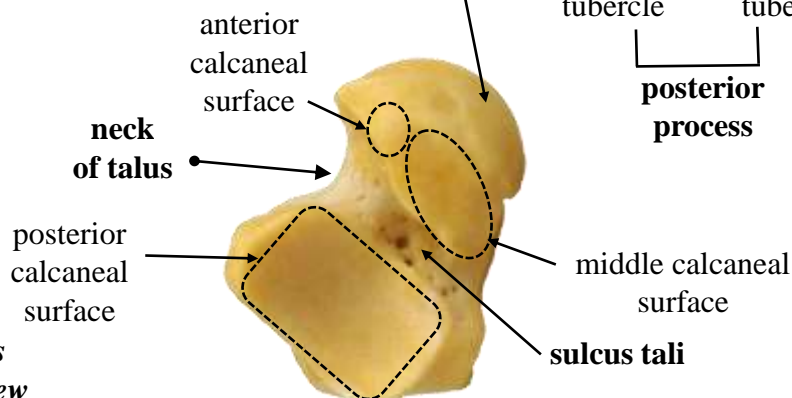


Fig. 49
Right talus
inferior view



trochlea
of talus

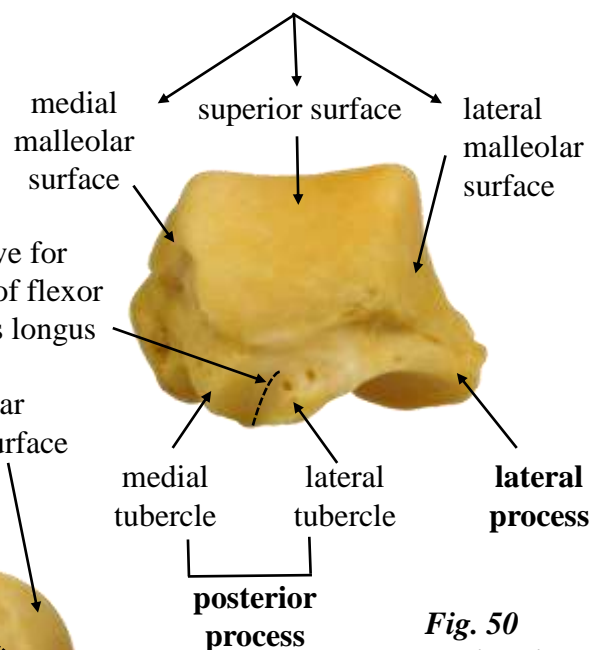


Fig. 50
Right talus
posterior view

CALCANEUS

Calcaneus, heel bone, is the largest of the tarsal bones. It transfers most of the body weight from the lower limb to the ground. It is situated below talus, so it supports it. Calcaneus articulates superiorly with talus, anteriorly with cuboid bone and it participates in the complex of talocalcaneonavicular joint.

Calcaneus is elongated, irregular bone with six surfaces.

The **superior surface** bears **anterior, middle and posterior talar articular surfaces (facets)**, which articulate with three corresponding articular surfaces on the inferior surface of talus. The middle and the posterior talar articular surfaces are separated by a deep groove – **calcaneal sulcus**. Calcaneal sulcus and sulcus tali together border the **tarsal sinus** in the articulated foot.

The **posterior surface** forms the prominence of the heel and projects behind the ankle joint. Its lower portion curves forward onto the inferior (plantar) surface as the **calcaneal tuberosity**, which gives insertion to calcaneal tendon (Achilles tendon) of the *triceps surae muscle* and to *plantaris muscle*.

The **anterior surface** is small and bears **articular surface for the cuboid bone**.

The **medial surface** extends into prominent process – **sustentaculum tali**. This shelflike process supports talus and bears most of its bulk. The sustentaculum tali forms a superior border of the **groove for tendon of flexor hallucis longus muscle**;

The **lateral surface** bears a small projection – **fibular trochlea** (peroneal trochlea). It is above the **groove for tendon of fibularis longus muscle**. The fibularis brevis muscle passes above the trochlea.

The **inferior (plantar) surface** is marked by the large **medial** and the small **lateral processes of the calcaneal tuberosity**. Anterior to named processes there is the **calcaneal tubercle**.

Beside the muscles named above, calcaneus provides attachment sites for *extensor hallucis brevis*, *extensor digitorum brevis*, *flexor digitorum brevis*, *quadratus plantae*, *abductor hallucis*, *abductor digiti minimi muscles*.

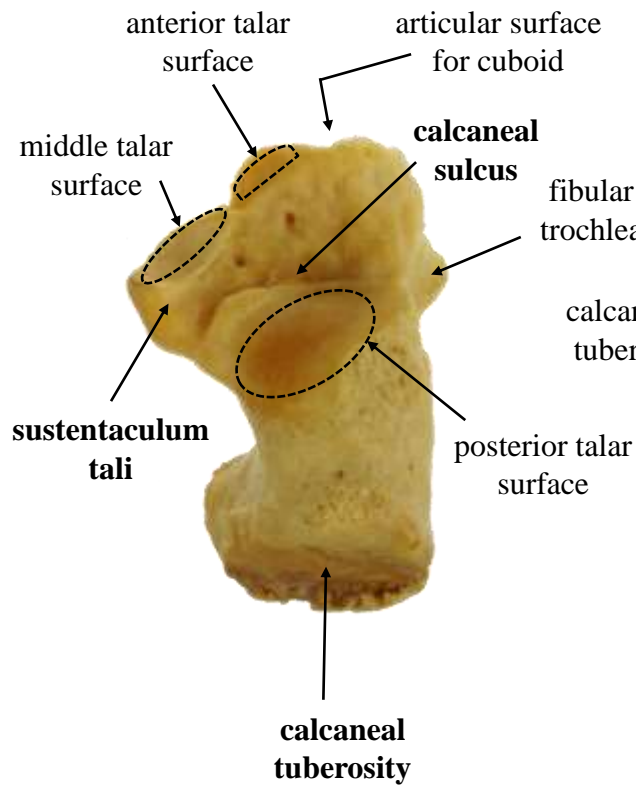


Fig. 51
Right calcaneus
superior view

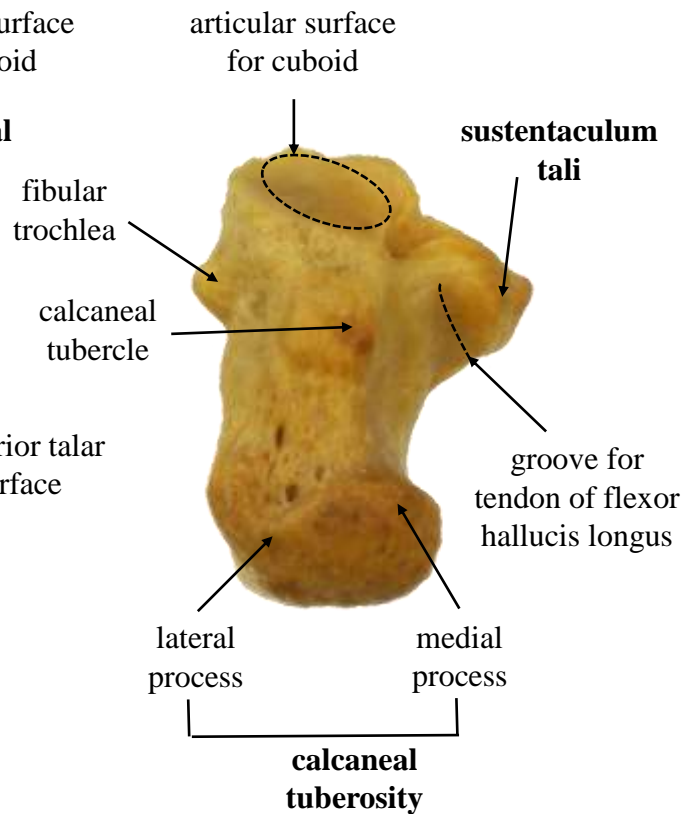


Fig. 52
Right calcaneus
inferior view

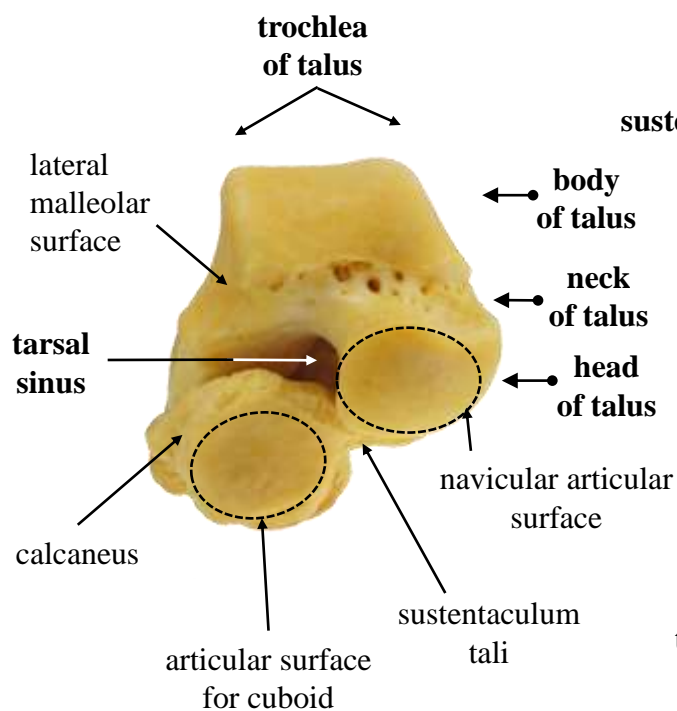


Fig. 53
Right talus and calcaneus
anterior view

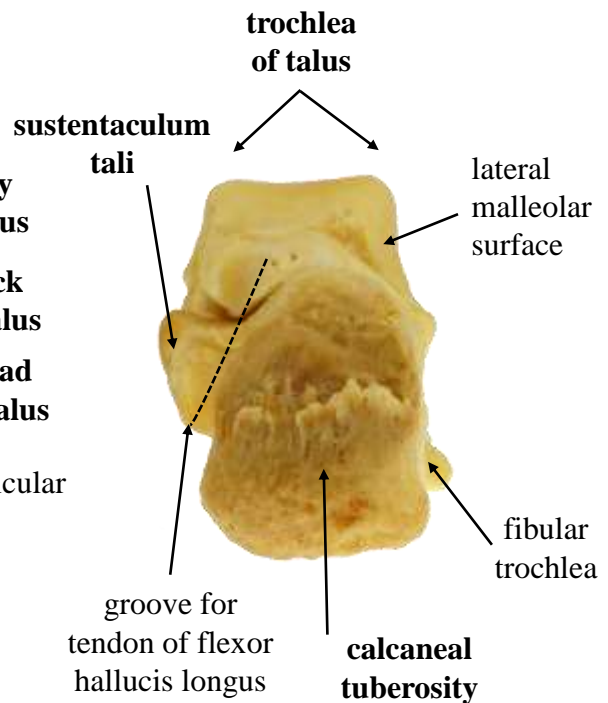


Fig. 54
Right talus and calcaneus
posterior view

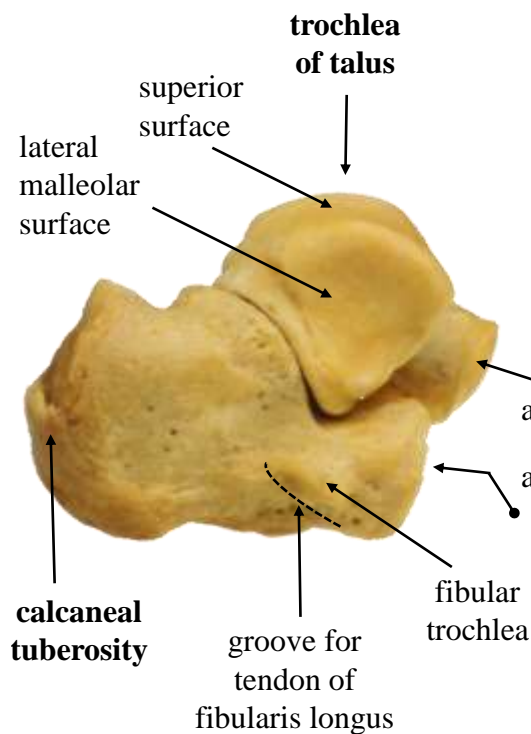


Fig. 55
Right talus and calcaneus
lateral view

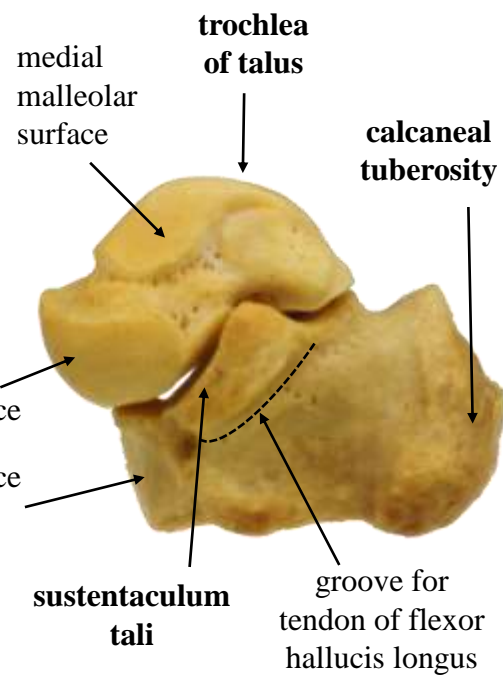


Fig. 56
Right talus and calcaneus
medial view

NAVICULAR BONE

The intermediate group of tarsal bones consists of a flattened, boat-shaped **navicular** bone. Posteriorly (proximally) it articulates with the head of talus. Anteriorly (distally) and on the lateral side it articulates with the all tarsal bones of distal group.

CUNEIFORM BONES

Three wedge-shaped cuneiforms, the **lateral**, the smallest **intermediate** and the largest **medial cuneiform bones** articulate posteriorly with navicular bone, anteriorly with three medial metatarsal bones. Furthermore, they articulate with each other. The lateral cuneiform bone also articulates with cuboid bone.

Navicular and medial cuneiform bones give attachment to *tibialis posterior muscle* and medial cuneiform serves as a place for insertion of *tibialis anterior* and *fibularis longus muscle*.

CUBOID BONE

Cuboid bone is approximately cubical in shape and is the most lateral tarsal bone of the distal group. It is interposed between calcaneus and metatarsal bones IV – V.

METARSAL BONES

Metatarsal bones together form **metatarsus**. They are five miniature long metatarsal bones. They are numbered I – V from the medial to lateral side of the foot. Each metatarsal bone is related to one digit – **metatarsal I** is associated with the great toe. **Metatarsals II – V** are associated with the corresponding toes II - V. Each metatarsal bone is composed of three parts:

- **base** – the larger proximal end;
- **shaft** – an elongate midportion, that is concave below;
- **head** – distal end.

The **bases** of the metatarsal bones articulate proximally with cuboid and three cuneiform bones. The **heads** articulate distally with the bases of their corresponding proximal phalanges. The plantar surface of the head of the metatarsal I also articulates with two sesamoid bones. In addition, the sides of the bases of metatarsals II to V articulate with each other.

- **The first metatarsal** plays an important role in supporting the weight of the body. It is the shortest and the thickest of all metatarsals. It has a large head. It serves as a place for insertion of *tibialis anterior* and *fibularis longus muscles*.
- **The second metatarsal** is the longest because fits backwards between lateral and medial cuneiform bones which are located more forward than intermediate cuneiform bone.
- **The fifth metatarsal** has on the lateral side of its base a prominent **tuberosity**, which is easily palpable through the skin on the lateral border of the foot. Tuberosity of the fifth metatarsal bone is attachment site for *fibularis brevis muscle*. The base of metatarsal V gives attachment to *fibularis tertius* and *flexor digiti minimi brevis muscles*.

Other muscles which originate from the metatarsal bones are *adductor hallucis*, *dorsal* and *plantar interossei muscles*

PHALANGES

There are miniature long bones that form the toes (digital bones of the foot). Their size is reduced. The great toe (hallux *in Latin terminology*) has a proximal and distal phalanx, while the rest of the digits have proximal, middle and distal phalanges. Each phalanx has:

- **base** – proximal end with a concave articular surface;
 - **shaft**;
 - **head** – distal end.
- **Proximal phalanx** – its base articulates with the head of related metatarsal bone.
 - **Middle phalanx**
 - **Distal phalanx** – its head is nonarticular and is marked by a roughened area – **plantar tuberosity** located on its inferior aspect.

The phalanges give insertion to numerous muscles; the extensors are inserted onto dorsal side (back) of the foot and the flexors onto plantar side (sole) of the foot:

PHALANX	INSERTION OF MUSCLE
Proximal phalanx of the great toe	<i>Extensor hallucis brevis</i> <i>Flexor hallucis brevis</i> <i>Adductor hallucis</i> <i>Abductor hallucis</i>
Proximal phalanges of the II – V toes	<i>Abductor digiti minimi</i> (onto toe V) <i>Flexor digiti minimi brevis</i> (onto toe V) <i>Dorsal interossei</i> (onto toes II – IV) via dorsal digital expansion <i>Plantar interossei</i> (onto toes III – V) via dorsal digital expansion
Middle phalanges	<i>Extensor digitorum longus</i> via dorsal digital expansion <i>Extensor digitorum brevis</i> via dorsal digital expansion <i>Flexor digitorum brevis</i> (onto toes II – V) <i>lumbricals</i> via dorsal digital expansion
Distal phalanx of the great toe	<i>Extensor hallucis longus</i> <i>Flexor hallucis longus</i>
Distal phalanges of the II – V toes	<i>Extensor digitorum longus</i> via dorsal digital expansion <i>Extensor digitorum brevis</i> via dorsal digital expansion <i>Flexor digitorum longus</i> (onto toes II – V) <i>Lumbricals</i> via dorsal digital expansion

Tab. 3
Overview of the insertion of the muscles to the phalanges of the foot

SESAMOID BONES OF THE FOOT

Generally, the sesamoid bones are embedded within the muscles or their tendons or ligaments. These small round bones protect the tendons from stress and wear.

Sesamoid bones of the foot are related to some of the metatarsophalangeal or interphalangeal joints. They are often found inferior to the head of the first metatarsal bone on the either side of the tendon of *flexor hallucis longus* or *flexor hallucis brevis* muscles.

Clinical column

- *The fractures of the bones of the foot usually occur as a result of direct trauma, e.g. when the heavy object droops onto the foot or due to the motor vehicle accident and the bones can break into several pieces. The fractures of the calcaneus are caused usually by careless fall from the height onto the hill.*
- *The fractures of the neck of the talus can be associated with interruption of blood supply that leads to the osteonecrosis.*
- *Complications can arise when the fractures involve disruption of the subtalar joint.*

- *Specific for the bones of the lower limb are stress fractures, that include fractures of the shaft of tibia (is the commonest), other common sites involve the metatarsals (mainly little toe), femoral neck, navicular bone, fibula, medial malleolus, calcaneus and sesamoid bones of great toe. Stress fractures are caused by the excessive and repetitive overloading and chronic mechanical fatigue of the bones in which the remodeling of the bone is not sufficient and bone resorption is more dominant. Stress fractures are typical in sport.*

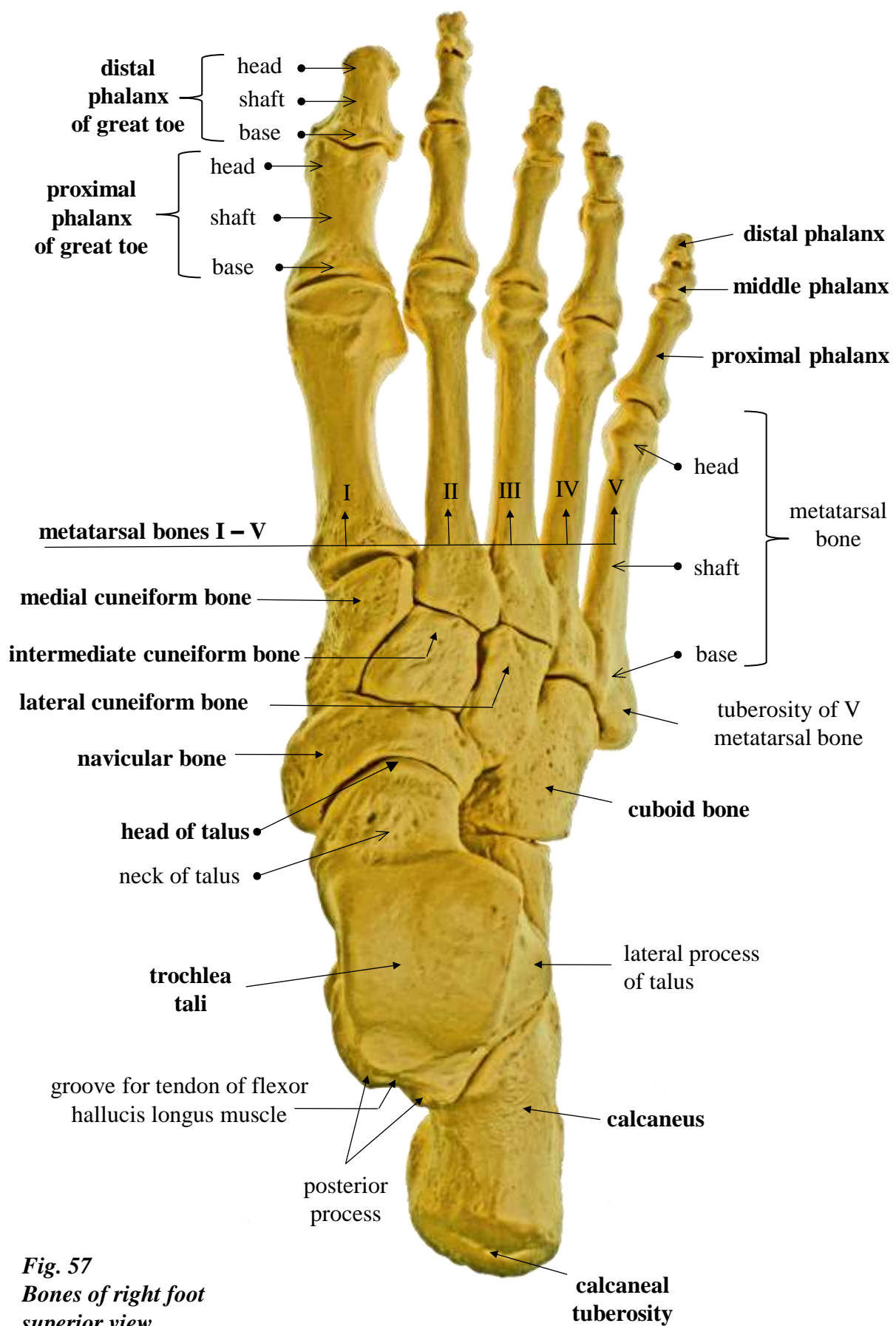


Fig. 57
Bones of right foot
superior view



Fig. 57
Bones of right foot
inferior view

SHORT INTRODUCTION TO ARTHROLOGY (SYNDESMOLOGY)

Joints are usually defined as the sites where two or more bones meet together or articulate. Function of the joint significantly determines its morphological structure and the presence of the soft tissue accessories.

The general classification subdivides the joints to **solid joints and synovial joints**.

SOLID JOINTS

Solid joints are the joints where the adjacent surfaces of the bones are connected by the intervening connective tissue, cartilage or fibrous tissue. There is no articular cavity between the articulating surfaces of the bones.

These joints are much less moveable than the synovial joints or they allow no or only minimal movement. Main types of the **solid joints** you can find in the following table.

Type of the solid joint	Subtype	Example at the upper and lower limb
Cartilaginous joint	synchondrosis - connection by hyaline cartilage	ilium, pubis and ischium in infancy
	symphysis - connection fibrous cartilage	pubic symphysis
Fibrous joint	suture	none at the limbs
	gomphosis	none at the limbs
	syndesmosis	interosseous membrane at the forearm and leg, tibiofibular syndesmosis
Osseous joint		ilium, pubis and ischium in adulthood

Tab. 3

Solid joints

SYNOVIAL JOINTS

Synovial joints are defined as the joints where articulating surfaces of the bones are separated by the **articular cavity**.

The bones are covered by periosteum, however, articular surfaces of the bones are covered by the **articular cartilage** - usually hyaline, in some joints fibrous cartilage. The articular cartilage contains neither vessels nor nerves. It is supplied from the synovial fluid and from the underlying bone.

Each synovial joint is enclosed by the **articular capsule** consisting of two layers, **fibrous and synovial membrane**. Externally there is a **fibrous membrane (fibrous stratum)**, internally **synovial membrane (synovial stratum)**. **Fibrous membrane** is formed by the dense connective tissue. Its thickened parts form capsular ligaments. It attaches to the areas near the periphery of articular surfaces, sometimes, especially in large joints, it can extend further away from the articular surfaces. **Synovial membrane** covers the structures in articular cavity, except the articular cartilages, discs and menisci.

Inside the articular cavity there is a **synovial fluid (synovia)** secreted by synovial membrane. It lubricates and nourishes the articular cartilages. Synovia is also contained in synovial bursae and synovial tendon sheaths. In many joints there are the **fat pads** inside the synovial membrane (e.g. elbow joint, knee joint) which have mechanical protective function.

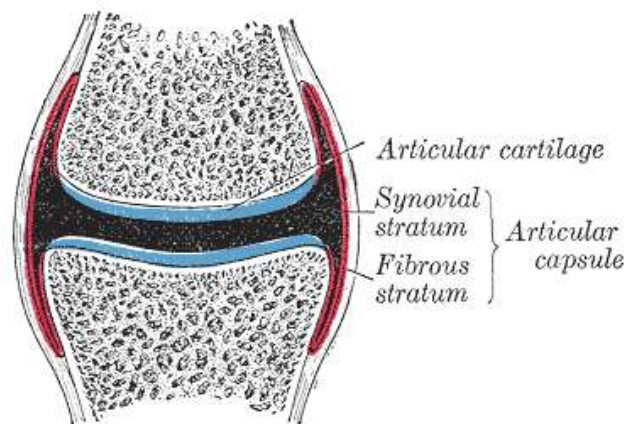


Fig. 58

Schema of the synovial joint

Retrieved from public domein Gray's Anatomy of human Body (1918) at Bartleby.com

Synovial membrane forms peripheral protrusions, **synovial bursae**, around some joints. **Synovial bursae** are pillows made by synovial membrane and filled by synovial fluid. They

are situated in the sites of the pressure and friction, e.g. between the muscle tendons and bones, muscle tendons and articular capsule or between the bones and articular capsule.

Some joints contain special accessories, **articular discs or menisci**, inserted between articulating bones. These fibrocartilaginous structures correct irregularities and compensate discrepancies between the articulating surfaces.

Each joint is stabilized by the **accessory ligaments**. They prevent the joint from excessive or abnormal movements. **Extraarticular ligaments** pass outside the joint and strengthen the articular capsule (e.g. collateral ligaments). **Intraarticular ligaments** run inside the articular cavity (e.g. cruciate ligaments in the knee joint, ligament of the femoral head).

According to the number of articulating bones or presence of the accessory articular discs or menisci, the joints are usually subdivided to:

- **simple joints** – consisting of two articulating bones
- **compound joints** – consisting of three or more articulating bones or contain articular disc or meniscus.

Classification in table 5 characterizes the type of synovial joint according to the shape (configuration) of articulating surfaces and permitted movements.

	type of the joint	movements	example
uniaxial joints	HINGE JOINT	flexion, extension	interphalangeal joint, ankle joint
	PIVOT JOINT	rotation	proximal and distal radioulnar joint
uniaxial joint with limited rotation	BICONDYLAR JOINT	flexion, extension, in flexion rotation	knee joint
biaxial joints	ELLIPSOID JOINT	flexion, extension, abduction, adduction, circumduction	radiocarpal (wrist) joint
	SADDLE JOINT	flexion, extension, abduction, adduction (limited rotation)	carpometacarpal joint of the thumb
multiaxial joints	PLANE JOINT	gliding movements in all directions	shoulder joint coxal (hip) joint
	BALL –AND– SOCKET JOINT	flexion, extension, abduction, adduction, rotation, circumduction	intertarsal joints intercarpal joints

Tab. 5

Classification of the joints according to the shape of articulating surfaces



HINGE JOINT



BALL-AND-SOCKET JOINT



PIVOT JOINT



PLANE JOINT



SADDLE JOINT



ELLIPSOID JOINT

Fig. 59

Type of synovial joint according the shape (configuration) of articulating surfaces and permitted movements

JOINTS OF THE UPPER LIMB

STERNOCLAVICULAR JOINT

Sternoclavicular joint is a **compound synovial joint** which connects the upper limb to the axial skeleton.

Sternal facet - the **articular surface** of the **sternal end of clavicle** articulates with the **clavicular notch** at the manubrium of sternum and partially with the upper margin of the first rib costal cartilage. Both articular surfaces are covered by fibrocartilage. The articular surface of the clavicle is much larger than the clavicular notch, so these two articular surfaces are not completely compatible. Therefore there is a fibrocartilaginous **articular disc** adjusting the incongruity of articular surfaces. The articular disc is flat, peripherally and dorsocranially thickened, and its circumference is firmly attached to the articular capsule, inferiorly to the costal cartilage of the first rib. Thus the articular cavity of the sternoclavicular joint is completely divided by the cartilaginous disc.

The **articular surfaces are almost plane**, although the sternal end of the clavicle is slightly convex and the clavicular notch is slightly concave. The sternoclavicular joint is usually classified as a **plane joint**, however occasionally it can be classified as a saddle or ball and socket joint.

The **articular capsule** is short and very strong, more lax around the clavicle, strengthened with the **anterior and posterior sternoclavicular ligament**. The ends of the clavicles are interconnected by the **interclavicular ligament** which passes across the jugular notch. The sternal end of the clavicle is connected to the first rib by the **costoclavicular ligament**.

This joint allows **limited gliding movement in all directions combined with the movements of the acromioclavicular and shoulder joint**.

Clinical column

Luxation of the sternoclavicular joint is very rare because of the strong articular capsule and surrounding accessory ligaments. Anterior luxations are more often than the posterior ones. Posterior luxation of sternoclavicular joint can cause injuries of the vessels of the neck and trachea.

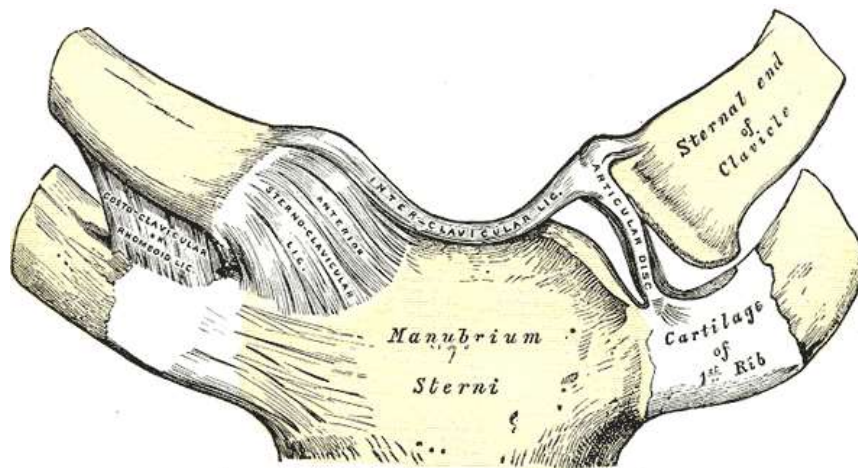


Fig. 60

Sternoclavicular joints

anterior view

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ACROMIOCLAVICULAR JOINT

Acromioclavicular joint is a **plane synovial joint** connecting scapula and clavicle.

The **articular surface** of the **acromion - clavicular surface (facet)** articulates with the articular surface of the **acromial end of clavicle - acromial surface (facet)**. Both articular surfaces are covered by fibrocartilage.

The articular cavity can be incompletely subdivided by the **articular disc** which is attached to the articular capsule superiorly.

The **articular capsule** is strengthened by the **acromioclavicular ligament** superiorly.

This joint performs only **passive and limited gliding movements** like coaction to the movements in sternoclavicular joint and shoulder joint. Furthermore, the movements between the clavicle and scapula are limited by the ligaments.

Coracoclavicular ligament connects the coracoid process of the scapula and coracoid tuberosity. It consists of two parts:

- **trapezoid ligament** - situated anteriorly and running from the coracoid process to the trapezoid line
- **conoid ligament** situated posteriorly and passing from the coracoid process to the conoid tubercle.

Coracoclavicular ligament maintains the clavicle and acromion in juxtaposition.

Coracoacromial ligament (fornix humeri) is situated above the shoulder joint between the coracoid process and acromion of the scapula. It limits the abduction of the arm to the horizontal plane, the abduction above the horizontal plane is possible only with the rotation of the scapula.

Transverse scapular ligament fills the scapular notch into the foramen which is traversed by the suprascapular nerve. Occasionally this ligament ossifies and can press the nerve.

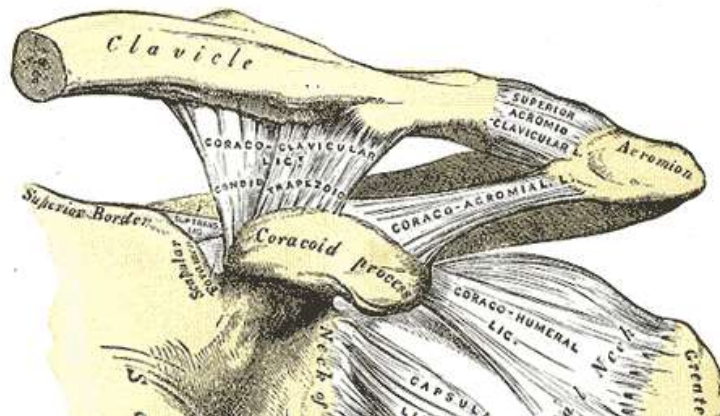


Fig. 61

Left coracoclavicular joint

anterior view

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PECTORAL GIRDLE MOVEMENTS

Movements of the pectoral girdle include movements in sternoclavicular and acromioclavicular joints which are associated with the movements of the scapula and usually accompanied by the movements in shoulder joint.

The **scapular movement** medially to the vertebral column is **retraction** of the scapula, movement lateroventrally from the vertebral column is **protraction** of the scapula. **Elevation and depression** is the movement upwards and downwards. **Rotation** of the scapula increases the range of the abduction in shoulder joint above the horizontal plane. Lateral or upward rotation is the movement of the inferior angle superolaterally and medial rotation is movement medially and inferiorly usually effected by gravity.

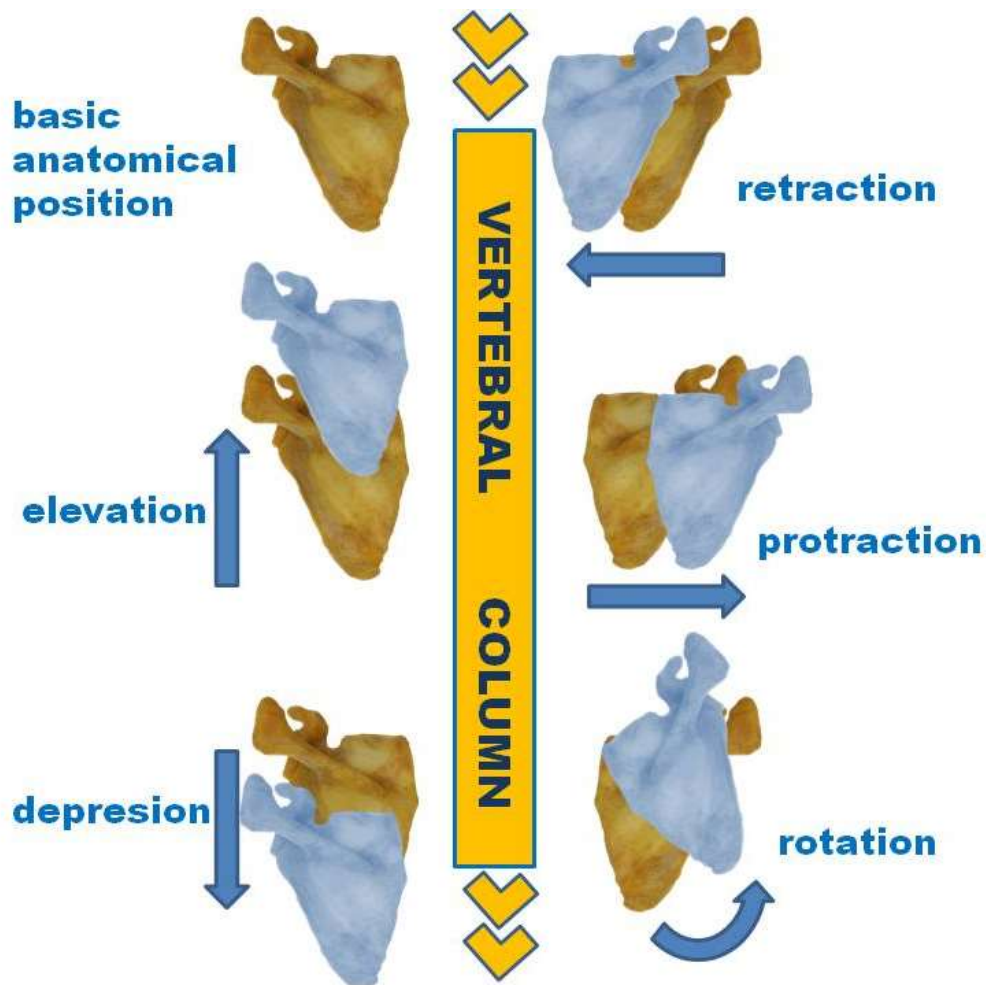


Fig. 62

Movements of the scapula

SHOULDER JOINT

The **shoulder** or **glenohumeral joint** is a **multiaxial ball - and socket synovial joint**.

Spheroid **head of humerus** articulates with slightly concave **glenoid cavity** at the scapula. Both articular surfaces are lined by the hyaline articular cartilage. Glenoid cavity is enlarged and deepened by the fibrocartilaginous rim - **glenoid labrum**.

The **articular capsule** of the shoulder joint extends from the neck of the scapula (glenoid neck – outside the glenoid labrum) to the anatomical neck of the humerus, except the medial side, where it reaches more distally, almost to the surgical neck of humerus.

The articular capsule is lax what is necessary for the wide range of the movements. The joint is strengthened by the accessory ligaments and by the tendons of the muscles as well.

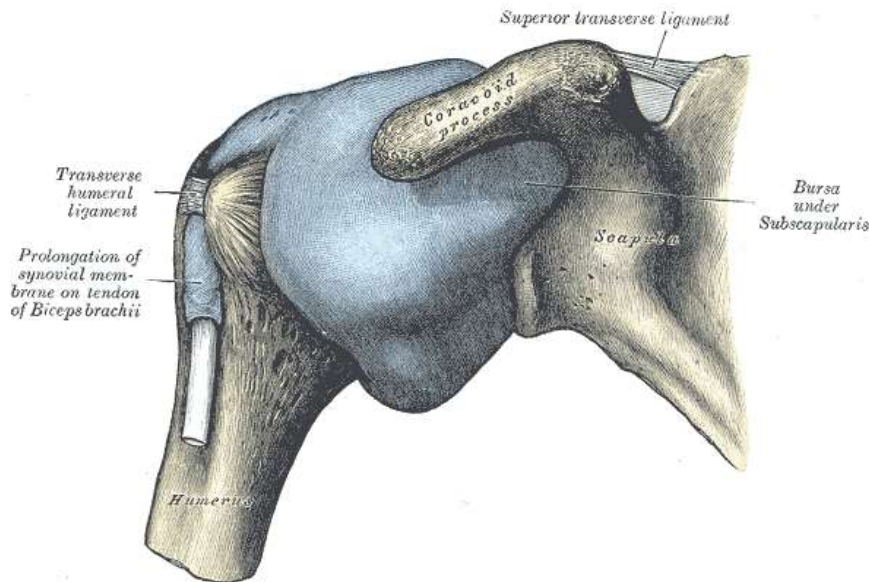


Fig.63

**Right shoulder joint
anterior view**

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Anteriorly, immediately outside the articular capsule there are **superior, middle and inferior glenohumeral ligaments**.

Coracohumeral ligament extends from the coracoid process to the greater tubercle of humerus. **Coracoacromial ligament** passes above the shoulder joint between the coracoid process and acromion of the scapula.

Tendons of supraspinatus, infraspinatus and teres minor run around the joint proximodorsally, the tendon of subscapularis muscle passes ventrally.

The articular capsule, ligaments and mentioned tendons together form **rotator cuff**, responsible for the stability of the joints during the movements.

Around the shoulder joint there are numerous **protrusions of synovial membrane - synovial bursae**. They are situated especially in the sites of the pressure or friction between the tendons and articular capsule (e.g. *subdeltoid bursa*, *subscapular subtendineous bursa*,

infraspinatus subtendineous bursa), between the bone and articular capsule (e.g. *subacromial bursa*) or between the bone and the tendon (e.g. *coracobrachialis bursa*).

Shoulder joint is the most moveable **joint** in the human body. It allows **flexion**, **extension (dorsal flexion)**, **abduction**, **adduction**, **medial rotation (pronation)**, **lateral rotation rotation (supination)**. **Circumduction** is a combination of flexion, abduction, extension and adduction.

The **tendon of the long head of biceps brachii muscle** arise from the supraglenoid tubercle, **runs through the articular cavity of the shoulder joint** and continues to the intertubercular sulcus. Synovial membrane envelopes the tendon of long head of biceps brachii muscle forming **synovial sheath** in its course in intertubercular sulcus. Moreover, the tendon is fixed within the intertubercular sulcus by the **transverse humeral ligament** passing between the greater and lesser tubercles.

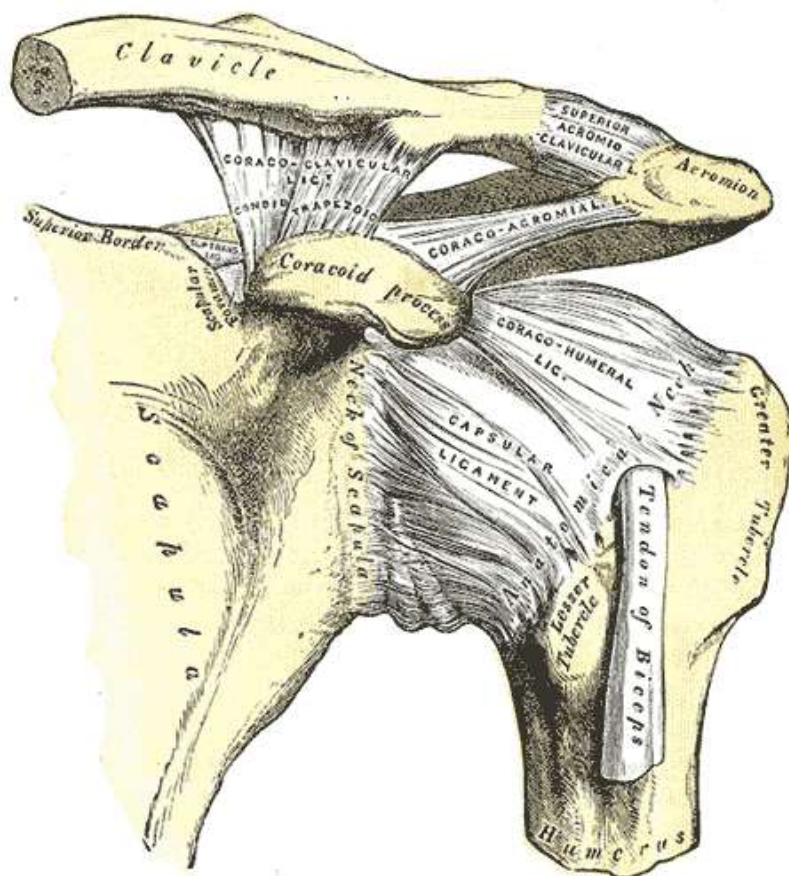


Fig. 64

Left shoulder joint

anterior view

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**flexion (ventral flexion)
in the right shoulder joint**



**extension (dorsal flexion)
in the right shoulder joint**



**abduction
in the right shoulder joint**



**adduction and hyperadduction
in the right shoulder joint**

Fig. 65
Movements in the shoulder joint

Clinical column

- *The shoulder joint is the most moveable joint in human body and the most often luxated (dislocated) joint in human body. Luxation of the shoulder joint is usually result of trauma. Because the articular capsule of the shoulder joint is thinnest ventrally and inferiorly, 96% of all luxations are ventral luxations when the head of humerus is dislocated anteriorly and below the coracoid process. Rarely the axillary or posterior luxations occur.*
- *Ruptures or destructions of the rotator cuff are usually result of degenerative changes, occasionally it can be caused by trauma.*

ELBOW JOINT

The elbow joint is a **compound synovial joint** where three bones - humerus, ulna and radius articulate. It consists of three parts:

- **humeroulnar joint**
- **humeroradial joint**
- **proximal radioulnar joint**

In **humeroulnar joint** the **articular surface** at the medial condyle of humerus, **humeral trochlea**, articulates with the **trochlear notch** at the proximal end of ulna. It is a typical uniaxial **hinge joint**.

The **capitulum of humerus** and superior slightly concave surface at the radial head, **articular facet (fovea)**, form the **humeroradial joint**. Although according the shape of the articular surfaces it is a ball and socket joint, its moveability is limited by the uniaxial humeroulnar joint.

Proximal radioulnar joint is an uniaxial **pivot joint**, where the **articular circumference at the radial head** rotates in the **radial notch** at the proximal end of ulna.

All three joints are enclosed by one articular capsule and form one articular cavity. The **articular capsule** is attached above the coronoid and radial fossa at the ventral aspect of humerus, to the upper margin of olecranon fossa at the dorsal side of humerus. Distally it extends to the coronoid process of ulna and the neck of radius. Medial and lateral epicondyles of humerus are not enclosed by the articular capsule, they stay free for the muscle attachments.

Synovial membrane forms a thin walled protrusion, **sacciform recess**, below the anular ligament of radius. Around the elbow joint, especially at the dorsal aspect of the joint, there are numerous **synovial bursae**. They are predominantly situated around the tendon of triceps brachii muscle: between the tendon and the skin (*subcutaneous olecranon bursa*), between the triceps tendon and articular capsule, or between the triceps tendon and the periosteum of olecranon. Some synovial bursae are situated ventrally, mainly between the tendon of biceps brachii muscle and radial tuberosity or around the epicondyles of humerus.

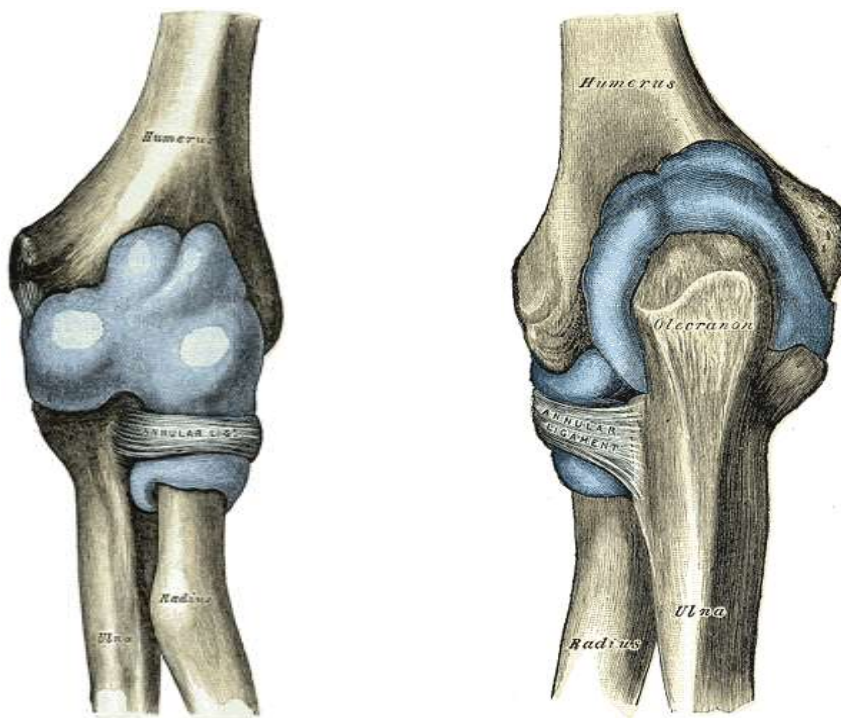


Fig. 66

Left elbow joint

anterior and posterior view

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The elbow joint is stabilized by the **radial and ulnar collateral ligaments** running from the epicondyles of humerus along the lateral and medial side of the joint. **Anular ligament of radius** forms a ring or shallow cup around the head and neck of radius. It is attached to the ulna and fused with the radial collateral ligament.

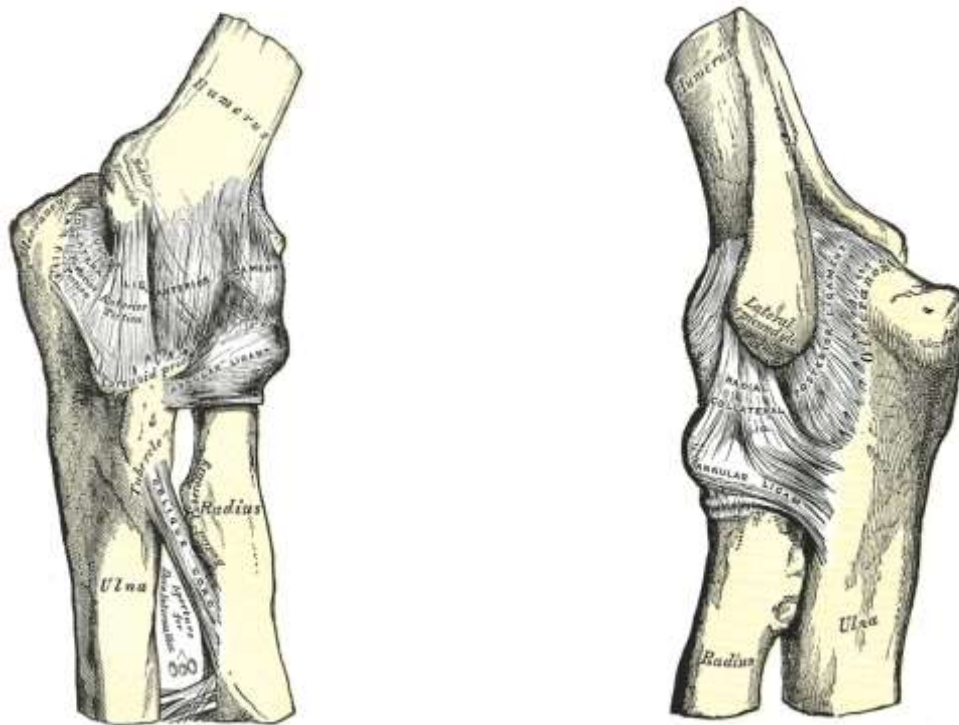


Fig. 67

Left elbow joint

anterior and posterior view

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In humeroulnar and humeroradial joint only **flexion** and **extension** can be performed. During the full flexion the coronoid process of the ulna enters the coronoid fossa above the humeral trochlea and the radius enters the radial fossa above the humeral capitulum. In full extension the olecranon of the ulna fits into the olecranon fossa. All mentioned fossae - coronoid, radial and olecranon have special arrangement of the articular capsule which covers them. In these sites the external or fibrous layer and internal or synovial layer of articular capsule are separated by the small amount of the fatty tissue. The fat pads fill the fossae instead of the bony processes, however, when the olecranon of ulna moves to the olecranon fossa or coronoid process moves to the coronoid fossa, fat pads are relocated out from the fossae because the triceps brachii muscle and brachialis muscle pull the articular capsule during their contraction.

The movements in proximal radioulnar joint are combined with the movements in distal radioulnar joint. These joints allow the rotation of radius along its long axis - **pronation** (medial rotation) and **supination** (lateral rotation).



**extension
in the right elbow joint
supination of the forearm**



**flexion
in the right elbow joint
supination of the forearm**



**flexion
in the right elbow joint
pronation of the forearm**



**supination of the right forearm
extension in the right elbow joint**



**pronation of the right forearm
extension in the right elbow joint**

Fig. 68

Movements in the elbow joint

Clinical column

- *Luxations of the elbow joint in humeroulnar and humeroradial parts are very rare because the collateral ligaments are strong and furthermore the articular surfaces of the participating bones interlock closely.*
- *However luxation or subluxation of the radial head from the anular ligament of radius is very often in children younger than 5 years. The head of radius is not fully developed and the anular ligament of radius is very lax in these children, thus the head of radius can be very easily dislocated from the cuff of anular ligament. This luxation occurs when the child's forearm and hand are extended and in pronation and the hand is intensively pulled up e.g. by mother or nurse. That's why this luxation is called „nurse elbow“.*

INTEROSSEOUS MEMBRANE OF THE FOREARM

Interosseal border of the ulna and radius are also connected by a **fibrous joint, the interosseous membrane of the forearm**. This membrane is strong and flexible. It is formed by the collagenous bands running obliquely from the radius distally to the ulna. Some bands run with opposite direction and they form chorda obliqua. The openings for the vessels and nerves which supply the anterior and posterior compartments of the forearm are visible at the proximal and distal portion of the interosseous membrane.

Interosseous membrane does not affect the pronation and supination of the forearm, however, it **prevents the bones from the mutual vertical shift** (dislocation).

DISTAL RADIOULNAR JOINT

Distal ends of ulna and radius articulate in **distal radioulnar joint**. It is an **uniaxial pivot synovial joint**.

At the **head of ulna** there is an **articular circumference** which connects with the **ulnar notch at the distal end of radius**.

Below the ulnar head there is an triangular **articular disc** which is attached to the radius and ulnar styloid. It holds the ulna and radius together and separates the distal radioulnar joint from radiocarpal joint.

The articular capsule of the distal radioulnar joint is lax, allowing rotation of the radius around the articular circumference at the ulnar head. Synovial membrane anteriorly extends more proximally forming the **sacciform recess** in front of the interosseous membrane.

The movements in distal radioulnar joint are **pronation (medial rotation)** and **supination (lateral rotation)**, both associated with the movements in proximal radioulnar joint which is a part of the elbow joint.

RADIOCARPAL JOINT (WRIST JOINT)

Radiocarpal joint is a **compound synovial joint** between the distal end of radius, articular disc and three carpal bones - scaphoid, lunate and triquetral.

Carpal articular surface of radius and articular disc form the proximal concave articular surface. Triangular fibrocartilaginous articular disc separates the ulnar head from the articular cavity of the wrist joint. Distal convex articular surface is formed by the **scaphoid, lunate and triquetral bone**. According to the shape of articular surfaces **the radiocarpal joint** is classified as the **ellipsoid joint**.

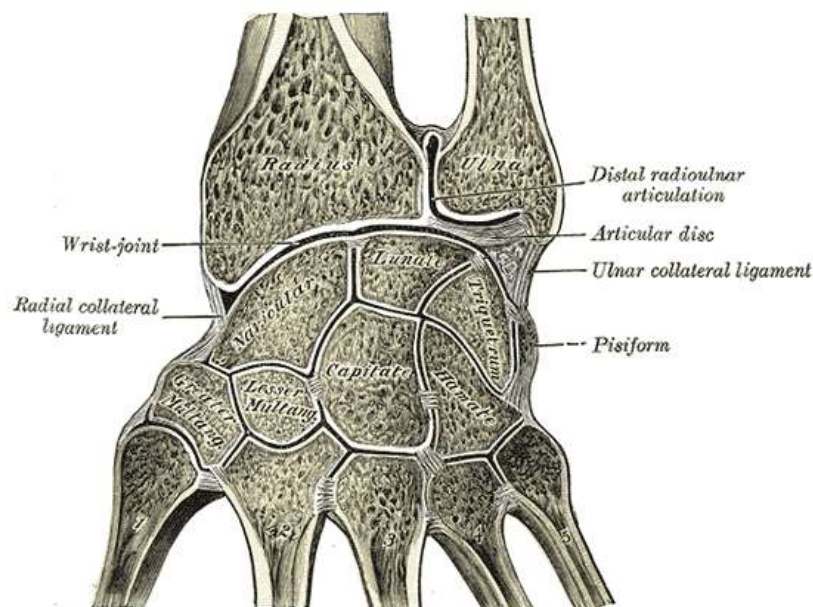


Fig. 69

Right wrist joint in cross-section

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This biaxial joint allows **flexion, extension, abduction (radial duction)** and **adduction (ulnar duction)**. **Circumduction** is the combination of all previously mentioned movements.

The articular capsule is strengthened by the **palmar** and **dorsal radiocarpal ligaments** and by the sides by **ulnar** and **radial collateral ligaments**.

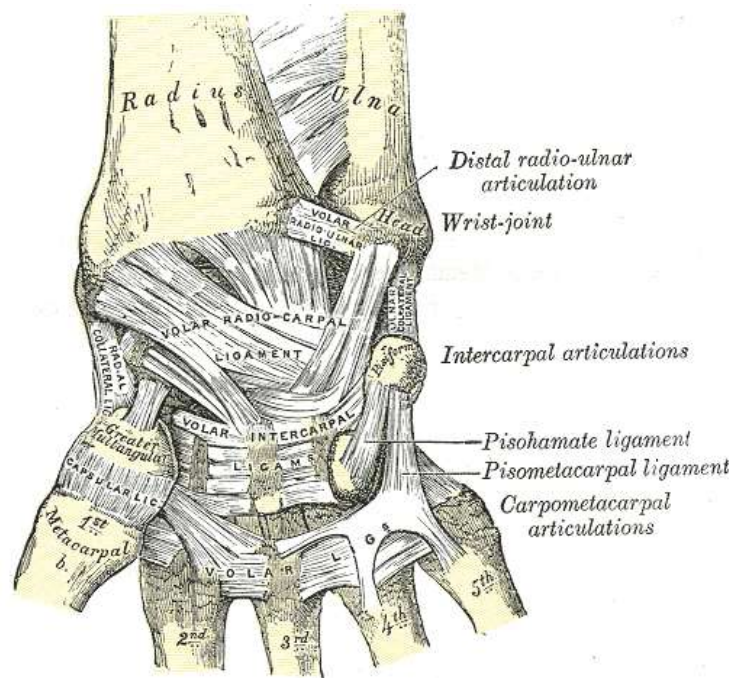


Fig. 70
Right wrist
palmar (anterior) view

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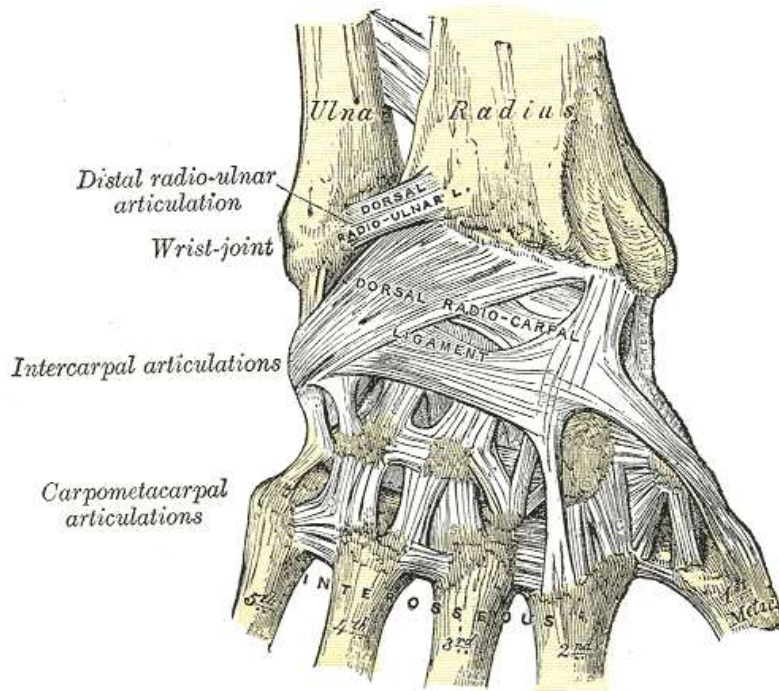


Fig. 71
Right wrist
dorsal (posterior) view

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**flexion (palmar flexion)
in the right wrist joint**



**extension (dorsal flexion)
in the right wrist joint**



**radial duction (lateral duction or
abduction) in the right wrist joint**



**ulnar duction (medial duction or
adduction) in the right wrist joint**

Fig. 72
Movements in the radiocarpal (wrist) joint

MIDCARPAL JOINT, INTERCARPAL JOINTS AND CARPOMETACARPAL JOINTS

The carpal bones in proximal row articulate with the bones in the distal row in a compound synovial midcarpal joint.

The articular cavity is narrow and transversely S – shaped. At the radial side, proximally there is a convex articular surface formed by the scaphoid bone which articulates with the concave articular surface formed by the trapezium and trapezoid. At the ulnar side, proximally there is concavity formed by scaphoid, lunate and triquetral bones which join with the convex articular surface formed by the capitate and hamate.

The midcarpal joint in both its parts is classified as **a compound saddle joint**.

Intercarpal joints are plane synovial joints between the neighbouring carpal bones. **Pisiform bone** articulates only with the **triquetral bone in a plane synovial joint**.

The movements in midcarpal and intercarpal joints are limited and associated with the movements in the wrist joint.

Carpal bones in the distal row articulate with the bases of the metacarpals in **carpometacarpal joints**.

Carpometacarpal joint of the thumb is a typical **saddle synovial joint** between the trapezium and the base of the first metacarpal bone. **Flexion, extension, abduction and adduction, mild rotation and circumduction** can be performed by this joint. Combination of the flexion, adduction and rotation is **opposition of the thumb**.

The other **carpometacarpal joints** include the joints between the trapezium and the second metacarpal bone, capitate and the third metacarpal bone and hamate articulates with the fourth and the fifth metacarpals. All these joints are **plane synovial joints**. Although the carpometacarpal joints allow **flexion, extension, abduction, adduction, rotation and circumduction, however, their moveability is limited**. The most mobile is the joint between the hamate and the fifth metacarpal bone, the least mobile is the carpometacarpal joint between the trapezoid and the second metacarpal bone. The intermetacarpal joints between the bases of the metacarpals II-V are associated with carpometacarpal joints.

The **articular capsules of all above mentioned joints** are short and strong.

The joints are stabilized by the accessory ligaments: **proximal row interosseous ligaments, distal row interosseous ligaments, palmar and dorsal midcarpal ligaments**.

The carpal bones form a carpus which is dorsally convex, palmar concave. The eminences at the radial and ulnar side are bridged by the **flexor retinaculum** forming an osteofibrous canal, the **carpal tunnel**. It is traversed by the tendon of the muscles (*flexor digitorum superficialis et profundus, flexor carpi radialis, flexor pollicis longus*) and median nerve.

Clinical column

- *Luxations of the wrist joint are more often in persons with inherited hypermobility of joints. These persons can suffer from carpal instability.*
- *In excessive forced dorsal flexion of the hand the joint between lunate and capitate bone can be dislocated. Subsequently luxated lunate bone can press the median nerve.*
- *„Sprained wrist“ is very often in athletes or gymnasts like a result of the fall on an outstretched hand. In this case the dorsal ligaments and/or the dorsal aspect of the articular capsule of the wrist joint can be only stretched but also partially or completely ruptured.*

METACARPOPHALANGEAL JOINTS

The **heads of metacarpal bones** articulate with the **bases of proximal phalanges** in a **synovial ellipsoid (condyloid) joints**.

The **articular surface** of the metacarpal heads has a special shape, dorsally and distally it is almost spheroid, however, palmar it is more cylindrical. The base of the proximal phalanges is slightly concave.

The **articular capsules** are short and strengthened by the **collateral and palmar ligaments**. **Transverse metacarpal ligament** consists of three bands connecting the metacarpophalangeal joints II-V. This ligament is important for the fixation of the metacarpal heads position.

These joints allow **flexion, extension, abduction, and adduction**. However **abduction and adduction is limited in flexion**, because of the stretched collateral ligaments and the shape of articular surfaces at the metacarpal heads (in palmar aspect they are cylindrical not sphaeroid).

INTERPHALANGEAL JOINTS

The **heads of the proximal phalanges** articulate with the **bases of the middle phalanges** in **proximal interphalangeal joints**.

Similarly, the **heads of the middle phalanges** connect with the **bases of the distal phalanges** in the **distal interphalangeal joints**.

At the thumb there is only one interphalangeal joint.

The **articular surfaces of the heads** of the proximal and middle phalanges have a typical **shape like a pulley** (trochlea) and they closely interlock with the fitting articular

surfaces at the bases of the middle and distal phalanges. Thus they form a typical **uniaxial hinge joints**.

Articular capsules of interphalangeal joints are short and strengthened by the **collateral ligaments** at both side. The ventral side of the interphalangeal joint is thickened by the **palmar ligament or volar plate**.

Interphalangeal joints allow only **flexion and extension**.

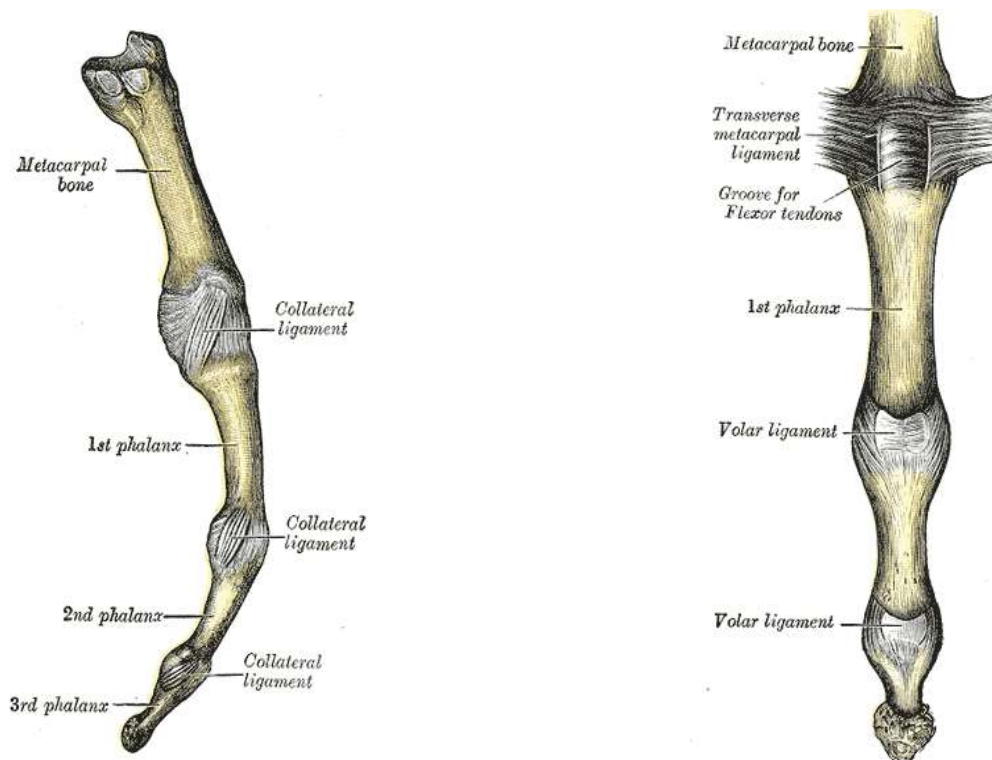


Fig. 73

Interphalangeal joints

lateral and palmar view

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Clinical column

- Distorsions and luxations of metacarpophalangeal joint are the most often at the thumb and index.
- „Mallet finger“ or „hammer finger“ is a result of the extensor tendon injury resulting in involuntary and painful flexion in distal interphalangeal joint and inability to extend it. It is caused by the strong impact on the extended distal phalanx of the finger or thumb, e. g. when a ball strikes outstretched finger.
- „Swan neck deformity“ is characterized by the hyperextension in proximal interphalangeal joint and flexion in distal interphalangeal joint. It is usually caused by the intrinsic spasmus or prolonged hammer finger.

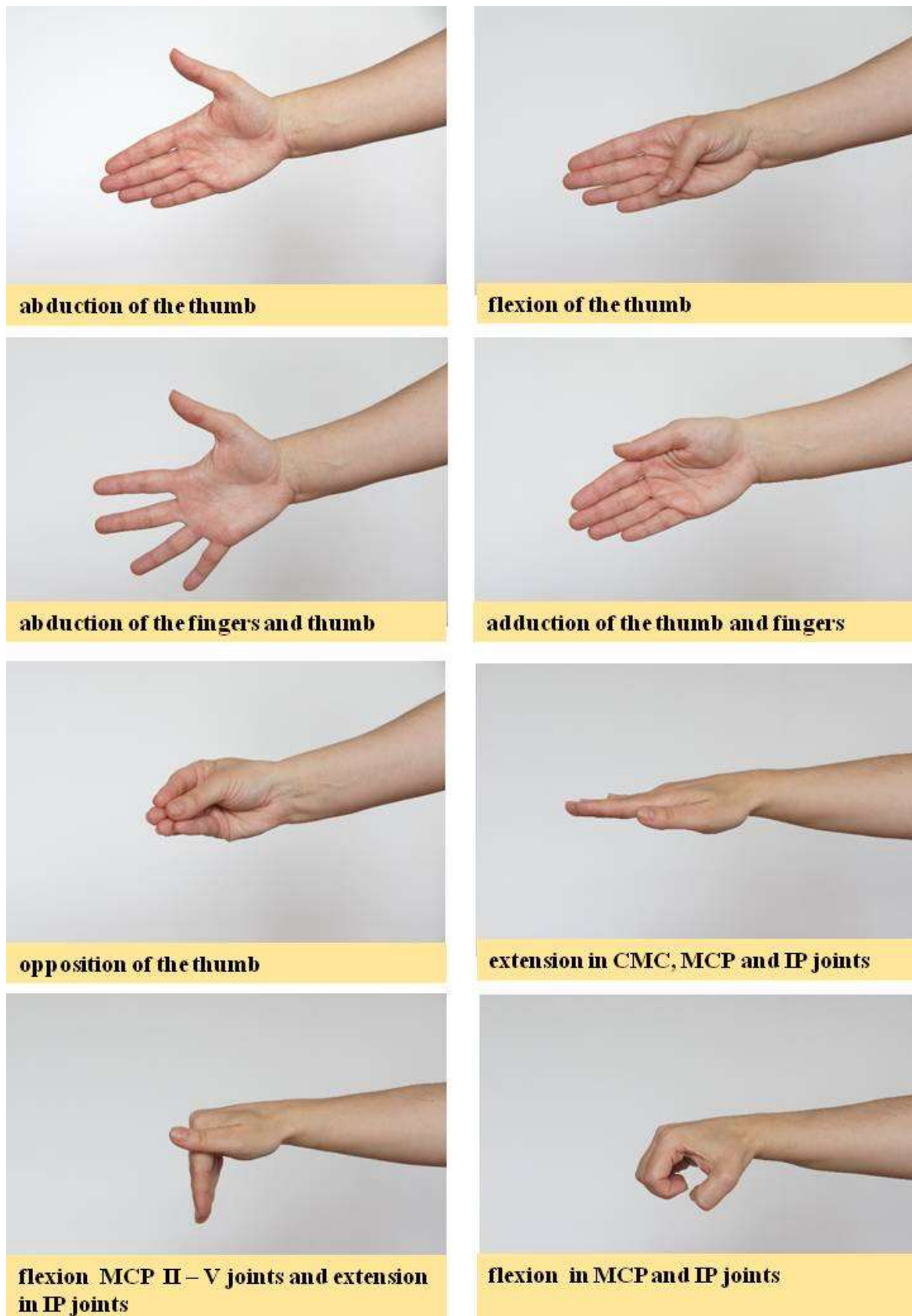


Fig. 73

Movements of the thumb and fingers

CMC – carpometacarpal, MCP – metacarpophalangeal, IP – interphalangeal

JOINTS OF THE UPPER LIMB - SUMMARY		
JOINT	ARTICULAR SURFACES	MOVEMENTS
sternoclavicular joint <i>plane synovial joint</i>	- sternal end of clavicle -clavicular notch at sternum	limited gliding movements
acromioclavicular joint <i>plane synovial joint</i>	-acromial end of clavicle -acromion of scapula	limited gliding movements
shoulder joint <i>ball-and-socket synovial joint</i>	-head of humerus -glenoid cavityenlarged by glenoid labrum	flexion, extension, abduction, adduction, rotation, circumduction
elbow joint humeroulnar joint <i>hinge synovial joint</i> ----- humeroradial joint <i>ball-and-socket synovial joint</i> ----- proximal radioulnar joint <i>pivot synovial joint</i>	-trochlea of humerus -trochlea notch ----- -capitulum of humerus -fovea at head of radius ----- -articular circumference at head of radius -radial notch at ulna	flexion, extension rotation - pronation, supination
interosseous membrane of forearm <i>fibrous joint - syndesmosis</i>	-interosseous border of ulna -interosseous border of radius	prevents the ulna and radius from the mutual vertical shift
distal radioulnar joint <i>pivot synovial joint</i>	- articular circumference at ulnar head -ulnar notch at radius	rotation - pronation, supination
radiocarpal joint <i>ellipsoid synovial joint</i>	-carpal articular surface of radius -scaphoid, lunate and triquetral bones	flexion, extension, ulnar duction, radial duction, circumduction
midcarpal joint <i>saddle synovial joint</i>	-scaphoid, lunate and triquetral bones -trapezium, trapezoi, capitate and hamate bones	only limited movements associated with movements in radiocarpal joint
intercarpal joints <i>plane synovial joints</i>	between neighbouring carpal bones	
carpometacarpal joint of the thumb <i>saddle synovial joint</i>	-trapezium -base of the first metacarpal (MTC) bone	flexion, extention, abduction, adduction, rotation, circumduction and opposition
carpometacarpal joints II-V <i>plane synovial joints</i>	trapezoid – base of the MTC II capitate - base of the MTC III hamate – base of the MTC IV,V	limited flexion, extension, abduction, adduction, rotation and circumduction
metacarpophalangeal joints <i>ellipsoid synovial joints</i>	-heads of the metacarpal bones -bases of the proximal phalanges	flexion, extension, in extension - abduction and adduction
interphalangeal joints <i>hinge synovial joints</i>	-heads of phalanges (proximal, middle) -bases of phalanges (middle, distal)	flexion, extension

Tab. 5 Joints of the upper limb - summary

JOINTS OF THE LOWER LIMB

SACROILIAC JOINT

Sacroiliac joint is a **plane synovial joint**, which connects the lower limb to the axial skeleton.

The **articular surfaces, auricular surface of the hip bone and auricular surface of sacrum** are uneven and roughened, covered by the inner layer of hyaline cartilage and outer layer of the fibrous cartilage. Irregularities of articular surfaces mutually interlock and thus limit the movements.

The **articular capsule** is very strong and short, stabilized by three ligaments.

The **interosseous sacroiliac ligaments** are strongest, running from the sacral tuberosity to iliac tuberosity. The **anterior sacroiliac ligaments** thicken the articular capsule anteriorly, **posterior sacroiliac ligaments** pass behind the interosseous sacroiliac ligaments.

Sacroiliac joint allows **limited anteroposterior rotation** around horizontal axis running through the second sacral vertebra.

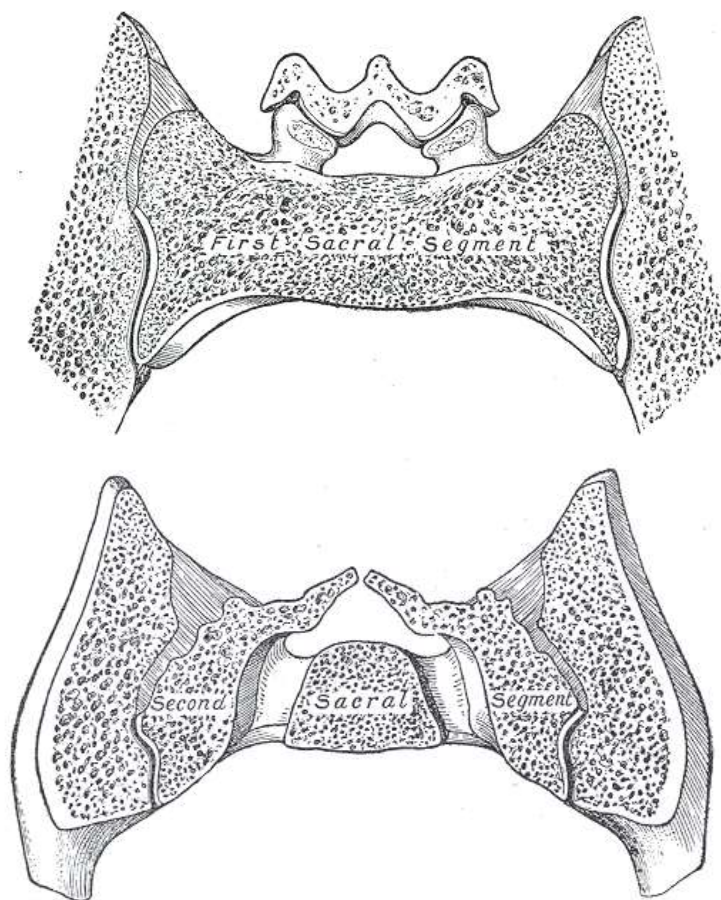


Fig. 74
Sacroiliac joint
in section
through SI and SII

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PUBIC SYMPHYSIS

Pubic bones are connected by fibrous cartilage forming a cartilaginous joint, **pubic symphysis**.

Symphysial surfaces of pubic bones are covered by hyaline cartilage and join through the **fibrocartilaginous disc**. In adulthood the disc can contain a narrow cavity in the midline.

Superior pubic ligament runs above the joint, connecting superior rami of pubic bones. **Inferior pubic ligament (arcuate pubic ligament)** is much stronger and runs along the pubic arch attaching to the inferior pubic rami.

Pubic symphysis is very strong joint. Only slight angulation, rotation can be performed in association with the movements in sacroiliac and hip joint.

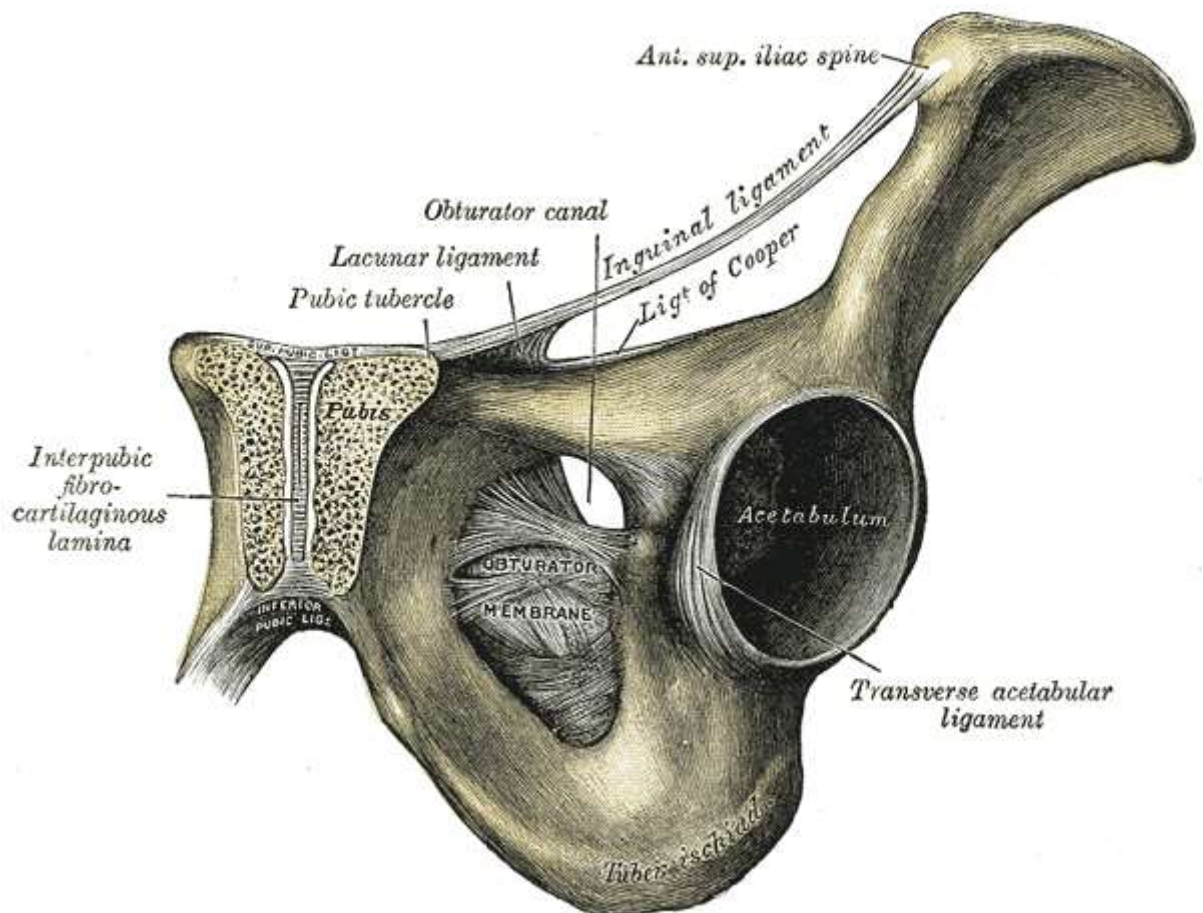


Fig. 75

***Pubic symphysis in cross-section
anterior view***

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Clinical column

- *Sacroilac joint can become fibrous or later even osseous in elderly.*
- *Pubic symphysis widens when the lower limbs are abducted excessively, that's why it is often injured in breast stroke swimmers or soccer players during overextended strike. Increased mobility and slight separation 2-3 mm in pubic symphysis can be physiologically seen during the third trimester of pregnancy and during the childbirth. It is caused by the hormonal stimulation.*
 - *Pubic symphysis diastasis is defined as a separation larger than 10 mm or more. The incidence of the pubic symphysis diastasis is below 3% in women during and post partum (delivery). It usually results from very rapid or longlasting vaginal delivery or instrumental forceps delivery.*

LIGAMENTS OF THE PELVIS

The bony pelvis is formed by the hip bones and sacrum. These bones are connected by sacroilac joint, pubic symphysis and accessory ligaments.

Inguinal ligament is untrue ligament. It is a thickened margin of the aponeurosis of obliquus externus muscle. It runs from the anterior superior iliac spine to pubic tubercle.

Sacroteruberous ligament consists of strong bands running from the sacrum and coccyx to the ischial tuberosity.

Sacrospinous ligament passes from the sacrum and coccyx to the ischial spine. Sacrotuberal and sacrospinous ligaments and greater and lesser sciatic notches enclose **greater sciatic foramen** and **lesser sciatic foramen**. Muscles, vessels and nerves traverse these foramina. Piriformis muscle subdivides the greater sciatic foramen into the foramen suprapiriforme and foramen infrapiriforme.

Superior gluteal vessel and nerve pass through the suprapiriform foramen. Inferior gluteal vessels and nerve, sciatic nerve, posterior cutaneous femoral nerve, internal pudendal vessels and pudendal nerve exit the pelvis through the infrapiriform foramen. Pudendal nerve and internal pudendal vessels curve around the ischial spine and return back to the pelvis through the lesser sciatic foramen.

Iliolumbar ligament runs from the iliac crest to the transverse process of the 4th and the 5th lumbar vertebra.

Obturator membrane closes the obturator foramen. Superiorly it is not attached to the superior ramus of pubis in the whole length, however, around the obturator groove at the superior ramus of pubis it forms the obturator canal. The obturator membrane is the site of the

obturator internus and externus muscle origin. Obturator vessels and nerve exit the pelvis through the obturator canal and continue to the medial side of the thigh.

Terminal line separates the greater and lesser bony pelvis. It runs through the superior border of pubic symphysis, pecten of pubis, arcuate line, margin of ala and promontory. **Greater pelvis** is the space above the terminal line between the alae of ilium. **Lesser pelvis** is below the terminal line, bordered by sacrum, ischium, pubis and obturator membrane.

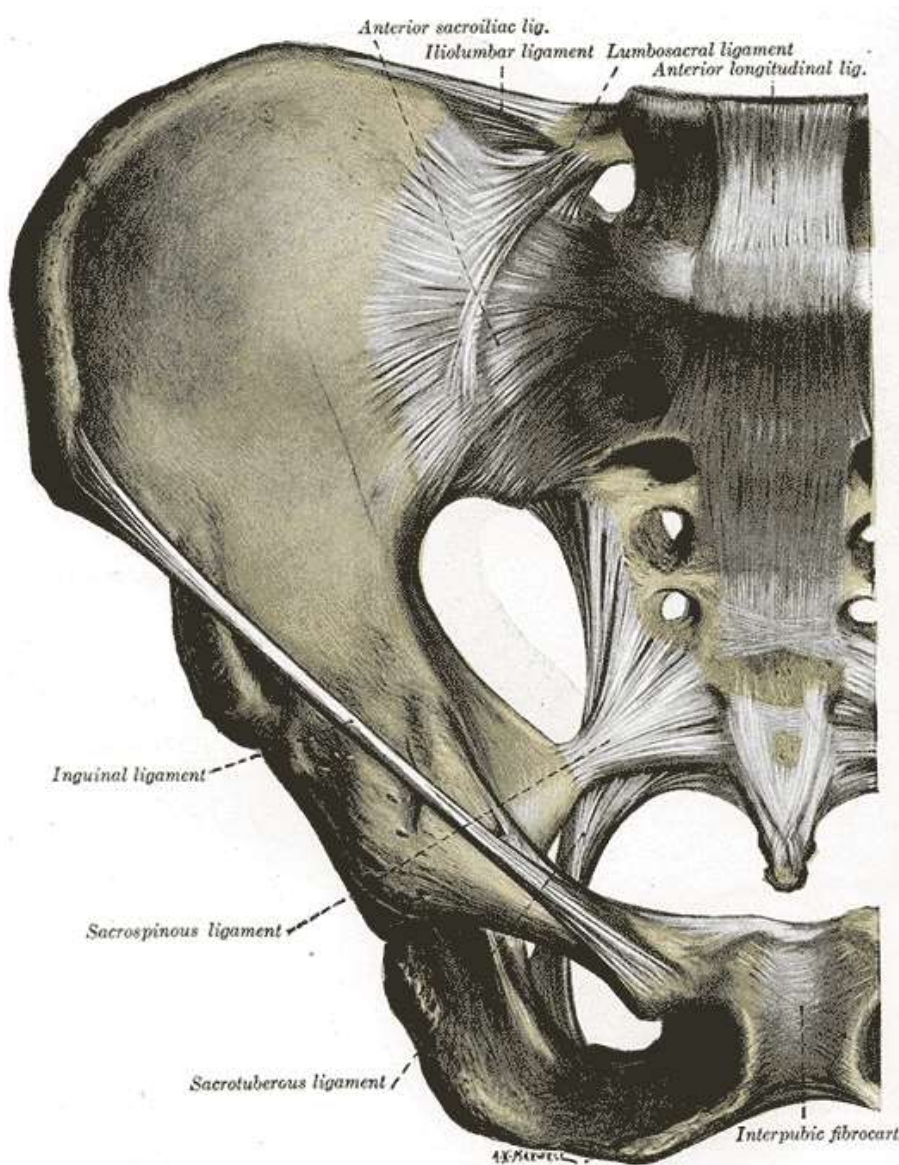


Fig. 76

***Right side of the bony pelvis with ligaments
anterior view***

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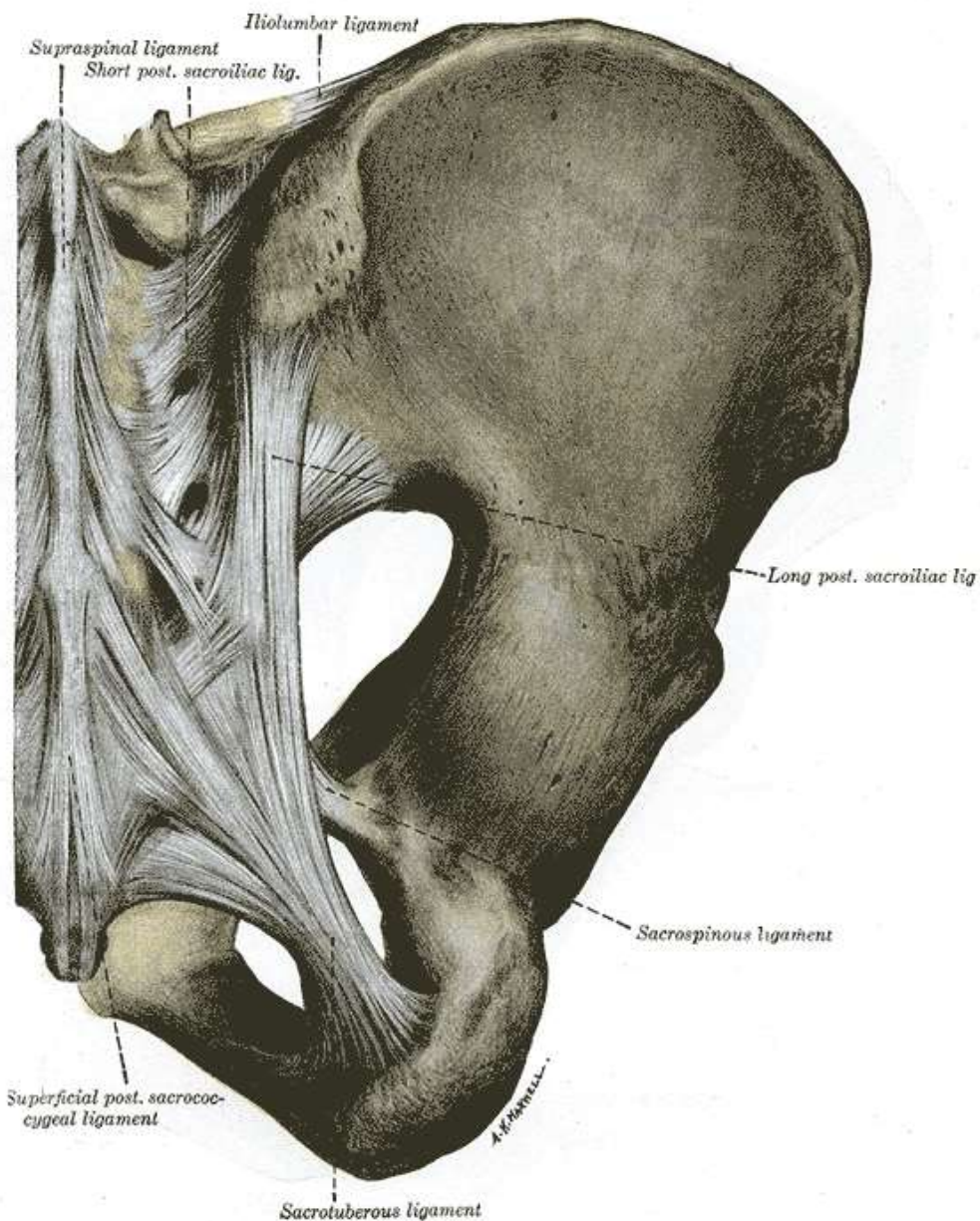


Fig. 76

***Right side of the bony pelvis with ligaments
posterior view***

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GENDER DIFFERENCES IN BONY PELVIS

Male and female bony pelvis differ in some characteristic features. Majority of these differences are associated a role of female pelvis during the delivery. See table below.

Feature	female	male
shape of the pelvic inlet	circular less distinct promontory wider alae	heart-shaped
angle formed by the inferior rami of pubic bones	larger 80°-85° pubic arch	sharper 50°-60° pubic angle
ischial spines	only slightly projected to the inlet	projected more medially than in female
pubic symphysis	lower cca 4.5cm	higher cca 5cm
coccyx	shorter and more moveable in sacrococcygeal synchondrosis than in male	

Tab. 6
Gender differences in bony pelvis

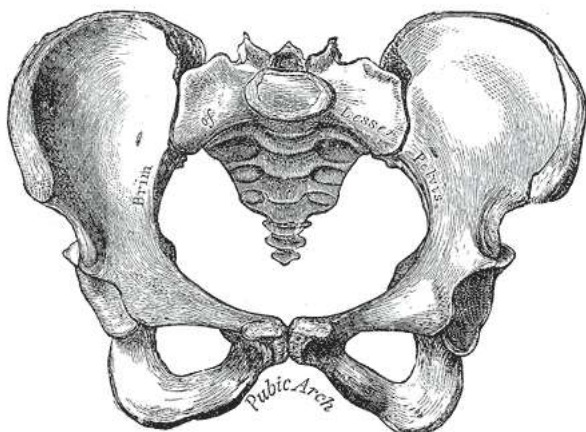


Fig.77
Female bony pelvis
anterior view

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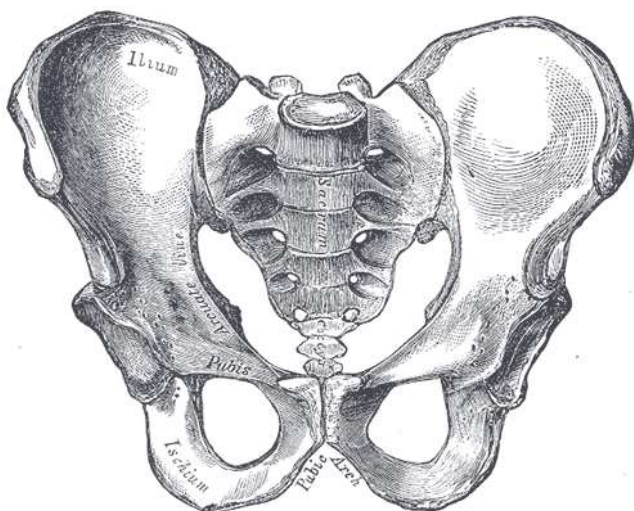


Fig. 78
Male bony pelvis
anterior view

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HIP (COXAL) JOINT

Hip joint is a **multiaxial ball-and-socket synovial joint**.

The **articular surface** of the **femoral head** joins with the **lunate surface** and **acetabular labrum**. The articular surface of the head of femur forms almost $\frac{3}{4}$ of the sphere. Lunate surface is in the acetabulum enlarged by the acetabular labrum, fibrocartilaginous rim which deepens the acetabulum. Articular surfaces are covered by the hyaline cartilage. Acetabular notch contains a fibrous and fatty tissue covered by the synovial membrane.

The **articular capsule** is very strong. It is attached to the margins of acetabulum and at the femur - to the intertrochanteric line at the anterior aspect, to femoral neck posteriorly. The articular capsule is thicker anterosuperiorly and weaker inferoposteriorly. **Zona orbicularis** is a circular fibrous band enclosing the neck of femur inside the articular capsule. It is fused with the fibres of pubofemoral and ischiofemoral ligaments.

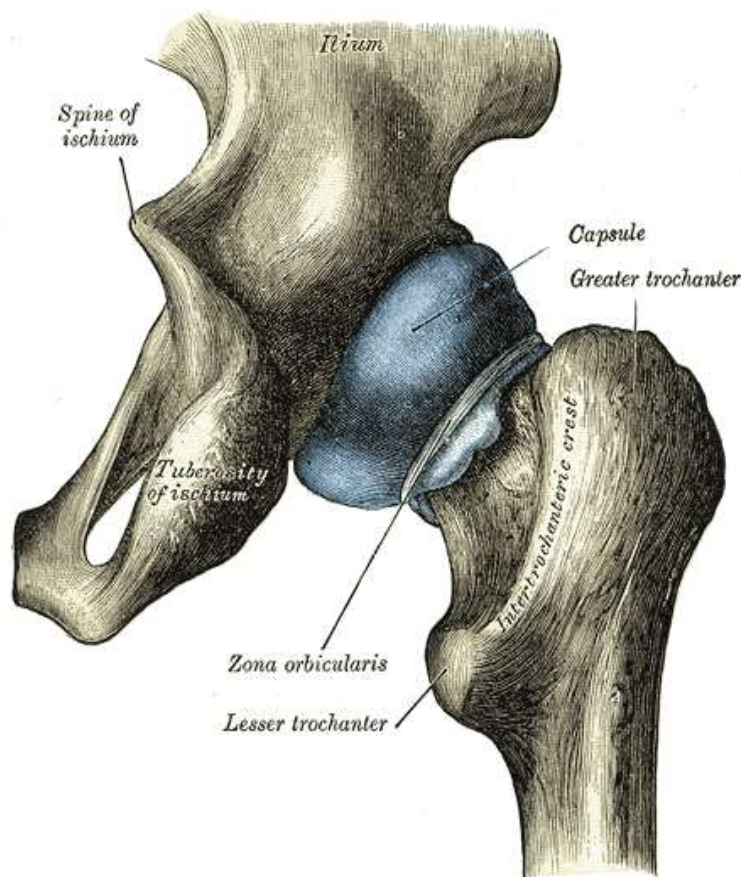


Fig. 79

Right hip joint
posterior view

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The hip joint is stabilized by the intraarticular and extrarticular ligaments. There are two ligaments inside the joint. The **transverse acetabular ligament** bridges the acetabular notch. **Ligament of the head of femur** (ligamentum teres) runs from the acetabular fossa, more precisely notch, to the fovea situated centrally at the femoral head. It contains the small vessels for the femoral head but it has no important function in stabilization of the hip joint as for the movements.

Externally there are three strong accessory ligaments: **iliofemoral, pubofemoral and ischiofemoral**.

Ilioferoral ligament passes from anterior inferior iliac spine to the intertrochanteric line at the femur. It prevets the joint from excessive extension. This ligament is the strongest ligament in the whole human body.

Pubofemoral ligament extends from the superior ramus of pubis to the ventral aspect of the articular capsule to zona orbicularis and to the lesser trochanter. It limits the abduction and pronation (medial rotation).

Ischiofemoral ligament runs from the site above ischial tuberosity to the trochanteric fossa and zona orbicularis. It prevents the joint from excessive adduction and supination (lateral rotation).

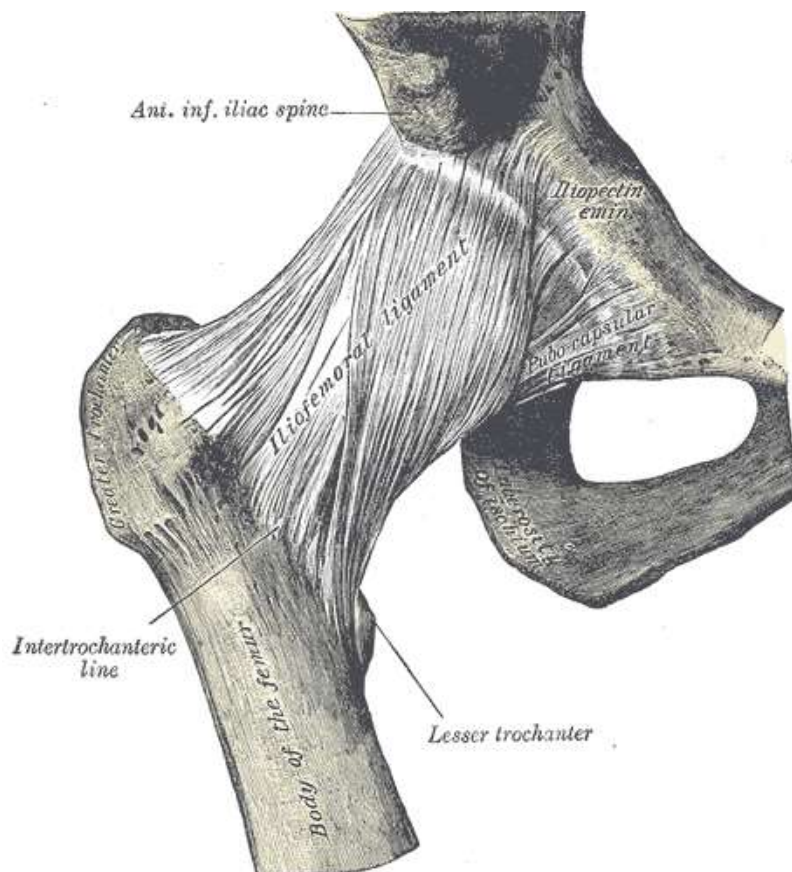


Fig. 80
Right hip joint
anterior view

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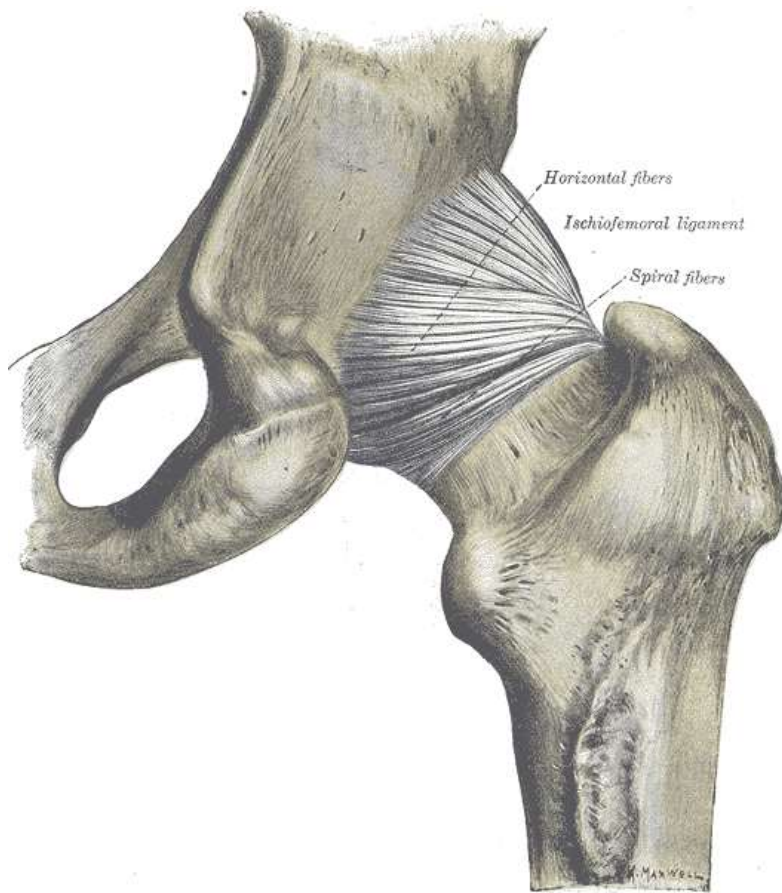


Fig. 81
Right hip joint
posterior view

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The joint is also reinforced by the tendons of the muscles (*psaos major, rectus femoris, gluteus minimus, pectineus, obturator externus and internus, gemellus superior and inferior and quadratus femoris muscles*). There are synovial bursae between the muscle tendons and the articular capsule to prevent the friction and press.

The joint allows **flexion, extension, abduction, adduction, rotation** and **circumduction**. Although it is a ball-and-socket joint, similarly as the shoulder joint, the range of movements in hip joint is lesser than in the shoulder joint, because the acetabulum is much deeper than the glenoid cavity and movements are therefore limited.

Clinical column

- Hip joint is relatively stable and traumatic injuries are less frequent than in shoulder joint. Hip dislocation is usually caused by high-energy trauma like car accidents or falling from the height.
- Hip joint is the weightbearing joint and therefore it is prone to the destruction of articular cartilages leading to coxarthrosis.
- Congenital dislocation of the hip joint (*luxatio coxae congenita*) is the most common musculoskeletal developmental disorder. The term *luxatio coxae congenita* has been known from the time of Hippocrates. In 1930s Marino Ortolani, Italian pediatrician, performed remarkable study concerning the early diagnosis and treatment of hip dysplasia. He noticed

that in babies with hip dislocation, a typical hearable and palpable „click“ can be detected when the femur is abducted and ventrally pulled („Ortolani maneuver“) and thus the dislocated femoral head moves over the posterior aspect of acetabular rim and enters the acetabulum. In 1962 Barlow published the study about the early diagnosis and treatment of congenital dislocation of the hip joint in the newborn. He described „Barlow maneuver“, in adducted hip the femur is pushed posteriorly, that allows to detect dislocatable femoral head. If Barlow maneuver is positive the femoral head exits the acetabulum during this test. Even nowadays, both the Barlow and Ortolani maneuvers are still accepted as accurate tests to detect developmental dislocation of the hip and they are widely used during the routine physical examination of newborns.



Fig. 82
Movements in the hip joint



**abduction
in the right hip joint**



**adduction and hyperadduction
in the right hip joint**



**supination (lateral rotation)
in the right hip joint**



**pronation (medial rotation)
in the right hip joint**

Fig. 83
Movements in the hip joint

KNEE (GENUAL) JOINT

Knee joint is the largest and the most complicated joint in human body. It is a **compound bicondylar synovial joint** containing the menisci and intraarticular ligaments inside the articular cavity.

In the knee joint, the **femoral condyles** articulate with **tibia** and **patella**.

The knee joint consists of two parts:

- **tibiofemoral joint**
- **patellofemoral joint**

In **tibiofemoral joint** the convex **articular surface at femoral condyles** and slightly concave **superior articular surface at the tibial condyles** are incongruent, therefore, the **menisci** are interposed between them. Menisci widen and deepen the articular surfaces of tibial condyles and diminish incongruity and act as shock absorbers. Both menisci are C – shaped fibrocartilaginous rings, thicker at the outer edge, thinner at the inner edge. Medial meniscus is larger and oval, lateral one is smaller, almost circular and more mobile. Horns of menisci are attached to the anterior and posterior intercondylar area at the superior surface of tibia, moreover, peripherally they are attached to the articular capsule. Anterior horns of menisci are interconnected by the transverse ligament of the knee. Posterior horn of lateral meniscus is fixed to the medial femoral condyle by meniscomfemoral ligaments.

Patella is the largest sesamoid bone situated inside the tendon of quadriceps femoris muscle. **Patellar articular facets** face posteriorly to join with the **patellar articular surface** of femur in **patellofemoral joint**.

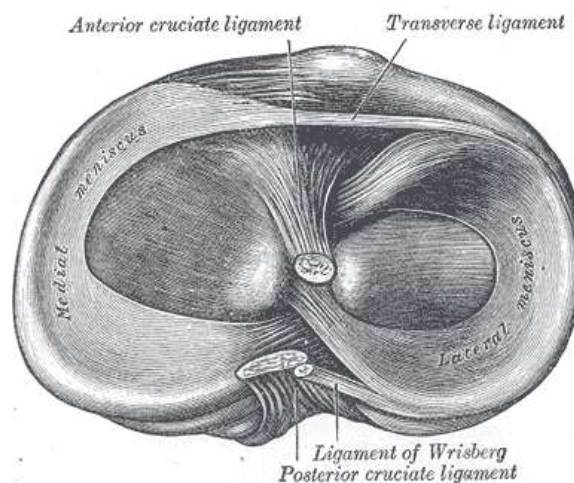


Fig.84

Superior surface of right tibia with menisci and ligaments

Superior view

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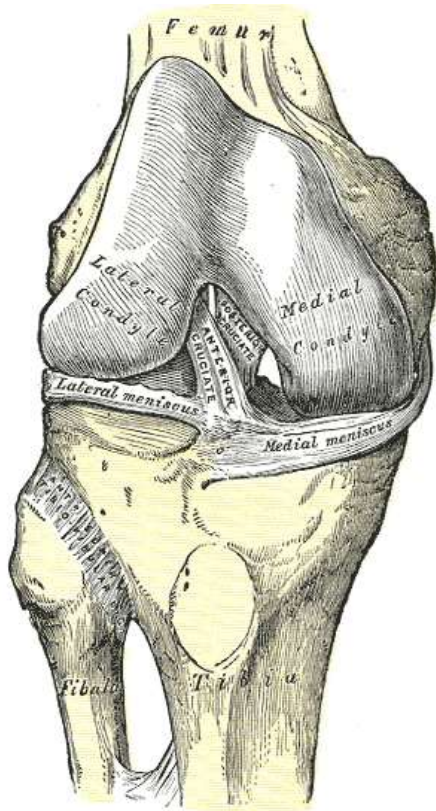


Fig.85
Right knee joint
anterior view

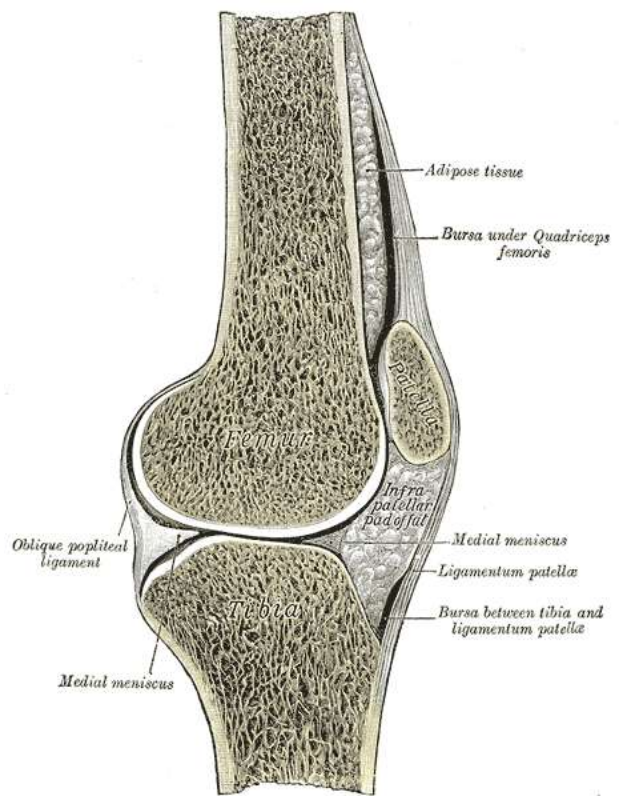


Fig. 86
Right knee joint
sagittal section

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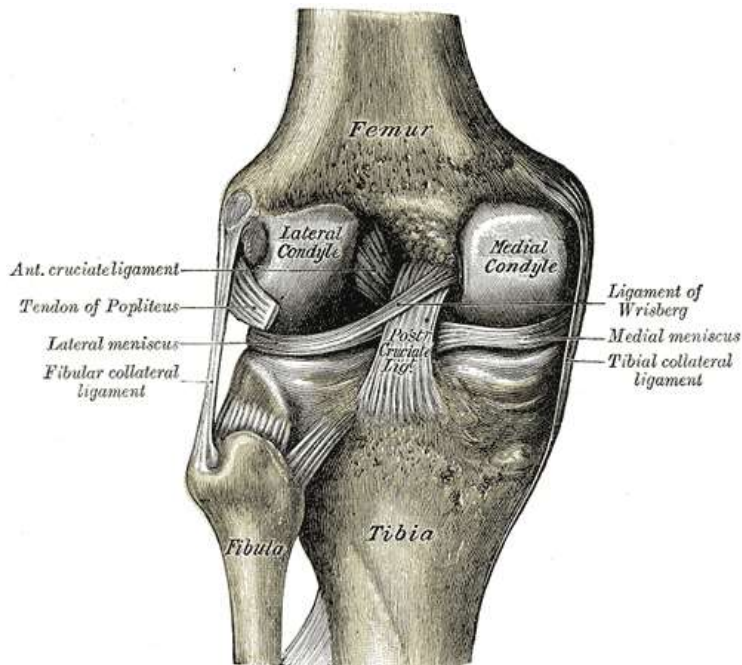


Fig.87
Left knee joint
posterior view

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The **articular capsule** of the knee joint is attached around the periphery of articular surfaces of femur, tibia and patella. Femoral epicondyles remain free for the muscle insertion.

The **articular cavity** of the knee joint has unusually complex shape. **Synovial membrane** of the knee joint contains an adipose tissue in some area and forms the folds. Sagittally oriented **infrapatellar synovial fold** extends to almost horizontal **alar folds** which are situated next to the transverse ligament of the knee. The **infrapatellar fat pad** is situated below the patella in anterior part of the joint capsule and it separates the capsule from patellar ligament. Synovial membrane forms numerous **synovial bursae** around the knee joint with or without communication with the articular cavity, to diminish friction between the tendons and neighbouring structures (articular capsules, bones, other muscle tendons (*suprapatellar bursa, subpopliteal bursa or recess, subcutaneous prepatellar bursa, deep and subcutaneous infrapatellar bursa etc.*)).

The knee joint is stabilized by the system of intraarticular and external ligaments.

Intraarticular ligaments mentioned above, **transverse ligament of the knee and meniscomfemoral ligaments**, fixate the menisci. **Anterior and posterior cruciate ligaments** are very important for the stability of the knee joint during the movement.

Anterior cruciate ligament prevents the femur from moving backward in relation to tibia during the flexion. It runs from the medial aspect of lateral femoral condyle to the anterior intercondylar area on the tibia. **Posterior cruciate ligament** stops the femur from moving forward on the tibia during the extension. It extends from the lateral aspect of the medial femoral condyle to posterior intercondylar area on the tibia.

The articular capsule of the knee joint is strengthened by the accessory ligaments in all sides. Along the medial side **tibial collateral ligament** runs from the medial epicondyle of femur to the anteromedial aspect of tibia. This ligament blends with the joint capsule and with medial meniscus as well. Laterally **fibular collateral ligament** passes from the lateral epicondyle of femur to the head of fibula, it is separated from the articular capsule. Collateral ligaments are more stretched in extension less stretched in flexion. They hold the femoral and tibial condyles together and prevent them from side to side movements.

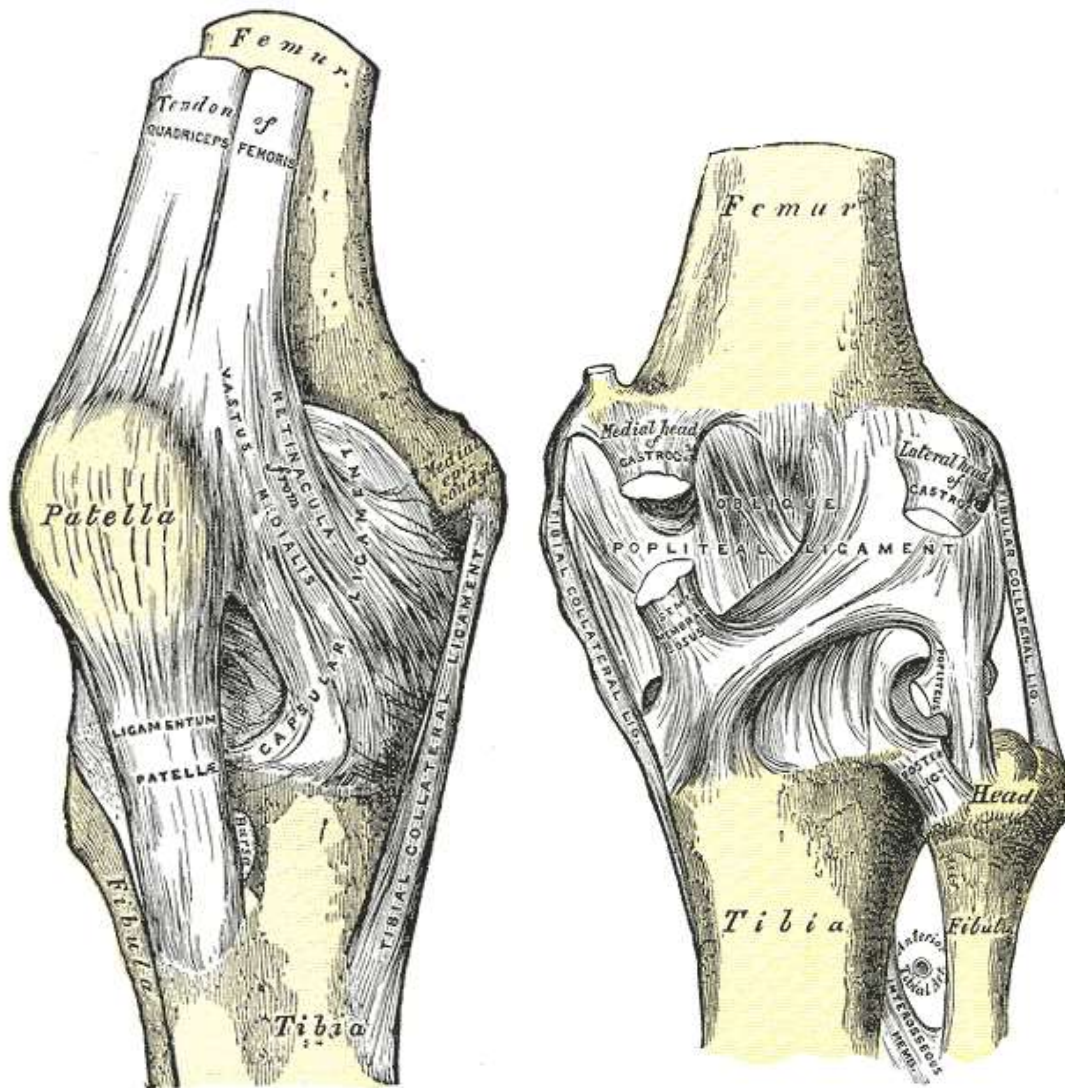


Fig.88

Right knee joint

anterior and posterior view

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Anteriorly **ligamentum patellae** (continuation of the quadriceps femoris tendon) arises from the apex of patella to tibial tuberosity. Between this ligament and the joint capsule there is the infrapatellar fat pad.

Posterior aspect of the joint is covered by **arcuate and oblique popliteal ligaments**. Together with articular capsule they prevent the joint fom overextension.

The knee joint performs **flexion** and **extension**. Slight **rotation** is allowed **in flexion**.



Fig.89
Movements in the knee joint

Clinical column

- *Knee joint is the weightbearing joint prone to the destruction of articular cartilages leading to gonarthrosis. The main risk factors are obesity, ligament or menisci injuries and repeated microtraumas e.g. during practising the sports.*

- *Injuries and ruptures to the knee joint ligaments are very often.*

As for the cruciate ligaments, the anterior cruciate ligament injuries are much more common than the injuries of posterior one. More than 70% of injuries to anterior cruciate ligament are non-contact injuries, without the blow to the knee. In this case the knee joint suddenly rotates but the foot is not able to follow this movement because it is fixed.

Contact injuries are result of high-energy mechanisms leading to traumatic knee dislocation. Injuries to anterior cruciate ligament are common in athletes practising the alpine skiing, soccer, basketball or handball. Interestingly they are approximately 3-times more often in females than males. Injuries to posterior cruciate ligament are usually contact injuries resulting from the high – energy impact on the flexed knee joint.

Injuries to the collateral ligaments are usually contact, caused by the strong blow to the knee. The blow which pushes the knee joint inward may result in medial collateral ligament injury. The blow to the inner surface of the knee that dislocates the joint outward may result in injury to lateral collateral ligament.

- *Dislocation of patella can be result of medial blow on patella or it can be caused by*

sudden contraction of quadriceps femoris muscle during rotation of the knee.

TIBIOFIBULAR JOINT

Tibiofibular joint is a plane synovial joint. In this joint, the **articular facet at the head of fibula** articulates with **fibular articular facet at the lateral condyle of tibia**.

The articular capsule is short strengthened by the anterior and posterior ligament of fibular head. This joint allows only limited gliding movements.

INTEROSSEOUS MEMBRANE OF THE LEG

Interosseous membrane of the leg is a fibrous plate spreading **between the** tibia and fibula. It is a type of **fibrous joint, syndesmosis**.

The fibres of the interosseous membrane pass obliquely from the interosseous border of tibia distally to the interosseous border of fibula. Proximally it shows the aperture for anterior tibial vessels, distally there is an aperture for perforating branch of fibular artery. The interosseous membrane keep the bones in parallel position, prevents the bones from mutual proximodistal movements. It is also the site of crural muscle origins.

TIBIOFIBULAR SYNDESMOSIS

Distal ends of tibia and fibula are connected by a **fibrous joint, syndesmosis tibiofibularis**, where fibula enters the fibular notch at tibia. **Anterior and posterior tibiofibular ligaments** strengthen the joint externally. **Interosseous tibiofibular ligament** is continuation of the interosseous membrane formed by numerous short fibres connecting adjoining surfaces of tibia and fibula. This band makes the strongest connection between tibia and fibula.

Tibiofibular syndesmosis is very strong joint which is usually stretched during the extension of the ankle (talocrural) joint when wider anterior part of superior facet of trochlea tali pushes on the socket formed by tibia and fibula.

ANKLE (TALOCRURAL) JOINT

Ankle (talocrural) joint is a compound hinge synovial joint where three bones - **tibia, fibula and talus**, articulate together.

All articular surfaces are lined by the hyaline cartilage. The trochlea of talus consists of three articular surfaces. Horizontally oriented **superior facet of trochlea tali** articulates with the **inferior articular surface of tibia**. Almost sagittally oriented **lateral malleolar facet of trochlea tali (lateral talar surface of trochlea tali)** articulates with **lateral malleolus** of fibula, and similarly, almost sagittal **medial malleolar facet of trochlea tali (medial talar surface of trochlea)** joins with the **medial malleolus** formed by tibia. Superior facet (surface) of trochlea tali is slightly wider anteriorly than posteriorly.

The **articular capsule** of the joint is thinner anteriorly and posteriorly. It is attached to tibia and fibula above malleoli and to the talus near the periphery of trochlea. The articular capsule is strengthened by **medial and lateral collateral ligaments** by the sides.

Medial collateral ligament or deltoid ligament is thick band consisting of 4 parts arising from medial malleolus to the neighbouring bones:

- **tibionavicular part** – from medial malleolus to the dorsomedial surface of navicular bone
- **tibiocalcaneal part** – from medial malleolus to sustentaculum tali on calcaneus
- **anterior tibiotalar part** – from medial malleolus to the neck of talus
- **posterior tibiotalar part** – from medial malleolus to posterior process of talus.

Lateral collateral ligament is formed by three thinner bands:

- anterior talofibular ligament – from lateral malleolus to the neck of talus
- posterior talofibular ligament – from malleolar fossa to the lateral tubercle at posterior process of talus
- calcaneofibular ligament – from lateral malleolus to calcaneus

This joint is uniaxial joint allowing the **plantar flexion (flexion)** and **dorsal flexion (extension)**.

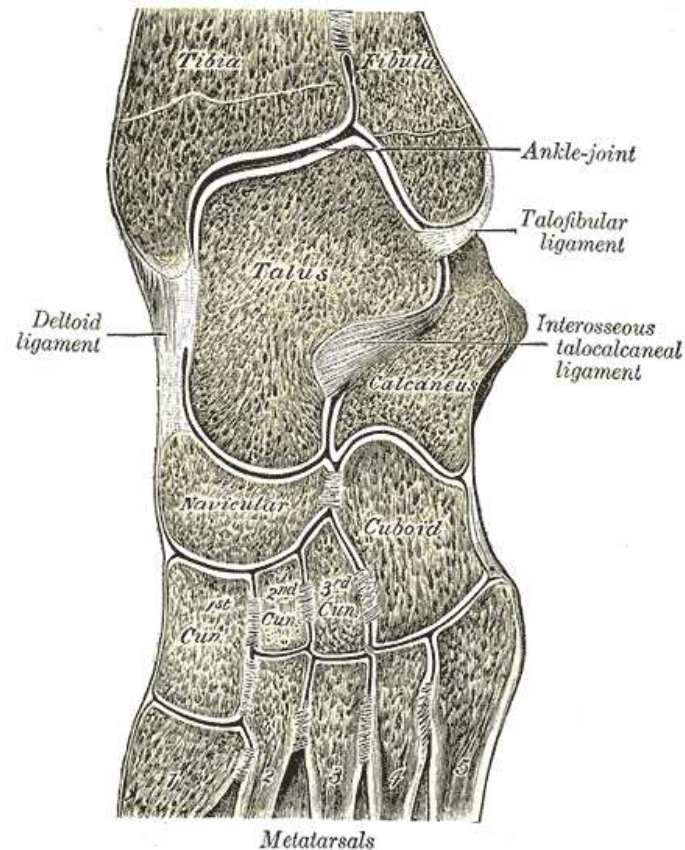


Fig. 90

Left talocrural joint in section

Anterior view

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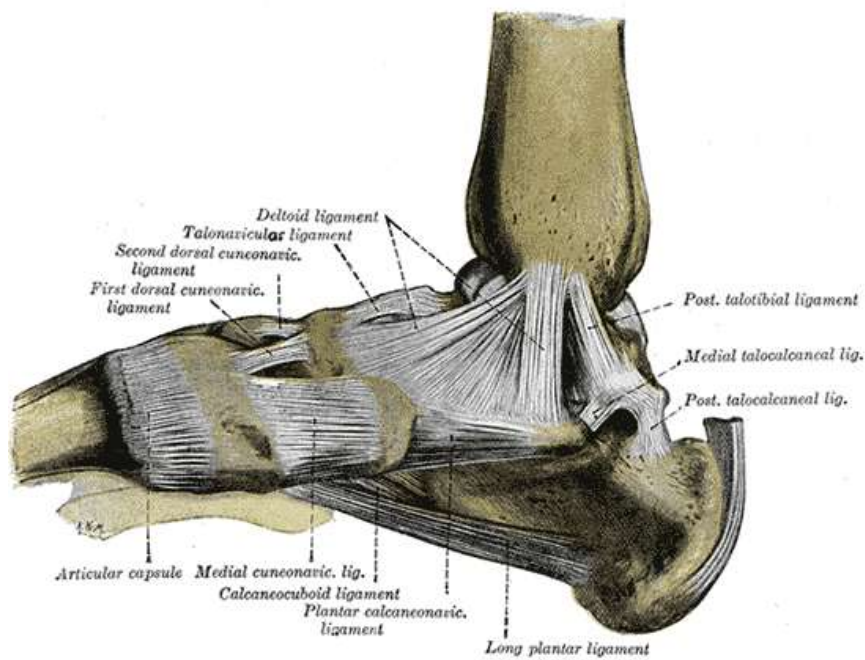


Fig. 91

Right foot (ankle and tarsus)

medial view

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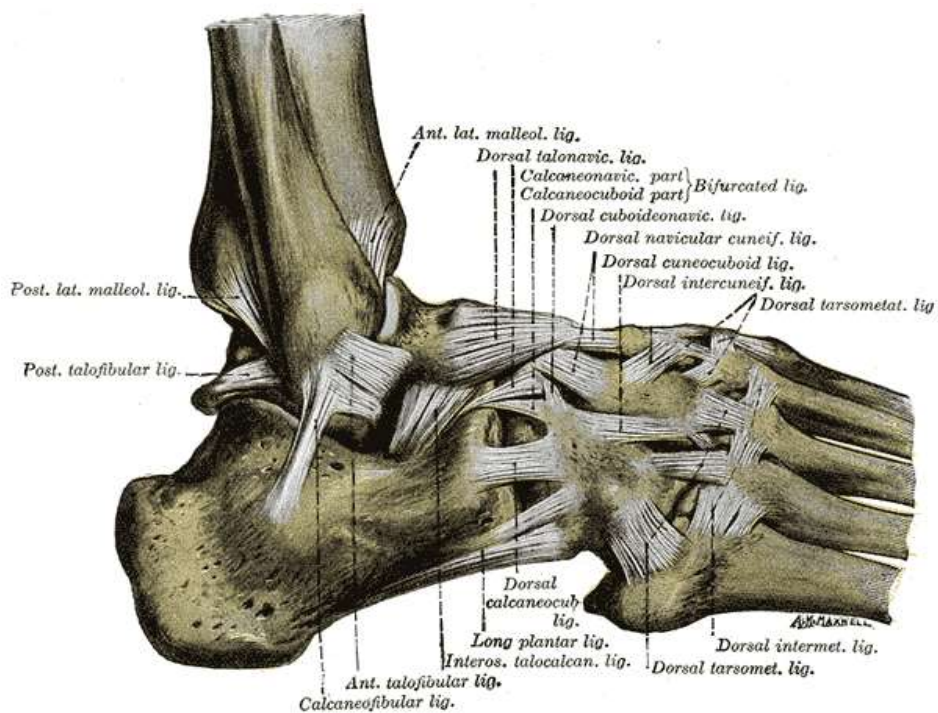


Fig. 92

Right foot (ankle and tarsus)

lateral view

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TALOCALCANEAL (SUBTALAR) JOINT

Talocalcaneal (subtalar) joint is a plane synovial joint which forms the posterior part of the functional unit called „the lower ankle joint“.

Posterior calcaneal articular surface (facet) is concave articular surface at the inferior aspect of talus. It articulates with slightly convex **posterior talar articular surface (facet)** at the superior surface of calcaneus.

The articular capsule of the joint is short and strong surrounded by the **medial and lateral talocalcaneal ligaments**. **Interosseous talocalcaneal ligament** passes obliquely from the sulcus of talus to sulcus of calcaneus. It separates the talocalcaneal (subtalar) joint from talocalcaneonavicular joint.

Movements in talocalcaneal (subtalar) joint are combined with the movements in talocalcaneonavicular joint. Both joints act as one and allow following **complex movements**:

- **inversion of the foot** - plantar flexion adduction and **supination** of the foot
- **eversion of the foot** - dorsal flexion, abduction, **pronation** of the foot.

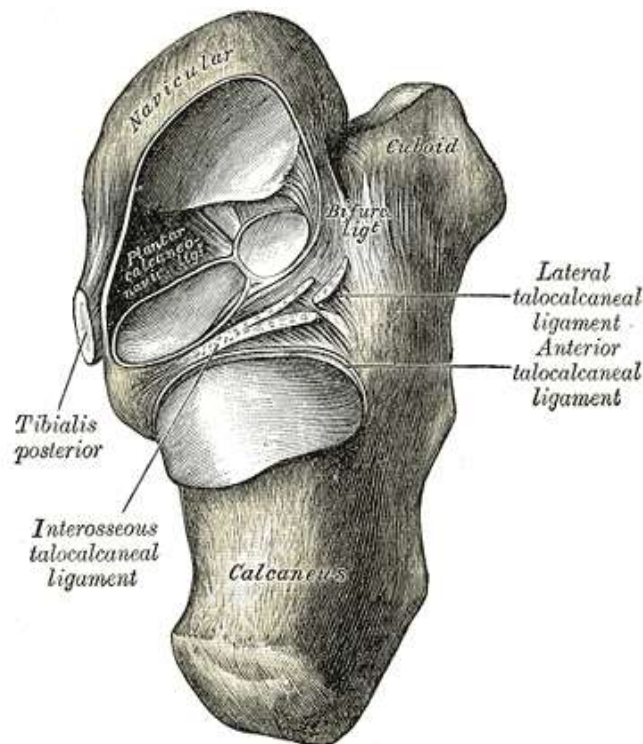


Fig. 93

Articular surfaces at the superior surface of calcaneus

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Fig. 94

Inversion and eversion of the foot

TALOCALCANEONAVICULAR JOINT

Talus, calcaneus and navicular bone articulate together in a **compound multiaxial synovial joint talocalcaneonavicular joint**.

Convex articular surface is formed by three articular surfaces at the **talus: the head, anterior and middle articular calcaneal surfaces (facets) of talus**. Concavity of this joint is formed by the **posterior articular surface of navicular bone and anterior and middle**

articular talar surface of calcaneus, and fibrocartilaginous surface of the calcaneonavicular (spring) ligament.

The **articular capsule** is thin, only posteriorly it is thickened by fusing with the interosseous talocalcaneal ligament running in sinus tarsi. The articular capsule is reinforced by the **dorsal and plantar talonavicular ligaments** and **plantar calcaneonavicular ligament (spring ligament)** which passes from sustentaculum tali to navicular bone.

Movements in talocalcaneonavicular joint are combined with the movements in subtalar joint. Both joints act as one and allow following **complex movements**:

- **inversion of the foot** - plantar flexion adduction and supination of the foot
- **eversion of the foot** - dorsal flexion, abduction, pronation of the foot.

CALCANEOCUBOID JOINT

Adjoining surfaces of calcaneus and cuboid bone form a **saddle synovial joint with minimal moveability**.

The joint has its own fibrous capsule strengthened by ligaments.

Bifurcate ligament extends from calcaneus in two bands to cuboid and to navicular bone.

Long plantar ligament runs along the sole of the foot from the calcaneus to the cuboid bone and to the bases of metatarsal bones II-V.

Plantar calcaneocuboid ligament (short plantar ligament) is deep to the long plantar ligament. It extends from calcaneal tubercle to the inferior surface of cuboid bone.

Clinical column

Transverse tarsal joint or Chopart's joint is the clinical term for the anterior part of talocalcaneonavicular joint and calcaneocuboid joint. It is the important surgical unit where the midfoot amputation (disarticulation) can be done like a surgical treatment of diabetic foot. The bifurcate ligament is termed as the key from the Chopart's joint („clavis articulationis Choparti“).

CUNEONAVICULAR (NAVICULOCUNEIFORM) JOINTS

Cuneonavicular joint is usually classified as a **compound plane synovial joint**.

Distal articular surface of navicular bone joins with the proximal surfaces of the medial, intermediate and lateral cuneiform bones.

The **articular capsule** is connected with the articular capsule of the intercuneiform joints and cuneocuboid joint. The articular capsule is reinforced by **dorsal and plantar ligaments** passing like three bands from the navicular bone to all cuneiforms.

Cuneonavicular joint allows only limited gliding movements.

CUBOIDEONAVICULAR JOINT (SYNDESMOSIS)

Cuboideonavicular joint is a **fibrous joint – syndesmosis**, where the cuboid bone and navicular bone are connected by the **dorsal, plantar and interosseous ligament**.

Rarely cuboideonavicular syndesmosis can be replaced by a plane synovial joint.

CUNEOCUBOID AND INTERCUNEIFORM JOINTS

Cuneocuboid joint is a **plane synovial joint** between the lateral cuneiform bone and cuboid bone.

Intercuneiform joints are **plane synovial joints** between the medial and intermediate cuneiform bone and similarly between the intermediate and lateral cuneiform bone.

The **articular capsules** are interconnected with the articular capsule of cuneonavicular joint.

These joints are stabilized by **the dorsal and plantar ligaments** which run like short transverse bands connecting the medial, intermediate, lateral cuneiform and cuboid bones. **Interosseous ligaments** form a very strong connection between nonarticular sites at adjoining surfaces of medial, intermediate, lateral cuneiform and cuboid bones.

Cuneocuboid joint and intercuneiform joints allow only limited gliding movements.

TARSOMETATARSAL JOINTS AND INTERMETATARSAL JOINTS

Tarsometatarsal joints are **plane synovial joints**.

The first tarsometatarsal joint is between the distal surface of the **medial cuneiform bone** and the base of **metatarsal bone I**.

In the second tarsometatarsal joint the intermediate and lateral cuneiform bone articulates with the bases of **metatarsal bones II and III**, respectively.

The third tarsometatarsal joint connects the distal surface of **cuboid bone** and the bases of the **metatarsal bones IV and V**.

Mentioned three joints have separated articular capsules strengthened by short and strong dorsal and plantar tarsometatarsal ligaments and three bands of interosseous cuneometatarsal ligaments.

Tarsometatarsal joints allow only limited **flexion and extension** (or gliding movements). The first tarsometatarsal joint (tarsometatarsal joint of the hallux – big toe) is more moveable than the other tarsometatarsal joints. It **allows limited flexion, extension, some abduction and rotation**.

Adjacent sides at the bases of metatarsal bones articulate in **intermetatarsal joints**. These joints have common articular capsule with tarsometatarsal joints. The joints are strengthened by **dorsal, plantar and interosseous metatarsal ligaments** transversely running between the bases of metatarsal bones.

The movements are combined with the movements in tarsometatarsal joints.

Clinical column

Tarsometatarsal joints and intermetatarsal joints together form another surgical unit „Lisfranc's joint“. It is the line where the distal midfoot amputation can be done. During the surgical disarticulation surgeons should remember that the base of the second metacarpal bone extends more proximally than the other ones what forms a typical irregular line of the „Lisfranc's joint“. Both Lisfranc's and Chopart's joints are the lines of distal or minor amputation where tibial weightbearing stump is preserved.

METATARSOPHALANGEAL JOINTS

Metatarsophalangeal joints are **ellipsoid synovial joints**.

The **articular surfaces** of the **metacarpal heads** are rounded distally and cylindrical plantarly and articulate with the concave articular surfaces at the **bases of proximal phalanges**.

The **articular capsules** are attached to the margins of articular surfaces. They are reinforced by strong **collateral ligaments** by the sides. **Plantar ligaments** are thick bands with fibrocartilaginous plate for flexor tendons. **Deep transverse metatarsal ligaments** are four short bands that connect adjoining metatarsophalangeal joints.

In metatarsophalangeal joints **flexion, extension, abduction and adduction** can be performed, however, **abduction and adduction are minimal or almost impossible in flexion**.

Below the articular capsule of the first metatarsophalangeal joint there are usually two sesamoid bones.

Clinical column

Hallux valgus or „bunion“ is a common positional deformity resulting from subluxation in the first metatarsophalangeal joint, the first metatarsal bone is deviated medially and the proximal phalanx of the hallux (big toe) is deviated laterally. Deformity leads to painful moveability in the joint and pain from shoe pressure. Hallux valgus occurs more frequently in females and in older people. Multifactorial ethiology with genetic predisposition is supposed. Association with poor - fitting or high – heeled shoes has been discussed, however, not yet confirmed.

INTERPHALANGEAL JOINTS

All **interphalangeal joints** at the foot are **hinge synovial joints**.

The **heads of the proximal phalanges** articulate with the **bases of the middle phalanges** in **proximal interphalangeal joints**.

Similarly, the **heads of the middle phalanges** connect with the **bases of the distal phalanges** in the **distal interphalangeal joints**.

At the hallux (big toe) there is only one interphalangeal joint between the proximal and distal phalanx.

The **articular surfaces** of the **heads** at proximal and middle phalanges have a typical shape like a pulley (trochlea). They closely interlock with the bases at the middle and distal phalanges.

The **articular capsules** of interphalangeal joints are short and strengthened by the collateral ligaments at both side. The plantar side of the capsule is thickened by a fibrous plate - plantar ligament.

Only **flexion and extension** can be performed **in interphalangeal joints**.



extension in the ankle, metatarsophalangeal and interphalangeal joints of the left foot



**flexion in metatarsophalangeal and interphalangeal joints of the left foot
extension in the ankle joint of the left foot**

Fig. 95

Movements in the metatarsophalangeal joints and interphalangeal joints of the foot

JOINTS OF THE LOWER LIMB – SUMMARY		
JOINT	ARTICULAR SURFACES	MOVEMENTS
sacroiliac joint <i>plane synovial joint</i>	- auricular surface of sacrum -auricular surface of ilium	limited anteroposterior rotation
pubic symphysis <i>cartilaginous joint</i>	-symphyseal surfaces of the pubic bones	only limited angulation
hip (coxal) joint <i>ball-and-socket synovial joint</i>	-head of femur -lunate surface enlarged by acetabular labrum	flexion, extension, abduction, adduction, rotation, circumduction
knee (genual) joint <i>bicondylar synovial joint</i> tibiofemoral joint ----- patellofemoral joint	-condyles of femur -condyles of tibia with menisci ----- -patellar facets -patellar art. surface at femur	flexion, extension in flexion rotation - pronation, supination
tibiofibular joint <i>plane synovial joint</i>	-head of fibula -fibular articular surface at tibia	only limited gliding movements
interosseous membrane <i>fibrous joint - syndesmosis</i>	-interosseous border of tibia -interosseous border of fibula	prevents fibula and tibia from the mutual vertical shift
tibiofibular syndesmosis <i>fibrous joint</i>	- fibular notch at tibia -fibula above the malleolus	strong joint – can be stretched in extended ankle
ankle (talocrural) joint <i>hinged synovial joint</i>	-tibia, fibula – distal ends -trochlea of talus	flexion, extension
subtalar (talocalcaneal) joint <i>plane synovial joint</i>	-posterior articular talar surface - posterior articular calcaneal surface	inversion and eversion
talocalcaneonavicular joint <i>ball-and-socket synovial joints</i>	-head of talus -anterior and middle talar articular surface -anterior and middle calcaneal articular surface	
calcaneocuboid joint <i>saddle synovial joint</i>	- articular surface of calcaneus -articular surface of cuboid bone	limited gliding movements
cuneonavicular joint <i>plane synovial joint</i>	-navicular bone distal surface - proximal surfaces of cuneiforms	limited gliding movements
cuboideonavicular joint <i>fibrous joint - syndesmosis</i>	-cuboid bone -navicular bone	limited gliding movements
cuneocuboid joint <i>plane synovial joint</i>	-lateral cuneiform bone -cuboid bone	limited gliding movements
intercuneiform joints <i>plane synovial joint</i>	-between adjacent surfaces of cuneiforms	limited gliding movements
tarsometatarsal joints <i>plane synovial joints</i>	-cuneiforms – base of the MTT bone I,II,III -cuboid - base of the MTT bone IV,V	flexion, extension, abduction, and rotation
metatarsophalangeal joints <i>ellipsoid synovial joints</i>	-heads of the MTT bones -bases of the proximal phalanges	flexion, extension, in extension - abduction and adduction
interphalangeal joints <i>hinge synovial joints</i>	-heads of phalanges (proximal, middle) -bases of phalanges (middle, distal)	flexion, extension

Tab. 6

Joints of the lower limb – summary

SHORT INTRODUCTION TO MYOLOGY

Muscular system involves generally three types of the muscles:

- **skeletal** that are striated and voluntary;
- **smooth** that are not striated and not voluntary;
- **cardiac** that are striated but are not voluntary.

Thus, only **skeletal muscles** work **under conscious control** and **they are responsible for every physical action which we consciously perform** – movements of all parts of the body. Skeletal muscles also include e.g. muscles of facial expression, muscles related to the eyes or muscles that change the size of the openings of digestive or urinary systems. They support the soft tissue and organs, stabilize the spine and maintain the posture and body temperature, store nutrient reserves.

Smooth muscles are contained in the walls of most of the internal organs and blood vessels. They are in the skin associated with the hair follicles and they are located in the eyeball. **Cardiac muscles** are found in the wall of the heart.

The contraction of the skeletal muscles is fast, powerful and not rhythmical. They require a high energy and fatigue more rapidly than the other. Skeletal muscles are innervated by the somatic and branchial motor nerves.

Most of skeletal muscles have **belly** and two ends – **origin** and **insertion**. The **origin** is attachment site that does not move during contraction. It is **stationary end**. The **insertion** is **movable end** so it moves during muscle contraction. Usually, the ends of the muscle are attached to two bones across the joint, therefore the contraction of the muscle moves the joint, that is bridged by this muscle. Skeletal muscles are also attached to the cartilage, the skin, one to another or to some combination of these structures.

MUSCLES OF THE UPPER LIMB

Muscles of the upper limb are subdivided to the groups in accordance with the topographic regions.

MUSCLES OF THE SCAPULA		<i>deltoid m.</i> <i>subscapularis m.</i> <i>supraspinatus m.</i> <i>infraspinatus m.</i> <i>teres minor m.</i> <i>teres major m.</i>
MUSCLES OF THE ARM	anterior brachial mm.	<i>coracobrachialis m.</i> <i>biceps brachii m.</i> <i>brachialis m.</i>
	posterior brachial mm.	<i>triceps brachii m.</i> <i>anconeus m.</i>
MUSCLES OF THE FOREARM	anterior antebrachial mm.	<i>pronator teres m.</i> <i>flexor carpi radialis m.</i> <i>palmaris longus m.</i> <i>flexor carpi ulnaris m.</i> <i>flexor digitorum superficialis m.</i> <i>flexor digitorum profundus m.</i> <i>flexor pollicis longus m.</i> <i>pronator quadratus m.</i>
	posterior antebrachial mm.	<i>brachioradialis m.</i> <i>extensor carpi radialis longus m.</i> <i>extensor carpi radialis brevis m.</i> <i>extensor digitorum m.</i> <i>extensor digiti minimi m.</i> <i>extensor carpi ulnaris m.</i> <i>supinator m.</i> <i>abductor pollicis longus m.</i> <i>extensor pollicis brevis m.</i> <i>extensor pollicis longus m.</i> <i>extensor indicis m.</i>
MUSCLES OF THE HAND	thenar mm.	<i>abductor pollicis brevis m.</i> <i>opponens pollicis m.</i> <i>flexor pollicis brevis m.</i> <i>adductor pollicis m.</i>
	hypothenar mm.	<i>palmaris brevis m.</i> <i>abductor digiti minimi m.</i> <i>flexor digiti minimi brevis m.</i> <i>opponens digiti minimi m.</i>
	intermediate mm.	<i>lumbrical mm.</i> <i>dorsal interossei mm.</i> <i>palmar interossei mm.</i>

Tab. 7
Muscles of the upper limb - summary

MUSCLES OF THE SCAPULA

Group of the muscles of scapula includes six muscles, that are relatively short – **deltoideus**, **subscapularis**, **supraspinatus**, **infraspinatus**, **teres major** and **teres minor**. These muscles bridge the shoulder joint and stabilize it. They attach humerus to scapula and move the arm at the shoulder joint. Four muscles of this group – supraspinatus, infraspinatus, teres minor and subscapularis form a musculotendinous **rotator cuff** around the shoulder joint. The cuff supports this joint and holds the correct position of the head of humerus in the glenoid cavity. Deltoid muscle is the major abductor of the arm. It is triangular-shaped and has an enlarged origin which is narrowed to insertion, so it is shaped like the Greek letter „delta“. Deltoid muscle forms a shape of the shoulder.

Muscles of scapula are nerve supplied by the nerves of the **brachial plexus**.

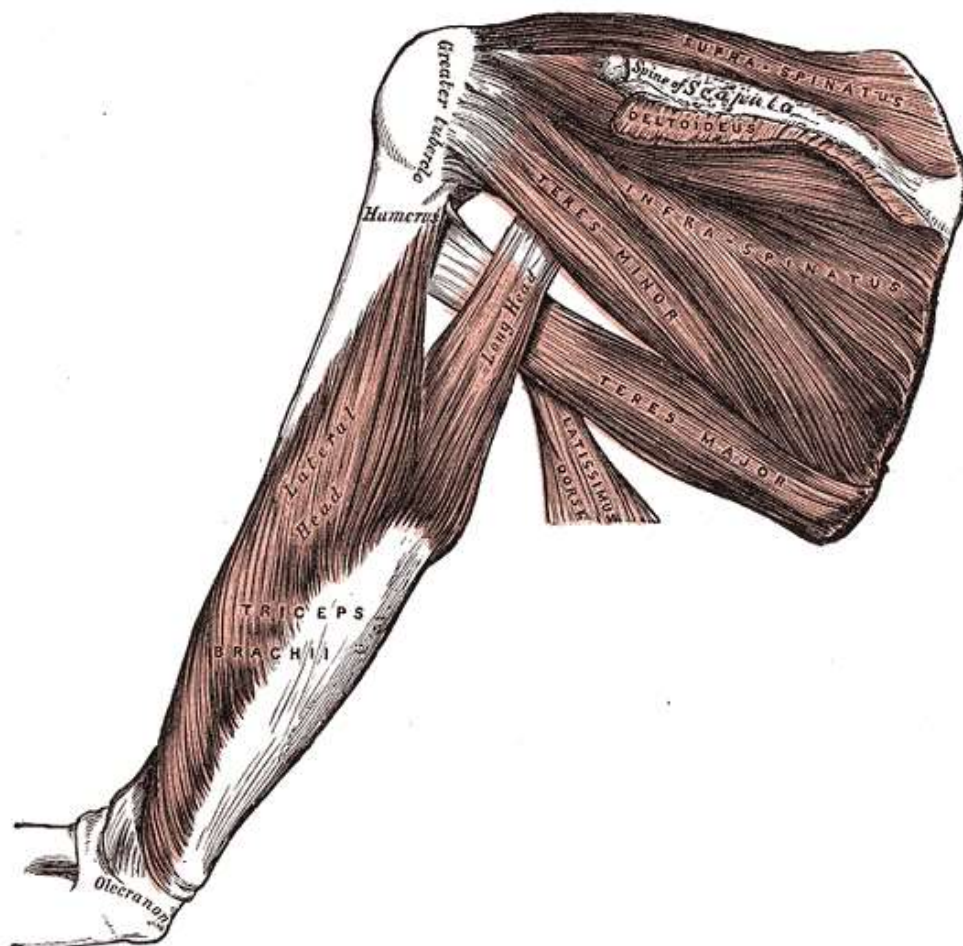


Fig. 96
Muscles of the left scapula – supraspinatus, infraspinatus, teres minor and teres major
posterior view

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MUSCLES OF THE SCAPULA

DELTOID MUSCLE

Origin: lateral one-third of clavicle, acromion and spine of scapula

Insertion: deltoid tuberosity of humerus

Function: abduction, flexion, extension of the arm

Nerve supply: axillary nerve

SUBSCAPULARIS MUSCLE

Origin: subscapular fossa

Insertion: lesser tubercle of humerus

Function: adduction and pronation (medial rotation) of the arm

Nerve supply: subscapular nerves

SUPRASPINATUS MUSCLE

Origin: supraspinous fossa of scapula

Insertion: greater tubercle of humerus

Function: abduction of the arm

Nerve supply: suprascapular nerve

INFRASPINATUS MUSCLE

Origin: infraspinous fossa of scapula

Insertion: greater tubercle of humerus

Function: supination (lateral rotation) of the arm

Nerve supply: suprascapular nerve

TERES MINOR MUSCLE

Origin: lateral border of scapula

Insertion: greater tubercle of humerus

Function: supination (lateral rotation) of the arm

Nerve supply: axillary nerve

TERES MAJOR MUSCLE

Origin: inferior angle of scapula

Insertion: medial lip of intertubercular sulcus of humerus

Function: adduction and pronation (medial rotation) of the arm

Nerve supply: subscapular nerve

Deltoid muscle is illustrated in Fig. 97. Subscapularis muscle is illustrated in Fig. 98.

MUSCLES OF THE ARM – BRACHIAL MUSCLES

Muscles of the arm (brachial muscles) move the shoulder and the forearm, however, their primary action is at the elbow joint. Muscles of this group are arranged into two compartments. **Anterior (flexor) compartment** contains **anterior brachial muscles** and **posterior (extensor) compartment** contains **posterior brachial muscles**.

Anterior brachial muscles include – **coracobrachialis, biceps brachii** and **brachialis muscles**. Biceps brachii and brachialis are **mainly flexors of the forearm** and when the elbow joint is flexed, biceps brachii also acts as powerful **supinator of the forearm**. Biceps brachii muscle has two heads, long and short. Tendon of its long head passes through the cavity of the shoulder joint and then it runs within the intertubercular sulcus of humerus. Both heads unite to form a single tendon. Biceps brachii muscle inserts primarily onto radial tuberosity. It also inserts by the bicipital aponeurosis that blends into antebrachial fascia. Brachial muscle lies deep to biceps brachii muscle.

Anterior brachial muscles are nerve supplied by the **musculocutaneous nerve**.

ANTERIOR BRACHIAL MUSCLES

CORACOBRACHIALIS MUSCLE

Origin: coracoid process of scapula

Insertion: middle part of humeral shaft

Function: flexion and adduction of the arm

Nerve supply: musculocutaneous nerve

BICEPS BRACHII MUSCLE

Origin: **long head** – supraglenoid tubercle of scapula

short head – coracoid process of scapula

Insertion: radial tuberosity and bicipital aponeurosis

Function: flexion and supination of the forearm
accessory flexion of the arm

Nerve supply: musculocutaneous nerve

BRACHIALIS MUSCLE

Origin: lower half of anterior surface of humeral shaft

Insertion: ulnar tuberosity

Function: flexion of the forearm

Nerve supply: musculocutaneous nerve

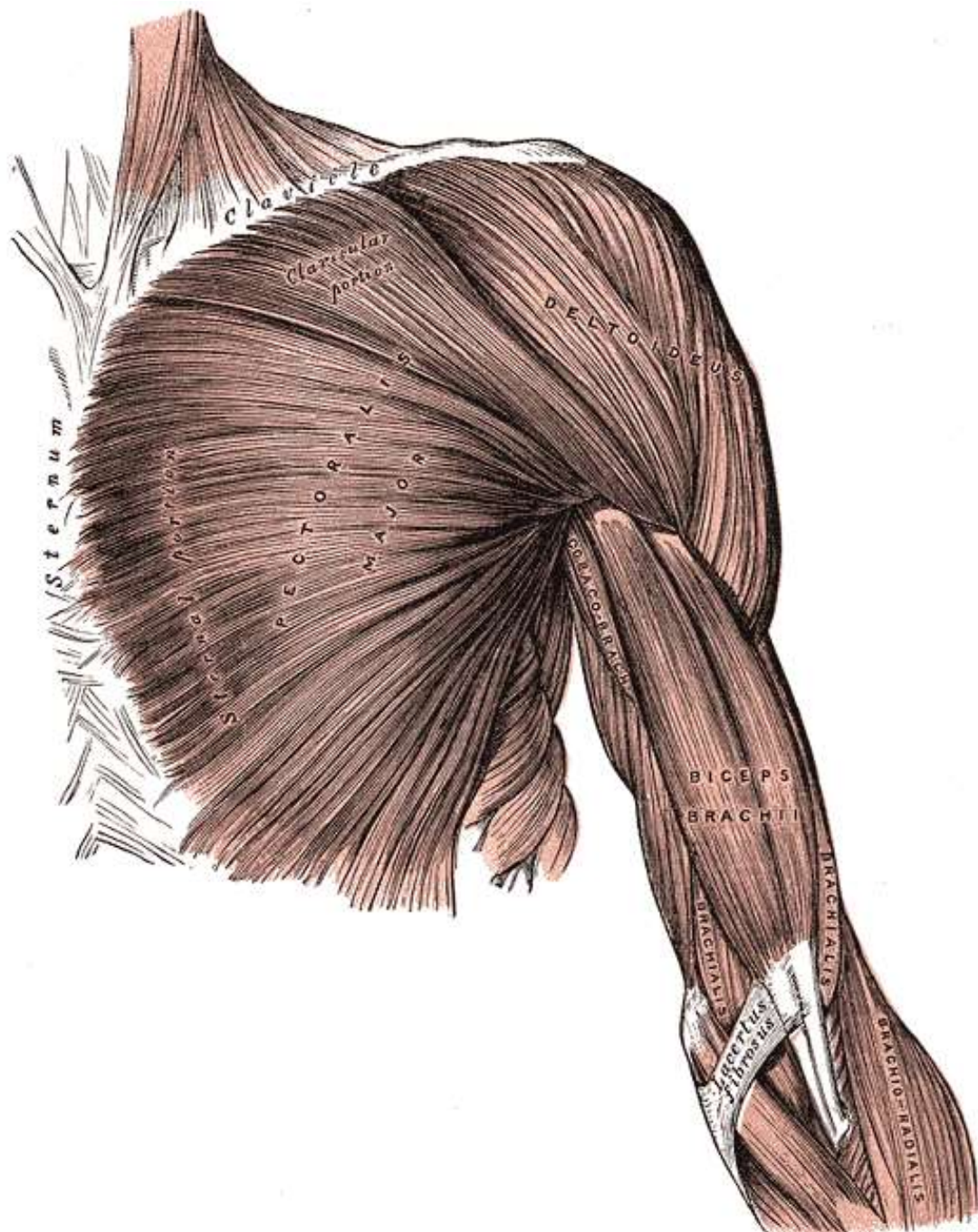


Fig. 97

***Anterior brachial muscle, pectoralis major muscle and deltoid muscle
left upper limb***

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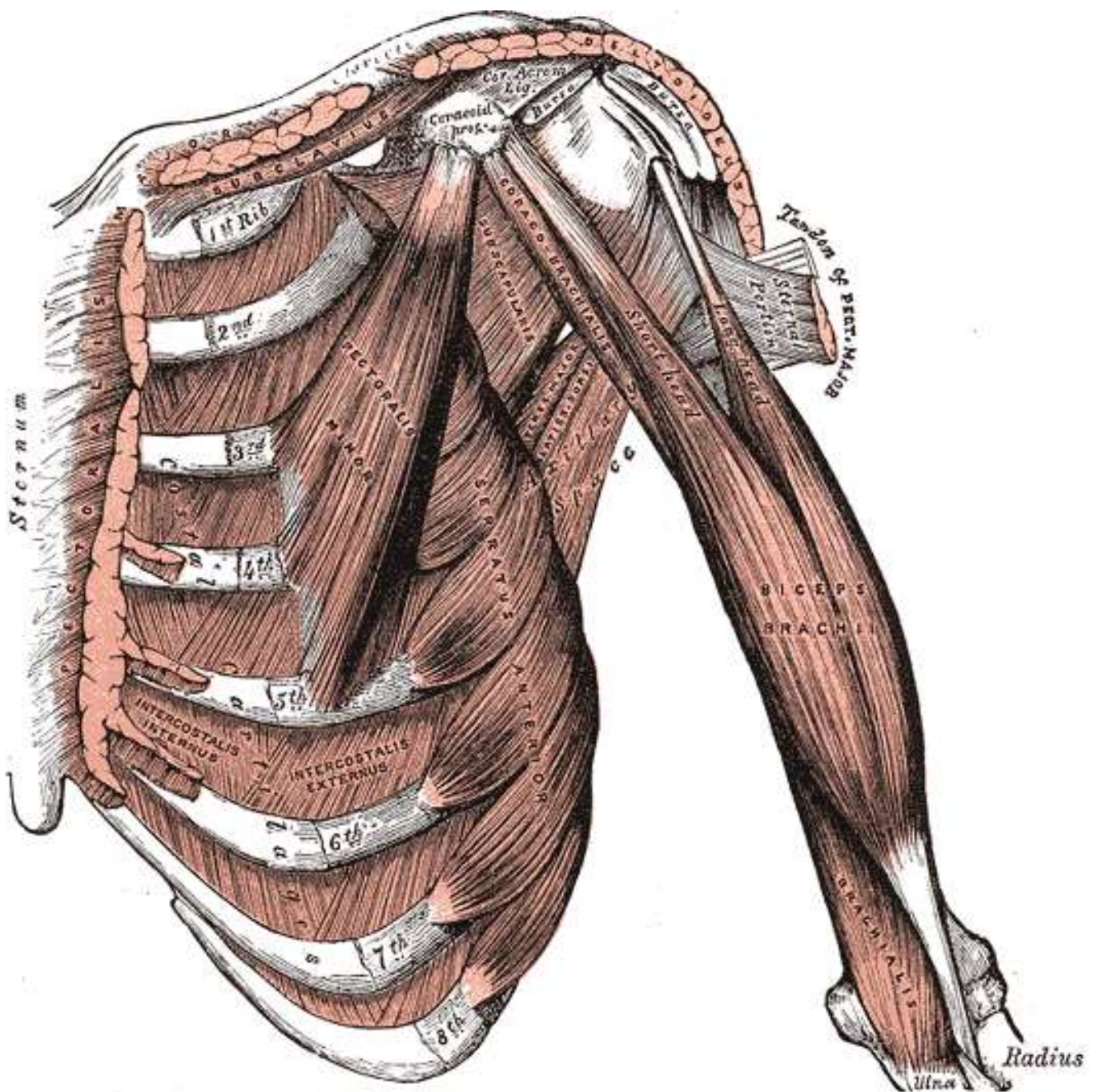


Fig. 98
Anterior brachial muscles, subscapularis, pectoralis minor, serratus anterior and subclavius muscles
left upper limb
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Posterior brachial muscles include – **triceps brachii** and **anconeus muscles**. Triceps brachii muscle is the **main extensor** at elbow joint. Anconeus muscle is small and has only accessory function at the elbow. Triceps brachii muscle has three heads – long, medial and lateral, which unite to form a common tendon of insertion.

Posterior brachial muscles are nerve supplied by the **radial nerve**.

POSTERIOR BRACHIAL MUSCLES

TRICEPS BRACHII MUSCLE

Origin: long head – infraglenoid tubercle of scapula

lateral head: dorsal surface of humerus – above the groove for the radial nerve

medial head: dorsal surface of humerus – below the groove for the radial nerve

Insertion: olecranon of ulna

Function: extension of the forearm

long head – accessory extension of the arm

Nerve supply: radial nerve

ANCONEUS MUSCLE

Origin: lateral epicondyle of humerus

Insertion: lateral side of the olecranon of ulna

Function: extension of the forearm

Nerve supply: radial nerve

Triceps brachii muscle is illustrated in Fig. 96.

MUSCLES OF THE FOREARM – ANTEBRACHIAL MUSCLES

Muscles of the forearm (antebrachial muscles) move the forearm, the wrist and the fingers. The wrist and the fingers have an extensive range of the movements. Accordingly, the most flexors and extensors of the forearm have a long contractile parts, as well as a long tendons, which bridge the joints of the wrist and the hand and allow these movements. Muscles of the forearm are arranged into two compartments. **Anterior (flexor) compartment** contains **anterior antebrachial muscles** and **posterior (extensor) compartment** contains **posterior antebrachial muscles**.

Anterior antebrachial muscles are mainly **flexors of the wrist and the fingers**. They are also **pronators of the forearm** and **abductor or adductor at the wrist**.

Anterior antebrachial muscles are divided into three **layers** – **superficial, intermediate** and **deep**. Muscles of the superficial layer originate more proximally than muscles of the deep layer.

Superficial layer of anterior antebrachial muscles contains – **pronator teres, flexor carpi radialis, palmaris longus** and **flexor carpi ulnaris muscles**. Flexor carpi ulnaris is the most medial of the muscles of superficial layer. Palmaris longus muscle lies between two flexors of this layer and it is absent in about 15% of the population.

These muscles origin together from medial epicondyle of humerus by common origin (common flexor attachment). Except for pronator teres, they pass from the forearm distally into the hand. Palmaris longus muscle is inserted to **palmar aponeurosis**, that is a thickened part of the palmar fascia at the hand. These muscles also act as accessory flexors at the elbow joint.

Muscles of the superficial layer are nerve supplied by the **median nerve**, except for flexor carpi ulnaris, which is innervated by the **ulnar nerve**.

ANTERIOR ANTEBRACHIAL MUSCLES – SUPERFICIAL LAYER

PRONATOR TERES MUSCLE

Origin: medial epicondyle of humerus, coronoid process of ulna

Insertion: lateral surface of the midshaft of radius

Function: pronation of the forearm

Nerve supply: median nerve

FLEXOR CARPI RADIALIS MUSCLE

Origin: medial epicondyle of humerus

Insertion: basis of the metacarpal bone II

Function: flexion and abduction of the wrist

Nerve supply: median nerve

PALMARIS LONGUS MUSCLE

Origin: medial epicondyle of humerus

Insertion: palmar aponeurosis

Function: flexion of the wrist

Nerve supply: median nerve

FLEXOR CARPI ULNARIS MUSCLE

Origin: medial epicondyle of humerus, olecranon of ulna

Insertion: pisiform bone and base of the metacarpal bone V

Function: flexion and adduction of the wrist

Nerve supply: ulnar nerve

Intermediate layer of anterior antebrachial muscles contains **flexor digitorum superficialis muscle**. Muscle has two origins – humeroulnar and radial. At the distal forearm, it is subdivided to four tendons, which pass through the carpal canal and run distally into the fingers. Tendons are inserted to middle phalanges from the second to the fifth finger. Near its insertion each tendon is subdivided into two arms, which are attached to the sides of middle phalanx. Tendon of flexor digitorum profundus passes between these two arms towards its insertion on distal phalanx.

Flexor digitorum superficialis muscle is innervated by the **median nerve**.

ANTERIOR ANTEBRACHIAL MUSCLES – INTERMEDIATE LAYER

FLEXOR DIGITORUM SUPERFICIALIS MUSCLE

Origin: medial epicondyle of humerus + coronoid process of ulna and anterior border of radius

Insertion: middle phalanges of the fingers II – V

Function: flexion of proximal interphalangeal joints of the fingers II – V and flexion of the wrist

Nerve supply: median nerve

Deep layer of anterior antebrachial muscles contains **flexor digitorum profundus**, **flexor pollicis longus** and **pronator quadratus muscles**. Flexor digitorum profundus is subdivided to four tendons. Tendons pass through the carpal canal, deep to tendons of flexor digitorum superficialis and they are inserted to the distal phalanges from the second to the fifth fingers.

Flexor digitorum profundus is innervated by two nerves. Lateral half of muscle is nerve supplied by the **median nerve** and medial half by the **ulnar nerve**. Flexor pollicis longus muscle is situated lateral to flexor digitorum profundus. Its tendon passes through the carpal canal to reach distal phalanx of the thumb. Pronator quadratus muscle is a small flat square-shaped muscle. It is situated at the distal forearm and lies beneath both flexors of this deep layer.

Flexor pollicis longus and pronator quadratus muscles are innervated by the **median nerve**.

ANTERIOR ANTEBRACHIAL MUSCLES – DEEP LAYER

FLEXOR DIGITORUM PROFUNDUS MUSCLE

Origin: proximal two-thirds of ulna and interosseous membrane

Insertion: distal phalanges of the fingers II – V

Function: flexion of interphalangeal joints of the fingers II – V and flexion of the wrist

Nerve supply: median nerve and ulnar nerve

FLEXOR POLLICIS LONGUS MUSCLE

Origin: anterior surface of radius and interosseous membrane

Insertion: distal phalanx of the thumb

Function: flexion of the thumb

Nerve supply: median nerve

PRONATOR QUADRATUS MUSCLE

Origin: distal anterior surface of ulna

Insertion: distal anterior surface of radius

Function: pronation of the forearm

Nerve supply: median nerve

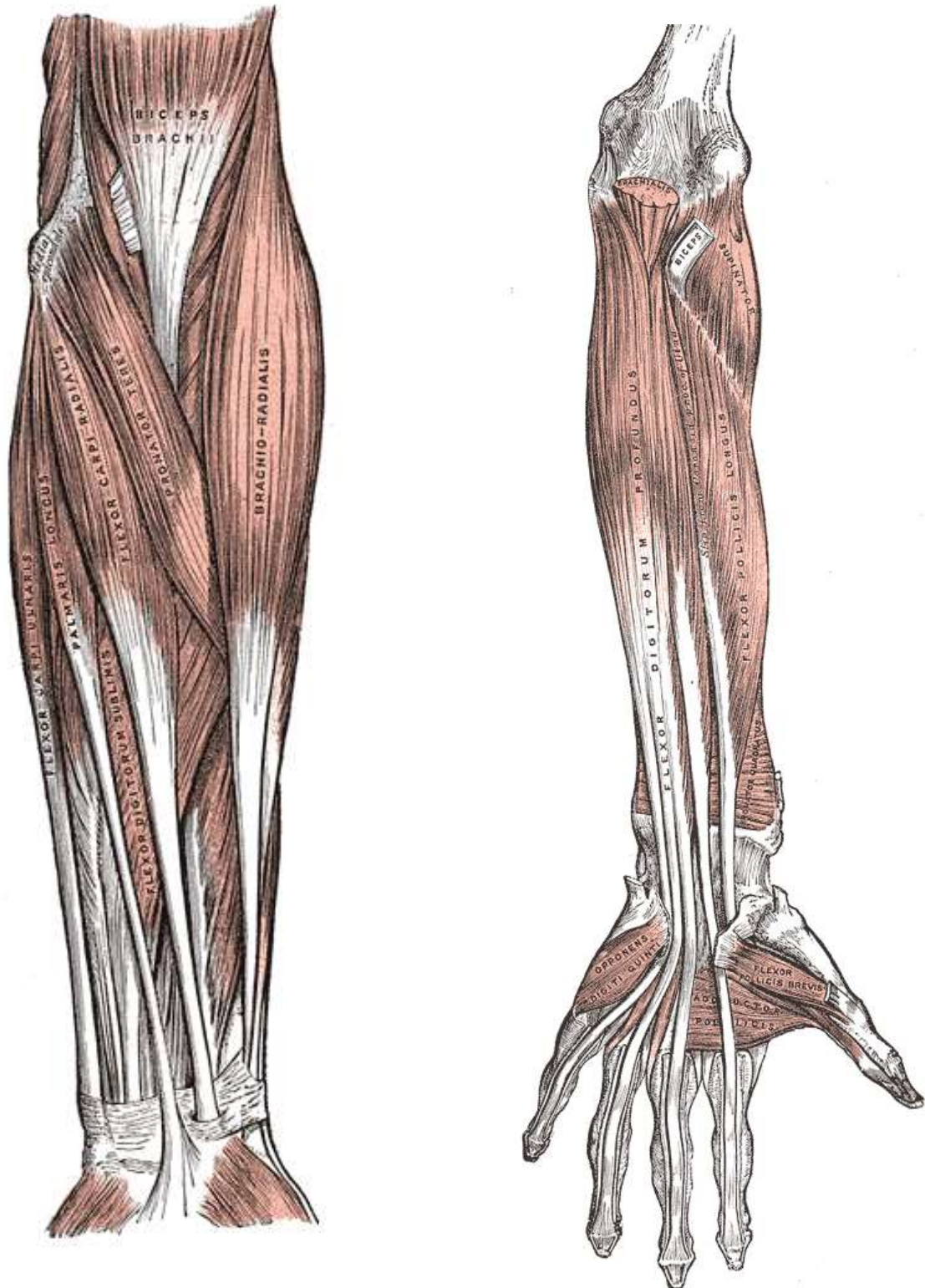


Fig. 99
Anterior antebrachial muscles
left upper limb
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Posterior antebrachial muscles are **mainly extensors of the wrist** and the **fingers**. They are also **supinators of the forearm** and **abductors** or **adductor at the wrist**. Some of them extend and abduct the thumb. Brachioradialis muscle is the only one of this posterior group that passes anterior to the elbow joint. Therefore it acts as an accessory **flexor** of the elbow joint, maximal when the forearm is in midpronated position.

The tendons of extensors of the fingers pass onto dorsal aspect of the fingers and flatten to form the small triangular tendinous aponeurosis, the **dorsal digital expansion** or **extensor hood**. The extensor hoods overlie distal interphalangeal joints and are attached to the phalanges.

All posterior antebrachial muscles are innervated by the **radial nerve**.

Posterior antebrachial muscles are divided into two **layers** – **superficial** and **deep**.

Superficial layer of posterior antebrachial muscles contains – **brachioradialis**, **extensor carpi radialis longus** and **brevis**, **extensor digitorum**, **extensor digiti minimi** and **extensor carpi ulnaris muscles**. These muscles originate from lateral supraepicondylar ridge or lateral epicondyle of humerus by common origin. Brachioradialis lies superficially on the anterolateral surface of the forearm. Brachioradialis originates more proximally. The origins of the other muscles of this group are located successively distally from brachioradialis. Except for brachioradialis, these muscles pass to the back of the hand. Extensor carpi radialis longus and brevis and extensor carpi ulnaris muscles are inserted to metacarpal bones. Extensor digitorum muscle is subdivided to four tendons which are inserted via extensor hoods to phalanges from the second to the fifth fingers.

Extensor carpi radialis brevis is shorter than longus and situated deeper. Brachioradialis muscle differs from the other muscles of this group by its function.

POSTERIOR ANTEBRACHIAL MUSCLES – SUPERFICIAL LAYER

BRACHIORADIALIS MUSCLE

Origin: lateral supraepicondylar ridge of humerus

Insertion: styloid process of radius

Function: flexion of the forearm

Nerve supply: radial nerve

EXTENSOR CARPI RADIALIS LONGUS MUSCLE

Origin: lateral supraepicondylar ridge + lateral epicondyle of humerus

Insertion: base of the metacarpal bone II

Function: extension and abduction of the wrist

Nerve supply: radial nerve

EXTENSOR CARPI RADIALIS BREVIS MUSCLE

Origin: lateral epicondyle of humerus

Insertion: base of the metacarpal bone III

Function: extension and abduction of the wrist

Nerve supply: radial nerve

EXTENSOR DIGITORUM MUSCLE

Origin: lateral epicondyle of humerus

Insertion: via the extensor hoods into the fingers II – V

Function: extension of the fingers II – V, extension of the wrist

Nerve supply: radial nerve

EXTENSOR DIGITI MINIMI MUSCLE

Origin: lateral epicondyle of humerus

Insertion: via the extensor hood into the little finger

Function: extension of the little finger

Nerve supply: radial nerve

EXTENSOR CARPI ULNARIS MUSCLE

Origin: lateral epicondyle of humerus + posterior border of ulna

Insertion: base of the metacarpal bone V

Function: extension and adduction of the wrist

Nerve supply: radial nerve

Deep layer of posterior antebrachial muscles contains – **supinator, abductor pollicis longus, extensor pollicis brevis and longus and extensor indicis muscles**. With exception of supinator, these muscles originate from posterior surface of interosseous membrane and from radius or ulna and act on the thumb and on the second finger. Abductor pollicis longus and both extensors of the thumb run obliquely above the tendons of the extensor carpi radialis brevis and longus and pass into the thumb. Tendon of abductor pollicis longus is accompanied by tendon of extensor pollicis brevis and they form lateral border of the anatomical snuff-box at the wrist. Tendon of extensor pollicis longus forms medial border of anatomical snuff-box. Supinator muscle does not reach the hand. It is inserted into radius.

POSTERIOR ANTEBRACHIAL MUSCLES – DEEP LAYER

SUPINATOR MUSCLE

Origin: lateral epicondyle of humerus + supinator crest of ulna

Insertion: proximal one-third of radius

Function: supination of the forearm

Nerve supply: radial nerve

ABDUCTOR POLLICIS LONGUS MUSCLE

Origin: posterior surface of ulna, radius and interosseous membrane

Insertion: base of the metacarpal bone I

Function: abduction of the thumb

Nerve supply: radial nerve

EXTENSOR POLLICIS BREVIS MUSCLE

Origin: posterior surface of radius and interosseous membrane

Insertion: base of proximal phalanx of the thumb

Function: extension of the thumb

Nerve supply: radial nerve

EXTENSOR POLLICIS LONGUS MUSCLE

Origin: posterior surface of ulna and interosseous membrane

Insertion: base of distal phalanx of the thumb

Function: extension of the thumb

Nerve supply: radial nerve

EXTENSOR INDICIS MUSCLE

Origin: posterior surface of ulna and interosseous membrane

Insertion: via the extensor hood into the index

Function: extension of the index

Nerve supply: radial nerve

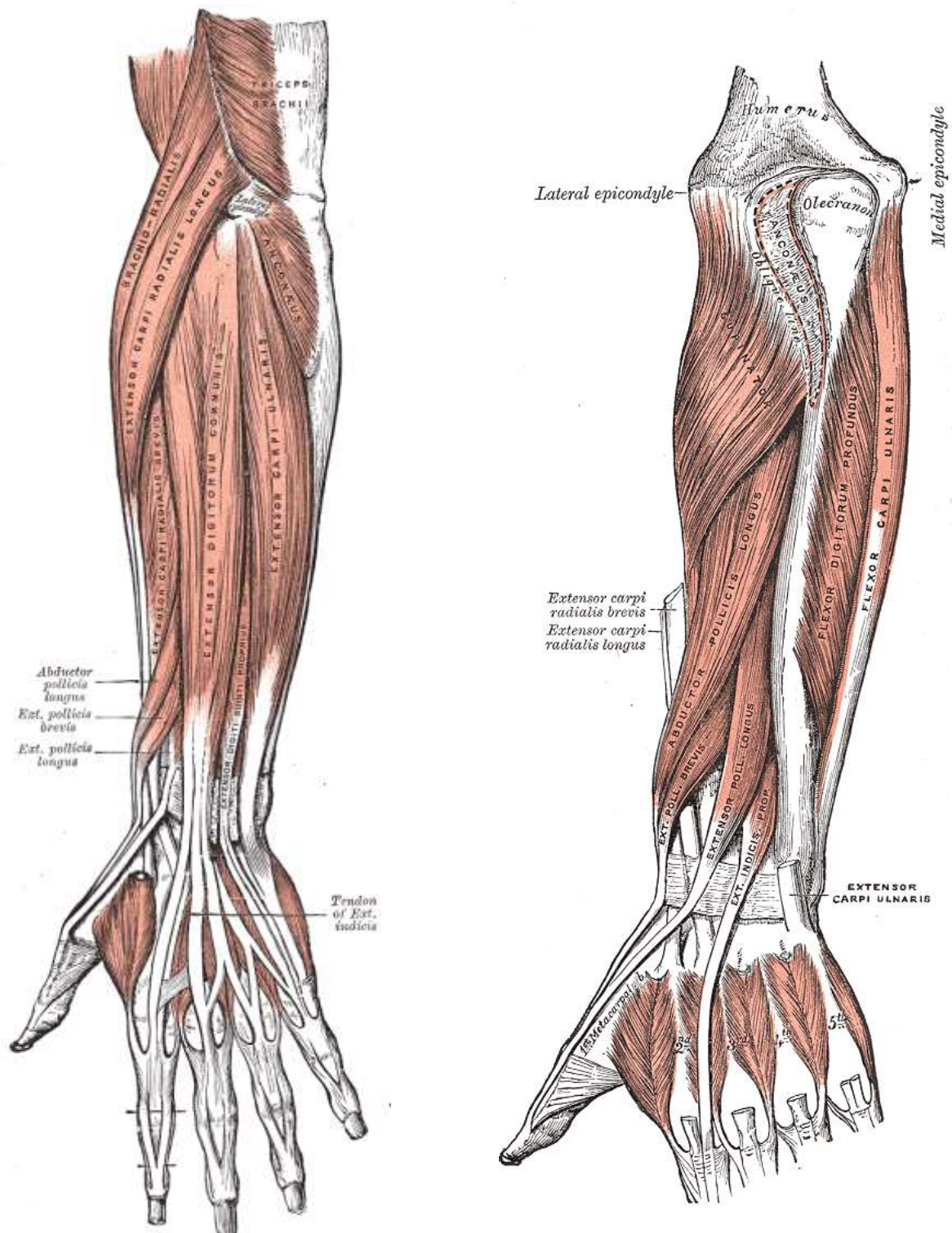


Fig. 100
Posterior antebrachial muscles
left upper limb

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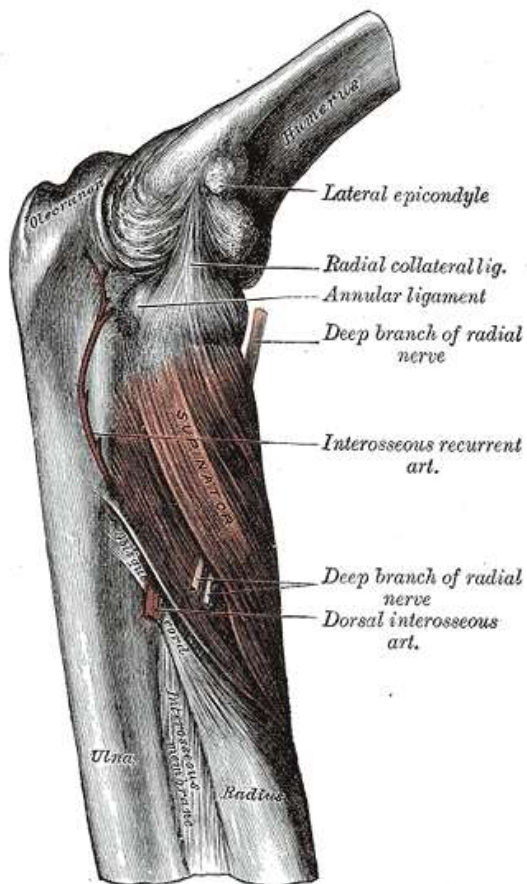


Fig. 101

Muscles of the forearm – posterior antebrachial muscles, supinator muscle

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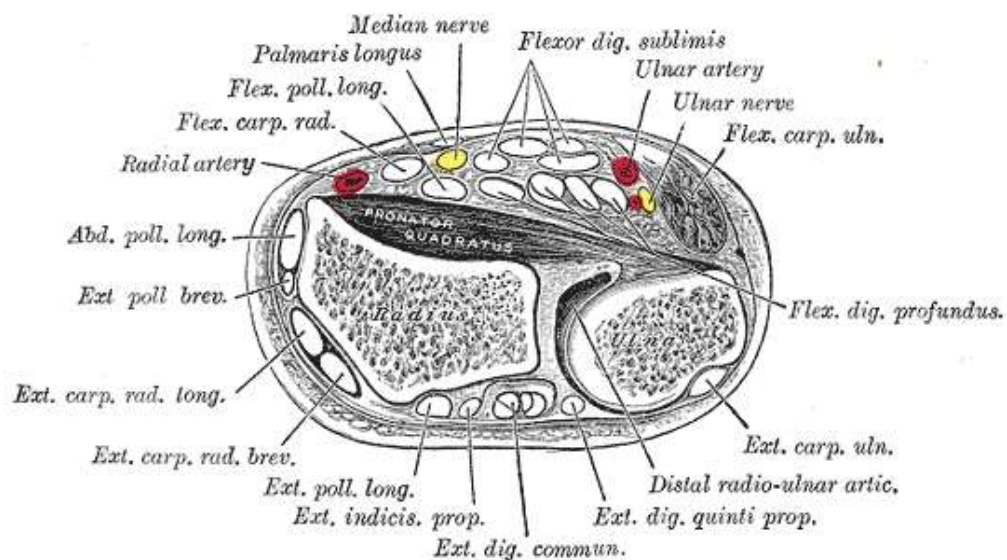


Fig. 102

Muscles of the forearm – transverse section across distal ends of ulna and radius

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MUSCLES OF THE HAND

Muscles of the hand are subdivided into two groups, **extrinsic** and **intrinsic** muscles. Extrinsic muscles belong to the muscles of the forearm. Majority of them insert into the hand by the long tendons so there are responsible for the movements of the joints of the hand and the digits. Extrinsic muscles of the hand control crude movements and produce a forceful grip. Intrinsic muscles of the hand are short muscles that originate and insert entirely within the area of the hand. These muscles are responsible for fine movements, precision grip and pinching. **Intrinsic muscles** include **thenar muscles**, **hypothenar muscles** and **intermediate muscles**.

THENAR MUSCLES

Thenar muscles are located at the base of the thumb and are responsible for the fine movements of the thumb and its opposite position to the fingers. Muscle bellies form a thenar eminence. Thenar muscles include **abductor pollicis brevis**, **opponens pollicis**, **flexor pollicis brevis** and **adductor pollicis** muscles. Abductor pollicis brevis lies superficially and forms lateral part of the thenar eminence. Adductor pollicis is a large triangular muscle. It has two heads and is a powerful adductor of the thumb. Flexor pollicis brevis is distal to abductor pollicis brevis.

Thenar muscles are nerve supplied by the **median** and the **ulnar nerve**.

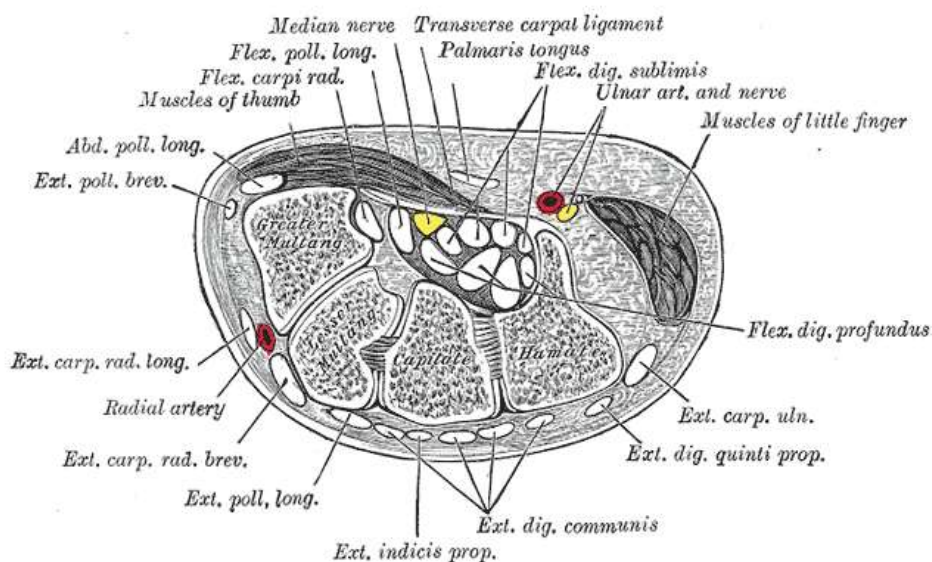


Fig. 103

Transverse section across the wrist and digits

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THENAR MUSCLES

ABDUCTOR POLLICIS BREVIS MUSCLE

Origin: scaphoid, trapezium, associated flexor retinaculum

Insertion: proximal phalanx of the thumb and extensor hood of the thumb

Function: abduction of the thumb

Nerve supply: median nerve

OPPONENS POLLICIS MUSCLE

Origin: trapezium, associated flexor retinaculum

Insertion: metacarpal bone I

Function: opposition of the thumb by medial rotation

Nerve supply: median nerve

FLEXOR POLLICIS BREVIS MUSCLE

Origin: trapezium, associated flexor retinaculum

Insertion: proximal phalanx of the thumb and extensor hood of the thumb

Function: flexion of the metacarpophalangeal joint of the thumb

Nerve supply: median nerve

ADDUCTOR POLLICIS MUSCLE

Origin: **transverse head** – metacarpal bone III

oblique head – capitate, metacarpal bone II + III

Insertion: proximal phalanx of the thumb and extensor hood of the thumb

Function: adduction of the thumb

Nerve supply: ulnar nerve

HYPOTHENAR MUSCLES

Hypothenar muscles are similar to the thenar in both name and organisation, however, they are located at the base of the little finger. These muscles form a hypothenar eminence, which is medially, smaller and less prominent than thenar eminence. Hypothenar muscles include **palmaris brevis**, **abductor digiti minimi**, **flexor digiti minimi brevis** and **opponens digiti muscles**. Palmaris brevis is a small subcutaneous muscle that overlies hypothenar muscles. It inserts into the skin on the medial margin of the hand. Opponens digiti minimi lies deep to the other muscles of this group.

Hypothenar muscles are nerve supplied by the **ulnar nerve**.

HYPOTHENAR MUSCLES

PALMARIS BREVIS MUSCLE

Origin: palmar aponeurosis, associated flexor retinaculum

Insertion: skin on the ulnar margin of the hand

Function: wrinkles the skin

Nerve supply: ulnar nerve

ABDUCTOR DIGITI MINIMI MUSCLE

Origin: pisiform

Insertion: proximal phalanx of the little finger

Function: abduction of the little finger at metacarpophalangeal joint

Nerve supply: ulnar nerve

FLEXOR DIGITI MINIMI BREVIS MUSCLE

Origin: hamate, associated flexor retinaculum

Insertion: proximal phalanx of the little finger

Function: flexion of the little finger at metacarpophalangeal joint

Nerve supply: ulnar nerve

OPPONENS DIGITI MINIMI MUSCLE

Origin: hamate, associated flexor retinaculum

Insertion: metacarpal bone V

Function: adduction and mild opposition of the little finger

Nerve supply: ulnar nerve

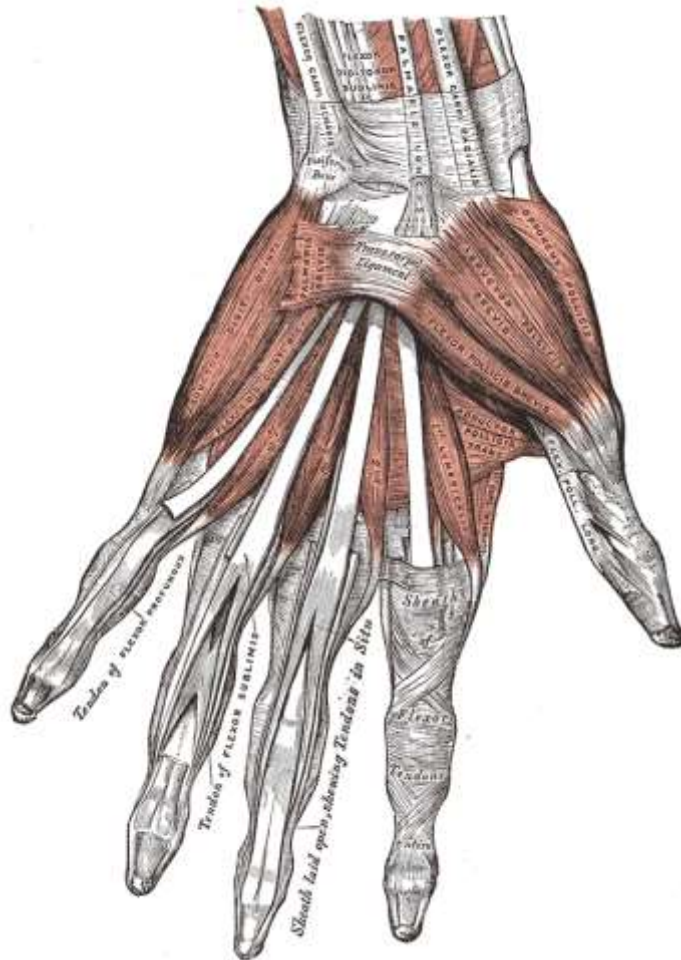


Fig. 104
Muscles of the hand
palmar view

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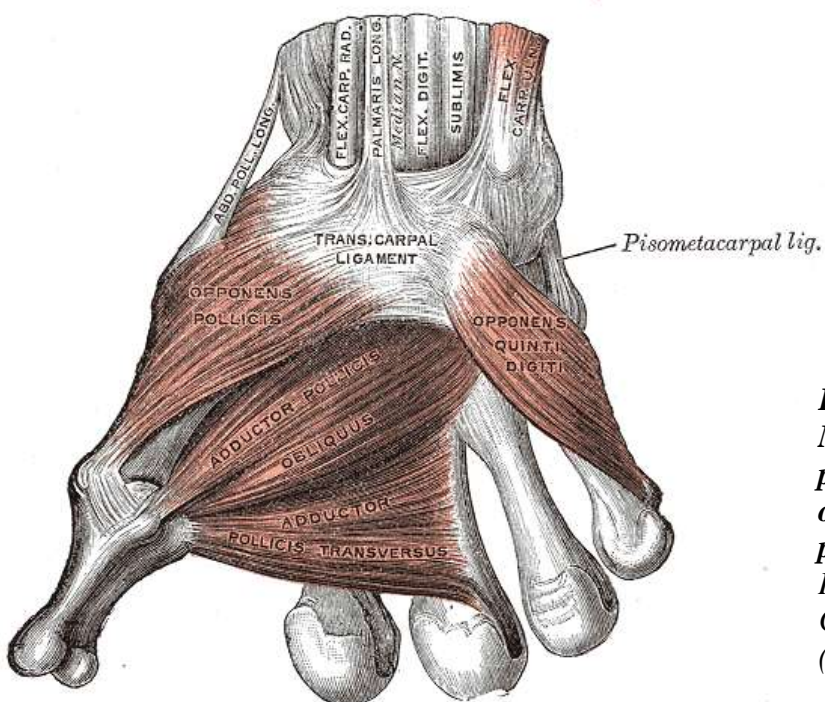


Fig. 105
Muscles of the hand – opponens pollicis, adductor pollicis and opponens digiti minimi
palmar view

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INTERMEDIATE MUSCLES

Intermediate muscles include **lumbrical, palmar** and **dorsal interossei muscles**. Lumbrical muscles (I – IV) are worm-like shaped and are associated with the four medial fingers. They arise from the tendons of flexor digitorum profundus and pass from palmar side around the lateral side of the finger into the back of the hand. They insert into the extensor hoods. Dorsal interossei are the most dorsally situated intrinsic muscles of the hand. There are four dorsal interossei muscles (1st – 4th), which are bipennate. Dorsal interossei muscles fill all intermetacarpal spaces. They originate from adjacent sides of metacarpal bones and act as abductors of the fingers. Palmar interossei are situated anterior to the dorsal interossei. There are three palmar interossei muscles (1st – 3rd), which are unipennate. They are placed in the 2nd, 3rd and 4th intermetacarpal spaces and act as adductors of the finger. Dorsal and palmar interossei muscles also act with lumbricals in flexing metacarpophalangeal joints and extending interphalangeal joints. All interossei muscles and medial two lumbricals are nerve supplied by the **ulnar nerve**. Lateral two lumbricals are innervated by the **median nerve**.

INTERMEDIATE MUSCLES OF THE HAND

LUMBRICAL MUSCLES

Origin: tendons of flexor digitorum profundus

Insertion: extensor hoods of medial four fingers

Function: flexion in the metacarpophalangeal joint and extension in the interphalangeal joint

Nerve supply: lateral two by median nerve, medial two by ulnar nerve

DORSAL INTEROSSEI MUSCLES

Origin: adjacent sides of the metacarpal bones (as bipennate muscles)

Insertion: extensor hoods and proximal phalanx of the second to the fourth fingers

Function: abduction of the fingers of the second to the fourth fingers from axial line

Nerve supply: ulnar nerve

PALMAR INTEROSSEI MUSCLES

Origin: medial or lateral sides of the second, fourth and fifth metacarpals

Insertion: extensor hoods and proximal phalanx of the second, fourth and fifth fingers

Function: adduction of the second, fourth and fifth fingers toward axial line

Nerve supply: ulnar nerve

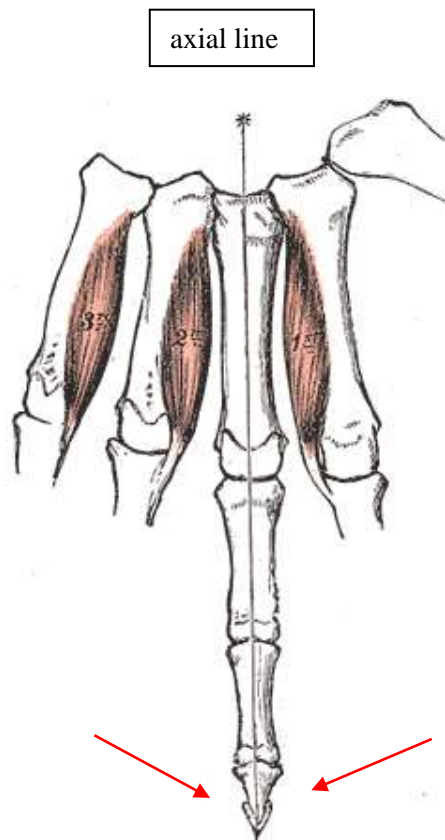


Fig. 106
Muscles of the hand – palmar
interossei muscles

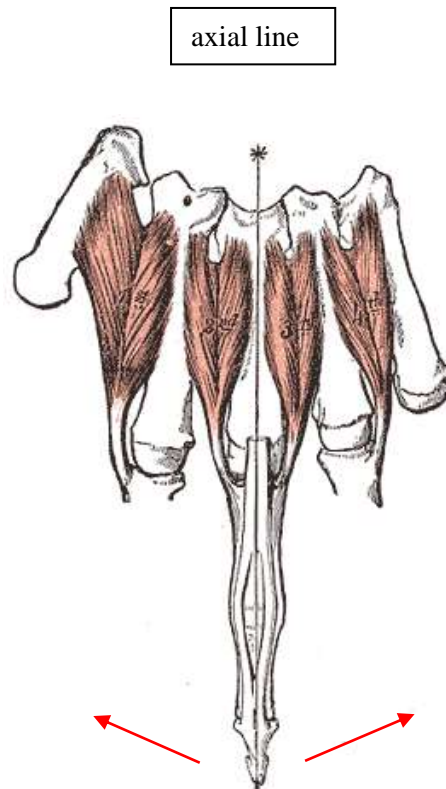


Fig. 107
Muscles of the hand – dorsal
interossei muscles

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FASCIAE, RETINACULA AND TENDON SHEATHS OF THE UPPER LIMB

Deltoid muscle is covered by **deltoid fascia**. It is attached superiorly to clavicle, acromion and spine of scapula and is continuous inferiorly with the brachial fascia on the arm and with the axillary fascia. The axillary fascia forms a floor of the axilla. Deltoid fascia bridges **deltopectoral triangle**, that contains cephalic vein. Subscapularis, supraspinatus and infraspinatus muscles are covered by the separate fasciae, with the same name. These deep fasciae are attached to the margins of the scapula and posteriorly to the spine of scapula that form separate **subscapular, supraspinous and infraspinous osseofibrous compartments**.

A deep fascia at the arm is **brachial fascia**. It is attached distally to the epicondyles of humerus and to olecranon of ulna. The arm is subdivided by the humerus and by two intermuscular septa into the **anterior (flexor)** and the **posterior (extensor) compartments of the arm**. Each compartment contains specific muscles, vessels and nerves. The intermuscular

septa of the arm are strong tendinous sheets that extend from deep surface of the brachial fascia to the periosteum of the humeral shaft and give origins for the muscle fibers. The **lateral intermuscular septum of the arm** extends from the attachment of deltoid muscle along lateral supraepicondylar ridge to lateral epicondyle of humerus. The **medial intermuscular septum of the arm** extends from the tendons of latissimus dorsi and teres major muscles along medial supraepicondylar ridge to medial epicondyle of humerus. Distally, brachial fascia is continuous with antebrachial fascia.

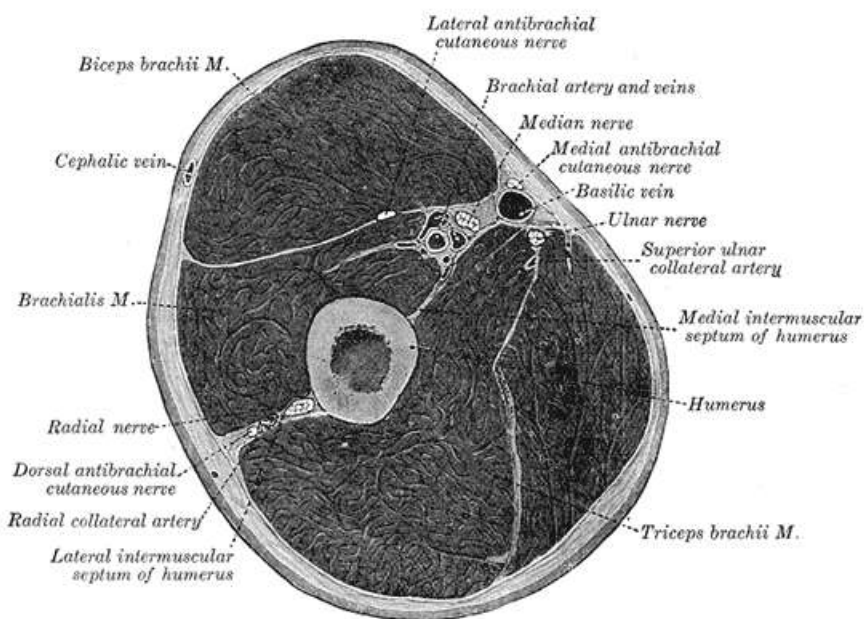


Fig. 108

Cross-section through the middle arm

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Muscles of the forearm are covered by **antebrachial fascia**. Proximally, it is stronger, firmly attached to the muscles and is thickened into aponeurosis of biceps brachii muscle. Proximally, it is attached to the epicondyles of humerus, olecranom of ulna and to the posterior border of ulna. Distally, it is attached to radius and ulna.

The forearm is subdivided into the **anterior (flexor)** and the **posterior (extensor) compartments of the forearm**. These compartments are separated by ulna, radius and interosseous membrane, by the lateral intermuscular septum and by the attachment of deep antebrachial fascia along the posterior border of the ulna. The lateral intermuscular septum extends from deep surface of antebrachial fascia to the periosteum of the anterior border of radius. Superficial flexors of anterior compartment (originating from medial epicondyle of

humerus) are separated from deep flexors (originating from ulna, radius and interosseous mebrane) by discreet deep layer of antebrachial fascia containing the median nerve. The posterior compartment includes a partially formed lateral (radial) part, which contains brachioradialis muscle. Posterior compartment is separated also by deep layer of antebrachial fascia into superficial and deep layers.

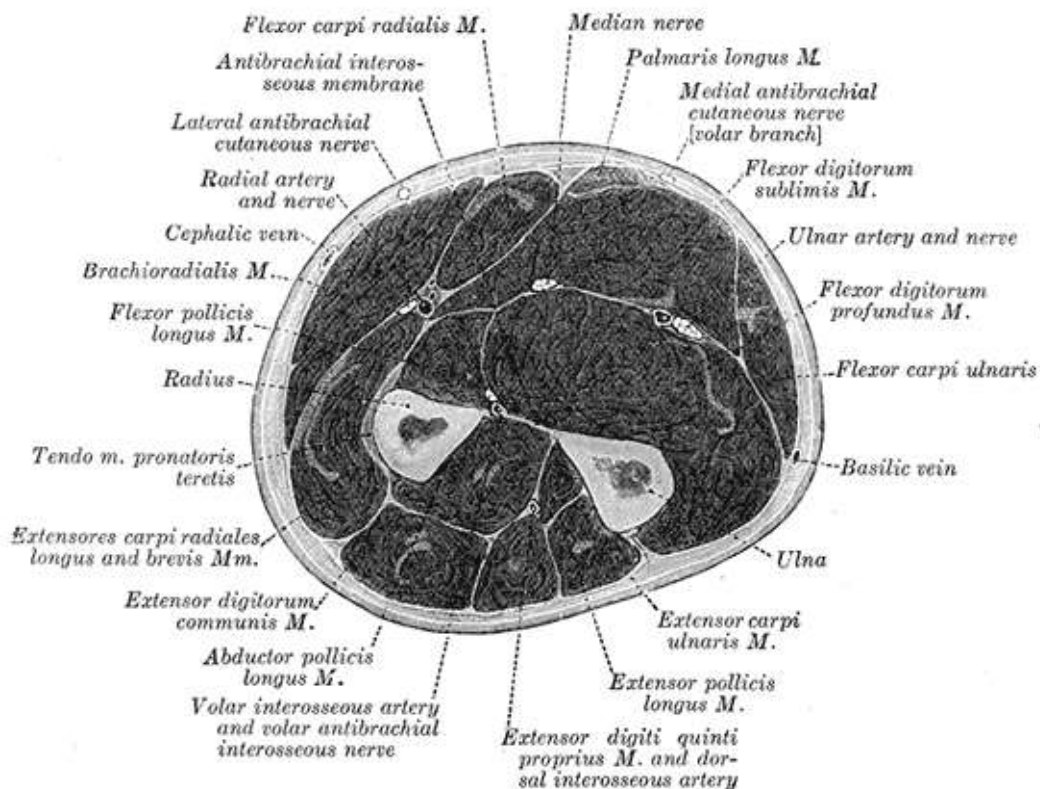


Fig. 109

Cross-section through the middle forearm

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Antebrachial fascia is thickened at the distal forearm forming **palmar carpal ligament**, **flexor retinaculum** (transverse carpal ligament) and **extensor retinaculum**. Palmar carpal ligament is stretched between styloid processes of ulna and radius overlying flexor tendons. Distally, it merges with flexor retinaculum. Retinacula of the antebrachial fascia keep the tendons of the muscles in position during bending of the hand and they provide stability and protection for the tendons.

The long tendons of the flexors are held to the bony plane by **flexor retinaculum** (transverse carpal ligament). It is a thick ligament (strong band), that bridges carpal arch between carpal eminences and converts the arch into the carpal tunnel. Tendons of the flexors

are enveloped by the **synovial sheaths**, which begin at the distal forearm and pass beneath flexor retinaculum. There is separate sheath of flexor pollicis longus and sheath of flexor carpi radialis muscles. These sheaths surround and accompany tendons of the muscles to their insertions. Tendons of flexor digitorum superficialis and profundus are surrounded by the common synovial sheath. It begins proximal to flexor retinaculum and passes through the carpal tunnel. At the level of the shaft of metacarpal bones, common synovial sheath is narrowed and continues distally, without interruption, only as digital synovial sheath for the little finger. It terminates on distal phalanx of the little finger. The common synovial sheath for tendons of the second, third and fourth fingers is interrupted in the middle of metacarpus. Tendons are enveloped again by the separate digital synovial sheaths extending from metacarpophalangeal joints to the distal phalanges, where the flexor digitorum profundus is inserted. Flexor retinaculum continuous with extensor retinaculum.

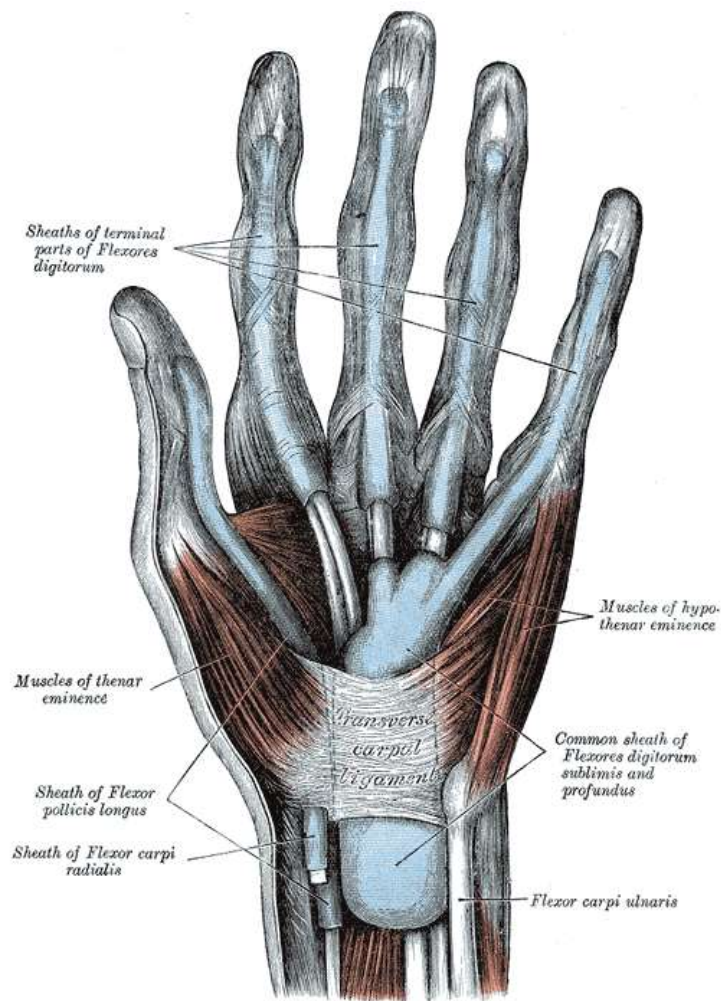


Fig. 110
Flexor retinaculum and tendon sheaths of the hand
palmar view

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Extensor retinaculum passes on the back of the forearm. It is extended between styloid process of the ulna and pisiform bone situated medially and lateral positioned radius. It is also attached to the ridges on the dorsal surface of radius. Extensor retinaculum retains the long tendons of the extensors and the tendon of the abductor pollicis longus in position. The tendons beneath extensor retinaculum are enveloped by separate synovial sheaths, that pass through six small osseofascial tunnels.

From lateral to medial side, there are **synovial sheaths** which surround tendons of following muscles:

- abductor pollicis longus with extensor pollicis brevis muscles
- extensor carpi radialis longus and brevis muscles
- extensor pollicis longus muscle
- extensor digitorum and extensor indicis muscles
- extensor digiti minimi muscle
- extensor carpi ulnaris muscle.

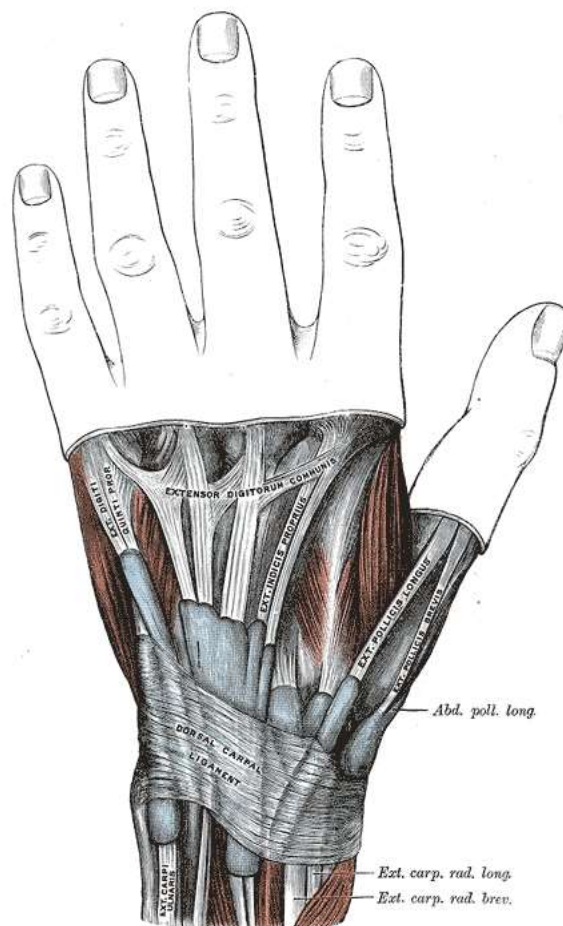


Fig. 111
Extensor retinaculum and tendon sheaths of the hand
dorsal view

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Antebrachial fascia continuous with **fasciae of the hand** – **deep fascia of the palm (palmar fascia)** and **deep fascia of the dorsum of the hand**. Distally, fasciae of the hand terminate at the level of metacarpophalangeal joints. Palmar fascia merges with fibrous digital sheaths, dorsal fascia of the hand merges with dorsal digital expansion (extensor hoods).

Superficial layer of palmar fascia overlying the thenar and hypothenar muscles is termed **thenar fascia** and **hypothenar fascia**. Thenar fascia is attached to the lateral side of the thumb and hypothenar fascia is attached to the medial side of the little finger. **Central part** of palmar fascia is thickened to form triangular-shaped **palmar aponeurosis** which protects underlying tendons and neurovascular structures. The palmar aponeurosis is continuous with the palmaris longus muscle. Proximally, it is attached to the flexor retinaculum, on the sides merges into thenar and hypothenar fasciae. Distally it fans out and its longitudinal fibers radiate towards the digits. **Deep layer of palmar fascia (palmar interosseous fascia)** interconnects palmar side of metacarpal bones and covers interosseous muscles.

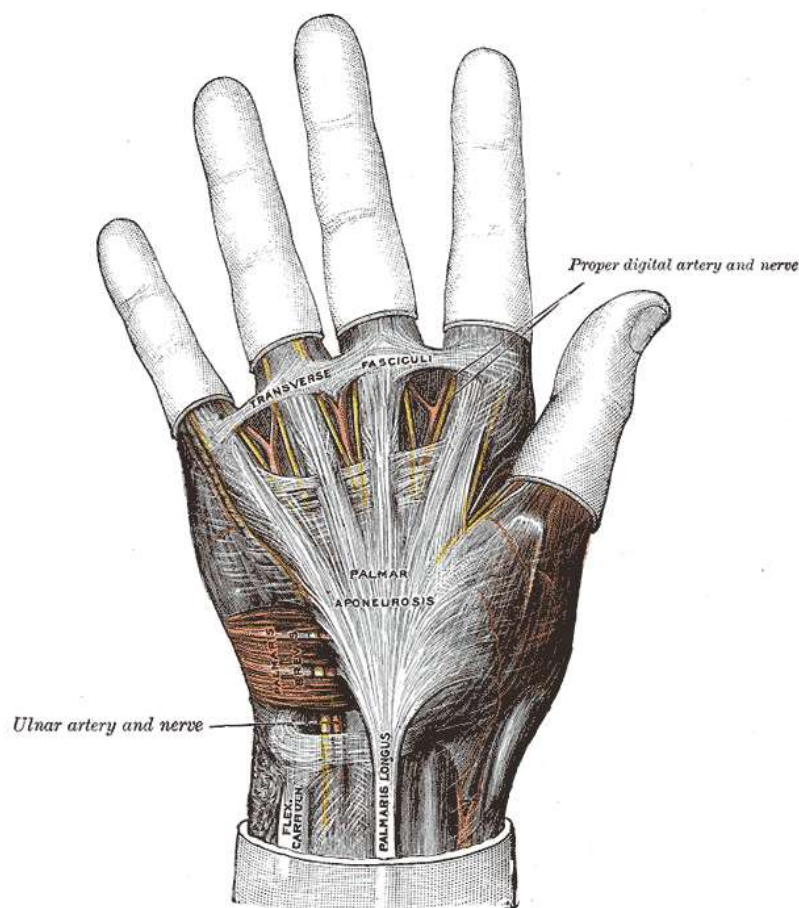


Fig. 112

Palmar aponeurosis

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Fascia of the dorsum of the hand has three layers – superficial, intertendinous and interosseous. **Superficial layer** is continuous with thenar fascia at the lateral border of the hand attaching to the first metacarpal bone. It also continuous with hypothenar fascia at the medial border of the hand attaching to the fifth metacarpal bone. **Intertendinous layer** is thin and interconnects tendons of the muscles on the dorsum of hand. **Interosseous layer (dorsal interosseous fascia)** interconnects dorsal side of metacarpal bones and covers interosseous muscles.

The space of the palm of the hand between the superficial and deep layers of palmar fascia is subdivided by the radial and ulnar osteofascial septa into three **compartments** – **thenar**, **hypothenar** and **central**. Radial septum extends from radial side of superficial palmar fascia to the third metacarpal bone. Ulnar septum extends from medial side of superficial palmar fascia to the fifth metacarpal bone. Central compartment is a space beneath palmar aponeurosis and above palmar interosseous fascia. It is extended between radial and ulnar osteofascial septa. Central compartment contains tendons of flexor digitorum superficialis and profundus and lumbrical muscles, the vessels and nerves and communicates with the carpal tunnel. Palmar and dorsal interosseous fasciae enclose interosseous spaces of the hand between metacarpals, that contain dorsal and palmar interosseous muscles.

MUSCLES CONNECTING UPPER LIMB TO VERTEBRAL COLUMN

Muscles connecting the upper limb to vertebral column are the part of the muscles of the back (musculi dorsi). Exactly, they form superficial group of extrinsic muscles of the back. These muscles are located in the back region but originate embryologically from locations other than the back. They primarily produce and control the movements of the upper limb. This group includes **trapezius**, **latissimus dorsi**, **rhomboid major** and **minor** and **levator scapulae** muscles.

Muscles of this group stabilize the pectoral girdle and attach it to the axial skeleton. They move scapula and the arm at the shoulder joint. Trapezius is flat, wide, triangular muscle on the posterior aspect of the neck and on the superior half of the trunk. It consists of three parts (superior or descending, middle or transverse and inferior or ascending part) that act together to position the scapula and clavicle. Trapezius and latissimus dorsi muscles lie the most superficially, rhomboids and levator scapulae are located deep to trapezius. Latissimus dorsi muscle forms a posterior border of the axilla.

Muscles connecting the upper limb to vertebral column are nerve supplied by the nerves of **supraclavicular part** of the **brachial plexus**, except for trapezius muscle, which is innervated by the **accessory nerve** (cranial nerve XI).

Trapezius muscle is enclosed by **nuchal fascia**. Fascia separates trapezius from deeper located cervical muscles. Nuchal fascia is a part of **superficial layer of the cervical fascia** and it blends anteriorly to the prevertebral fascia and medially is connected with the nuchal ligament. At the back, the nuchal fascia continues inferiorly as **thoracolumbar fascia**. The superficial layer of thoracolumbar fascia forms the aponeurotic origin for the latissimus dorsi muscle.

MUSCLES CONNECTING UPPER LIMB TO VERTEBRAL COLUMN

TRAPEZIUS MUSCLE

Origin: superior nuchal line, external occipital protuberance, spinous processes of the cervical and thoracic vertebrae

Insertion: clavicle, acromion and spine of scapula

Function: elevation, retraction (adduction), depression of scapula

assists in rotating of scapula during abduction of humerus above horizontal

Nerve supply: accessory nerve

LATISSIMUS DORSI MUSCLE

Origin: spinous processes of TVII to LV, sacrum, iliac crest, thoracolumbar fascia

Insertion: lesser tubercle, exactly – medial lip of intertubercular sulcus

Function: adduction, pronation (medial rotation), extension of the arm

Nerve supply: thoracodorsal nerve

RHOMBOID MINOR MUSCLE

Origin: spinous processes of CVI to TI

Insertion: medial border of scapula

Function: retraction (adduction) and elevation of scapula

Nerve supply: dorsal scapular nerve

RHOMBOID MAJOR MUSCLE

Origin: spinous processes of TII to TV

Insertion: medial border of scapula

Function: retraction (adduction) and elevation of scapula

Nerve supply: dorsal scapular nerve

LEVATOR SCAPULAE MUSCLE

Origin: transverse processes of CI to CIV

Insertion: superior angle of scapula

Function: elevation of scapula

Nerve supply: dorsal scapular nerve

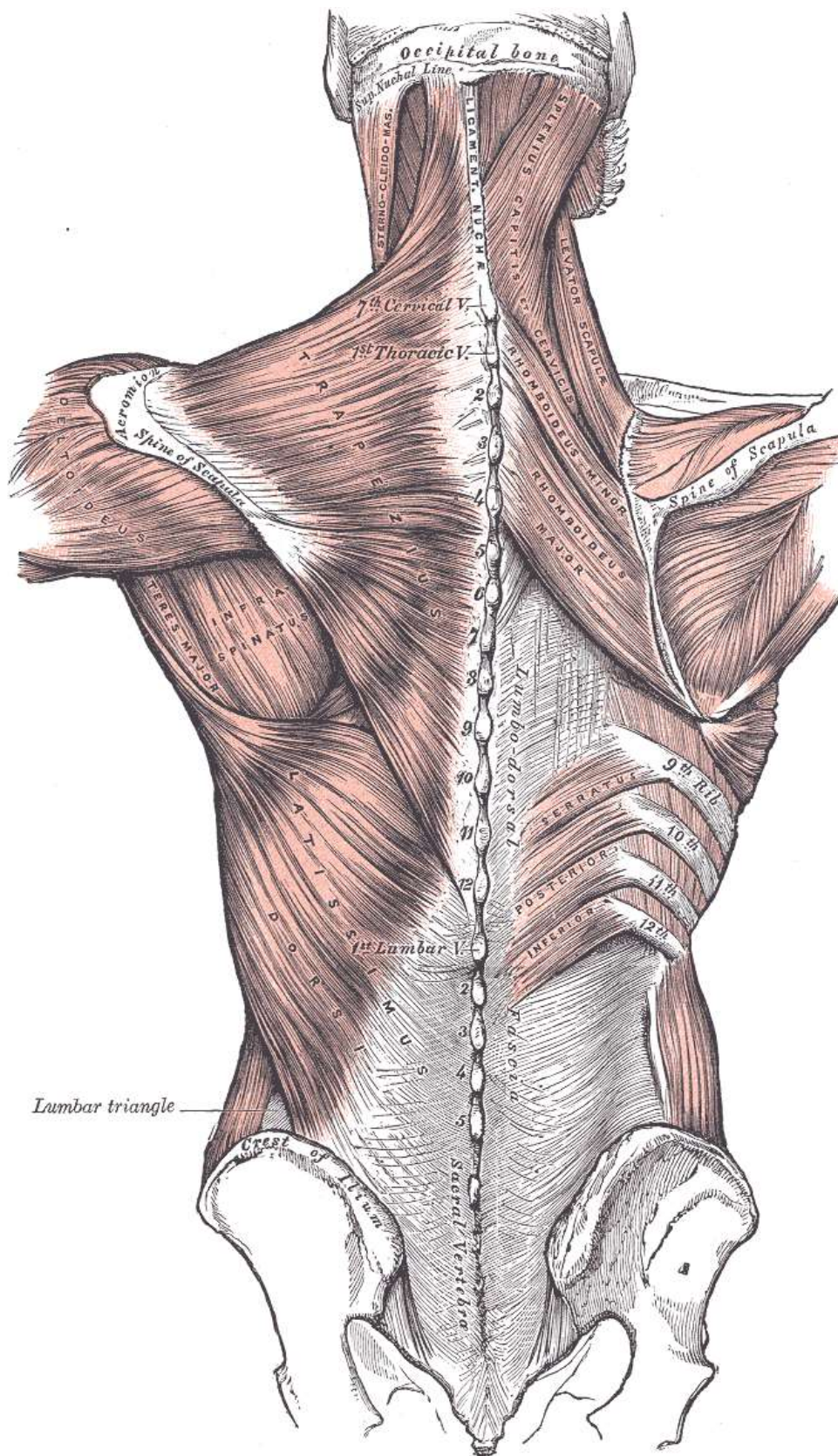


Fig. 113
Muscles connecting the upper limb to vertebral column
posterior view
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MUSCLES CONNECTING UPPER LIMB TO ANTERIOR AND LATERAL THORACIC WALLS

Muscles connecting upper limb to anterior and lateral thoracic walls include **pectoralis major** and **minor**, **subclavius** and **serratus anterior muscles**.

These muscles stabilize pectoral girdle and attach it to the thoracic walls. Muscles move clavicle, scapula and they also move the arm at the shoulder joint. Pectoralis major is a large and fan-shaped muscle that covers superior and anterior part of the thorax. It is the most superficial muscle in the pectoral region. Both pectoralis muscles and serratus anterior muscle border the axilla. The attachment of pectoralis minor to coracoid process of scapula bridges the space through which the vessels and nerves pass into the arm.

Muscles connecting upper limb to anterior and lateral thoracic walls are nerve supplied by the nerves of **supraclavicular part** of the **brachial plexus**.

The pectoralis major muscle is covered by **pectoral fascia**. This fascia covers the anterior and lateral thoracic wall and it is attached to sternum and clavicle. It encloses pectoralis major muscle. Pectoral fascia is continuous superiorly with the cervical fascia, inferiorly with the fascia of the anterior abdominal wall and laterally with the brachial and deltoid fasciae. Inferiorly, from the lateral border of pectoralis major muscle pectoral fascia continues as **axillary fascia**. Axillary fascia forms the floor of the axilla and it is continuous with brachial fascia and with the fascia of the latissimus dorsi and serratus anterior muscles.

Clavipectoral fascia located beneath the pectoralis major is thick. It is attached to clavicle above and to axillary fascia below. Clavipectoral fascia encloses pectoralis minor and subclavius muscles and it is pierced by neurovascular structures that pass between the axillary fossa and anterior wall of the axilla (cephalic vein, thoracoacromial artery and lateral pectoral nerve).

MUSCLES CONNECTING UPPER LIMB TO ANTERIOR AND LATERAL THORACIC WALLS

PECTORALIS MAJOR MUSCLE

Origin: clavicle, sternum, first seven costal cartilages, aponeurosis of obliquus externus abdominis muscle

Insertion: greater tubercle, exactly – lateral lip of intertubercular sulcus of humerus

Function: adduction, pronation (medial rotation) and flexion of the arm

Nerve supply: pectoral nerves

PECTORALIS MINOR MUSCLE

Origin: rib III – V

Insertion: coracoid process of scapula

Function: protraction of scapula, depression of the tip of the shoulder

Nerve supply: pectoral nerves

SUBCLAVIUS MUSCLE

Origin: rib I

Insertion: clavicle

Function: stabilizes clavicle and sternoclavicular joint

Nerve supply: subclavian nerve

SERRATUS ANTERIOR MUSCLE

Origin: ribs I – IX

Insertion: medial border of scapula

Function: protraction and rotation of scapula

Nerve supply: long thoracic nerve

Pectoralis major muscle is illustrated in Fig. 97.

Pectoralis minor, serratus anterior and subclavius muscles are illustrated in Fig. 98.

MUSCLES OF THE LOWER LIMB

Muscles of the lower limb are subdivided to the groups in accordance with the topographic regions (see table 8).

MUSCLES OF THE LOWER LIMB		
MUSCLES OF THE ILIAC REGION		<i>iliopsoas m.</i> <i>psoas minor m.</i>
MUSCLES OF THE GLUTEAL REGION	gluteal mm. superficial group	<i>gluteus maximus m.</i> <i>gluteus medius m.</i> <i>gluteus minimus m.</i>
	pelvitrochanteric mm. deep group	<i>piriformis m.</i> <i>obturator internus m.</i> <i>gemellus superior m.</i> <i>gemellus inferior m.</i> <i>quadratus femoris m.</i>
MUSCLES OF THE THIGH	anterior femoral mm.	<i>tensor fasciae latae m.</i> <i>sartorius m.</i> <i>quadriceps femoris m.</i>
	medial femoral mm.	<i>pectineus m.</i> <i>gracilis m.</i> <i>adductor longus m.</i> <i>adductor brevis m.</i> <i>adductor magnus m.</i> <i>obturator externus m.</i>
	posterior femoral mm.	<i>semitendinosus m.</i> <i>semimebranosus m.</i> <i>biceps femoris m.</i>
MUSCLES OF THE LEG	anterior crural mm.	<i>tibialis anterior m.</i> <i>extensor hallucis longus m.</i> <i>extensor digitorum longus m.</i> <i>fibularis (peroneus) tertius m.</i>
	lateral crural mm.	<i>fibularis (peroneus) longus m.</i> <i>fibularis (peroneus) brevis m.</i>
	posterior crural mm.	<i>triceps surae m.</i> <i>plantaris m.</i> <i>popliteus m.</i> <i>tibialis posterior m.</i> <i>flexor digitorum longus m.</i> <i>flexor hallucis longus m.</i>
MUSCLES OF THE FOOT	dorsal mm.	<i>extensor digitorum brevis m.</i> <i>extensor hallucis brevis m.</i>
	plantar mm.	<i>flexor digitorum brevis m.</i> <i>quadratus plantae m.</i> <i>lumbrical mm.</i> <i>interosseal mm.</i> <i>abductor hallucis m.</i> <i>flexor hallucis brevis m.</i> <i>adductor hallucis m.</i> <i>abductor digiti minimi m.</i> <i>flexor digiti minimi m.</i>

Tab. 8 Muscles of the lower limb

MUSCLES OF THE ILIAC REGION

Three muscles of the iliac region, **iliacus muscle, psoas major and minor muscles**, are related to the iliac fossa. They run around the ventral aspect of the hip joint. All these muscles are nerve supplied by the nerve fibres arising from lumbar plexus.

Psoas major muscle is fusiform in shape and passes on the side of the lumbar part of vertebral column. Iliacus muscle is flat and triangular occupying the iliac fossa. Iliacus and psoas major muscles converge and run through lacuna musculorum, the lateral part of subinguinal hiatus. Both they are inserted at lesser trochanter forming a common functional unit – iliopsoas muscle.

Psoas minor muscle is very often absent, it can be found approximately in 60% of subjects. It runs in front of the psoas major muscle and reaches the iliac fascia above the iliopectineal eminence.

MUSCLES OF THE ILIAC REGION

ILIACUS MUSCLE

Origin: iliac fossa

Insertion: lesser trochanter

PSOAS MAJOR MUSCLE

Origin: vertebral bodies and transverse processes of TXII- LV

Insertion: lesser trochanter

ILIACUS M. + PSOAS MAJOR M. = ILIOPSOAS MUSCLE

Function: flexion of the hip joint, both sides contraction raises the trunk from lying to sitting position

Nerve supply: femoral nerve + fibres from lumbar plexus

PSOAS MINOR MUSCLE

Origin: vertebra TXII - LI

Insertion: iliac fascia or iliopectineal eminence

Function: very poor flexion of the trunk

Nerve supply: fibres from lumbar plexus

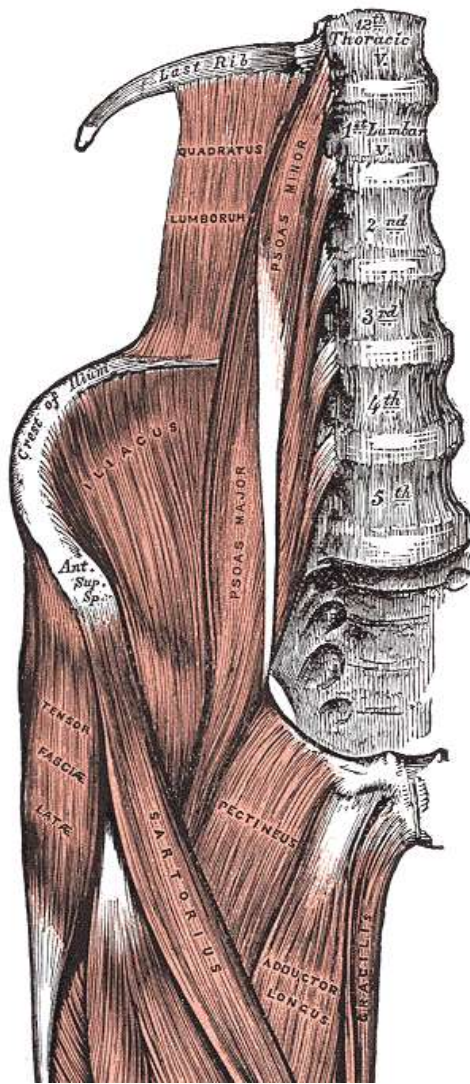


Fig. 114

Muscles of the right iliac region

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MUSCLES OF THE GLUTEAL REGION

Muscles of the gluteal region include **superficial group** of large **gluteal muscles** (gluteus maximus, medius and minimus) and **deep group** containing small **pelvitrochanteric muscles** situated below the gluteus maximus muscle.

Gluteal muscles originate mainly from the gluteal (lateral) surface at the ala of ilium and they are inserted at the area around the greater trochanter. They act as **extensors, abductors and rotators of the hip joint (thigh)**.

Gluteus maximus is the most superficial of all gluteal muscles. Its fibres have laterodistal direction. **Gluteus medius** is covered by gluteus maximus, except its anterior part which is covered by deep fascia. **Gluteus minimus** is the deepest fan-shaped muscle lying below the gluteus medius. Gluteus medius and minimus muscle fibres converge distally and

both insert at the greater trochanter. Gluteal muscles are innervated by **superior and inferior gluteal nerves** from **sacral plexus**.

MUSCLES OF THE GLUTEAL REGION – SUPERFICIAL GROUP

GLUTEUS MAXIMUS MUSCLE

Origin: gluteal surface of the iliac ala, lower dorsal part of sacrum and margin of coccyx

Insertion: gluteal tuberosity and iliotibial tract

Function: extension, abduction and supination of the thigh (hip joint)

Nerve supply: inferior gluteal nerve

GLUTEUS MEDIUS MUSCLE

Origin: gluteal surface of the iliac ala

Insertion: greater trochanter

Function: abduction, pronation and supination of the thigh

Nerve supply: superior gluteal nerve

GLUTEUS MINIMUS MUSCLE

Origin: gluteal surface of the iliac bone

Insertion: greater trochanter

Function: abduction, pronation and supination of the thigh

Nerve supply: superior gluteal nerve

TENSOR FASCIAE LATAE MUSCLE

Origin: anterior superior iliac spine and outer lip of iliac crest anteriorly

Insertion: iliotibial tract

Function: tightens fascia lata femoris and stabilizes the knee in extension

Nerve supply: superior gluteal nerve

Pelvitrochanteric muscles originate from the bones of pelvis and insert to the area of greater trochanter. **Piriformis muscle** is the most cranially situated pelvitrochanteric muscle. It runs through the greater sciatic foramen subdividing it to the suprapiriform and infrapiriform foramen. These foramina are traversed by the vessels and nerves running from the pelvis to lower limb. **Obturator internus muscle** originates from the inner surface of obturator membrane and its tendon turns below ischial spine continuing through the lesser sciatic foramen to trochanteric fossa. **Gemellus superior and inferior** muscles run above and below the tendon of obturator internus in lesser sciatic foramen. Square – shaped **quadratus femoris muscle** is the most distal pelvitrochanteric muscle.

The main function of pelvitrochanteric muscles is **supination** (lateral rotation) **of the thigh**. These muscles are nerve supplied by the **fibres of sacral plexus**.

MUSCLES OF THE GLUTEAL REGION – DEEP GROUP

PIRIFORMIS MUSCLE

Origin: pelvic surface of sacrum

Insertion: greater trochanter

Function: supination and abduction of the thigh (hip joint)

Nerve supply: fibres of sacral plexus

OBTURATOR INTERNUS MUSCLE

Origin: pelvic (internal) surface of obturator membrane

Insertion: trochanteric fossa

Function: supination and abduction of the thigh (hip joint)

Nerve supply: fibres of sacral plexus

GEMELLUS SUPERIOR MUSCLE

Origin: ischial spine

Insertion: trochanteric fossa

Function: supination of the thigh

Nerve supply: fibres of sacral plexus

GEMELLUS INFERIOR MUSCLE

Origin: upper part of ischial tuberosity

Insertion: trochanteric fossa

Function: supination of the thigh

Nerve supply: fibres of sacral plexus

QUADRATUS FEMORIS MUSCLE

Origin: ischial tuberosity

Insertion: intertrochanteric crest

Function: supination and adduction of the thigh

Nerve supply: fibres of sacral plexus

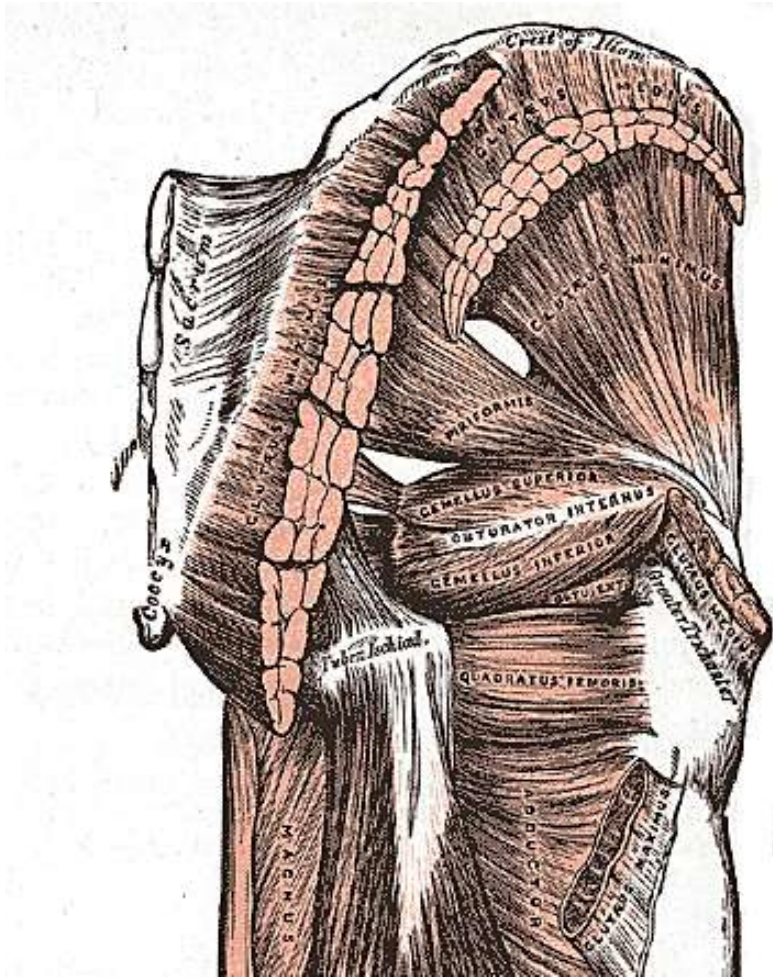


Fig. 115

Muscles of the gluteal region
right lower limb

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MUSCLES OF THE THIGH

The thigh forms three compartments (muscle groups): **anterior, middle and posterior.**

Anterior group includes **sartorius muscle** and **quadriceps femoris muscle**. **Sartorius** is the longest muscle in the human body. It has only weak function in walking, however, significant role in climbing. **Quadriceps femoris muscle**, consisting of four heads (**rectus femoris muscle**, **vastus medialis**, **vastus lateralis** and **vastus intermedius**), is the huge **extensor of the knee joint (leg)**.

Both muscles are nerve supplied by the **femoral nerve**.

ANTERIOR FEMORAL MUSCLES

SARTORIUS MUSCLE

Origin: anterior superior iliac spine

Insertion: by aponeurosis inferomedially to the tibial tuberosity (together with gracilis and semitendinosus tendons it forms pes anserinus - „goose foot“)

Function: flexion, abduction and supination of the thigh, flexion and pronation of the leg

Nerve supply: femoral nerve

QUADRICEPS FEMORIS MUSCLE

Origin: rectus femoris - anterior inferior iliac spine

vastus medialis - dorsal surface of femoral shaft - medial lip of line aspera

vastus lateralis - dorsal surface of femoral shaft - lateral lip of line aspera

vastus intermedius - ventral surface of femoral shaft

Insertion: tibial tuberosity (the tendon contains the largest sesamoid bone – patella)

Function: extension of the leg (knee joint), rectus femoris also helps in flexion of the thigh

Nerve supply: femoral nerve

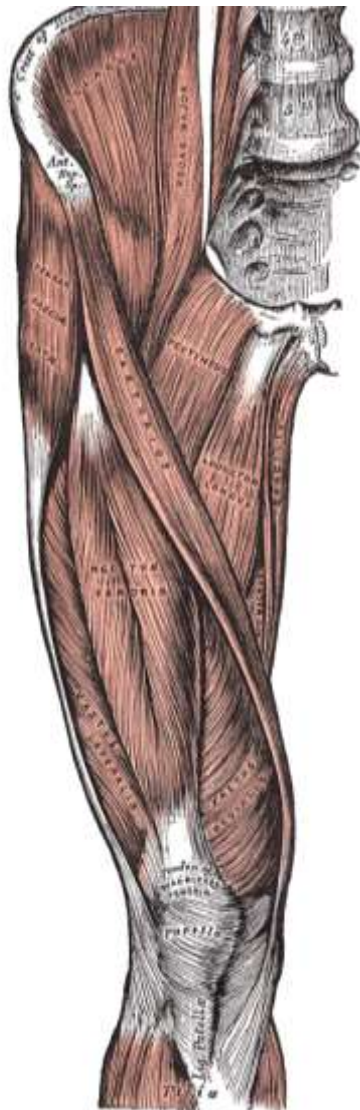


Fig. 116

Anterior femoral muscles

right lower limb

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Medial compartment contains **gracilis, pectineus, obturator externus, adductor longus, brevis and magnus muscles**. Medial femoral muscles originate from superior and inferior ramus of pubis, ramus of ischium, ischial tuberosity and obturator membrane. Majority of the muscles are inserted to the dorsal aspect of the femoral shaft.

Their main function is **adduction of the thigh**, however, some of them are also pronators of the thigh (adductor longus, adductor magnus) and some are supinators (obturator externus, adductor magnus).

Medial femoral muscles are nerve supplied by the **obturator nerve**.

Two muscles are **diploneural** (supplied by two nerves), **pectineus** innervated by the **obturator and femoral nerve**, and **adductor magnus** innervated by **the obturator and sciatic nerve**.

MEDIAL FEMORAL MUSCLES

PECTINEUS MUSCLE

Origin: pecten of pubis at superior ramus of pubis

Insertion: pectineal (spiral) line at the femur

Function: adduction of the thigh

Nerve supply: femoral and obturator nerve

GRACILIS MUSCLE

Origin: pubis - closely to pubic symphysis

Insertion: inferomedially to the tibial tuberosity (together with sartorius and semitendinosus tendons it forms pes anserinus - „goose foot“)

Function: adduction of the thigh, it helps in flexion of the knee joint (leg)

Nerve supply: obturator nerve

ADDUCTOR LONGUS MUSCLE

Origin: pubis – closely to pubic symphysis

Insertion: medial lip of linea aspera at the dorsal surface of femur

Function: adduction and pronator of the thigh (hip joint)

Nerve supply: obturator nerve

ADDUCTOR BREVIS MUSCLE

Origin: inferior ramus of pubis

Insertion: medial lip of linea aspera at the dorsal surface of femur

Function: adduction of the thigh (hip joint)

Nerve supply: obturator nerve

ADDUCTOR MAGNUS MUSCLE

Origin: inferior ramus of pubis, ischial tuberosity

Insertion: medial lip of linea aspera, adductor tubercle

Function: adduction of the thigh (hip joint), weak rotation of the thigh (hip joint)

Nerve supply: obturator and sciatic nerve

OBTURATOR EXTERNUS MUSCLE

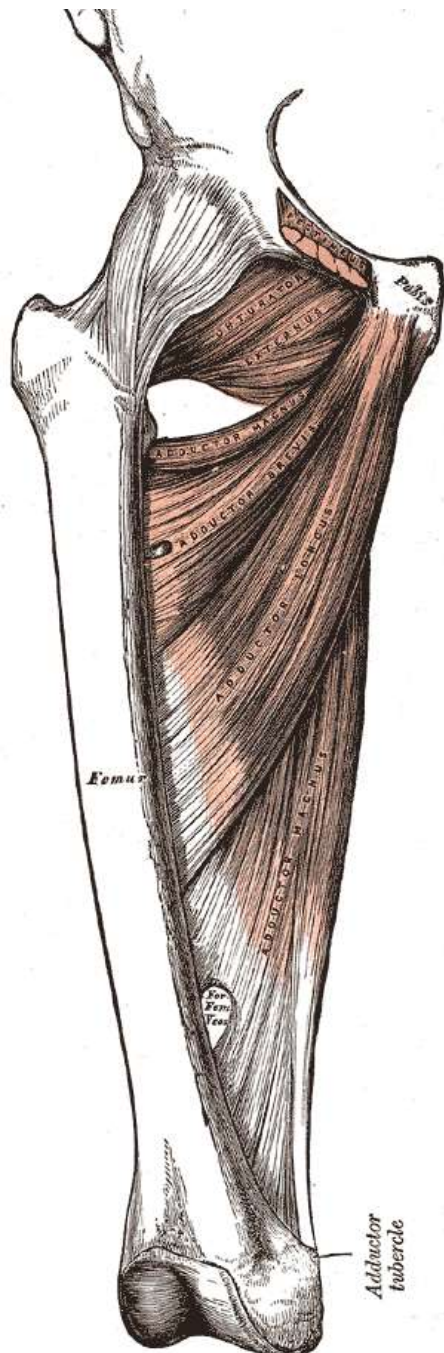
Origin: external surface of obturator membrane

Insertion: trochanteric fossa

Function: supination of the thigh (hip joint)

Nerve supply: obturator nerve

Fig. 117



Medial femoral muscles

right lower limb

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Posterior compartment includes **semitendinosus, semimembranosus and biceps femoris muscle**. These muscles are also known as **harmstrings**.

Their main function is **flexion of the knee joint and extension in the hip joint**. They originate from the ischial tuberosity. Semitendinosus and semimembranosus run more medially in this compartment, biceps femoris more laterally.

Posterior femoral muscles are nerve supplied by the **sciatic nerve**.

POSTERIOR FEMORAL MUSCLES

BICEPS FEMORIS MUSCLE

Origin: **long head** – ischial tuberosity
short head – lateral lip of linea aspera

Insertion: head of fibula

Function: extension of the thigh (hip joint), flexion of the leg (knee joint)

Nerve supply: sciatic nerve

SEMITENDINOSUS MUSCLE

Origin: ischial tuberosity

Insertion: inferomedially to the tibial tuberosity (together with sartorius and gracilis tendons it forms pes anserinus - „goose foot“)

Function: extension of the thigh (hip joint), flexion of the leg (knee joint), pronation of thigh and leg

Nerve supply: sciatic nerve

SEMIMEBRANOSUS MUSCLE

Origin: ischial tuberosity

Insertion: medial and posterior surface of medial tibial condyle

Function: extension of the thigh (hip joint), flexion of the leg (knee joint), pronation of thigh and leg

Nerve supply: sciatic nerve

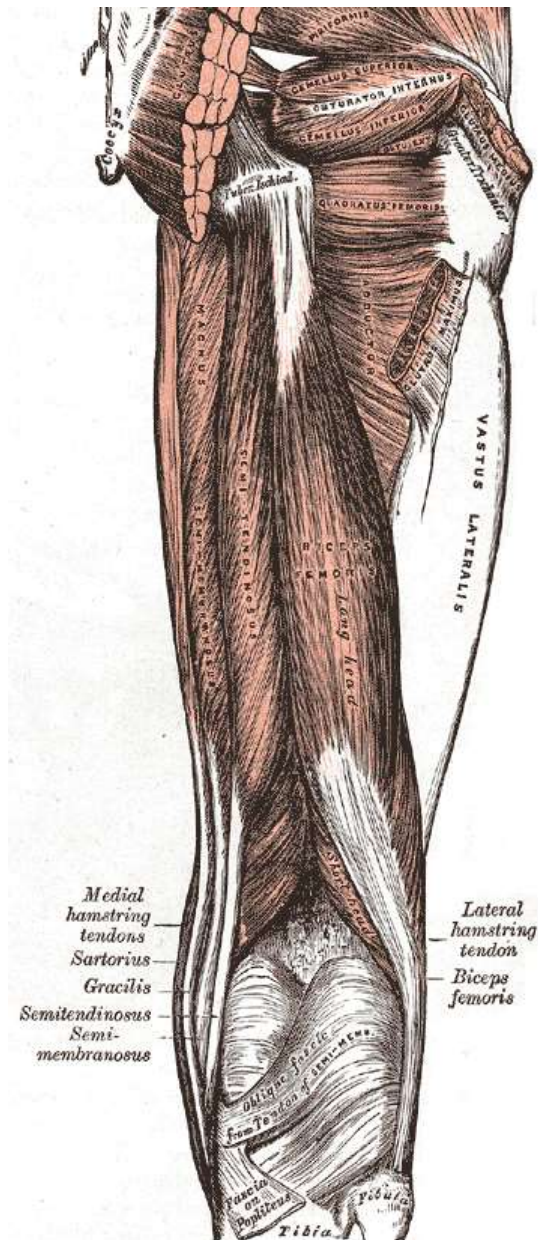


Fig. 118

Posterior femoral muscles

right lower limb

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MUSCLES OF THE LEG (CRURAL MUSCLES)

Muscles of the leg are arranged in three groups - **anterior, lateral and posterior crural muscles.**

Anterior crural muscles (tibialis anterior, extensor hallucis longus, extensor digitorum longus and fibularis tertius) are mainly **extensors of the ankle and toes.** Moreover, tibialis anterior turns the sole of the foot inward or invert the foot, thus it is also a **supinator of the foot.**

Tibialis anterior muscle running along the lateral surface of the tibial shaft is the most medially situated anterior crural muscle. **Extensor hallucis longus** passes laterally to tibialis anterior and its belly is partially covered by the belly of tibialis anterior and the belly of **extensor digitorum longus** lying the most laterally in anterior compartment. At the back of the foot, the tendon of **extensor digitorum longus** subdivides into four parts inserting through the dorsal digital expansions at the dorsal aspect of middle and distal phalanges of the second to the fifth toes. **Fibularis tertius muscle** is very often regarded as a part of extensor digitorum longus.

Anterior crural muscles are innervated by the **deep fibular nerve**.

ANTERIOR CRURAL MUSCLES

TIBIALIS ANTERIOR MUSCLE

Origin: lateral condyle of tibia, upper part of lateral surface of tibial shaft, interosseous membrane

Insertion: medial cuneiform bone and the base of the metatarsal bone I

Function: extension (dorsiflexion) of the foot (ankle joint), supination (inversion) of the foot

Nerve supply: deep fibular nerve

EXTENSOR HALLUCIS LONGUS MUSCLE

Origin: middle part of fibular shaft and interosseous membrane

Insertion: base of the distal phalanx of the hallux (great toe)

Function: extension (dorsiflexion) of the great toe and foot

Nerve supply: deep fibular nerve

EXTENSOR DIGITORUM LONGUS MUSCLE

Origin: proximal part of the fibular shaft and interosseous membrane

Insertion: through the dorsal digital expansions to the base of the middle and distal phalanges of the toe II – toe V

Function: extension (dorsiflexion) of the toes II-V and foot

Nerve supply: deep fibular nerve

FIBULARIS TERTIUS MUSCLE

Origin: distal part of fibular shaft

Insertion: base of the metatarsal bone V

Function: extension (dorsiflexion) of the foot

Nerve supply: deep fibular nerve

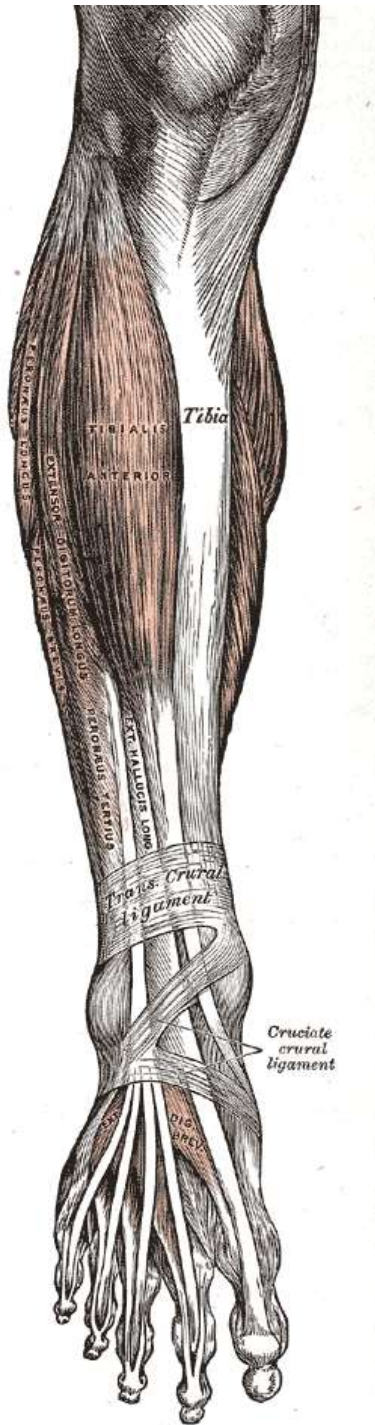


Fig. 119

**Anterior and lateral crural muscles
right lower limb**

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There are two **lateral crural muscles** – fibularis longus and fibularis brevis. They turn the sole outward or evert the foot, thus they are **pronators of the foot**.

Fibularis longus arises more proximally, inserts more distally and runs more superficially than **fibularis brevis**. The tendons of fibularis longus and brevis pass from the leg to the sole of the foot via the lateral retromalleolar space.

Lateral crural muscles are innervated by the **superficial fibular nerve**.

LATERAL CRURAL MUSCLES

FIBULARIS LONGUS MUSCLE

Origin: fibular head and proximal part of the fibular shaft

Insertion: medial cuneiform bone and the base metatarsal bone I

Function: pronation (eversion) of the foot, plantar flexion of the foot (ankle joint)

Nerve supply: superficial fibular nerve

FIBULARIS BREVIS MUSCLE

Origin: middle and distal part of fibular shaft

Insertion: base of the metatarsal bone V

Function: pronation (eversion) of the foot

Nerve supply: superficial fibular nerve

Posterior crural muscles are arranged in two layers: superficial and deep. Main function of these muscles is **flexion of the foot and toes**. All they are nerve supplied by the **tibial nerve**.

Superficial layer contains the **triceps surae muscle** consisting of **gastrocnemius** with two heads (medial and lateral) **soleus** deeper to gastrocnemius. **Plantaris muscle** is a rudimentary muscle with small belly and long tendon, usually passing between the gastrocnemius and soleus.

POSTERIOR CRURAL MUSCLES – SUPERFICIAL GROUP

TRICEPS SURAE MUSCLE

– MEDIAL AND LATERAL HEAD OF GASTROCNEMIUS AND SOLEUS

Origin:- medial and lateral head of gastrocnemius – medial and lateral condyle of femur
- soleus – soleal line at the dorsal surface of tibia

Insertion: through calcaneal tendon to calcaneal tuberosity

Function: plantar flexion of the foot (ankle joint), gastrocnemius – flexion of the knee

Nerve supply: tibial nerve

PLANTARIS MUSCLE

Origin: lateral epicondyle of femur

Insertion: fuses with calcaneal tendon

Function: unimportant (weak flexion of the knee)

Nerve supply: tibial nerve

Deep layer contains four muscles: popliteus, tibialis posterior, flexor digitorum longus and flexor hallucis longus. **Popliteus** is the most proximal muscle of this layer forming the floor of popliteal fossa. The belly of **tibialis posterior** muscle is situated in the middle between the bellies of flexor digitorum longus and flexor hallucis longus. Surprisingly, the belly of **flexor hallucis longus** is situated at the lateral side (the side of the toes) and the belly of **flexor digitorum longus** at the medial side (the side of the big toe), however, the tendons of these muscles change their position (cross) twice before they reach the phalanges of the toes. At the leg there is the first crossing where the tendon of flexor digitorum longus crosses the tendon of tibialis posterior. At the sole of the foot there is the second crossing between the tendon of flexor hallucis longus and tendon of flexor digitorum longus. Thus they achieve correct position - the tendon of flexor hallucis longus at the medial side, the tendon of flexor digitorum longus at the lateral side of the sole.

The tendons of tibialis posterior, flexor digitorum longus and flexor hallucis longus pass from the leg to the sole of the foot via the medial retromalleolar space.

POSTERIOR CRURAL MUSCLES – DEEP GROUP

POPLITEUS MUSCLE

Origin: lateral femoral condyle

Insertion: posterior surface of tibia above the soleal line

Function: stabilizes the knee joint

Nerve supply: tibial nerve

TIBIALIS POSTERIOR MUSCLE

Origin: tibia, fibula and adjacent interosseous membrane

Insertion: tuberosity of navicular bone and medial cuneiform bone

Function: plantar flexion of the foot (ankle joint), supination (inversion) of the foot

Nerve supply: tibial nerve

FLEXOR HALLUCIS LONGUS MUSCLE

Origin: fibula and adjacent interosseous membrane

Insertion: plantar surface of the distal phalanx of the hallux (great toe)

Function: flexion of the great toe and foot

Nerve supply: tibial nerve

FLEXOR DIGITORUM LONGUS MUSCLE

Origin: tibia and interosseous membrane

Insertion: plantar surfaces of distal phalanges of the toes II – V

Function: flexion of the toes II-V, flexion of the foot

Nerve supply: tibial nerve

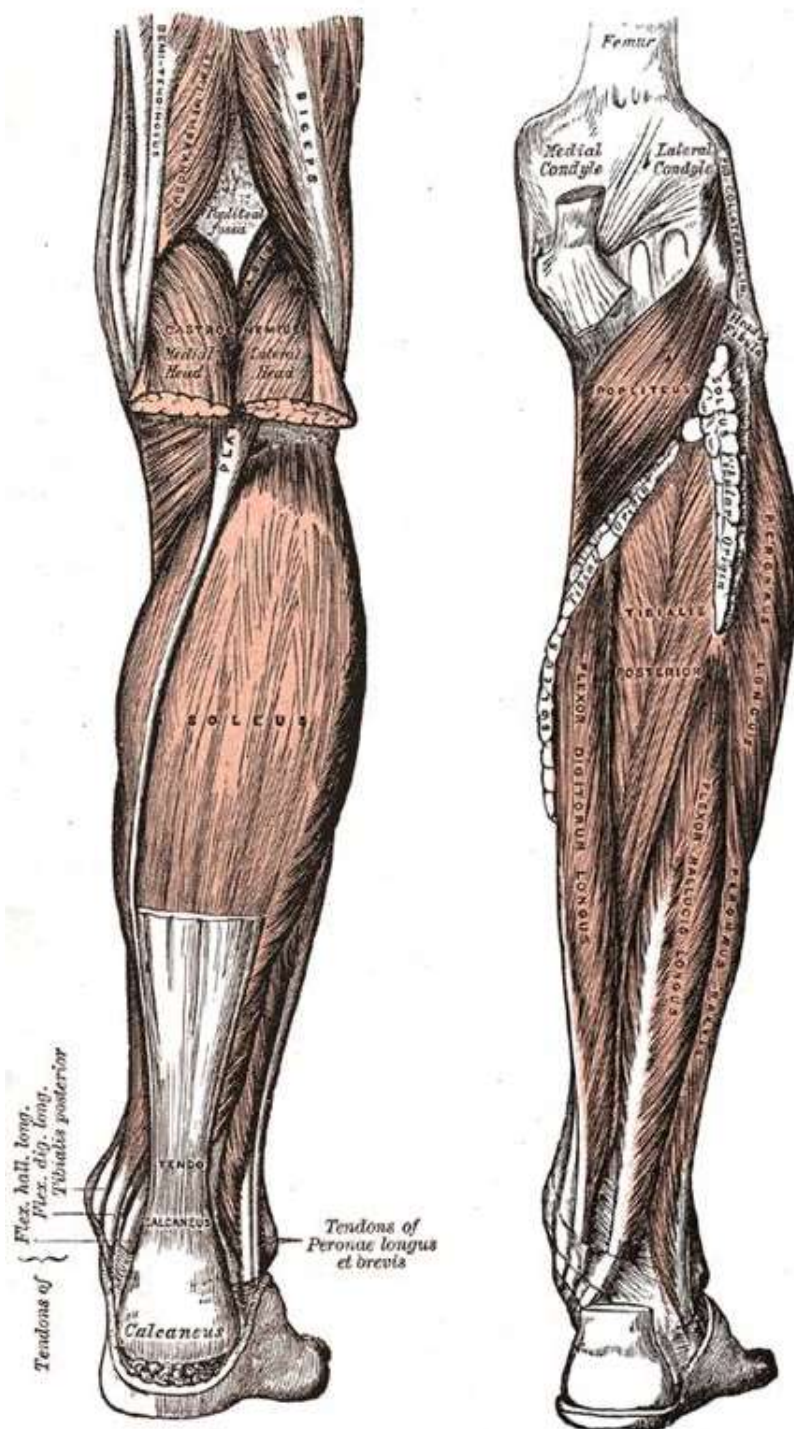


Fig. 120
Posterior crural muscles
right lower limb

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MUSCLES OF THE FOOT

Muscles of the foot are at the back of the foot, **dorsal muscles**, and at the sole of the foot, **plantar muscles**.

DORSAL MUSCLES

At the back of the foot there are two muscles: **extensor digitorum brevis** and **extensor hallucis brevis**. They are situated below (deeper to) the tendons of the anterior crural muscles (see figure 119) and act as **extensors of the toes**. Dorsal muscles of the foot are supplied by the **deep fibular nerve**.

DORSAL MUSCLES OF THE FOOT

EXTENSOR DIGITORUM BREVIS MUSCLE

Origin: dorsal aspect of calcaneus

Insertion: dorsal aspect of the middle and distal phalanges of the toe II-V

Function: extension of the toes II-V

Nerve supply: deep fibular nerve

EXTENSOR HALLUCIS BREVIS MUSCLE

Origin: dorsal aspect of calcaneus

Insertion: dorsal aspect of proximal phalanx

Function: extension of the great toe

Nerve supply: deep fibular nerve

PLANTAR MUSCLES

Muscles at the sole of the foot are arranged in three groups: **medial, lateral and intermediate (middle) group**. All plantar muscles are supplied by the **medial and lateral plantar nerves, branches of the tibial nerve**.

Intermediate plantar muscles include **flexor digitorum brevis muscle, quadratus plantae, lumbrical muscles** and **plantar and dorsal interosseal muscles**.

Flexor digitorum muscle is the most superficial plantar muscle situated directly below the plantar aponeurosis. **Quadratus plantae** is deeper to flexor digitorum brevis.

Lumbrical muscles (I-IV) arise from the tendons of flexor digitorum longus, they are deeper

to quadratus plantae. **Interosseal muscles** fill the intermetatarsal spaces and form the deepest layer of the sole. **Plantar interossei (I-III)** originate from the bases and pass along the medial sides of the 3rd, 4th and 5th metatarsal bones. They insert at the bases of the proximal phalanges. They act as adductors of the 3rd, 4th and 5th toe.

Dorsal interossei (I-IV) are bipennate muscles arising from adjacent sides of metatarsal bones and inserted to the dorsal digital expansion. They abduct the toes to the longitudinal axis passing through the 2nd metatarsal bone.

PLANTAR MUSCLES – INTERMEDIATE GROUP

FLEXOR DIGITORUM BREVIS MUSCLE

Origin: calcaneus

Insertion: plantar surface of the middle phalanges toes II-V

Function: flexion of the toes II-V

Nerve supply: medial plantar nerve a branch of tibial nerve

QUADRATUS PLANTAE MUSCLE

Origin: calcaneus

Insertion: tendon of the flexor digitorum longus

Function: assist in flexion of the toes II-V

Nerve supply: lateral plantar nerve - a branch of tibial nerve

LUMBRICAL MUSCLES (I-IV)

Origin: tendons of flexor digitorum longus

Insertion: dorsal digital expansions of the toe II-V

Function: flexion the metatarsophalangeal joints and extension of the interphalangeal joints

Nerve supply: medial and lateral plantar nerves – branches of tibial nerve

PLANTAR INTEROSSEI MUSCLES (I-III)

Origin: medial sides of the metatarsal bones II,IV,V

Insertion: bases of the proximal phalanges of the toe III, IV,V

Function: adduction of the toes II,IV, V

Nerve supply: lateral plantar nerve a branch of tibial nerve

DORSAL INTEROSSEI MUSCLES (I-IV)

Origin: adjacent sides of metatarsal bones I-V

Insertion: bases of proximal phalanges of the toe II-V

Function: abduction of toes to the longitudinal axis passing through the metatarsal bone II

Nerve supply: lateral plantar nerve - a branch of tibial nerve and deep fibular nerve

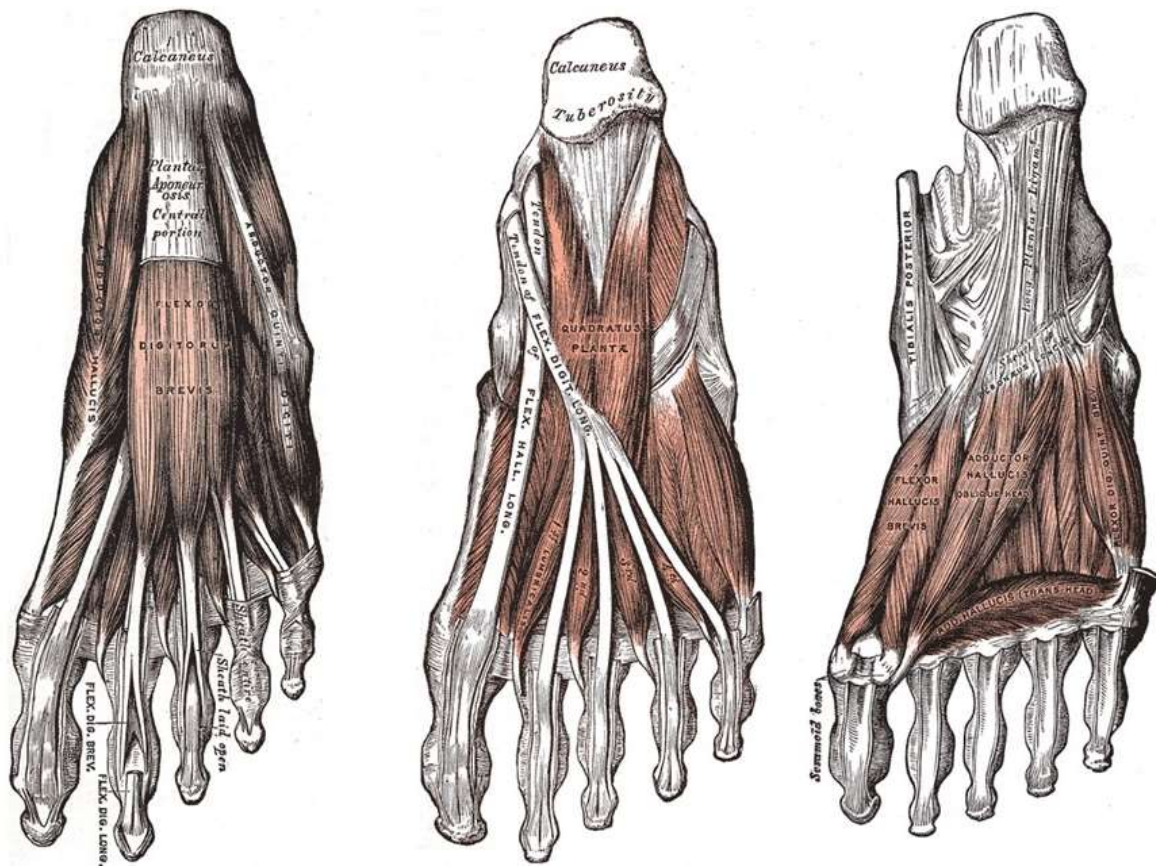


Fig. 121
Plantar muscles
right foot

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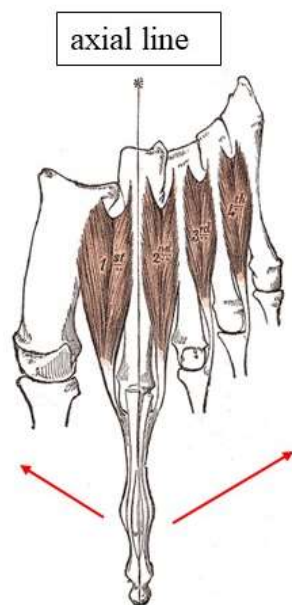


Fig. 122
Dorsal interossei muscles
right foot

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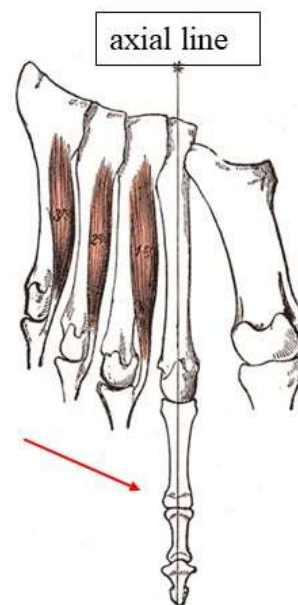


Fig.123
Plantar interossei muscles
right foot

In the **medial group of plantar muscles** there are three muscles: abductor hallucis, flexor hallucis brevis and adductor hallucis. **Abductor hallucis muscle** is more superficially (approximately at the level of flexor digitorum brevis). **Flexor hallucis brevis** and **adductor hallucis** are deeper, above the interossei muscles.

PLANTAR MUSCLES – MEDIAL GROUP

ABDUCTOR HALLUCIS MUSCLE

Origin: calcaneus

Insertion: base of the proximal phalanx of the great toe

Function: abduction of the great toe

Nerve supply: medial plantar nerve - a branch of tibial nerve

FLEXOR HALLUCIS BREVIS MUSCLE

Origin: calcaneus

Insertion: base of the proximal phalanx of the great toe

Function: flexion of the great toe

Nerve supply: medial plantar nerve - a branch of tibial nerve

ADDUCTOR HALLUCIS MUSCLE

Origin: metatarsal bones II-IV

Insertion: base of the proximal phalanx of the great toe

Function: adduction of the great toe

Nerve supply: lateral plantar nerve – a branch of tibial nerve

In the **lateral group of plantar muscles** there are two muscles: abductor digiti minimi and flexor digiti minimi brevis. Abductor digiti minimi is more superficial than the flexor digiti minimi.

PLANTAR MUSCLES – LATERAL GROUP

ABDUCTOR DIGITI MINIMI MUSCLE

Origin: calcaneus

Insertion: proximal phalanx of little toe

Function: abduction of the little toe

Nerve supply: lateral plantar nerve - a branch of tibial nerve

FLEXOR DIGITI MINIMI BREVIS MUSCLE

Origin: metatarsal bone V

Insertion: proximal phalanx of little toe

Function: flexion of the little toe

Nerve supply: lateral plantar nerve - a branch of tibial nerve

FASCIAE, RETINACULA AND TENDON SHEATHS OF THE LOWER LIMB

Fascia overlying the psoas major and iliacus is thin. **Iliac fascia** spreads from iliac crest to terminal line. Laterally it is attached to inguinal ligament from which it distally continues as iliopectineal fascia. **Iliopectineal fascia** subdivides the subinguinal hiatus (space below inguinal ligament) into lacuna vasorum (medially) and lacuna musculorum (laterally). At the posterior surface of the anterior abdominal wall iliac fascia continues as transversalis fascia.

Gluteal muscles are covered by **gluteal fascia** which is attached to iliac crest and sacrum. It separates the gluteus maximus from subcutaneous adipose tissue.

At the thigh there is a deep fascia termed as **fascia lata femoris**. It is attached to inguinal ligament, iliac crest, rami of pubis and ischium and sacrotuberous ligament. It is thickened proximally and medially. Laterally below the belly of tensor fasciae latae, it forms a strong band, **iliotibial tract** reaching the lateral condyle of tibia. Osteofascial septa separating the anterior, medial and posterior femoral compartments are connected with fascia lata femoris.

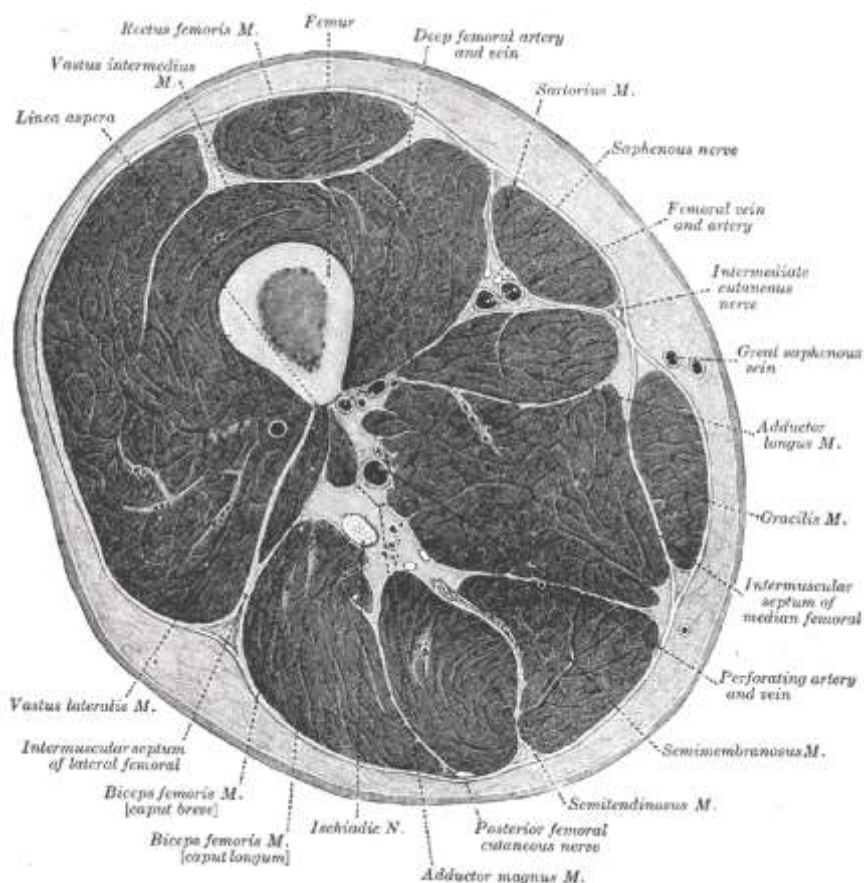


Fig.124

Transverse section of the right thigh

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A deep fascia at the leg is **crural fascia**. It is continuous with fascia lata femoris. Proximally it is attached to patella, ligamentum patellae, tibial condyles and tibial tuberosity and fibular head. It is attached to the anterior border of tibial shaft and distally to the ankles (malleoli). Posteriorly it continues to popliteal fascia lining the popliteal fossa.

The leg is subdivided to three compartments by the osteofascial septa situated anteriorly and posteriorly to fibular muscles and separating lateral compartment from anterior and posterior one. Anterior and posterior compartments are separated by interosseous membrane. Posterior compartment is subdivided by deep layer of fascia cruris to superficial and deep compartment.

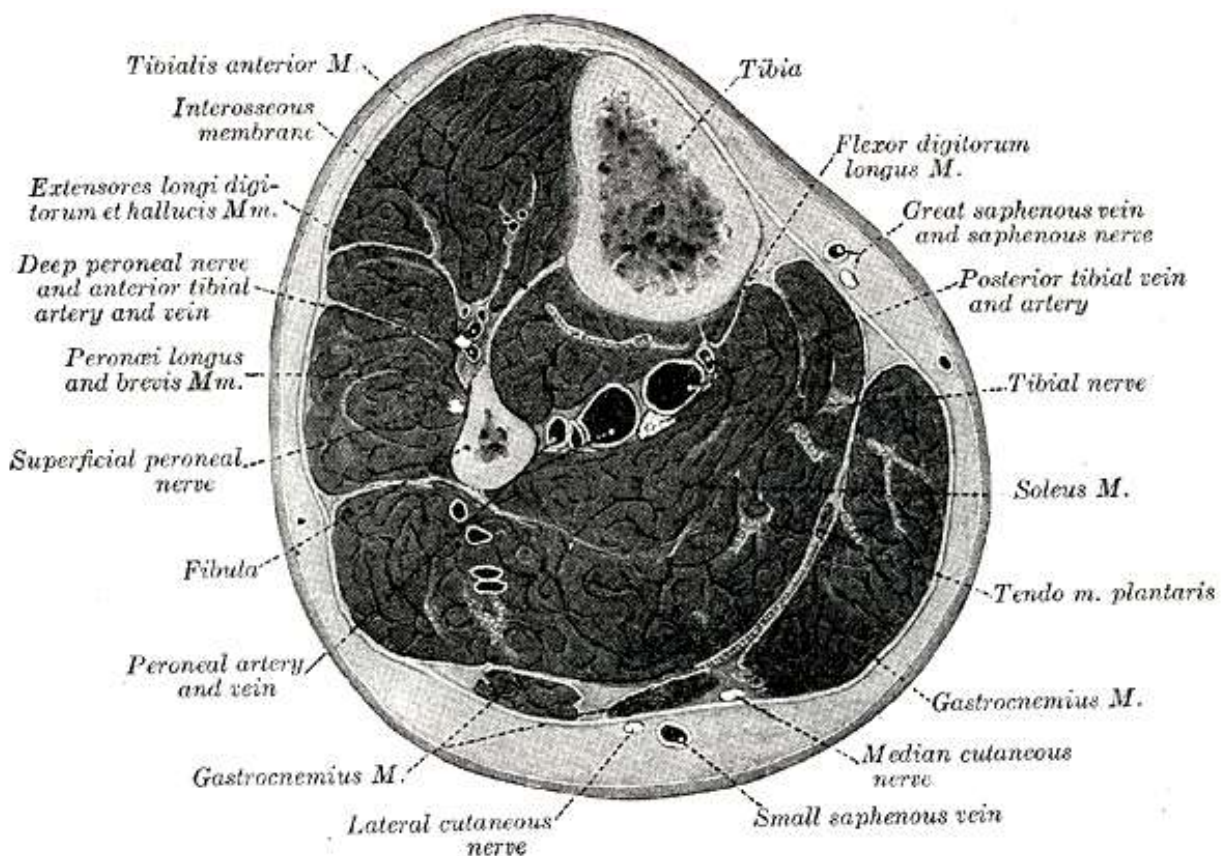


Fig. 125

Transverse section of the left leg

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Crural fascia is thickened distally (around the ankles) forming **retinacula: flexor retinaculum, extensor retinacula and fibular retinacula**.

Flexor retinaculum bridges the groove of medial malleolus and medial surface of talus and calcaneus. Flexor retinaculum changes the groove of medial malleolus to the channel - medial retromalleolar space. This space contains the muscle tendons and vessels running from the leg to the sole of the foot. In the channel the tendons of the muscles (tibialis anterior, flexor digitorum longus and flexor hallucis longus) are enveloped by the **synovial sheaths**.

Extensor retinacula are situated at the anterior aspect of the ankle. Above the ankle joint there is **superior extensor retinaculum** spreading between the tibia and fibula. **Inferior extensor retinaculum** is Y or V-shaped. Its proximal arm runs from the lateral side of calcaneus to medial malleolus, distal arm to plantar aponeurosis. The extensor retinacula bind the tendons of tibialis anterior, extensor digitorum longus (with fibularis tertius) and extensor hallucis longus to the ankle. The tendons are surrounded by **synovial sheaths** while passing below retinacula.

The tendons of fibularis longus and brevis are strapped to the lateral retromalleolar space by the **superior and inferior fibular retinaculum**. Superior fibular retinaculum spans the lateral malleolus and calcaneus. Inferior fibular retinaculum passes from the fibular trochlea to the inferior extensor retinaculum. Tendons of fibularis longus and brevis are enveloped by the **synovial sheaths**.

Fascia at the back of the foot is thin and covers the tendons of long extensors and bellies and tendons of short extensors. At the sides it is continuous with the plantar fascia.

Plantar fascia covers the medial and lateral group of plantar muscles and centrally it fuses with **plantar aponeurosis**. The tendons of flexor digitorum longus, flexor hallucis longus and flexor digitorum brevis are surrounded by the **synovial sheaths** from the level of metacarpophalangeal joints to the distal phalanges.

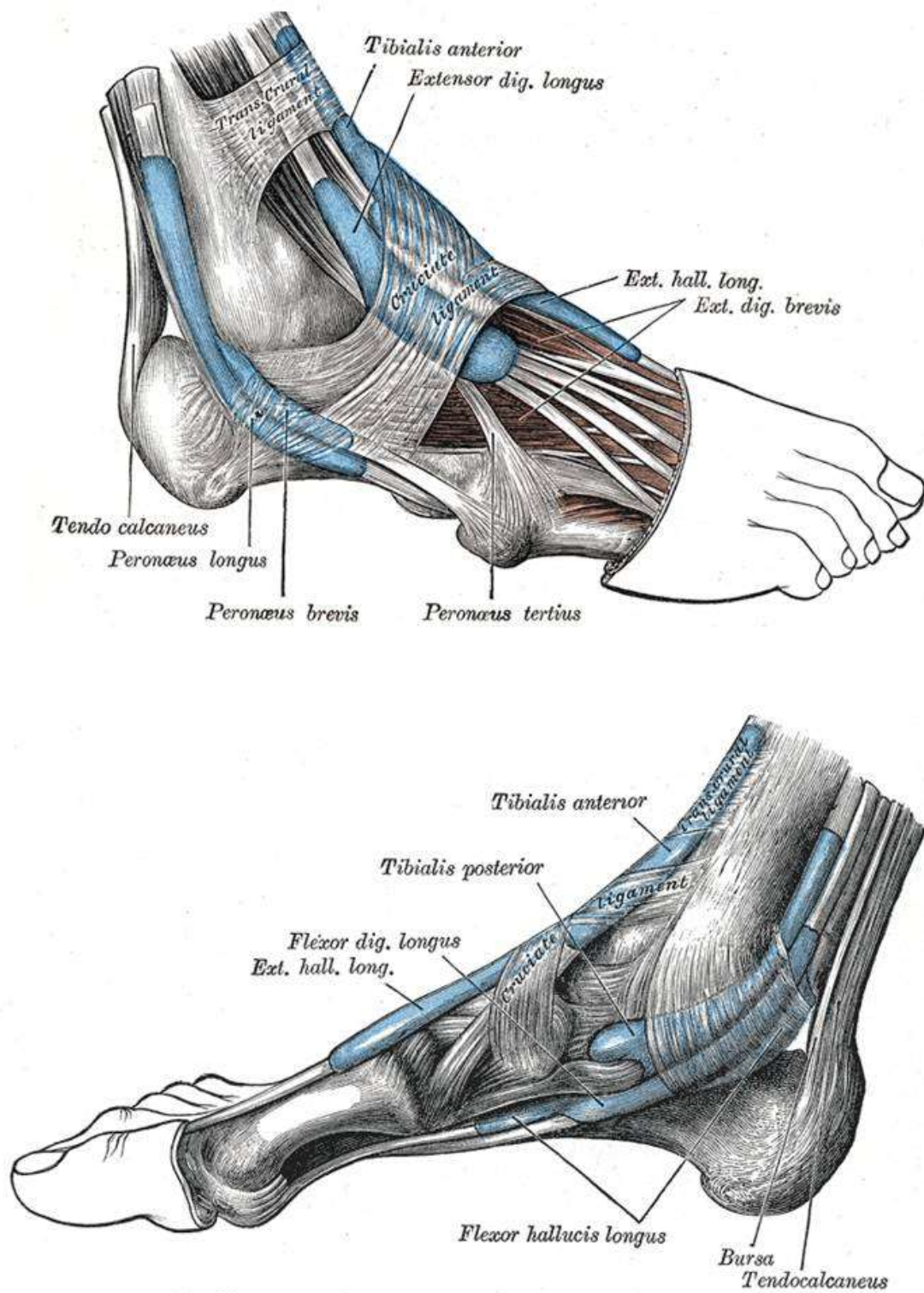


Fig. 126

Synovial tendon sheaths at the tight foot

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The bones of the foot form **plantar arches**. **Longitudinal arch** is anteroposterior concavity between posterior end of calcaneus and the heads of metatarsals. It is higher at the medial side and lower at the lateral. **Transverse arch** is concavity in frontal plane in the level of the heads of the metatarsals.

The arches are supported by the **ligaments** (spring ligament, long plantar ligament, short plantar ligament and plantar aponeurosis) and the **muscles** (tibialis anterior, tibialis posterior and fibularis longus).

QUESTIONS FOR REVISION

In each question at least one sentence is correct. It means 1,2,3,4 or 5 sentences can be correct.

OSTEOLOGY

UPPER LIMB

Mark correct sentences about the bones which form the pectoral girdle:

- a/ tuberosity of coracoclavicular ligament is situated on the sternal end of the clavicle
- b/ groove for the subclavian artery is situated on the inferior surface of the clavicle
- c/ coracoid process of the scapula projects ventrolaterally
- d/ subscapular fossa is situated on the costal surface of the scapula
- e/ scapular notch is situated on the medial border of the scapula

Scapula:

- a/ it has three borders: medial, lateral and superior
- b/ glenoid cavity (fossa) is situated at the medial angle
- c/ scapular spine subdivides the dorsal surface of the scapula into two fossae
- d/ supraspinous fossa is larger than infraspinous fossa
- e/ acromion articulates with the clavicle

Scapula:

- a/ is a flat bone
- b/ costal surface is subdivided by the scapular spine into two fossae
- c/ glenoid cavity (fossa) is situated at the lateral angle
- d/ scapular notch is situated at the lateral border
- e/ scapular spine ends as acromion

Clavicle:

- a/ the sternal end of the clavicle is enlarged and more robust than acromial end
- b/ the acromial end forms the medial end of the clavicle
- c/ impression of costoclavicular ligament is situated on the acromial end
- d/ inferior surface of the clavicular shaft shows groove for the subclavian artery and vein
- e/ tuberosity for coracoclavicular ligament is situated on the superior surface of the medial end

Clavicle:

- a/ the acromial end is enlarged and more robust than the sternal end
- b/ medial 2/3 of the clavicle are convex ventrally (forwards)
- c/ the groove for subclavius muscle is situated at the inferior surface of the shaft
- d/ impression of coracoclavicular ligament is situated at the sternal end of the clavicle
- e/ superior surface of the shaft is smooth

Humerus:

- a/ olecranon fossa is situated at the distal end dorsally
- b/ humeral head contains a fovea of the head for the attachment of intraarticular ligament
- c/ groove for the ulnar nerve runs behind the medial epicondyle
- d/ lesser tubercle is situated at the proximal end ventromedially (is ventromedial in position)
- e/ capitulum of the humerus articulates with the trochlear notch of the ulna

Humerus:

- a/ the greater tubercle is situated laterally at the proximal end of the humerus
- b/ groove for the radial nerve is situated at the dorsal surface of the shaft
- c/ groove for the ulnar nerve is situated behind the lateral epicondyle
- d/ anatomical neck is narrow part between the proximal end and the shaft of the humerus
- e/ trochlea is the articular surface on the medial condyle

Humerus:

- a/ groove for the radial nerve is situated behind the medial epicondyle of the humerus
- b/ deltoid tuberosity is situated at the lateral side of the humeral shaft
- c/ coronoid fossa is situated at the distal end of the humerus - ventrally above the trochlea
- d/ intertubercular sulcus is situated on the ventral surface of the proximal end of the humerus
- e/ lesser tubercle is situated at the distal end of the humerus

Ulna:

- a/ the ulnar head is situated at the proximal end
- b/ trochlear notch is formed between the olecranon and coronoid process
- c/ medial surface of the coronoid process is marked by the radial notch
- d/ the interosseous border of the ulna faces laterally to the radius
- e/ distal end of the ulna is enlarged and forms olecranon

Ulna:

- a/ olecranon extends upwards from the proximal end of ulna
- b/ supinator crest descends from the radial notch to the posterior border of the ulna
- c/ radial notch is situated at the distal end of the ulna
- d/ ulnar head joins with ulnar notch on the radius forming distal radioulnar joint
- e/ the interosseous border of the ulna faces medially

Radius:

- a/ the head of radius is situated at the proximal end
- b/ radial tuberosity is situated at the dorsal surface of the shaft
- c/ interosseous border of the radius faces laterally
- d/ ulnar notch is situated at the distal end on the medial side
- e/ ventral surface of the distal end of radius is grooved by the tendons of extensor mm.

Radius:

- a/ the head of the radius is situated at the proximal end
- b/ radial tuberosity is situated ventromedially immediately below the neck of the radius
- c/ groove for the radial nerve is situated on the dorsal surface of the shaft of radius
- d/ upper concave surface of the head of radius joins with the capitulum of humerus
- e/ carpal articular surface of the radius joins with the distal row of the carpal (wrist) bones

Bones of the hand:

- a/ the metacarpal bones belong to the long bones (according to the shape)
- b/ the head of the metacarpal bone is situated proximally, the base is situated distally
- c/ trapezium joins with the first metacarpal bone to form carpometacarpal joint of the thumb
- d/ scaphoid bone is situated the most medially in the proximal row of the carpal bones
- e/ hamate forms the centre of the carpus

Carpal (wrist) bones :

- a/ scaphoid bone is the most lateral bone in the proximal row
- b/ trapezium bone is the most medial bone in the distal row
- c/ hamate bone is the most lateral bone in the proximal row
- d/ capitate forms the centre of the carpus (wrist)
- e/ the bones of the distal row join with the bases of the metacarpal bones forming the carpometacarpal joints

Metacarpal bones and phalanges:

- a/ they are miniature long bones
- b/ the heads of the metacarpal bones join with the carpal bones of the distal row
- c/ the bases of the metacarpal bones join with the heads of proximal phalanges
- d/ the second metacarpal bone is usually the longest of all metacarpals
- e/ the heads of the proximal and middle phalanges are pulley – shaped

LOWER LIMB**Hip bone (innominate bone, pelvic bone):**

- a/ inferior ramus of the pubic bone is grooved by the obturator groove
- b/ iliac fossa forms the lateral surface of the ala of ilium
- c/ sacropelvic surface bears the iliac tuberosity
- d/ ischial spine separates the lesser sciatic notch from the greater sciatic notch
- e/ terminal line separates the greater and the lesser pelvis

Hip bone (innominate bone, pelvic bone):

- a/ lesser sciatic notch is situated below the ischial tuberosity
- b/ ilium and pubis meet in iliopubic eminence
- c/ iliac crest ends dorsally as posterior superior iliac spine
- d/ sacropelvic surface of ilium bears the auricular surface
- e/ acetabulum is the socket on the medial surface of the hip bone

Hip bone (innominate bone, pelvic bone):

- a/ iliac crest ends ventrally as the anterior superior iliac spine
- b/ pecten of pubis is situated at the inferior ramus of pubis
- c/ lunate surface is articular surface situated inside the acetabulum
- d/ gluteal surface is the lateral surface of the ala of ilium
- e/ lesser sciatic notch is situated between the ischial spine and ischial tuberosity

Hip bone (innominate bone, pelvic bone):

- a/ iliac crest forms upper margin of the ala of ilium
- b/ superior ramus of the pubis joins with the ramus of ischium
- c/ iliac fossa faces medially
- d/ the greater sciatic notch is situated between the posterior inferior iliac spine and ischial spine
- e/ sacropelvic surface bears lunate surface

Femur:

- a/ gluteal tuberosity is situated immediately below the lesser trochanter
- b/ medial surface of the lesser trochanter forms trochanteric fossa
- c/ dorsal surface of the femoral shaft is marked by linea aspera
- d/ the head of femur articulates with the lunate surface in acetabulum
- e/ popliteal surface is situated on the distal end ventrally

Femur:

- a/ linea pectinea ascends towards the greater trochanter
- b/ intercondylar fossa is situated at the distal end dorsally between the femoral condyles
- c/ trochanteric fossa lies behind the lesser trochanter
- d/ patellar articular surface is situated at the distal end ventrally
- e/ linea aspera is situated at the ventral surface of the femoral shaft

Femur:

- a/ intertrochanteric crest connects the greater and lesser trochanter ventrally
- b/ gluteal tuberosity is situated immediately below the lesser trochanter
- c/ patellar articular surface is situated at the distal end of femur ventrally
- d/ popliteal surface is bordered by the medial and lateral supracondylar crest
- e/ trochanteric fossa lies behind the lesser trochanter

Femur:

- a/ intertrochanteric line connects the greater and lesser trochanter ventrally
- b/ dorsal surface of the femoral shaft is marked by linea aspera
- c/ patellar surface is bordered by medial and lateral supracondylar lines
- d/ gluteal tuberosity ascends towards the greater trochanter
- e/ intercondylar fossa separates the femoral condyles ventrally

Femur

- a/ the head of femur contains a fovea for the attachment of the intraarticular ligament
- b/ intertrochanteric crest connects greater and lesser trochanters dorsally
- c/ the neck of the femur connect the head to the shaft
- d/ dorsal surface of the femoral shaft is marked by gluteal lines
- e/ linea pectinea ascends towards the lesser trochanter

Tibia:

- a/ anterior surface of the tibial shaft is marked by the soleal line
- b/ tibial tuberosity is situated at the dorsal surface of the tibial shaft
- c/ distal end of the tibia extends into medial malleolus
- d/ superior articular surfaces are separated by the intercondylar eminence
- e/ distal end of the tibia shows fibular notch on the lateral side

Tibia:

- a/ tibial tuberosity is situated ventrally just below the condyles
- b/ distal end of tibia extends into the medial malleolus
- c/ fibular articular surface is situated below the medial condyle
- d/ interosseous border of tibia faces medially
- e/ dorsal surface of the shaft of tibia is marked by linea aspera

Fibula:

- a/ the head of fibula is situated at the proximal end
- b/ interosseous border of fibula faces laterally
- c/ distal end of the fibula extends into the lateral malleolus
- d/ malleolar fossa is situated at the medial surface of the lateral malleolus
- e/ distal end of the fibula shows the fibular notch

Tibia and fibula:

- a/ the distal end of the tibia forms the lateral malleolus
- b/ tibial tuberosity is situated just below the condyles
- c/ proximal part of posterior surface of tibial shaft is marked by soleal line
- d/ distal end of the fibula is marked by the fibular notch
- e/ distal end of the fibula forms medial malleolus

Tarsal bones:

- a/ the head of talus directs distally
- b/ calcaneus joins with the talus and cuboid bone
- c/ sustentaculum tali is medial projection of the talus
- d/ cuneiform bones join with the metatarsal bones I, II, III
- e/ trochlea tali is situated at the superior surface of the body of talus

ARTHROLOGY

UPPER LIMB

Shoulder joint:

- a/ according to the shape of articular surfaces it is a hinge joint
- b/ it is a multiaxial joint
- c/ it allows rotation
- d/ it allows flexion, extension, abduction, adduction
- e/ it contains glenoid labrum which enlarges the articular surface of glenoid cavity

Shoulder joint:

- a/ tendon of the long head of biceps brachii m. runs through the articular cavity of this joint
- b/ in this joint the glenoid cavity enlarged by the glenoid labrum joins with the head of humerus
- c/ articular capsule of this joint is attached to the surgical neck of the humerus
- d/ this joint allows pronation and supination
- e/ this joint allows abduction and adduction

Elbow joint:

- a/ it is a compound synovial joint
- b/ it allows abduction and adduction
- c/ according to the shape of articular surfaces the humeroulnar joint is a hinge joint (trochlear joint)
- b/ in the humeroradial joint – the trochlea of the humerus joins with the upper concavity of the radial head
- e/ in the proximal radioulnar joint the ulnar head joins with the radial notch

Radiocarpal (wrist) joint:

- a/ it is a compound synovial joint
- b/ according to the shape of articular surfaces it is an ellipsoid joint
- c/ in this joint trapezium, trapezoid and capitate bones join with the carpal articular surface of the radius
- d/ this joint allows radial and ulnar deviations
- e/ this joint allows only rotation

Radiocarpal (wrist) joint:

- a/ in this joint - scaphoid, lunate and triquetrum join with the carpal articular surface of the radius and articular disc
- b/ according to the shape of articular surfaces it is a pivot joint
- c/ this joint allows flexion and extension
- d/ this joint allows abduction and adduction
- e/ it is an uniaxial joint

Carpometacarpal joint of the thumb :

- a/ it is a fibrous joint
- b/ according to the shape of articular surfaces it is a saddle (sellar) joint
- c/ it is uniaxial joint (it allows movements only in one axis)
- d/ it is a joint between the trapezoid bone and the base of the metacarpal bone I
- e/ it allows only rotation

Which of following joints allow rotation (pronation and supination)?

- a/ shoulder joint
- b/ elbow joint
- c/ distal radioulnar joint
- d/ carpometacarpal joint of the thumb
- e/ interphalangeal joint

Mark correctly classified joints according to the shape of the articular surfaces:

- a/ sternoclavicular joint is a pivot joint
- b/ acromioclavicular joint is a ball-and-socket (spheroid) joint
- c/ interphalangeal joints are plane joints
- d/ radiocarpal joint is an ellipsoid joint
- e/ carpometacarpal joint of the thumb is a saddle (sellar) joint

Mark correctly classified joints according to the shape of the articular surfaces:

- a/ distal radioulnar joint is a pivot joint
- b/ shoulder joint is a ball and socket (sphaeroid) joint
- c/ interphalangeal joints are hinge joints
- d/ radiocarpal joint is a plane joint
- e/ acromioclavicular joint is a plane joint

LOWER LIMB

Joints of the pelvis:

- a/ sacroiliac joint is a synovial joint
- b/ in sacroiliac joint auricular surface of the ilium joins with the auricular surface of the sacrum
- c/ sacroiliac joint allows only limited anteroposterior rotation
- d/ pubic symphysis is a fibrous joint
- e/ in pubic symphysis symphyseal surfaces of the pubic bones are connected by the fibrous cartilage

Coxal (hip) joint:

- a/ in this joint the head of femur articulates with the lunate surface and labrum in acetabulum
- b/ this joint is a multiaxial joint
- c/ this joint contains intraarticular ligament of the head of femur
- d/ this joint allows no rotation
- e/ this joint is amphiarthrosis which allows only limited gliding movements

Knee (genual) joint:

- a/ it is a ball and socket joint
- b/ in this joint femoral condyles articulate with the fibular head
- c/ this joint allows flexion and extension
- d/ this joint allows rotation only in extension
- e/ articular capsule of this joint is externally (on the outside) covered by the cruciate ligaments

Ankle (talocrural joint):

- a/ it is a compound joint
- b/ in this joint tibia and fibula articulate with sustentaculum tali
- c/ this joint allows flexion and extension
- d/ this joint allows rotation
- e/ according to the shape of the articular surfaces it is a hinge joint

Joints of the foot:

- a/ posterior talar and calcaneal articular surfaces join to form the subtalar joint
- b/ posterior articular calcaneal surface and cuboid bone join to form calcaneocuboid joint
- c/ cuboid bone joins with the metatarsal bones IV, V to form tarsometatarsal joints
- d/ cuneiform bones join with the metatarsal bones I, II, III to form tarsometatarsal joints
- e/ the bases of the metatarsal bones join with the heads of the proximal phalanges to form metatarsophalangeal joints

Mark correctly classified joints:

- a/ pubic symphysis is a cartilaginous joint
- b/ sacroiliac joint is a plane synovial joint
- c/ ankle joint is a hinge synovial joint
- d/ coxal (hip) joint is a pivot synovial joint
- e/ subtalar (talocalcaneal) joint is a syndesmosis

Mark correctly classified joints according to the shape of the articular surfaces:

- a/ coxal (hip) joint is a ball and socket joint
- b/ knee joint is a pivot joint
- c/ interphalangeal joints are hinge joints
- d/ subtalar (talocalcaneal) joint is a hinge joint
- e/ sacroiliac joint is a plane joint

Mark correctly classified joints according to the shape of the articular surfaces:

- a/ coxal (hip) joint is a plane joint
- b/ ankle (talocrural) joint is a hinge joint
- c/ tibiofibular joint is a pivot joint
- d/ interphalangeal joints are hinge joints
- e/ knee joint is a ball and socket joint

MYOLOGY

UPPER LIMB

Position of the muscles:

- a/ triceps brachii m. belongs to the mm. of the arm (brachial mm.)
- b/ coracobrachialis m. belongs to the mm. of the scapula
- c/ flexor carpi radialis m. belongs to the superficial group of the anterior antebrachial mm.
- d/ extensor pollicis brevis m. is situated in the deep layer of the posterior antebrachial mm.
- e/ opponens digiti minimi m. belongs to the mm. of the thenar

Position of the muscles:

- a/ teres major m. belongs to the mm. of the scapula
- b/ coracobrachialis m. belongs to the mm. of the arm
- c/ palmaris longus m. belongs to the superficial group of anterior antebrachial mm.
- d/ abductor pollicis longus m. belongs to the deep group of posterior antebrachial mm.
- e/ flexor digiti minimi m. belongs to the mm. of the thenar

Position of the muscles:

- a/ supraspinatus m. belongs to the muscles of the scapula
- b/ brachioradialis m. belongs to the muscles of the arm
- c/ flexor carpi ulnaris m. belongs to the deep group of anterior antebrachial mm.
- d/ supinator m. belongs to the deep group of posterior antebrachial mm.
- e/ extensor digiti minimi m. belongs to the mm. of the hand

Position of the muscles:

- a/ subscapularis m. belongs to the mm. of the scapula
- b/ deltoideus m. belongs to the mm. of the arm
- c/ pronator teres m. is situated in the deep layer of the anterior antebrachial mm.
- d/ abductor pollicis brevis m. is situated in the deep layer of the posterior antebrachial mm.
- e/ lumbrical mm. belong to the antebrachial mm.

Origins / insertions of the muscles:

- a/ medial head of the triceps brachii m. originates from the lesser tubercle of the humerus
- b/ extensor digitorum m. originates from the medial epicondyle of the humerus
- c/ supinator m. is inserted on the radius
- d/ deltoideus m. is inserted on the greater tubercle of the humerus
- e/ biceps brachii m. is inserted on the olecranon of the ulna

Origins / insertions of the muscles:

- a/ the long head of the biceps brachii m. originates from the supraglenoid tubercle
- b/ brachioradialis m. originates from the medial epicondyle of humerus
- c/ flexor digitorum superficialis m. is inserted on the distal phalanges
- d/ triceps brachii m. is inserted on the olecranon of the ulna
- e/ supraspinatus m. is inserted on the lesser tubercle of the humerus

Origins / insertions of the muscles:

- a/ the short head of biceps brachii m. originates from the supraglenoid tubercle
- b/ triceps brachii m. is inserted on the olecranon of the ulna
- c/ extensor carpi radialis longus m. originates from the ventral surface of the radius, ulna and interosseous membrane
- d/ teres minor m. is inserted on greater tubercle
- e/ brachioradialis m. originates from the medial epicondyle of the humerus

Origins / insertions of the muscles:

- a/ deltoideus m. originates from the scapular spine, acromion and clavicle
- b/ pronator teres m. originates from the lateral epicondyle of the humerus
- c/ coracobrachialis m. originates from the infraglenoid tubercle of the humerus
- d/ biceps brachii m. is inserted on the radial tuberosity
- e/ extensor carpi radialis longus m. is inserted on the 5th metacarpal bone

Which of following muscles have correctly assigned function?

- a/ triceps brachii m. – flexion of the arm
- b/ infraspinatus m. – supination of the arm
- c/ brachialis m. – flexion of the wrist
- d/ teres major m. – abduction of the arm
- e/ palmar interossei mm. – adduction of the fingers of the hand

Which of following muscles have correctly assigned function?

- a/ biceps brachii m. - flexion of the forearm
- b/ brachioradialis m. – flexion of the forearm
- c/ deltoid m.– abduction of the arm
- d/ coracobrachialis m. – flexion of the arm
- e/ lumbrical mm. – abduction of the fingers

Which of following muscles have correctly assigned function?

- a/ supraspinatus m. – flexion of the arm
- b/ brachialis m. – extension of the forearm
- c/ biceps brachii m. – flexion of the forearm
- d/ lumbrical mm. - flexion in the metacarpophalangeal joint and extension in the interphalangeal joint
- e/ teres minor m. – pronation of the arm

Which of following muscles have correctly assigned function?

- a/ biceps brachii m. – flexion of the wrist
- b/ supraspinatus m. – abduction of the arm
- c/ flexor digitorum superficialis m. – flexion of the distal phalanges
- d/ triceps brachii m. – flexion of the forearm
- e/ dorsal interossei mm. – abduction of the fingers

LOWER LIMB

Position of the muscles:

- a/ sartorius m. belongs to the group of posterior femoral mm.
- b/ quadratus femoris m. belongs to the group of anterior femoral mm.
- c/ pectineus m. belongs to the group of the medial femoral mm.
- d/ extensor digitorum longus m. belongs to the group of anterior crural mm.
- e/ flexor hallucis longus m. belongs to the deep group of posterior crural mm.

Position of the muscles:

- a/ iliopsoas m. belongs to the group of anterior femoral mm.
- b/ obturator externus m. belongs to the group of medial femoral mm.
- c/ semimembranosus m. belongs to the group of the medial femoral mm.
- d/ biceps femoris m. belongs to the group of anterior femoral mm.
- e/ piriformis m. belongs to the mm. of the foot

Position of the muscles:

- a/ piriformis m. belongs to the mm. of the gluteal region
- b/ adductor magnus m. belongs to the group of posterior femoral mm.
- c/ pectineus m. belongs to the group of medial femoral mm.
- d/ fibularis brevis m. belongs to the group of anterior crural mm.
- e/ extensor hallucis brevis m. belongs to the plantar mm.

Position of the muscles:

- a/ semitendinosus m. belongs to the group of posterior femoral mm.
- b/ quadriceps femoris m. belongs to the group of anterior femoral mm
- c/ quadratus femoris m. belongs to the group of the medial femoral mm.
- d/ popliteus m. belongs to the group of anterior crural mm.
- e/ flexor hallucis longus m. belongs to the group of anterior crural mm.

Position of the muscles:

- a/ sartorius m. belongs to the group of anterior femoral mm.
- b/ adductor magnus m. belongs to the group of medial femoral mm.
- c/ gracilis m. belongs to the group of posterior femoral mm
- d/ extensor digitorum brevis m. belong to the group of anterior crural mm.
- e/ flexor hallucis longus m. belongs to the deep group of posterior crural mm.

Origins / insertions of the muscles:

- a/ m. rectus femoris originates from the pecten of pubis
- b/ semitendinosus m. originates from the ischial tuberosity
- c/ fibularis brevis muscle originates from the lateral epicondyle of the femur
- d/ gluteus maximus m. is inserted on the lesser trochanter of the femur
- e/ biceps femoris m. is inserted on the head of the fibula

Origins / insertions of the muscles

- a/ vastus medialis m. and vastus lateralis m. originate from linea aspera on the femur
- b/ the long head of biceps femoris m. originates from the ischial spine
- c/ sartorius m. is inserted on medial epicondyle of the femur
- d/ iliopsoas m. is inserted on the lesser trochanter of the femur
- e/ fibularis brevis m. is inserted on the lateral malleolus

Origins / insertions of the muscles:

- a/ the short head of biceps femoris m. originates from linea aspera
- b/ sartorius m. originates from anterior inferior iliac spine
- c/ fibularis longus m. originates from the lateral epicondyle of the femur
- d/ piriformis m. is inserted on the greater trochanter of the femur
- e/ adductor longus m. is inserted on linea aspera

Origins / insertions of the muscles:

- a/ sartorius m. originates from the anterior superior iliac spine
- b/ semimembranosus m. originates from the ischial spine
- c/ piriformis m. originates from the sacrum
- d/ biceps femoris muscle is inserted to tibial tuberosity
- e/ tibialis anterior m. is inserted on calcaneal tuberosity

Origins / insertions of the muscles:

- a/ long head of biceps femoris m. originates from the ischial tuberosity
- b/ vastus medialis muscle originates from the greater trochanter of the femur
- c/ obturator internus m. originates from the trochanteric fossa
- d/ triceps surae m. is inserted on the calcaneal tuberosity
- e/ adductor longus m. is inserted on the lesser trochanter of the femur

Which of following muscles have correctly assigned function?

- a/ gluteus maximus m. – extension of the thigh (extension of coxal joint)
- b/ pectineus m. – abduction of the thigh
- c/ semitendinosus m. – extension of the leg (extension of the knee joint)
- d/ triceps surae m. – dorsiflexion of the foot (extension of the foot)
- e/ tibialis anterior m. – plantar flexion (flexion of the foot)

Which of following muscles have correctly assigned function?

- a/ gluteus maximus m. – flexion of the thigh
- b/ quadriceps femoris m. – flexion of the leg
- c/ semimembranosus m. – extension of the leg
- d/ triceps surae m. – plantar flexion (flexion of the foot)
- e/ gracilis m. – adduction of the thigh

Which of following muscles have correctly assigned function?

- a/ triceps surae m. – plantar flexion (flexion of the foot)
- b/ gluteus medius m. – flexion of the thigh
- c/ biceps femoris m. – flexion of the leg
- d/ fibularis brevis m. – pronation of the foot
- e/ gracilis m. – abduction of the thigh

Which of following muscles have correctly assigned function?

- a/ gracilis m. – adduction of the thigh
- b/ biceps femoris m. - extension of the leg (extension of the knee joint)
- c/ iliopsoas m. – extension of the thigh
- d/ semitendinosus m. – flexion of the leg (flexion of the knee joint)
- e/ fibularis brevis m. – supination of the foot

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