Applied anatomy of the lower leg, ankle and foot

CHAPTER CONTENTS

Definitions

The functional terminology in the foot is very misleading, because the same terms are often used for very different things. The following definitions and explanations are used here:

- *Plantiflexion–dorsiflexion* indicate movement at the ankle. Plantiflexion is movement downwards towards the ground, and dorsiflexion upwards towards the tibia. There is also a plantiflexion–dorsiflexion movement at the midtarsal joint.

- *Varus–valgus:* these movements occur at the subtalar joint. In valgus, the calcaneus is rotated outwards on the talus; in varus, the calcaneus is rotated inwards on the talus.

- *Abduction–adduction:* these take place at the midtarsal joints. Abduction moves the forefoot laterally and adduction moves the forefoot medially on the midfoot.

- *Pronation–supination* are also movements at the midtarsal joints. In pronation, the forefoot is rotated big toe downwards and little toe upwards. In supination, the reverse happens: the big toe rotates upwards and the little toe downwards. Sometimes the terms internal rotation and external rotation are used to indicate supination or pronation.

- *Inversion–eversion:* these are combinations of three movements. In inversion, the varus movement at the subtalar joint is combined with an adduction and supination movement at the midtarsal joint. During eversion, a valgus movement at the subtalar joint is combined with an abduction and pronation movement at the midtarsal joint.

The leg

The bones (tibia and fibula) together with the interosseous membrane and fasciae divide the leg into three separate compartments: anterolateral, lateral and posterior. They contain the so-called extrinsic foot muscles. Each compartment has its own blood supply and innervation.

Anterolateral compartment

The muscles of the anterolateral compartment are the tibialis anterior, the extensor hallucis and the extensor digitorum, which are all dorsiflexors. The tibialis anterior, however, is also an invertor. The muscles lie in a strong osteofibrous envelope,
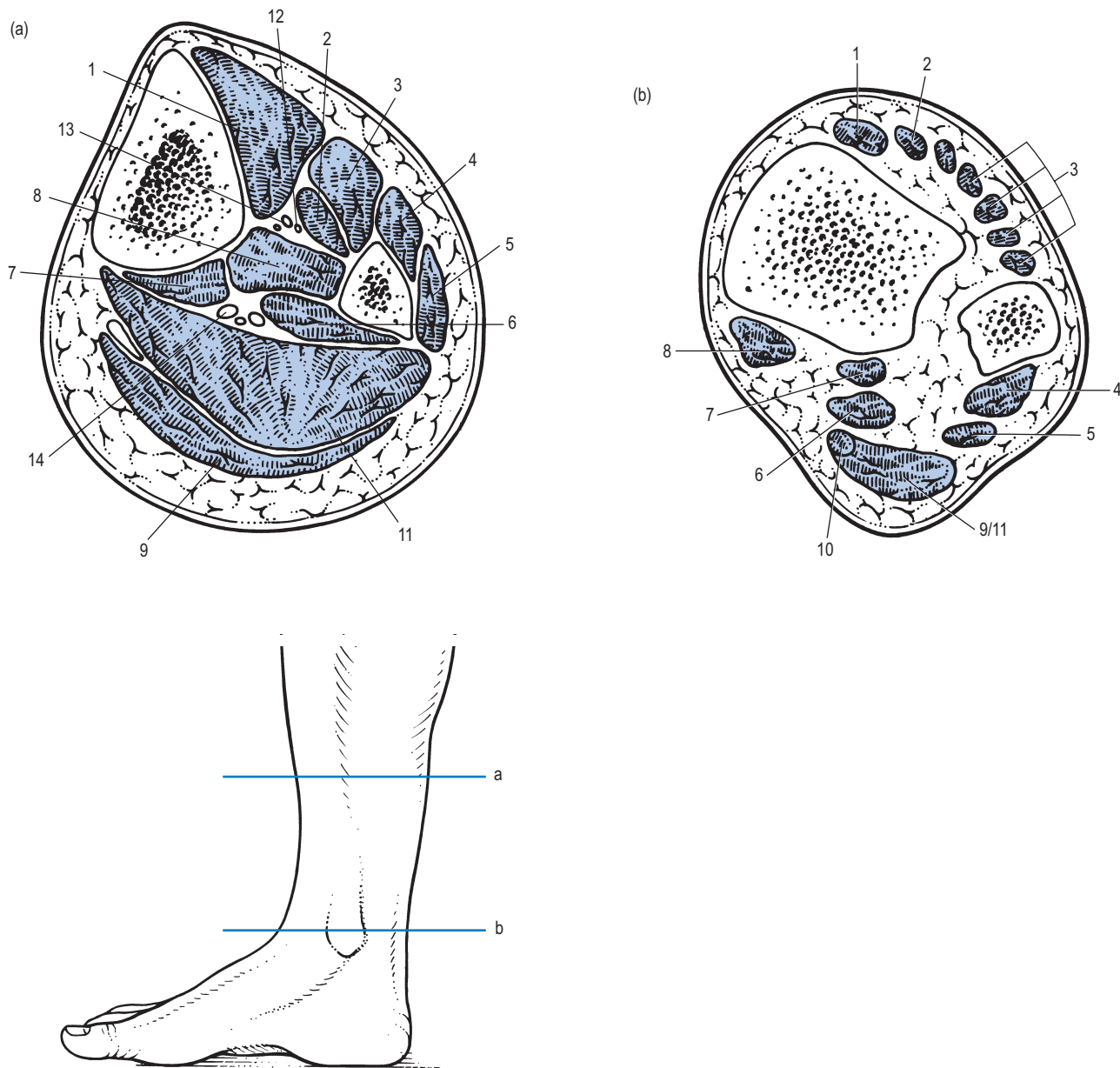
Fig 1 • Transverse sections halfway down the leg (a) and at the malleoli (b). 1, tibialis anterior; 2, extensor hallucis longus; 3, extensor digitorum longus; 4, peroneus brevis; 5, peroneus longus; 6, flexor hallucis longus; 7, flexor digitorum longus; 8, tibialis posterior; 9, soleus; 10, plantaris; 11, gastrocnemii; 12, anterior tibial nerve; 13, anterior tibial vessels; 14, posterior tibial neuromuscular bundle.

consisting of tibia, fibula, interosseous membrane and superficial fascia. The anterior tibial artery (Fig. 1) is located at the anterior surface of the interosseous membrane. It supplies the muscles of the anterior compartment and continues at the dorsum of the foot as the dorsalis pedis artery. The nerve supply of the anterior compartment is from the deep peroneal nerve, a branch of the common peroneal nerve.

Lateral compartment

The lateral compartment contains the peronei longus and brevis muscles. These are strong evertors and weak plantiflexors. Blood supply is from the peroneal artery, a branch of

the posterior tibial artery and nerve supply from the superficial peroneal nerve.

Posterior compartment

The posterior compartment has a deep and a superficial part. The deep part consists of the tibialis posterior, flexor hallucis longus and flexor digitorum longus muscles. The tendons run behind the medial malleolus to the inner aspect of the sole and to the toes. Hence they are invertors of the foot and flexors of the toes. They also act as weak plantiflexors of the foot. The muscles of the superficial part are both heads of the gastrocnemius, the soleus and the plantaris. The soleus and both

gastrocnemii form the triceps surae which inserts – via the Achilles tendon – at the upper posterior aspect of the calcaneus. The plantaris muscle usually has a separate insertion, just medial to the Achilles tendon. This group of muscles acts as a very strong plantiflexor. The artery of the posterior compartment is the posterior tibial. The tibial nerve provides the nerve supply.

The ankle and foot

The 26 bones of the foot create an architectural vault, supported by three arches and resting on the ground at three points, which lie at the corners of an equilateral triangle (Fig. 2). Ligaments bind the bones to provide the static stability of the foot. The dynamic stability of the vault is achieved by the intrinsic and extrinsic muscles.

Three functional segments can be distinguished: forefoot, midfoot and ankle (Fig. 3). Each has its particular functions and specific disorders (see Standring, Fig. 84.8A). The
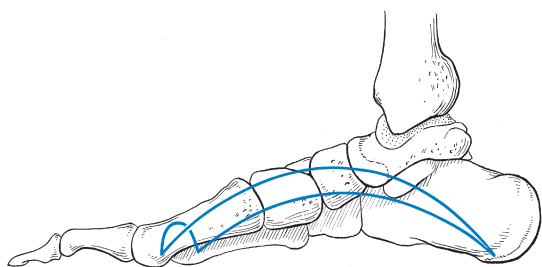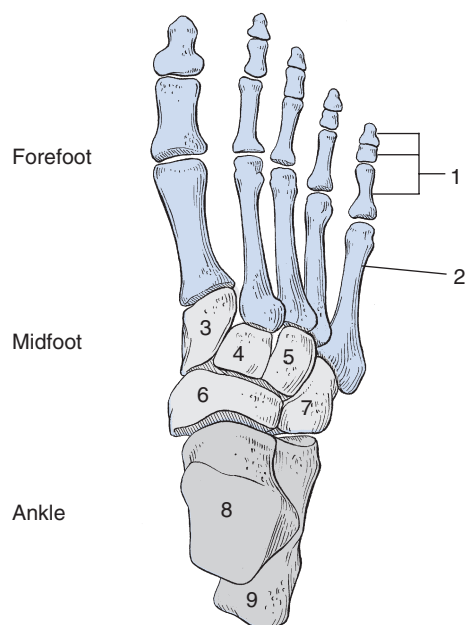
posterior segment (ankle) is the connection between foot and leg. It lies directly under the tibia and fibula and is connected to them by strong ligaments. This segment contains the talus (in the mortice between the fibula and the tibia) and the calcaneus.

The middle segment (midfoot) contains the five tarsal bones and is the keystone in the plantar vault. Excessive stresses falling on the vault therefore influence the midfoot in particular.

The anterior segment (five metatarsals and 14 phalangeal bones) takes the whole body weight during the 'heel-off' phase in walking or running. This specific function of the forefoot underlies pressure disorders at the plantar surface of the metatarsals and toes.
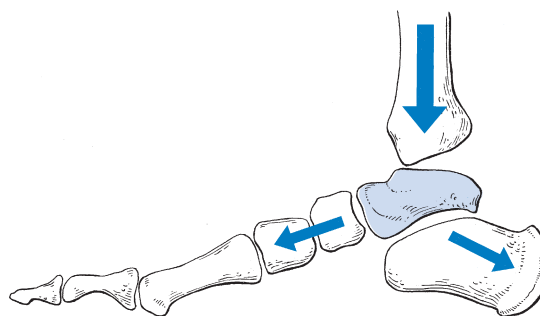
The posterior segment

The talus is the mechanical keystone at the ankle (Fig. 4). It distributes the body weight backwards towards the heel and forwards towards the midfoot (medial arch of the plantar vault). The talus has no muscular insertions but is entirely covered by articular surfaces and ligamentous reinforcements. It is also crossed by the tendons of the extrinsic muscles of the foot.
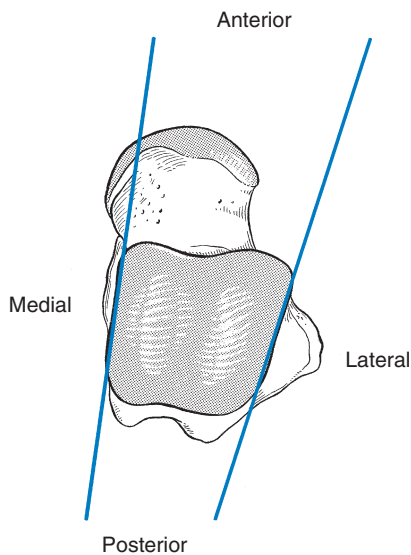
Ankle joint

The superior surface and the two sides of the body of the talus are gripped between fibular and tibial malleoli, forming the ankle mortice (see Standring, Fig. 84.16). Stability of this tibiofibular mortice is provided by the anterior and posterior tibiofibular ligaments and the interosseous ligament. Because the body of the talus is wedge shaped, with the wider portion anterior, no varus–valgus movement will be possible with an ankle held in dorsiflexion, unless the malleoli or the tibiofibular ligaments are damaged (Fig. 5).

The normal movement of the ankle joint is plantiflexion–dorsiflexion, through an axis that passes transversely through the body of the talus. The lateral end of this axis goes through the lateral malleolus (Fig. 6). Hence, a normal plantiflexion–dorsiflexion movement does not influence the tightness of the calcaneofibular ligament. At the medial end, however, the axis is placed under the tip of the medial malleolus and thus under

Fig 2 • The three arches of the foot.

Fig 3 • The three segments of the foot: 1, phalanges; 2, metatarsals; 3–5, medial, intermediate and lateral cuneiforms; 6, navicular; 7, cuboid; 8, talus; 9, calcaneus.

Fig 4 • The talus distributes the body weight to the heel and midfoot.

**Fig 5** • The body of the talus is wedge shaped with a wider anterior portion.
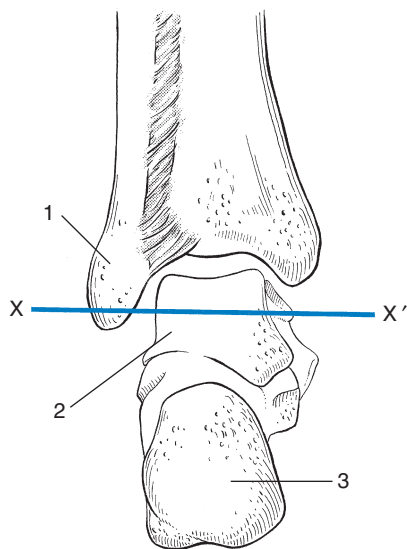
Fig 6 • Axis of plantiflexion–dorsiflexion (X–X′): 1, lateral malleolus; 2, talus; 3, calcaneus.

the malleolar point of attachment of the medial ligaments. Here, the posterior fibres of the deltoid ligament will become taut on dorsiflexion and the anterior fibres on plantiflexion (Fig. 7).

Subtalar joint

The subtalar or talocalcaneal joint consists of two separate parts, divided by the tarsal canal (Fig. 8), which is funnel shaped with the wide portion at its lateral end. The lateral end of the canal is easily palpated in front of the fibular malleolus between talus and calcaneus, especially when the foot is inverted. The canal runs posteromedially, to have its medial opening just behind and above the sustentaculum tali. In the canal a strong ligament, the interosseous talocalcaneal ligament, binds the two bones (see Standring, Fig. 84.15).
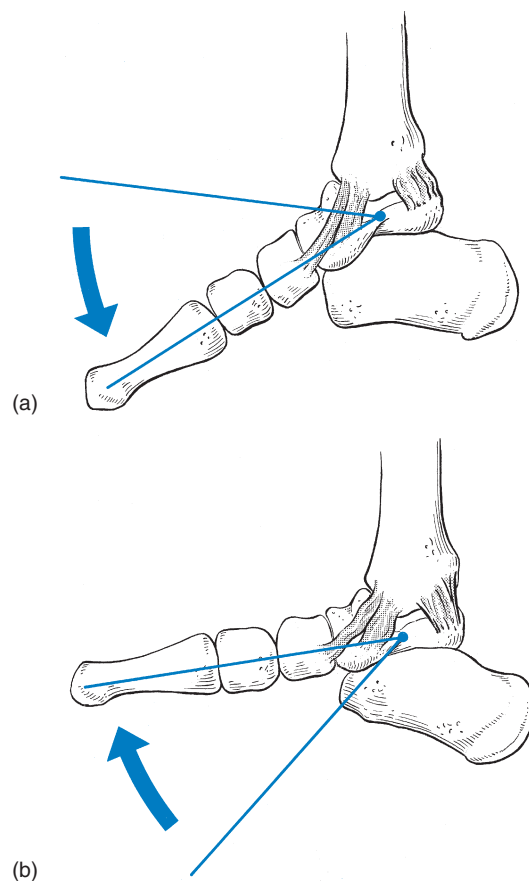
Fig 7 • The anterior fibres of the deltoid ligament become taut during plantiflexion (a) and the posterior fibres during dorsiflexion (b).
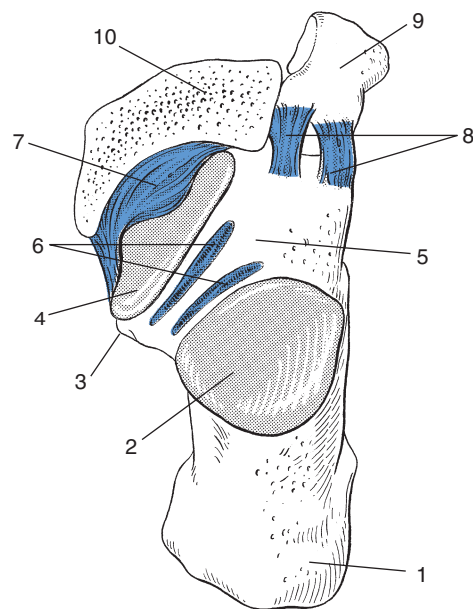
Fig 8 • View of the plantar calcaneonavicular ligament from above, with the talus removed: 1, calcaneus; 2, posterior part of subtalar joint; 3, sustentaculum tali; 4, anterior part of subtalar joint; 5, tarsal canal; 6, interosseous talocalcaneal ligament; 7, plantar calcaneonavicular ligament; 8, dorsal calcaneocuboid ligament; 9, cuboid; 10, navicular (transsection).

The main movement of the subtalar joint is a varus–valgus movement around an axis through the talus. This axis has a 45° angle to the horizontal and a 15° angle medial to a line drawn through the second metatarsal.

Ligaments of ankle and subtalar joints
(see Standring, Fig. 84.13)

Lateral ligaments

The anterior talofibular ligament is a triangular structure, its base attached to the anterior margin of the fibular malleolus and the smaller insertion at the neck of the talus (Fig. 9), just behind the mouth of the sinus tarsi.

The calcaneofibular ligament is a strong round band running obliquely downwards and backwards from the apex of the fibular malleolus to the lateral surface of the calcaneus.
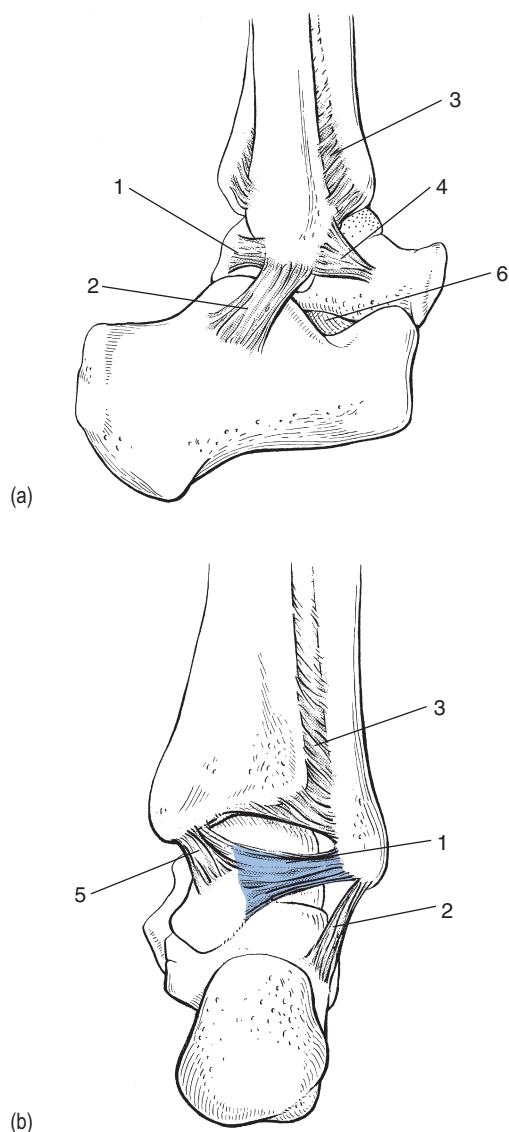
The posterior talofibular ligament arises from the medial surface of the lateral malleolus and runs horizontally and medially to insert at the posterolateral tubercle of the talus.

Because the axis of plantiflexion–dorsiflexion runs through the origin of these ligaments (the tip of the fibula), they are not taut during these movements. The exception is the anterior talofibular ligament, the medial fibres of which originate higher up on the fibula. These become stretched at the end of the plantiflexion movement.

The main function of the lateral ligaments is to prevent excessive varus movement, especially during plantiflexion. In extreme plantiflexion, the mortice no longer stabilizes the broader anterior part of the talus; varus movement of the ankle is then possible.
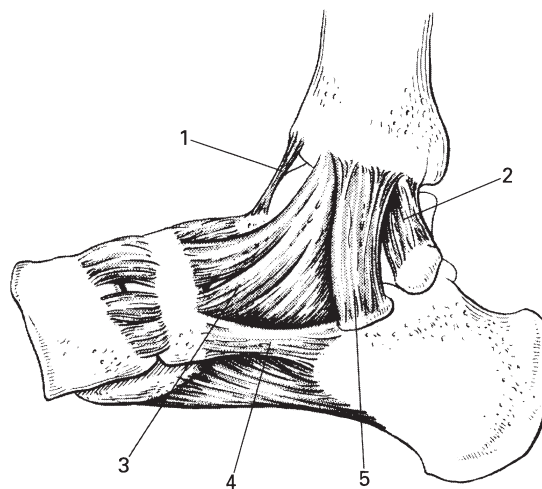
Medial ligaments

The deltoid ligament is a strong and thick ligament and has deep and superficial layers. The first has fibres which run from the medial malleolus to separate parts of the talus (anterior tibiotalar and posterior tibiotalar ligaments; Fig. 10). The second runs from the medial malleolus to the sustentaculum tali (tibiocalcaneal ligament) and to the navicular bone (tibionavicular ligament).

The inferior part of the ligamentous structures at the inner side of the ankle is the plantar calcaneonavicular ligament, which runs from the sustentaculum tali to the inferior border of the navicular bone. This ligament also helps to form the talocalcaneonavicular joint (Fig. 8).

The middle segment

There are five tarsal bones: navicular, cuboid and the three cuneiforms (see Standring, Fig. 84.11). They form a semi-rigid transverse arch, held together with the interosseous ligaments and the functional stirrup of the tibialis anterior and the peroneus longus (see Standring, Fig. 84.4).

(a)

(b)

Fig 9 • Lateral and posterior ligaments of the ankle: (a) lateral view; (b) posterior view: 1, posterior talofibular ligament; 2, calcaneofibular ligament; 3, distal tibiofibular ligament; 4, anterior talofibular ligament; 5, posterior tibiotalar ligament; 6, tarsal canal.

Fig 10 • Medial ligaments of the ankle: 1, anterior tibiotalar ligament; 2, posterior tibiotalar ligament; 3, tibionavicular ligament; 4, plantar calcaneonavicular ligament; 5, tibiocalcaneal ligament.
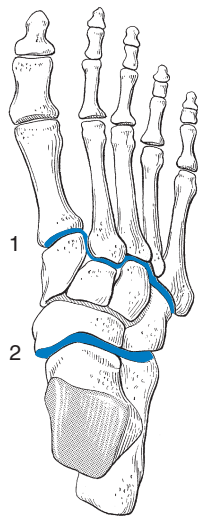
Fig 11 • Midtarsal joint: Lisfranc's (1) and Chopart's (2).
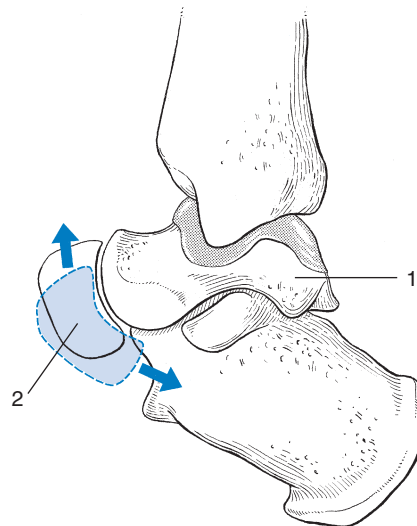
Fig 12 • Mobility of the talonavicular joint: 1, talus; 2, navicular.

The middle segment is the keystone in the plantar vault. Its elasticity permits accommodation of uneven surfaces during walking.

The joint between the posterior segment (talus and calcaneus) and the middle segment (navicular and cuboid) is the transverse tarsal or *Chopart's* joint; that between middle and anterior segment is the tarsometatarsal or *Lisfranc's* joint (Fig. 11). Functionally, all the articulations act as one structure. Therefore, Cyriax called them the midtarsal joint. Passive clinical testing evokes considerable movement in three possible directions: flexion–extension, pronation–supination and abduction–adduction.

Chopart's joint

The calcaneocuboid joint, being semi-rigid, only permits some gliding movement. At the talonavicular joint, larger movements are possible in the three directions (flexion–extension, pronation–supination and abduction–adduction). This greater mobility is because the articular surface of the talar head is larger than the surface of the adjoining navicular bone, so permitting a gliding of the navicular bone along the surface of the talus (Fig. 12).

Lisfranc's joint

The joint line is not a continuous one between the bases of the metatarsals and the anterior border of the cuneiforms and navicular bones: the intermediate cuneiform is set back and forms a fork into which fits the base of the second metatarsal (Fig. 13). Hence, the second metatarsal moves only in a plantiflexion–dorsiflexion plane and forms the axis of rotation in the tarsometatarsal joint. The base of the third metatarsal rotates around the second, the fourth around the third, and the base of the fifth moves around the fourth. The base of the first metatarsal also rotates around that of the second.

Apart from this rotational movement, the Lisfranc joint allows some abduction–adduction and considerable plantiflexion–dorsiflexion movements. The specific nature of the
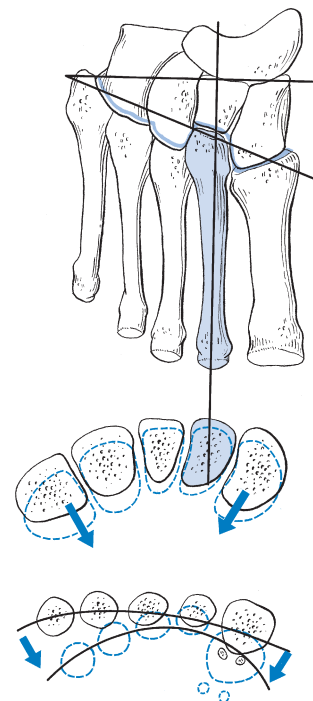
Fig 13 • Movements at Lisfranc's joint.

Lisfranc line has a particular consequence for plantiflexion–dorsiflexion: because the line of the tarsometatarsal joints runs obliquely (its medial end lies 2 cm anterior to its lateral end), dorsiflexion will include some adduction. Furthermore, the bases of the metatarsals have a cone-shaped form. During plantiflexion the heads of the metatarsals therefore do not move straight downwards but incline towards the axis of the foot and so increase the curvature of the anterior arch (Fig. 13). In contrast, extension of the metatarsals is followed by flattening of the arch. These relationships are of great importance in understanding the mechanism of splay foot.

Ligaments of the middle segment

The architecture of the plantar vault is protected by strong plantar and interosseous ligaments. Some of these have particular clinical importance and play a role in a number of painful conditions at the midfoot. These ligaments are (see Standring, Fig. 84.13):

- *At the lateral aspect:* the lateral calcaneocuboid ligament (Fig. 14), which can be easily palpated at the lateral joint line between calcaneus and cuboid, just above the peroneal tendons. This ligament is often damaged after an inversion sprain.
- *At the medial aspect:* the plantar calcaneonavicular ligament, which is of great importance in preventing excessive dorsiflexion–abduction movements at the midfoot and thus prevents a flattening of the medial anteroposterior arch (Fig. 10).

The anterior segment

The metatarsal shafts and the tarsometatarsal joints form the transverse anterior arch of the plantar vault (see Standring, Fig. 84.4).

Changes in the curvature of the anterior arch result from movements occurring in the tarsometatarsal joints. In a plantiflexed position the anterior part of the foot is hollowed, whereas in a dorsiflexed position it is flattened. In that the arch is spanned only by relatively weak intermetatarsal ligaments and by only one muscle, the transverse head of the adductor hallucis, the plantiflexed position at the tarsometatarsal joints is of great importance in maintaining the curvature of the arch and in preventing flattening of the foot.

The two pillars of the arch are in contact with the ground through the soft tissues: the head of the first metatarsal rests on the sesamoid bones, about 6 mm from the ground; the head of the fifth metatarsal bone lies 5 mm above the ground; the head of the second metatarsal bone is, at about 9 mm, the highest of the row; and those of the third and fourth take up an intermediate position (Fig. 15).

The sesamoid bones are incorporated into the tendons of the flexor hallucis brevis and act as a fulcrum in its function. They also play a role in bearing the body weight. The base of the proximal phalanx articulates in a gliding manner upon the convex articular surface of the metatarsal head, thus allowing a considerable range of plantiflexion–dorsiflexion movement. The first metatarsophalangeal joint is normally capable of 30° of flexion and 90° of extension.

The particular insertions of the flexor hallucis longus and the flexor hallucis brevis muscles to the proximal and distal phalanges of the big toe cause the toe to be pressed to the ground during the 'foot-off' phase of walking (Fig. 16b), which distributes the body load. In the outer four toes, the proximal phalanx is free from muscle insertions, because the insertions of the flexor digitorum longus and flexor digitorum brevis fall at the base of the distal and middle phalanges. Contraction of these muscles therefore produces a prehensile movement in the forefoot (Fig. 16a).
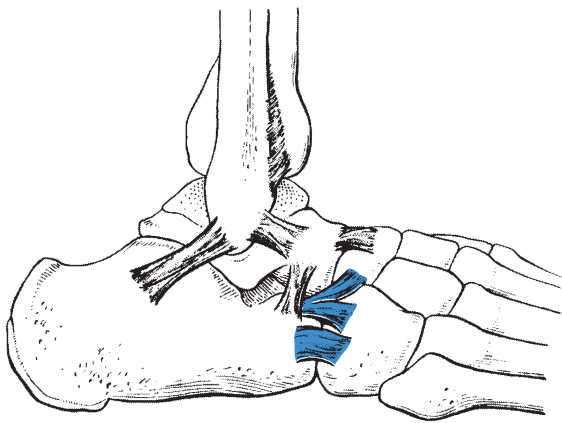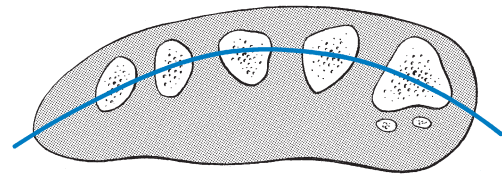

Fig 14 • Calcaneocuboid ligaments.

Fig 15 • The anterior arch at the level of the metatarsal heads.
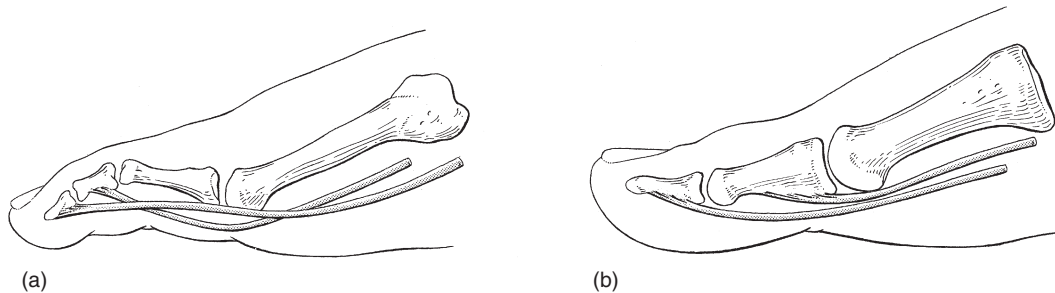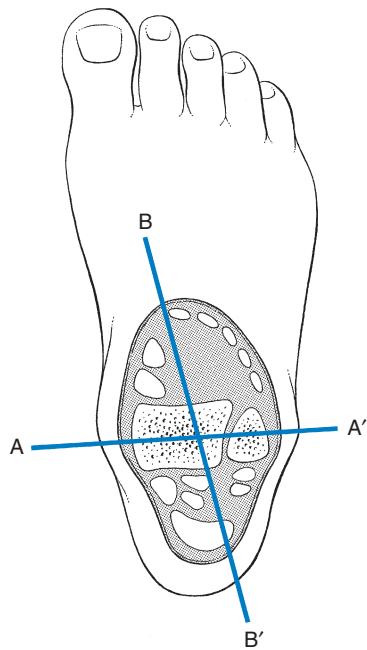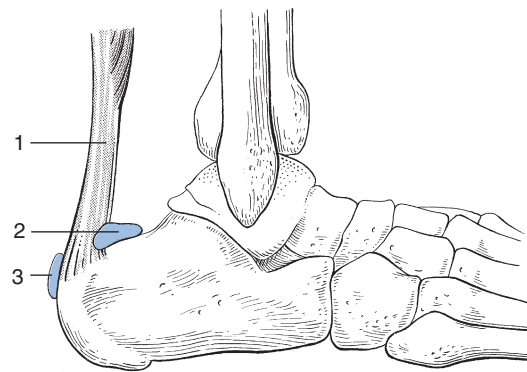

(a)   (b)

Fig 16 • Gripping movement at the outer toes during contraction of the flexor digitorum (a) and pressing movement at the big toe during contraction of the flexor hallucis (b).

Fig 17 • Functional position of the tendons in relation to the axes of the foot.

Table 1 The plantiflexors

	Peripheral nerve	Spinal innervation
Triceps	Tibial	S1–S2
Tibialis posterior	Tibial	L4/L5, S1
Peronei	Superficial peroneal	L5, S1
Flexor hallucis longus	Tibial	L5, S1
Flexor digitorum longus	Tibial	L5, S1

Muscles and tendons

Plantiflexors

All the tendons lying behind the axis AA′ at the ankle (Fig. 17) are plantiflexor muscles (Table 1). In practice, however, the triceps (soleus and both gastrocnemii) generates almost all the strength of plantiflexion (see Standring, Fig. 83.10).

The gastrocnemius originates by two heads, one at each femoral condyle. It spans two joints and is therefore not only a plantiflexor at the ankle but also a weak flexor of the knee.

The soleus originates from the upper tibia and fibula, below the knee joint. Halfway down the leg, the soleus and gastro-cnemius muscles meet in the Achilles tendon. The anterior fibres of the soleus run further downwards along the tendon and the medial head of the gastrocnemius ends a little higher than the lateral. The strong Achilles tendon inserts at the pos-terior surface of the calcaneus (Fig. 18). The Achilles tendon is surrounded throughout its length by thin gliding membranes called the paratenon. The paratenon functions as an elastic

Fig 18 • Insertion of the Achilles tendon, and the relationship of the bursae to it: 1, Achilles tendon; 2, sub-Achilleal bursa; 3, subcutaneous bursa.

sleeve (although probably not so effectively as a true tendon sheath) and permits free movement of the tendon within the surrounding tissues. A bursa lies between the upper part of the calcaneus and the anterior surface of the Achilles tendon. Sometimes a pathological subcutaneous bursa forms between the posterior aspect of the calcaneus and the skin.

Because the insertion at the calcaneus is medial to the axis of rotation (BB′, Fig. 17) of the subtalar joint, the triceps surae is also a weak invertor of the foot.

The other plantiflexor muscles – the tibialis posterior, flexor hallucis longus, flexor digitorum longus, and peronei – are rather weak (see Standring, Fig. 83.11). Although they can achieve active plantiflexion of the foot after a rupture of the Achilles tendon, they can only do this when the foot is free and unsupported. An intact triceps muscle and Achilles tendon are necessary to stand on tiptoe. The main function of the tibialis posterior is inversion and the function of both the peronei is eversion: these muscles are discussed later.
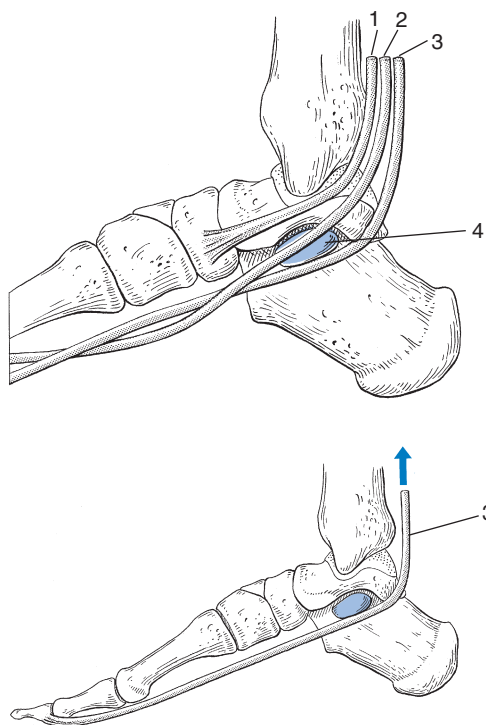
The flexor hallucis longus originates at the distal two-thirds of the posterior surface of the fibula and at the interosseous membrane. It runs behind and under the medial malleolus, in a sulcus of the talus, under the sustentaculum tali and along the inner border of the foot to insert at the base of the distal phalanx of the big toe. The flexor digitorum longus arises from the posterior aspect of the tibia and passes under the flexor retinaculum and behind the medial malleolus to attach at the distal phalanges of the four outer toes. Because its tendons cross the tendon of the flexor hallucis longus from below at the midfoot, the function of the latter will be reinforced by the first.

The three tendons at the medial malleolus run in a fibrous tunnel, formed by the tibia and the flexor retinaculum. At this level they are covered by a tendon sheath. From anterior to posterior they are the tendons of the tibialis posterior, the flexor digitorum longus and the flexor hallucis longus. The flexor hallucis longus is the only tendon of the three running behind the sustentaculum tali. This position seems to play a role in maintaining the medial arch. The long flexor tendon of the big toe acts on the sustentaculum tali as a string on a pulley, and pushes the medial arch upwards during contraction (Fig. 19).

Table 2 The dorsiflexors

	Peripheral nerve	Spinal innervation
Tibialis anterior	Deep peroneal	L4 (L5)
Extensor hallucis longus	Deep peroneal	L4, L5
Extensor digitorum longus	Deep peroneal	L4, L5

Table 3 The invertors

	Peripheral nerve	Spinal innervation
Tibialis anterior	Deep peroneal	L4, L5
Tibialis posterior	Tibial nerve	L4, L5, S1
Extensor hallucis longus	Deep peroneal	L4, L5
Flexor digitorum longus	Tibial nerve	L5, S1
Flexor hallucis longus	Tibial nerve	L5, S1, S2

Fig 19 • The tendons at the medial malleolus: 1, tibialis posterior; 2, flexor digitorum longus; 3, flexor hallucis longus; 4, sustentaculum tali.

Dorsiflexors

The tendons lying in front of the axis AA' at the ankle (Fig. 17) are those of the dorsiflexor muscles: the tibialis anterior, extensor hallucis longus and extensor digitorum longus (Table 2, see Standring, Fig. 83.7).

Because the extensor hallucis longus and the tibialis anterior are situated at the medial side of the axis of rotation (BB'), they act as supinators. The extensor digitorum longus, passing lateral to this axis, acts as a pronator.

The extensor hallucis longus arises from the anterior surface of the fibula and the interosseus membrane, and passes across the anterior surface of the ankle to insert at the distal phalanx of the big toe. Its main function is extension of the big toe. It also assists in dorsiflexion of the foot.

The extensor digitorum longus arises from the lateral condyle of the tibia and the anterior surface of the fibula. It runs anterior to the ankle, under the lateral half of the retinaculum extensorum digitorum, and divides into four tendons which run to the four outer toes. At its end, each tendon

divides into a central slip that inserts at the base of the middle phalanx and two lateral slips inserting at both sides of the distal phalanx. The strongest function of the extensor digitorum is dorsiflexion at the ankle. It is of course also the main extensor of the toes but this function is only apparent when dorsiflexion at the ankle is counteracted by an antagonistic plantiflexion movement of the triceps surae.

The tibialis anterior is a strong dorsiflexor but first of all an adductor and supinator of the foot. Its dorsiflexion function is only possible when adduction–supination is counteracted by contraction of the peronei muscles.

Invertors (adduction–supination)

The tendons of the ankle lying medial to the axis BB' (Fig. 17) are those of invertor muscles (adduction–supination; Table 3). The two most important invertors are the tibialis posterior and tibialis anterior (see Standring, Fig. 84.2B).

The tibialis posterior originates from the posterior aspect of the tibia and fibula, runs behind the medial malleolus and inserts at the medial and plantar aspect of the tarsal and metatarsal bones. The most important insertion, however, is at the tubercle of the navicular bone (Fig. 20).

Because the tibialis posterior crosses the ankle, the subtalar and the transverse joints, it can act simultaneously on all three. The attachments to the other tarsal and metatarsal bones produce supination and are, therefore, very important in maintenance of the plantar vault.

The tibialis posterior is also a weak plantiflexor. Through its fibrous plantar attachments at the bases of the metatarsals, it also provides a plantiflexion movement at the midtarsal joints and therefore is responsible for supporting the anterior arch (see plantar movement at Lisfranc's joint). Congenital absence of these plantar attachments is therefore one of the causes of pes planus valgus.
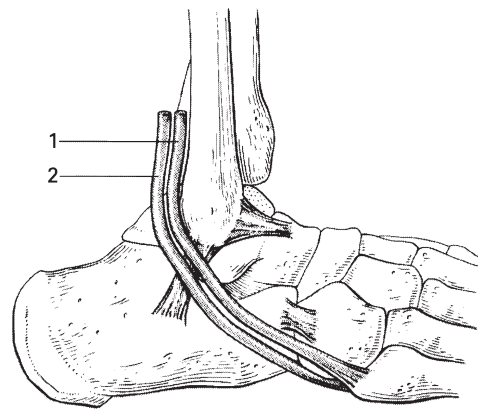
The tibialis anterior originates from the upper lateral half of the tibia and crosses the dorsum of the foot to insert at the medial aspect of the medial cuneiform. Because it lifts all the structures of the medial arch – first metatarsal, first cuneiform, navicular and talus – it is an adductor, dorsiflexor and supinator.
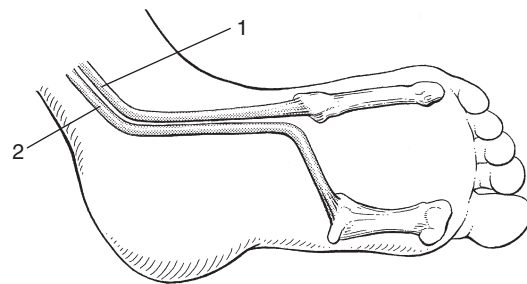
Evertors (abduction–pronation)

The muscles with tendons that lie lateral to the axis BB' act as evertors (abduction and pronation; Table 4). They are the
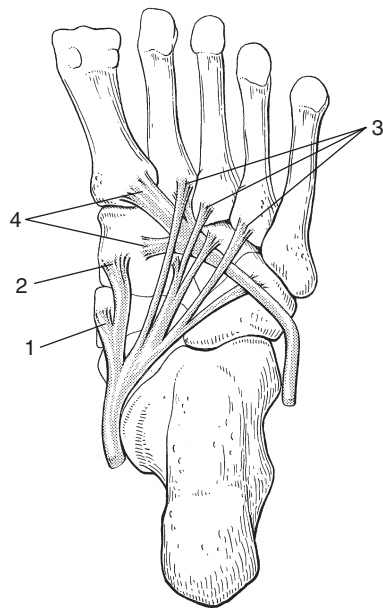
Fig 20 • Plantar view of the insertions of tibialis posterior, and its relationship with the tendon of the peroneus longus. 1, attachment to the tubercle of the navicular bone; 2, attachments to the tarsal bones; 3, attachments to the metatarsals; 4, insertions of the peroneus longus tendon.

Table 4 The evertors		
	Peripheral nerve	**Spinal innervation**
Peronei	Deep peroneal	L5, S1
Extensor digitorum longus	Deep peroneal	L4, L5, S1

extensor digitorum longus, peroneus tertius and peronei longus and brevis. The small peroneus tertius is absent in more than 10% of subjects and does not have any role in disorders of the foot.

The most powerful evertors are the peronei longus and brevis (see Standring, Fig. 84.2A). They arise from the lateral aspect of the fibula, the longus more proximally than the brevis. Their tendons run together in a common synovial sheath behind the lateral malleolus and are held in place by the retinaculum peroneorum. The tendon of the peroneus brevis, running more anteriorly and superiorly, inserts at the lateral tubercle of the base of the fifth metatarsal (Fig. 21). It acts as a strong abductor but also produces pronation of the anterior half of the foot.

The peroneus longus runs under the tendon of the brevis, along the lateral border of the foot. At the cuboid tubercle it turns obliquely medially and anteriorly to insert at the base of the first metatarsal and the first cuneiform bone (Fig. 20). The peroneus longus not only is an abductor–pronator and a weak plantiflexor of the foot, but it also plays an important role in the dynamics of the plantar arches. The abduction–pronation function is obvious from the view shown in Fig 22.

Plantiflexion is produced in two ways; directly and indirectly. Direct plantiflexion needs no further explanation,

Fig 21 • The peronea.

Fig 22 • Plantar view of the peronei in abduction-pronation: 1, peroneus brevis; 2, peroneus longus.

because the tendon runs behind the axis AA′ (Fig. 17). To understand indirect plantiflexion, the action of the triceps must be considered. Contraction of the triceps plantiflexes the calcaneus and the lateral metatarsals, connected through the cuboid with the calcaneus. By coupling the medial with the lateral metatarsals, the peroneus longus allows the triceps to pull on all the metatarsals at one time.

Another function of the peroneus longus is to accentuate the curvature at the three arches of the plantar vault. Together with the plantar expansions of the tibialis posterior, it provides an important muscular support of the transverse arch. In that it runs obliquely to the anterior and medial side, it also acts as a tightening device for the medial and lateral arches.

Intrinsic muscles

The sole of the foot contains a number of muscles that take origin and insert on the plantar aspect of the foot. Most arise from the calcaneus and the inferior part of the posterior segment and insert at or close to the phalanges.

The intrinsic muscles are the main contributors to the muscular support of the arches of the foot. They also assist the function of the long (extrinsic) muscles. Only the intrinsic muscles of the big toe and the dorsal interossei are clinically important.

The muscles of the big toe (flexor hallucis brevis, abductor hallucis and adductor hallucis) are inserted on the lateral aspect
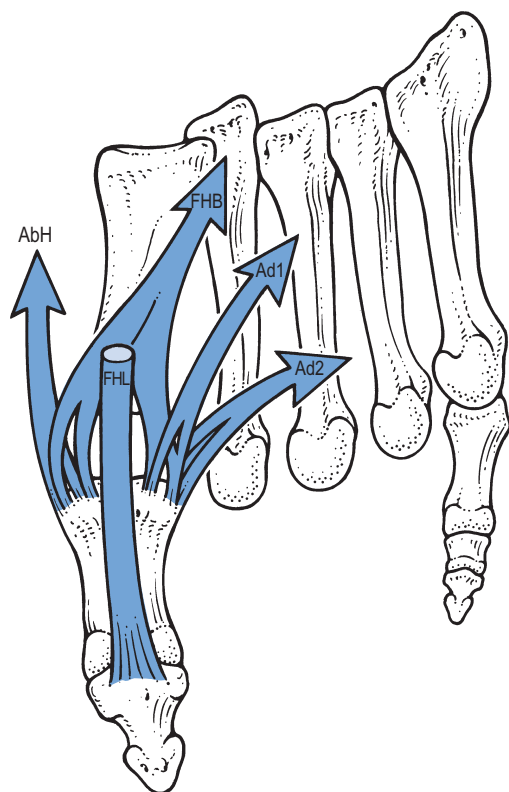
Fig 23 • Intrinsic muscles of the big toe: AbH, abductor hallucis; FHB, flexor hallucis brevis; FHL, flexor hallucis longus; Ad1 and Ad2, adductor hallucis.

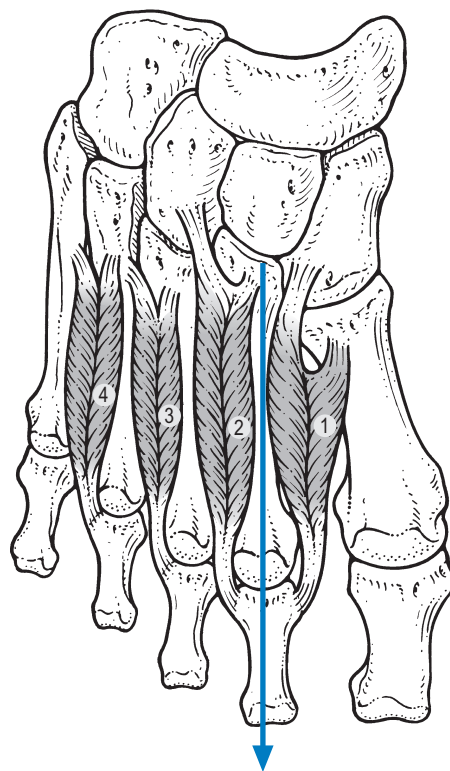Fig 24 • Dorsal interossei of the foot.

of the basal phalanx and into the two sesamoid bones articulating with the head of the first metatarsal. The medial sesamoid gives insertion to the abductor hallucis and to the medial portion of the flexor hallucis brevis. The lateral portion of the flexor hallucis brevis and the adductor hallucis insert on the lateral sesamoid (Fig. 23).
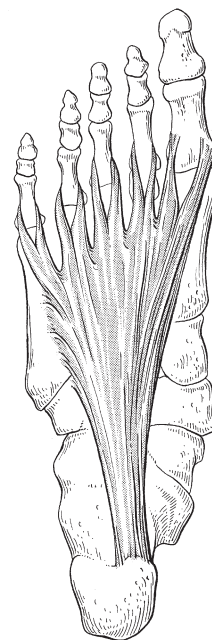
Dorsal interossei

The four bipenniform dorsal interossei originate from the sides of the adjacent metatarsal bones. The muscle bellies fill the intermetatarsal spaces and their tendons attach to the bases of the proximal phalanges and to the dorsal digital expansions. The first interosseus inserts into the medial side of the second toe; the other three pass to the lateral sides of the second, third and fourth toes (Fig. 24). They abduct the toes away from the axis of the foot (second row) and assist in flexion and extension movement of the toes.

The plantar fascia

Another structure that plays an important role in maintaining the longitudinal arches in the foot is the plantar fascia (Fig. 25). This multilayered fibrous aponeurosis originates at the medial tuberosity of the calcaneus and passes anteriorly to split into five fibrous bands, which attach to the digits in the following manner: each splits at the level of the corresponding
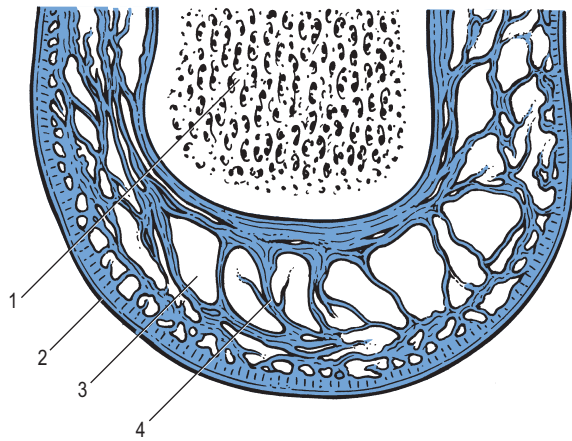

Fig 25 • The plantar fascia and its insertions.

metatarsophalangeal joint to allow passage of the short and long plantiflexor tendons and attaches at both sides of these joints and their ligaments. When the metatarsophalangeal joints are dorsiflexed during walking, the plantar fascia tightens and raises the longitudinal arch.

Fig 26 • Coronal section of the heel demonstrating the heel pad: 1, calcaneus; 2, skin and subcutis; 3, chambers; 4, vertical septa.

The heel pad

The heel pad is specifically constructed to function as an efficient shock absorber to attenuate the peaks of the dynamic forces during walking and running. The thick skin is connected with the periosteum of the calcaneus by large vertical fibrous septa, dividing the subcutis into separate compartments, filled with fat (Fig. 26). During compression these heel chambers are deformed and turn around the tuberosity of the os calcis. This deformation of the chambers together with the flow of the enclosed adipose tissue contributes to the shock absorption.