MEDICAL EDUCATION RESOURCE

Bones: Femur,Patella,Tibia,Fibula and bones of feet

Femur

Introduction

- The **femur** (thigh bone) is the **longest and strongest bone** in the human body.
- It extends from the **hip joint** to the **knee joint** and transmits the **weight of the body** from the pelvis to the tibia.
- Its length is about **1/4 of the body height**.
- It forms the **upper segment of the lower limb skeleton** and participates in:
    - **Hip joint** (proximally)
    - **Knee joint** (distally)

Parts of the Femur

1. **Upper End**
2. **Shaft**
3. **Lower End**

Upper End

Consists of:

1. **Head** –
    - Smooth, spherical structure forming **2/3 of a sphere**.
    - Directed **medially, upward, and slightly forward**.
    - Covered with **articular cartilage**, except at the **fovea capitis**, where the **ligament of head of femur** attaches.
2. **Neck** –
    - Connects the head to the shaft.
    - Forms an angle of **125°–130° with the shaft** (angle of inclination).
    - In newborns, this angle is about **150°** and decreases with age.
    - *Clinical correlation:* Decrease in angle ? **coxa vara**; Increase ? **coxa valga**.
3. **Greater Trochanter** –
    - Large, quadrangular projection on the lateral side.
    - Gives attachment to:
        - *Gluteus medius* (lateral surface)
        - *Gluteus minimus* (anterior surface)
        - *Piriformis* (superior border)
        - *Obturator internus and gemelli* (medial surface)

        - *Vastus lateralis* (base)
    - Palpable on lateral aspect of thigh; used to locate hip joint level.

4. **Lesser Trochanter** –
    - Small, conical projection on the **posteromedial surface**.
    - Gives insertion to *psoas major* and *iliacus* muscles (as iliopsoas).
5. **Intertrochanteric Line** –
    - On anterior surface between the two trochanters.
    - Gives attachment to *iliofemoral ligament* (of hip joint capsule).
6. **Intertrochanteric Crest** –
    - On posterior surface between trochanters.
    - Has a rounded tubercle called **quadrate tubercle** for *quadratus femoris* muscle.

Shaft

- Long, cylindrical, and slightly bowed **forward (anterior convexity)**.
- Has **three surfaces** — anterior, medial, and lateral — separated by **three borders** — medial, lateral, and posterior.
- **Posterior border** forms a prominent **linea aspera**, which divides above into:
    - *Gluteal tuberosity* (for gluteus maximus)

- *Pectineal line* (for pectineus)
- *Spiral line* (leading to lesser trochanter)

- **Linea aspera** below divides into **medial and lateral supracondylar lines**.

Attachments along Linea Aspera

- **Lateral lip:** Gluteus maximus, vastus lateralis, short head of biceps femoris.
- **Medial lip:** Adductor longus, adductor magnus, vastus medialis.
- **Between lips:** Adductor brevis and part of adductor magnus.

Lower End

- Expanded and articulates with the **tibia and patella**.
- Has:
    1. **Two condyles (medial and lateral)** – separated by **intercondylar fossa (posteriorly)** and **patellar surface (anteriorly)**.
    2. **Patellar surface:** Smooth anterior area for articulation with patella.
    3. **Medial condyle:** Larger and projects lower; bears the **adductor tubercle** for insertion of *adductor magnus*.
    4. **Lateral condyle:** Provides attachment to *popliteus* tendon.
- **Intercondylar fossa:** Lodges *cruciate ligaments* of the knee.

Ossification of Femur

Primary Centres

- **Shaft** – appears **in the 7th week of intrauterine life** (one of the earliest long bone centres).

Secondary Centres

PART	APPEARANCE	FUSION WITH SHAFT
Lower end (distal epiphysis)	9th month of intrauterine life	18–20 years
Head	1 year	18 years
Greater trochanter	4 years	18 years
Lesser trochanter	12–14 years	18 years

Note: The **lower end** ossification centre appears **before birth** and is used in **determining fetal viability** in forensic medicine.

Sequence of Fusion

1. Lesser trochanter ? 18 years
2. Greater trochanter ? 18 years
3. Head ? 18 years
4. Lower end ? 20 years

Complete fusion by about 20 years of age.

Clinical Anatomy of Femur

1. Fractures

- **Neck of Femur**
  - Common in **elderly osteoporotic females**.
  - Classified as **intracapsular** or **extracapsular**.
  - *Intracapsular fracture* ? poor healing due to interruption of **retinacular arteries** (branches of medial circumflex femoral artery).
  - Leads to **avascular necrosis** of the femoral head.
- **Intertrochanteric Fracture**
  - Between greater and lesser trochanters.
  - Extracapsular ? heals well due to good blood supply.
- **Shaft Fracture**
  - Common in young adults (motor accidents).
  - Causes **shortening** due to muscle pull:
    - *Upper fragment* ? flexed, abducted, externally rotated (gluteus medius, iliopsoas).
    - *Lower fragment* ? pulled upward by *adductors*.

- **Supracondylar Fracture**
    - May injure **popliteal artery**, leading to ischemia and gangrene.

---

2. Developmental & Pathological Conditions

- **Coxa Vara** – Decrease in neck-shaft angle (<120°).
    - Causes limp and limited abduction.
    - May be congenital or post-traumatic.
- **Coxa Valga** – Increase in neck-shaft angle (>135°).
    - Causes unstable hip joint.
- **Slipped Capital Femoral Epiphysis** – Displacement of femoral head epiphysis in adolescence.

---

3. Applied Surgical Importance

- **Intramedullary nailing** for shaft fractures – entry through **greater trochanter**.
- **Bone marrow biopsy** rarely done in femur due to thick cortex.
- **Femoral head vascularity**:
    - Mainly from *medial circumflex femoral artery* via **retinacular vessels**.
    - Damage leads to **avascular necrosis**.

---

4. Radiological Importance

- **Centre of ossification of lower end** appears before birth — useful for determining **fetal maturity**.
- **Neck-shaft angle measurement** helps in diagnosing deformities (coxa vara, valga).

---

5. Forensic Importance

- **Length of femur** can be used to **estimate body height** using anthropometric formulas.

Patella

Introduction

- The **patella** is a **large sesamoid bone** developed within the **tendon of quadriceps femoris**.
- It is the **largest sesamoid bone** in the body.
- It is **triangular**, with:
  - **Apex** pointing **downward**.
  - **Base** directed **upward**.
  - **Anterior surface** convex and rough.
  - **Posterior surface** divided into **articular and non-articular areas**.

- It articulates with the **patellar surface of the femur** to form the **patellofemoral part of the knee joint**.

Position and Orientation

To hold the bone in **anatomical position**:

- The **apex** should point downward.
- The **base** should be above.
- The **lateral articular surface** is **larger** than the medial one — this helps in identifying the side.

Features

1. Anterior Surface

- Convex and rough for attachment of:
  - *Fibres of quadriceps tendon* (above).
  - *Patellar retinacula* (sides).
- The **lower part** gives attachment to the **ligamentum patellae**, which connects the patella to the **tibial tuberosity**.

2. Posterior Surface

- **Upper three-fourths:** Articular and smooth — covered with **hyaline cartilage**.
  - Divided into **two facets** by a **vertical ridge**:

    - **Lateral facet:** Larger and deeper; articulates with the lateral femoral condyle.
    - **Medial facet:** Smaller and shallower; articulates with the medial femoral condyle.
- **Lower one-fourth:** Rough, non-articular area for attachment of **ligamentum patellae**.

3. Margins

- **Medial and lateral borders** give attachment to **medial and lateral patellar retinacula** (expansions of vastus medialis and vastus lateralis).

4. Apex

- The **apex** is the pointed inferior tip of the patella.
- Gives attachment to **ligamentum patellae**.

5. Base

- Broad superior margin.
- Gives attachment to the **rectus femoris** and **vastus intermedius** tendons.

Side Determination

1. Place the **apex downwards** and **anterior surface facing forward**.
2. The **larger articular facet** will be **lateral** ? this determines the side.

Muscular and Ligamentous Attachments

- **Base:** Tendon of *quadriceps femoris*.
- **Apex:** *Ligamentum patellae* (to tibial tuberosity).
- **Medial border:** *Vastus medialis* and *medial patellar retinaculum*.
- **Lateral border:** *Vastus lateralis* and *lateral patellar retinaculum*.

Ossification of Patella

- **Type:** Sesamoid bone ossifying in tendon.
- **Centre of ossification:**
  - Appears during the **3rd to 5th year** of life.
  - Sometimes appears as **two or more centres**, which may not unite — forming a **bipartite patella**.
- **Fusion:** Ossification is completed by **puberty** (around 14–16 years).

Summary Table

STAGE	TIME OF APPEARANCE	REMARKS
Primary centre	3rd–5th year	Develops within quadriceps tendon
Accessory centres	May appear occasionally	Cause bipartite or tripartite patella
Complete ossification	By puberty	Around 14–16 years

Clinical Anatomy of Patella

1. Patellar Fractures

- **Transverse fractures** are common due to **direct blow or sudden quadriceps contraction**.
- The **upper fragment** is pulled upward by the *quadriceps femoris*; the **lower fragment** remains attached to *ligamentum patellae*.
- **Comminuted fractures** (multiple fragments) occur from severe trauma.
- **Treatment:** Tension-band wiring or open reduction fixation.

---

2. Bipartite / Tripartite Patella

- Occurs when **ossification centres fail to unite**.
- Usually **asymptomatic**, discovered incidentally on X-ray.
- Commonly located at the **superolateral angle**.
- Must be differentiated from **fracture** (margins smooth, no pain).

---

3. Chondromalacia Patellae

- Also called **runner's knee**.
- Softening and degeneration of **articular cartilage** on posterior surface of patella.
- Causes **anterior knee pain**, especially while climbing stairs.

---

4. Patellar Dislocation

- More common in **adolescent females**.
- Usually **lateral dislocation** due to:
  - Shallow trochlear groove.
  - Lateral pull of *vastus lateralis*.
  - Weakness of *vastus medialis oblique (VMO)*.
- Predisposing factors: genu valgum, high patella (patella alta).

---

5. Patellar Reflex (Knee Jerk)

- Tapping the **ligamentum patellae** causes **extension of the leg** via *quadriceps contraction*.
- Tests the integrity of **L2–L4 spinal segments** and the **femoral nerve**.

---

6. Patellar Tracking Disorders

- Abnormal movement of patella during knee flexion/extension.
- May cause **crepitus** or **pain** due to uneven cartilage wear.

---

7. Surgical Relevance

- **Patellectomy:** Surgical removal of patella, done rarely for comminuted fractures.

- Results in **loss of mechanical advantage** of quadriceps ? decreased extension strength.

---

8. Radiological Uses

- The **shape and height** of patella used to assess **patellar alta** or **baja** (high-riding or low-riding patella).
- **Sunrise or skyline X-ray view** shows alignment of patella in femoral trochlea.

Tibia

Introduction

- The **tibia** (shin bone) is the **medial and larger bone of the leg**.
- It is the **second longest bone** in the body, after the femur.
- It bears the **weight of the body** from the femur and transmits it to the talus (ankle bone).
- It articulates:
    - **Above** – with *femur* and *fibula* (at superior tibiofibular joint).
    - **Below** – with *talus* and *fibula* (at inferior tibiofibular joint).

General Features

The tibia has **two ends** and a **shaft**:

1. **Upper end**
2. **Shaft**
3. **Lower end**

Upper End

- Expanded for articulation with the **femoral condyles** and for the attachment of ligaments and muscles.

Important Parts

1. **Medial and Lateral Condyles**
    - Flattened articular surfaces separated by an **intercondylar area**.
    - Covered with **hyaline cartilage** for articulation with femoral condyles.
    - *Medial condyle* is larger and oval; *lateral condyle* is circular.
2. **Intercondylar Area**
    - Between condyles, divided into:
        - *Anterior intercondylar area*
        - *Posterior intercondylar area*
    - Gives attachment to *anterior and posterior cruciate ligaments* and *menisci* of the knee.

3. **Intercondylar Eminence**
    - A raised bony ridge between the articular surfaces.
    - Composed of:
        - *Medial intercondylar tubercle*
        - *Lateral intercondylar tubercle*
    - Prevents lateral displacement of femoral condyles.
4. **Tibial Tuberosity**
    - Prominent rough elevation below the condyles on anterior surface.
    - *Upper smooth part* – attachment of *ligamentum patellae*.
    - *Lower rough part* – for *patellar retinacula*.
5. **Gerdy's Tubercle**
    - On lateral condyle, for insertion of *iliotibial tract*.
6. **Articular Facet for Fibula**
    - Located on posteroinferior aspect of lateral condyle, for *head of fibula*.

Shaft

- **Triangular in cross-section**, with **three borders** and **three surfaces**.

Borders

1. **Anterior border (shin)** – sharp and prominent; palpable under skin.
2. **Medial border** – smooth and rounded.
3. **Interosseous border (lateral)** – sharp ridge for attachment of *interosseous membrane* connecting tibia and fibula.

Surfaces

1. **Medial surface** – subcutaneous and easily palpable (skin over the shin).
2. **Lateral surface** – between anterior and interosseous borders; origin of *tibialis anterior*.
3. **Posterior surface** – marked by *soleal line* (oblique ridge) giving attachment to *soleus*; below it lies the *nutrient foramen* (directed downward).

Lower End

- Smaller and quadrangular; forms part of the ankle joint.

Parts

1. **Medial Malleolus**
    - Prominent downward projection on medial side; subcutaneous and palpable.
    - Lateral surface articulates with *talus*.
    - Medial surface gives attachment to *deltoid ligament*.
2. **Fibular Notch**

- On lateral aspect for *inferior tibiofibular articulation*.

3. **Inferior Articular Surface**
   - Quadrilateral surface articulating with the *superior surface of talus*.
4. **Groove for Tendons**
   - Posterior aspect has grooves for *tibialis posterior* and *flexor digitorum longus* tendons.

Side Determination

1. Medial malleolus points downward and medially.
2. Tibial tuberosity is anterior.
3. Smooth articular surface for fibula lies laterally.
   ? The bone belongs to the side of the medial malleolus.

Muscular Attachments

STRUCTURE	MUSCLES ATTACHED
Upper anterior surface of tibia	*Sartorius*, *gracilis*, *semitendinosus* (Pes anserinus)
Upper lateral surface	*Tibialis anterior*
Soleal line (posterior surface)	*Soleus*
Below soleal line	*Tibialis posterior*, *Flexor digitorum longus*

STRUCTURE	MUSCLES ATTACHED
Lateral surface (upper two-thirds)	*Tibialis anterior*
Lateral surface (lower third)	*Extensor digitorum longus*
Medial surface (subcutaneous)	No muscle attached

Ossification of Tibia

CENTRE	TIME OF APPEARANCE	FUSION
Primary centre (shaft)	7th week intrauterine life	—
Secondary centre for upper end	At birth	20–22 years
Secondary centre for lower end	1–2 years	18–20 years
Secondary centre for tibial tuberosity	12–14 years	18 years (may fuse with upper epiphysis)

Sequence

1. Shaft – prenatal (7th week IU)
2. Upper end – at birth (contains an epiphysis with a large tibial tubercle)

3. Lower end – 1 to 2 years

4. Tibial tuberosity (accessory) – 12 to 14 years
   ? All unite with shaft by **20–22 years**.

Special Note

- **Upper epiphyseal centre** appears before birth ? used in **determining neonatal maturity**.
- The **tibial tuberosity** may ossify separately and later unite with the upper epiphysis.

Clinical Anatomy of Tibia

1. Fractures

- **Shaft fractures** are common due to its subcutaneous position (especially lower third).
  - Usually **open fractures** because of poor soft-tissue cover.
- **Union is slow** because of poor blood supply.
- **Upper end fractures** may extend into **knee joint (tibial plateau fractures)**, causing joint effusion and instability.
- **Lower end fractures** (near medial malleolus) may involve the **ankle joint**, producing *Pott's fracture*.

---

2. Osgood–Schlatter Disease

- Occurs in adolescents due to **avulsion or microfracture at the tibial tuberosity** (site of patellar ligament attachment).
- Caused by repetitive strain from *quadriceps contraction*.
- Presents with localized **pain and swelling** over tibial tuberosity.

---

3. Compound (Open) Fractures

- The **subcutaneous anterior surface** of tibia predisposes to *compound fractures* with risk of infection, delayed union, or osteomyelitis.

---

4. Stress Fractures

- Seen in athletes and military recruits due to **repeated microtrauma**.
- Typically in the **lower third of shaft**; visible on bone scan or MRI before X-ray.

---

5. Nutrient Artery Importance

- The **nutrient artery** (from posterior tibial artery) enters the bone **below the soleal line** and runs **downward** — “to the elbow I go, from the knee I flee.”
- Injury to this artery may delay healing.

---

6. Flatfoot and Tibial Deformities

- **Medial malleolus** serves as attachment for the *deltoid ligament*, maintaining the **medial arch** of foot.

- Malalignment (e.g., **tibia vara** or **tibia valga**) may alter gait and foot mechanics.

---

7. Surgical and Radiological Relevance

- **Tibial crest** and **medial surface** used for bone graft harvesting.
- **Intraosseous infusion** in emergencies (children) given in **upper medial tibial surface** below tibial tuberosity.

---

8. Forensic Relevance

- Length of tibia used for **stature estimation** in skeletal remains.

Fibula

Introduction

- The **fibula** is the **lateral and smaller bone of the leg**.
- It lies **parallel to the tibia** and is connected to it by an **interosseous membrane**.
- It **does not bear body weight**; its main role is to provide **muscle attachment** and form the **lateral wall of the leg**.
- The lower end forms the **lateral malleolus**, which takes part in forming the **ankle joint**.

Parts of the Fibula

Like other long bones, it has:

1. **Upper end (Head)**
2. **Shaft**
3. **Lower end (Lateral malleolus)**

Upper End

- Expanded into a **head**, with a rounded apex called the **styloid process**.
- **Articular facet** on the upper surface of the head ? articulates with the *lateral condyle of tibia* (superior tibiofibular joint).
- **Neck of fibula** – constricted part below the head.
    - *Common peroneal (fibular) nerve* winds around it ? vulnerable to injury.
- **Styloid process** – projects upward from the head; gives attachment to:
    - *Fibular collateral ligament* (of knee joint).
    - *Biceps femoris* tendon.

Shaft

- Long, slender, and twisted.
- Has **three borders** (anterior, posterior, interosseous) and **three surfaces** (medial, lateral, posterior).

Borders

1. **Anterior border** – begins below the anterior aspect of head and continues to anterior border of lateral malleolus.

2. **Posterior border** – extends from the back of head to the posterior border of lateral malleolus.

3. **Interosseous border (medial)** – for attachment of *interosseous membrane*.

Surfaces

1. **Medial surface (anterior)** – origin for *extensor digitorum longus* and *extensor hallucis longus*.

2. **Lateral surface** – origin for *peroneus longus* and *peroneus brevis*.

3. **Posterior surface** – has a vertical *nutrient foramen* directed upward;

    - Above: *Soleus* and *Flexor hallucis longus*.

    - Below: *Peroneus longus*.

Lower End

- Expanded to form the **lateral malleolus**, which extends lower and posterior to the medial malleolus of the tibia.

Features

1. **Medial surface** – has a triangular articular facet for *lateral surface of talus*.

2. **Anterior border** – attachment to *anterior talofibular ligament*.

3. **Posterior border** – has a shallow *groove for tendons* of *peroneus longus* and *peroneus brevis*.

4. **Lateral surface** – subcutaneous, easily palpable.

5. **Tip of lateral malleolus** – attachment for *calcaneofibular ligament*.

Side Determination

1. **Head upward**, **lateral malleolus downward**.

2. Smooth *articular facet* faces medially.

3. The *groove for peroneal tendons* lies posteriorly.
   ? The side corresponds to the position of the lateral malleolus.

Muscular Attachments of Fibula

REGION	MUSCLES ATTACHED
Head	*Biceps femoris*, *fibular collateral ligament*
Upper two-thirds anterior surface	*Extensor digitorum longus*, *Extensor hallucis longus*
Lateral surface	*Peroneus longus*, *Peroneus brevis*
Posterior surface	*Soleus*, *Flexor hallucis longus*
Lower fourth medial surface	*Peroneus tertius*
Interosseous border	*Interosseous membrane*

Ossification of Fibula

CENTRE	TIME OF APPEARANCE	FUSION WITH SHAFT
Primary centre (shaft)	8th week intrauterine life	—
Secondary centre (lower end)	1st year	18–20 years
Secondary centre (upper end)	3–4 years	20–25 years

Key Points

- **Lower end ossifies first** but **fuses later**.
- **Upper end ossifies later** but **fuses first**.
  ? This is the reverse of the pattern seen in the tibia.

Mnemonic

"**Lower first, upper last — but upper joins first, lower joins last**."

Clinical Anatomy of Fibula

1. Fractures

- **Fibular neck fracture** – may injure **common peroneal nerve**, leading to:
  - *Foot drop* (loss of dorsiflexion and eversion).
  - Sensory loss over dorsum of foot.

- **Fibular shaft fracture** – usually accompanies tibial fracture; rarely isolated because it's non-weight-bearing.
- **Avulsion fractures** – at the **lateral malleolus**, due to pull of *lateral ligaments* of ankle.

---

2. Pott's Fracture

- A **bimalleolar fracture** involving **lateral and medial malleoli**.
- Occurs due to **forcible eversion of foot**.
- The **lateral malleolus** is fractured due to tension of the *deltoid ligament* pulling the medial malleolus and pushing the talus laterally.

---

3. Surgical and Orthopedic Importance

- **Fibular grafts:**
  - Commonly used for **bone grafting**, since fibula is expendable and non-weight-bearing.
  - Middle third is preferred for graft harvest.
- **Free vascularized fibular grafts** are used in reconstructive surgery of long bones and mandible.

---

4. Relation to Common Peroneal Nerve

- The **common peroneal nerve winds around the neck** of fibula, making it vulnerable in:
  - Fibular head fractures.

    - Plaster casts or tight bandages.

- Injury causes **foot drop** and loss of eversion.

---

5. Ankle Joint Relevance

- **Lateral malleolus** extends **lower and posterior** to medial malleolus ? stabilizes ankle joint and prevents *lateral displacement* of talus.

- Provides attachment for the **lateral ligament complex**:

    - *Anterior talofibular ligament*

    - *Posterior talofibular ligament*

    - *Calcaneofibular ligament*

---

6. Radiological and Forensic Uses

- Length of fibula is used for **height estimation** in anthropology.

- *Epiphyseal union timing* helps in **age estimation** in forensic medicine.

---

7. Clinical Palpation Points

- **Head of fibula** – palpable below lateral side of knee joint; landmark for nerve block.

- **Lateral malleolus** – forms the outer prominence of ankle; used in assessing malleolar fractures.

---

8. Deformities

- **Fibular hemimelia** – congenital absence or underdevelopment of fibula, leading to shortening of limb and foot deformities.
- **Fibular malunion** – improper healing can cause rotational deformities affecting gait.

Bones of the Foot

Introduction

- The **skeleton of the foot** is formed by **26 bones**, arranged to provide **support, balance, and locomotion**.
- These bones are grouped into three parts:
    1. **Tarsus (Tarsal bones)** – 7 bones
    2. **Metatarsus (Metatarsal bones)** – 5 bones
    3. **Phalanges (Toes)** – 14 bones
- The tarsal bones form the **posterior half of the foot** and are responsible for **forming the arches** and **bearing body weight**.

Tarsus / Tarsal Bones

Names of Tarsal Bones (7)

1. **Talus**

2. **Calcaneus**
3. **Navicular**
4. **Cuboid**
5. **Medial cuneiform**
6. **Intermediate cuneiform**
7. **Lateral cuneiform**

Arrangement

- **Proximal row** ? *Talus* and *Calcaneus*
- **Intermediate row** ? *Navicular*
- **Distal row** ? *Three cuneiforms* and *Cuboid*
- *Mnemonic:* **“Tiger Cubs Need MILC”**
  (Talus, Calcaneus, Navicular, Medial–Intermediate–Lateral cuneiforms, Cuboid)

Key Features

- The **talus** articulates with tibia and fibula to form the **ankle joint**.
- The **calcaneus** forms the **heel** and articulates with talus and cuboid.
- The **navicular** lies in front of talus, behind the cuneiforms.
- The **cuboid** lies lateral, articulating with calcaneus and 4th–5th metatarsals.

- The **cuneiforms** (medial, intermediate, lateral) articulate with navicular and first three metatarsals.

Talus

Introduction

- The **talus** is the **second largest tarsal bone** and the **only bone connecting the foot to the leg**.
- It transmits **body weight** from the tibia to the calcaneus and forefoot.
- Unique feature: **no muscular attachments** ? entirely covered by **articular cartilage and ligaments**.

Parts

1. **Head**
2. **Neck**
3. **Body**

---

1. Head

- Rounded and directed **forward and slightly downward and medial**.
- Articulates:
    - **Anteriorly** ? with *navicular bone* (forming talonavicular joint).

- **Inferiorly** ? with *calcaneus* via *anterior subtalar facet*.

- The head supports the **spring ligament (plantar calcaneonavicular ligament)**.

---

2. Neck

- Narrow constricted part between head and body.
- Upper surface ? *groove for dorsalis pedis artery*.
- Inferior surface ? *sulcus tali*, forming **tarsal sinus** with *sulcus calcanei*.
- Ligament attachments:
  - *Cervical ligament* and *interosseous talocalcaneal ligament* in the sinus tarsi.

---

3. Body

- Largest part, cuboidal in shape, with **five surfaces**:

SURFACE	FEATURES / ARTICULATIONS
Superior	Trochlear surface articulates with tibia ? forms **ankle joint**
Inferior	Three facets for calcaneus (posterior, middle, anterior)
Medial	Comma-shaped facet for *medial malleolus*
Lateral	Triangular facet for *lateral malleolus*

SURFACE	FEATURES / ARTICULATIONS
Posterior	Groove for *flexor hallucis longus* tendon; lateral and medial tubercles on either side

- **Posterior process:**
  - *Lateral tubercle* – attachment for *posterior talofibular ligament*.
  - *Medial tubercle* – attachment for *posterior talocalcaneal ligament*.
  - Between them: *groove for flexor hallucis longus*.

Side Determination

1. Head faces **forward, medially, and downward**.
2. Larger facet on **lateral side** for fibula.
3. Groove on posterior surface runs **obliquely downward and medially**.
   ? Bone belongs to that side.

Articulations of Talus

1. **Superiorly** – with *tibia* (ankle joint)
2. **Laterally** – with *fibula* (ankle joint)
3. **Inferiorly** – with *calcaneus* (subtalar joint)
4. **Anteriorly** – with *navicular* (talonavicular joint)

Ossification of Talus

CENTRE	TIME OF APPEARANCE	FUSION / REMARKS
Primary centre	7th month intrauterine life	—
Secondary centre (for lateral tubercle)	8–10 years	May fail to fuse, forming *os trigonum*

- The **talus ossifies from a single centre**, but occasionally a separate secondary centre appears for the **lateral tubercle** of posterior process.
- Ossification complete by **20 years**.

Clinical Anatomy of Talus (and Tarsal Region)

1. Fractures of Talus

- **Common sites:** Neck and body.
- **Mechanism:** Fall from height or forced dorsiflexion of foot.
- **Complication:** High risk of **avascular necrosis (AVN)** of body due to disrupted blood supply (mostly from posterior tibial and dorsalis pedis arteries).
- *Hawkins classification* used for neck fractures.

---

2. Os Trigonum Syndrome

- Occurs when the **secondary ossification centre of lateral tubercle** fails to fuse ? accessory bone (*os trigonum*).
- May cause posterior ankle pain, especially in ballet dancers and footballers due to repetitive plantar flexion.

---

3. Congenital and Developmental Anomalies

- **Tarsal coalition:** Fusion between talus and calcaneus or navicular ? restricted inversion/eversion, flatfoot.
- **Talipes equinovarus (clubfoot):** Medial rotation of talus leads to inward-turned foot.

---

4. Flatfoot (Pes Planus)

- Collapse of the **medial longitudinal arch**, commonly due to stretching of the **spring ligament** beneath the talar head.
- The **head of talus** moves downward and medially ? foot appears flat on the ground.

---

5. Dislocations

- **Subtalar dislocation:** Talus remains in ankle mortise, but calcaneus and navicular are displaced medially or laterally.
- **Total dislocation of talus:** Rare but serious; disrupts all articular connections, often causing necrosis.

---

6. Blood Supply Significance

- Blood supply mainly from:
    - *Posterior tibial artery* ? via tarsal canal branch.
    - *Dorsalis pedis artery* ? via sinus tarsi branch.
    - *Perforating peroneal artery*.
- Because of poor anastomosis, talar fractures are prone to **avascular necrosis**.

---

7. Radiological Importance

- **Lateral view (Harris-Beath view)** helps assess tarsal coalition and talar fractures.
- **Ossification pattern** aids in **fetal maturity estimation**.

---

8. Surgical Note

- **Talectomy** (excision of talus) may be performed in severe clubfoot unresponsive to correction.
- **Talar replacement** prosthesis is rarely used due to complex blood supply.

Calcaneus (Calcaneum)

Introduction

- The **calcaneus** (or **heel bone**) is the **largest tarsal bone** and forms the **prominence of the heel**.
- It lies **below the talus** and **behind the cuboid**.
- Functionally, it **transmits the weight of the body** from the talus to the ground.
- It forms part of both:
    - **Subtalar joint** (with talus above)
    - **Calcaneocuboid joint** (with cuboid in front)

Position and Orientation

To hold the bone in **anatomical position**:

1. The **posterior surface** (for Achilles tendon) faces backward.
2. The **anterior articular facet** faces forward.
3. The **sustentaculum tali** projects medially.
   ? The bone belongs to the side of the **sustentaculum tali**.

Parts and Surfaces

The calcaneus has **six surfaces**: superior, inferior, anterior, posterior, medial, and lateral.

---

1. Superior Surface

Divided into **three areas** (from behind forward):

- **Posterior area:** Rough, for attachment of **calcaneal (Achilles) tendon** and **bursa**.

- **Middle area:** Bears the **posterior articular facet** for talus (forming part of subtalar joint).
- **Anterior area:** Bears the **middle and anterior articular facets** for talus, separated by *sulcus calcanei* (forms *tarsal sinus* with sulcus tali of talus).

---

2. Inferior Surface

- Rough, with **three tubercles**:
  - **Medial process of tuberosity:** Large, for origin of *abductor hallucis* and *flexor digitorum brevis*.
  - **Lateral process:** Smaller, for origin of *abductor digiti minimi*.
  - **Anterior tubercle:** For attachment of *long plantar ligament*.

---

3. Anterior Surface

- Bears a **saddle-shaped facet** for articulation with the **cuboid bone** (calcaneocuboid joint).

---

4. Posterior Surface

- Divided into three parts:
  - **Upper smooth area:** For *retrocalcaneal bursa*.
  - **Middle rough area:** For insertion of *tendo calcaneus (Achilles tendon)*.
  - **Lower rough area:** For origin of *plantar aponeurosis* and *abductor digiti minimi*.

---

5. Medial Surface

- Shelf-like projection called **sustentaculum tali**, which:
  - Supports the *head of talus*.
  - Has a **groove below it** for *flexor hallucis longus tendon*.
  - Gives attachment to *spring ligament* (plantar calcaneonavicular ligament).
  - Provides surface for *tibialis posterior* tendon attachment.

---

6. Lateral Surface

- Marked by:
  - *Peroneal trochlea (fibular trochlea)* between the tendons of *peroneus longus* (below) and *peroneus brevis* (above).
  - *Peroneal tubercle* acts as pulley for peroneal tendons.
  - Smooth area for *retinaculum* attachment.

Articulations of Calcaneus

1. **Superiorly** – with *talus* (subtalar joint).
2. **Anteriorly** – with *cuboid* (calcaneocuboid joint).

Attachments on Calcaneus

REGION	STRUCTURES ATTACHED
Posterior surface	*Tendo calcaneus*, *plantar aponeurosis*
Inferior surface	*Abductor hallucis*, *Flexor digitorum brevis*, *Abductor digiti minimi*
Medial surface	*Spring ligament*, *Flexor retinaculum*
Lateral surface	*Peroneal retinacula*, *Peroneal trochlea*
Anterior surface	*Long plantar ligament*
Sustentaculum tali	*Spring ligament*, *Tibialis posterior tendon*

Ossification of Calcaneus

CENTRE	TIME OF APPEARANCE	FUSION
Primary centre	6th month intrauterine life	—
Secondary centre (for calcaneal tuberosity)	6–8 years	14–16 years

- The calcaneus ossifies from **two centres**:
    1. **Primary centre** – forms most of the bone.
    2. **Secondary centre** – appears for the **posterior tuberosity** (insertion of Achilles tendon).
- Failure of fusion of the secondary centre may form an accessory bone called **os calcaneus secundarius**.

Clinical Anatomy of Calcaneus

1. Fractures

- **Commonest tarsal bone to fracture.**
- **Mechanism:** Fall from height landing on heel (axial compression).
- **Fracture types:**
  - **Comminuted fracture:** Disruption of *subtalar joint* and *calcaneal body*.
  - **Avulsion fracture:** At the *posterior tuberosity* (due to violent pull of Achilles tendon).
- **Radiological feature:** Decrease in *Böhler's angle* (normally 20°–40°) indicates collapse of calcaneus.

---

2. Calcaneal Spur

- Chronic traction on the **medial process of calcaneal tuberosity** ? formation of **bony outgrowth (spur)** at plantar fascia attachment.
- Causes **heel pain (plantar fasciitis)**, especially during first steps in the morning.

---

3. Tendo Calcaneus (Achilles Tendon) Rupture

- Sudden, forceful dorsiflexion (in athletes) can rupture the tendon at its insertion on the **posterior surface of calcaneus**.
- Causes inability to stand on toes.

- Treated by surgical repair or immobilization.

---

4. Flatfoot (Pes Planus)

- Weakness or stretching of the **spring ligament** under the **sustentaculum tali** leads to descent of talar head, flattening the **medial longitudinal arch**.
- Pain occurs along medial side of heel.

---

5. Clubfoot (Talipes Equinovarus)

- Deformity due to **inversion and adduction** of calcaneus with medial rotation of talus.
- Leads to inward turning of sole and heel.

---

6. Sever's Disease (Calcaneal Apophysitis)

- Seen in growing children (8–14 years).
- Due to **inflammation of secondary ossification centre** of calcaneal tuberosity from overuse.
- Presents with **heel pain** during activity.

---

7. Surgical and Radiological Notes

- **Böhler's angle** and **Gissane's angle** on X-ray help evaluate calcaneal fractures.
- **Calcaneal bone grafts** are used in reconstructive foot surgery.

- **Peroneal tubercle** serves as an important surgical landmark for lateral foot incisions.

Navicular Bone

Introduction

- The **navicular bone** is a **boat-shaped tarsal bone** located in the **medial side of the foot**, between the **head of the talus** (behind) and the **three cuneiform bones** (in front).
- It forms part of the **medial longitudinal arch** and helps in **weight transmission** from the talus to the forefoot.

Surfaces and Features

1. **Posterior Surface**
    - Concave and oval.
    - Articulates with the **head of the talus** (forming the *talonavicular joint*).
2. **Anterior Surface**
    - Convex, divided into **three facets** for articulation with the **medial, intermediate, and lateral cuneiform bones**.
3. **Medial Surface**
    - Prominent **tuberosity** projects downward and medially.

- Gives insertion to the **tibialis posterior tendon** — key structure maintaining the **medial arch** of the foot.

4. **Lateral Surface**
   - Small facet for articulation with the **cuboid bone** (variable).
5. **Superior Surface**
   - Rough and narrow; for *ligament attachment*.
6. **Inferior Surface**
   - Rough for attachment of *plantar calcaneonavicular (spring) ligament* and part of *tibialis posterior tendon*.

Side Determination

- Concave surface faces **posteriorly**, convex surface **anteriorly**.
- **Tuberosity** projects **medially**.
  ? The bone belongs to the side of the projecting tuberosity.

Articulations

1. **Posteriorly** – *Talus*
2. **Anteriorly** – *Three cuneiforms*
3. **Laterally** – *Cuboid (occasionally)*

Ossification of Navicular Bone

CENTRE	TIME OF APPEARANCE	REMARKS
Primary centre	3rd year (in girls), 4th year (in boys)	Single centre forms entire bone
Accessory centre (Navicular tuberosity)	Occasionally present	Failure to fuse ? *Accessory navicular bone*

- The **navicular** is the **last tarsal bone to ossify**.
- Ossification completes around **12–14 years**.

Clinical Anatomy of Navicular

1. **Accessory Navicular Bone (Os Tibiale Externum)**
    - Results from non-fusion of the accessory centre at the tuberosity.
    - Causes **pain and tenderness on medial side of foot**, may mimic fracture.
2. **Navicular Fracture**
    - Occurs due to **indirect trauma or stress** (e.g., in runners).
    - May cause **collapse of medial arch**.
3. **Flatfoot (Pes Planus)**

- Displacement of **talus head** downward stretches the **spring ligament**, pressing against the navicular, producing flat appearance.

4. **Tarsal Coalition**

   - Fusion between navicular and calcaneus (*calcaneonavicular coalition*) ? restricted inversion/eversion.

Cuneiform Bones (Medial, Intermediate, and Lateral)

Introduction

- The **three cuneiform bones** are **wedge-shaped tarsal bones** lying in the **distal row** of tarsus, between the **navicular bone (behind)** and the **first three metatarsals (in front)**.
- They form part of the **medial longitudinal** and **transverse arches** of the foot.

General Arrangement

BONE	POSITION	ARTICULATES ANTERIORLY WITH
Medial cuneiform	Largest, most medial	1st metatarsal
Intermediate cuneiform	Smallest, between the other two	2nd metatarsal
Lateral cuneiform	Between intermediate cuneiform and cuboid	3rd metatarsal

---

Medial Cuneiform

Features

- **Largest** of the three and **wedge-shaped**, base directed downward.
- **Medial surface** is subcutaneous and easily palpable.
- **Anterior surface** – articulates with *base of 1st metatarsal*.
- **Posterior surface** – articulates with *navicular bone*.
- **Lateral surface** – articulates with *intermediate cuneiform* and *base of 2nd metatarsal*.
- **Inferior surface** – rough for *tibialis posterior* and *peroneus longus* attachments.

Attachments

- **Medial surface:** *Tibialis anterior* insertion.
- **Lateral surface:** *Peroneus longus tendon* crosses inferiorly.
- **Inferior surface:** Partly gives origin to *flexor hallucis brevis*.

Intermediate Cuneiform

Features

- **Smallest** of the three.
- **Wedge-shaped**, with base directed **upward**.

- **Posterior surface:** Articulates with *navicular bone*.
- **Anterior surface:** Articulates with *2nd metatarsal base*.
- **Medial surface:** Articulates with *medial cuneiform*.
- **Lateral surface:** Articulates with *lateral cuneiform*.
- **Superior and inferior surfaces:** Rough for ligament attachment.

Lateral Cuneiform

Features

- Lies between *intermediate cuneiform (medial)* and *cuboid (lateral)*.
- **Posterior surface:** Articulates with *navicular*.
- **Anterior surface:** Articulates with *3rd metatarsal*.
- **Medial surface:** Articulates with *intermediate cuneiform* and *2nd metatarsal*.
- **Lateral surface:** Articulates with *cuboid* and *4th metatarsal*.
- Gives partial origin to *flexor hallucis brevis*.

Ossification of Cuneiform Bones

BONE	CENTRE APPEARANCE	FUSION COMPLETED

Lateral cuneiform	1st year	12 years
Medial cuneiform	2nd year	12 years
Intermediate cuneiform	3rd year	12 years

- Occasionally, the **medial cuneiform** may have **two ossification centres** that later fuse.
- Ossification usually completes by **12 years of age**.

Clinical Anatomy of Cuneiform Bones

1. **Fractures**
    - Rare, due to protection by surrounding bones and strong ligaments.
    - Usually part of complex **Lisfranc fracture-dislocation** (at tarsometatarsal joint).
2. **Cuneiform Coalition**
    - Fusion between cuneiforms may lead to *restricted midfoot movement* and *foot stiffness*.
3. **Flatfoot (Pes Planus)**
    - Collapse of **medial arch** involves downward displacement of medial cuneiform; weight-bearing line shifts medially.
4. **Accessory Cuneiforms**
    - Occasionally found as small separate ossicles near normal bones (harmless, but may mimic fracture on X-ray).

5. **Palpation**
    - The **medial cuneiform** is palpable just anterior to the *navicular tuberosity* — a surface landmark in medial foot.

Cuboid

Introduction

- The **cuboid** is the **most lateral bone of the distal row of tarsus**.
- It is **cube-shaped**, forming the **lateral part of the foot's skeleton**.
- It lies **in front of the calcaneus** and **behind the 4th and 5th metatarsal bones**.
- It participates in forming the **lateral longitudinal arch** of the foot.

Surfaces and Features

1. **Anterior Surface**
    - Divided into **two facets** for articulation with the **bases of the 4th and 5th metatarsals**.
2. **Posterior Surface**
    - Saddle-shaped facet articulates with the **calcaneus** (calcaneocuboid joint).
3. **Medial Surface**

- Articulates with the **lateral cuneiform** and **navicular** (occasionally).

4. **Lateral Surface**
   - Smooth and forms the outer border of the foot.
5. **Inferior (Plantar) Surface**
   - Prominent **tuberosity** near its posterior part for attachment of the **long plantar ligament**.
   - Has a **groove for peroneus longus tendon**, obliquely directed forward and medially.
   - Medial end of the groove shows a **ridge (peroneal ridge)** and a **small sesamoid bone** within the tendon.
6. **Superior Surface**
   - Rough, non-articular area for ligament attachment.

Articulations

1. **Posteriorly** – *Calcaneus*
2. **Medially** – *Lateral cuneiform* and sometimes *navicular*
3. **Anteriorly** – *4th and 5th metatarsals*

Ossification of Cuboid

CENTRE	TIME OF APPEARANCE	FUSION COMPLETED
Primary centre	9th month intrauterine life (just before birth)	12 years

- The **cuboid** is the **first tarsal bone to ossify after birth** and is used in **determining full-term maturity of the newborn**.

Clinical Anatomy of Cuboid

1. **Cuboid Syndrome**
    - Partial subluxation or malalignment of cuboid bone due to *peroneus longus traction*.
    - Causes *lateral foot pain* and *difficulty in weight bearing*.
    - Common in athletes and ballet dancers.
2. **Fractures**
    - Usually due to **crush injuries** or **forced inversion** of the foot.
    - May cause collapse of the **lateral longitudinal arch**.
3. **Accessory Ossicles**
    - *Os peroneum* – small sesamoid bone sometimes found within the *peroneus longus tendon* near the cuboid groove.

Metatarsus

Introduction

- The **metatarsus** consists of **five metatarsal bones**, numbered **I to V** from medial to lateral side.
- They form the **skeleton of the forefoot** and connect the tarsus with the phalanges.
- Each metatarsal is a **miniature long bone** with:
    1. **Base** – proximal, articulating with tarsal bones
    2. **Shaft** – body
    3. **Head** – distal, articulating with proximal phalanges

---

Special Features

METATARSAL	SPECIAL CHARACTERISTICS
1st	Shortest, thickest, bears body weight; base has *facet for medial cuneiform* and *sesamoid bones under head*.
2nd	Longest; base wedged between medial and lateral cuneiforms (least mobile).
3rd	Base articulates with *lateral cuneiform*.
4th	Base articulates with *cuboid* and *lateral cuneiform*.
5th	Has prominent *tuberosity (styloid process)* on base for *peroneus brevis* tendon insertion.

Articulations Summary

BONE	POSTERIORLY	ANTERIORLY	LATERALLY / MEDIALLY
1st	Medial cuneiform	1st proximal phalanx	—
2nd	Medial, intermediate, lateral cuneiforms	2nd proximal phalanx	1st and 3rd metatarsals
3rd	Lateral cuneiform	3rd proximal phalanx	2nd and 4th metatarsals
4th	Cuboid and lateral cuneiform	4th proximal phalanx	3rd and 5th metatarsals
5th	Cuboid	5th proximal phalanx	4th metatarsal

Ossification of Metatarsals

CENTRE	TIME OF APPEARANCE	FUSION
Primary centre (shaft)	9th week intrauterine life	—
Secondary centre (head)	3rd year (1st – base)	18 years

- **1st metatarsal** – secondary centre appears at the **base**.

- **2nd to 5th metatarsals** – secondary centres appear at the **heads**.
- All fuse with shaft by **18 years**.

Clinical Anatomy of Metatarsals

1. **March Fracture**
    - Stress fracture of **2nd or 3rd metatarsal** from repetitive stress (common in soldiers, dancers).
    - Causes dorsal foot pain and swelling.
2. **Jones Fracture**
    - Transverse fracture at the **base of 5th metatarsal**, due to *peroneus brevis pull* during inversion injury.
    - Pain and tenderness at lateral midfoot.
3. **Hallux Valgus (Bunion)**
    - Lateral deviation of *1st metatarsophalangeal joint*, often with *medial bony prominence (bunion)*.
4. **Metatarsalgia**
    - Pain in forefoot due to *collapsed transverse arch*; involves *heads of 2nd and 3rd metatarsals*.

Phalanges

Introduction

- There are **14 phalanges** in the foot:
    - **2 in the great toe (hallux)**
    - **3 in each of the other four toes**
- Arranged as: **proximal, middle, and distal phalanges** (except great toe).
- Each phalanx has:
    - **Base** – proximal, articulates with metatarsal or preceding phalanx
    - **Shaft** – middle part
    - **Head** – distal, small and rounded (or expanded distally in distal phalanges)

Features

- **Proximal phalanges:** Longest; articulate with metatarsal heads.
- **Middle phalanges:** Absent in great toe.
- **Distal phalanges:** Flattened distal ends supporting the nail bed.
- The **distal phalanx of the great toe** is thick and strong, bearing much of the push-off weight in walking.

Ossification of Phalanges

CENTRE	TIME OF APPEARANCE	FUSION
Primary centre (shaft)	9th–10th week intrauterine life	—
Secondary centre (base)	3rd year	18 years

- Each phalanx ossifies from **two centres** — one for the **shaft**, and one for the **base** (which appears later).
- Ossification completes by **18 years of age**.

Clinical Anatomy of Foot Bones

1. Flatfoot (Pes Planus)

- Collapse of **medial longitudinal arch** due to ligament or muscle weakness.
- Navicular, talus, and cuneiform bones sink downward.

2. High Arch (Pes Cavus)

- Exaggerated medial arch due to contracture of intrinsic foot muscles or neurological disorders.

3. Claw Toes / Hammer Toes

- Deformities of phalanges due to *imbalance between long and short toe muscles*.

4. Metatarsalgia

- Pain under metatarsal heads due to **loss of transverse arch** or fat pad atrophy.

5. Accessory Ossicles

- Common small extra bones: *os peroneum*, *os trigonum*, *accessory navicular* — may mimic fractures radiologically.

Sesamoid Bones

Introduction

- **Sesamoid bones** are small nodules of bone embedded within tendons where they pass over joints or pressure points.
- They reduce friction, protect tendons, and improve the mechanical efficiency of muscles.

Sesamoid Bones in the Foot

1. **Two constant sesamoid bones** under the **head of 1st metatarsal**:
    - *Medial (tibial) sesamoid* ? in tendon of **flexor hallucis brevis (medial head)**
    - *Lateral (fibular) sesamoid* ? in tendon of **flexor hallucis brevis (lateral head)**
2. **Occasional sesamoids** may be present in tendons of:
    - *Peroneus longus* (near cuboid groove)
    - *Tibialis anterior* or *posterior*

- *Flexor digitorum longus* in toes

Clinical Anatomy of Sesamoid Bones

1. **Sesamoiditis**
   - Inflammation due to repetitive pressure on *1st metatarsal sesamoids* (common in runners and dancers).
   - Causes forefoot pain and tenderness beneath the great toe.
2. **Fracture of Sesamoids**
   - May mimic bipartite sesamoid (which has smooth margins).
   - Pain aggravated by toe dorsiflexion.
3. **Bipartite Sesamoid**
   - Congenital division into two parts; usually painless unless traumatized.
4. **Functionally Important**
   - Protect tendons from wear.
   - Increase leverage of *flexor hallucis brevis* during toe-off in walking.