THE LEG, ANKLE & FOOT

- Distal ends of tibia & fibula articulate with the bones of the ankle.

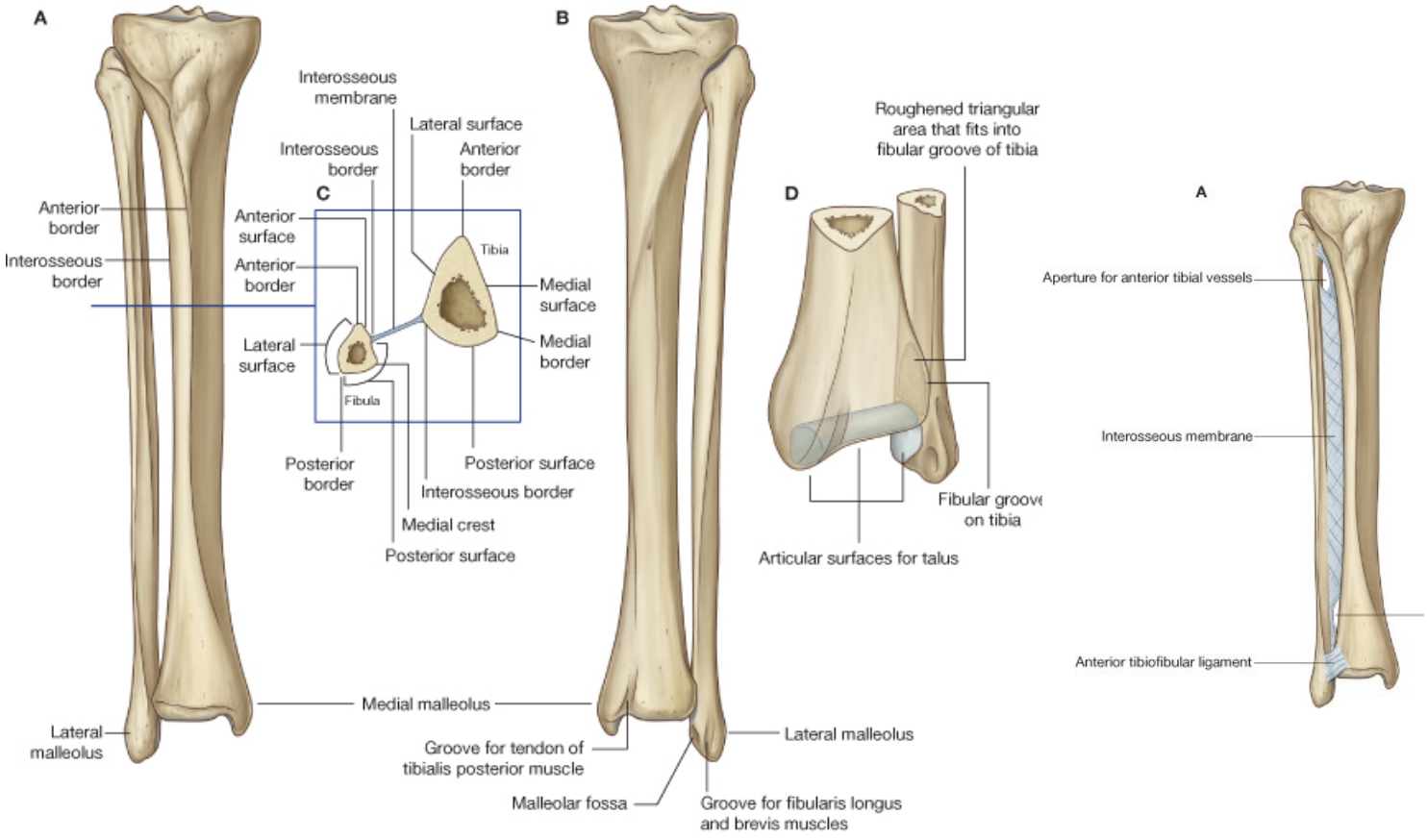
Shaft of the tibia:

- Shaft of the tibia has a very **sharp anterior border** – subcutaneous so easy to palpate
- Laterally, facing the fibula, there is another sharp border – **interosseous border**.
- Δ transverse section of tibia is triangular in shape

Fibula:

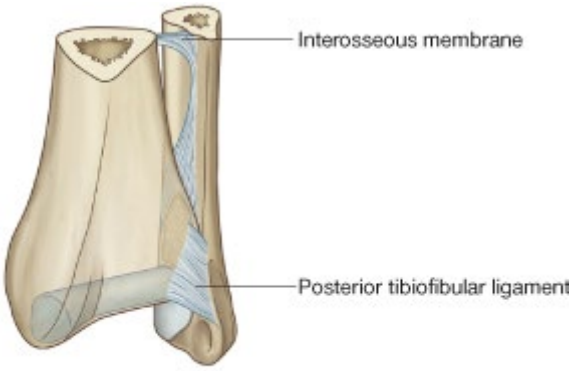
- Has a **head** at proximal end
- Head articulates with the lateral tibial condyle at the **proximal tibiofibular joint**.
- Below head of fibula is a narrow **neck**
- Thin shaft
- Shaft has an **interosseous border** which faces that of the tibia

- The interosseous borders of the tibia and fibula are united by **interosseous membrane**
    - Provides site for muscle attachment (as in the forearm)
    - Fibres slope obliquely downwards: tibia → fibula
    - Hole in upper membrane, which transmits **anterior tibial artery** from popliteal fossa → front of leg.



- **Soleal line** is only notable landmark on back of tibia

Femur = linea aspera
Tibia = soleal line



Distal ends of the tibia & fibula:

- Distal ends of the tibia & fibula are joined by the **distal tibiofibular joint**
- This is a **strong fibrous joint**
- The bones are linked further by the:
    - **Anterior tibiofibular ligament**
    - **Posterior tibiofibular ligament**

- Posterior tibiofibular ligament is particularly strong – projects low over back of ankle joint.

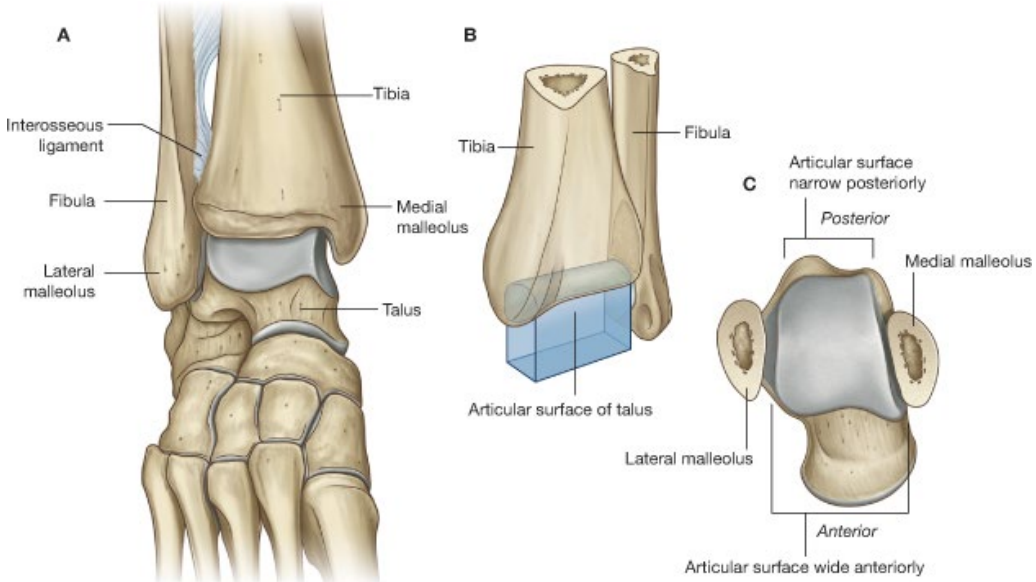
- Lower surface of tibia = quadrilateral articular surface
- Medially, tibia projects downwards as **medial malleolus**

- Laterally, the fibula projects downwards as the **lateral malleolus**:
    - Projects lower than the medial malleolus
    - Posterior to the medial malleolus

- Both medial and lateral malleoli can be palpated easily.

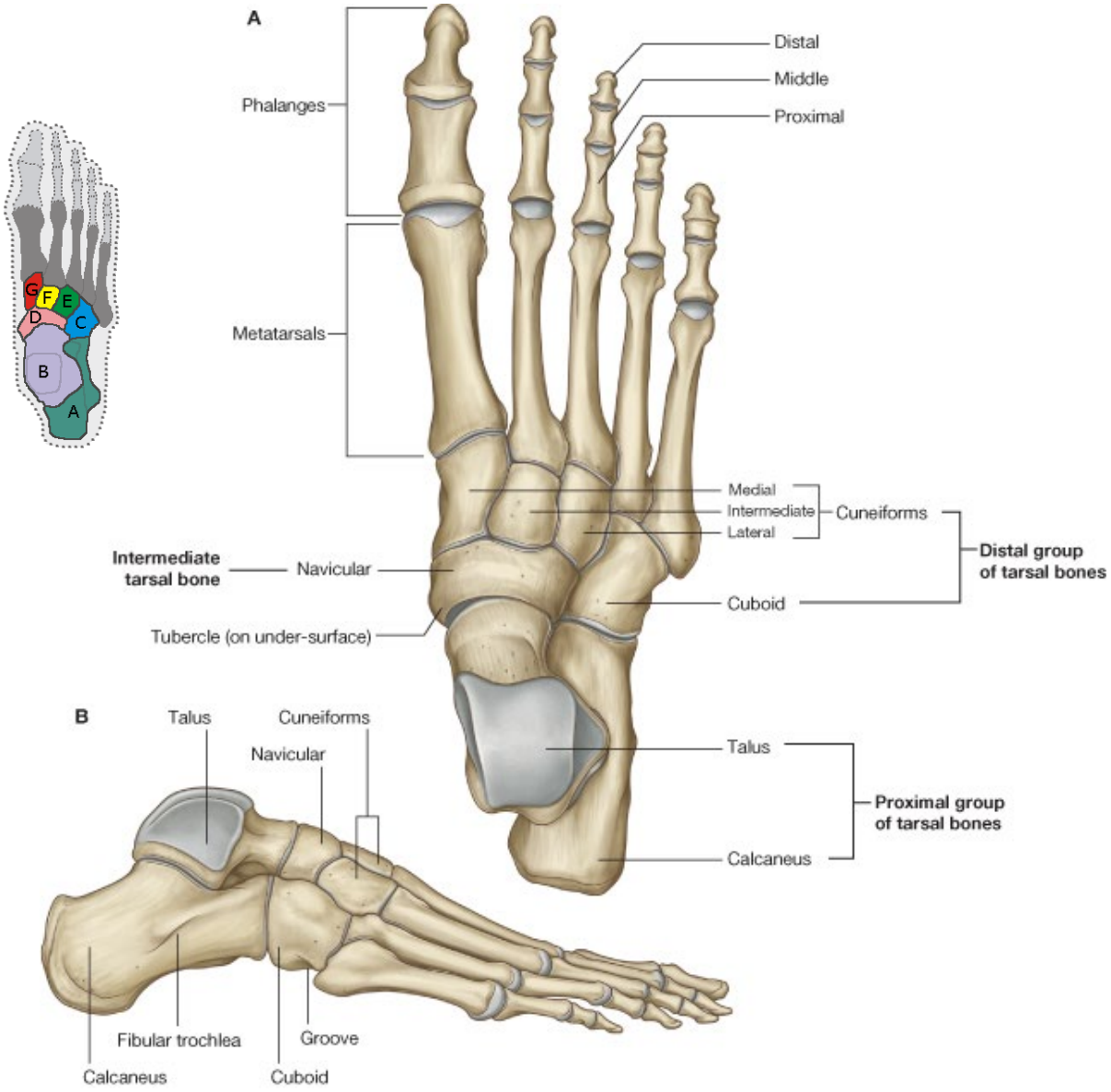
Mortise:

- The **mortise** is the articular surface formed by the:
    - Lateral & medial malleoli
    - Inferior surface of tibia
    - Posterior tibiofibular ligament
- The mortise articulates with the ankle bone.
- The distal tibiofibular joint must be v. strong to maintain integrity of mortise – or else ankle bone would ride up between tibia & fibula during running etc.



BONES OF THE FOOT:

- The **tarsal** bones are more irregularly arranged than the mobile carpal bones of the wrist.
- **Tarsus** refers to bones between the tibia/fibula and the metatarsals
- Arrangement allows for stability – essential for upright bipedal locomotion.



- **Nav Cubed Turnips Cautiously**

- **Talus** sits at summit of the foot – fits into the ankle mortise to form the **ankle joint**
- Talus is mounted on the **calcaneus** – the heel bone.
- Joint between talus & calcaneus = **subtalar joint**

- Along lateral edge of foot, the calcaneus articulates with the **cuboid** via the **calcaneocuboid joint**

- Medial edge of foot is raised off of the floor by 4 bones:
  - Talus → **navicular**: **talonavicular joint**
  - Navicular → **cuneiforms** (**medial, intermediate, lateral)**

- This arrangement of bones has primative mammalian origins

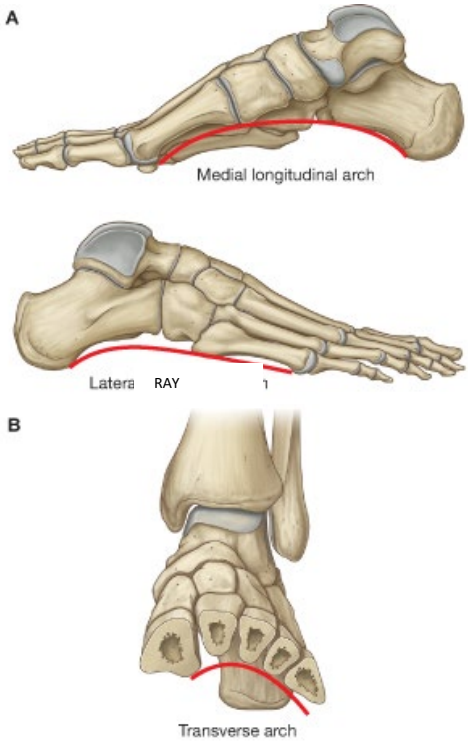
THE ARCH OF THE FOOT:

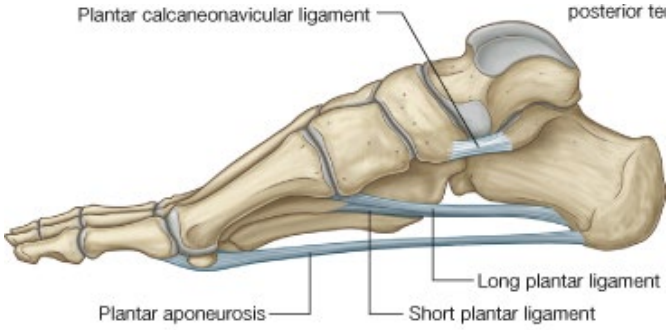
- The arrangement of the tarsal bones ensures that body weight is transmitted in an even manner
- Talus transmits weight through itself to two boney pillars – **rays** - which rest on the ground; thus it acts like the **keystone** of a roman arch:
- *Posterior ray:* **calcaneus**
- *Anterior ray:* **navicular + 3 cuneiforms**
- The arch formed is the **medial longditudinal arch of the foot**
- Arch is maintained by:
    - Shape of bones
    - Small muscles
    - Ligaments & tendons

- During running, arch is compressed 1cm ↓ downwards ground
- This stretches the ligaments spanning the arch:
    - **Long plantar ligament**
    - **Short plantar ligament**
- These ligaments store elastic potential energy, and release 70% of it when foot leaves the ground.

LATERAL RAY:

- The lateral ray of the foot is composed of:
    - **Cuboid**
    - **4th + 5th metacarpal**
- Lies in gentle contact with ground on standing (as no arch here)
- Lateral ray doesn't bear much weight – only briefly when walking
- More important for balance.



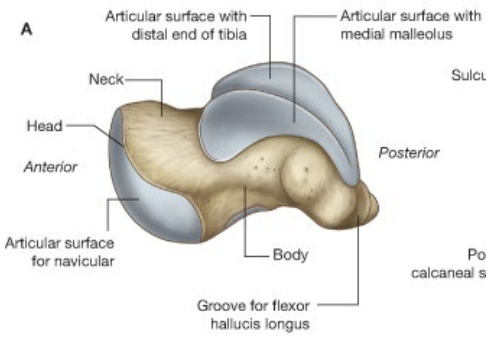


DISTRIBUTION OF WEIGHT OVER FOOT WHILST WALKING:

1. **Heel strike** – weight of body passes through heel
2. Weight spreads along lateral aspect of foot → head of metatarsals
3. Weight rolls across ball of foot → 1st metatarsal
4. **Toe off** – powerful big toe, the **<u>hallux</u>**, propels the body forwards.

JOINTS OF THE TARSAL REGION:

- 4 important joints to consider



Ankle joint

- Synovial
- <u>Hinge joint</u>
- Artciulation:
  - **Mortise** of tib & fib
  - **<u>Trochlea</u>** (the upper artciular surface of talus)
  - Trochlea articulates with:
    - Lower tibial surface
    - Medial & lateral malleoli
- The malleoli clamp either side of the trochlea – holding it in place.
- In some, the trochlea of the talus narrows towards the back.

- ***Neutral position*** *of ankle joint*: foot right angles to the leg.
- ***Plantar flexed****:* toes point downwards
- ***Dorsiflexed:*** toes pointed upwards

- People with a trochlea which narrows towards the back – plantarflexion brings the narrow bit of the trochlea between the malleoli.
- **BUT** the joint is not loose: the inferior tibiofibular ligaments can strech & the fibula can bend, such that the narrow part is held firm, and then as the foot is returned to the neutral postion, the malleoli separate a few mm to accommodate the larger part of the trochlea.

The fibrous capsule of ankle joint:

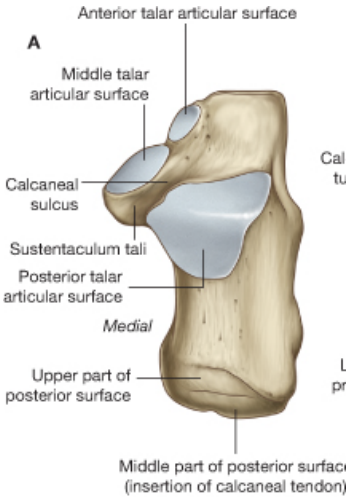
- Strong
- Attached to the articular margins
- Strengthed at the back by the <u>posterior tibiofibular ligament</u>
- Also strengthed by ligaments on either side.

- SM covers all non-articular surfaces.

Subtalar joint

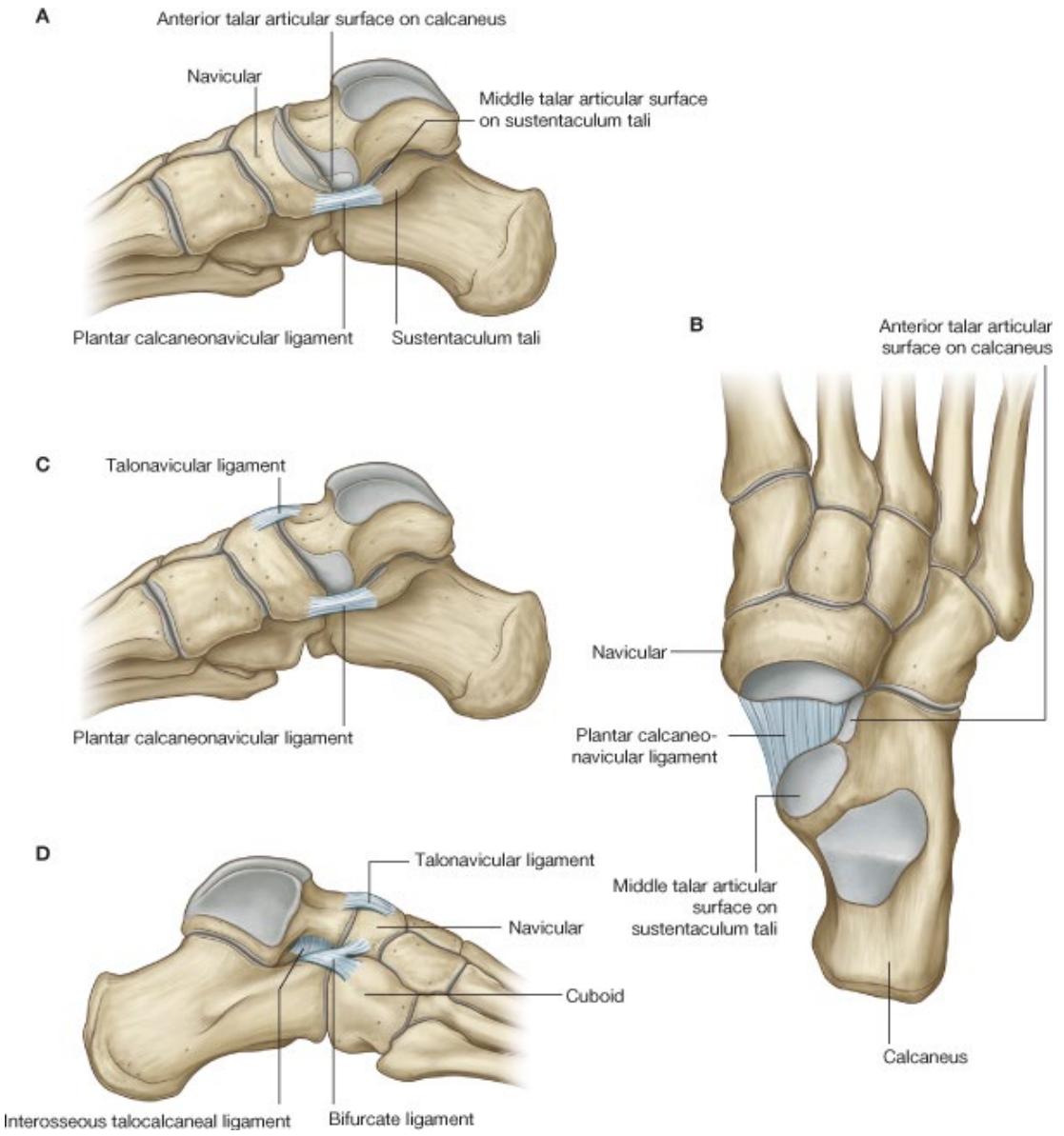
- Joint between **talus & calcaneus**
- Synovial
- **Calcaneous has 3 articular surfaces for the talus: anterior + middle + posterior**
- Articular surface of the calcaneus is dome shaped & curved – ensure particular movement of the calcaneus under the talus:
- **<u>Abduction</u>** of foot away from midline → <u>lateral</u> edge of foot raised off ground; **eversion**
- **<u>Adduction</u>** of foot towards mideline → <u>medial</u> edge of foot raised off ground; **inversion**
- **Abduction-eversion**

- **Adduction-inversion**
- Due to shape of articular surfaces of subtalar joint.
- In these movements, the talus is stationary and the calcaneus swings beneath it.
- **<u>Inversion / eversion of the ankle happens at the level of the subtalar joint</u>**



Talonavicular joint

- Between talus and navicular
- Synovial
- <u>Ball & socket</u>
- **Connection of talus to the <u>medial ray</u>**
- Ball: **head of talus**
- Socket:
    - **Navicular**
    - **Sustentaculum tali** (boney platform on medial side of <u>calcaneus</u>)
- <u>Between the navicular and the calcaneus</u> is the **<u>spring ligament</u>** (called plantar calcaneonavicular ligament in grays)
- Although this is a ball and socket joint, it doesn't show much mobility.
- Movement is resricted to the tarsus swinging beneath the talus
    - Abduction-eversion
    - Adduction-inversion



Calacenocuboid joint:

- Between **calcaneus & cuboid**
- Synovial
- Articular surfaces are flat – movements are sliding.

- **<u>TRANSVERSE TARSAL JOINT</u>: talonavicular joint + calcaneocuboid joint**

ANKLE, SUBTALAR AND TALOCALCANEONAVICULAR JOINTS

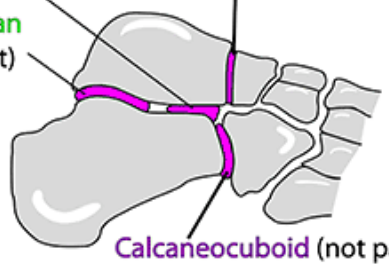
ANKLE (talocrural)

- Effectively a hinge joint but-
- Trochlear surface is slightly wider anteriorly so that there is a slight wiggle in full flexion
- Forces are transmitted to talus from tibia
- Plantar flexion - 30-50°
- Dorsiflexion - 20-30°
- Inversion injury may 1. tear ligaments, 2. pull off lower fibula, 3. pull of lower tibia & fibula

TALOCALCANEONAVICULAR
(effectively a ball and socket joint)
Made up of 2 parts

1
Between talus & calcaneus (2 joints)
Talocalcaneal (2 facets)
+
Talocalcanean joint (1 facet)

2
Between talus & navicular (Single joint)
Talonavicular



Calcaneocuboid (not part of the talocalcaneonavicular)

SUBTALAR (3 facets)

Talocalcanean (posterior & separate, 1 facet)
+
Talocalcaneal part of talocalcaneonavicular (2 facets)

MIDTARSAL (2 facets)

Calcaneocuboid
+
Talonavicular part of the talocalcaneonavicular

INVERSION
Always with some adduction of toes
Muscles: Tibialis anterior/posterior (+/- flexor hallucis longus)

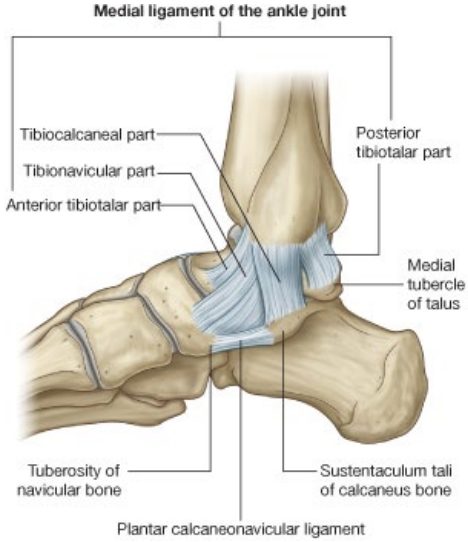
EVERSION
Always with some abduction of toes
Muscles: Fibularis longus/brevis (+ flexion), tertius (+ extension)

As all these tendons insert distal to the midtarsal joint, this joint moves first and a little, soon reaches its maximum and the torque is then transmitted to the subtalar joint which gives most of each movement

LIGAMENTS AROUND THE TARSAL JOINTS:

Medial ligament (aka **deltoid ligament**)

- Triangular shaped (hence 'deltoid')
- Apex: medial malleolus
- Base: talus, navicular, calcaneum
- **Δ spans the <u>ankle joint</u>**, supporting it.



- Part of the base also inserts into the calcaneus bone at the sustentaculum tali.
- **Δ spans the subtalar joint** as well.

- Part of the base also inserts into the spring ligament & navicular.
- **Δ spans the talonavicular joint** as well – giving it support

Lateral ligament

- Strong, but often strained in ankle injuries
- Has **3** fibrous bands

- Anterior band:
  - Lateral malleolus → anterior talus
- Posterior band:
  - Lateral malleolus → posterior talus

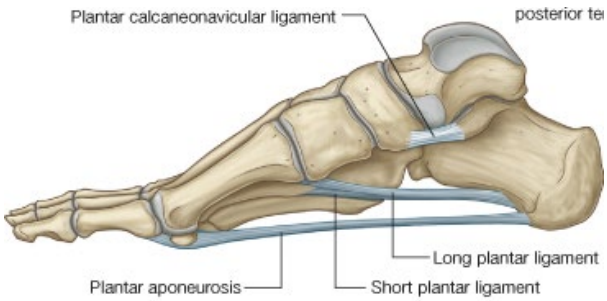
➢ Δ anterior & posterior bands both strengthen the ankle joint

- Middle band:
  - Lateral malleolus → calcaneus
  - Orientation is downwards & backwards.

➢ Δ middle band strengthens both the ankle and subtalar joints

Long plantar ligament:

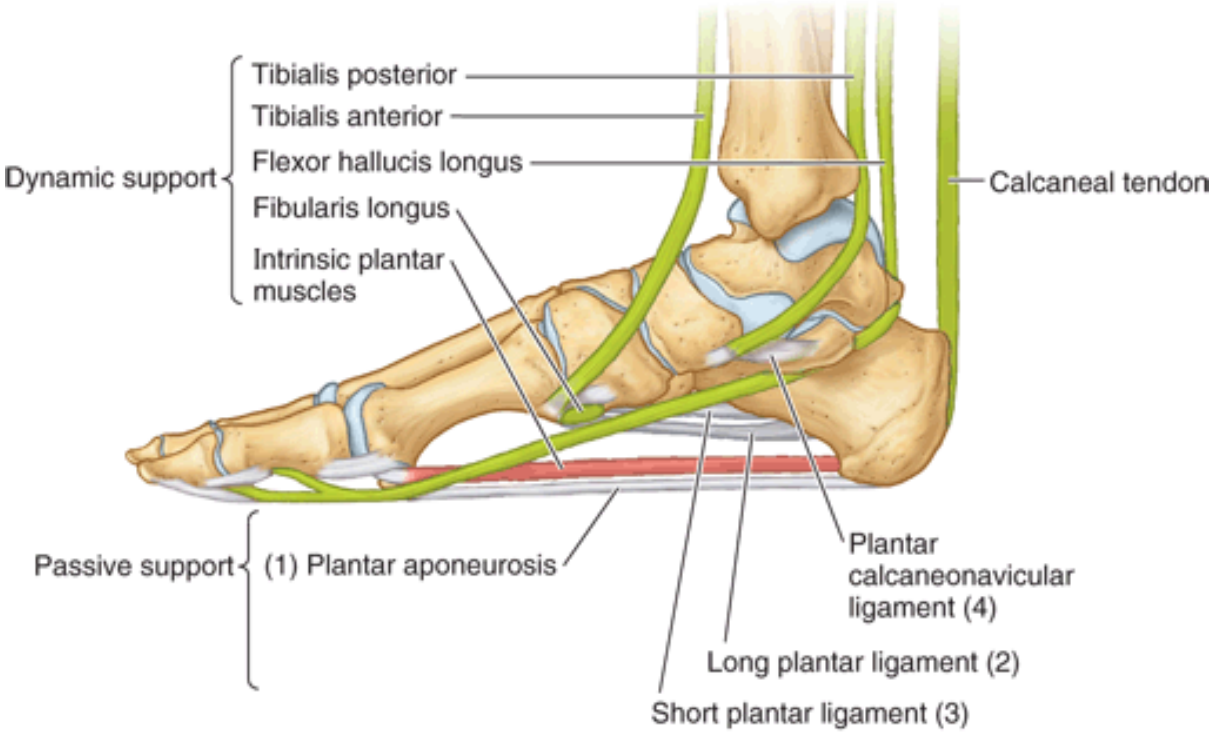
- Sole of foot
- Origin: inferior surface of calcaneus
- → extends under surface of cuboid
- Inserts: base of metatarsals
- **Δ supports the calcaneocuboid joint**



- The other tarsal bones are united by synovial joints as well as the 4 described above, but these are less important.
- The other joints of the foot are also **synovial**:
  - **Tarsometatarsal**
  - **Metatarsophalangeal**
  - **Interphalangeal**

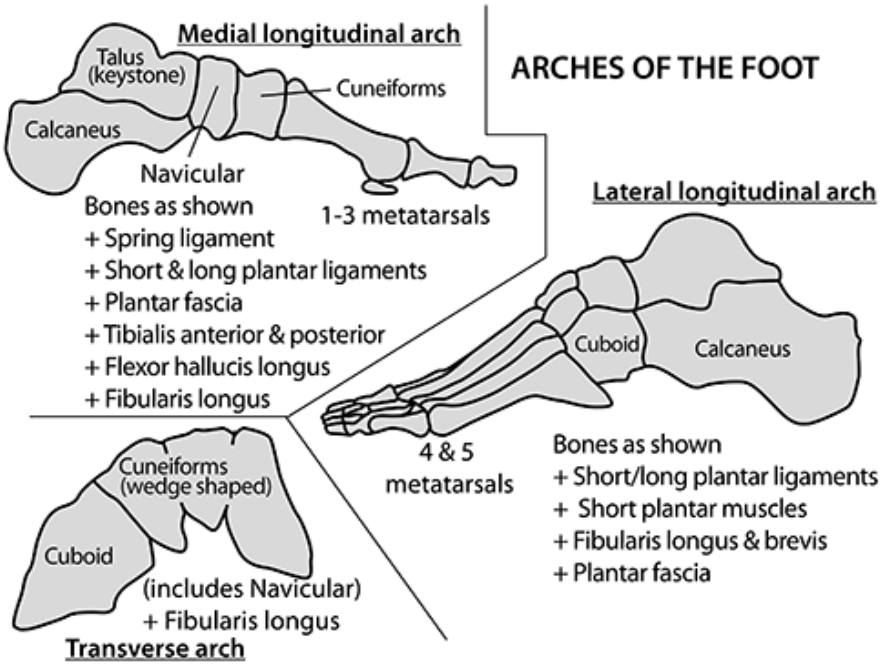
- The metatarsophalangeal joint (MTP) of the **big toe** is clinically important.
- Often the site of:
  - **Arthritis**
  - **Gout**

- NOTE, unlike the finger MCP joint, the MTP joint of the toe can only *actively* perform **flexion & extension**.
- The other movements of adduction, abduction & circumduction can be produced in the metatarsophalangeal joints, but only **passively.**

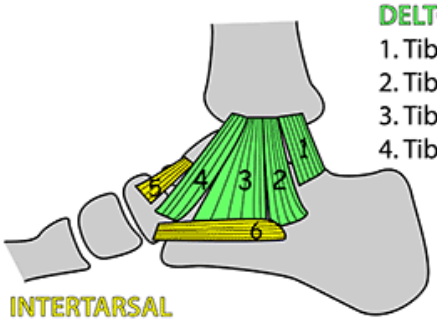


(E) Medial longitudinal arch (medial view)

BONES AND ARCHES OF RIGHT FOOT



ANKLE LIGAMENTS



DELTOID/MEDIAL COLLATERAL
1. Tibiotalar (posterior)
2. Tibiosustenacular
3. Tibio-spring ligament
4. Tibionavicular

LIGAMENTS OF MEDIAL SIDE OF RIGHT ANKLE

INTERTARSAL
5. Talonavicular
6. Spring (plantar calcaneo-navicular)
   Thick, strong, non-elastic, from sustenaculum tali to navicular. Upper surface articulates with head of talus.

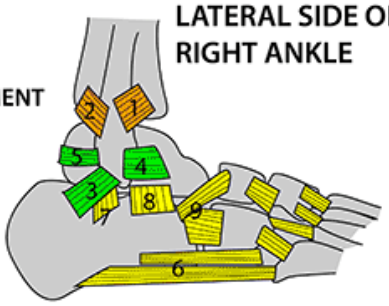
Joints
- Intertarsal
- Ankle

INFERIOR TIBIOFIBULAR LIGAMENT
1. Anterior tibiofibular
2. Posterior tibiofibular

LATERAL COLLATERAL LIGAMENT
3. Calcaneofibular
4. Anterior talofibular
5. Posterior talofibular

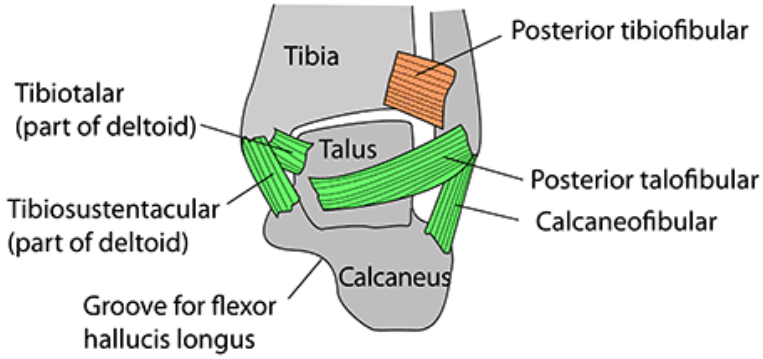
TARSAL/METATARSAL LIGAMENTS
6. Short/long plantar
7. Lateral talocalcaneal
8. Cervical
9. Bifurcate

LIGAMENTS OF LATERAL SIDE OF RIGHT ANKLE



Joints
- Inferior tibiofibular
- Ankle
- Intertarsal

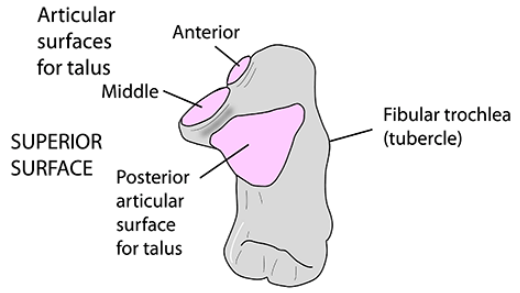
POSTERIOR VIEW OF RIGHT ANKLE

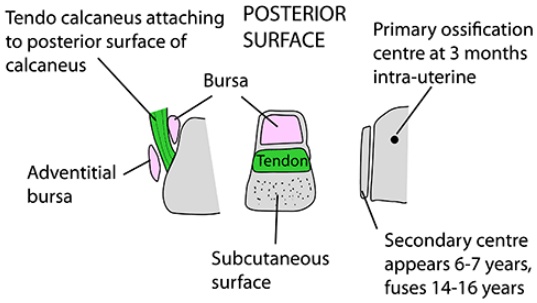


Because the fibula sticks out more laterally from the ankle joint than the tibia, the 3 parts of the lateral ligament are less strong and are easily torn in an inversion injury

Joints
- Inferior tibiofibular
- Ankle

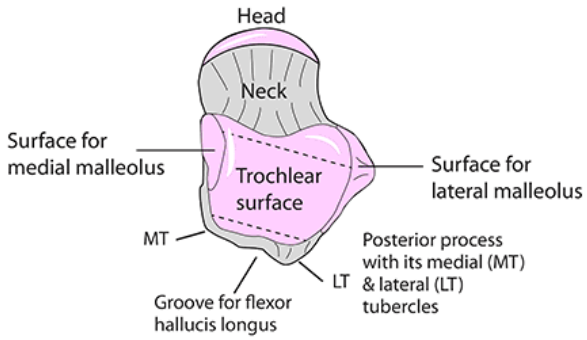
RIGHT CALCANEUS





RIGHT TALUS

SUPERIOR SURFACE



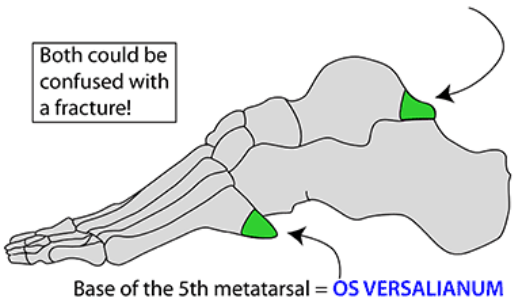
Dotted lines indicate the width of the anterior and posterior aspects of the trochlear surface. Anterior is longer therefore the ankle joint is "tighter" in dorsiflexion

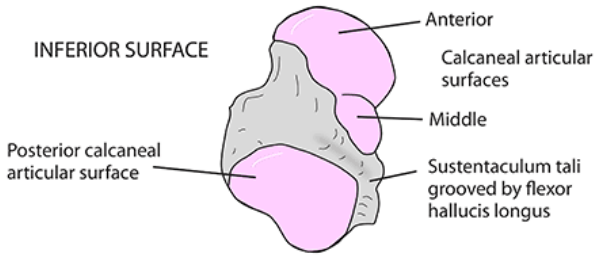
Talus has a single primary ossification centre that appears at 6 months intra-uterine

Mnemonic "TPP" reminds that the TALUS has a POSTERIOR PROCESS with 2 tubercles. The lateral tubercle has a separate ossification centre (age 7-13) that may fail to fuse in 7% of feet giving an "OS TRIGONUM"

ACCESSORY OSSIFICATION OF FOOT BONES

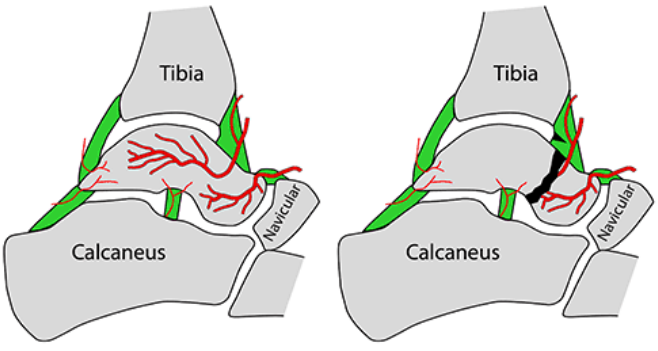
Posterior process of talus may have its own ossification centre that fails to fuse = **OS TRIGONUM**





NOTE: Talus has no muscle attachments, it is almost entirely intra-articular & its blood supply to its body is via its neck with the risk of avascular necrosis with a fracture

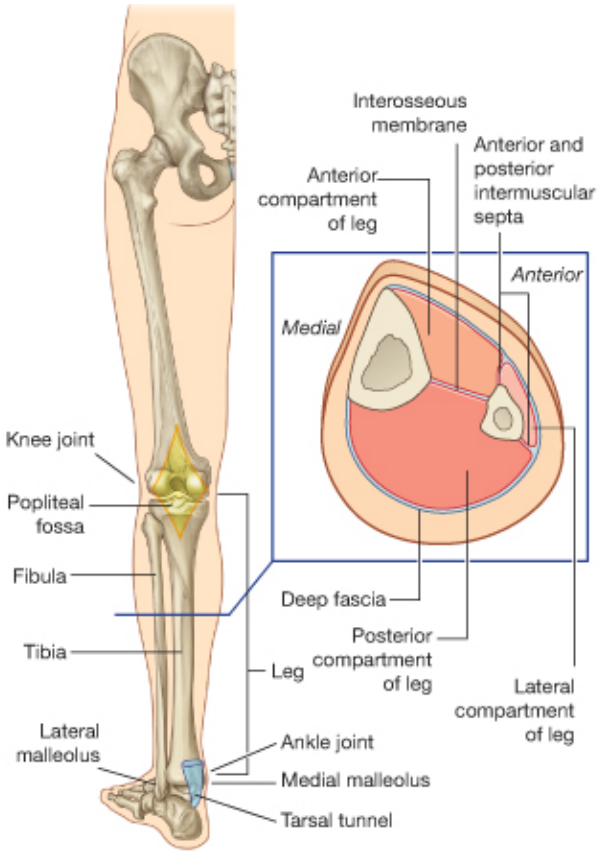
FRACTURE OF NECK OF TALUS



Similar to the scaphoid in the carpus, the talus has most of its blood supply entering distally. Thus a fracture of the neck often leads to avascular necrosis of its posterior part.

MUSCLES OF THE LEG & FOOT

- Below knee joint – muscles of the leg are for movement of ankle & toes.
- Lower leg is divided into an anterior & posterior compartment by **osseofascial septum:**
    - **Tibia →**
    - **Interosseous membrane →**
    - **Fibula →**
    - **Posterior intermuscular septum**
- Osseofascial septum divides the lower leg into:
    - Anterior compartment
    - Posterior compartment



- **Anterior compartment:**
    - Dorsiflexion of ankle
    - Extend toes

    - ***Medial group*** <u>of anterior compartment</u>:
        - Adduction-inversion
    - ***Lateral group*** <u>of anterior compartment</u>:
        - Abduction-eversion

- All muscles of anterior compartment: innervated by **<u>common peroneal nerve</u>** (of sciatic)

- **Posterior compartment:**
    - Plantar flexion of ankle
    - Flexion of toes
- Tendons of these muscles pass to heel and into sole of foot

- One muscle also performs adductor-inversion
- All muscles of posterior compartment: innervated by **tibial nerve** (of sciatic)

MUSCLES OF THE ANTERIOR COMPARTMENT OF LOWER LEG

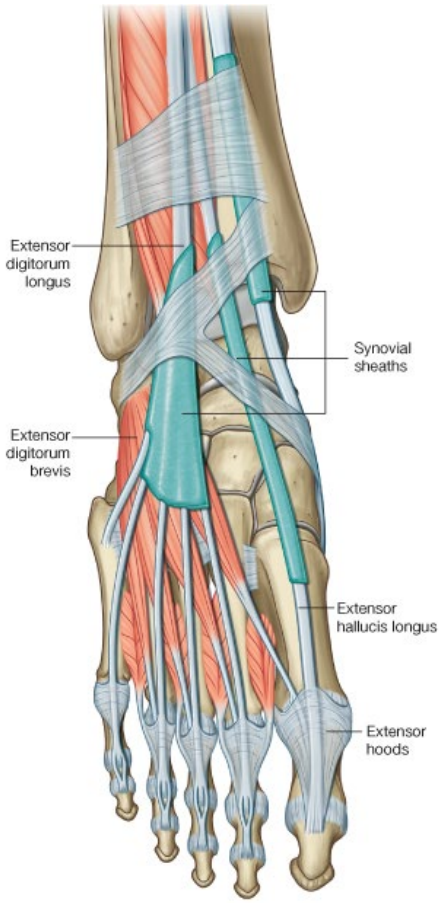
- **Central muscles of this group**:
  - Primarily: **extension of the toes**
  - Secondarily: **dorsiflexion of ankle**

- **Extensor digitorum longus**
- **Extensor hallucis longus**

- As both muscles pass over the front of the ankle, they are held down by thickenings in the deep fascia – **extensor retinacula**
- The extensor retinacula is composed of **superior retinacula** and **inferior retinacula.**

- **Superior extensor retinacula:**
  - Extends between tibia & fibula

- **Inferior extensor retinacula:**
  - 'Y'-shaped
  - Stem attached to lateral calcaneus
  - Upper limb attached to medial malleolus
  - Lower limb attached to medial border of foot, blending with deep fascia of the sole.



Extensor digitorum longus:

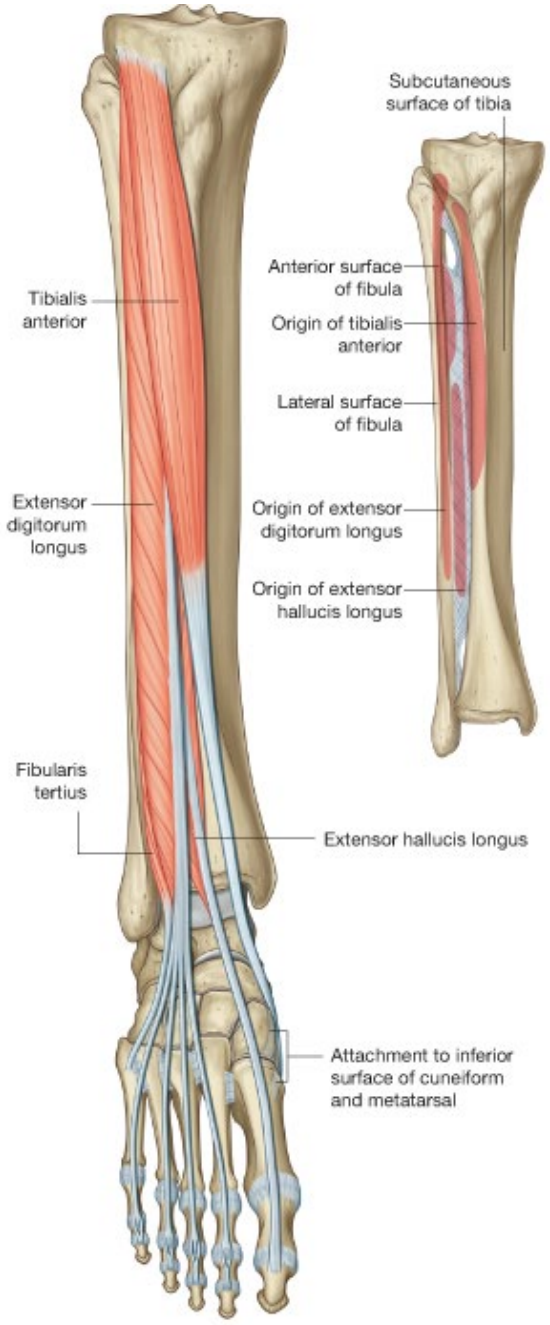
- **Origin: fibula**
- Passes down leg towards ankle
- Becomes a tendon which passes beneath the extensor retinacula.
- Covered by synovial sheath as it passes beneath the extensor retinacula.
- Divides in 4 tendons, which pass to the 4 lateral toes.

- Over the proximal phalanges the tendons form **extensor expansion** (similar to those in the fingers).

- ***Central slip*** then gains insertion into middle phalynx
- ***2 collateral slips*** insert into base of distal phalynx.

- Action of extensor digitorum longus:
  - **Extension of lateral 4 toes**:
    - Metatarsophalangeal joints
    - Interphalangeal joints

- Nerves supply is from the ***deep peroneal nerve***



Extensor hallucis longus:

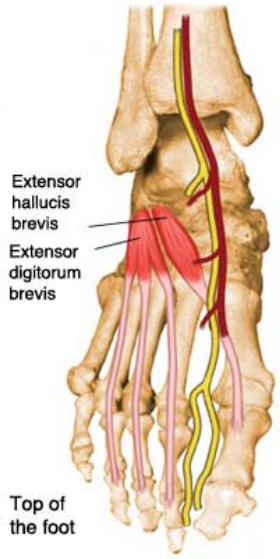
- Origin: **mid-fibular shaft + interosseous membrane**
- Passes under extensor retinacula – surrounded by its own synovial sheath
- Strong tendon
- Inserts into distal phalanx of big toe

- Action: **extend the big toe joints:**
  - Metatarsophalangeal
  - Interphalangeal

- Supplied by ***deep peroneal nerve***

- Tendon of extensor hallucis longus can be ruptured in injury → impossible to extend big toe – it stays in a flexed position.
- → difficult to walk without shoes – flexed big toe trips patient up.

Extensor digitorum brevis & extensor hallucis brevis



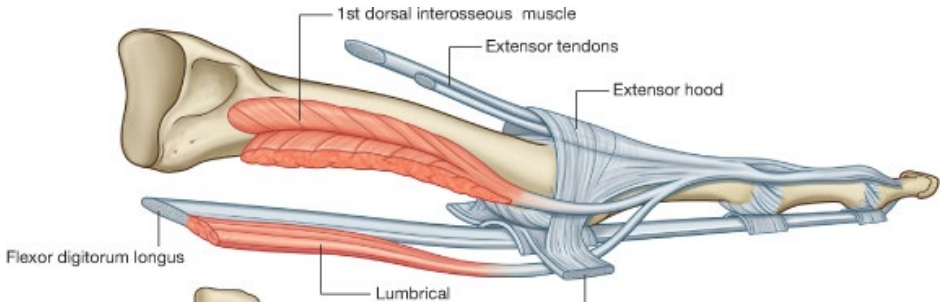
- The extensor digitorum and hallucis longus are assisted in extension by a short muscle on the dorsum of the foot:
  - **Extensor digitorum brevis / hallucis brevis**
- The muscle arises from the **upper surface of the calcaneus**
- **Divides into 4 tendons**:
  - Most medial tendon: **extensor hallucis brevis**
    - Passes to the **proximal** phalynx of big toe
  - Lateral 2nd, 3rd & 4th tendons: **extensor digitorum brevis**
  - Insert into the extensor expansions of the toes
- The muscle is supplied by the ***deep peroneal nerve***

LUMBRICAL & INTEROSSEOUS MUSCLES:

- As in the hand
- But play a much less important role than those in the hand

- Lumbricals:
  - Arise: long flexor tendons in the sole of the foot
- Interossei:
  - Arise: metatarsal bones
- The tendons of both insert into the extensor expansions of 2nd, 3rd, 4th & 5th toes.

- Action:
  - **Flex metatarsophalangeal joint**
  - **Weakly extend interphalangeal joint**



- **Most medial (& superficial) muscle of anterior compartment:**

Tibialis anterior:

- Large
- Origin:
  - **Tibia** (this is a medial muscle)

- **Interosseous membrane**

➢ Passes deep to extensor retinacula – covered with its own synovial sheath

➢ Insertion: medial side of foot:
- **Medial cuneiform**
- **First metatarsal**

➢ Action:
- **Dorsiflexion of the foot**
- **Adductor-inversion** (points toes towards midline and raises medial foot)

➢ Tibialis anterior is supplied by the ***deep peroneal nerve***

➢ **Most lateral muscle of the anterior compartment:**

Peroneal muscles:

- **Peroneus longus**
  - Origin: upper part of fibula
- **Peroneus brevis**
  - Origin: lower part of fibula

- Both curl around the lateral malleolus → lateral aspect of ankle

- Held in place by 2 retinacula:
  - **Superior peroneal retinacula**
    - Lateral malleolus ←→ calcaneus
  - **Inferior peroneal retinacula**
    - Attached to lateral calcaneus at both ends
- The 2 peroneus tendons pass beneath the peroneal retinacula:
  - Surrounded by **common sheath** beneath the superior retinacula
  - Surrounded by **separate individual sheaths** beneath inferior retinacula

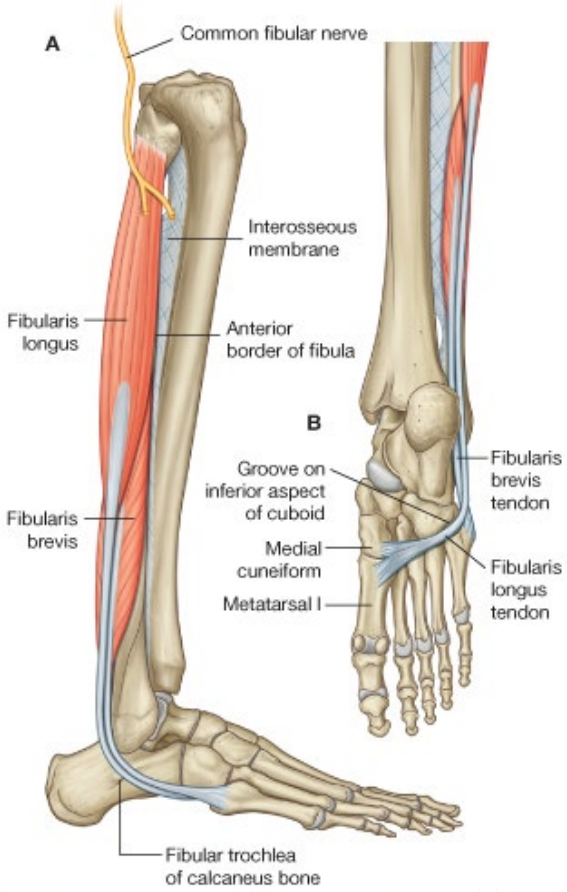
- **Peroneus brevis:** inserts into **peroneal tubercle at base of 5th metatarsal**

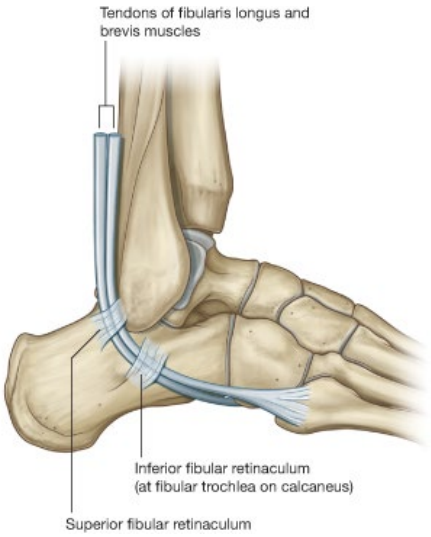
- **Peroneus longus:**
  - Sweeps around to sole of foot – held in groove on cuboid by *long plantar ligament* – surrounded by synovial sheath.
  - Inserts into same bones as tibialis anterior on the medial side of the foot:
    - **Medial cuneiform**
    - **1st metatarsal**
- The tendons of peroneus longus (lateral origin) and tibialis anterior (medial origin) thus pull in opposite directions:
  - Tibialis anterior: adduction-inversion
  - Peroneus longus: abduction-eversion

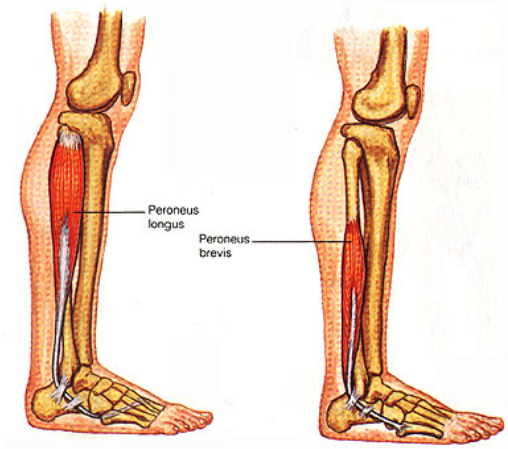
- Both peroneal muscles are supplied by ***superficial peroneal nerve***.
- Blood supply from **peroneal branch** of ***posterior*** **tibial artery** (all the rest of the anterior compartment is supplied by the anterior tibial artery).

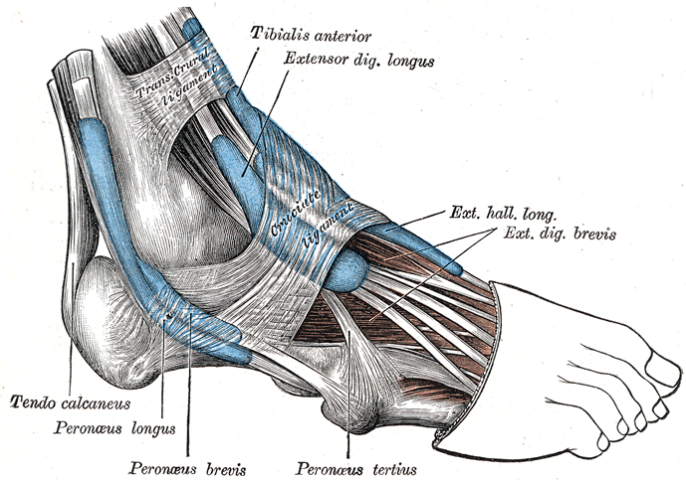
- **Peroneus tertius** is a small muscular slip

- Actually slip of extensor digitorum longus, arising from lower fibula
- Tendon is delicate and doesn't pass through the peroneal retinacula – instead passes deep to the extensor retinaculum**.**
- Should be considered with the muscles which pass beneath the extensor retinaculum
- Inserts into base of 5th metatarsal (like peroneus brevis)
- Supplied by: ***deep peroneal nerve***
- Action: **weak dorsiflexion**.

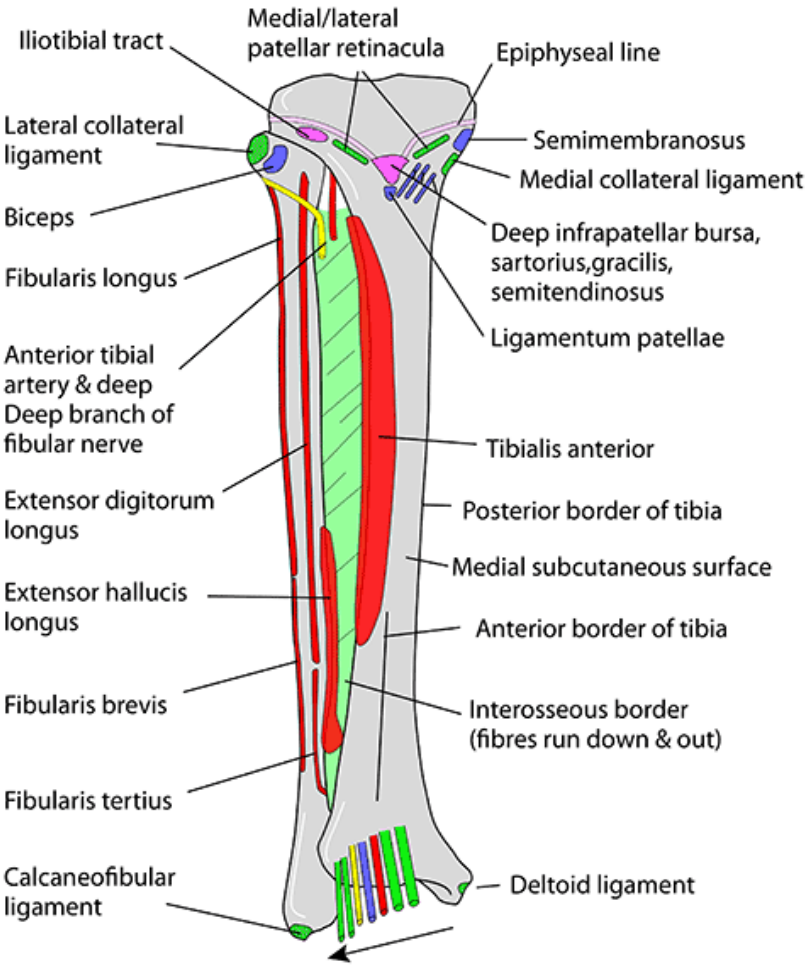






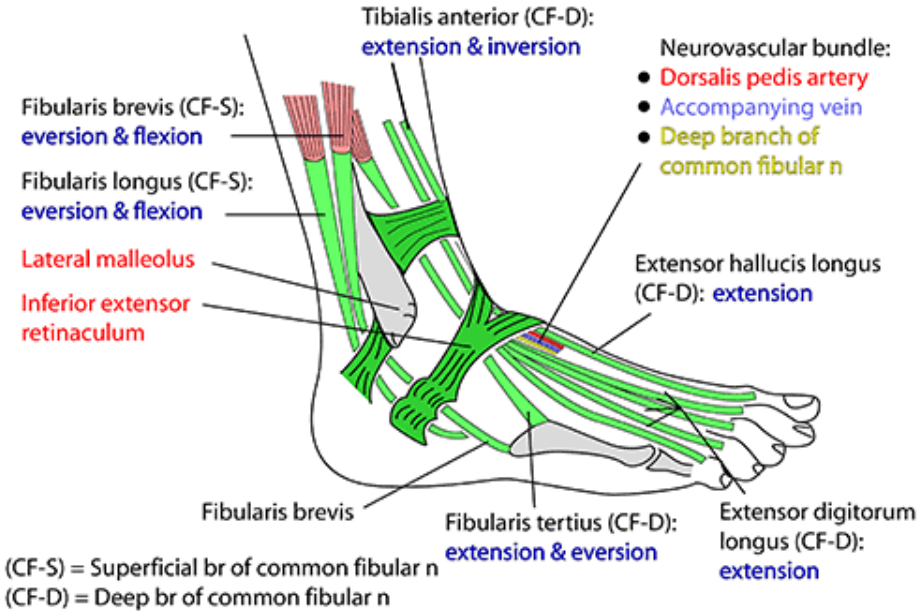


ANTERIOR LOWER RIGHT LEG



Order of structures across dorsum of foot in direction of arrow: Tibialis anterior, extensor hallucis longus, anterior tibial artery/vein, deep fibular nerve, extensor digitorum longus, fibularis tertius
Mnemonic: Timothy Has A Very Nasty Diseased Foot

TENDON & NEUROVASCULAR RELATIONSHIPS ON LATERAL ASPECTS OF RIGHT ANKLE

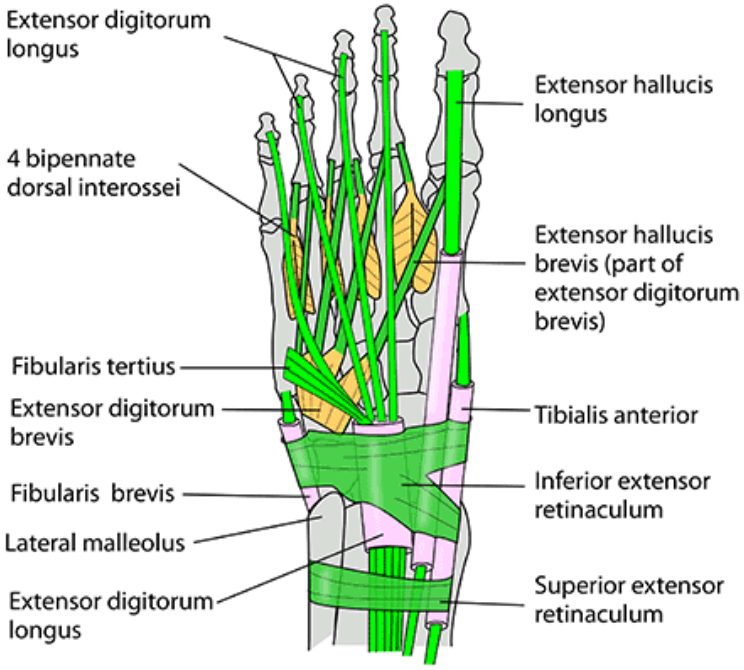


(CF-S) = Superficial br of common fibular n
(CF-D) = Deep br of common fibular n

Mnemonic for dorsal tendons, vessels & nerves from medial to lateral :

"Timothy Has A Very
Nasty Diseased Foot"

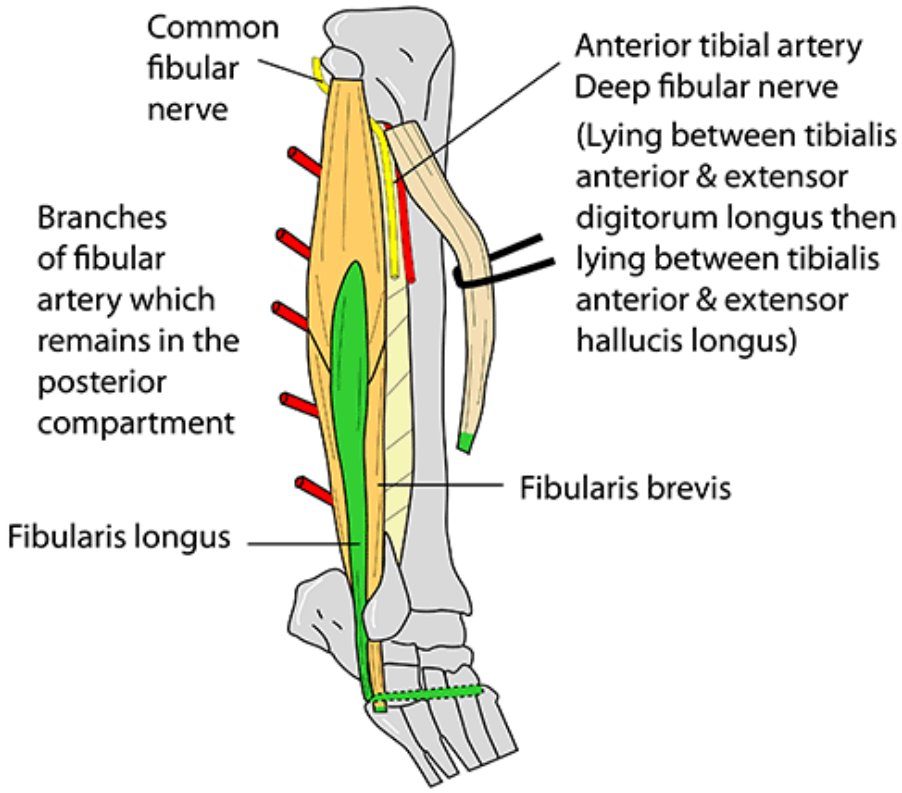
DORSUM OF LEFT FOOT



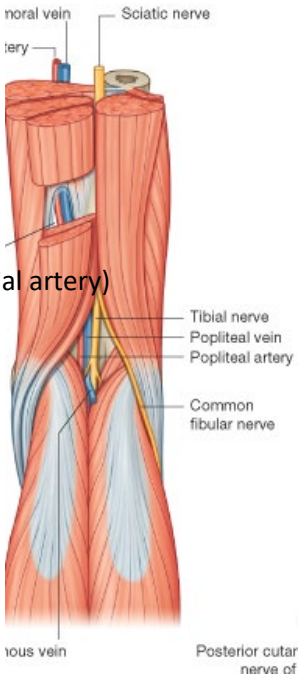
Extensor digitorum brevis
Arises: Superior/anterior calcaneus
Inserts: 4 tendons. Proximal phalanx big toe (could be called extensor hallucis brevis) & into long extensor tendons to 2,3,4.
Acts: Extends toes 1-4 when foot is fully dorsiflexed
Nerve: Deep fibullar (L5,S1)
Note: This muscle breaks the rule in that, as a short "digitorum" muscle it does not supply the 5th digit (cf. Flexor digitorum superficialis in hand)

For details of muscles, please see muscle section in the book - Instant Anatomy, by R H Whitaker & N R Borley. 4th edition. Wiley-Blackwell 2010

RIGHT FIBULAR COMPARTMENT



For more details of muscle actions please see section on ankle & foot movements. Also in muscle section of the book - Instant Anatomy, by R H Whitaker & N R Borley. 4th edition. Wiley-Blackwell 2010



NEUROVASCULAR SUPPLY TO THE FRONT OF THE LEG:

- Muscles of the front of the leg are supplied by:
    - **Common peroneal branch** of the sciatic nerve (grays calls it fibular nerve)
    - **Anterior tibial branch** of the **popliteal artery**
      (*Except* peroneal muscles – supplied by peroneal branch of the posterior tibial artery)

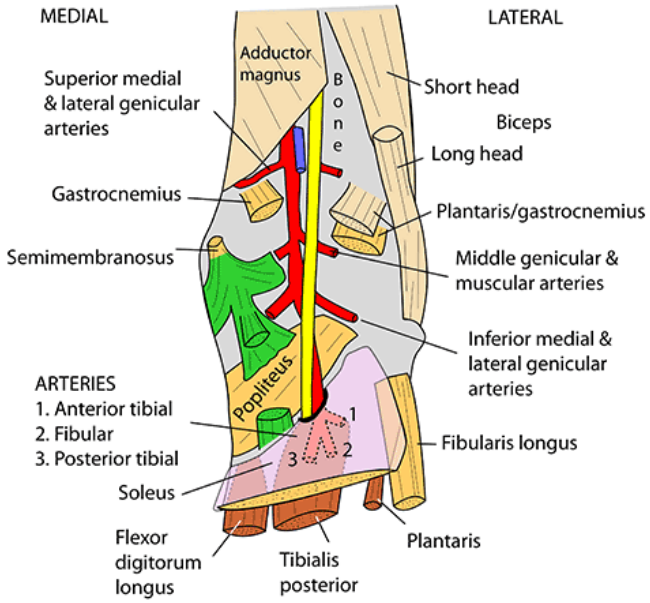
RIGHT POPLITEAL FOSSA
DEEP DISSECTION

CONTENTS

- Popliteal artery & vein
- Tibial nerve
- Common fibular nerve
- Fat
- Lymph nodes

NOTE ON POPLITEAL ARTERY

- 8" long
- Starts medial to tibial nerve
- Ends lateral to tibial nerve
- Vein always between two



- **Common peroneal branch** was identified leaving the popliteal fossa
- Runs beneath the head of the fibula
- Comes to **lie on neck of fibula** on lateral side of knee (can be rolled beneath the skin here)
- Divides into:
    - **Deep peroneal branch**
    - **Superficial peroneal branch**
- Mixed nerves – supply all muscles and skin on the front of the leg

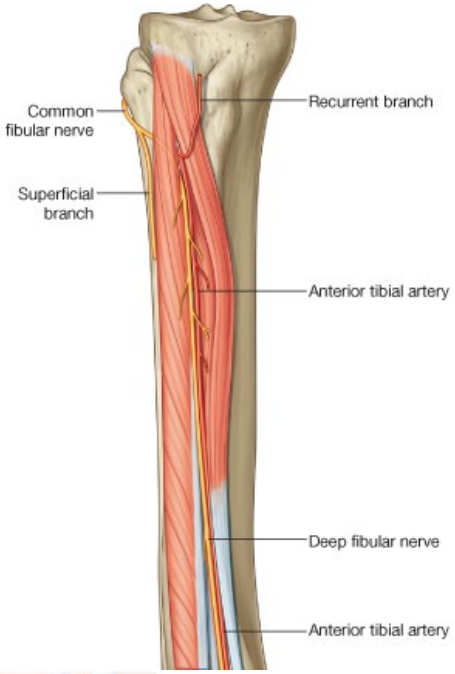
Deep peroneal branch:

- Passes onto the front of the interosseous membrane

- Can be seen here by seperating the tibialis anterior from the extensor digitorum longus & extensor hallucis longus.

- At ankle it is <u>crossed by tendon of extensor hallicus longus</u> (as the tendon passes to big toe)
- On dorsum of foot it lies <u>between</u> the tendons of extensor digitorum longus & extensor hallucis longus.
- It passes **<u>beneath the extensor retinacula</u>**
- Then divides into <u>lateral and medial branches</u>.
- **Lateral division**: supplies **<u>extensor digitorum brevis</u>**
- **Medial division**: **<u>cutaneous</u>** – supplies 1st cleft skin.

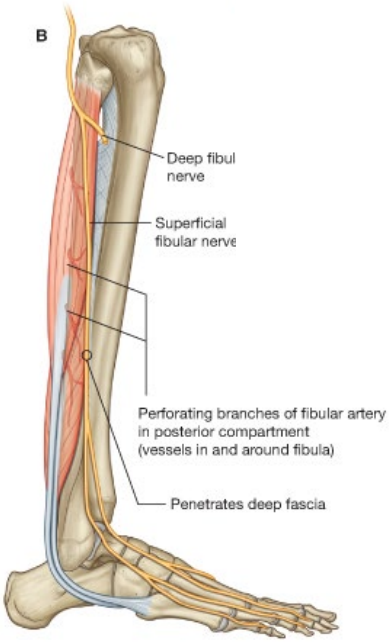
- Whilst in the front of the leg, the **deep peroneal branch supplies all the muscles of the anterior compartment** *<u>except</u>* <u>the peroneal muscles</u>:
  - Extensor digitorum longus
  - Extensor digitorum brevis
  - Extensor hallucis longus
  - Extensor hallucis brevis
  - Tibialis anterior
  - Peroneus tertius

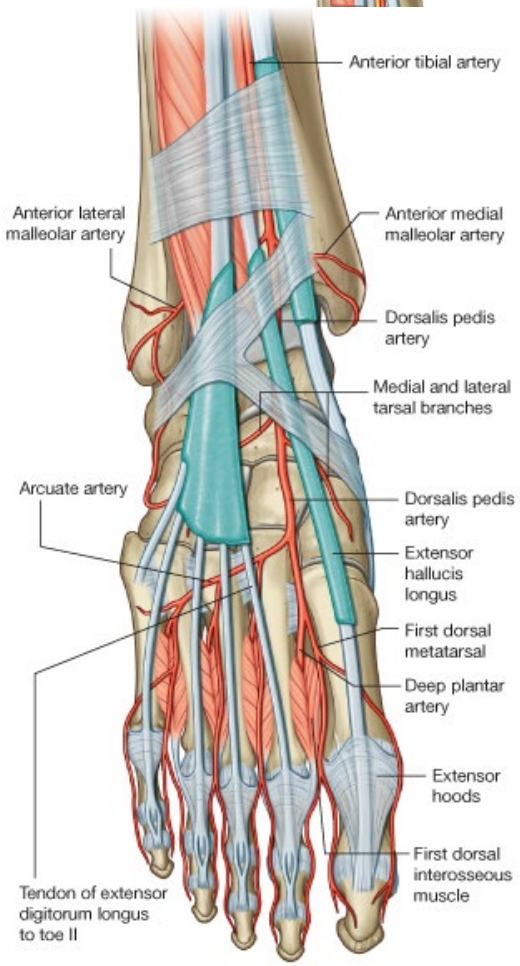


Superficial peroneal branch:

- From the posterior aspect of the neck of the fibula, the superficial branch passes immediately **into the substance of the peroneus longus & peroneus brevis**
- The superficial branch <u>supplies only these 2 peroneal muscles.</u>

- The superficial nerve then divides into <u>lateral & medial branches</u>.
- These branches pass **<u>superficial to the extensor retinacula</u>** (unlike the deep branch)
- **<u>Supplies skin of dorsum of foot and toes.</u>**





Anterior tibial artery

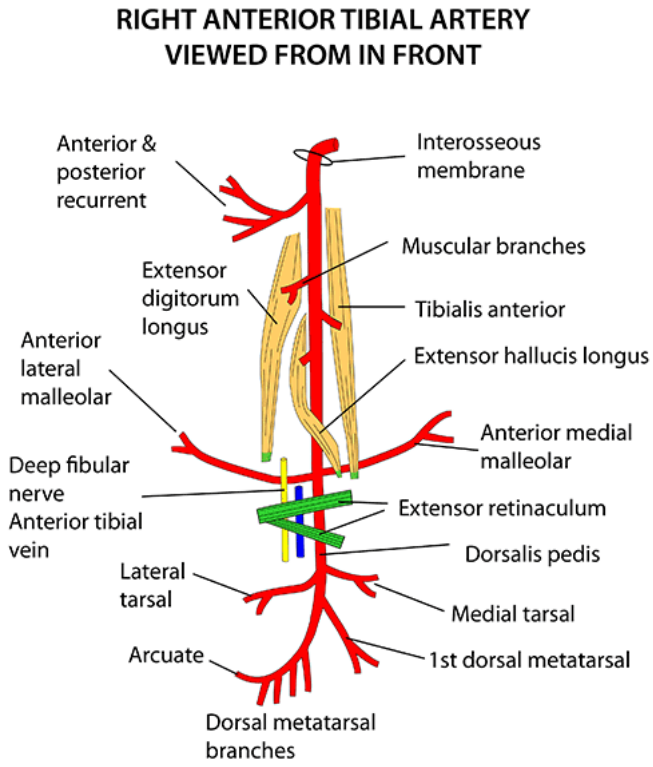
- Branch of popliteal artery
- Pierces interosseous membrane to enter front of leg
- Accompanies the deep peroneal nerve down the leg.
- Supplies blood to muscles on front of leg (except peroneus longus & brevis)
- Passes **deep to the extensor retinacula**
- Like the deep peroneal nerve, it lies between the tendons of the extensor digitorum longus & extensor hallucis longus.
- Can be easily palpated in this region
- (The tendon of extensor hallacis longus is particularly visible if the toe is bent).
- At the ankle it gives off the **medial and lateral malleolar arteries**
- At the foot it gives off the **medial and lateral tarsal arteries**

- As the anterior tibial artery passes onto the dorsum of the foot it is renamed the **dorsalis pedis**

- On the dorsum of the foot the dorsalis pedis runs to the 1st web space with the medial branch of deep peroneal nerve
- Passes into sole of foot

- On the dorsum of the foot the dorsalis pedis also gives off:
    - **First dorsal metatarsal artery**
    - **Arcuate branch** which supplies the metatarsals and toes by means of:
        - **Dorsal metatarsal branches**
        - **Digital branches**

➢ Note it is the **peroneal branch** of the ***posterior*** **tibial artery** which supplies the peroneal muscles.

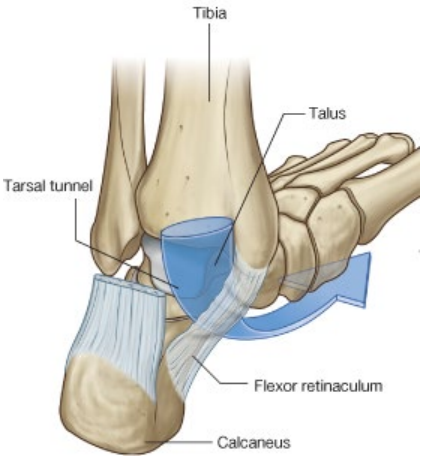


MUSCLES OF THE BACK OF THE LOWER LEG

- **Plantar flexion** of ankle
- **Flexion** of toes

- All muscles on the back of the leg are supplied by the ***tibial nerve***

- The muscles are arranged in **3 layers**:
  - Deepest layer: **tibialis posterior**
    - Origin: tibia + fibia + interosseous membrane
    - Insertion: sole of foot
  - Middle layer: **long flexors of the toes**
    - Insertion: toes
  - Superficial layer: **platar flexors of ankle**
    - Insertion: heel



- The deep and middle layers reach the sole of foot and toes by curling beneath the medial malleolus (tibia malleolus).
- The outermost layer (platarflexors) insert into the calcaneous tendon.
- **Flexor retinaculum** is thickening of deep fascia here, holding these tendons in place.
- Flexor retinaculum: **medial malleolus ←→ calcaneus**

DEEPEST LAYER OF MUSCLES ON BACK OF LEG:

- **Tibialis posterior**
- Origin:
  - **Tibia**
  - **Fibula**
  - **Interosseous membrane**
- Tendon passes deep to the flexor retinaculum – surrounded by synovial sheath
- In sole, sends fibrous insertions to nearly all bones of sole
- Main insertion: **navicular**

- Action:
  - **Plantar flexion**
  - **Adduction-inversion** (as it pulls on medially placed navicular)

- Innervation: ***tibial nerve***

MIDDLE LAYER OF MUSCLES ON BACK OF LEG:

- **Flexor digitorum longus**
- **Flexor hallucis longus**
- Next layer of "onion" out from the tibialis posterior – so must have an origin further out.

- **Flexor digitorum longus**
  - Origin: tibia
  - Inserts: divides into 4 tendons which insert into **terminal phalanges** of lateral 4 toes.

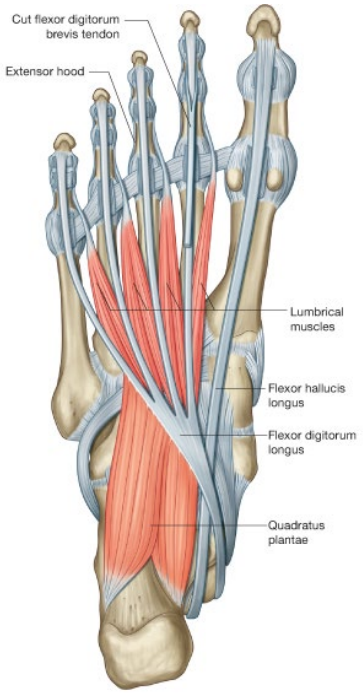
- **Flexor hallucis longus**

- Origin: fibula
- Inserts: single tendon which inserts into **terminal phalanx** of big toe.

- Both pass **deep** to the flexor retinaculum – are **covered with separate synovial sheaths**.

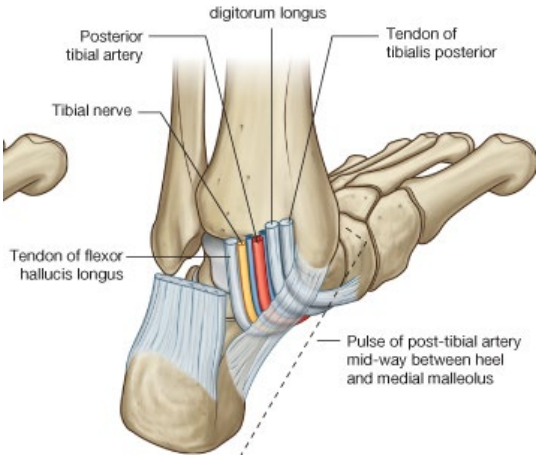
- Action: **flexion of metatasophalangeal joint & interphalangeal joint**.

- Innervation: **tibial nerve**



NOTE the order of the tendons of the deep and middle layers as they pass beneath the flexor retinaculum:

Tom **D**ick **A**nd a **V**ery **N**aughty **H**arry
Tibialis posterior, flexor **D**igitorum longus, **A**rtery, **V**ein, **N**erve, flexor **H**allucis longus



- As the tendons of flexor digitorum longus & flexor hallicus longus travel along the plantar suface of the toes, they are held in place by **fibrous flexor sheaths**.
- Δ are also surrounded by synovial sheaths

- NOTE the tendons of the flexor digitorum longus would exert a v. oblique pull on toes – as they travel from medial malleolus and spread to the toes.
- To correct this, a small muscle – **flexor accessorius** – arises from calcaneus to insert into the tendon of flexor digitorum longus (note in grays diagrams, called quadratus plante)

- A **lumbrical muscle** arises from **medial side** of each tendon of the flexor digitorum longus.
- The muscle winds around to front of metatarsal & insert into **extensor expansion**
- Assist in flexion of metatarsophalangeal joint – but not as important as in the hand.

***SUPERFICIAL* LAYER OF MUSCLES ON BACK OF LEG:**
- Platar flexion of ankle
- **Soleus**
- **Gastrocnemius**
- **Plantaris**

- All 3 muscles **<u>insert as a common tendon into calcaneus</u>**

Soleus

- Is the deepest of the 3 muscles
- Origin:
    - <u>Tibia: **soleal line**</u>
    - <u>Fibula</u>
- Forms a fibrous arch between these 2 origins.
- Ends in a tendon at the ankle which <u>inserts into common tendon into calcaneus</u>.

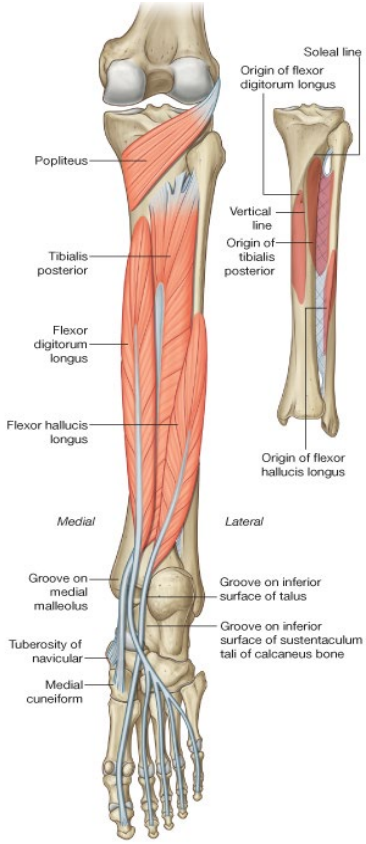
Gastrocnemius

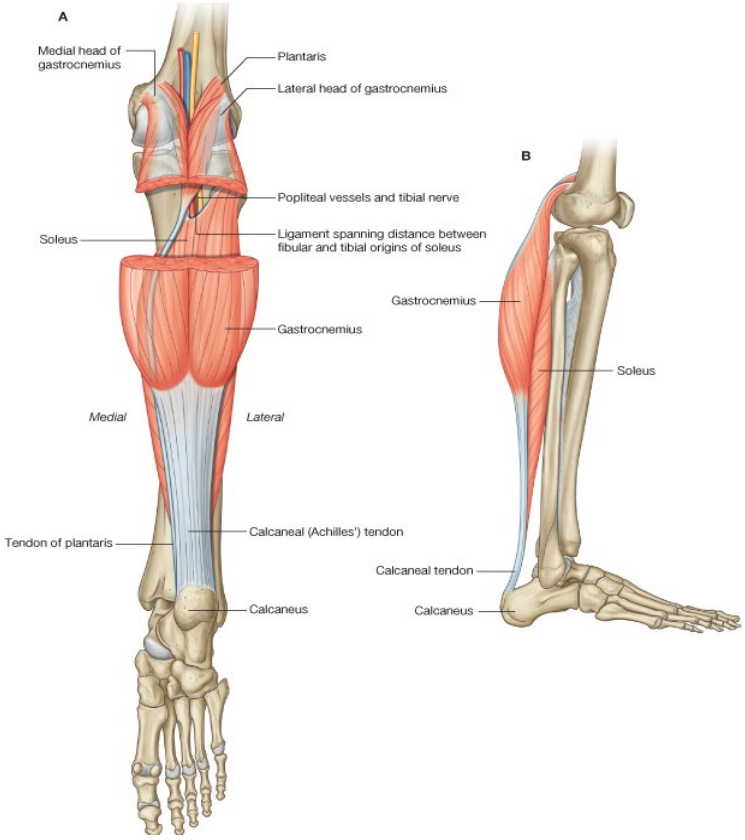
- Arises as 2 heads:
    - One from lateral femoral condyle
    - One from medial femoral condyle
- Makes up most of the muscle mass of the calf
- Inserts into common tendon into calcaneus

Plantaris

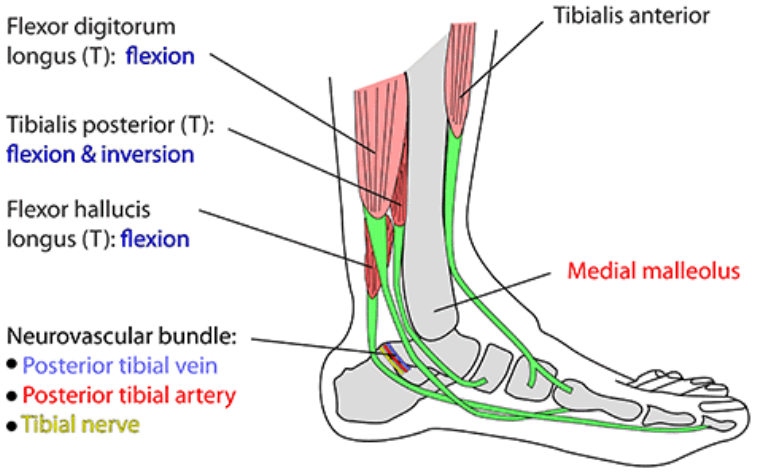
- Delicate muscle – mainly exists as <u>tendon</u>
- Arises from <u>femur</u> on <u>medial side of lateral gastrocnemius head</u>
- Plantaris tendon is stretched during running / walking <u>like elastic</u>
- Can return 90% of the elastic potential energy stored
- (important in animals like kangeroos for locomotion)

- Near the ankle, the tendons of gastrocnemius & plantaris fuse with the soleal tendon
- The 3 tendons combined make up the **<u>tendo calcaneus</u>** – aka **achilles tendon**.
- Tendo calcaneus inserts into the calcaneus
- Easily palpated on back of ankle.
- Tendo calcaneus is seperated from underlying bone by a small bursa.
- All 3 muscles of the superficial layer are:
    - **Plantar flexors**
    - Innervated by the ***tibial nerve***





TENDON & NEUROVASCULAR RELATIONSHIPS ON MEDIAL ASPECTS OF ANKLE

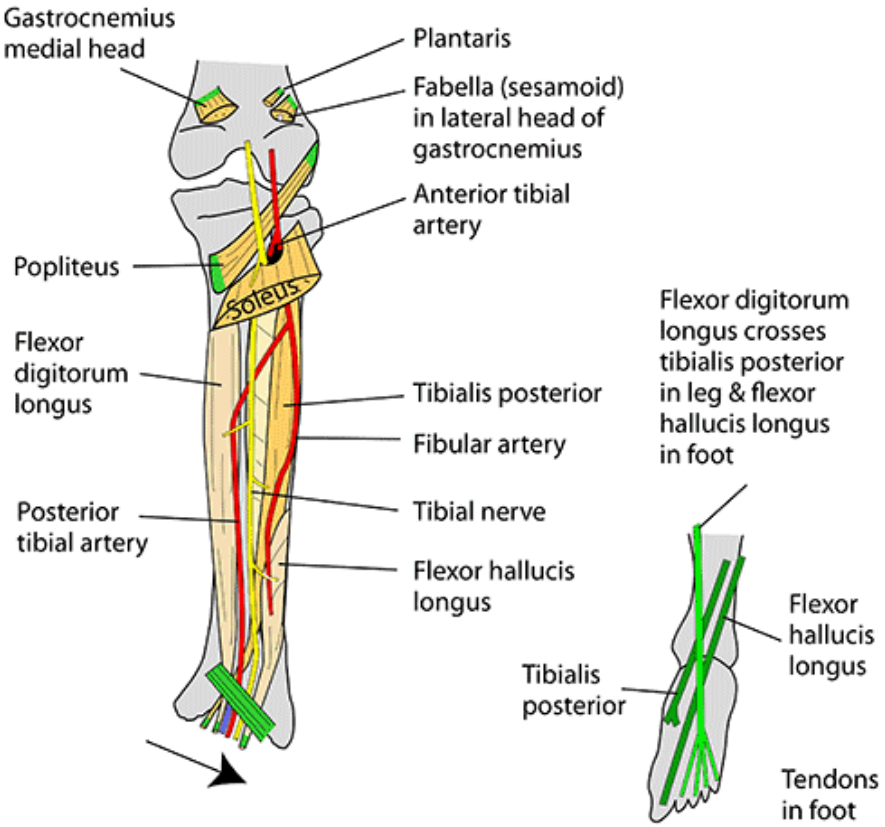


"Timothy Doth Vex All Nervous Housemaids"
or "Tom, Dick And A Very Nervous Harry"

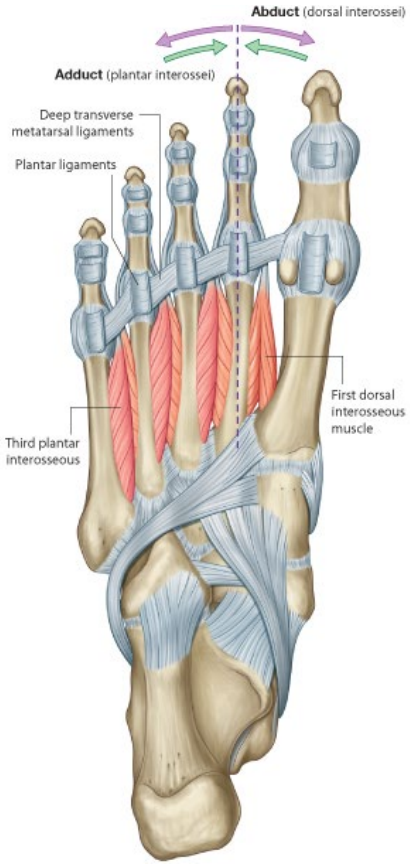
Order of structures behind medial malleolus from anterior to posterior:
Tibialis posterior, flexor digitorum longus, posterior tibial vein & artery, tibial nerve, flexor hallucis longus
Mnemonic: Timothy Doth Vex All Nervous Housemaids

Flexor retinaculum
Tip of medial malleolus to medial calcaneal process and plantar aponeurosis

POSTERIOR LOWER RIGHT LEG & TENDONS AT MEDIAL ANKLE



Order of structures behind medial malleolus as indicated by arrow:
Tibialis posterior, flexor digitorum longus, posterior tibial vein & artery, tibial nerve, flexor hallucis longus
Mnemonic: Timothy Doth Vex All Nervous Housemaids OR
Tom Dick And A Very Nervous Harry



TENDONS ON THE SOLE OF THE FOOT:

- Deepest layer:
  - **Tibialis posterior**
    - → navicular (+other bones of sole)
  - **Peroneus longus** (aka fibularis longus)
    - → medial border of foot: medial cuneiform + base of big toe metatarsal
    - Same insertion as tibialis anterior

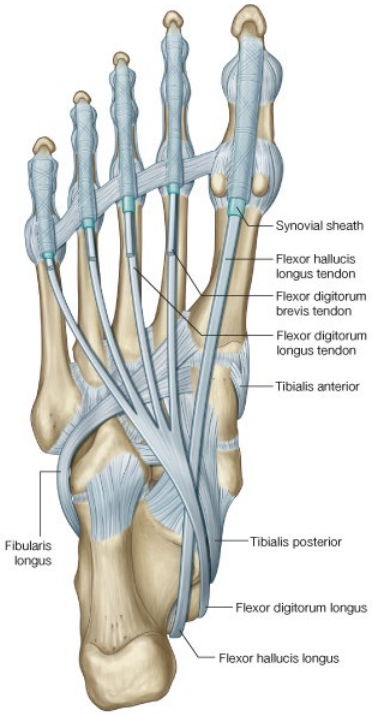
- Peroneus longus passes obliquely beneath the **long plantar ligament**

- **Interossei**
  - Arise as 2 groups (like those in the hand)
  - Insert into the extensor expansions
  - Flex the metatarsophalangeal joints

- Much less precise & important than those in the hand

Summary of ***deepest layer of sole:***

- Metatarsals + their interossei
- Tibialis posterior
- Peroneus longus
- Long plantar ligament



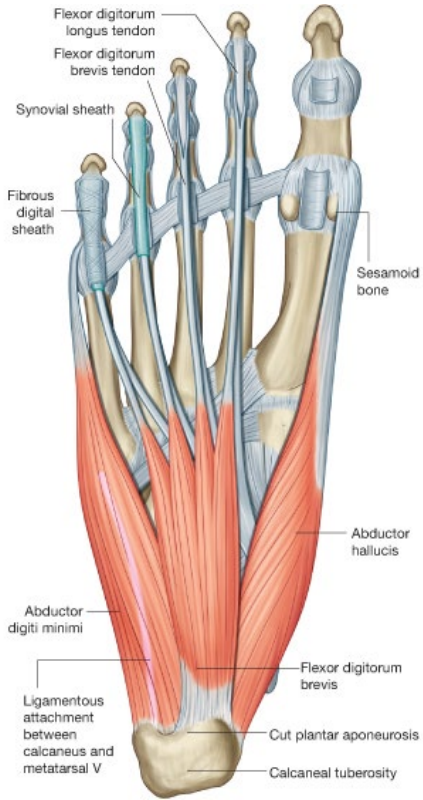
- **<u>Superficial</u>** to this deep layer on the sole of the foot is:
  - **Flexor digitorum longus (+ flexor accessorius muscle)**
  - **Flexor hallucis longus**

Small muscles form 2 further layers:

<u>Most superficial</u>

- **Abductor hallucis**
- **Abductor digiti minimi**
  - Arise from the calcaneus
  - Insert into the **proximal phalanx** of the big and little toe

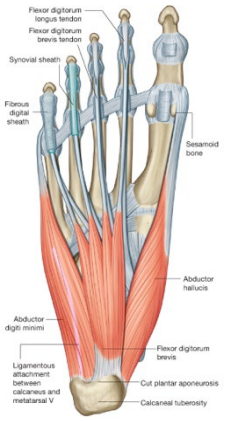
- **Flexor digitorum brevis:**
  - Between the 2 short abductors
  - Arises from calcaneus
  - Splits into 4 tendons
  - Insert into fibrous flexor sheaths of **<u>middle phalanges</u>** of <u>lateral 4 toes</u>



- Split on the middle phalanges to allow the tendon of the flexor digitorum longus to reach the terminal phalanges.

Deeper layer of small muscles:

- Short flexors of big toe & toe 5**:**
  - **Flexor hallucis brevis**
  - **Flexor digiti minimi**
  - Insert into the proximal phalanges of big toe & toe 5
- **Adductor hallicus:**
  - Akin to adductor pollicis of hand
  - Origin: **metatarsals**
  - Insertion: **proximal phalanx** of big toe



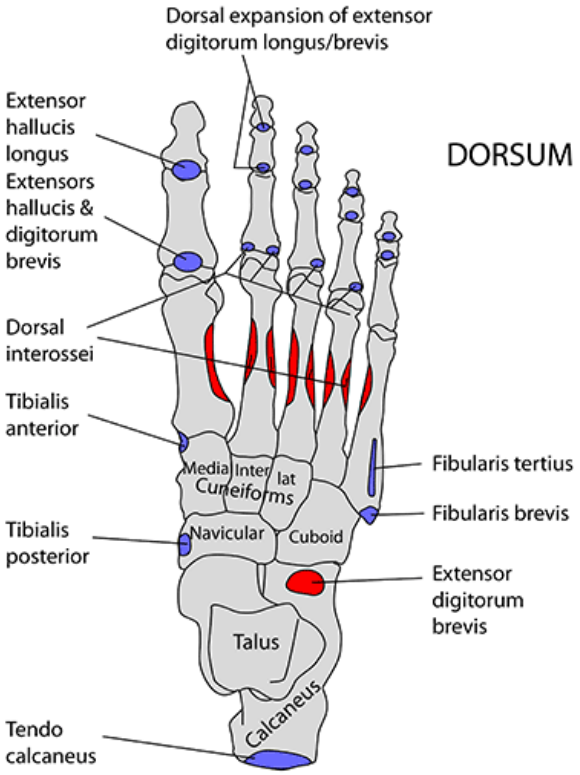
SEE SEPARATE SUMMARY SHEET FOR LAYERS OF SOLE OF FOOT

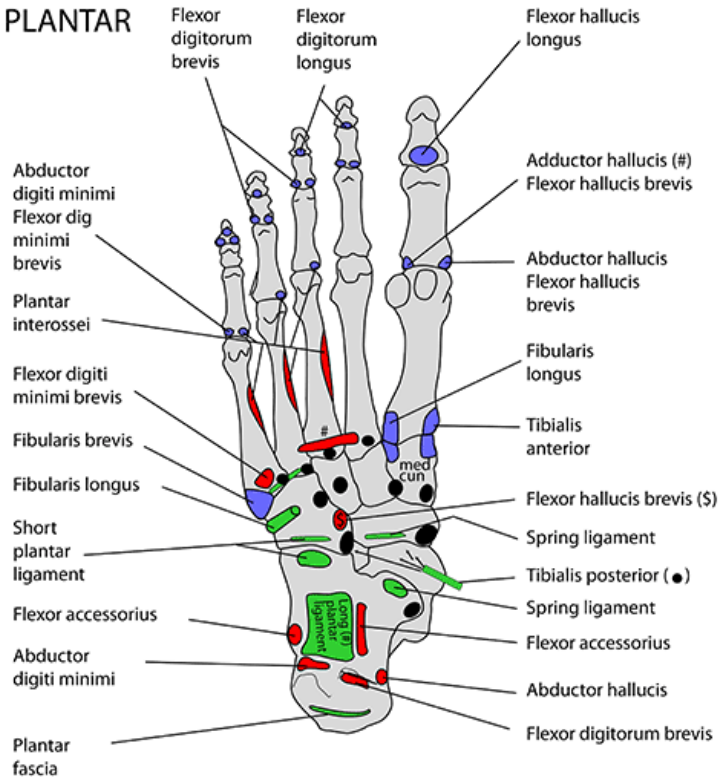
SUMMARY OF LAYERS OF THE SOLE OF FOOT

PLANTAR APONEUROSIS

LAYER 1	3 MUSCLES (AHB, ABDM, FDB)
	NEUROVASCULAR PLANE
LAYER 2	2 MUSCLES (LUMBRICALS, ACCESSORIUS) 2 TENDONS (FHL, FDL)
LAYER 3	3 MUSCLES (ADH, FHB, FDMB) 2 LIGAMENTS (SPRING, LONG PLANTAR)
LAYER 4	1 MUSCLE (INTEROSSEI) 1 LIGAMENT (SHORT PLANTAR) 3 TENDONS (FL, TP, TA)

MUSCLE ATTACHMENTS TO RIGHT FOOT





Tarsal sinus

- Between talocalcaneonavicular & talocalcanean joints
- Contains ligaments between bones
- Closed off by cervical ligament, extensor digitorum brevis, extensor retinaculum

Talus: No muscles attached, almost entirely intra-articular, neck blood supplies body (avascular necrosis with fracture likely)

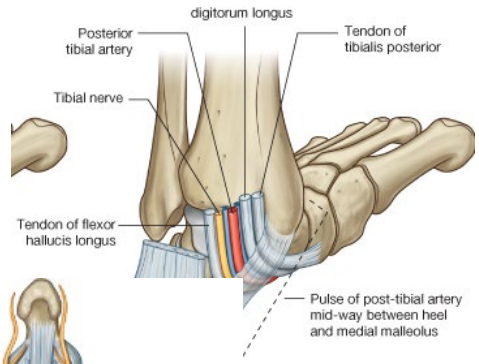
NEUROVASCULAR STRUCTURES OF LEG & SOLE OF FOOT

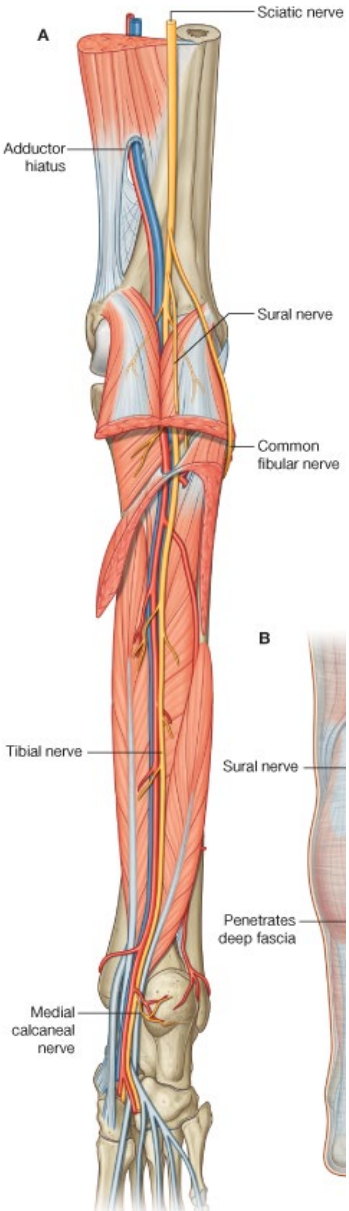
- Sciatic nerve divides in the popliteal fossa
    - Common peroneal nerve
    - Tibial nerve

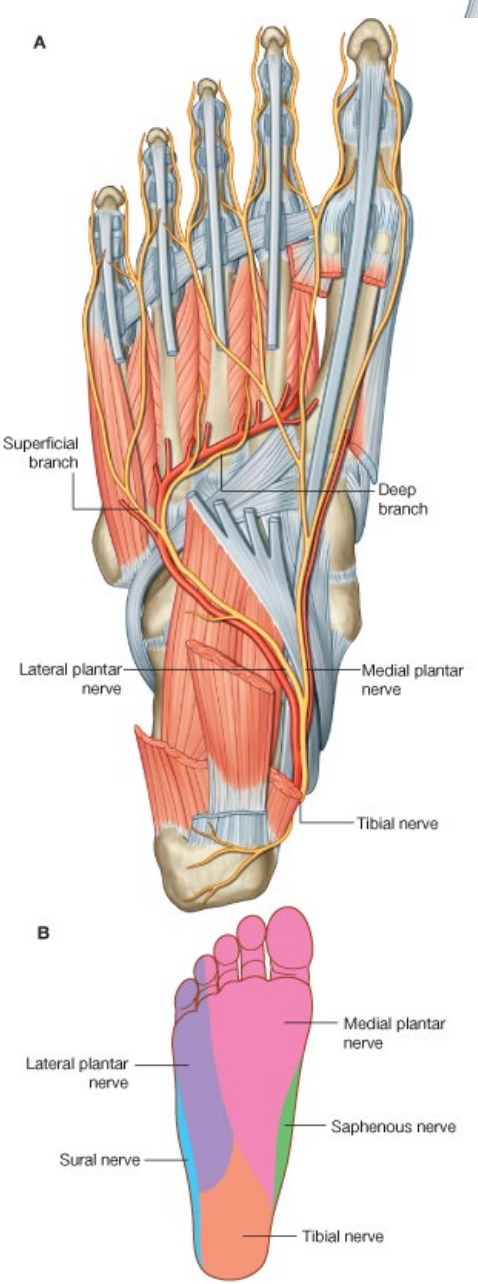
- **Tibial nerve** is responsible for the nerve supply to muscles on back of leg & sole of foot.

- Tibial nerve leaves lower angle of popliteal fossa
- Immediately passes deep to the fibrous arch formed by origin of soleus (superficial layer muscle)
- Δ lies beneath the superficial layer of muscles on the back of the leg
- Passes down the leg between the muscles of the middle stratum:
    - (tibia) Flexor digitorum longus – tibial nerve – flexor hallucis longus (fibia)
- Curls around medial malleolus at ankle, along with the tendons of these muscles (T, D, ANd H)
- Passes beneath the flexor retinaculum

- Under the flexor retinaculum, it divides into 2 terminal branches:
    - **Medial plantar nerve**
    - **Lateral plantar nerve**







- Make comparisons with the nerves of plam of hand:
    - **Medial plantar nerve** (median nerve of hand)
    - **Lateral plantar nerve** (ulnar nerve of hand)

Medial plantar nerve	Median nerve
Short muscles of big toe	Short muscles of thumb
Most medial lumbrical	Lateral 2 lumbricals
Flexor digitorum brevis	*Counterpart is 'flexor digitorum superficialis' which originates in forearm, & is supplied here.*

- The **lateral plantar nerve** is counterpart of ulnar nerve in hand
- Both divide into superficial & deep branches
- The superficial branches supply similar cutaneous segments
- The deep lateral plantar nerve supplies all the short muscles of the foot not supplied by the medial plantar nerve.

BLOOD SUPPLY TO BACK OF LEG & SOLE OF FOOT

- **Popliteal artery**
- At lower border of popliteus muscle, popliteal artery divides into 2 terminal branches:
    - **Anterior tibial artery**
    - **Posterior tibial artery**

Anterior tibial artery:

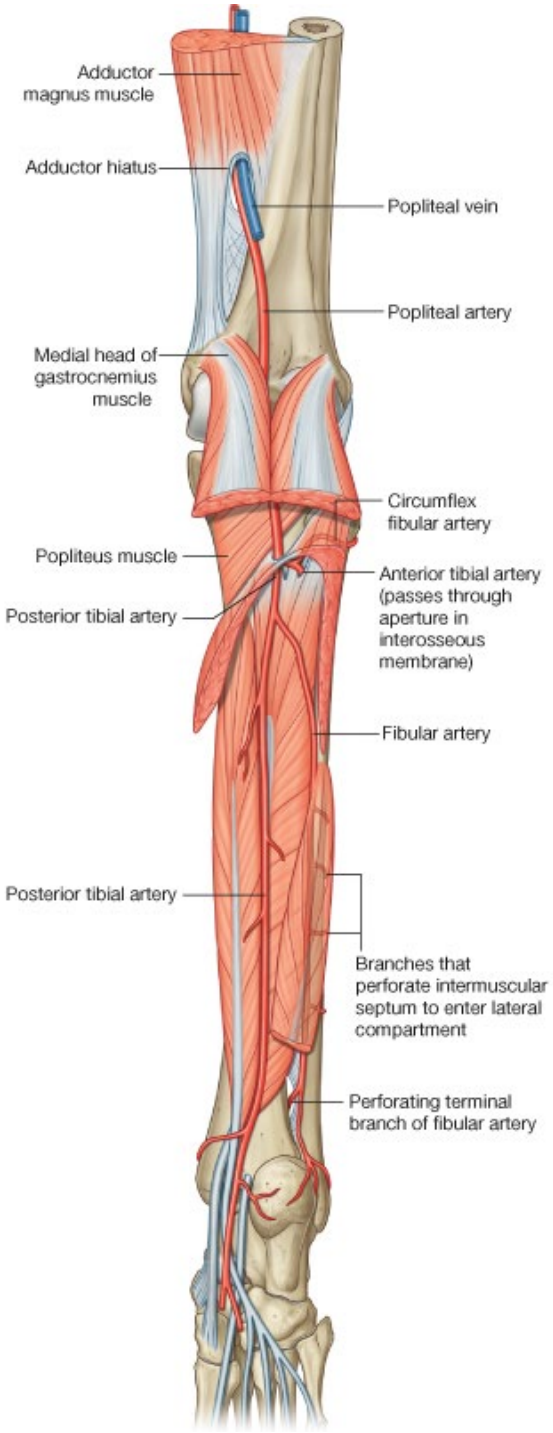
- Immediately pierces interosseous membrane
- **Supplies musculature on front of leg**

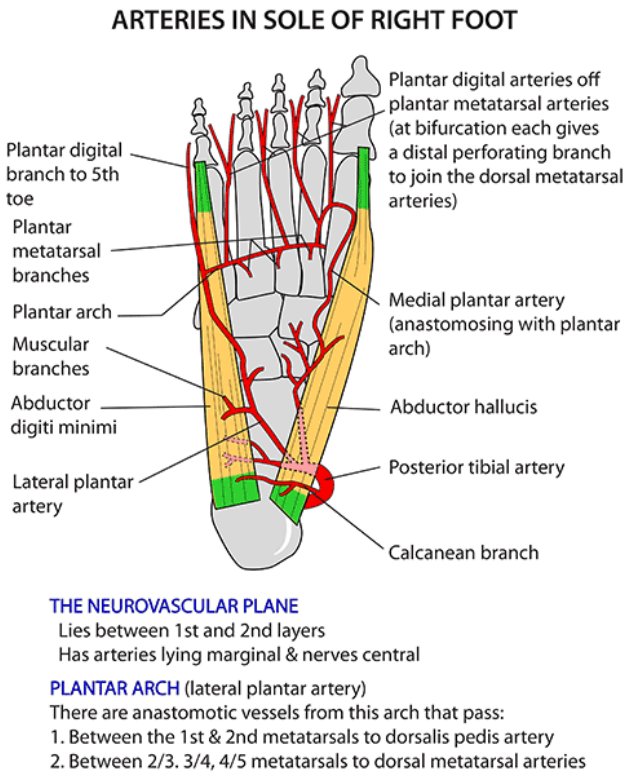
Posterior tibial artery:

- Larger – as has a greater muscle mass to supply
- Gives off **peroneal branch**
    - Passes deep to soleal bridge → lateral side of leg
    - Supplies peroneal muscles

- **Posterior tibial artery** then continues with the tibial nerve
- Deep to the flexor retinaculum it divides into:
    - **Medial plantar artery**
    - **Lateral planter artery**
- Accompany nerves of the same name (derived from tibial nerve)

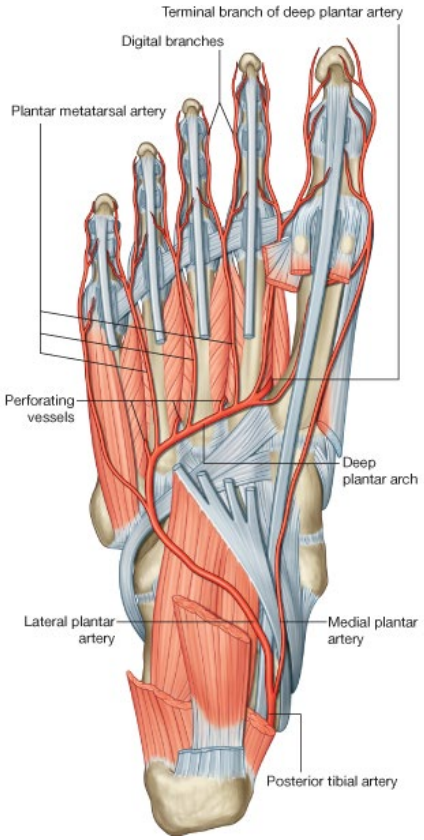
- Lateral plantar artery
    - Follows deep branch of lateral plantar nerve into depths of sole – the **plantar arch**.
- Both medial plantar arteries & lateral plantar arteries then give of metatarsal & digital vessels.





THE NEUROVASCULAR PLANE
Lies between 1st and 2nd layers
Has arteries lying marginal & nerves central

PLANTAR ARCH (lateral plantar artery)
There are anastomotic vessels from this arch that pass:
1. Between the 1st & 2nd metatarsals to dorsalis pedis artery
2. Between 2/3. 3/4, 4/5 metatarsals to dorsal metatarsal arteries



VENOUS DRAINAGE OF LOWER LIMB:

- Upright position → considerable hydrostatic pressure for venous blood to overcome.
- Venous return aided by:
  - Skeletal muscle pump
  - Valves
  - Proximity of veins to arteries – pulsation of arteries massages blood up the veins. Especially true for **venae comitantes**.

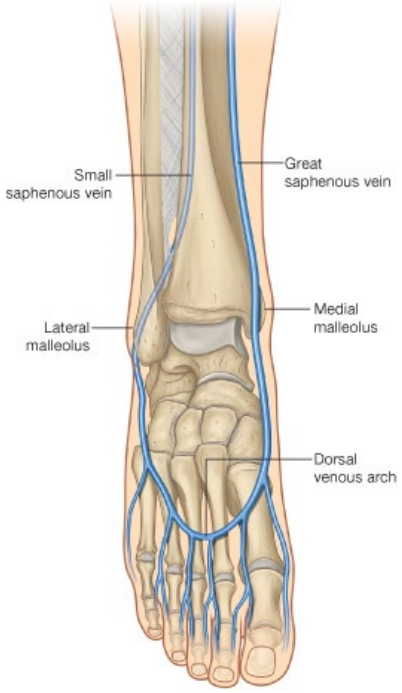
- In leg blood is drained from superficial & deep tissues.
- **Superficial veins: outside deep fascia**
- **Deep veins: inside sheath of deep fascia**

- **Deep veins**:
- Accompany (below + their branches)
  - Tibial artery
  - Popliteal artery
  - Femoral arteries
- Blood flows → **external iliac vein**
- Blood flows efficiently in the deep veins as are surrounded by muscle & pulsating arteries, & have valves.

- **Superficial veins:**
- Have no muscular surround
- Travel in subcutaneous fat, and often have no surrounding arteries.
- They *do* have valves
- Superficial veins pierce deep fascia → drain into deep veins.

- Valves at the point of perforation ensure that blood drains from superficial → deep (and not other way round).
- Superficial veins are not good at dealing with engorgement as surrounded by fat: excess blood extends them and stagnates.

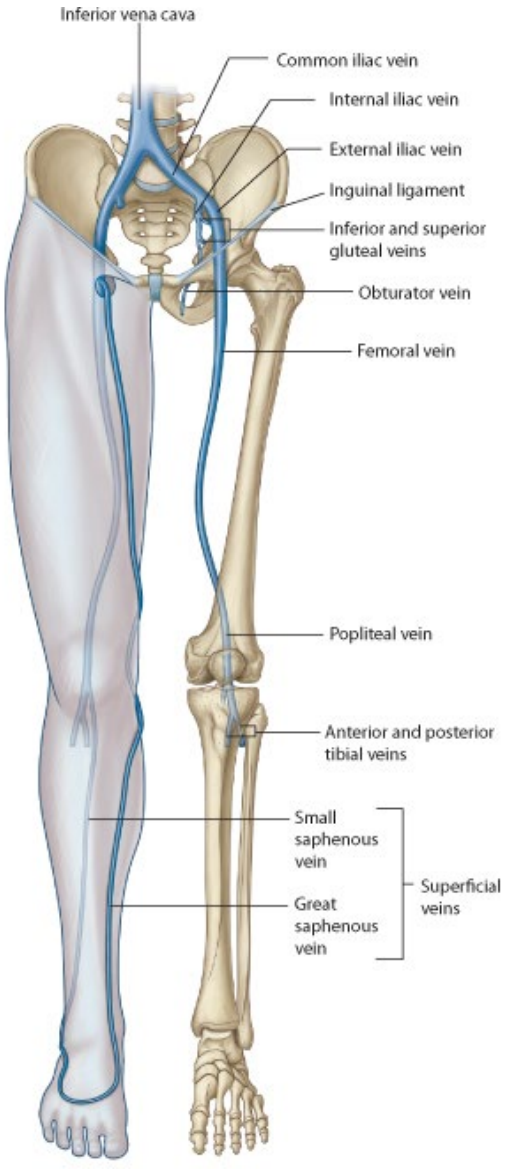
- 2 important superficial veins:
  - **Great saphenous vein**
  - **Small saphenous vein**
- Blood of the foot drains through veins between the metatarsals into **venous arch** on dorsum of foot (similar to hand).
- Why this venous arch structure?
  - Pressure on dorsum of foot when walking (& palm when gripping).
  - Venous arch between the boney struts of the foot allows pressure-free escape-route for blood.
- The venous arch runs into:
  - Medially: **great saphenous vein**
  - Laterally: **small saphenous vein**



Great saphenous vein:
- Runs up over anterior surface of medial malleolus
- Runs through subcutaneous tissue of medial side of leg
- Several important perforations to the deep veins at the level of the ankle and lower leg.

- Reers posteriorly to negotiate the knee
- → front of the thigh
- Recieves several tributaries in upper part of thigh

- Terminates just below medial end of the inguinal ligament by perforating the deep fascia through the saphenous opening.
- Surrounded by cribriform fascia as it passes through the saphenous opening.
- As with all superficial venous perforations, there is a valve as the great saphenous vein passes through the deep fascia.



Small saphenous vein:
- Lateral side of foot → lateral side of ankle → midline of back of lower leg
- Perforates deep fascia (popliteal fascia) in popliteal fossa
- Enters the **popliteal vein**.

LYMPHATIC DRAINAGE OF THE LOWER LIMB

General rule:
- **Superficial lympatics follow veins**
- **Deep lymphatics follow arteries**

Superficial lymphatics

- Most lympathics drain along **great** saphenous vein → **vertical** inguinal lymph nodes of groin

- Not much lymph drains along the small saphenous vein.

- Since lymph drains from the foot & leg → inguinal nodes, infections of the foot or lower leg lead to enlarged inguinal lymph nodes.

Deep lymphatics of lower limb:

- Follow arteries & drain into deep inguinal LNs
- Drain through lymph vessels in the **femoral canal** → abdominal cavity.
- → lymph vessels surrounding external iliac artery → surrounding aorta → thoracic duct

LYMPH NODES IN FEMORAL TRIANGLE

- LNs in femoral triangle are important in filtering lymph from lower limb.
- Arranged in **superficial and deep groups.**

- **Superficial inguinal LNs:**
- Arranged like letter 'T'
- **Horizontal**: subcutaneous fat below inguinal ligament – receives lymph from lower abdominal wall, back and perineum.
- **Vertical**: around great saphenous vein – receives lymph from the lower leg & foot which travels up superficial lymphatics with the great sapenous vein.

- **Deep inguinal LNs:**
- Efferents from superficial inguinal LNs pass through the cribriform fascia into the deep inguinal LNs.
- Deep LNs surround the upper end of the femoral vein
- One node is consistantly found in the femoral canal (medial to femoral vein in the femoral sheath).

APPLIED ANATOMY OF THE ANKLE & FOOT

FRACTURE OF TIBIA & FIBULA

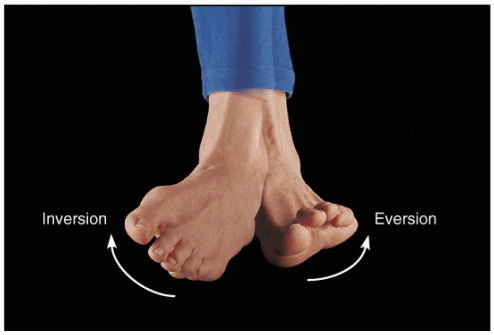
- Extremely common
- Pattern of fracture depends on force applied:
    - Car bumper hitting leg: both tib & fib fracture @ same point
    - Skiing accident (a twisting force): tib & fib fracture @ different levels.

- **Pott's fracture:** both bones are broken at the level of the malleoli

SPRAINED ANKLE

- V. common
- Usually forced inversion
- Lateral ligament of ankle joint is partially/completely torn.

- Lateral ligament consists of 3 bands
- The bands usually damaged are the:
    - Anterior band: talofibular
    - Middle band: calcaneofibular
- The posterior band of the ligament ruptures only in severe injury.



MUSCLE / TENDON DAMAGE:

- **Plantaris tendon** can rupture spontaneously:
    - → severe pain in the calf.

- **Tendo calcaneus (achilles tendon)** can also partially/completely rupture

- **Poliomyelitis**: often affects the <u>dorsiflexors</u> & <u>evertors</u> of the leg.
    - Less common nowadays due to polio vaccine

PROBLEMS WITH NERVES:

- **Pressure on common peroneal nerve → paralysis of muscles** supplied by this nerve.
- Problem spot is where common peroneal nerve lies <u>superficially on neck of femur</u>.
    - Bad positioning of patient on operating table
    - Tight plaster of paris / torniquet

Foot drop:

- Permanent damage to <u>common peroneal nerve</u> as it winds around head of the fibula → **<u>foot drop</u>**; inability to <u>evert</u> or <u>dorsiflex</u> the foot.
- Patient must walk with high step, so toes don't hit floor first & trip patient up.

VASCULAR SUPPLY TO THE FOOT:

- **Impaired blood supply** to lower limb →
    - Changes in skin
    - Pain in muscles on walking
    - Gangrene (death of tissue)
- Should therefore be able to palpate normal pulses in:
    - Femoral artery
    - Popliteal artery
    - Dorsalis pedis
    - Posterior tibial artery

- Blockage is often high in aorta / iliacs
- But sometimes localised to leg arteries; these blockages can be removed / bypassed.

Varicose veins

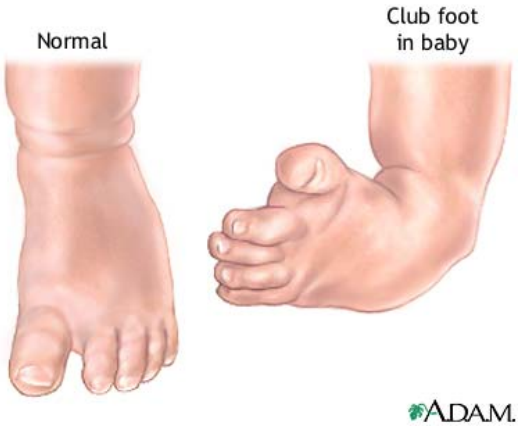
- Abnormally dilated veins in the leg
- Due to loss of function of valves in the perforators (superficial veins → deep veins through deep fascia):
    - At level of ankle
    - At perforating terminations of great & small saphenous veins
- → accumilation of blood in the superficial veins
- → dilation of superficial veins
- Blood supply to skin & subcutaneous tissues suffers.

- Varicose veins of perforators on medial side of ankle →
    - Skin discolouration
    - Ulcers

CONGENITAL ABNORMALITIES

Club foot (talipes equinovarus):

- Baby's foot is:
    - **Plantarflexed** (toes point downwards)
    - **Adducted**
    - **Inverted**
- Special names for congenital deformities:
    - Abnormal plantarflexion: **equinis**
    - Abnormal adduction towards midline: **varus**



- Generic name for an abnormal ankle position: **talipes**

- Δ 'club foot' = **<u>talipes equinovarus</u>**

- Many congenital abnormalities at the time of birth lie in the <u>soft tissues</u> and so can be corrected by manipulation.
- BUT if they are neglected, the <u>bones ossify in the abnormal shape</u> & <u>ligaments & capsules contract further</u> → more drastic surgery needed.
- The same is true for **congenital dislocation of the hip**.