

## Basic Anatomy of the Foot

The foot is a perfect marriage of form and function. The foot contains 26 bones, 2 sesamoid bones, 33 joints, 19 muscles and 107 ligaments.



*Dorsal view of foot illustrating first layer of muscles and tendons.*

# The Musculoskeletal System

The skeletal system consists of bone, which is the hard substance that forms the framework of the body. Ligaments tie the bones together to form joints. Each bone and each joint has a name. The bone of the thigh is called the femur, the bones of the leg are called the tibia and fibula, and the joint between these bones is called the knee joint. The skeleton and all its parts are moved by muscles and tendons. Bones, ligaments, muscles, and tendons are the tissues of the locomotor or musculoskeletal system of the body.

Bones consist of two kinds of tissue:

1. compact tissue: the hard, outside part of a bone.
2. cancellous tissue: the spongy part on the inside.

Bones are covered with fibrous membrane called periosteum. The periosteum contains nerve fibres and transmits pain sensation if inflamed or torn away from the underlying bone.

The muscular system consists of muscle, which is the tough, elastic tissue that makes body parts move. The human body has more than 600 major muscles.

Skeletal muscles hold the bones of the skeleton together and make the body move. Skeletal muscles vary greatly in size, depending on their function. For example, eye muscles are small and fairly weak, but thigh muscles are large and strong.

The ends of most skeletal muscles are attached to bones by a tough, flexible connective tissue called tendon. The origin of the muscle is the proximal end that is attached to bone that does not move when the muscle contracts (draws together). The distal end, the insertion, is attached to a bone that moves when the muscle contracts.

Skeletal muscles act in pairs called flexors and extensors.

1. flexor: bends a joint and decreases joint angle.
2. extensor: does the opposite, and moves a limb away from the body.

For example, the hamstring muscle at the back of the femur is a knee flexor. When it contracts, the knee bends and the leg moves toward the hip. The quadriceps muscle at the front of the femur is an extensor. When it contracts, the knee straightens and the leg moves away from the hip. At the same time, the hamstring relaxes so the quadriceps can pull the limb back to its original length.

## Joints and Ligaments

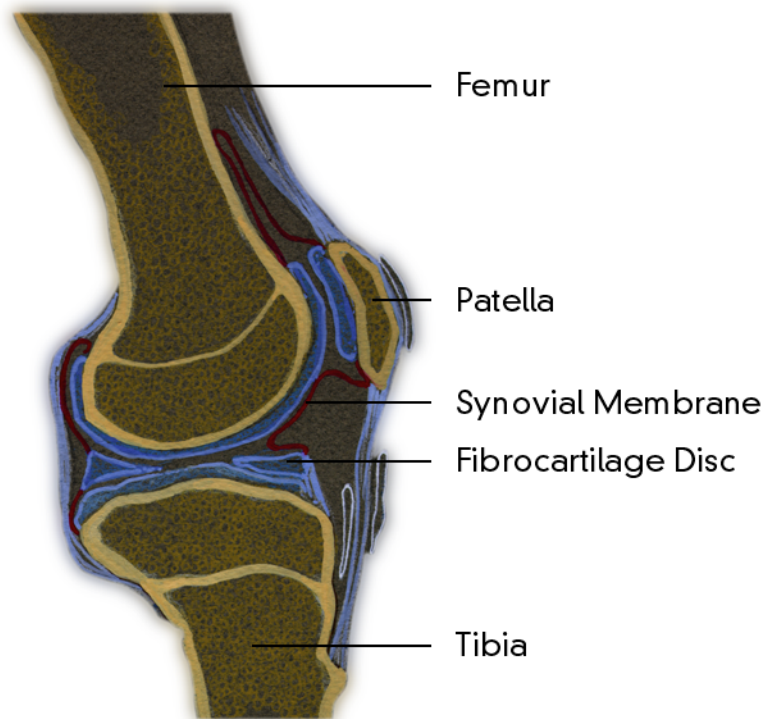
A joint is the place that two or more bones meet. This is also called an articulation.

Freely-mobile joints such as the elbow and knee contain a synovial cavity. This cavity is lined inside by synovial membrane, which produces joint fluid ("synovial fluid"). The fluid reduces the friction of the moving bones. The synovial membrane is surrounded by a fibrous joint capsule which, in key places, is reinforced by ligaments.

Joints are protected from wear and tear in several ways. A smooth layer of cartilage (gristle) covers the end of bones that move over one another. The elasticity of cartilage breaks the force of sudden shocks and also, the smooth quality of the cartilage makes a joint move easily. In addition to cartilage, the synovial fluid keeps the joints moist and lubricated.

Bones are held together at the joint by strong ligaments that attach above and below the joint. The "joint capsule" encircles the joint and seals it to maintain the synovial fluid inside the capsule. This creates the "synovial cavity" (see diagram).

### Left Leg Medial (Inside) View



Medial view of left knee

A ligament is a fibrous tissue that holds organs of the body in place and fastens bones together. Ligaments are grouped together in cords, bands, or sheets. A sprain occurs when ligaments

covering a joint are torn or twisted. A sprained ankle is a partial tearing of the talofibular ligament that binds the bones of the lower leg to the bones of the foot. Ligaments heal slowly and they may not fully heal if they are completely torn apart.

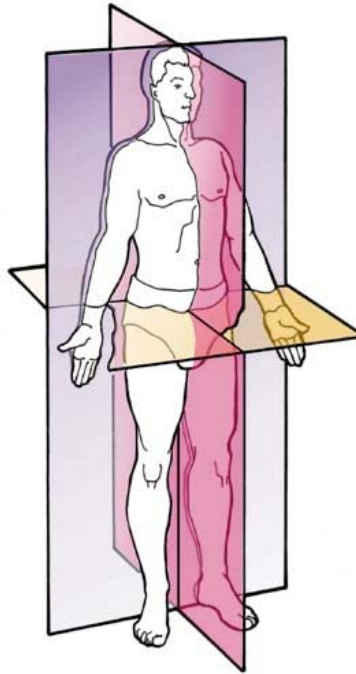
Fascia is a broad connective tissue band serving a stabilization and supportive function (e.g. iliotibial band, plantar fascia).

## **Basic Anatomical Terms**

There is a “language” used by medical practitioners of all kinds (podiatrists, chiropractors, orthopaedic surgeons, etc.). When discussing the body and its ailments, the basic terms you will need to know are:

1. proximal and distal: “proximal” means closer to the heart and “distal” means further away from the heart. Thus, each toe has three bones: the proximal phalanx, the middle phalanx, and the distal phalanx (except the big toe, which has two bones).
2. The three anatomical planes: transverse, frontal and sagittal – there are three planes that divide the body and are used as points of reference.
  - A. transverse: divides top and bottom.
  - B. frontal: divides front and back.
  - C. sagittal: divides left from right.

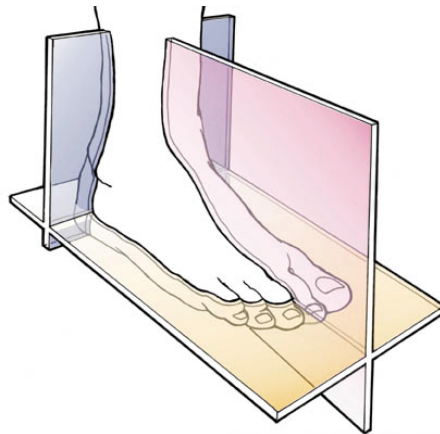
## **Three Anatomical Planes of the Body**



*Transverse, Frontal and Sagittal planes.*

### Three Anatomical Planes of the Foot

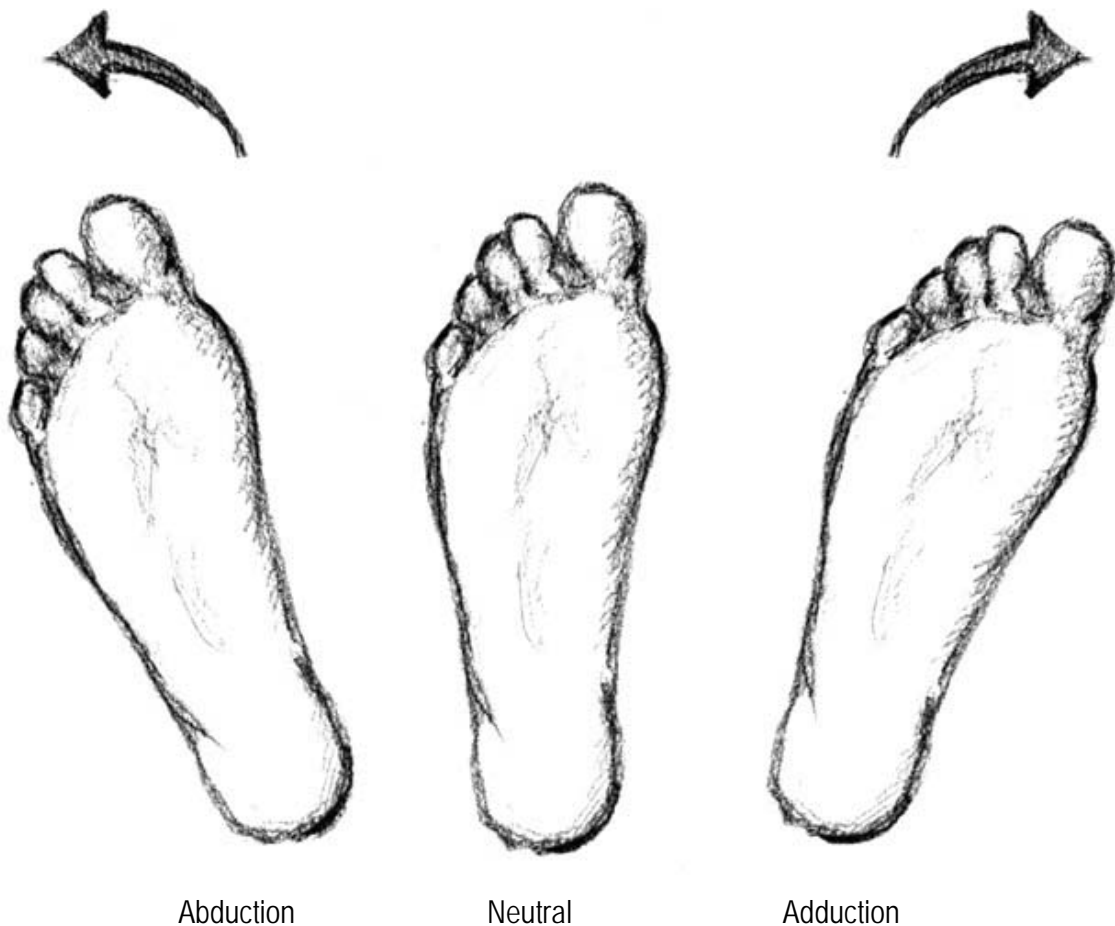
When dealing with the foot, the midline is relative to the foot itself. Therefore, the midline of the foot divides the 2<sup>nd</sup> and 3<sup>rd</sup> toe.



*Anatomical planes with respect to the foot.*

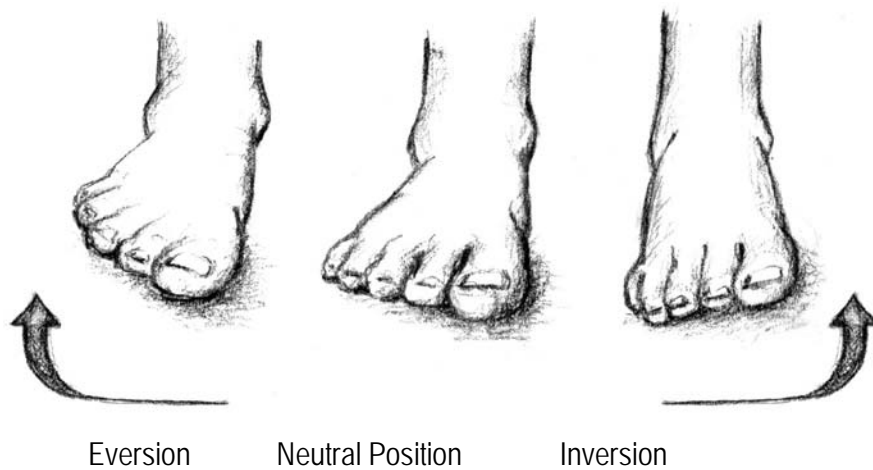
3. The single plane motions of the foot:

- A. Abduction and adduction: These movements occur in the transverse plane. The foot abducts when it rotates laterally (i.e. away from the centre). It adducts when it rotates medially (i.e. towards the centre.)



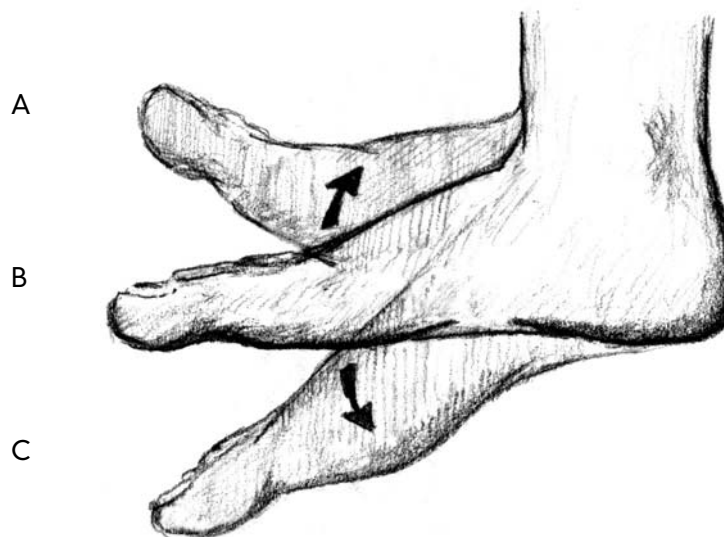
*Single transverse plane motion of the foot.*

- B. Inversion and eversion: These movements occur in the frontal plane. The foot inverts when it rotates inward and upward (the sole toward the midline), and everts when it rotates outward and upward (the sole away from the midline).



*Single frontal plane motion of the foot  
Inversion and eversion of the foot (right foot).*

- C. Plantarflexion and dorsiflexion: These movements occur in the sagittal plane. The foot plantar flexes when it moves downwards away from the tibia and dorsiflexes when it moves upwards toward the tibia.



A: Dorsiflexion, B: Neutral Position, C: Plantarflexion

*Single sagittal plane motion of the foot  
Dorsiflexion and plantarflexion of the foot (right foot).*

4. Pronation and supination: There are two motions of the foot, pronation and supination, which include simultaneous movement in the frontal, sagittal, and transverse planes. These are termed tri-plane movements.

Pronation is a tri-plane motion consisting of simultaneous movements of abduction, dorsiflexion, eversion.



***Pronated foot (right foot).***

Supination is a tri-plane motion which combines the movements of adduction, plantarflexion, inversion.



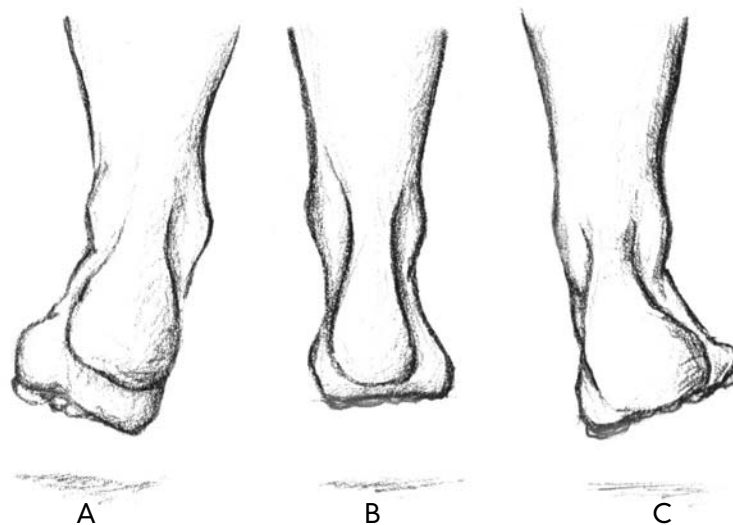
***Supinated foot (right foot).***

It is difficult to clinically measure a tri-plane motion in the ankle at the subtalar joint ("STJ"). Therefore, frontal plane motion is used as an index to measure tri-plane motion at the STJ. The



*number of degrees of inversion or eversion in the frontal plane signifies the amount of pronation and supination.*

As the foot strikes the ground it immediately begins pronating to absorb shock and acts as a “mobile adaptor” (“loose bag of bones”) for variance in the terrain. It must then serve as a “rigid lever” to propel the body forward in locomotion. The latter occurs when the foot is supinated, as the foot structure becomes more rigid when supinated.



***Back of Right Foot***

- a) The STJ and foot in a supinated position. b) the STJ and foot in the neutral position. c) the STJ and foot in a pronated position.***

5. lateral and medial - Lateral means on the side away from the mid-line sagittal plane and medial means on the side closer to the mid-line sagittal plane.
6. dorsum and plantar surfaces - The dorsum is the top part of the foot. The plantar surface is the sole of the foot.
7. positions of the foot:
  - a. dorsiflexed and plantarflexed: In the normal foot, the reference point for a dorsiflexed or plantarflexed position is a transverse plane which runs through the heel. If the foot is positioned below this transverse plane, it is said to be plantarflexed; above this transverse plane, it is said to be dorsiflexed.
  - b. Everted and inverted: A foot or part of a foot is said to be inverted when it is tilted parallel to the frontal plane so that the plantar surface of the foot or part of the foot faces toward the midline of the body. A foot or part of the foot is said to be everted

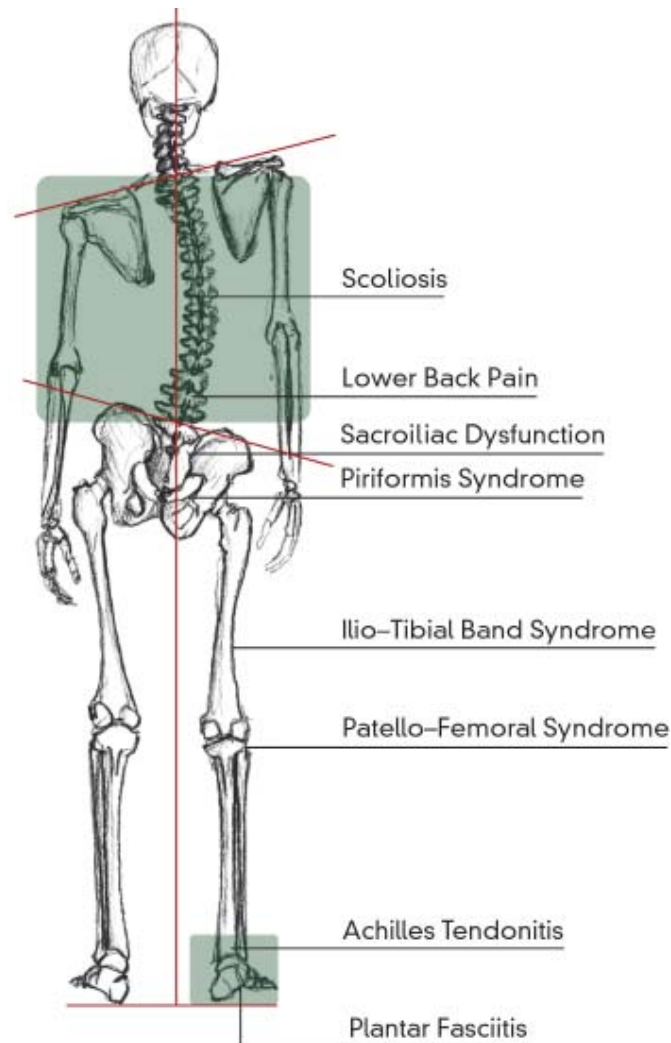
when it is tilted parallel to a frontal plane so that the plantar surface faces away from the midline of the body.

- c. abducted and adducted: The two transverse plane positions of the foot are abducted and adducted. The reference point is the mid-line sagittal plane.
- 8. Fixed structural positions of the foot can occur due to the inherent structure of bone, ligament, etc. of a particular foot.
  - a. Adductus and Abductus: Adductus denotes a fixed structural position in which the foot is held in an adducted position in the transverse plane. Abductus denotes a fixed structural position in which the foot is held in an abducted position in the transverse plane.
  - b. Varus and Valgus: the two frontal plane fixed structural positions which the foot may assume relative to the inverted and everted positions. The fixed structural position in which the foot or part of the foot appears inverted is classified as varus. The fixed structural position in which the foot or part of the foot appears everted is classified as valgus.



*Uncompensated (non-weight bearing)  
Rearfoot Varus (right foot).*

## Anatomy of the Lower Limbs



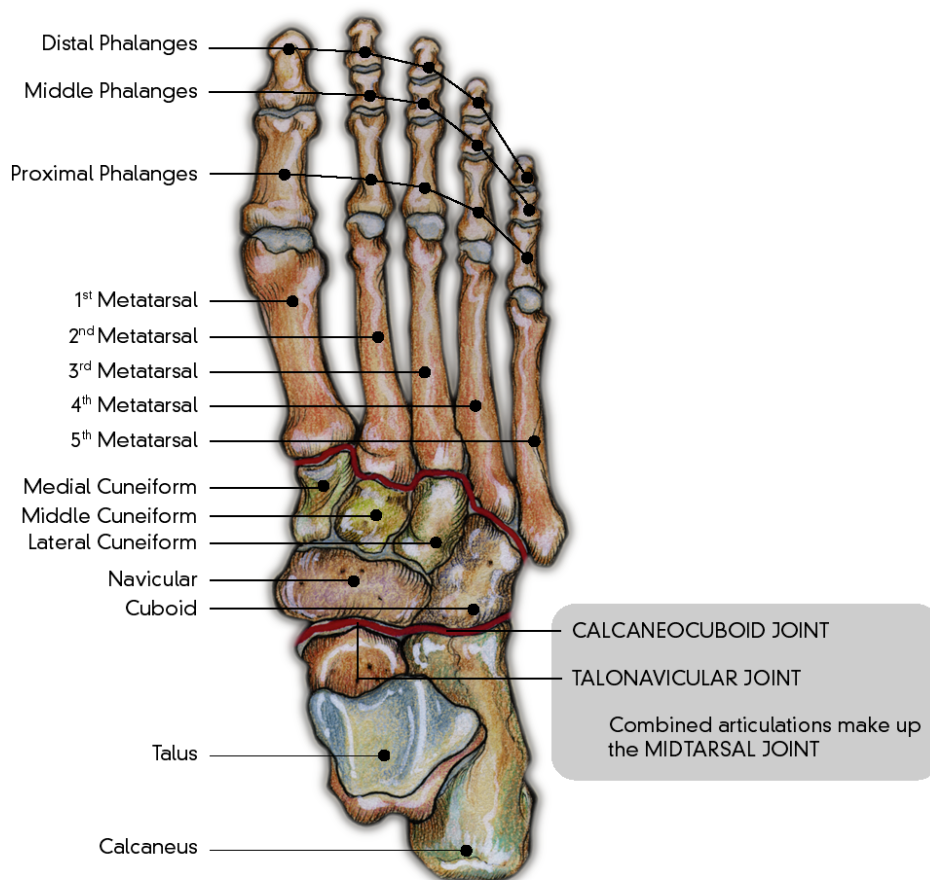
***The skeletal structure displaying various pathologies.***

The function of all of the muscles in the lower limb originating below the knee is to move the foot. These muscles insert on any one or several of the 26 bones of the foot.

# Bones of the Foot

The 26 bones of the foot, separated into the three main sections of the foot: Forefoot, Midfoot, Hindfoot, is summarized below:

## Bones of the Right Foot (Dorsal View)



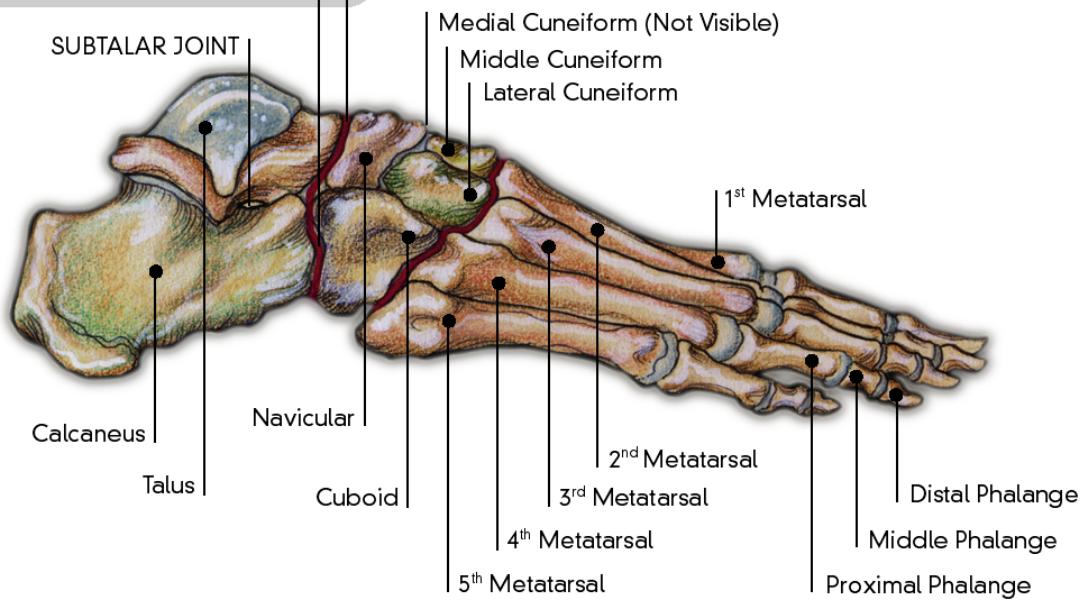
*Dorsal View, right foot*

## Bones of the Right Foot (Lateral View)

Combined articulations make up the MIDTARSAL JOINT

TALONAVICULAR JOINT  
CALCANEOCUBOID JOINT

SUBTALAR JOINT



*Lateral View, right foot*

## Joints of the Foot

### The forefoot

The forefoot consists of five metatarsals starting with the first to the fifth; and five toes, each of which consists of three bones (except for the big toe which consists of two). The bones of each toe are the proximal phalanx, the middle phalanx, and the distal phalanx (except the big toe which has only proximal and distal). Between each of these bones is a joint which allows for the movement necessary of each section of the foot.

The joints of the forefoot are:

1. MTP joint - metatarsal phalangeal joint - between the metatarsal and the proximal phalanx of the adjacent toe.
2. PIP joint - proximal interphalangeal joint - between the proximal phalanx and the middle phalanx of each toe.
3. DIP joint - distal interphalangeal joint - between the middle phalanx and the distal phalanx of each toe.
4. The big ("great") toe has only one joint between its two phalanges and therefore this joint is called the great (or "big" ) toe interphalangeal joint.

Metatarsal head is the end of the metatarsals, which articulate with the joints of the adjacent bones (generally used to describe the distal metatarsal head, the portion that articulates with the proximal phalanx of the adjacent toe.)

### The midfoot

The Midfoot consists of five bones with numerous articular surfaces (surfaces which articulate by way of joints with other bones).

1. navicular
2. cuboid
3. three cuneiform bones: medial, middle and lateral

Distally, the fourth and fifth metatarsals articulate with the cuboid bone. The first, second and third metatarsals articulate with each of their respective cuneiform bones. Each of these has an individual joint capsule but all are wrapped in one big capsule as well to form the tarso-metatarsal joint (the "Lis Franc joint").

Proximally, the talonavicular and calcaneocuboid joints, together form the combined articulations of the midtarsal joint (of "Chopart").

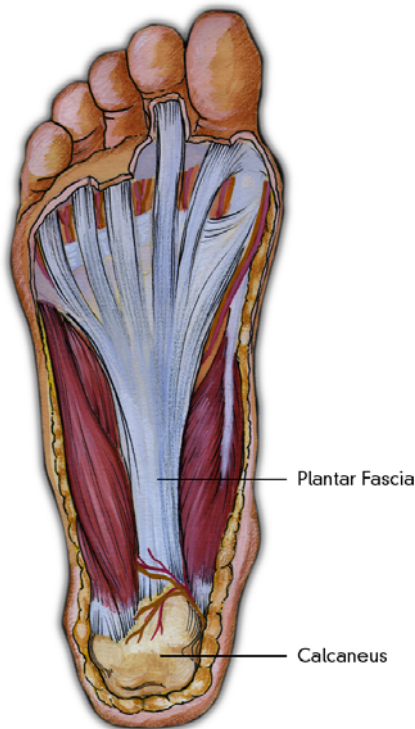
### The Hindfoot

The tibia articulates with the dome of the talus and thereby transmits the forces of the leg to the ankle. This is commonly called the "Tibialtalus joint" or simply the "Ankle joint". In turn, the talus articulates with the calcaneus, the main weight-bearing (and the largest) bone of the foot by way of the subtalar joint.

The subtalar joint, known as the "agility joint", is a key joint in the ankle. It has three surfaces of articulation with three separate facet joints. A great deal of the movement in the ankle happens in this joint - the rest of the movement happens at the tibialtalus joint.

The plantar fascia is an important stabilizer in the foot where a great deal of foot pathology begins. The plantar fascia originates from the plantar surface of the calcaneus and attaches to the plantar surfaces of the five metatarsal heads and proximal phalanges of the toes. The plantar fascia acts as a major stabilizer of the foot (see diagram). It helps maintain the arch of the foot and is an anti-pronator. In its function of maintaining the congruity of the relationship between the calcaneus and the metatarsal heads, it resists the torsion movement of the forefoot in relation to the hindfoot during pronation. Most of the eversion of pronation occurs in the mid and forefoot while the calcaneus remains stable in the hindfoot.

### Plantar Fascia



*Plantar fascia, plantar view of right foot*

The Achilles Tendon is one of the longest and strongest tendons in the body. It also has one of the lowest blood supplies of any tendon and therefore is prone to chronic injury. Once inflammation, or particularly a rupture, occurs it is difficult to repair given the low blood supply.

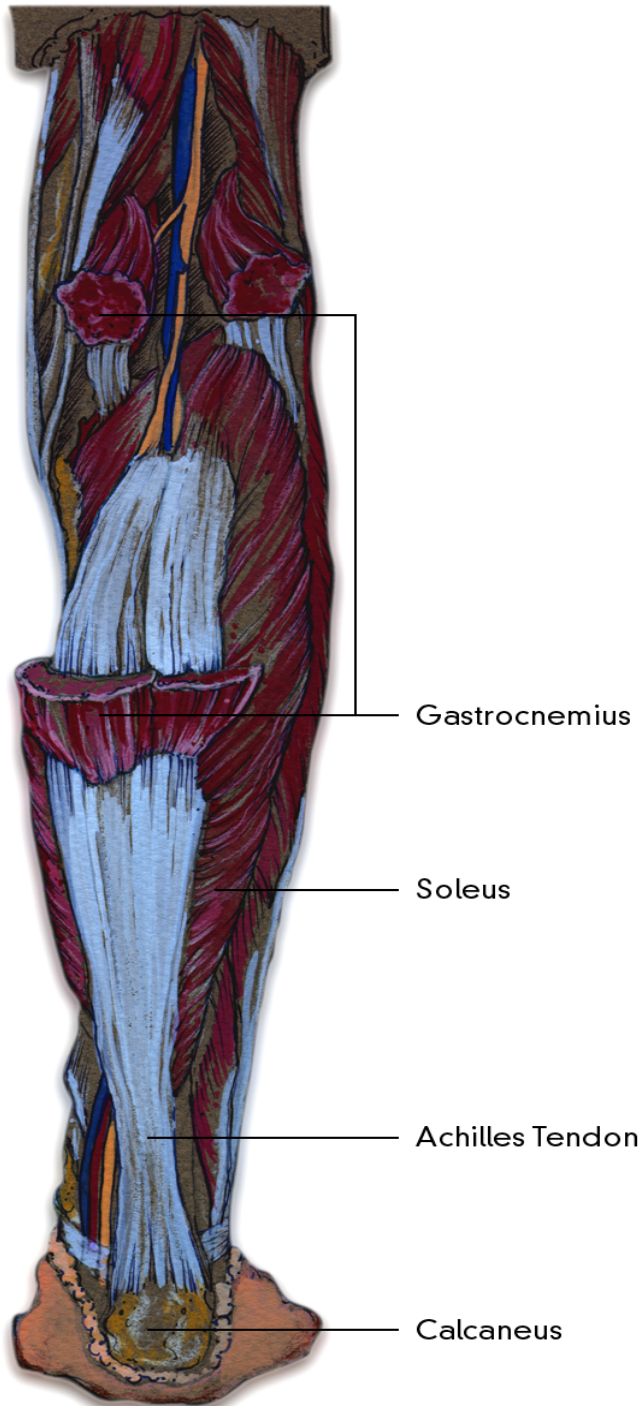
The Achilles Tendon inserts on the calcaneus (posterior aspect) and is the main muscle which plantarflexes the foot and thereby allows for propulsion. It is also a major anti-pronator. Dorsiflexion is a significant component of pronation, and therefore the Achilles Tendon acts as an antagonist. It also causes inversion at the extreme.

The Achilles Tendon is formed in the middle third of the posterior aspect of the tibia. The two calf muscles join in the middle third of the tibia to form the Achilles Tendon.

1. Gastrocnemius is a large muscle which originates on the posterior aspect of the femur.
2. Soleus is a large muscle which originates on the posterior aspect of the upper third of the tibia.



## Dissection of the Superficial Muscles in the Posterior Compartment of the Right Leg



The Achilles tendon proximally attaches to the soleus and gastrocnemius muscles and distally attaches to the calcaneus.