1 Bones of Lower Limb

Competencies

AN14.1: Identify the given bone, its side, important features, and keep it in anatomical position.

AN14.2: Identify and describe joints formed by the given bone.

AN14.3: Describe the importance of ossification of lower end of femur and upper end of tibia.

AN14.4: Identify and name various bones involved in foot articulation with individual muscle attachment.

AN20.7: Identify and demonstrate important bony landmarks of lower limb: vertebral levels of highest point of iliac crest, posterior superior iliac spines, iliac tubercle, pubic tubercle, ischial tuberosity, adductor tubercle; tibial tuberosity, head of fibula; medial and lateral malleoli; condyles of femur and tibia, sustentaculum tali, tuberosity of fifth metatarsal, tuberosity of the navicular.

Q1. Write short notes on:

a. Names of the parts of hip bone, the bones with which it articulates, the joints formed and the type. (AN14.1, 14.2)

b. Iliac crest. (AN14.1)

c. Ischial tuberosity. (AN14.1)

d. Greater and lesser sciatic foramina—structures passing through. (AN14.1)

e. Linea terminalis. (AN14.1)

f. Vertebral levels of highest point of iliac crest, posterior superior iliac spine, iliac tubercle, pubic tubercle, ischial tuberosity, adductor tubercle. (AN20.7)

a. Hip Bone

Parts

- Ilium: It has two ends (upper and lower), three borders (anterior, posterior, and medial), and three surfaces (sacropelvic, gluteal, and iliac fossa).
- Ischium: It has two parts, the body and ramus.
- Pubis.

These three parts meet at the acetabulum.

Articulations and Type

- Acetabulum and head of femur take part in hip joint: synovial joint of ball and socket type.
- With other hip bone to form pubic symphysis: secondary cartilaginous joint.
- With sacrum to form sacroiliac joint: synovial-plane joint.

b. Iliac Crest

- It is the broad ridge (upper border) of ilium.
- It forms the lateral boundary between abdominal and pelvic cavities.

Presenting Parts

It has two ends and two segments (**Fig. 1.1** and **Table 1.1**).

- Ends: anterior superior iliac spine (ASIS) and posterior superior iliac spine (PSIS) at anterior and posterior ends, respectively.
- Segments: ventral (two-thirds) and dorsal (one-third). Ventral segment presents inner and outer lips and a broad intermediate area. Dorsal segment is separated by a ridge into medial and lateral surfaces. At 5.0 cm behind ASIS ventral segment presents tubercle of iliac crest.

Clinical Importance

- Iliac crest is used for mandibular, maxillary, and tibial reconstructions.
- Site of bone marrow biopsy/aspiration.

c. Ischial Tuberosity

Synonyms

- Sitting bone.
- Sitz bone.

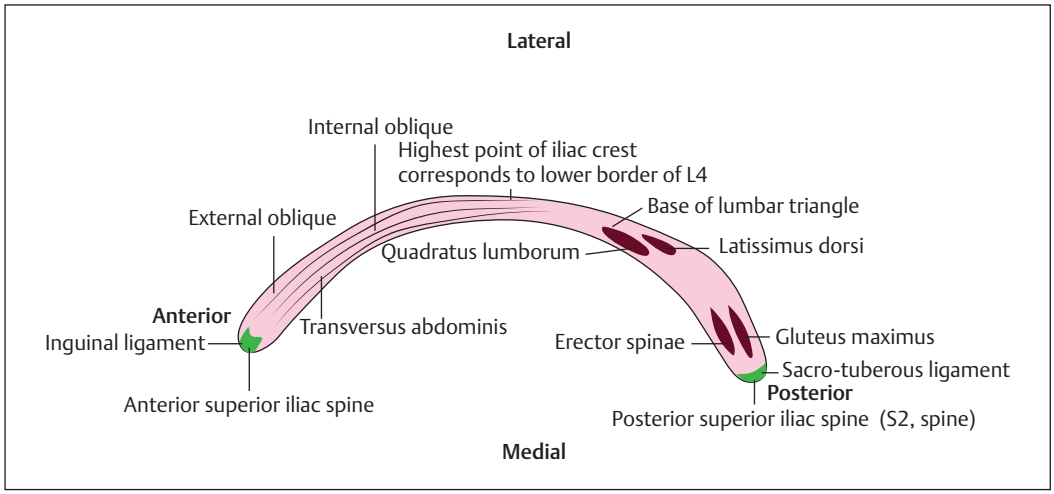

Fig. 1.1 Iliac crest—attachments.

Table 1.1 Parts and attachment of iliac crest

Parts	Important attached muscles/ligaments, articulating bones
Anterior superior iliac spine	▪ Attachment to inguinal ligament ▪ Sartorius (origin)
Posterior superior iliac spine	▪ Piriformis
Ventral segment—outer lip	▪ External oblique abdominis (insertion)—anterior two-thirds ▪ Tensor fascia latae (origin)—anterior part ▪ Latissimus dorsi (origin)—behind highest point of iliac crest
Ventral segment—inner lip	▪ Transversus abdominis (origin)—anterior two-thirds ▪ Quadratus lumborum (origin)—posterior one-third
Ventral segment—intermediate area	▪ Internal oblique (origin)
Dorsal segment—medial surface	▪ Erector spinae (origin)
Dorsal segment—lateral surface	▪ Gluteus maximus (origin)
Posterior superior iliac spine	▪ Sacro tuberous ligament

Location

It contributes to the lower boundary of pelvic outlet.

Definition

The ischial tuberosity is a roughened projection from the body of ischium.

- It protrudes posteroinferiorly. It is covered by gluteus maximus muscle while standing and exposed while sitting. It supports weight of body while sitting.
- It is a palpable landmark, 5 cm lateral to the midline when the hip joint is flexed.
- It gives origin to hamstring muscles and attachment to sacrotuberous ligament.
- It forms the boundary line dividing the perineum into anterior urogenital and posterior anal triangles.

Divisions and Muscles Attached

It is divided by a transverse ridge into two portions (**Fig. 1.2**):

- Upper portion: It is smooth and quadrilateral region. It is divided by an oblique ridge that runs downward and laterally into:
  - Upper lateral part: semimembranosus (origin).

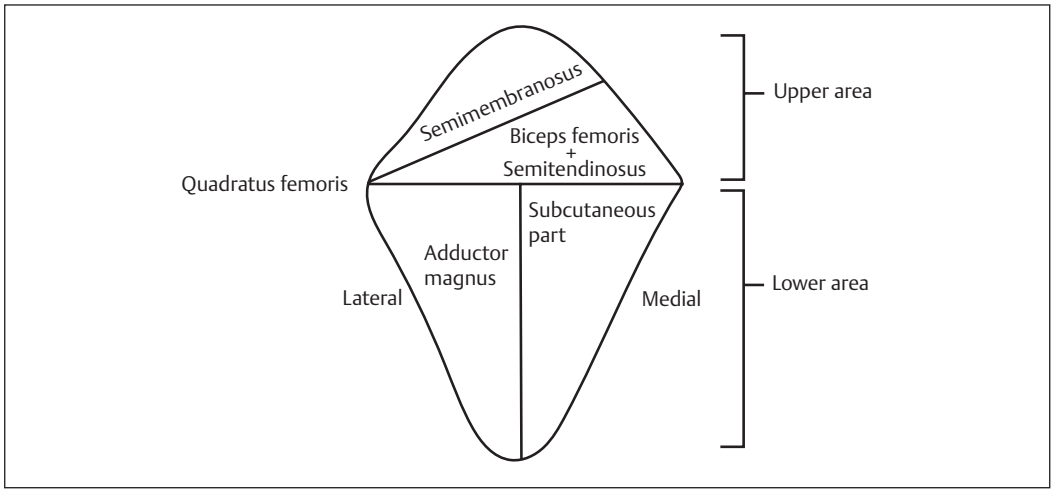

Fig. 1.2 Ischial tuberosity.

  - Lower medial part: biceps femoris (origin) and semitendinosus (origin).
- Lower portion: it is rough and triangular region. It is divided by a longitudinal/vertical ridge into:
  - Lateral part: adductor magnus (origin).
  - Medial part: subcutaneous part and covered by fibrous tissue.
- Lateral surface: quadratus femoris (origin).
- Medial surface:
  - Attachment to obturator internus and the obturator fascia over it.
  - Along with obturator fascia forms lateral boundary for ischiorectal fossa and pudendal canal (4 cm above its tip) that lodges pudendal nerve and vessels.

Clinical Importance

- Lower medial part bears the weight of the body in a seated position.
- Ischial tuberosity pain due to prolonged sitting and inflammation of bursa. It is more common in athletes—soccer players, cyclists, baseball players etc.
- This is the palpable landmark for pudendal nerve block by perineal approach in surgeries of perineal region—anorectal surgeries and urological procedures, in forceps delivery in obstetric practice.

d. Greater and Lesser Sciatic Foramina and Structures Passing Through It

Greater Sciatic Foramen

- Structures passing above the piriformis muscle—superior gluteal nerve and vessels.
- Structures passing below the piriformis muscle:
  - Nerves: inferior gluteal, pudendal, sciatic, posterior cutaneous nerve of thigh, nerve to obturator internus, and nerve to quadratus femoris.
  - Vessels: inferior gluteal and internal pudendal.

Lesser Sciatic Foramen (Mnemonic: PIN)

- Pudendal nerve.
- Internal pudendal vessels.
- Nerve to obturator internus.

e. Linea Terminalis

- Lateral boundary of pelvic inlet.
- Formed by union of three parts—arcuate line, pecten pubis, pubic crest.
- Structures crossing it are:
  - Vessels: internal iliac and ovarian (females).
  - Tubes: ureter, vas deferens (males).
  - Ligament: round ligament of uterus (female).

- Importance: linea terminalis + margin of ala of sacrum + sacral promontory separate the greater and lesser pelvis.

f. Vertebral Levels/Palpable Landmarks in Relation to Hip Bone and their Clinical Importance

The vertebral levels of hip bone and their clinical importance are listed in **Table 1.2**.

Q2. Write short notes on:

a. Parts of femur and the joints formed. (AN14.1)

b. Upper end of femur—parts and important muscles attached. (AN14.1)

c. Linea aspera of femur. (AN14.1)

d. Lower end of femur. (AN14.1)

e. Ossification of lower end of femur and upper end of tibia and their medicolegal importance. (AN14.3)

a. Parts of Femur and the Joints Formed

- Femur is a long bone and has a shaft, upper end, and lower end.
- Upper end consists of head, neck, greater trochanter, lesser trochanter, intertrochanteric line, intertrochanteric crest, quadrate tubercle, and trochanteric fossa.
- Lower end consists of medial and lateral condyles that are joined anteriorly and separated posteriorly by intercondylar notch. Medial and lateral epicondyles are present in relation to their respective condyles.

Table 1.2 Vertebral levels of certain parts of hip bone and their clinical importance

Parts	Vertebral levels/palpable landmarks	Clinical importance
Highest point of iliac crest	Intervertebral disk between L3 and L4 vertebrae	Guidance for lumbar puncture
Posterior superior iliac spine	Spine of S2	▪ Presents a dimple ▪ Guidance for bone marrow aspiration—1.0 cm below and lateral to the dimple
Iliac tubercle/tubercle of iliac crest	▪ The line connecting the two tubercles is transtubercular plane ▪ It corresponds to L5 vertebra	Greater trochanter—10.0 cm distal to iliac tubercle
Pubic tubercle	Palpable at the lateral end of upper border of pubic bone (pubic crest)	▪ Saphenous opening—1.5 inches below and lateral to pubic tubercle ▪ Superficial inguinal ring—above and lateral to pubic tubercle ▪ Spermatic cord—can be felt and rolled medial to pubic tubercle where it crosses pubic crest ▪ Giving anesthesia to genital branch of genitofemoral or obturator nerve ▪ For differentiating hernias—inguinal hernia will be anteromedial and femoral hernia will be inferolateral to it
Ischial tuberosity	It is palpable 5 cm lateral to the midline when the hip joint is flexed	▪ Boundary line dividing the perineum into anterior urogenital triangle and posterior anal tringle ▪ Landmark for pudendal nerve block by transperineal approach
Ischial spine	Palpable bony prominences at about a finger-length distance into the vagina, at 4 and 8 o'clock	▪ Landmark for pudendal nerve block by transvaginal approach ▪ When the woman is in labor the position of fetal head is measured in centimeters above or below the ischial spine

b. Upper End of Femur: Parts and Important Muscles Attached

The parts, attachments, and articulations of upper end of femur are described in **Table 1.3.**

c. Linea Aspera of Femur

- It is a roughened vertical ridge on the middle one-third of posterior surface of femur.
- It consists of a medial lip and a lateral lip with floor in between.
- Muscles (origin/insertion) and the intermuscular septa that are attached to it from medial to lateral are:
  - Vastus medialis (origin)—medial lip.
  - Medial intermuscular septum.
  - Pectineus.
  - Adductor brevis (insertion).
  - Adductor longus (insertion).
  - Adductor magnus (insertion).
  - Posterior intermuscular septum.
  - Short head of biceps femoris (origin).
  - Vastus lateralis (origin)—lateral lip.
  - Lateral intermuscular septum.

d. Lower End of Femur

Presenting Parts

- Condyles (medial and lateral).
- Epicondyles (medial and lateral).
- Intercondylar fossa/notch.

Condyles

- They consist of anterior, inferior, and posterior articular surfaces.
- They are massive and convex. Lateral condyle is more massive but bulges with less prominence than medial. It takes larger share in weight transmission. Medial condyle projects further distally.
- Inverted V-shaped articular surface extends onto all surfaces and both condyles for articulation with patella (above) and tibia (below).
- Patellar area forms the apex of V and is in contact with patella. Lateral part of it is broader and extends to higher level to adjust articular surface of patella.
- Tibial area is in contact with condyles of tibia separated by menisci. Narrow strip of patellar surface extends to tibial surface of medial condyle along intercondylar notch and patella is in contact with it in extreme flexion.

Epicondyles

- Lateral epicondyle: behind and below it lies the popliteal groove which is deeper anteriorly and shallow posteriorly. The anterior part of groove is for origin of the popliteus muscle and the posterior part is for the tendon of popliteus in flexion of knee. The lateral epicondyle

Table 1.3 Upper end of femur—parts, attachments, articulation

Parts	Important attached muscles/ligaments, articulating bones
Head	▪ Directed medially, upwards and forwards; articulates with acetabulum of hip bone and forms hip joint
Neck	▪ It makes a 125 degrees angle with the shaft. Greater and lesser trochanters are near the junction of neck with the shaft
Greater trochanter	▪ Trochanteric fossa on its medial surface ▪ Anterior aspect—gluteus minimus (insertion) ▪ Lateral surface—oblique line—gluteus medius (insertion) ▪ Medial surface: - Anterior part—obturator internus and gemelli (insertion) - Trochanteric fossa—obturator externus (insertion) ▪ Upper border—piriformis (insertion)
Lesser trochanter	▪ Psoas major and iliacus (insertion)
Quadrate tubercle	▪ Quadratus femoris (insertion)
Gluteal tuberosity	▪ Gluteus maximus (insertion)
Lesser trochanter	▪ Pectineus

is intracapsular and gives attachment to upper end of fibular collateral ligament.

- Medial epicondyle: the upper part presents adductor tubercle. The medial epicondyle gives attachment to upper end of tibial collateral ligament. Adductor tubercle gives attachment to adductor magnus (insertion) muscle.

Intercondylar Fossa

It consists of the following:

- Medial wall: the anteroinferior part gives attachment to upper end of posterior cruciate ligament.
- Lateral wall: the posterosuperior part gives attachment to upper end of anterior cruciate ligament.
- Floor: the upper margin (intercondylar line) gives attachment to fibrous capsule and oblique popliteal ligament. Lower margin gives attachment to apex of infrapatellar synovial fold.

Mnemonic for Attachments: LAMP

- Lateral condyle anterior cruciate ligament; medial condyle posterior cruciate ligament.

e. Ossification of Lower End of Femur and Upper End of Tibial and Their Medicolegal Importance

- According to laws of ossification of bones, all secondary centers appear after birth except for lower end of femur and upper end of tibia where the center appears before 9 months of intrauterine life.
- The X-ray of lower end of femur and upper end of tibia for the appearance of ossification centers in a newborn is of medicolegal importance in cases of dispute about the maturity or viability of fetus. It will prove that the newborn found dead was born after full term and was viable (capable of independent existence).

Q3. Name the parts, important muscle, and ligament attachments to upper end of tibia. (AN14.1)

The parts, muscles, and ligaments attached to the upper end of tibia are listed in **Table 1.4**.

Table 1.4 Tibia—parts, muscles, and ligaments attached

Parts	Muscles, ligaments
Medial condyle	▪ Semimembranosus (insertion) ▪ Capsular ligament of knee joint ▪ Tibial collateral ligament
Lateral condyle	▪ Extensor digitorum longus (origin) ▪ Peroneus longus (origin) ▪ Capsular ligament of superior tibiofibular joint ▪ Tendon of popliteus
Intercondylar area (anterior to posterior) **Mnemonic: M**edical **C**ollege **L**ondon. **L**ondon **M**edical **C**ollege **(take first letter of each word)**	▪ Medial meniscus (anterior horn) ▪ Cruciate ligament (anterior) ▪ Lateral meniscus (anterior horn) ▪ Lateral meniscus (posterior horn) ▪ Medial meniscus (posterior horn) ▪ Cruciate ligament (posterior)
Tibial tuberosity (above downwards)	▪ Ligamentum patella ▪ Epiphyseal line ▪ Infrapatellar bursa

Q4. Name the parts and important muscle attachments of fibula. (AN14.1)

The parts and important muscle attachments of fibula are listed in **Table 1.5**.

Q5. Name the tarsal bones and the muscles attached to tarsal bones. (AN14.4)

Tarsal bones and muscles attached are described in **Table 1.6**.

Table 1.5 Fibula—parts, muscles attached, joints formed

Parts	Muscles and ligaments
Upper end (styloid process)	▪ Biceps femoris (insertion) ▪ Fibular collateral ligament
Shaft	Medial surface: ▪ Extensor digitorum longus ▪ Extensor hallucis longus ▪ Peroneus tertius Lateral surface: ▪ Peroneus longus ▪ Peroneus brevis Posterior surface: ▪ Soleus ▪ Tibialis posterior ▪ Flexor hallucis longus
Lower end	Malleolar fossa: ▪ Posterior tibiofibular ligament ▪ Posterior talofibular ligament ▪ Anterior border—anterior talofibular ligament Posterior surface—groove for tendon of peroneus longus and brevis Lower border—calcaneofibular ligament

Table 1.6 Tarsal bones and muscles attached

Bone	Muscle origin	Muscle insertion
Calcaneus	▪ Abductor hallucis. ▪ Abductor digiti minimi. ▪ Flexor digitorum brevis. ▪ Flexor accessories. ▪ Extensor digitorum brevis.	▪ Gastrocnemius. ▪ Plantaris. ▪ Soleus.
Talus	▪ No muscle attachments.	
Cuboid	▪ Flexor hallucis brevis.	–
Navicular	–	▪ Tibialis posterior.
Medial cuneiform	–	▪ Peroneus longus. ▪ Tibialis anterior. ▪ Tibialis posterior.
Intermediate cuneiform	–	▪ Tibialis posterior.
Lateral cuneiform	▪ Flexor hallucis brevis. ▪ Adductor hallucis (oblique head)	▪ Tibialis posterior.

Q6. Write short note on patella. (AN14.1)

Patella

- Largest sesamoid bone.
- Ossified in tendon of quadriceps femoris.
- Lies in front of knee joint.
- Shape—triangular.
- Presenting parts and structures related are shown in **Table 1.7** and **Fig. 1.3.**

Table 1.7 Patella—structures attached and in contact with articular surface of femur

Part	Structures related
Apex	▪ Ligamentum patellae.
Base/upper border (before backwards)	▪ Rectus femoris. ▪ Vastus medialis and lateralis. ▪ Vastus intermedius.
Medial border	▪ Vastus medialis—upper two-thirds. ▪ Medial patellar retinaculum—lower one-third.
Lateral border	▪ Vastus lateralis—upper one-third. ▪ Lateral patellar retinaculum—rest.
Anterior surface	▪ Covered by superficial part of quadriceps femoris. ▪ Prepatellar bursa. ▪ Longitudinal ridges.
Posterior surface Seven areas in contact with patellar surface of femur	Articular—most of it articulates with anterior surface of femoral condyles. Their divisions and their articulation with femoral condyles during knee movements are: Divisions by vertical ridge: ▪ Large lateral part—further division by two horizontal lines. ▪ Small medial part—further divisions by vertical ridge. ▪ Lower two areas—ordinary extension. ▪ Middle two areas—semi-flexion. ▪ Upper two areas—ordinary flexion. ▪ Most medial narrow strip; under surface of medial condyle of femur along intercondylar fossa—full flexion. ▪ Floating of patella in the joint; no contact with femur—in relaxed knee with full extension.

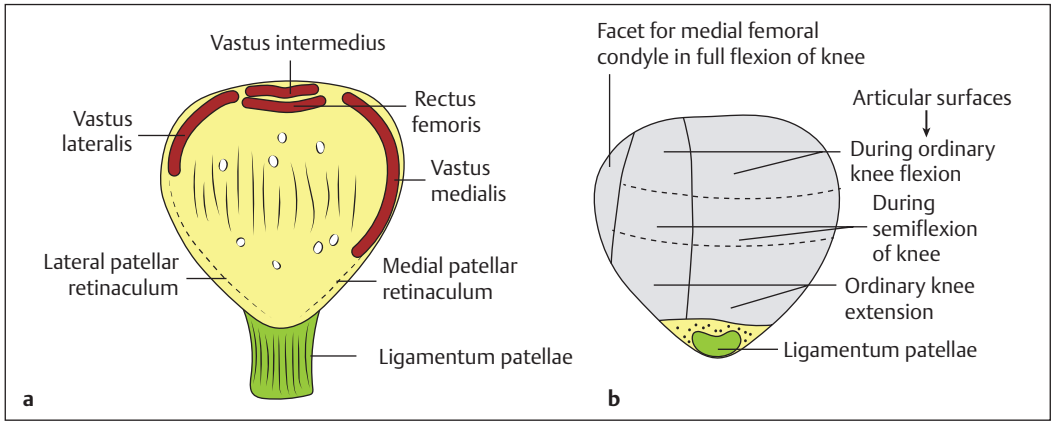

Fig. 1.3 Attachments of patella (right). **(a)** Anterior view. **(b)** Posterior view.