



Movements of the Foot

- Plantar flexion: foot movement when the sole turns posteriorly,
- Dorsiflexion: foot movement when the sole turns anteriorly,
- Inversion: foot movement when the sole turns medially,
- Eversion: foot movement when the sole turns laterally,

The axis of plantar flexion-dorsiflexion passes horizontally between the medial & lateral malleoli, through the trochlea of talus.

The axis of inversion-eversion passes anterosuperomedially from the posterior surface of the calcaneus to the neck of talus.

See the tables for the muscles producing each movement.

Movements	Muscles producing movements	
	Principal muscles	Accessory muscles
Dorsiflexion	<i>Tibialis anterior</i>	<ul style="list-style-type: none"> • Extensor digitorum longus • Extensor hallucis longus • Peroneus tertius
Plantar flexion	<ul style="list-style-type: none"> • Gastrocnemius • Soleus 	<ul style="list-style-type: none"> • Plantaris • Tibialis posterior • Flexor hallucis longus • Flexor digitorum longus

Movements	Muscles	
	Principal muscles	Accessory muscles
Inversion (ROM = 30°)	<ul style="list-style-type: none"> • Tibialis anterior • Tibialis posterior 	<ul style="list-style-type: none"> • Flexor hallucis longus • Flexor digitorum longus
Eversion (ROM = 20°)	<ul style="list-style-type: none"> • Peroneus longus • Peroneus brevis 	<ul style="list-style-type: none"> • Peroneus tertius

THE ANKLE JOINT

The ankle joint is a big synovial joint formed between the distal ends of the tibia & fibula (above) & the talus bone (below). The ankle joint mainly allows hinge-like dorsiflexion and plantarflexion of the foot on the leg. The distal end of the fibula is firmly anchored to the larger distal end of the tibia by strong ligaments (interosseous, anterior & posterior tibiofibular ligaments).

Articular Surfaces:

- Together, the fibula and tibia create a deep bracket-shaped socket that has a roof & medial & lateral walls: the roof of the socket is formed by the inferior surface of the distal end of the tibia; the medial side is formed by the medial malleolus of the tibia; & the longer lateral side is formed by the lateral malleolus of the fibula. The lateral malleolus extends more inferiorly than the medial malleolus.
- The articular part of the talus forming the ankle joint is the "trochlea". It is the uppermost part of the talus shaped like a short 1/3rd-cylinder with its axis passing horizontally between the medial & lateral malleoli. The trochlea has 3 surfaces: curved upper surface articulating with the lower tibial surface, comma-like medial surface articulating with the medial malleolus, & triangular lateral surface articulating with the lateral malleolus. The trochlea fits into the bracket-shaped socket formed by the distal ends of the tibia and fibula. All of the articular surfaces are covered by hyaline cartilage.

When viewed from above, the trochlea of the talus is much wider anteriorly than it is posteriorly. As a result, the trochlea fits tighter into its socket when the foot is dorsiflexed (allowing minimal side to side movement) than in plantarflexion. The joint is therefore most stable when the foot is dorsiflexed.

Synovial Membrane & Fibrous Capsule:

The articular cavity is enclosed by a synovial membrane, which attaches around the margins of the articular surfaces, and extends shortly into the inferior tibiofibular joint. The fibrous capsule covers the synovial membrane and is also attached to the adjacent bones. It is thin anteriorly & posteriorly to allow plantarflexion-dorsiflexion movement, & thick on the sides, where it blends with the collateral ligaments.

Ligaments:

The ankle joint is stabilized by medial and lateral collateral ligaments.

Medial Collateral Ligament (deltoid ligament):

The medial (deltoid) ligament is large, strong and triangular in shape. Its apex is attached above to the medial malleolus and its broad base is attached below to a number of structures, based on which the ligament is subdivided into 4 parts (anteroposteriorly):

1. Anterior tibio-talar part: attached to the medial surface of the talus (deep to the second & third parts of the ligament);
2. Tibio-navicular part: attached to the navicular bone & the medial margin of the plantar calcaneonavicular ligament (spring ligament), which connects the navicular bone to the sustentaculum tali of the calcaneus;
3. Tibio-calcaneal part: attached to the sustentaculum tali of the calcaneus bone;
4. Posterior tibio-talar part: attached to the medial tubercle of the talus.

Lateral Collateral Ligament:

The lateral ligament of the ankle is composed of three separate ligaments, the anterior talofibular ligament, the posterior talofibular ligament, and the calcaneofibular ligament:

1. The anterior talo-fibular ligament is a short ligament attaching the anterior margin of the lateral malleolus to the adjacent region of the talus;
2. The posterior talo-fibular ligament runs horizontally from the lateral malleolus to the posterior process of the talus;
3. The calcaneo-fibular ligament passes posteroinferiorly from the lateral malleolus to a tubercle on the lateral surface of the calcaneus.

Arterial Supply: the malleolar branches of anterior tibial, posterior tibial, and peroneal arteries.

Nerve Supply: branches of deep peroneal and tibial nerves (L4, L5; S1, S2 spinal segments).

Relations:

- Anteriorly (medial to lateral): tendons of tibialis anterior, extensor Hallucis longus, anterior tibial artery, deep peroneal nerve, extensor digitorum longus, & peroneus tertius.
- Posteriorly (medial to lateral): tendons of tibialis posterior, flexor digitorum longus, posterior tibial artery, tibial nerve, & flexor hallucis longus tendon (all deep to flexor retinaculum), calcaneal tendon, tendons of peroneus longus & peroneus brevis.

INTERTARSAL JOINTS

The numerous synovial joints between the individual tarsal bones mainly invert, evert, supinate, and pronate the foot: these movements allow the foot to maintain normal contact with the ground when in different stances or when standing on irregular surfaces.

- The major joints at which movements occur include the subtalar, talocalcaneonavicular, and calcaneocuboid joints.
- The talocalcaneonavicular and calcaneocuboid joints together form the transverse tarsal joint.
- Intertarsal joints between the cuneiforms and between the cuneiforms and the navicular allow only limited movement.
- The joint between the cuboid and navicular is normally fibrous.

Subtalar joint

The subtalar joint is a plane synovial joint between the large posterior calcaneal facet on the inferior surface of the talus; and the corresponding posterior talar facet on the superior surface of the calcaneus.

The articular cavity is enclosed by synovial membrane, which is covered by a fibrous capsule. The subtalar joint allows gliding and rotation movements involved in inversion and eversion of the foot. Lateral, medial, posterior, and interosseous talocalcaneal ligaments stabilize the joint.

Talocalcaneonavicular joint

The talo-calcaneo-navicular joint is a complex joint in which the head of the talus articulates with the calcaneus and plantar calcaneonavicular ligament (spring ligament) inferiorly, and the concave surface of navicular bone anteriorly. So, it is a rough ball and socket synovial joint.

The talocalcaneonavicular joint allows gliding and rotation movements, which together with similar movements of the subtalar joint are involved with inversion and eversion of the foot. It also participates in pronation and supination.

The talocalcaneonavicular joints consists of 4 articulations:

1. Between the ovoid head of talus & the concave posterior surface of navicular bone;
2. Between the medial facet of talar head & the calcaneonavicular ligament (spring ligament);
3. Between the anterior calcaneal surface of the talus & anterior talar surface on the calcaneus;
4. Between the middle calcaneal surface of the talus & middle talar surface on the sustentaculum tali of the calcaneus.

Ligaments

The capsule of the talocalcaneonavicular joint, is reinforced:

- posteriorly by the interosseous talocalcaneal ligament;
- superiorly by the talonavicular ligament, which passes between the neck of the talus and the navicular;
- superolaterally by the calcaneonavicular part of the bifurcate ligament;
- medially by the tibionavicular part of the deltoid ligament;
- inferiorly by the plantar calcaneonavicular ligament (spring ligament).

Note: The bifurcate ligament is a Y-shaped ligament on the dorsal aspect of tarsal bones, the base of the ligament is attached to the anterior aspect of the calcaneus, and its 2 arms are attached to the dorsal aspects of the navicular & cuboid bones (so, bifurcate ligament = calcaneonavicular ligament + calcaneocuboid ligament).

The plantar calcaneonavicular ligament (spring ligament) is a broad thick fibrocartilaginous ligament that extends between the sustentaculum tali behind and the navicular bone in front. Its upper surface has a triangular fibrocartilaginous facet for the head of the talus. Its plantar surface is supported by the tendon of tibialis posterior, flexor hallucis longus and flexor digitorum longus. It supports the head of the talus, & represents the most important ligament to maintain the medial longitudinal arch.

Calcaneocuboid joint

The calcaneocuboid joint is a saddle-type synovial joint between the facet on the anterior surface of the calcaneus; and the corresponding facet on the posterior surface of the cuboid.

The calcaneocuboid joint allows sliding and rotating movements involved with inversion and eversion of the foot, and also contributes to pronation and supination of the forefoot on the hindfoot.

Ligaments

The calcaneocuboid joint is reinforced by:

- the bifurcate ligament (calcaneocuboid part) superiorly;
- the long plantar ligament & the short plantar ligament inferiorly.

The short plantar ligament (plantar calcaneocuboid ligament) is short, wide, and very strong, and connects the calcaneal tubercle to the inferior surface of the cuboid. It also assists the long plantar ligament in maintaining the lateral arch of the foot.

The long plantar ligament is the longest ligament in the sole of the foot and lies inferior to the short plantar ligament: posteriorly, it attaches to the inferior surface of the calcaneus; anteriorly, it attaches to the inferior surface of the cuboid bone behind the groove for the peroneus longus tendon. More superficial fibers of the long plantar ligament extend to the bases of the metatarsal bones.

The long plantar ligament supports the calcaneocuboid joint and is the strongest ligament maintaining the lateral arch of the foot.

TARSOMETATARSAL JOINTS

The tarsometatarsal joints between the metatarsal bones and adjacent tarsal bones are plane joints and allow limited sliding movements, except the 1st one (between the metatarsal of the great toe and the medial cuneiform) which allows some flexion, extension, and rotation. The tarsometatarsal joints, with the transverse tarsal joint, take part in pronation and supination of the foot.

METATARSOPHALANGEAL JOINTS

The metatarsophalangeal joints are ellipsoid synovial joints between the sphere-shaped heads of the metatarsals and the corresponding bases of the proximal phalanges of the digits. The metatarsophalangeal joints allow extension-flexion, and limited abduction-adduction (with the 2nd toe as the axis), rotation, and circumduction.

The joint capsules are reinforced by medial and lateral collateral ligaments, and by plantar ligaments, which have grooves on their plantar surfaces for the long tendons of the digits.

Deep transverse metatarsal ligaments

Four deep transverse metatarsal ligaments link the heads of the metatarsals together and enable the metatarsals to act as a single unified structure. The ligaments blend with the plantar ligaments of the adjacent metatarsophalangeal joints.

Note: there is a deep transverse metatarsal ligament between the first metatarsal (of the great toe) & the second metatarsal, but there is no deep transverse metatarsal ligament between the first metatarsal (of the thumb) & the second metatarsal bone (what is the significance of this?)

INTERPHALANGEAL JOINTS

The interphalangeal joints are hinge joints that allow mainly flexion and extension. They are reinforced by medial and lateral collateral ligaments and by plantar ligaments.

Clinical Applications:

- *Ankle sprains: The excessive stretching and/or tearing of ligaments of the ankle joint is called the ankle sprain. The ankle sprains are usually caused by the falls or twists. When the plantar-flexed foot is excessively inverted, the anterior and posterior talofibular and calcaneofibular ligaments are stretched and torn. The anterior talofibular ligament is most commonly torn. When the plantar flexed foot is excessively everted, the deltoid ligament is not torn instead there is a fracture of medial malleolus. The inversion sprains are more common than eversion sprains.*
- *Dislocation of the Ankle: The dislocations of ankle joint are rare because it is very stable joint due to tibiofibular socket. However, whenever dislocation occurs it is always accompanied by the fracture of one of the malleoli.*
- *Bunion: a bunion is abnormal excessive adduction of the big toe at the first metatarsophalangeal joint. It occurs due to abnormal stresses in this region of the joint may produce the bunion deformity. This deformity tends to occur among people who wear high-heeled or pointed shoes, but osteoporosis and a hereditary predisposition are also risk factors.*

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