

LAB 19: POSTERIOR LEG AND PLANTAR FOOT

GOALS

1. Identify the small saphenous vein and the sural nerve.
2. Dissect and identify muscles, nerves, and vessels in the posterior compartment of the leg.
3. Dissect and identify muscles, nerves, and vessels on the sole of the foot.
4. Clean and identify the contents of the tarsal tunnel.

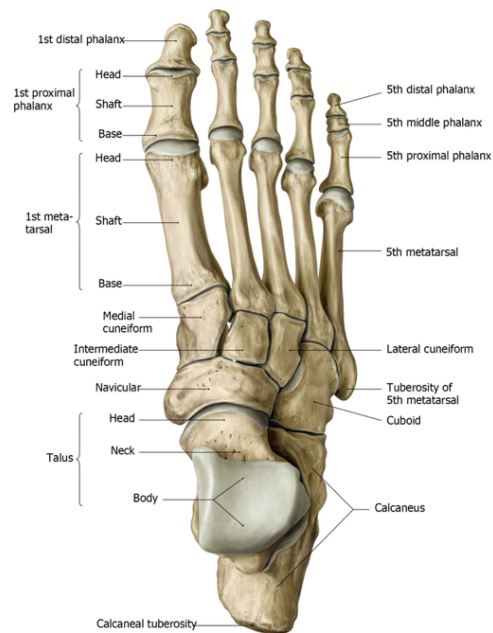
OSTEOLOGY



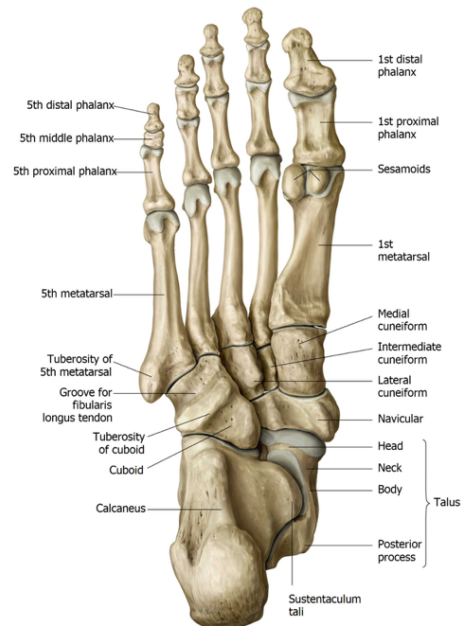
COMPLETE ANATOMY

Osteology of the foot

Review the bony landmarks of the tibia, fibula, and bones of the foot.



Gilroy, Atlas of Anatomy, 3rd ed., Fig. 33.2 A. Illustrator: Wesker/Voll, ©2021 Thieme Medical Publishers, Inc. All Rights Reserved.



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Figure 1. Bones of the foot: Right foot, dorsal (superior) view. Figure 2. Bones of the foot: Right foot, plantar (inferior) view.

POSTERIOR COMPARTMENT OF THE LEG



Let's divide up the work in this lab. Turn over the detached limb in your donor and have 2 members of your group work on the posterior side of the leg (calf region)—we will only dissect the posterior leg on one side of the body. The other members of the group should start work on the dissection of the plantar surface of the foot on the attached limb. Use a plastic block to elevate the foot.



COMPLETE ANATOMY

Superficial muscles of the posterior leg



Remove the skin from the posterior leg.

Make a **shallow** incision down the midline of the calf to the Achilles tendon. Don't cut too deep to avoid damage to the **small saphenous vein** and **sural nerve**. Then make two horizontal cuts around the ankle below the malleoli. Reflect the skin of the calf in two flaps. Continue reflecting the skin flaps all the way around the leg, so that you can completely remove the skin of the leg. Leave the detached skin flaps in your donor's bag.

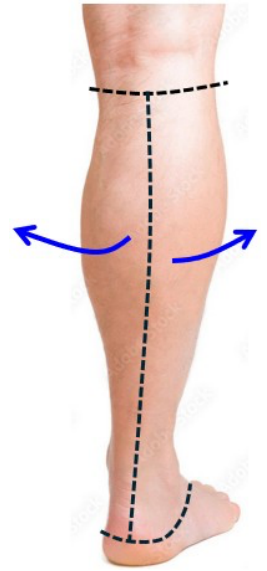


Figure 3.

Clean away the superficial fascia, but keep an eye out for these superficial structures (from medial to lateral): **saphenous nerve**, **small saphenous vein**, and **sural nerve**.

The **sural nerve** is a sensory nerve to the calf and heel. It is formed by contributions from both the common fibular and tibial nerves (the **lateral and medial sural cutaneous nerves**, respectively). Once it is formed, it travels down the center of the calf with its companion—the **small saphenous vein**.

The sural nerve and saphenous nerve together supply the skin of the calf. The sural nerve also supplies the lateral side of the heel—the territory innervated by the S-1 dermatome.

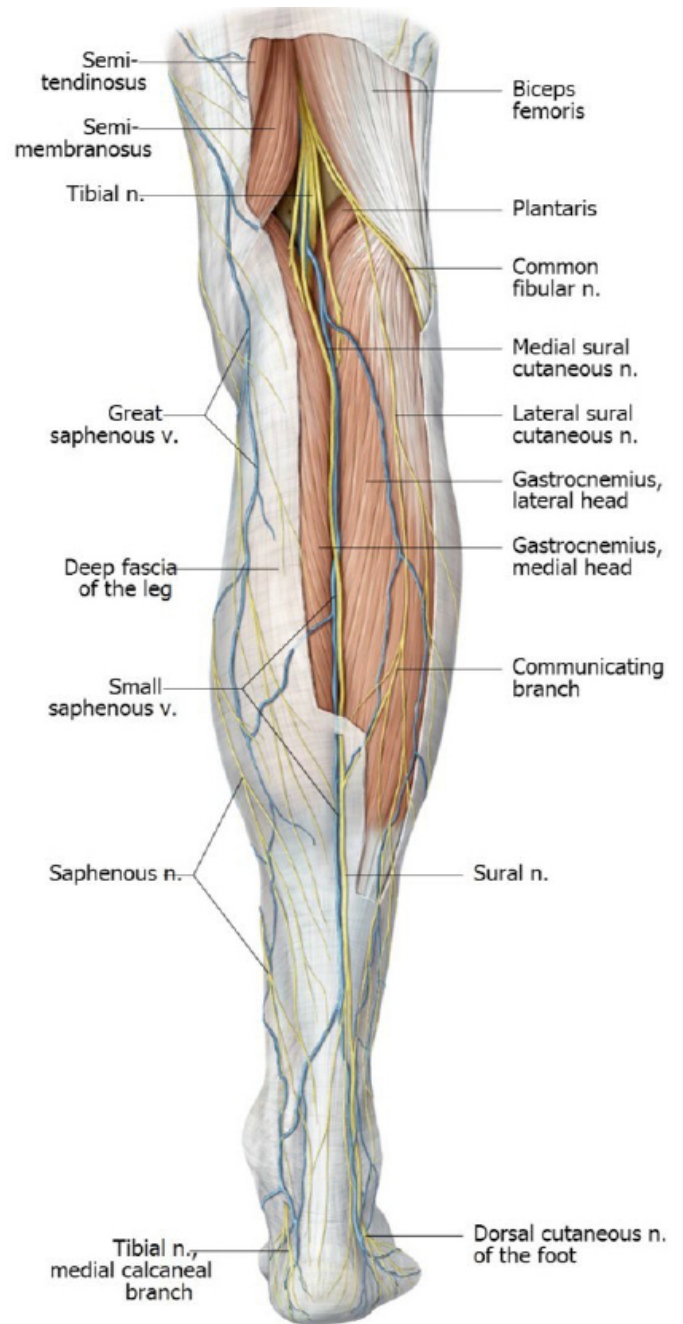


Figure 4.



After you have identified structures within the superficial fascia, remove the crural fascia to reveal the gastrocnemius muscle.

The gastrocnemius arises via two heads from the posterior surfaces of the medial and lateral condyles of the femur. Distally the two heads fuse. ***Since the gastrocnemius crosses two joints—it acts upon both. It is a weak flexor of the knee—its prime function is plantar flexion of the foot at the ankle.***

Use blunt dissection to separate the **gastrocnemius** and underlying **soleus muscles**.

The gastrocnemius and soleus fuse distally and insert together on to the **tuberosity of the calcaneus** via the **Achilles (calcaneal) tendon**.

Because the soleus distally is wider than the gastrocnemius, it can be seen and palpated both medial and lateral to the tapering distal part of the gastroc.

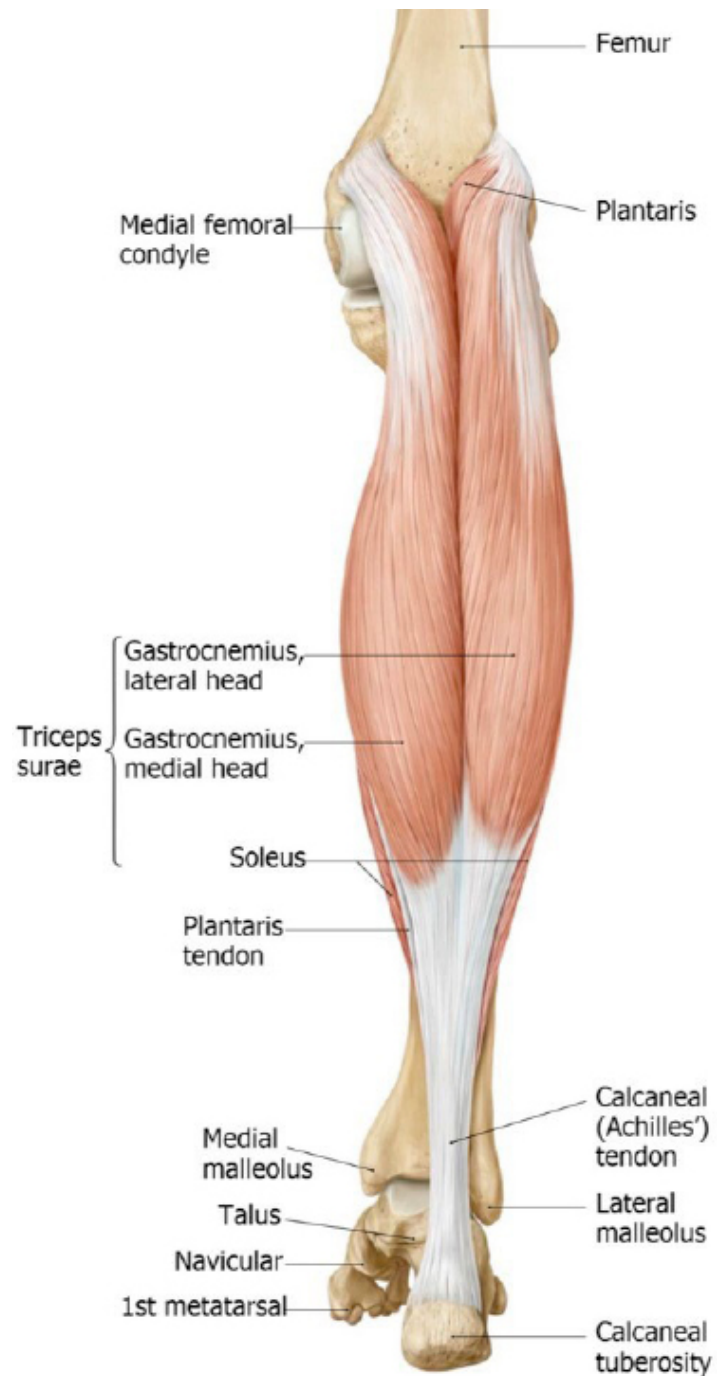


Figure 5.



Transect the two heads of the gastrocnemius.

Make a transverse cut a few centimeters below the origin of the two heads of the gastrocnemius and reflect them distally.

Identify the **soleus muscle**. The name comes from the Latin word for *sandal*. The fish called a “sole” is an odd-shaped, flattened fish which the muscle resembles.



Figure 6.

The soleus arises proximally from both the fibula and tibia. Between these two origins a tendinous arch is formed—under which the tibial nerve and artery travel.

Between the gastrocnemius and soleus you may be able to identify what looks like a skinny nerve in between them (it is actually the tendon of the **plantaris muscle**!).

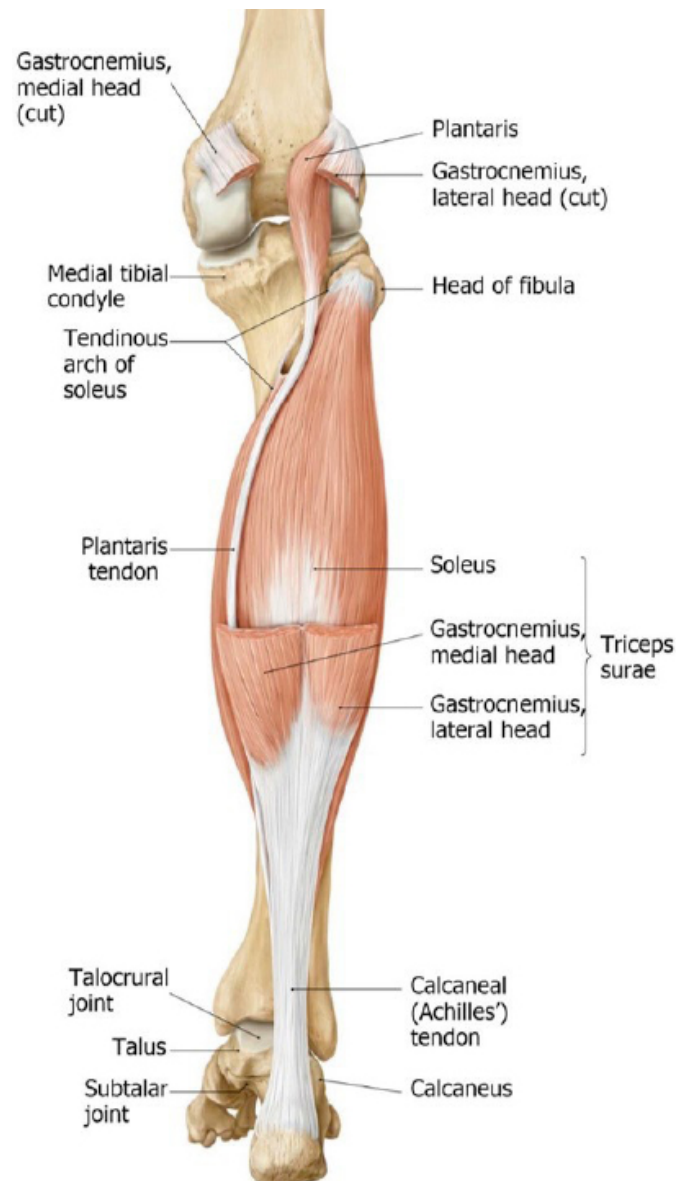


Figure 7.

NOTE



The plantaris muscle is often called the “freshman’s nerve” because first-year students may mistake it for a nerve. Don’t be that student! 😊

The plantaris arises proximally from the lateral condyle of the femur. Distally it attaches to the calcaneus separately— although sometimes it fuses to the Achilles tendon. See Figure 7.

The gastrocnemius, soleus, and plantaris together occupy the superficial portion of the posterior compartment of the leg. The deep portion of this compartment will be dissected next.



Detach the soleus from its proximal attachment to the tibia along the soleal line.



Take care to preserve the tibial nerve and popliteal artery where they pass beneath the arch of the soleus muscle! Also note that this location is a common entrapment point clinically.

Reflect the soleus laterally, using its attachment to the fibula like a hinge.

You should now see the **transverse intermuscular septum** that separates the **superficial and deep parts of the posterior compartment**. The tibial nerve and posterior tibial vessels run with-
in this transverse intermuscular septum.

Now on to the muscles in the deep part of the posterior compartment of the leg:

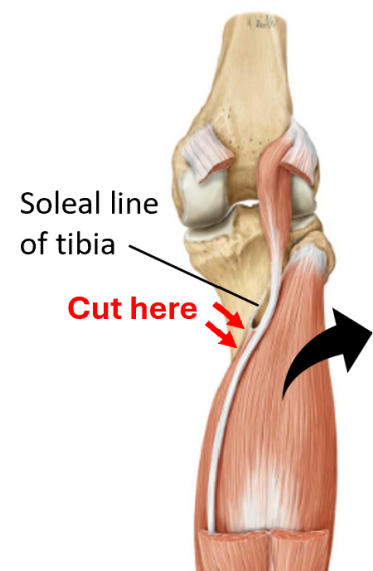


Figure 8.



COMPLETE ANATOMY

Deep posterior muscles of the leg

Clean and identify the flat **popliteus muscle**, located proximal to the attachments of the soleus, below the capsule of the knee joint in the floor of the popliteal fossa. Recall that the popliteus muscle contracts to “unlock” the fully extended knee when it is in the close pack position, so that the leg can be flexed at the knee joint.



Use blunt dissection to separate and identify the remaining three muscles in this deep part of the posterior compartment:

- **Flexor hallucis longus:** Lateral—on the fibula, it has a characteristic “bipennate” appearance, resembling a feather.
- **Flexor digitorum longus:** Medial, on the tibia
- **Tibialis posterior:** In the middle and very deep, partially hidden by the other two muscles

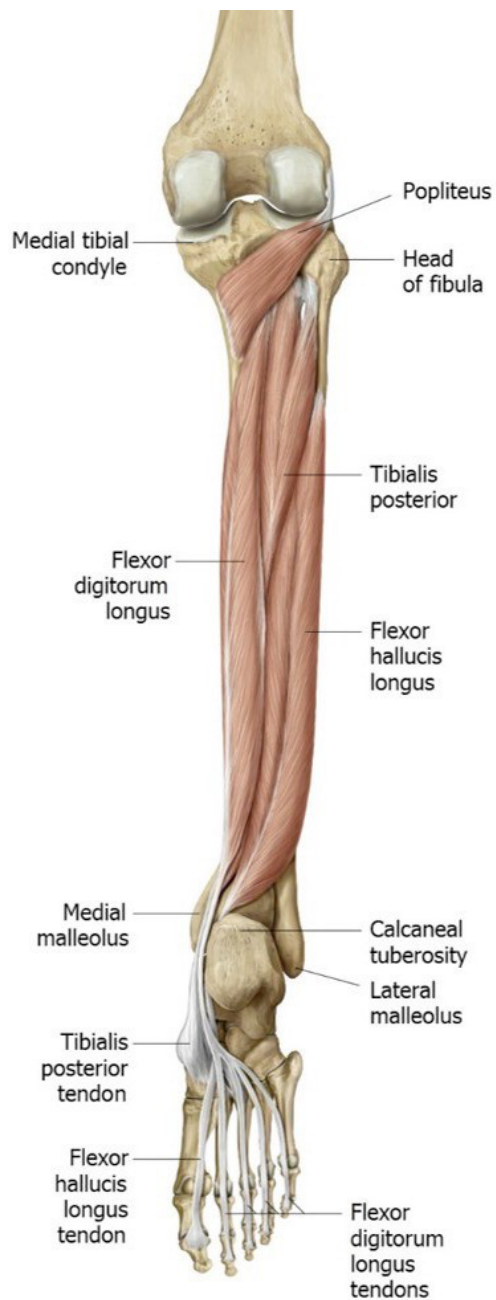


Figure 9.

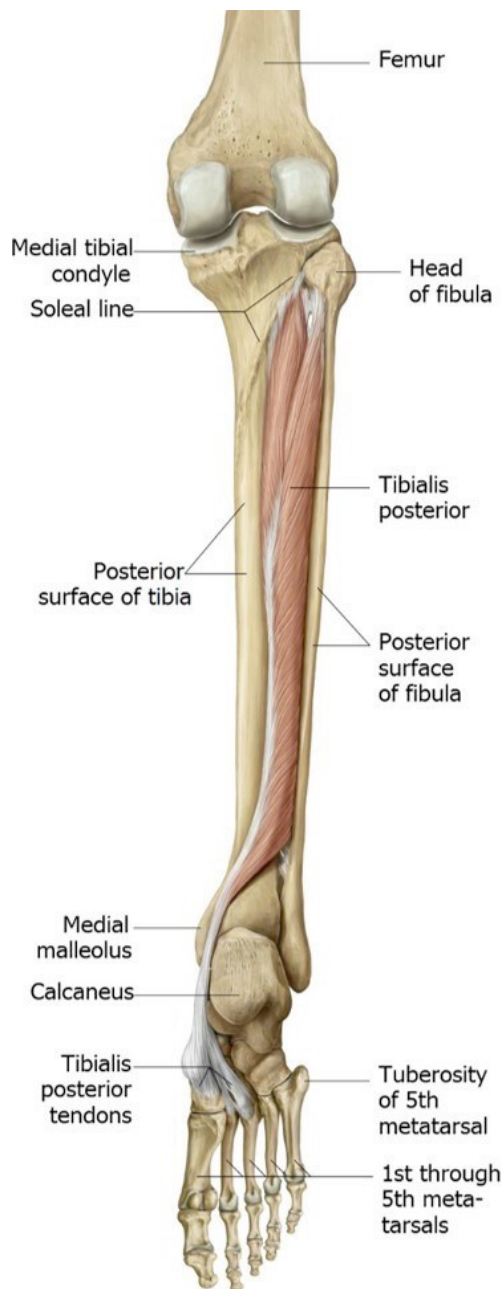


Figure 10.



Clean and identify the nerves and arteries of the posterior leg.



COMPLETE ANATOMY

Structures of the posterior leg

Return to the popliteal fossa and re-identify the **popliteal artery**. Clean and trace it inferiorly—it will terminate by bifurcating at the inferior border of the popliteus into the anterior and posterior tibial arteries.

- The **anterior tibial artery** passes through a gap in the interosseous membrane to enter the anterior compartment of the leg.
- Identify the **posterior tibial artery** coursing with the tibial nerve.

Trace the posterior tibial artery inferiorly. Identify the **fibular artery** branching from it and traveling inferiorly between tibialis posterior and the flexor hallucis longus. The fibular artery is the deep artery of the leg . . . it is the counterpart of the interosseous artery of the forearm.

Note that the **posterior tibial artery and veins** and the **tibial nerve** both enter the sole of the foot by passing through the **tarsal tunnel** posterior to the **medial malleolus**. The tendons of the three muscles in the deep layer of the posterior compartment also pass through the tarsal tunnel.

Identify the **flexor retinaculum**, a transversely-oriented fascial thickening extending posteriorly from the **medial malleolus**—it functions to hold down the tendons of the three muscles in the deep layer of the posterior compartment, so that they are close to the ankle joint and function effectively without “bowstringing.”

The **flexor retinaculum** is the roof of the **tarsal tunnel**. Compression of the neurovasculature in the tarsal tunnel can cause numbness in the foot and is called **tarsal tunnel syndrome**.

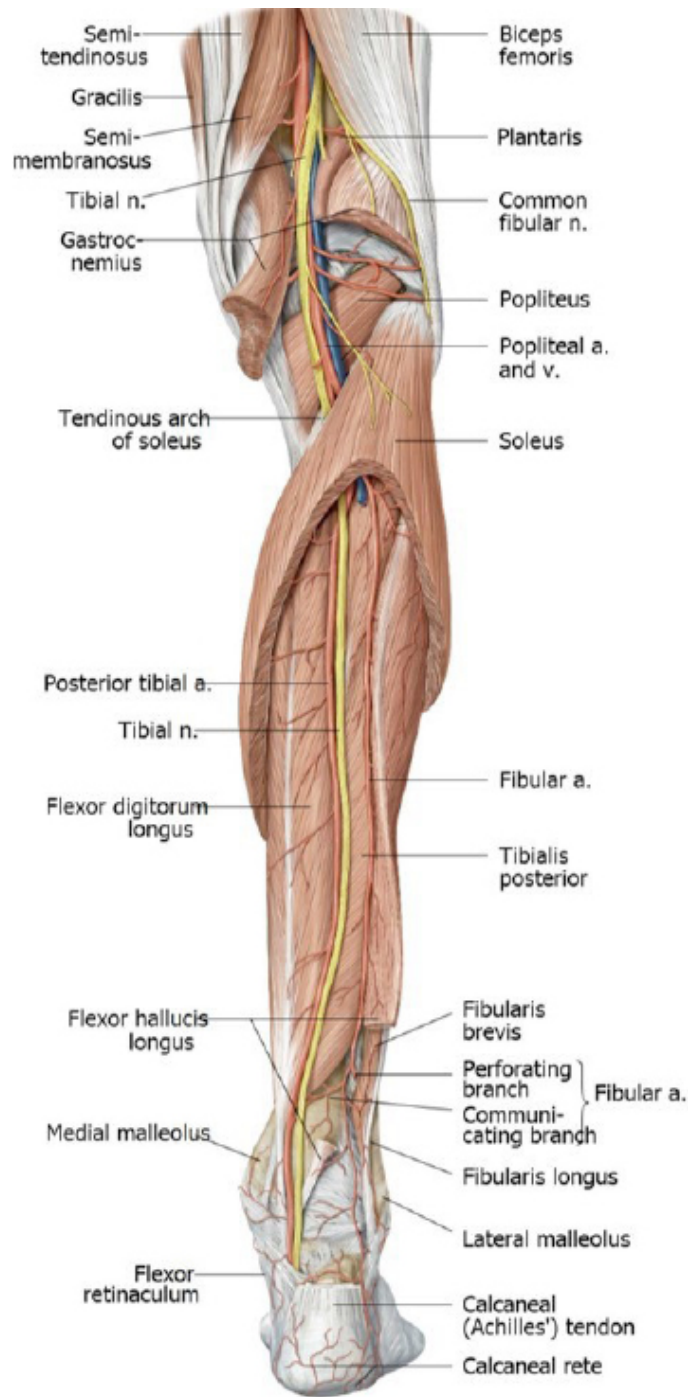


Figure 11.

QUESTION

The order of the structures as they course posterior to the medial malleolus in the tarsal tunnel, from anterior to posterior can be recalled using this mnemonic: **T**om **D**ick **A**nd **V**ery **N**ervous **H**arry.

Can you figure out what the first letters of these words refer to?



COMPLETE ANATOMY

Tarsal tunnel



Open the tarsal tunnel.

Use scissors to cut the flexor retinaculum, and the open/close scissor technique to separate the structures found in the connective tissue below the retinaculum.

Identify the following structures passing into the plantar surface of the foot posterior to the malleolus (in the **tarsal tunnel**), from anterior to posterior:

- tendon of **tibialis posterior**
- tendon of **flexor digitorum longus**
- posterior **tibial artery**
- posterior tibial veins
- **tibial nerve**
- tendon of **flexor hallucis longus**

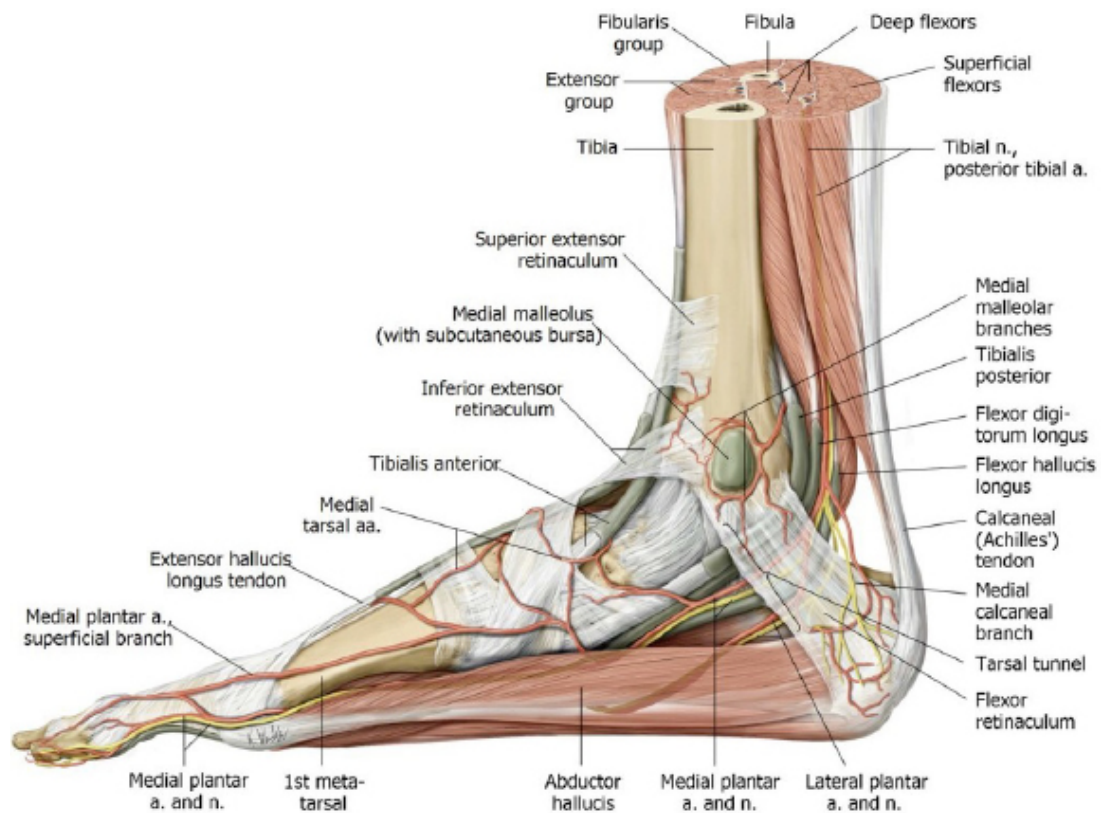


Figure 12.

CLINICAL CORRELATION



The pulse of the posterior tibial artery can be obtained behind the medial malleolus, as the posterior tibial artery is entering the tarsal tunnel.

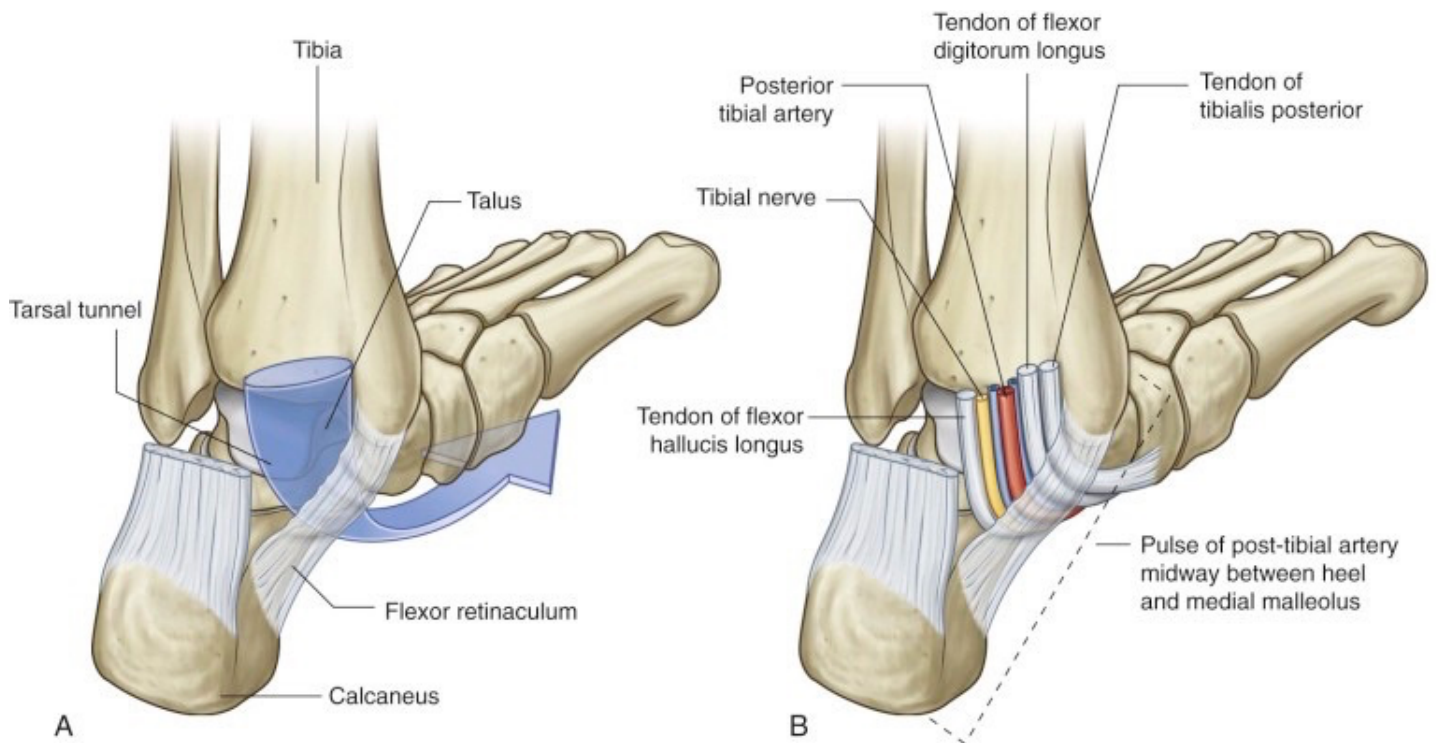


Figure 13. The tarsal tunnel is the gateway to the sole of the foot from the leg.

SOLE OF THE FOOT



Both sides: Remove the skin from both feet of your donor.

One foot will be the superficial dissection—the other, the deep.

With a sharp scalpel blade and scissors, remove the skin and superficial fascia from the sole of BOTH feet. This is tough going, because the superficial fascia here is odd in that it is firmly attached to the overlying skin and to the underlying deep fascia—it doesn't slide and glide over the deep fascia as it does in other regions of the body. The skin here is also quite thick, as you would expect.

It will be difficult to remove the skin from the sole of the foot in one or two flaps. Make shallow incisions with your scalpel blade from the center of the heel to the middle toe, then another incision perpendicular to this cut, across the mid foot. Remove the skin in four flaps if possible.



Figure 14.

The deep fascia on the sole of the foot is the plantar fascia. The thickened central portion of the plantar fascia is the **plantar aponeurosis**. Like the palmar aponeurosis in the hand, this is a thick, shiny protective layer in the center of the plantar foot.

There is a thick fat pad over the heel on the plantar foot. You will need to remove this fat to get a good look at the plantar aponeurosis.

Proximally, the plantar aponeurosis attaches to a bony tubercle on the medial side of the calcaneus. Distally, it sends thick, fibrous bands onto the plantar surfaces of all the toes. The plantar aponeurosis protects the sole of the foot, but it also is important as a rigid bowstring that absorbs and dissipates shock across the foot and helps maintain the arches of the foot.

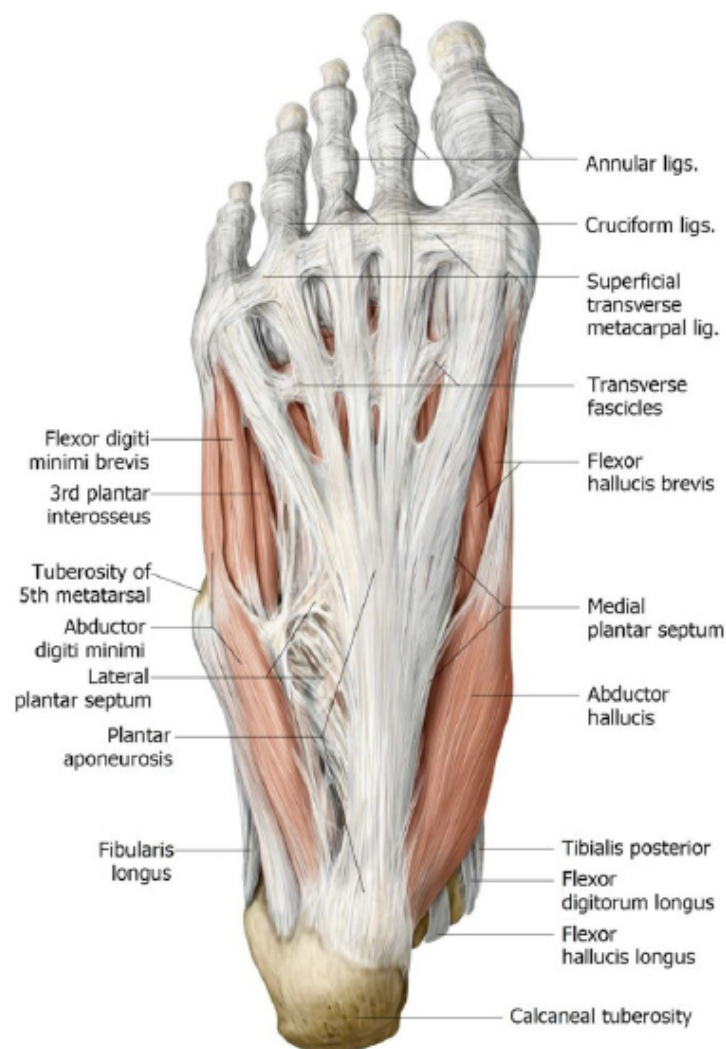


Figure 15.

CLINICAL CORRELATION



Irritation and inflammation of the plantar aponeurosis—possibly due to repetitive microtears—is **plantar fasciitis**. This usually occurs near the heel where the plantar aponeurosis attaches to the medial tubercle of the calcaneus. It is very common—there are estimates that up to 10% of the U.S. population may experience bouts of plantar fasciitis.



Both sides: Reflect the plantar aponeurosis.

Transect the plantar aponeurosis just proximal to the toes—near the metatarsophalangeal joints. Carefully reflect the plantar aponeurosis proximally, leaving it attached to the calcaneus.

Make sure you remove the skin from the plantar surfaces of the toes—especially the big toe. We will want to trace tendons onto the toes.



Figure 16.

IMPORTANT NOTE



In the palm of the hand, the palmar aponeurosis was fairly easy to remove—it covered the long flexor tendons from the forearm as they passed through the palm to the fingers. This is not the case in the foot. Just deep to the plantar aponeurosis is an intrinsic flexor muscle of the toes = the flexor digitorum brevis. It arises from the calcaneus, but also arises from the deep surface of the plantar aponeurosis itself. If you are too aggressive in removing the aponeurosis you will damage the flexor digitorum brevis. Use a sharp scalpel or scissors to carefully trim away the aponeurosis from the underlying flexor digitorum brevis.

Our goal in this deep dissection is to identify the intrinsic muscles on the sole of the foot. These are best studied by arranging them in four layers. The layers contain 3, 5, 3, and 7 muscles, respectively. 3:5:3:7.

With the plantar aponeurosis reflected, the first layer of intrinsic foot muscles is revealed. It contains three muscles, all of which attach proximally to the calcaneus.

Layer 1: [3 muscles]



COMPLETE ANATOMY

Plantar foot layer 1

Clean and identify the:

- 1 **Abductor hallucis**
- 2 **Flexor digitorum brevis** (attached to deep surface of plantar aponeurosis)
- 3 **Abductor digiti minimi**

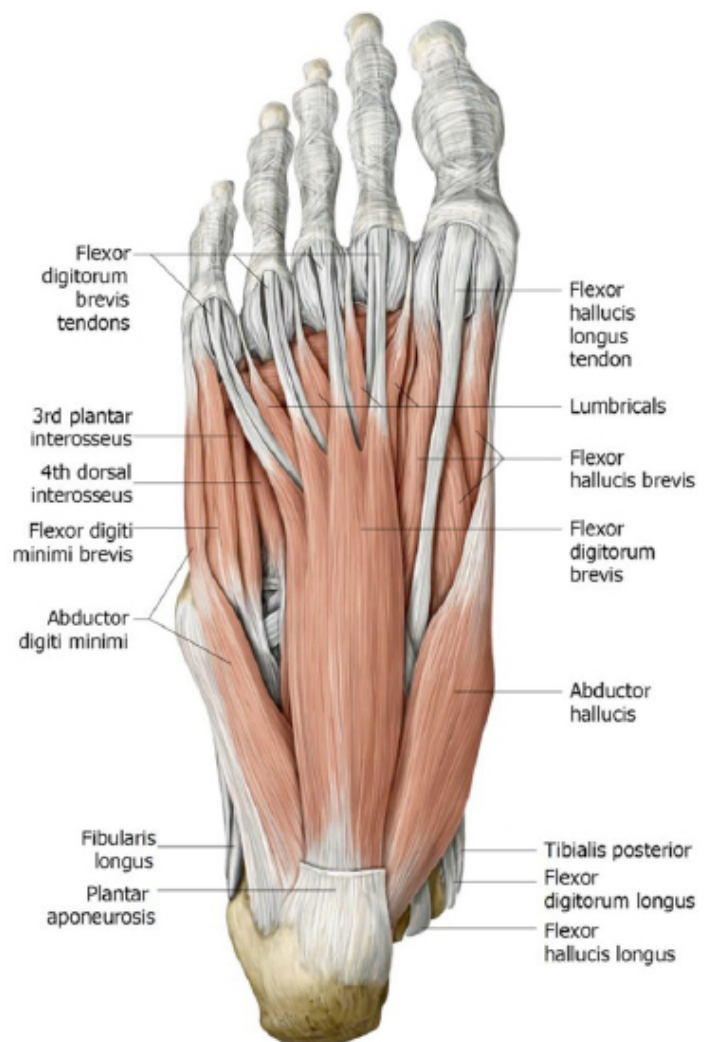


Figure 17.



Pick one side to be a deep dissection.



Deep side: Make cuts in layer 1.

The long tendons of the toe flexors (flexor digitorum longus and flexor hallucis longus), the tibial nerve, and the posterior tibial vessels enter the sole of the foot via the tarsal tunnel.

They pass just deep to the abductor hallucis muscle to reach the center of the plantar foot. To see them, we will need to transect and reflect the plantar aponeurosis, abductor hallucis, and flexor digitorum brevis.

Cut the attachment of the plantar aponeurosis to the calcaneus and remove it. Transect the flexor digitorum brevis, as shown in Figure 18.

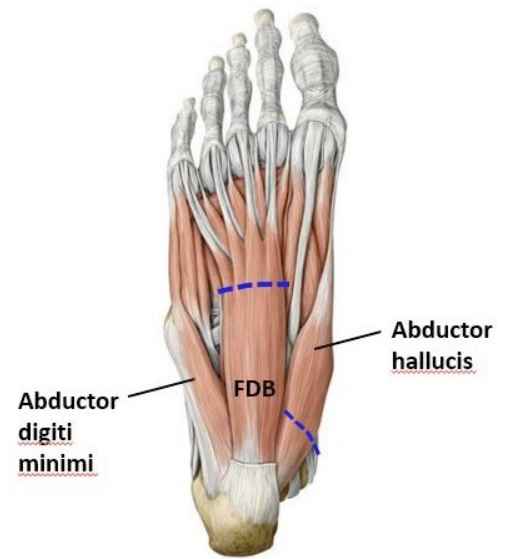


Figure 18.

Slide a metal probe under the abductor hallucis muscle (to protect structures deep to it) and transect the muscle over the probe, as shown in Figure 18. Reflect the cut edges of the muscle.

If you haven't done so already, cut the flexor retinaculum behind the medial malleolus. Open the cut retinaculum to view the contents of the tarsal tunnel. Identify the tibial nerve and posterior tibial vessels. Follow the nerve and vessels forward into the foot.

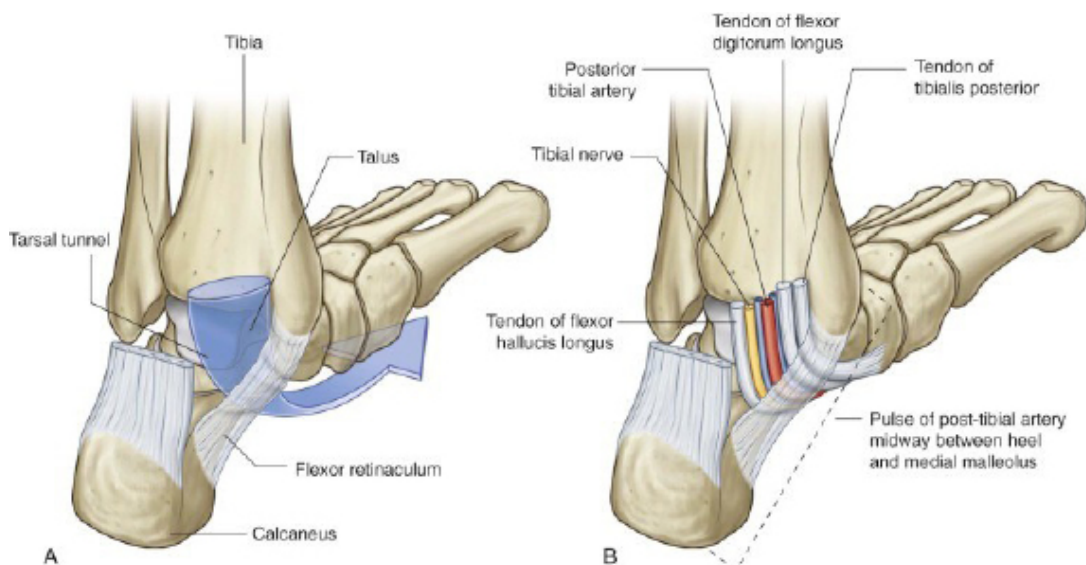


Figure 19.

The tibial nerve divides into **medial** and **lateral plantar nerves**.

- The posterior tibial vessels divide into **medial** and **lateral plantar vessels**.

The nerves and vessels of the plantar foot traverse the fascial plane just deep to the first muscle layer.

Layer 2: [5 intrinsic muscles, 2 long tendons, and a neurovascular plane]



COMPLETE ANATOMY

Plantar foot layer 2

Now you can identify the tendons of the long flexors of the toes as they pass through the plantar foot: the tendon of the **flexor digitorum longus** (“Dick”) and **flexor hallucis longus** (“Harry”).

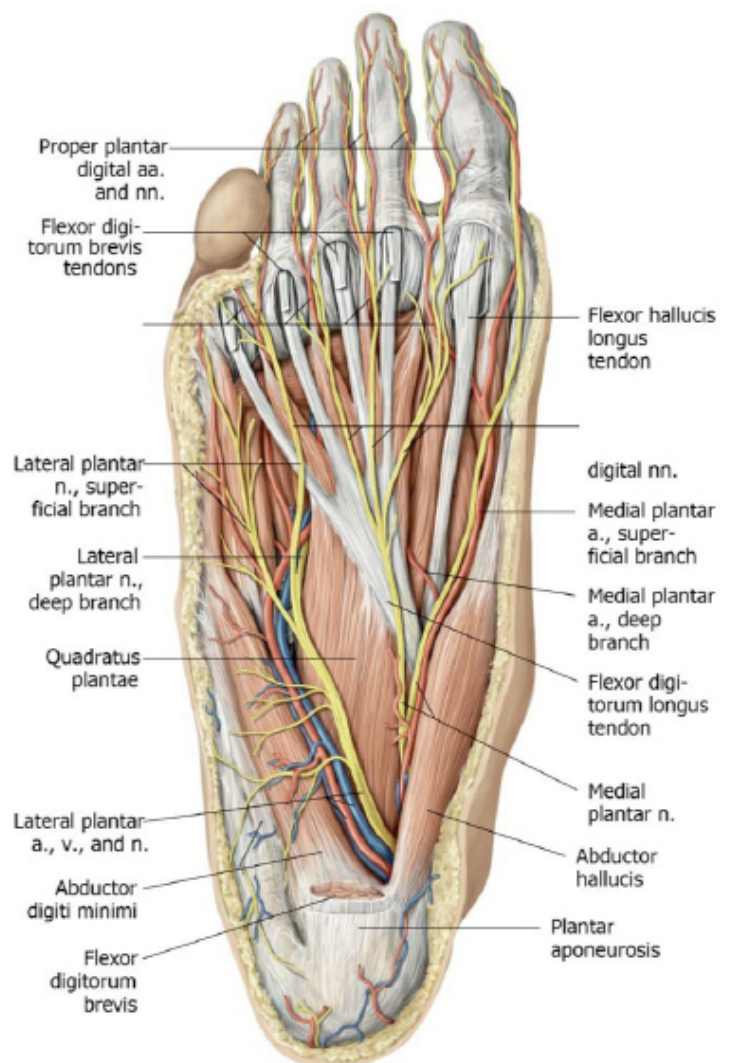


Figure 20.

In this same plane identify the 2nd layer of intrinsic muscles:

1. **Quadratus plantae** muscle: An odd muscle, attached proximally to the calcaneus and distally to the common tendon of the flexor digitorum longus (before it divides into individual tendons to the four lateral toes).

- 2, 3, 4, 5. **Lumbrical muscles** (4): Similar to the hand, these are attached proximally to the tendons of the flexor digitorum longus. They cross the metatarsophalangeal joint and insert on the dorsal surfaces of the four lateral toes (to a dorsal hood of the toes)

Notice the oblique angle of the flexor digitorum longus tendon as it passes along the plantar foot. It is thought that the role of the quadratus plantae muscle is to straighten out the tendons of the flexor digitorum longus to adjust their pull on toes 2–5 and to allow the lumbricals to do their job.

Before you leave this layer, also follow the tendon of the **tibialis posterior** through the tarsal tunnel. Distal to the tunnel, it disappears deep to the tendon of flexor hallucis longus. Tibialis posterior has broad and complicated distal attachments to the plantar surfaces of the navicular, cuneiform, and metatarsal bones. Tibialis posterior plantarflexes and inverts the foot—it is also very important in maintaining the medial longitudinal arch of the foot.

MORE ON NERVES AND VESSELS

Carefully clean the **medial and lateral plantar nerves** (and **vessels**). Let's compare them to nerves in the hand.

The medial plantar nerve is the equivalent of the median nerve in the hand. It sends motor branches to the muscles that move the big toe (as the median nerve does for the thumb) = the abductor hallucis and the flexor hallucis brevis. It also sends sensory branches to the plantar skin of the first 3 and ½ digits (toes).

The medial plantar nerve also innervates the flexor digitorum brevis muscle. This may not seem that obvious, but this muscle is the equivalent of the flexor digitorum superficialis in the forearm—recall that the FDS in the upper limb was innervated by the median nerve.

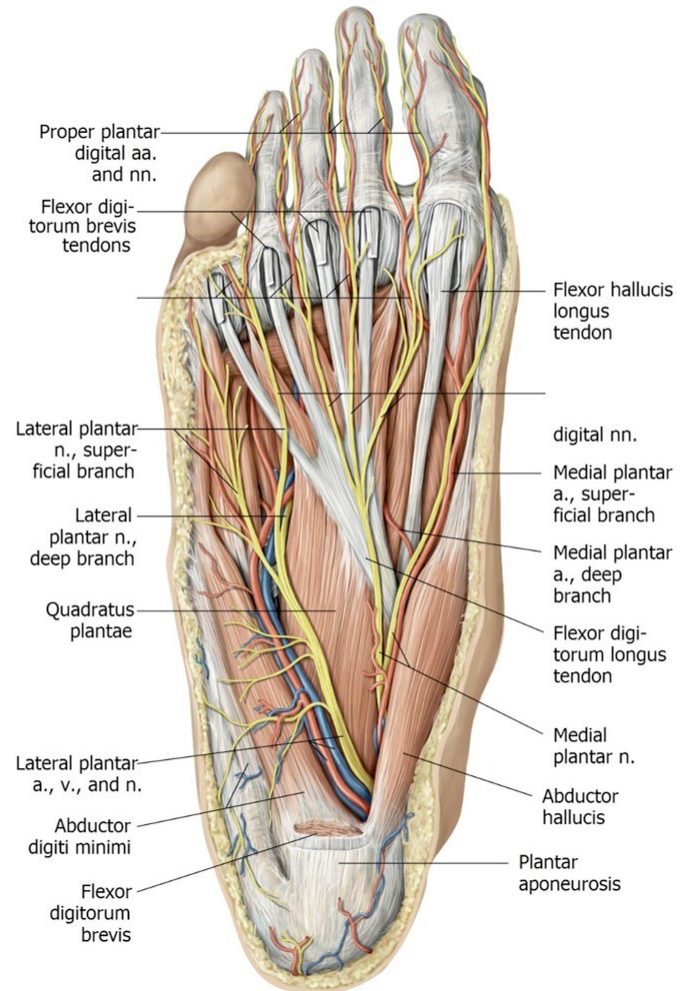


Figure 21.

NOTE

The medial plantar nerve innervates the abductor hallucis, flexor hallucis brevis, flexor digitorum brevis, and the first lumbrical muscle. These muscles are a LAFF! [medial lumbrical—abductor—flexor—flexor]



All the other intrinsic muscles on the sole of the foot are innervated by the lateral plantar nerve.

The lateral plantar nerve in the foot is the equivalent of the ulnar nerve in the hand—the lateral plantar innervates the majority of muscles in the plantar foot—most of which are deep muscles. It sends sensory fibers to the lateral 1 and 1/2 digits (toes), as does the ulnar nerve in the hand. See if you can trace sensory fibers from the lateral plantar nerve to the lateral two toes.

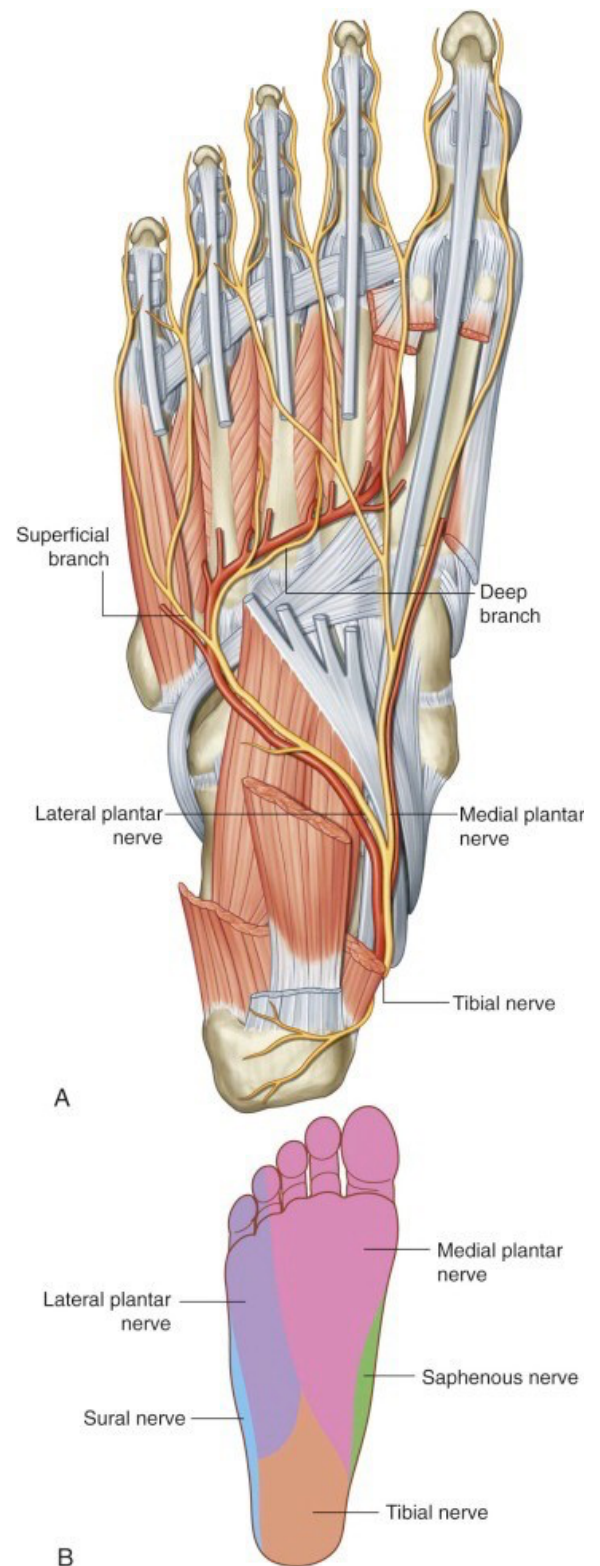


Figure 22.

We won't compare arteries—because it is complicated and there is not strict correspondence between arteries of the hand and foot. We will note however that there are two anastomotic arterial arches in the foot. We saw the **arcuate artery** (from the anterior tibial artery) arching across the dorsum of the foot in the last lab. On the plantar foot, the lateral plantar artery forms a **deep plantar arch** as it passes across the deep plantar foot. The **deep plantar artery** (passing between the first and second metatarsal bones), connects the two arterial arches.

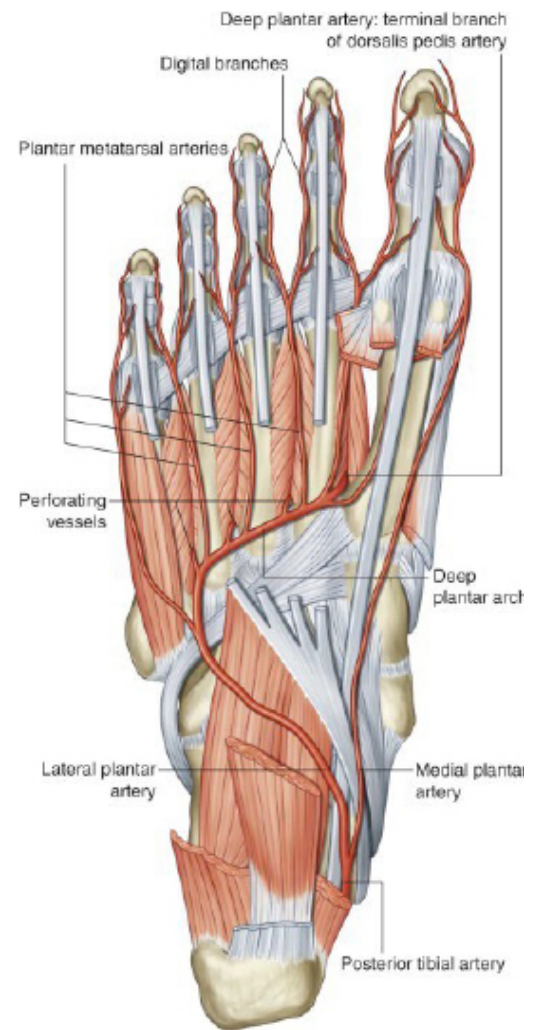


Figure 23.



Deep side: Make cuts in layer 2.

Transect the quadratus plantae muscle along with the tendon of the flexor digitorum longus (FDL) as shown in Figure 24. Reflect the quadratus plantae and tendon of FDL proximally toward the heel.

Reflect the tendons of the flexor digitorum longus and lumbrical muscles distally toward the toes.

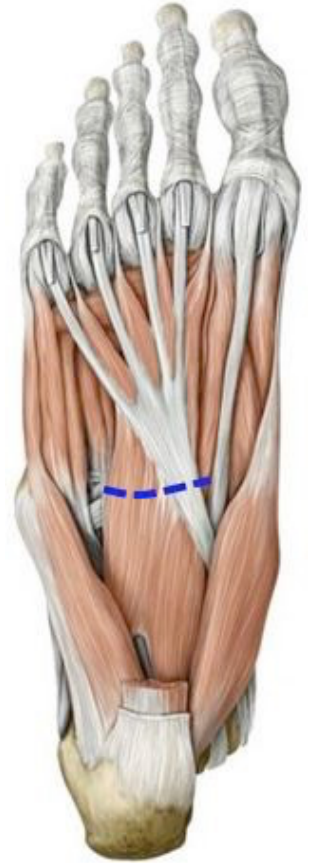


Figure 24.

Layer 3: [3 muscles]



COMPLETE ANATOMY

Plantar foot layer 3

Now you can clean and identify the 3rd layer of intrinsic muscles—there are three muscles in this layer.

- 1 **Flexor digiti minimi brevis**
- 2 **Flexor hallucis brevis** = has medial and lateral heads, each containing a sesamoid bone—creating a ‘gutter’ for the tendon of the flexor hallucis longus.

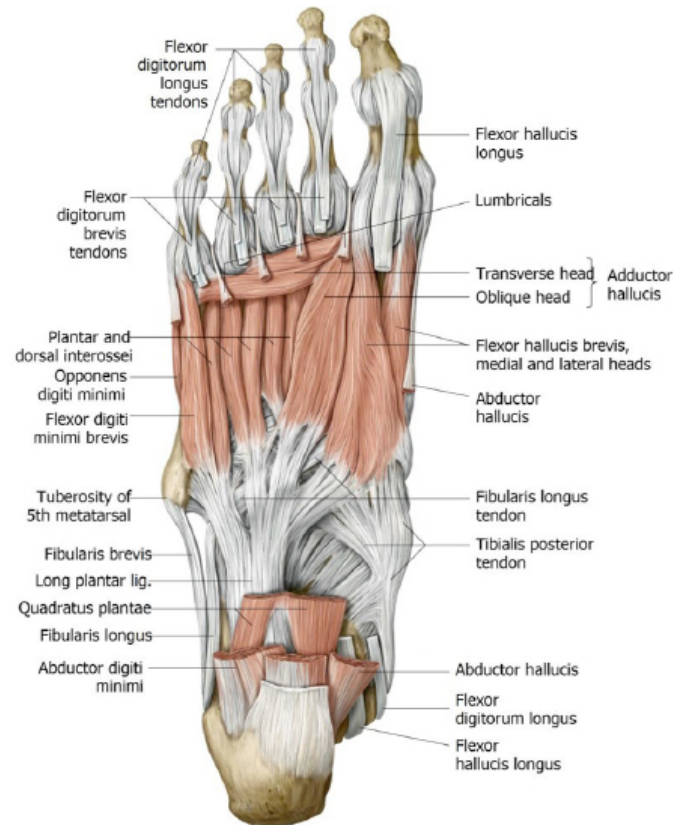


Figure 25.

Cut the tendon of the flexor hallucis longus where it attaches to the distal phalanx of the big toe and reflect it proximally toward the heel. Note the channel between the two heads of the flexor hallucis brevis.

Palpate the plantar surface of the first metatarsophalangeal joint (the “ball” of the big toe) and verify that the two heads of the flexor hallucis brevis contain **sesamoid bones**. Functionally, the sesamoid bones bear the weight placed on the “ball” of the big toe. This allows the tendon of the flexor hallucis longus muscle to move freely—otherwise it would be trapped between the ground and the first metatarsal bone when weight is placed on the “ball” of the foot—this would prevent flexion of the big toe, which is an important part of the gait cycle called the “toe off” phase—when the flexor hallucis longus contracts and pushes the toe off the ground—propelling the body forward when walking.



Figure 26.

- 3 **Adductor hallucis** (has oblique and transverse heads)—you will have to remove the skin from the proximal parts of the lateral four toes and dig deep at the level of the metatarsophalangeal joints to have a chance of seeing the transverse head of the adductor hallucis

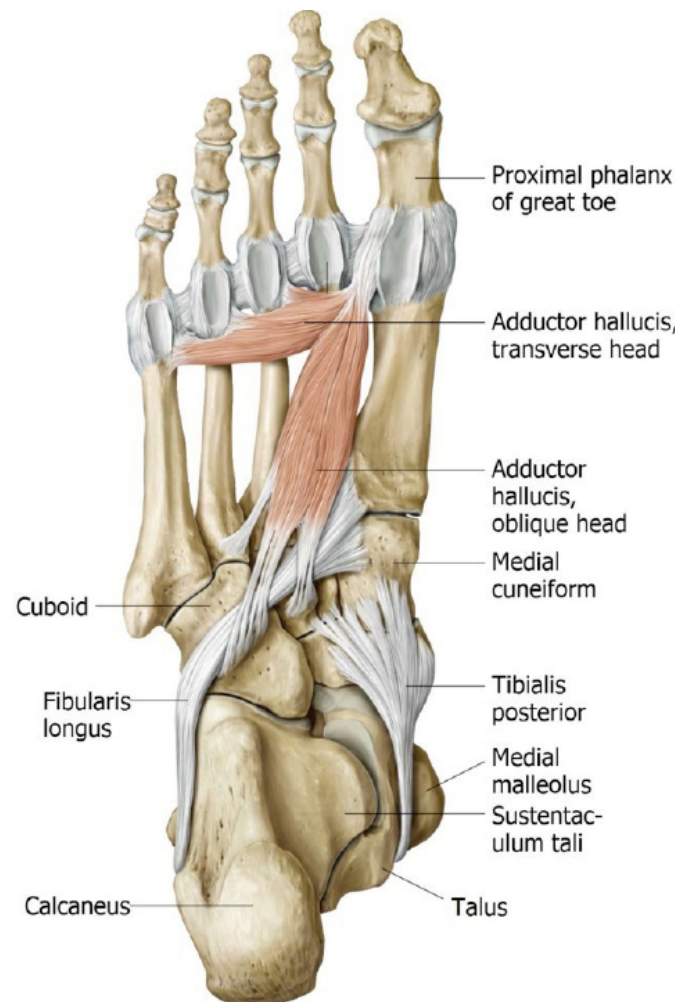


Figure 27.

Layer 4: [7 muscles]



COMPLETE ANATOMY

Plantar foot layer 4

Now, clean the deep plantar surface of the foot, between the flexor hallucis brevis and flexor digiti minimi brevis. Locate a few of the plantar interosseus muscles = the deepest layer on the plantar foot.

The **plantar interosseous muscles** (3) are located adjacent to the metatarsal bones on the plantar foot. These P-A-D the toes.

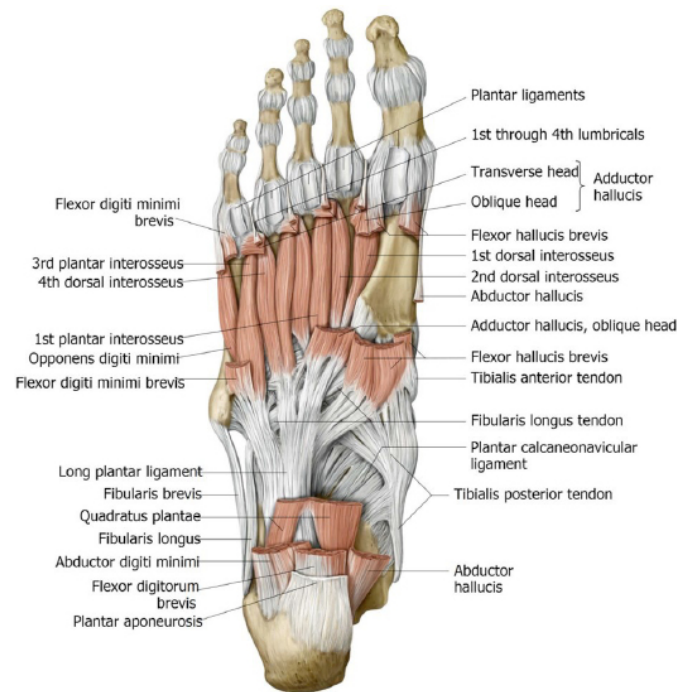


Figure 28.

ARCHES OF THE FOOT

The bones of the foot do not lie within the same horizontal plane—that is, the foot is not flat. Instead, the bones form longitudinal and transverse arches above the ground. These arches absorb and distribute the forces placed upon the foot by the weight of the body above it.

The three arches are:

- Medial longitudinal arch (the largest and most important)
- Lateral longitudinal arch
- Transverse arch

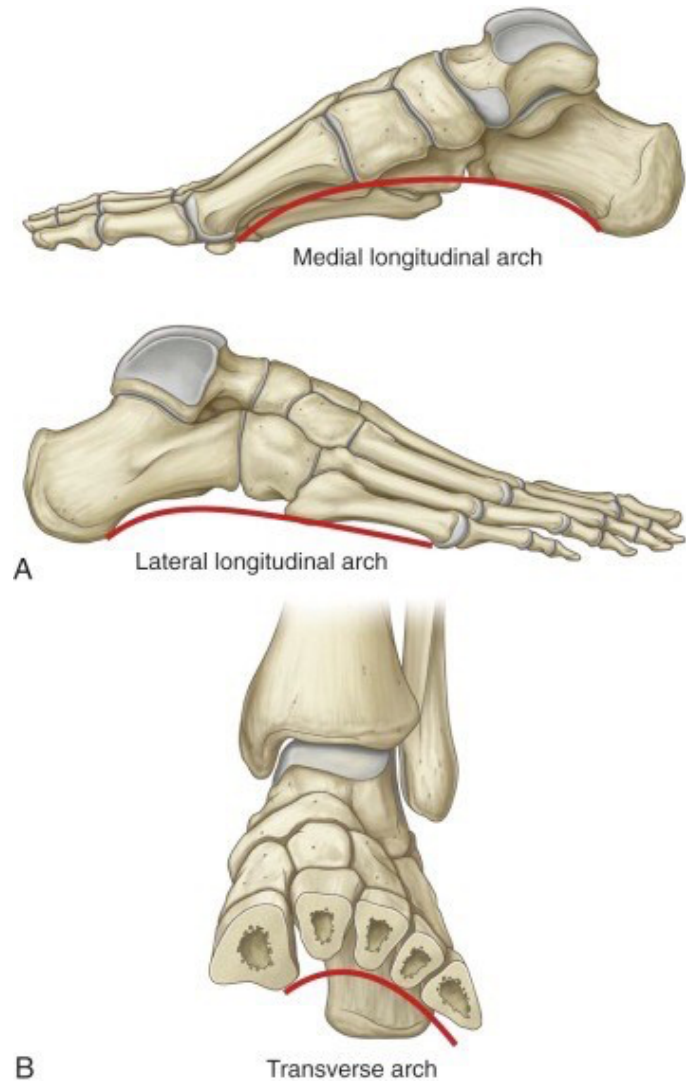


Figure 29.

The arches are maintained by:

- 1 Muscles (the most important of which are the tibialis anterior and tibialis posterior—which both attach to the tarsal bones where they actively raise the bones upward when the muscles contract)
- 2 Intrinsic ligaments within the foot
- 3 The plantar aponeurosis

Identify the three arches on the donor foot if possible and on your own feet in the comfort of your home.

CHECKLIST, LAB #19

REVIEW AND MAKE SURE YOU HAVE IDENTIFIED EACH OF THE STRUCTURES BELOW.

MUSCLES

- ☐ Gastrocnemius
- ☐ Soleus
- ☐ Plantaris
- ☐ Popliteus
- ☐ Tibialis posterior
- ☐ Flexor digitorum longus
- ☐ Flexor hallucis longus
- ☐ Abductor hallucis
- ☐ Abductor digiti minimi
- ☐ Flexor digitorum brevis
- ☐ Quadratus plantae
- ☐ Lumbricals (4)
- ☐ Flexor hallucis brevis
- ☐ Adductor hallucis
- ☐ Flexor digiti minimi brevis
- ☐ Plantar interosseous muscles (3)
- ☐ Dorsal interosseous muscles (4)

NERVES AND VESSELS

- Small saphenous vein
- Sural nerve
- Common fibular nerve
- Tibial nerve
- Posterior tibial artery and veins
- Fibular artery
- Medial and lateral plantar nerves and vessels

OTHER

- Flexor retinaculum (roof of tarsal tunnel)
- Tarsal tunnel and its contents
- Plantar aponeurosis
- Medial longitudinal arch