Ankle complex

- Types, axis of motion, arthro & osteokinematics

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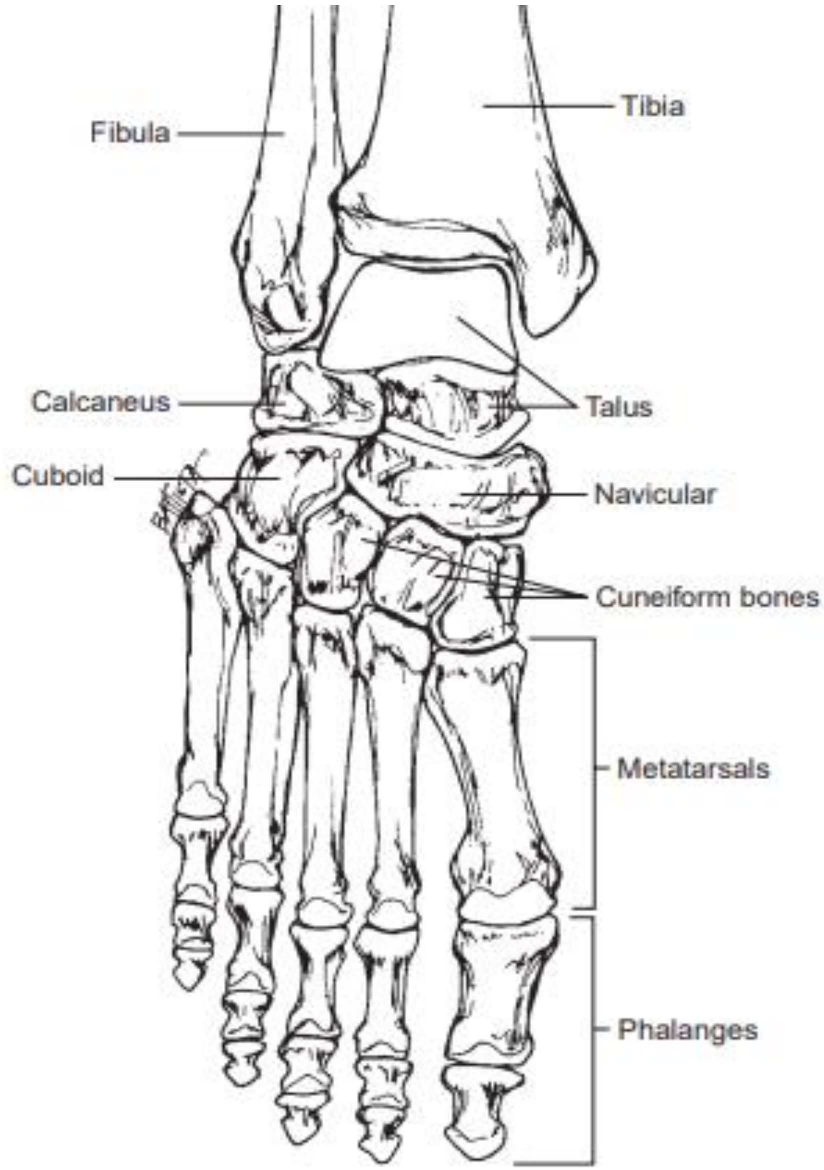
INTRODUTION

ANKLE AND FOOT

- The bones of ankle/foot complex consists of

❖ distal tibia and fibula
❖ 7 tarsal bones
❖ 5 metatarsals
❖ 14 phalanges.



The foot is divided into three segments:

Hindfoot

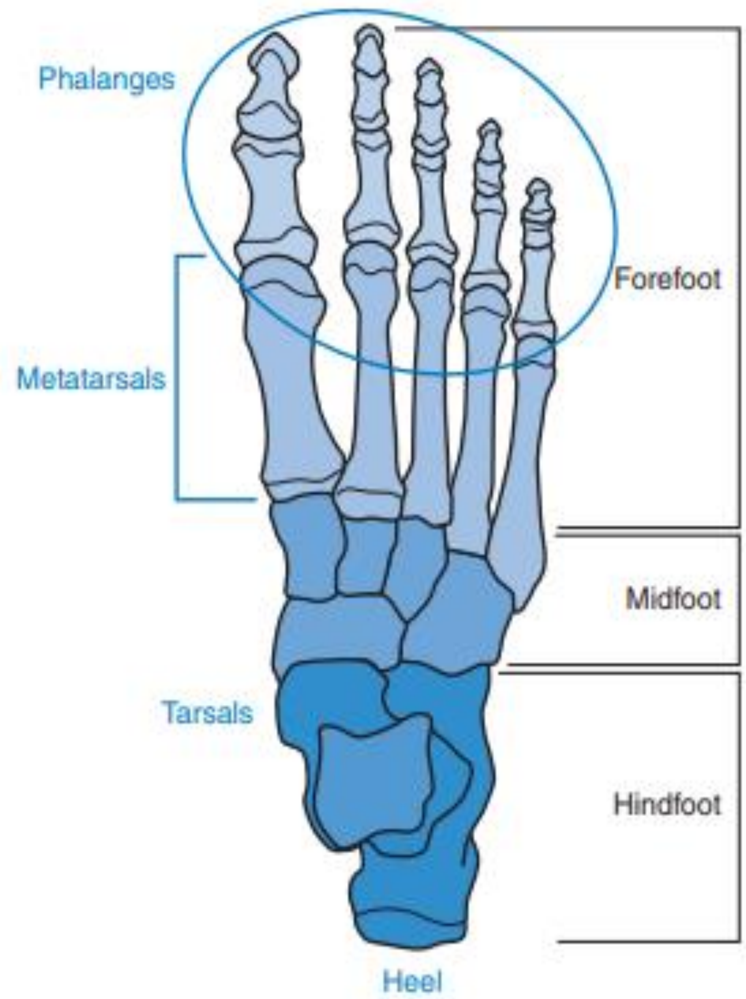
- Posterior segment
- Talus and calcaneus

Midfoot

- Middle segment
- Navicular, cuboid and 3 cuneiforms

Forefoot

- Anterior segment
- 5 metatarsals & 14 phalanges



JOINTS

- 28 bones that form 25 component joints:

- **Proximal and distal tibiofibular joints**
- **Talocrural (ankle) joint**
- **Talocalcaneal (subtalar) joint**
- **Talonavicular and calcaneocuboid joints (transverse tarsal joint)**
- 5 tarsometatarsal joints
- 5 **metatarsophalangeal** (MTP) joints
- 9 interphalangeal (IP) joints.

ANKLE / FOOT COMPLEX MOTIONS

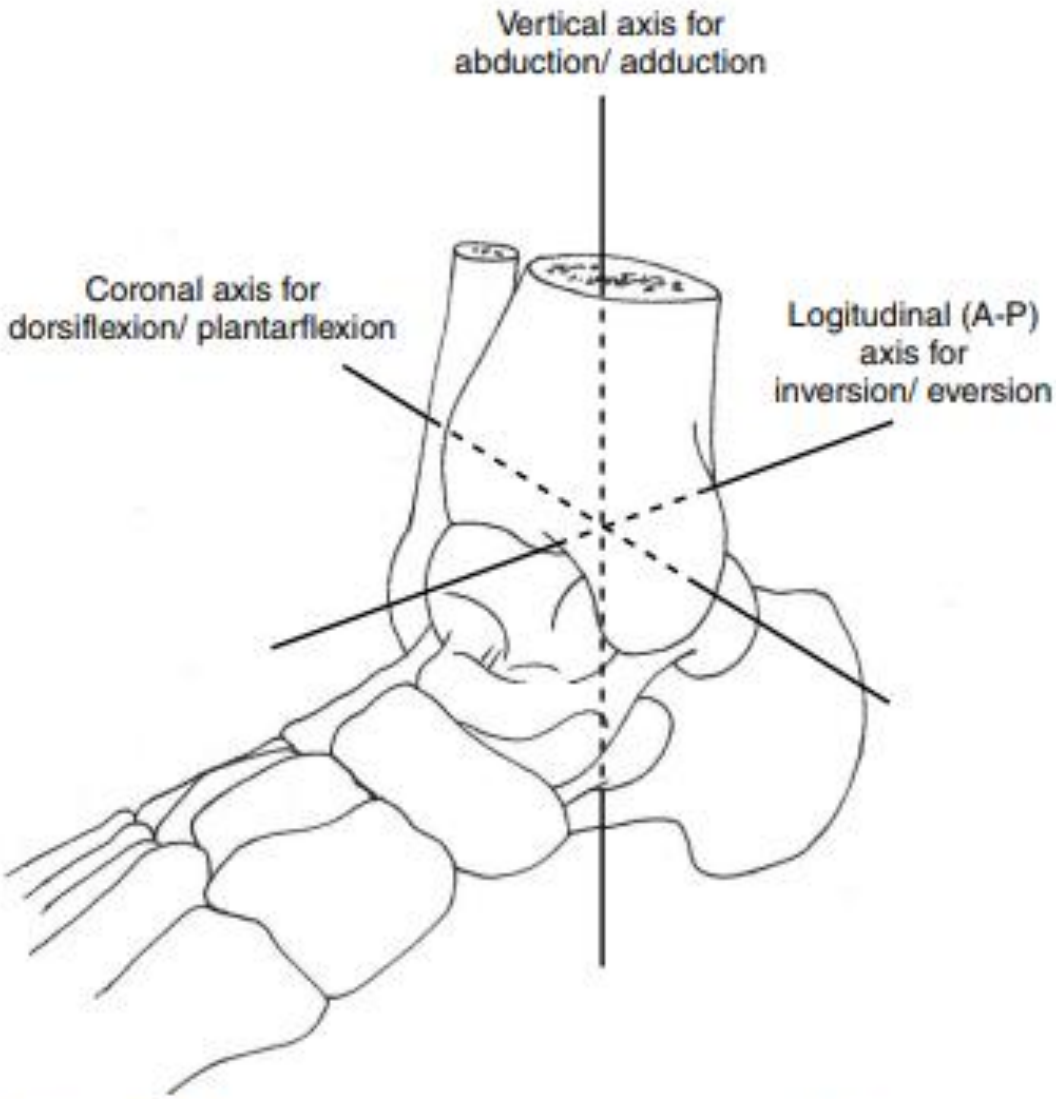


Figure 12–2 "Cardinal" axes for the motions of the ankle/foot complex.

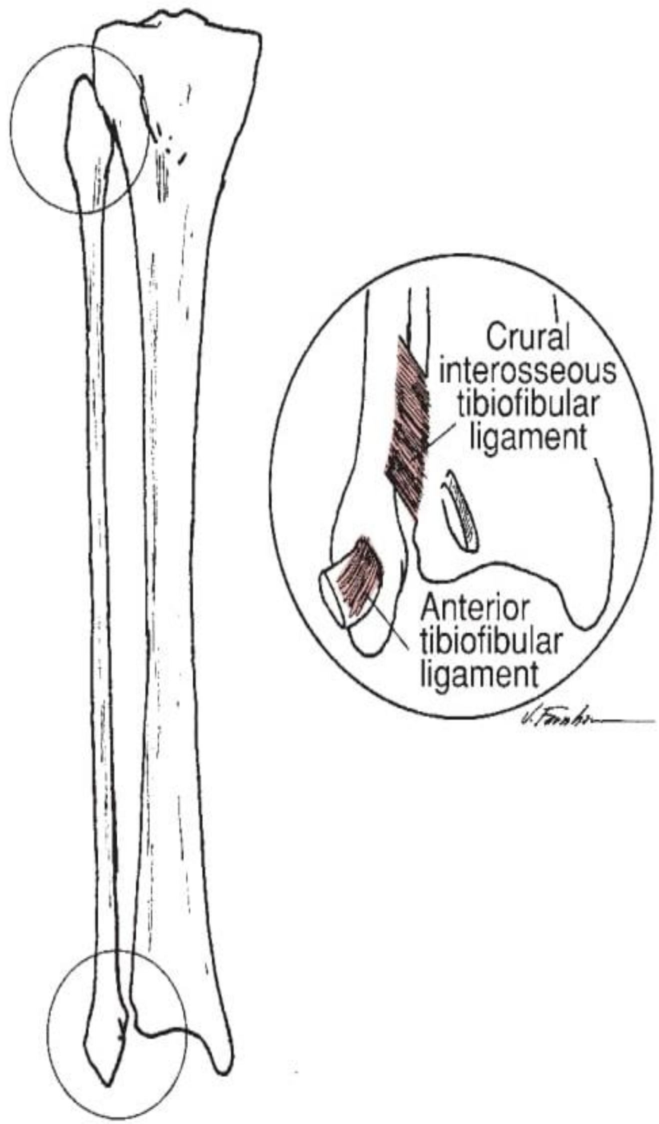
Motions in the ankle complex

- Plantarflexion
- Dorsiflexion
- Abduction
- Adduction
- Inversion
- Eversion
- Combination of these called:
- **Supination**:PF, adduction , inversion
- **pronation**: DF, abduction, eversion

- PROXIMAL TIBIOFIBULAR JOINT:
- Proximal tibia is convex
- Fibula is concave
- Joint: synovial

DISTAL TIBIOFIBULAR JOINT

- Distal tibia : concave
- Distal fibula: convex
- Joint: syndesmosis.



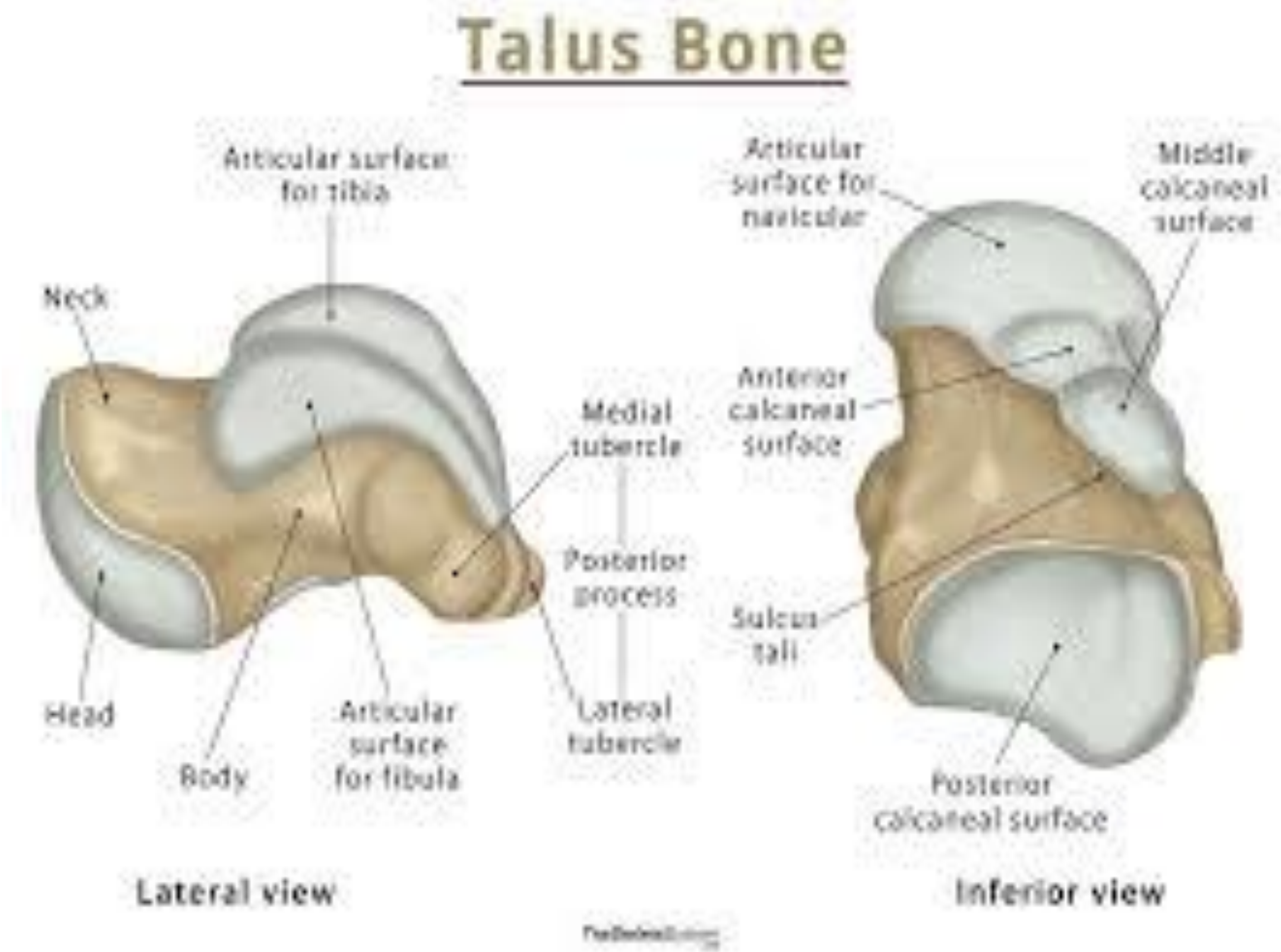
▲ **Figure 12-5** ■ Proximal and distal tibiofibular joints.

- This joint is reinforced by :
- **Anterior tibiofibular ligament**
- **Posterior tibiofibular ligament.**
- **Crural interrosseous tibiofibular ligament.**
- Tibia takes 90% of joint weight- hence stability
- Fibula takes only 10% of joint weight- hence mobility

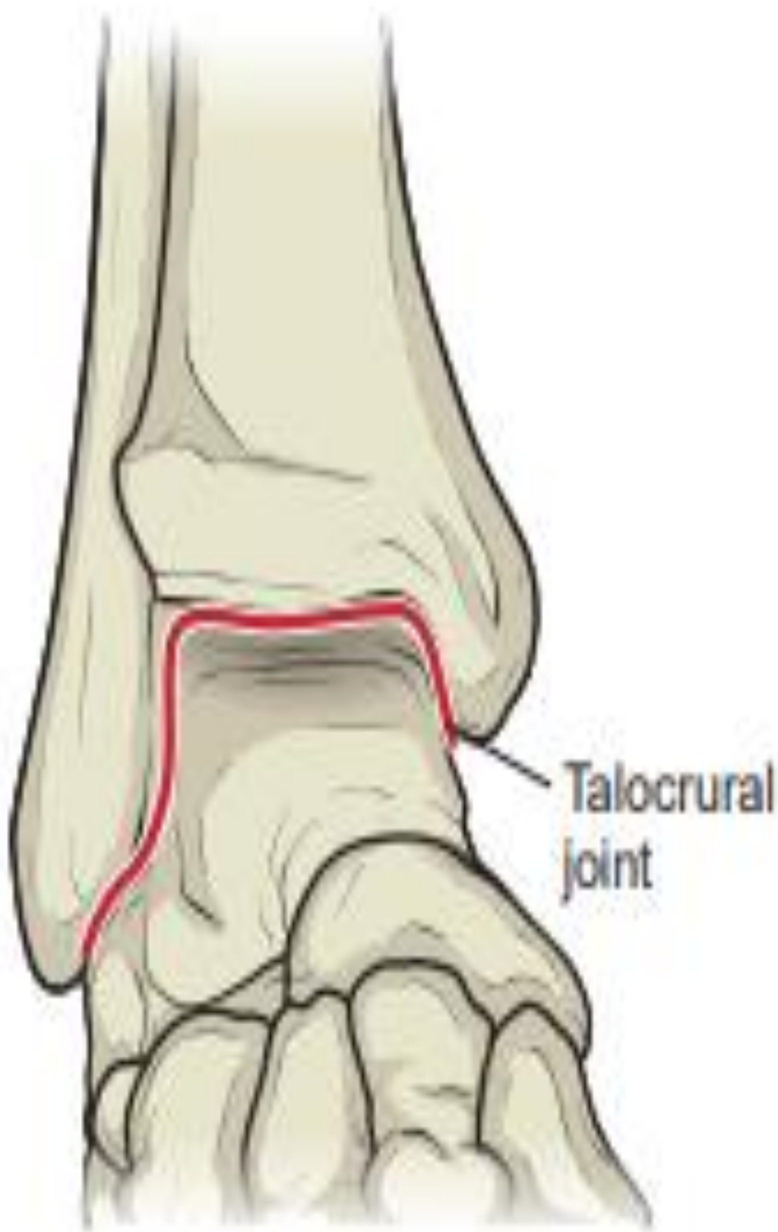
ANKLE/ TALOCRURAL JOINT

- Synovial hinge joint.
  - It is the articulation: between the distal **tibia and fibula proximally**
  - body of the **talus** distally.

- Talus:
- Body, neck, head
- Facets:
- Superior facet: tibia
- Lateral facet: aticulates with fibula
- Anteriorly: navicular
- Inferiorly: calcaneum


Talus Bone
Articular surface for tibia
Neck
Head
Body
Articular surface for fibula
Medial tubercle
Posterior process
Lateral tubercle
Articular surface for navicular
Middle calcaneal surface
Anterior calcaneal surface
Sulcus tali
Posterior calcaneal surface
Lateral view
Inferior view

- The tibia and fibula form a deep, bracket shaped socket for the trochlea of the talus, known as **mortise**.
- Single oblique axis
- 1 degree of freedom→ dorsiflexion/ plantarflexion



Anterior View

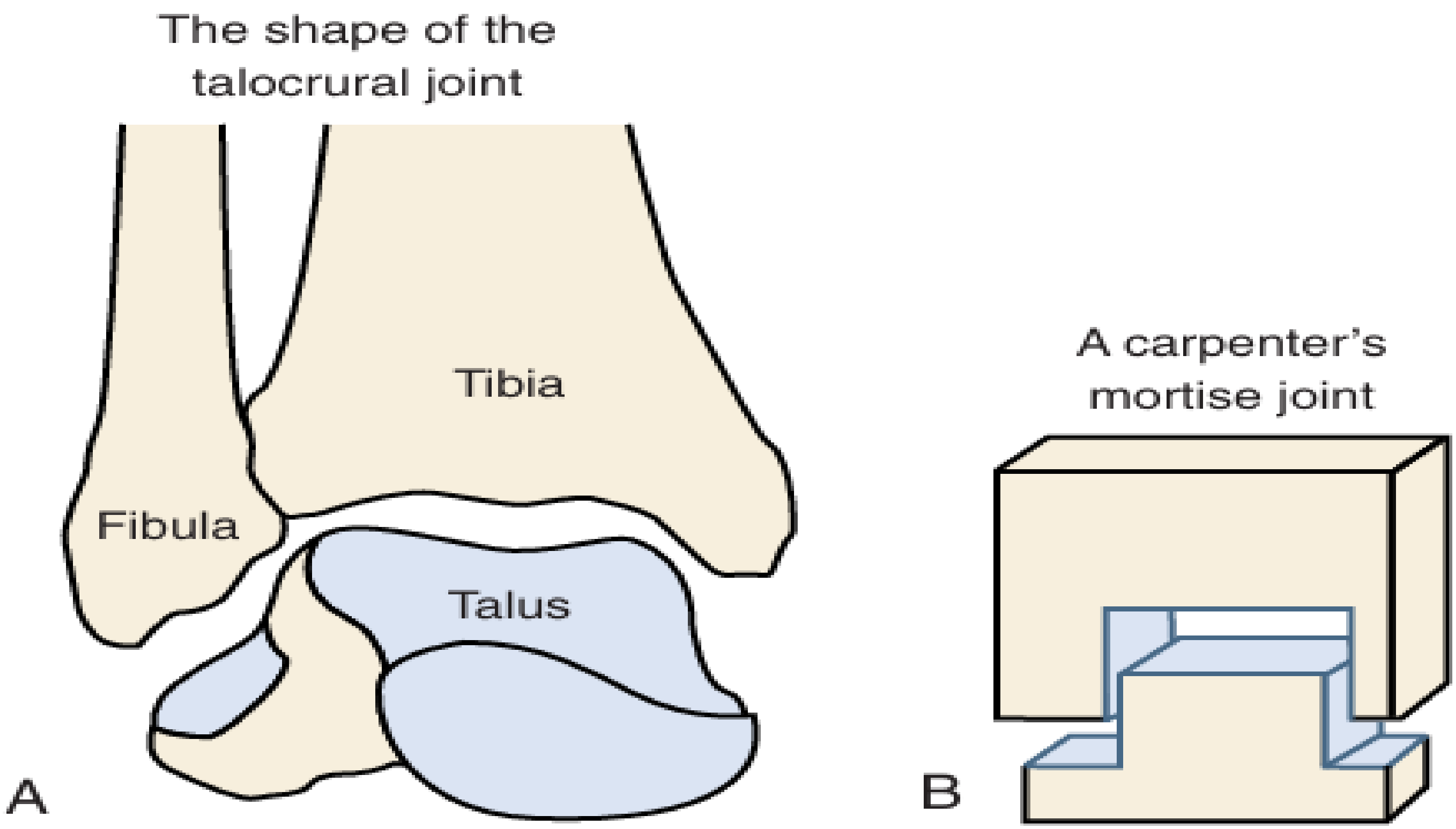
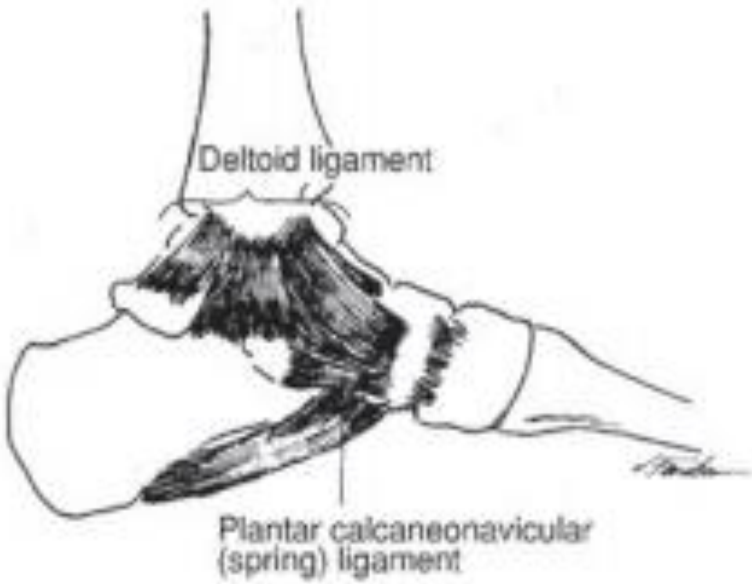


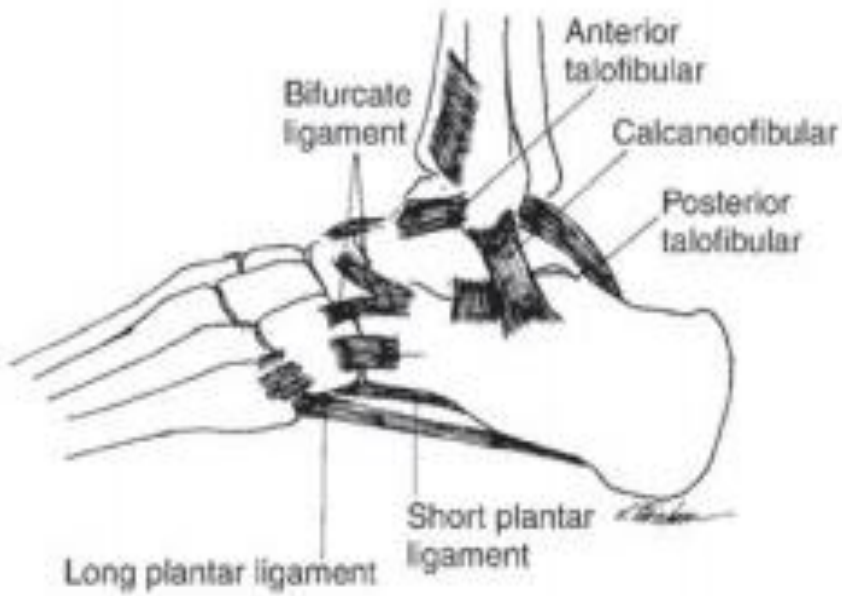
FIGURE 14-13. The similarity in shape of the talocrural joint **(A)** and a carpenter's mortise joint **(B)** is demonstrated. Note the extensive area of the talus that is lined with articular cartilage *(blue)*.

- Capsule: weak, thin
- Attached proximally to margins of medial and lateral malleolus
- Distally to surface of talus.
- Collateral ligaments reinforce the capsule medially and laterally.

The ligaments of the ankle joint:

- medially by the **medial collateral (deltoid)** ligament
- laterally by the **lateral collateral (anterior and posterior talofibular and calcaneofibular)**
- **Tibiofibular** ligaments.





- **MCL(deltoid ligament):**
- fan shape
- Connects tibia to calcaneum ,talus, navicular.
- Provides resistance against **valgus forces.**
- **If there is a force that comes from the lateral side, this ligament stabilises the force**

LCL

- Anterior talofibular ligament
- Posterior talofibular ligament
- Calcaneofibular ligament

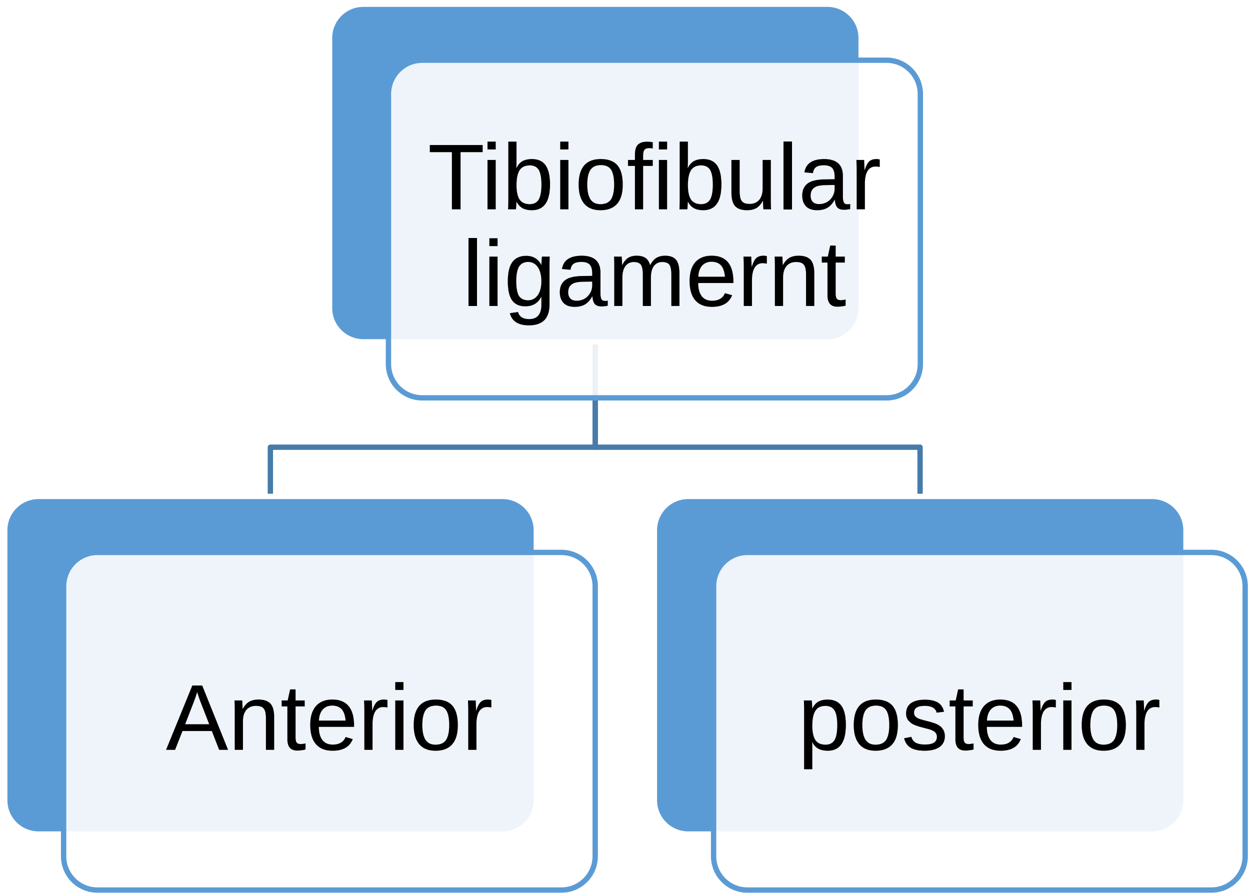
- Fibula getting connected to other bones.

- Anterior and posterior lig are horizontally placed.
- Gives resistance to adduction,inversion and PF.
- More prone to injury during landing.
- Most commonly injured is **anterior talofibular ligament(ankle sprain)**
- **Least injured- posterior talofibular lig.**

ligaments

- **MCL**
  - Injury occurs, when eversion / pronation of ankle and talus
    - Outward rotation of foot combined with inward rotation of tibia
      - Fracture/ displace tibial malleoli before ligament tear
- **LCL**
  - **Calcaneofibular lig**
    - Stressed when ankle DF
- **LCL**
  - **postr talofibular lig**
    - Stressed when DF, externally rotated

- **TibiofibularLigament:**
- Connects tibia to fibula



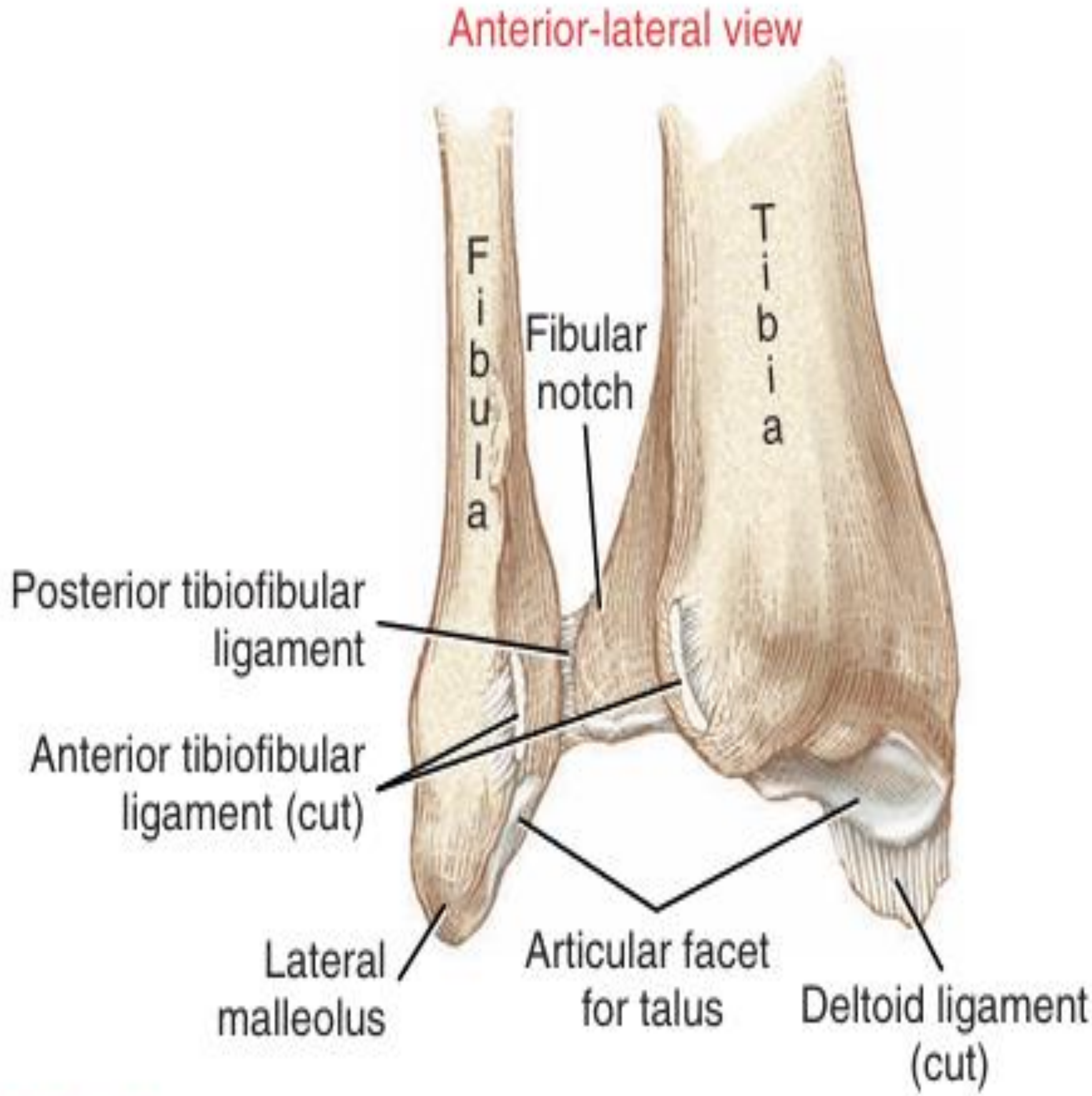


FIGURE 14-11. An anterior-lateral view of the right distal tibiofibular joint with the fibula reflected to show the articular surfaces.

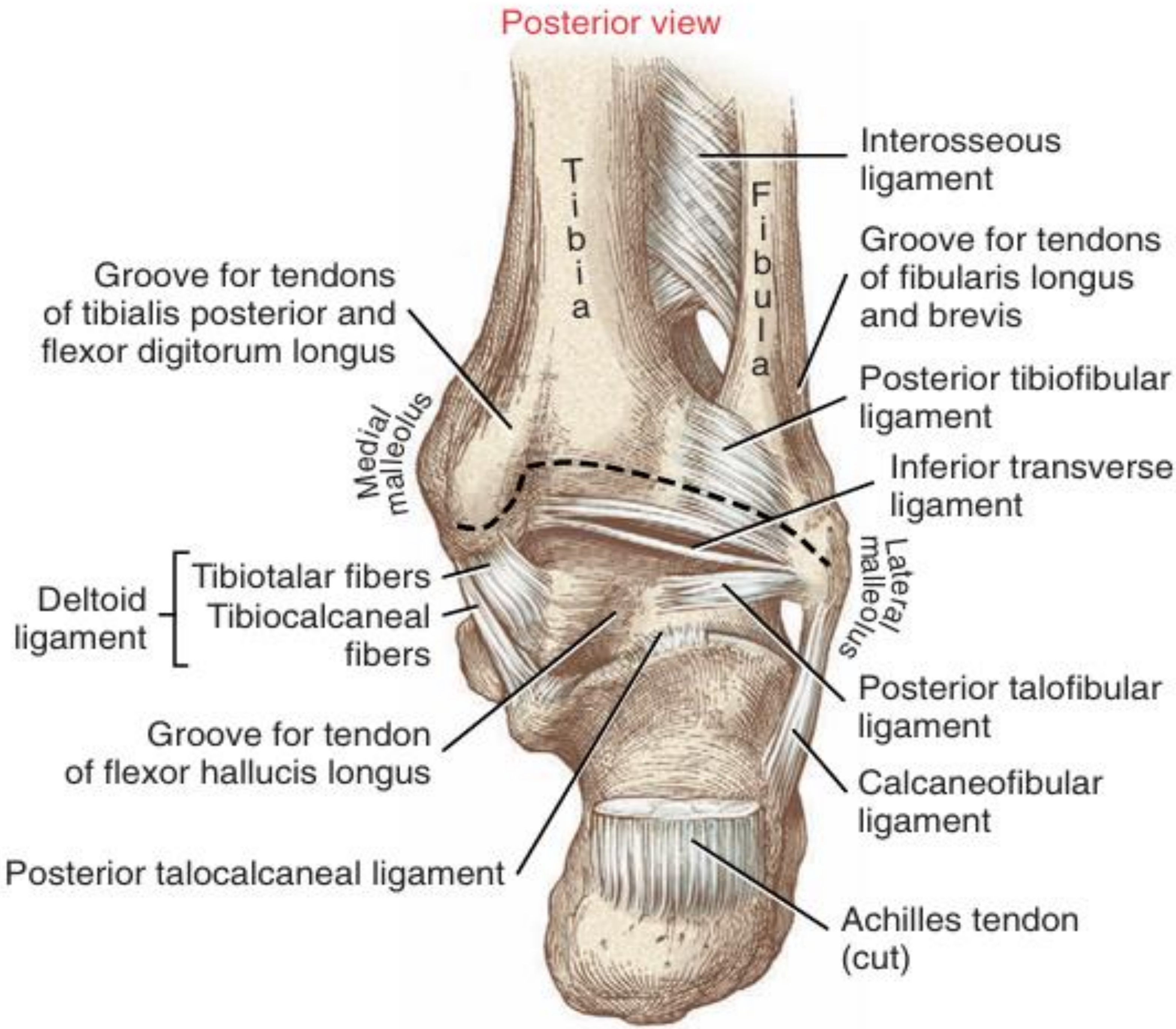
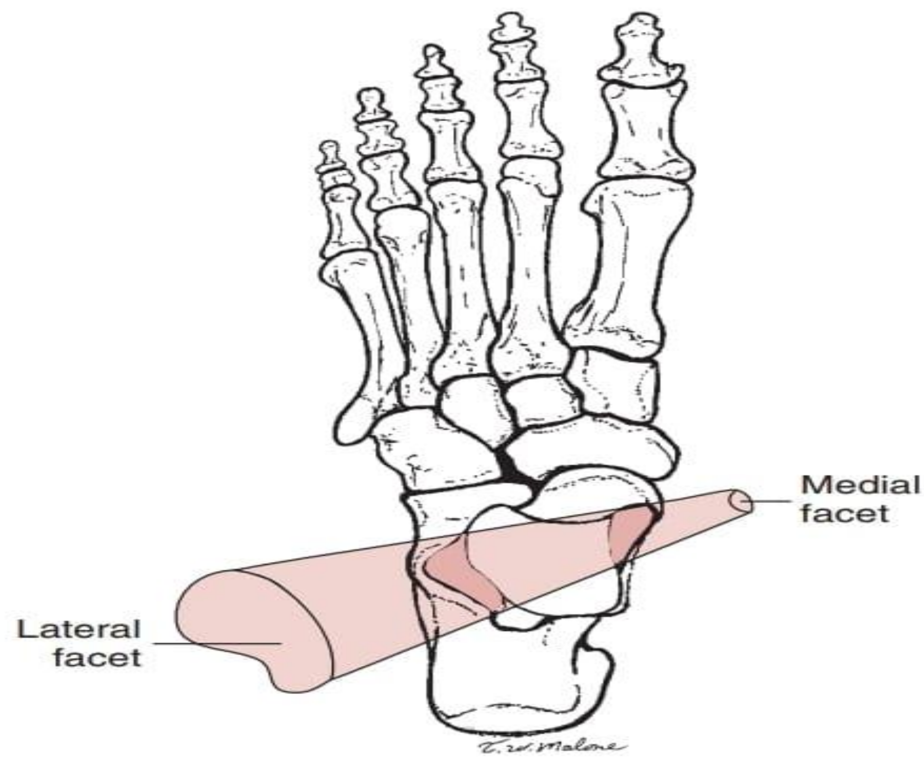


FIGURE 14-12. Posterior view of the right ankle region shows several ligaments of the distal tibiofibular, talocrural, and subtalar joints. The dashed line indicates the proximal attachments of the capsule of the talocrural (ankle) joint.

- **Axis**
- Passes through **lateral malleolus, talus to medial malleolus.**
- Because of the lower position of fibula malleolus – axis of ankle joint is inclined down on lateral side .

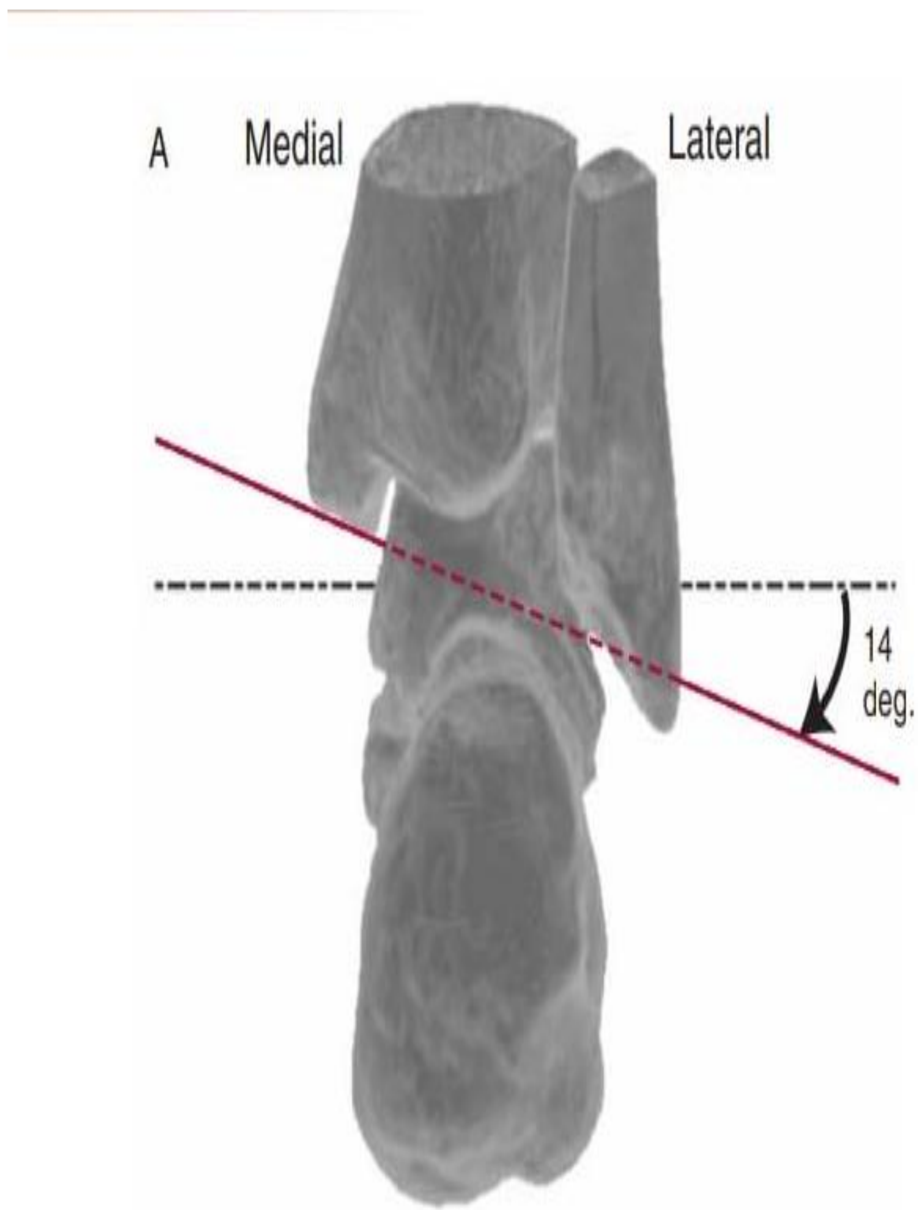


▲ **Figure 12–11** ■ The three articular surfaces of the talus (the trochlea, smaller medial facet, and larger lateral facet) can be pictured as part of a cone-shaped surface, with ends of the cone cut off (the larger end of the cone facing laterally).

- **<u>Transverse plane</u>**

<u>(posterior view):</u>

- **Downward inclination of** **14 degree** of ankle joint axis



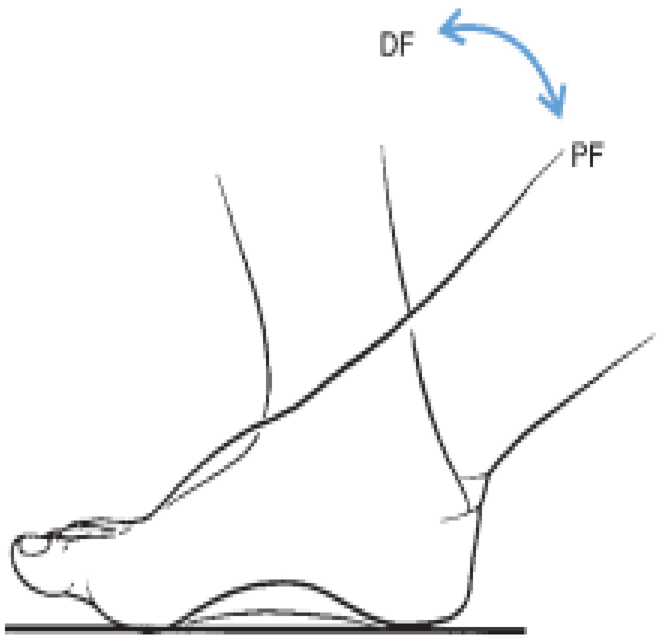
- frontal plane (Superior view)
- 23 degree upward inclination

▲ **Figure 12-10** ■ The axis of the ankle joint. **A.** Posterior view showing the mortise around the body of the talus and the average 14° inclination of the of the ankle axis from the transverse plane. **B.** Superior view showing the ankle axis rotated, on average, 23° from the frontal plane.

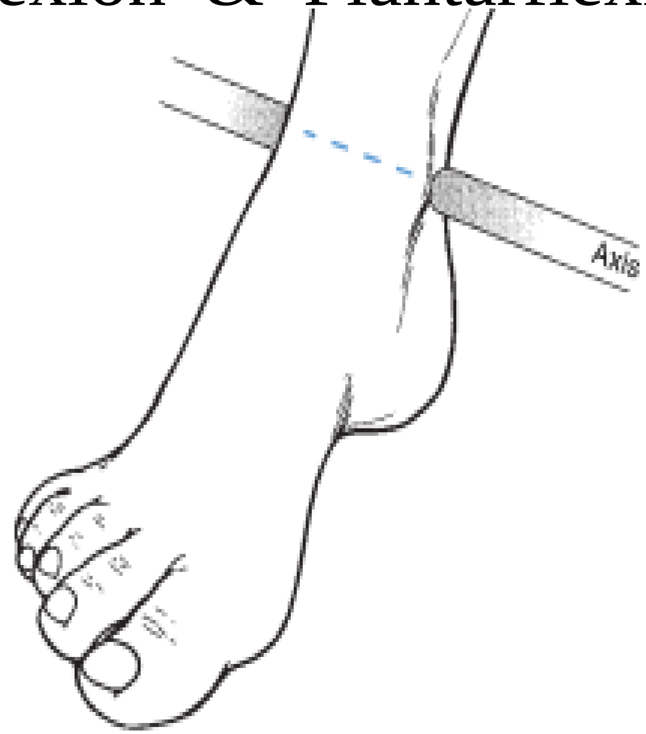
osteokinematics

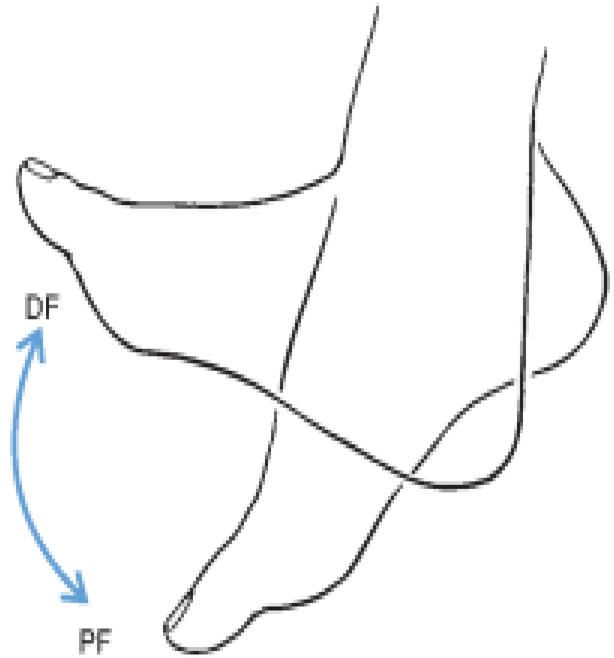
<u>Movements at the ankle</u>

- Motion occurs primarily in the **sagittal plane**
- The axis of rotation for the ankle joint is a line between the 2 malleoli, running oblique to the tibia and not in line with the body
- Motions: Dorsiflexion & Plantarflexion



PF and DF with fixed foot





PF and DF with fixed tibia

- Range:
- Dorsiflexion- 0-20 degree
- Planflexion: 0-50 degree
- **PF- UNSTABLE**, posterior **narrow** part of talus is in contact with the mortise
- **DF – STABLE**, Wide anterior part of talus is in contact with the tibia and fibula.

- Fibula has more mobility.
- Moves superiorly, medialy, inferiorly.
- Tibia provide more stability, and most of the forces from talus transmit to tibia.

Arthrokinematics:

- **Concave** articulating surface **- mortise**
- **Convex** articulating surface **- body of the talus**.
- With physiological motions of the foot, the articulating surface of the talus slides in the opposite direction

Talocrural joint: motion of talus

Physiologic motion	Roll	Slide
Dorsiflexion	Anterior	Posterior
Plantarflexion	Posterior	Anterior

Talocrural joint

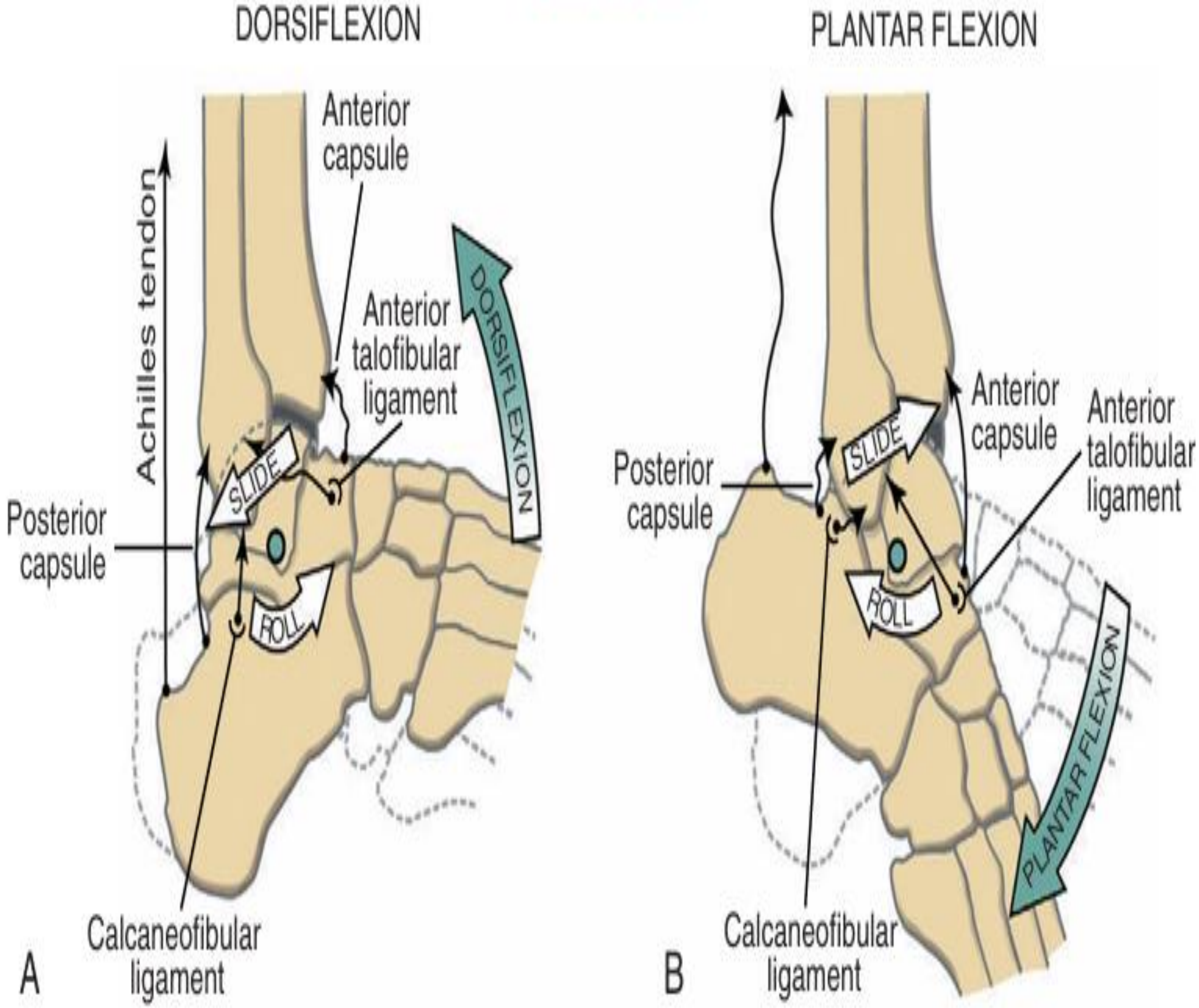
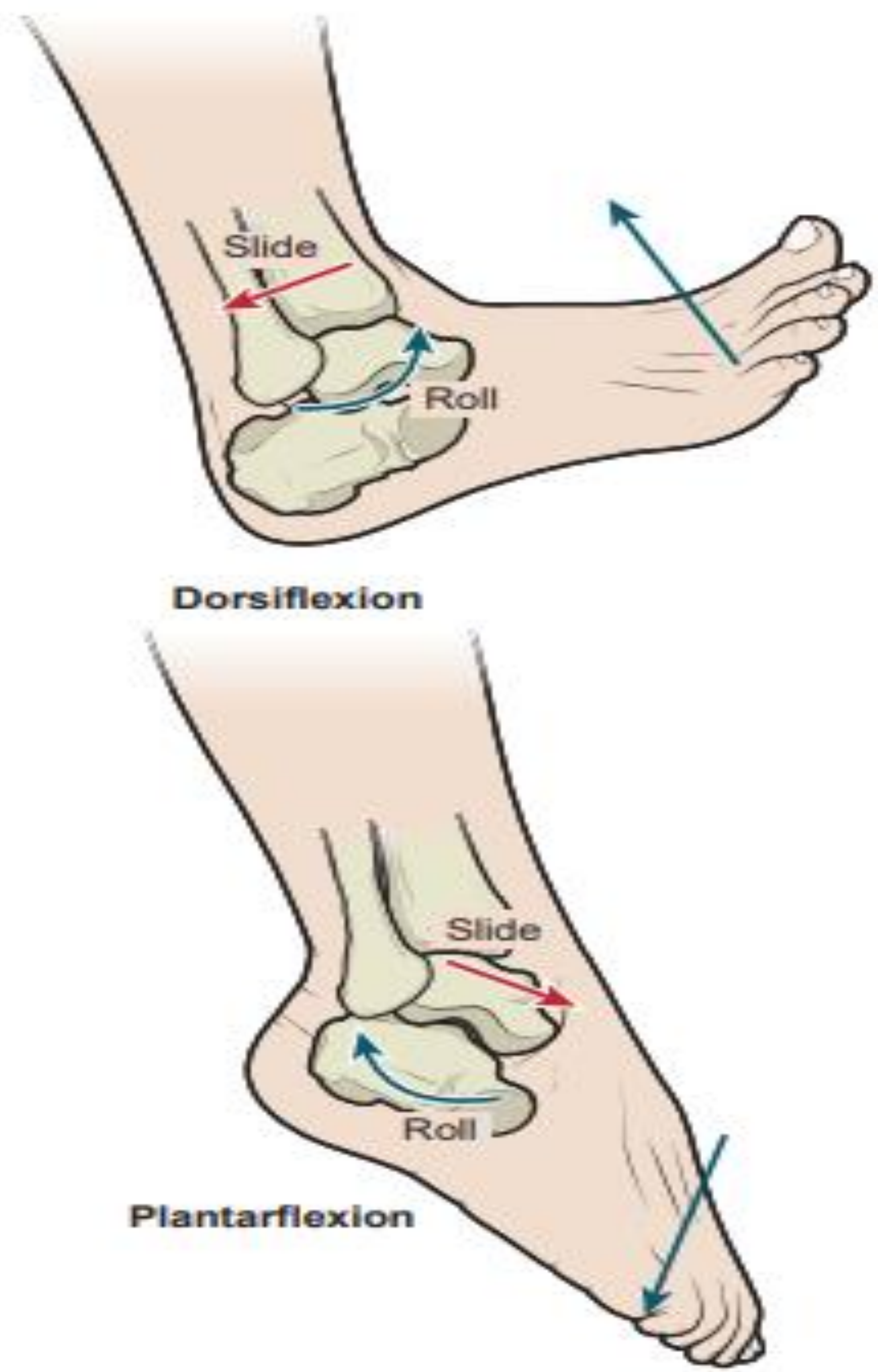


FIGURE 14-18. A lateral view depicts the arthrokinematics at the talocrural joint during passive dorsiflexion **(A)** and plantar flexion **(B)**. Stretched (taut) structures are shown as thin elongated arrows; slackened structures are shown as wavy arrows.



TALOCRURAL ARTHROKINEMATICS.

In an open kinetic chain, the talus **rolls and slides in opposite directions** during

A)dorsiflexion and

B) plantarflexion

Muscles

- Anterior to the malleoli are dorsiflexors
- Posterior to the malleoli serve as plantar flexors.

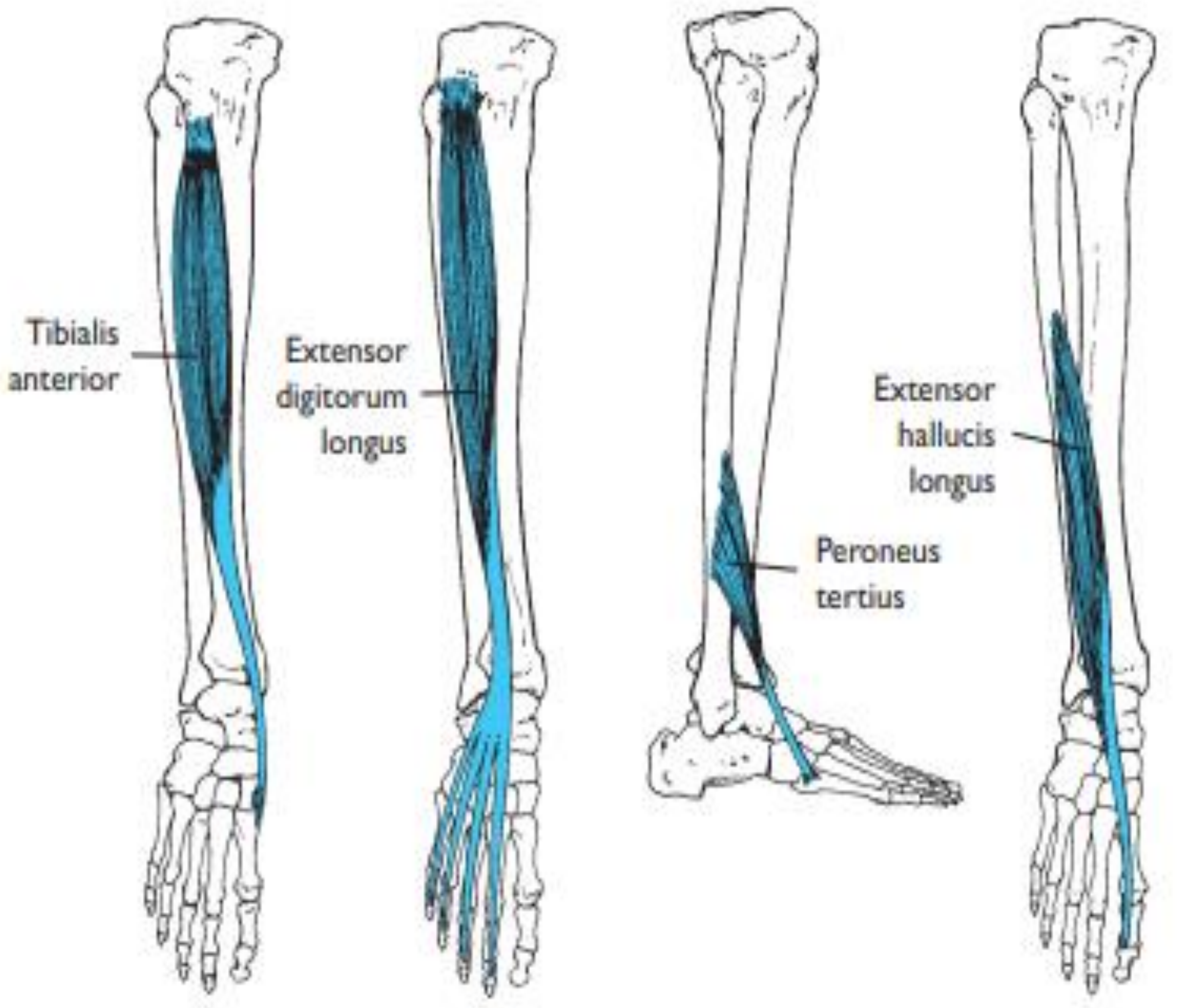
Dorsiflexors:

Prime dorsiflexors of the foot are;

- **Tibialis anterior**
- **Extensor digitorum longus**
- **Peroneus tertius**

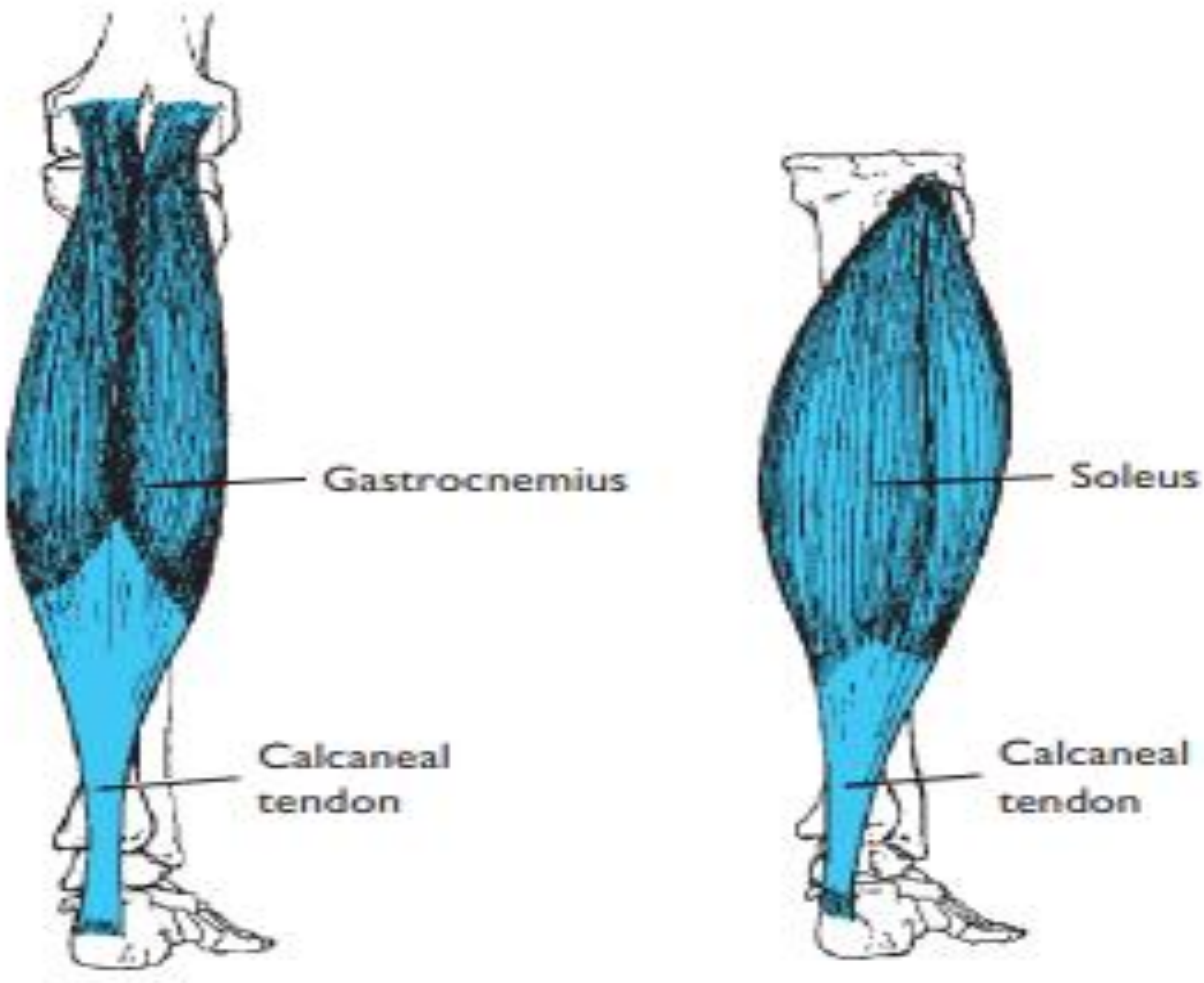
- **Extensor hallucis longus-** assists in dorsiflexion

The dorsiflexors of the ankle



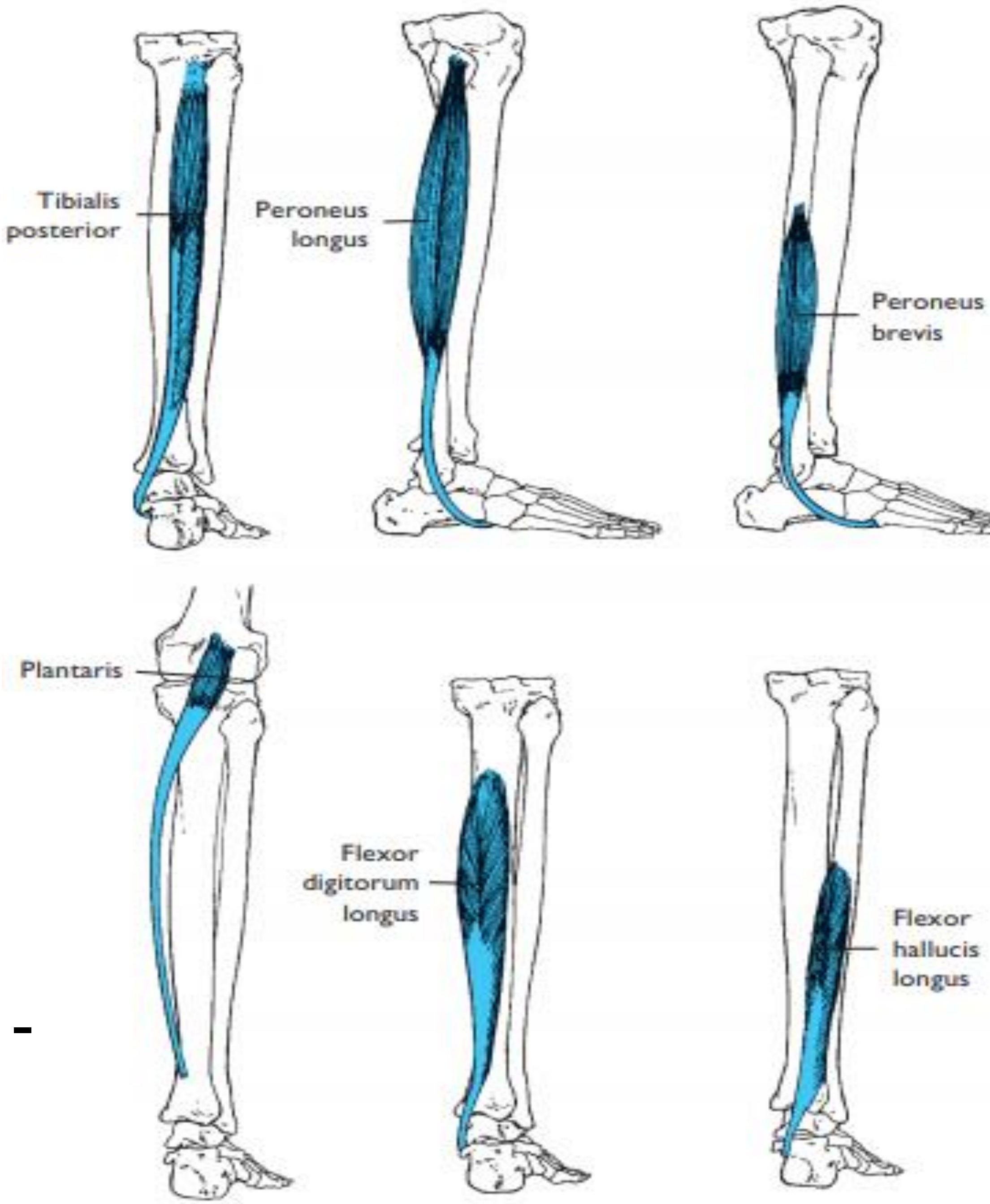
PLANTAR FLEXORS

- The major plantar flexors
- 2 heads of the powerful two- joint gastrocnemius and the soleus.
- **Gastrocnemius and soleus prevents DF.(**when they get tight)


Gastrocnemius
Calcaneal tendon
Soleus
Calcaneal tendon

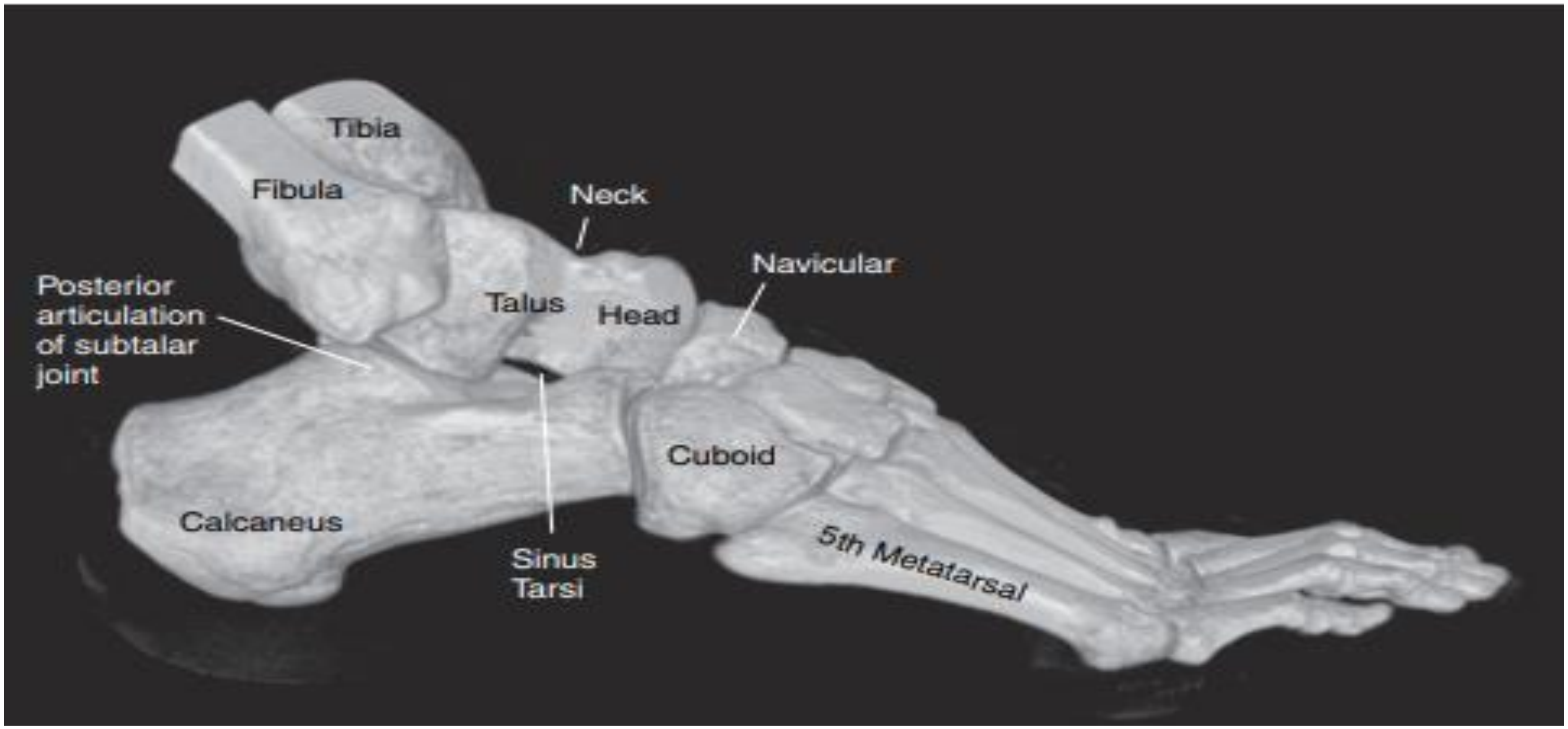
Assistant plantar flexors

- **Tibialis posterior-** medial side stability
- **Peroneus longus-** lateral side stability
- **Peroneus brevis-** lateral side stability
- **Plantaris**
- **Flexor hallucis longus-** medial side stability
- **Flexor digitorum longus -** medial side stability



Subtalar/ Talocalcaneal joint

- The subtalar (talocalcaneal) joint is a complex joint with three articulations between the talus and calcaneus.



- Talus contains:
- 2 anterior Articulation- Convex
- 1 posterior Articulation-Concave

- Calcaneum contains:
- 2 anterior articulation- concave
- 1 posterior articulation- convex
- these articulating surface provide us the **triplanar movement.**

Articulating surfaces:

- **Posterior** articulation→ a concave facet on the undersurface of the body of the talus and a convex facet on the body of the calcaneus
- **anterior** articulations → 2 convex facets on the inferior body and neck of the talus and 2 concave facets on the calcaneus.


Anterior calcaneal facet
Medial calcaneal facet
Posterior calcaneal facet

Sinus tarsi:

- Tunnel formed between **posterior articulating** surface of talus and calcaneum and the **anterior articulating surface** of talus and calcaneum.
- Capsule is present in the tarsal tunnel


SINUS TARSI

SINUS TARSI SYNDROME

DEFINITION Vague, persistent pain at the outside ankle due to trauma or compression of the contents in the sinus tarsi.

ANATOMY The depression (sinus) at the outside ankle that contains ligaments, blood vessels, nerves and fat. These structures can be injured from trauma or repetitive strain.

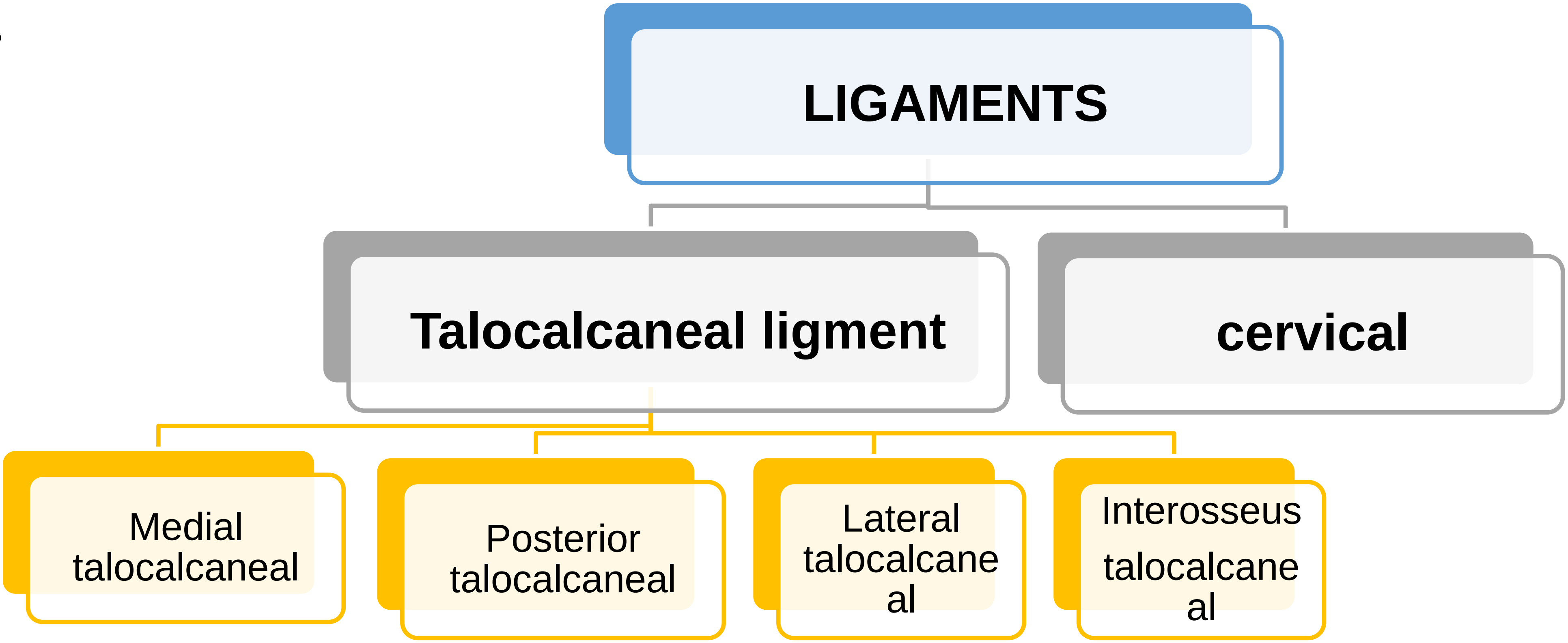
SYMPTOMS

1. Chronic pain along the front and outer aspect of the ankle
2. Pain when foot is turned in or turned out
3. Instability when weight-bearing
4. Swelling

CAUSES

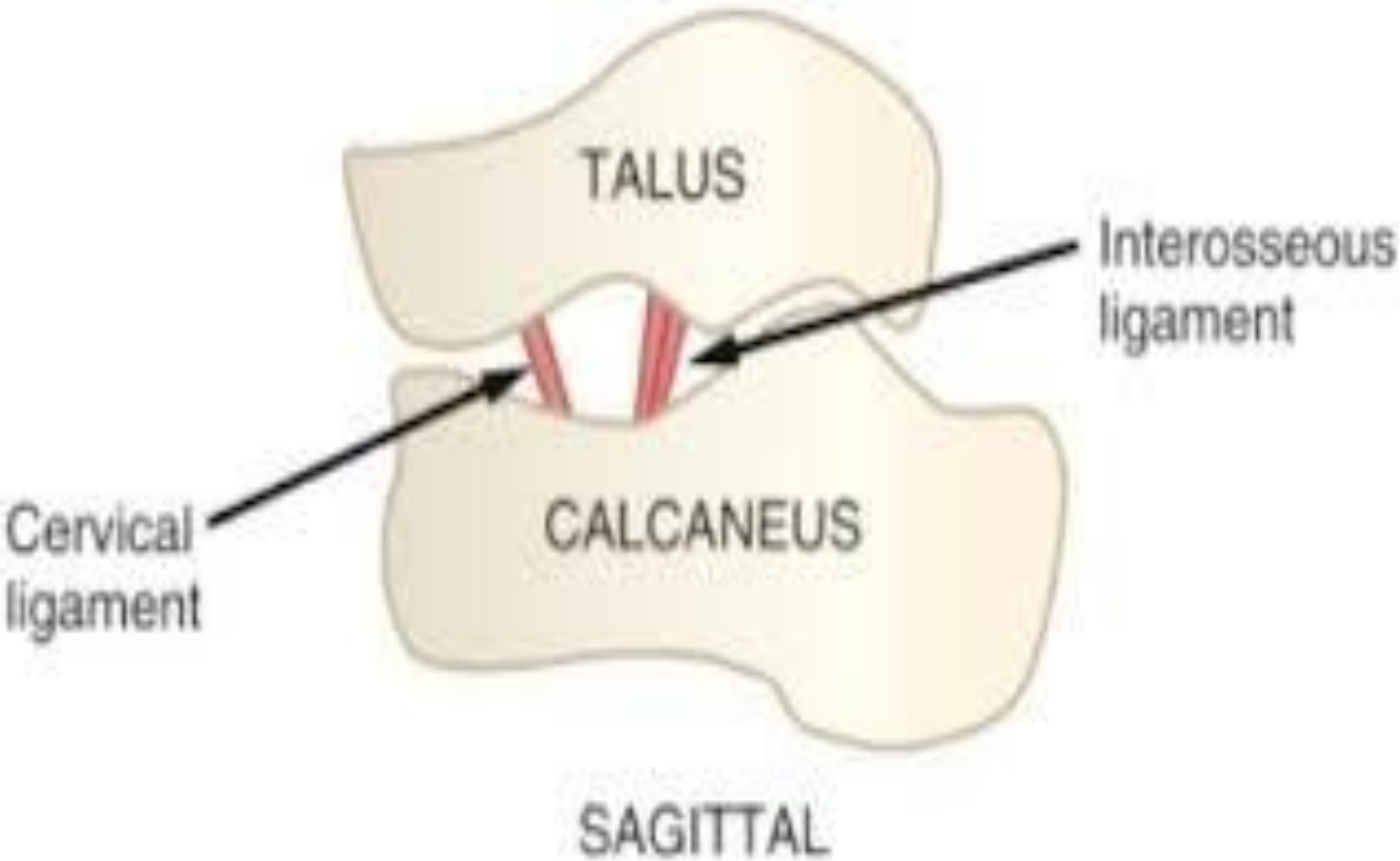
1. Previous Ankle Sprain
2. Impingement of structures in sinus tarsi depression

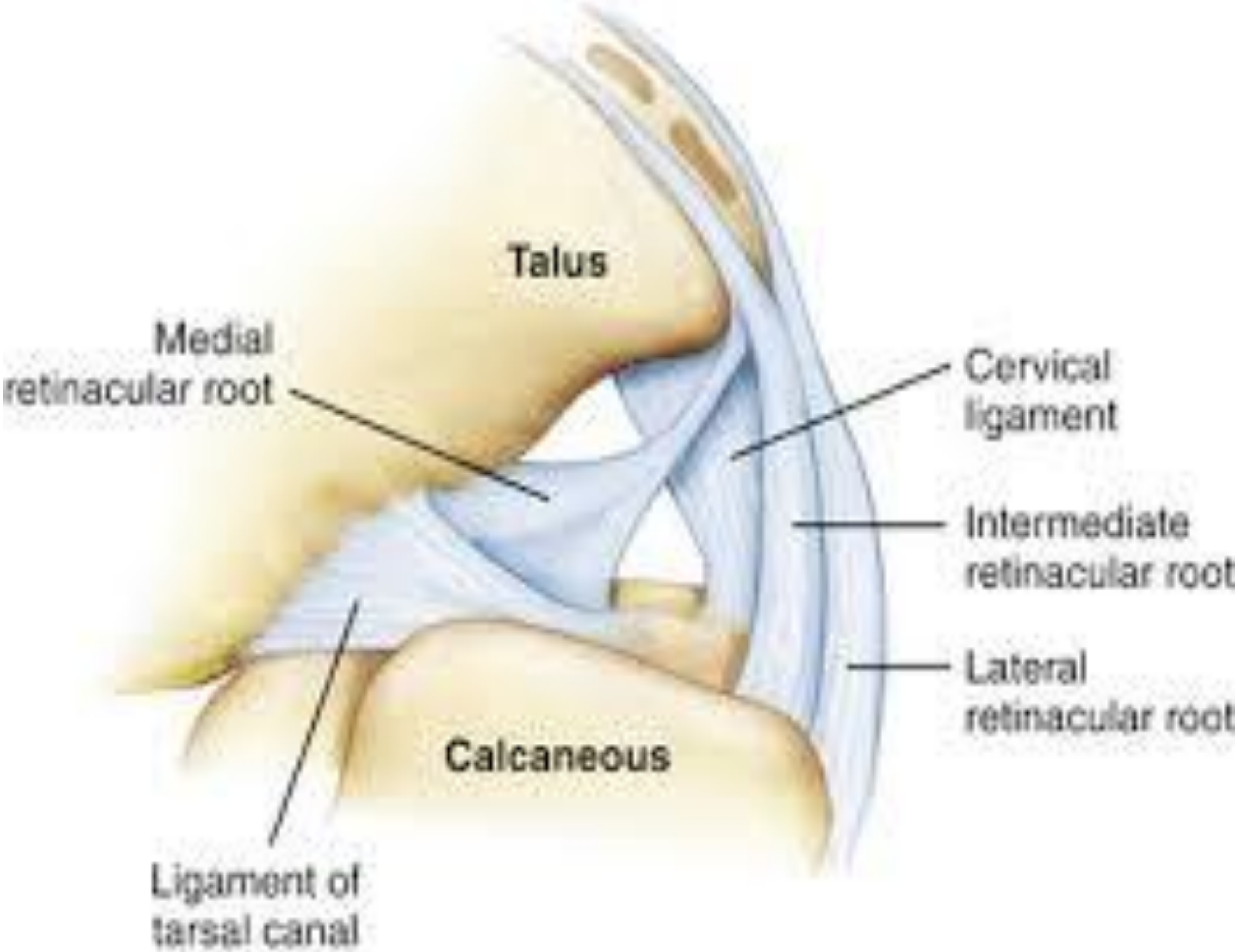
- Capsule covers the anterior part of talus with navicular
- Capsule covers the posterior part of talus with calcaneum.
- Anterior part takes up 75% of force transmission.
- Posterior part takes up 25% of force transmission.



Talocalcaneal ligament is the strongest

Also contains retinaculum to provide stability


TALUS
Interosseous ligament
Cervical ligament
CALCANEUS
SAGITTAL


Talus
Medial retinacular root
Cervical ligament
Intermediate retinacular root
Lateral retinacular root
Calcaneous
Ligament of tarsal canal

Mechanism of injury

Injury occur when **talus forcily lateral rotated** within the ankle mortise

Tibia and fibula get **seperated**

High**/ syndesmotic ankle sprain**

If force continues- **fracture of fibula** proximal to distal tibiofibular joint

Axis Of Motion

- The axis of rotation runs obliquely from the posterior lateral plantar surface to the anterior dorsal medial surface of the talus
- This **oblique axis** lies approximately
  - **42° from the transverse plane and**
  - **16° from the sagittal plane (midline)**
- Because the axis of the subtalar joint is oblique through the sagittal, frontal, and transverse planes of the foot, **triplanar motion** can occur.

- Allowing the calcaneus to pronate and supinate in a triplanar motion on the talus.

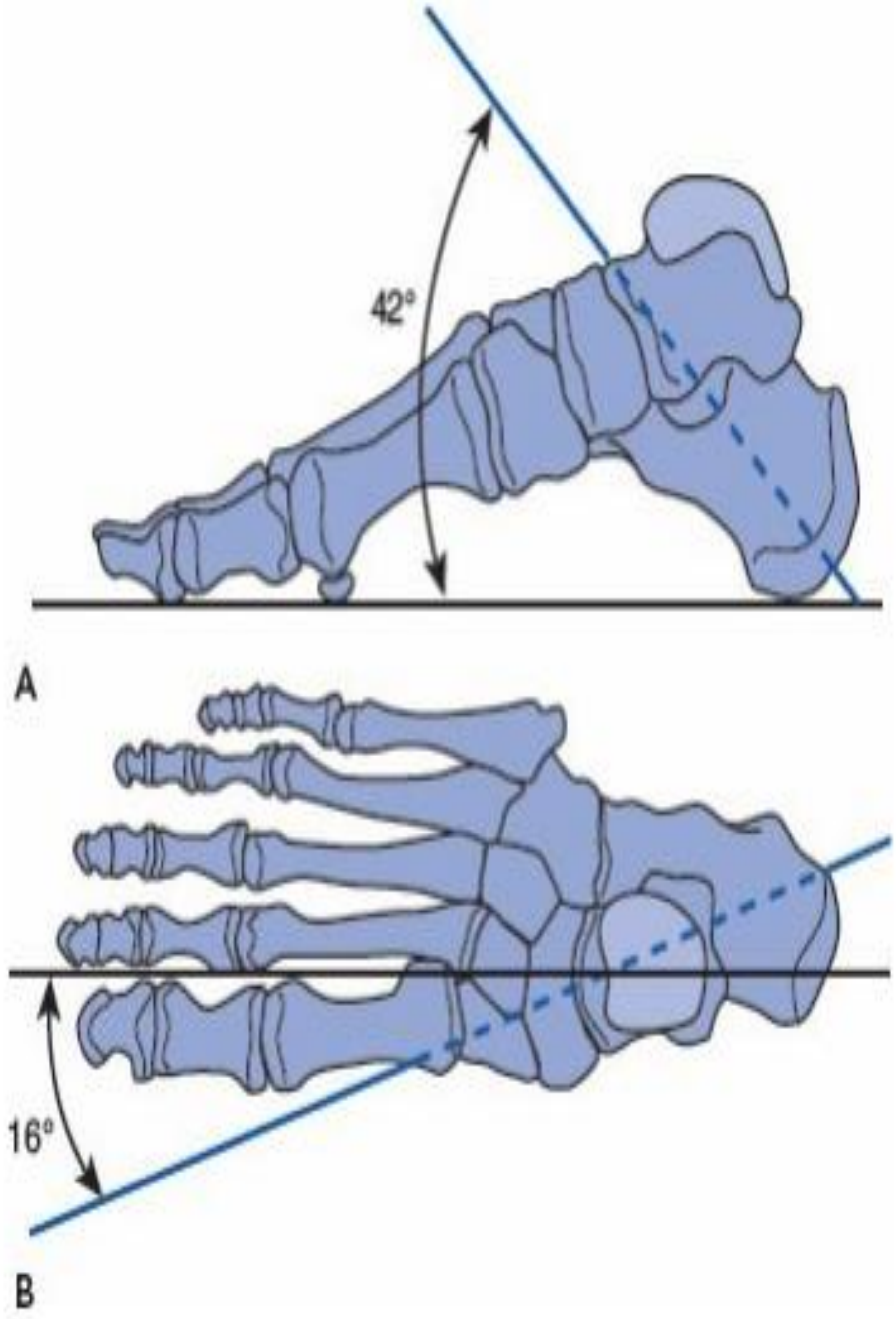


FIG. Subtalar joint axis.

A. Sagittal plane (lateral view). The axis rises up at a 42° angle from the plantar surface.
B. B. Transverse plane (top view). The axis is oriented 16° medial to the midline of the foot

OSTEOKINEMATICS

Subtalar joint motions:

Triplanar motion

- Pronation
- Supination

- Talus has bigger concave articulating surface and 2 convex anterior articulating surface.
- Posterior concave talus moves on convex calcaneum- glide and role in same direction.
- Convex anterior talus moves on concave anterior calcaneum- roll and glide in opp direction.
- **Screw like movement**

- SUPINATION: INVERSION + ADDUCTION + PF
- PRONATION: EVERSION + ABDUCTION + DF

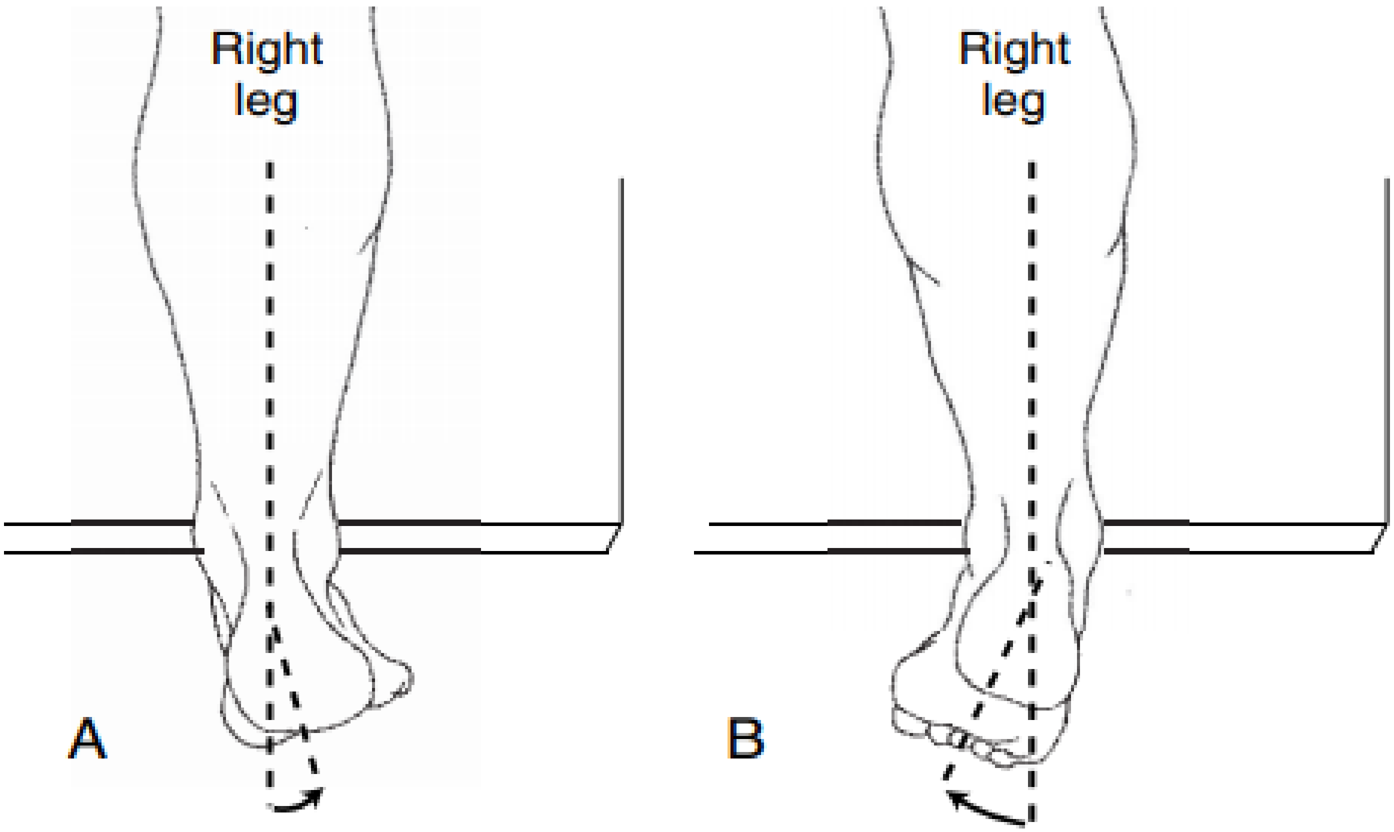
NON - WEIGHTBEARING SUBTALAR JOINT MOTION

- In non – weight bearing supination and pronation - motion of **Calcaneus** (the distal segment) on the

Supination	Pronation
Calcaneal inversion (/ Varus)	Calcaneal eversion (/ Valgus)
Calcaneal adduction	Calcaneal abduction
Calcaneal plantarflexion	Calcaneal dorsiflexion

A. Pronation of the subtalar joint

B. Supination of the subtalar joint



WEIGHT- BEARING SUBTALAR JOINT MOTION

- In weight bearing, the calcaneus is on the ground.
- Free to move inversion/ eversion motion)

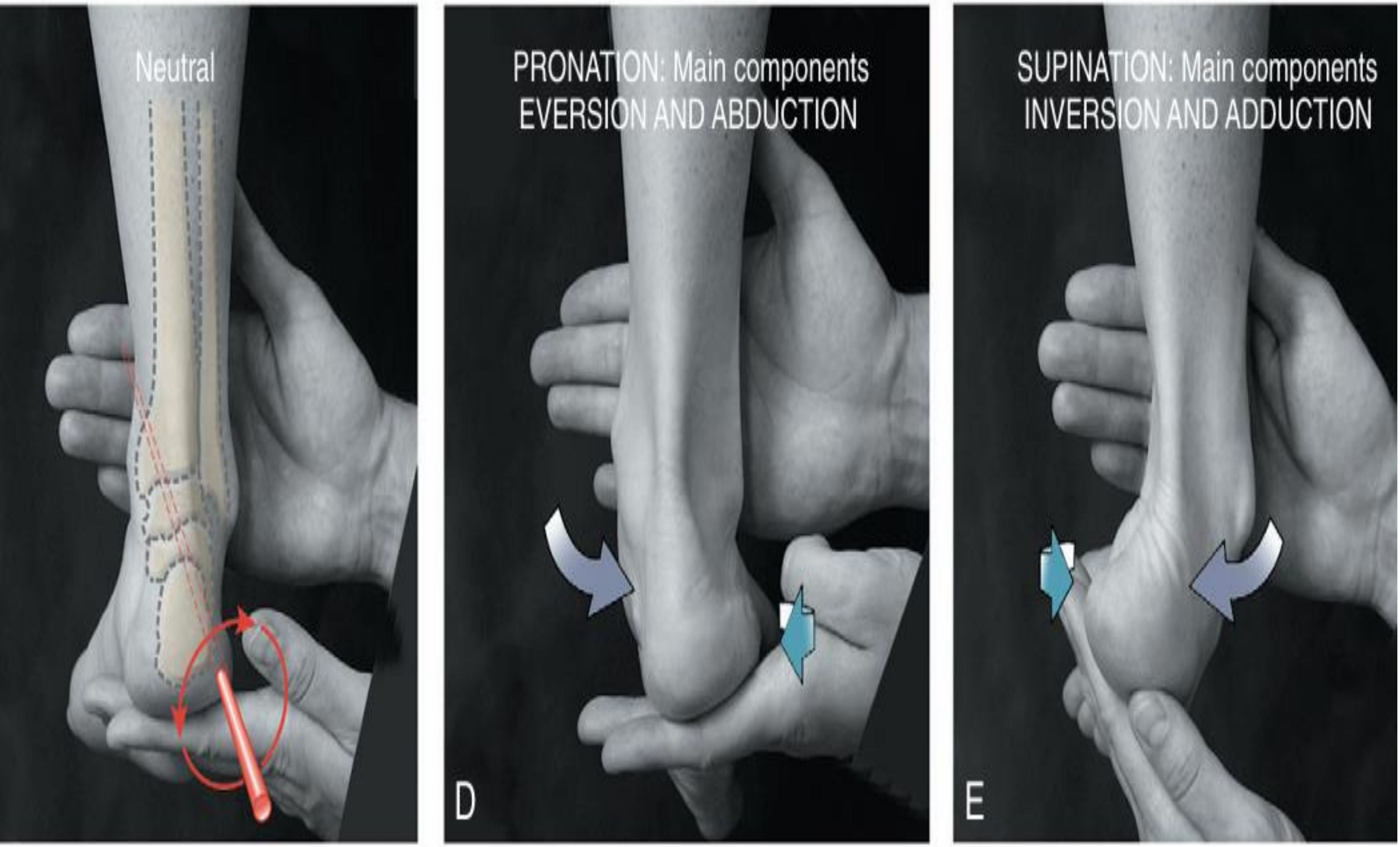
  but , not around adduction, plantarflexion because of superimposed body weight.
- Coupled motions that contribute to pronation/ supination cannot be accomplished exclusively by calcaneus.
- **Calcaneus** contributes to **inversion/ eversion**.

- During supination(Wt bearing):
- calcaneum will go for inversion.
- But other 2 coupled motion adduction and PF cannot be carried out.
- Hence talus will help in to do that movement.
- That is talus will go for DF, abduction.

- During pronation (non wt bearing):
- Calcaneum will go for eversion.
- Talar- adduction, PF

- While **talus** contributes to other 2 coupled components of subtalar motion (**abduction/ adduction & plantar flexion/ dorsiflexion**)

Supination	Pronation
Calcaneal inversion (/ Varus)	Calcaneal eversion (/ Valgus)
Talar abduction (/ lateral rotation)	Talar adduction (/ medial rotation)
Talar dorsiflexion	Talar plantarflexion
Tibiofibular lateral rotation	Tibiofibular medial rotation



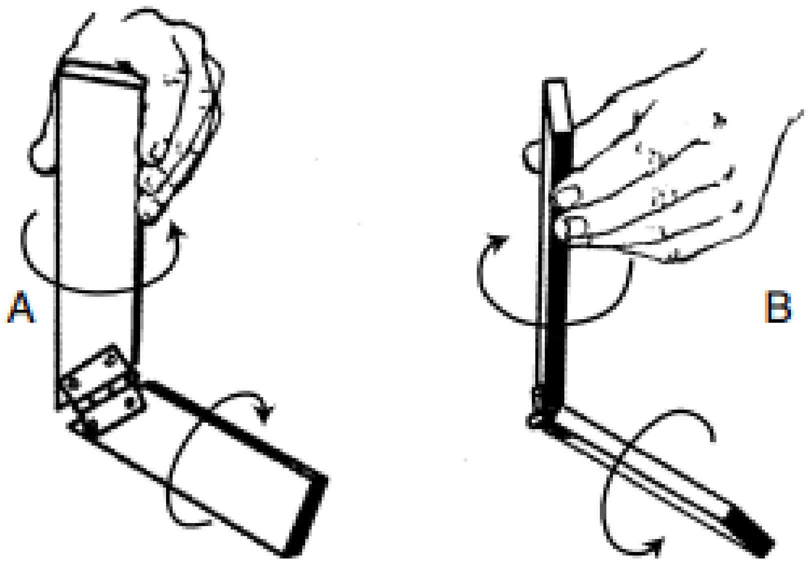
Blue arrow indicate – abduction / adduction
Purple arrow- inversion/ eversion

Weight- Bearing Subtalar Joint Motion And Its Effects On Leg

- During weight-bearing subtalar supination/ pronation, the coupled component motions of dorsiflexion /plantarflexion and abduction/adduction of the talar head require that the body of the talus move as well.
- **Dorsiflexion of the head of the talus** requires the **body of the talus to slide posteriorly within the mortise**
- whereas **plantarflexion of the head of the talus** requires the **body of the talus to move anteriorly within the mortise**

- When the **head of the talus abducts in weight-bearing subtalar supination**, the **body of the talus must rotate laterally in the transverse plane → lateral rotation of the leg**
- When the **head of the talus adducts in weight-bearing subtalar pronation,** the **body of the talus rotate medially in the transverse plane → tibia and fibula into medial rotation.**

- Subtalar pronation and supination may impose rotary forces on the leg in weight-bearing



A. Medial rotation of the weight-bearing leg imposes pronation on the distally located subtalar joint.
B. Lateral rotation of the leg proximally imposes supination on the distally located subtalar joint.

- Subtalar instability
- High ankle sprain(syndesmotic injury):
- External rotation injury in professional players.
- Tenderness over interrroseous membrane can be seen

THANK YOU