# Extensor Muscles

# 17

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The tibialis anterior, extensor hallucis longus and extensor digitorum longus muscles occupy the anterior compartment of the leg (Fig. 17.1). They are separated from the deep posterior muscles by the tibia, the fibula and the interosseous membrane.

## 17.1 Anatomy Key Points

### 17.1.1 Tibialis Anterior

The *tibialis anterior* is the largest and most medial muscle of the anterior compartment of the leg.

It is a fusiform muscle, located on the lateral side of the tibia. Its belly is thick and fleshy at its proximal third and becomes thin and fibrous at its distal third forming a strong oval tendon which is led by both extensor retinacula of the foot before its insertion.

The tibialis anterior is a circumpennate muscle with a thick central intramuscular aponeurosis.

It arises from several structures: the lateral femoral condyle, the superior half of the lateral surface of the tibia, the interosseous membrane and the deep surface of the fascia.

The muscular fibres run vertically downwards and end in a tendon, which is eccentric and lies on the anterior aspect of the muscle at the lower third of the leg.

It attaches on the medial and inferior surface of the first cuneiform bone and into the base of the first metatarsal bone.

This muscle overlaps the anterior tibial vessels and deep peroneal nerve in the upper part of the leg.

The blood supply to the tibialis anterior muscle comes from the anterior tibial artery, which originates from the popliteal artery in the posterior compartment of the leg and passes forward into the anterior compartment of the leg trough an aperture in the interosseous membrane. In the proximal third of the leg, the anterior tibial artery lies between the tibialis anterior and extensor digitorum longus muscles; in the middle third between the tibialis anterior and

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**Fig. 17.1** Anatomical scheme of the anterior leg compartment muscles. *TA* tibialis anterior, *EDL* extensor digitorum longus, *EHL* extensor hallucis longus. *EHL* lies in a deeper layer than *TA* and *EDL* and its muscle belly arises more distally

the extensor hallucis longus muscles and at the ankle lies between the tendon of the extensor hallucis longus and the first tendon of the extensor digitorum longus.

The main functions of the tibialis anterior muscle are dorsiflexion of the foot, inversion raising the medial side of the foot off the ground and stabilization of the ankle during walking.

The tibialis anterior tendon together with the extensor hallucis longus and extensor digitorum tendons are anchored to the tibial bony surface by the extensor retinacula, which are canal-like thickenings of the crural fascia or deep fascia of the leg.

The superior extensor retinaculum (transverse crural ligament) lies between the fibula and tibia proximal to the malleoli.

The inferior extensor retinaculum (cruciate crural ligament) presents a Y shape and extends more distally between calcaneus, medial malleolus and plantar aponeurosis.

### 17.1.2 Extensor Hallucis Longus

The *extensor hallucis longus* muscle is a thin muscle located in the anterior lower leg compartment between the tibialis anterior and the extensor digitorum longus muscles. It arises more distally with respect to the tibialis anterior and the extensor digitorum longus, from the middle third of the anterior surface of the fibula and from the anterior surface of the interosseous membrane. The fibres run downwards, merging into a tendon above the superior extensor retinaculum.

The extensor hallucis longus tendon is eccentric and lies on the anterior aspect of the muscle, passes deep to the superior extensor retinaculum and through the inferior extensor retinaculum inserting into the dorsal aspect of the base of the distal phalanx of the hallux.

In proximity of the metatarsophalangeal joint, a thin prolongation merges from each side of the tendon and covers the dorsal surface of the joint. An expansion

from the medial side of the tendon usually attaches on the base of the proximal phalanx.

In the distal third of the leg, the extensor hallucis longus tendon crosses the tendon of the extensor digitorum longus.

The extensor hallucis longus muscle is innervated by the *deep fibular nerve* and vascularized by the *anterior tibial vessels* which course between it and the tibialis anterior.

The extensor hallucis longus muscle works in synergy with the other extensor of the big toe (the extensor hallucis brevis muscle), pulling the toe upwards and extending the phalanges of the hallux. The extensor hallucis longus also plays a role in the dorsiflexion of the ankle joint.

### 17.1.3 Extensor Digitorum Longus

The *extensor digitorum longus* muscle lies lateral and deep to the tibialis anterior muscle and medial to the peroneus brevis muscle.

It is a pennate muscle arising from several structures such as the lateral tibial condyle, the upper part of the anterior surface of the shaft of the fibula, the upper part of the interosseous membrane, the deep surface of the fascia cruris and the anterior crural intermuscular septum.

The extensor digitorum longus is serviced by the deep peroneal nerve and the anterior tibial artery, which, in the upper part of the leg, courses between the extensor digitorum and the tibialis anterior muscles.

The extensor digitorum longus fibres course downwards along the anterior aspect of the lower leg and near the ankle turn into a long distal tendon which passes behind the superior and the inferior extensor retinaculum together with the Peroneus tertius, an additional fifth tendon present in about 90 % of the people running towards the lateral foot edge and inserting at the fifth metatarsal bone. The peroneus tertius is a small muscle, laying laterally to the extensor digitorum longus and is considered as a part of it.

The extensor digitorum longus tendon divides into four parts, running towards the corresponding small toe and inserting into the second and third phalanges.

The tendons to the second, third and fourth toes, on the lateral side of the metatarsophalangeal joints, combine with one of the extensor digitorum brevis tendons to form a broad dorsal aponeurosis, which covers the dorsal surface of the proximal phalanx. At the interphalangeal joint, it divides into three slips: the central one is inserted into the base of the middle phalanx and the two laterals are inserted into the base of the distal phalanx.

Variations within the extensor digitorum longus muscle are not uncommon and include attachment also to the hallux.

When the extensor digitorum longus muscle is in contraction, it causes the extension of the lateral four toes and the dorsiflexion of the foot. In addition, it is responsible for a powerful eversion (pronation).

## 17.2 Ultrasound Examination Technique

The patient is seated on the examination bed with the knee flexed about 20–45°, and the plantar surface of the foot lies flat on the table (Fig. 17.2).

Palpate the tibial tuberosity on the anterior aspect of the tibia, which can be considered an important bony landmark, and place the probe on it in an axial position.

Move the transducer slightly lateral and identify the myotendinous junction of the tibialis anterior near the patellar tendon (Fig. 17.3).

Rotate the probe by 90° to evaluate on a longitudinal plane the proximal attachment of the tibialis anterior tendon on the tibial tuberosity (Fig. 17.4).

Replace the probe in a transverse plane and shift it caudally and lateral to identify the cortical surface of the fibula and the anterior tibial crest in the same scan (Fig. 17.5).

The cortex of the tibia and fibula are identified as continuous hyperechoic lines with posterior shadowing.

The interosseous membrane can be seen as a thin concave hyperechoic layer between the tibial and fibular cortex and opposite to the tibialis posterior muscle.

Power Doppler could be useful in order to identify the anterior neurovascular bundle and the passage of the anterior tibial vessel through the interosseous membrane (Fig. 17.6).

At this level, it is possible to demonstrate the large muscular belly of the tibialis anterior characterized by a thick central aponeurosis (Fig. 17.7).

**Fig. 17.2** Leg position to evaluate the anterior leg compartment

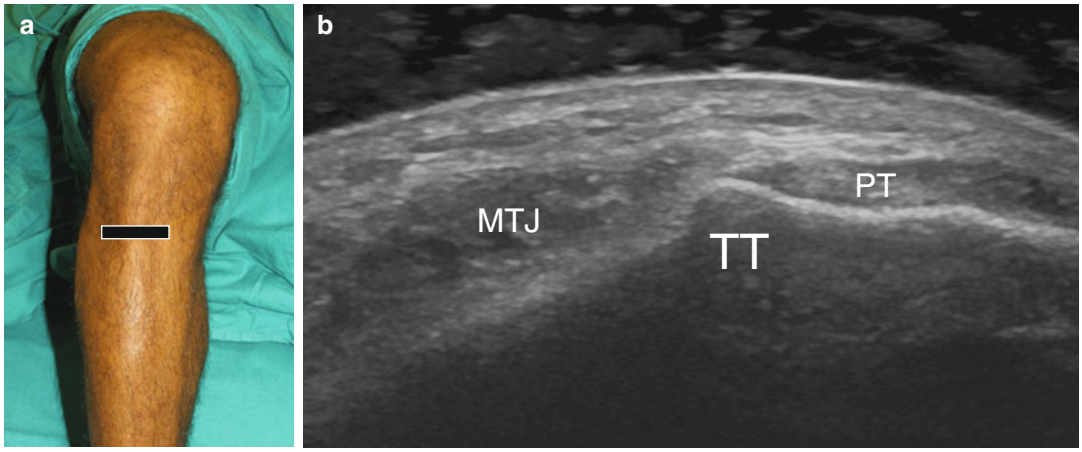


**Fig. 17.3** (**a**) Probe position to evaluate the myotendinous junction of the tibialis anterior muscle on axial plane; (**b**) US axial scan: the myotendinous junction (*MJT*) lies lateral to the patellar tendon (*PT*). *TT* tibial tuberosity

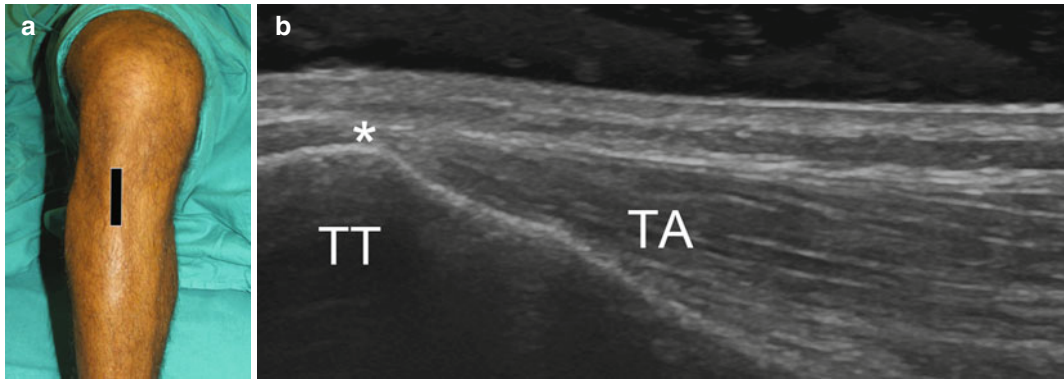


**Fig. 17.4** (**a**) Probe position to evaluate the myotendinous junction of the tibialis anterior muscle on longitudinal plane; (**b**) US longitudinal scan shows the myotendinous junction (*) and the proximal insertion of the tibialis anterior (*TA*) on the tibial tuberosity (*TT*)

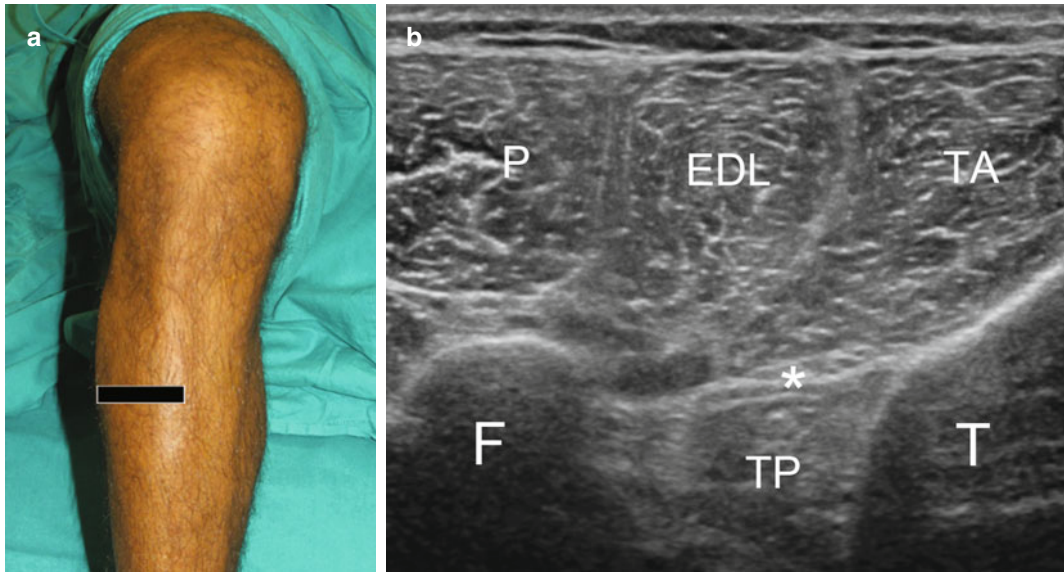


**Fig. 17.5** (**a**) Probe position to evaluate the anterior leg compartment at the proximal third of the leg on axial plane. (**b**) US axial scan at the proximal third of the leg illustrates the relationship between the tibialis anterior (*TA*), the extensor digitorum longus (*EDL*) and the peronei muscles (*P*). The interosseous membrane (*) appears as a hyperechoic line, which extends between the tibia (*T*) and the fibula (*F*). *TP* tibialis posterior muscle

This muscle is covered by a thin echogenic fascia (crural fascia) that continues with the anterior fascia of the leg.

A focused evaluation of the integrity of this structure is mandatory if muscle hernia is suspected. A squatting position can be useful to demonstrate the herniation of the muscle and the focal defect of the fascia.

Longitudinal US scan with the probe oriented perpendicular to the skin, in the sagittal plane, is useful to visualize the muscle belly on its long axis. The central aponeurosis appears as a hyperechoic structure that continues from the extra muscular tendon and extends into the muscle dividing in two unipennate halves, above and below the aponeurosis (Fig. 17.8).

At this level, we can measure the muscular thickness and pennation angle (see Chap. 4).

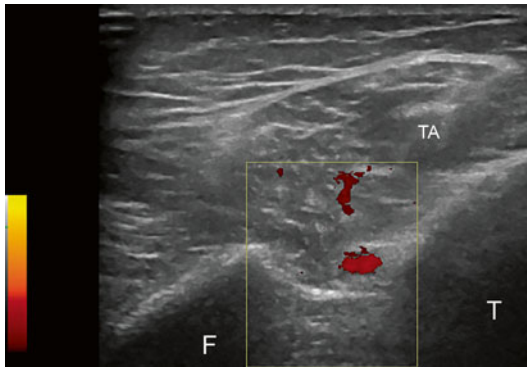


**Fig. 17.6** US axial scan at the proximal third of the leg. Power Doppler is useful to identify the anterior tibial artery at the level of the interosseous membrane. *TA* tibialis anterior muscle, *T* tibia, *F* fibula

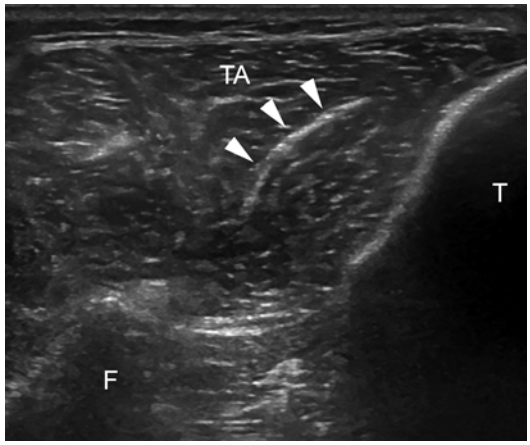


**Fig. 17.7** US axial scan at the proximal third of the leg. Note the large muscular belly of the tibialis anterior muscle (*TA*) and the thick central aponeurosis (*arrowheads*). *T* tibia, *F* fibula

Ask the patient to contract the muscle with dorsiflexion of the foot to evaluate the increasing of the pennation angle.

Always remember to move the transducer caudally following the tibialis anterior muscle belly until the myotendinous junction (Figs. 17.9 and 17.10).

Then place the transducer on the proximal middle third of the tibial shaft and shift the probe laterally to examine the extensor digitorum longus muscle belly on an axial scan. In this scan, the extensor digitorum longus muscle is located laterally to the tibialis anterior muscle (Fig. 17.5).

Then move the transducer caudally, always in a transversal plane, until the middle of the leg to visualize the extensor hallucis longus muscle which arises at this level (Fig. 17.11).

If the extensor hallucis longus and the extensor digitorum longus muscles are not well separated, an active or passive muscular contraction can be helpful to distinguish them.

Always remember to move the transducer caudally following the extensor digitorum longus and the extensor hallucis longus muscle bellies until the myotendinous junction (Figs. 17.12 and 17.13).

Rotate the probe by 90° to assess the internal structure of each muscle belly (Fig. 17.14).

Place the transducer over the dorsum of the ankle to examine the extensor tendon group in the axial plane. In this scan, it is possible to visualize, from medial to lateral, the tibialis anterior, the extensor hallucis longus and the extensor digitorum longus tendons. Always examine these structures from the myotendinous junction to their distal insertion (Fig. 17.15).

At this level, also examine the deep peroneal nerve, which runs on the medial side of the anterior tibial artery (Fig. 17.16).

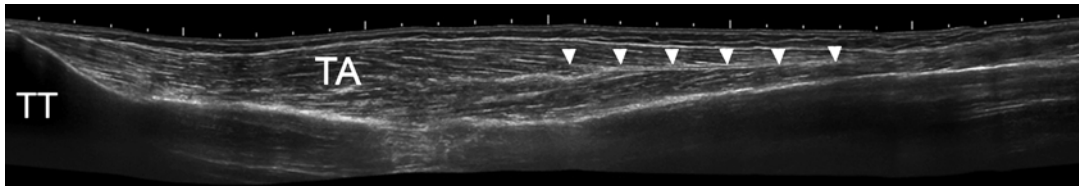


**Fig. 17.8** EFV US longitudinal scan of the tibialis anterior muscle (*TA*) from the tibial tuberosity (*TT*). Note the thick central aponeurosis (*arrowheads*) that appears as a hyperechoic structure into the muscular belly

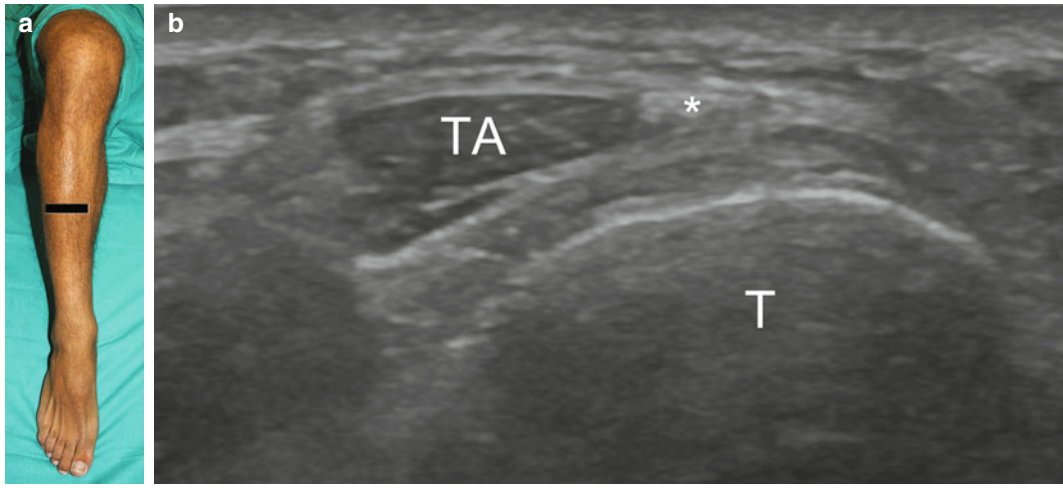


**Fig. 17.9** (**a**) Probe position to evaluate the myotendinous junction of tibialis anterior muscle (*TA*) on an axial scan. (**b**) US axial scan of the myotendinous junction (*) of TA. *T* tibia

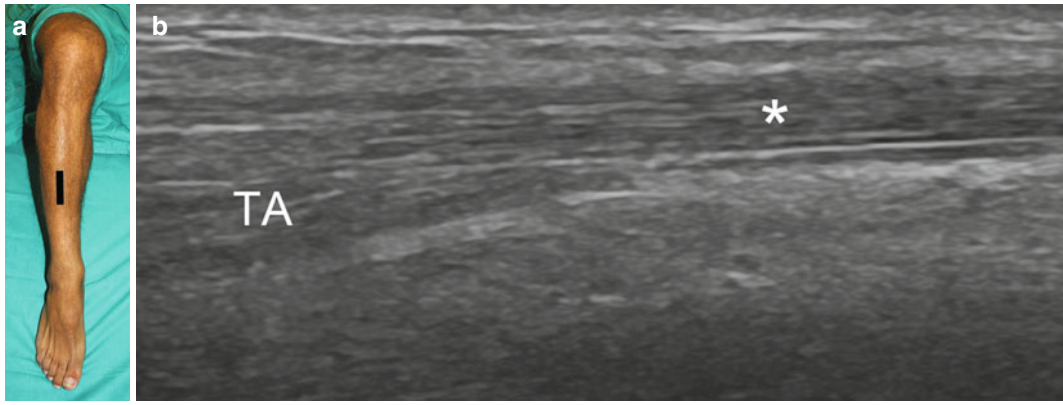


**Fig. 17.10** (**a**) Probe position to evaluate the myotendinous junction of the tibialis anterior muscle (*TA*) on a longitudinal scan. (**b**) US longitudinal scan of the myotendinous junction (*) of TA

**Focus On**

The *deep peroneal nerve (deep fibular nerve)* originates from the common fibular nerve near the neck of the fibula, between the fibula and upper part of the peroneus longus.

The deep fibular nerve travels in the anterior compartment of the leg on the anterior surface of the interosseous membrane.

It passes inferomedially, deep to extensor digitorum longus and, at the middle of the leg, comes in relation with the anterior tibial artery.

It runs initially lateral to the anterior tibial artery, but in proximity of the ankle joint it crosses over to run on the medial side.

At this level, the extensor hallucis longus muscle and tendon and the inferior

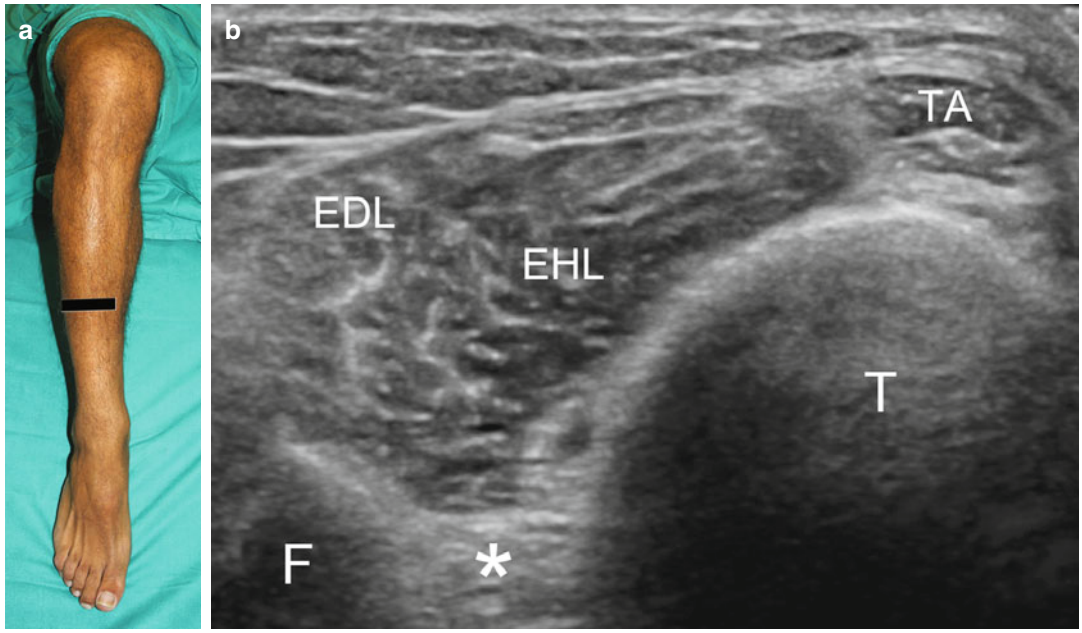


**Fig. 17.11** (**a**) Probe position to evaluate the anterior leg compartment at the distal third of the leg on axial plane. (**b**) US axial scan at the distal third of the leg. At this level, the myotendinous junction of the tibialis anterior (*TA*) may be evaluated. The extensor hallucis longus muscle (*EHL*) lies between the myotendinous junction of the tibialis anterior (*TA*) and the extensor digitorum longus muscle (*EDL*) belly. *T* tibia, *F* fibula, * interosseous membrane

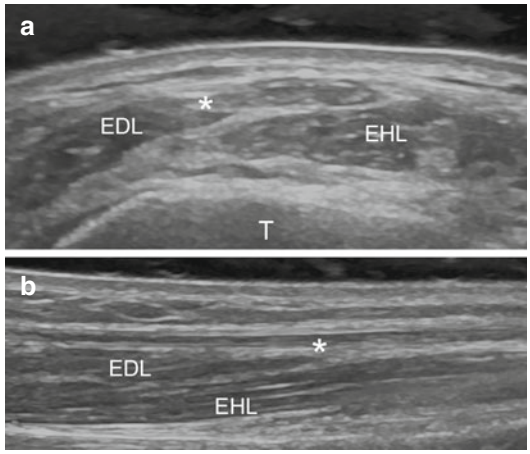


**Fig. 17.12** (**a**) US axial scan of the myotendinous junction (*) of the extensor digitorum longus (*EDL*) muscle (**b**) US longitudinal scan of the myotendinous junction (*) of the extensor digitorum longus (*EDL*) muscle. *EHL* extensor hallucis longus muscle

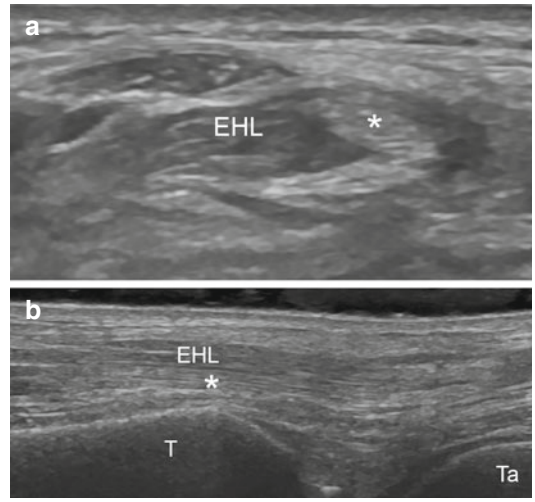


**Fig. 17.13** (**a**) US axial scan of the myotendinous junction (*) of the extensor hallucis longus (*EHL*) muscle (**b**) US longitudinal scan of the myotendinous junction (*) of the extensor hallucis longus (*EHL*) muscle. *T* tibia, *Ta* talus

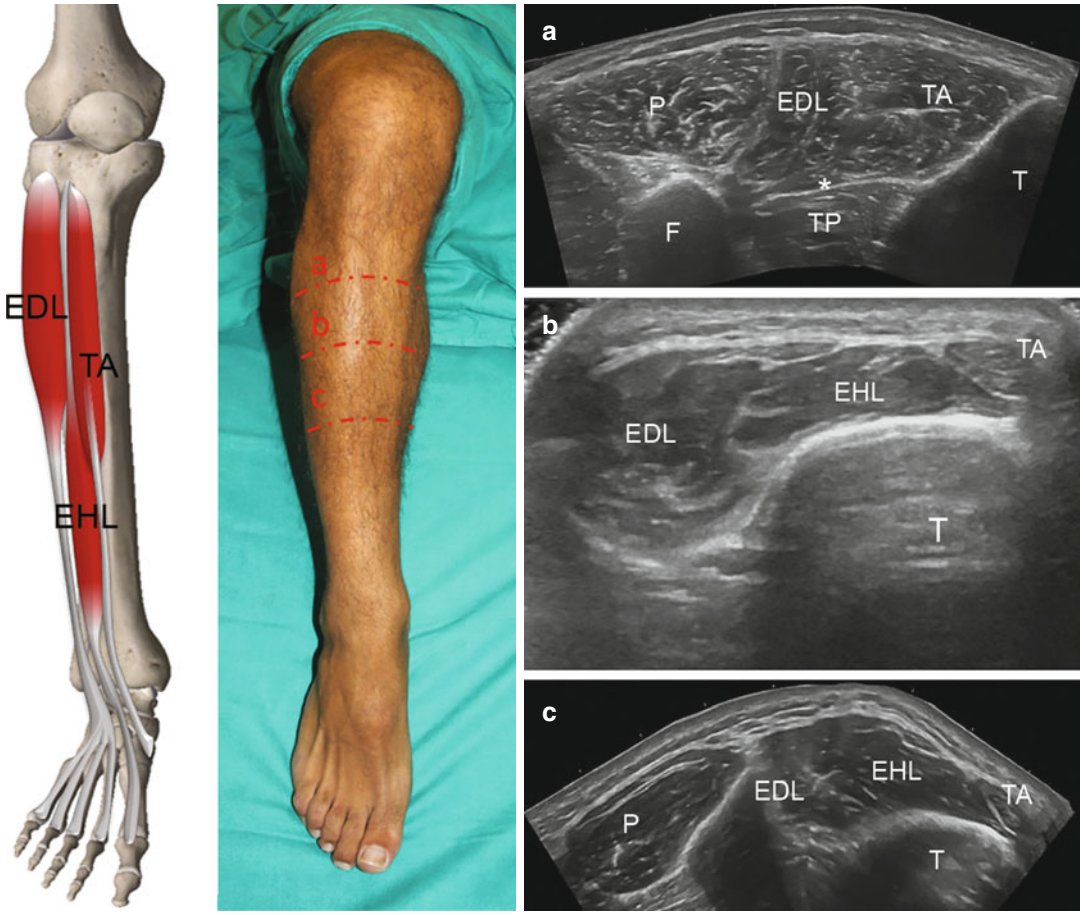


**Fig. 17.14** Anatomical scheme correlated to *EFV* US axial scans at different levels of the anterior compartment of leg muscles. (**a**) Proximal anterior compartment. EFV axial scan visualizes the relationship between the peroneus muscles (*P*) and the extensor muscles. The tibialis anterior muscle (*TA*) lies just lateral to the tibial crest and medial to the extensor digitorum longus muscle (*EDL*). The interosseous membrane (*) appears as a hyperechoic layer which separates *TA* from the tibialis posterior muscle (*TP*). (**b**) Middle third of leg anterior compartment. *EFV* axial scan shows *TA* myotendinous junction with its oval tendon anterior to the tibial edge. Note the *EDL* and extensor hallucis longus (*EHL*) muscle bellies. (**c**) Distal anterior compartment of the leg. *EFV* US axial scan evaluates the relationship between the peroneus muscle (*P*) and the extensor muscle at the distal third of the leg. The peroneus brevis and peroneus longus are not well separated. *T* tibia, *F* fibula

extensor retinaculum overly ventrally the nerve that passes through the anterior tarsal tunnel (the space located between the inferior extensor retinaculum and the fascia overlying the talus and the navicular bones).

Just under the inferior extensor retinaculum, the deep peroneal nerve divides into lateral and medial terminal branches.

The lateral terminal branch (external branch) passes across the tarsus anterolaterally and supplies the extensor digitorum brevis and the extensor hallucis brevis muscles. From the enlargement, it gives three small interosseous branches (dorsal interosseous nerves) for the innervation of the tarsal joints and the metatarsophalangeal joints of the second, third and fourth toes.

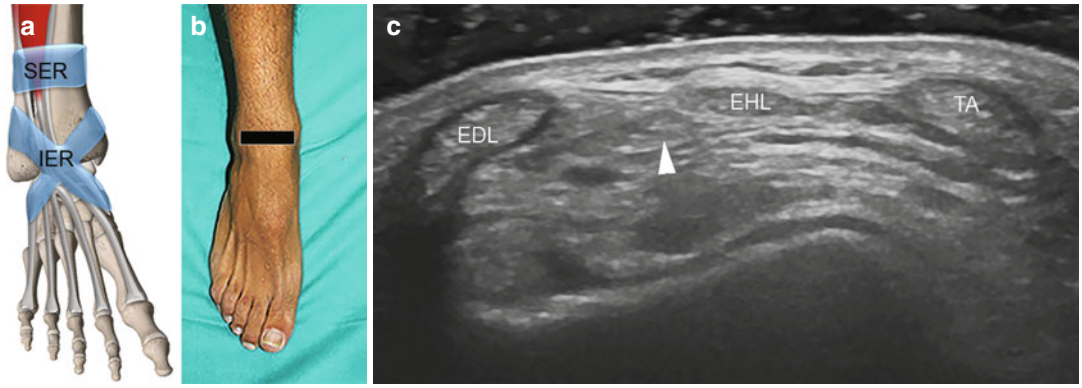


**Fig. 17.15** (**a**) Anatomical scheme of the extensor tendon group and extensor retinacula. *SER* superior extensor retinaculum, *IER* inferior extensor retinaculum. (**b**) Probe position to evaluate the extensor tendon group in the axial plane. (**c**) US axial scan of the extensor tendon group. *TA* tibialis anterior tendon, *EDL* extensor digitorum longus tendon, *EHL* extensor hallucis longus tendon, *arrow* deep peroneal nerve

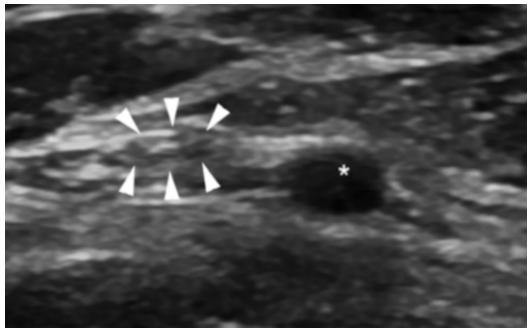


**Fig. 17.16** US axial scan of the deep peroneal nerve (*arrowheads*) at the level of the ankle joint. * anterior tibial artery

The medial terminal branch (internal branch) travels medial to the dorsalis pedis artery along the dorsum of the foot. At the first interosseous space, it divides into dorsal digital nerves, which provide sensory innervation to the first webspace and the adjacent dorsum of the foot between the first and second toes.

The deep fibular nerve provides motor innervation to the muscles of the anterior compartment of the leg, the tibialis anterior, extensor digitorum longus, extensor hallucis longus and peroneus tertius muscles.

It also provides sensory innervation to the webspace between the hallux and second digit.

Injury to the deep fibular nerve typically produces loss of dorsiflexion of the foot (foot drop), loss of extension of the toes and loss of sensation in the first webspace.

Complete the examination with dynamics scans in order to evaluate muscles and tendons also during contraction.

Evaluate also the integrity of the superior and inferior extensor retinacula and the relationship between tendons and tibial bony surface at this level (Figs. 17.17 and 17.18).

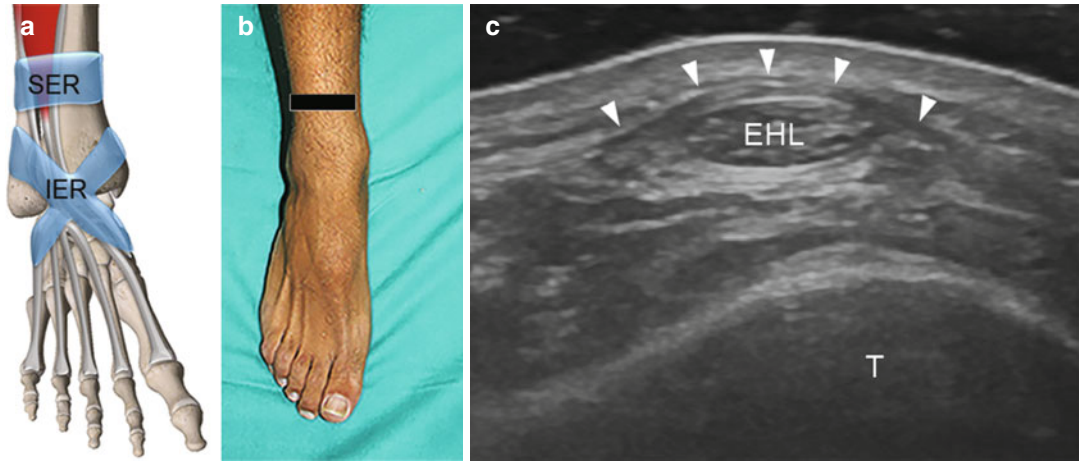


**Fig. 17.17** (**a**) Anatomical scheme of the extensor tendon group and extensor retinacula. *SER* superior extensor retinaculum, *IER* inferior extensor retinaculum. (**b**) Probe position to evaluate the superior extensor retinaculum at the level of the extensor hallucis longus tendon. (**c**) US axial scan of the superior extensor retinaculum (*arrowheads*) at the level of the extensor hallucis longus (*EHL*) tendon

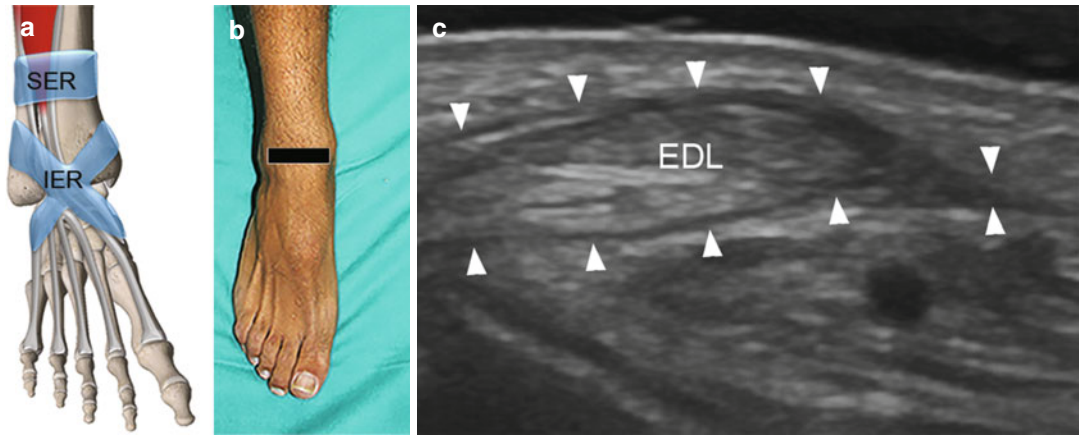


**Fig. 17.18** (**a**) Anatomical scheme of the extensor tendon group and extensor retinacula. *SER* superior extensor retinaculum, *IER* inferior extensor retinaculum. (**b**) Probe position to evaluate the inferior extensor retinaculum at the level of the extensor digitorum longus tendon. (**c**) US axial scan of the superior inferior extensor retinaculum (*arrowheads*) at the level of the extensor digitorum longus tendon (*EDL*)

## 17.3 Summary Table

| Muscle | Origin | Insertion | Innervation | Action |
|---|---|---|---|---|
| Tibialis anterior | Lateral surface of the tibia and neighbouring interosseous membrane in the upper leg | Dorsal aspect of the first metatarsal and medial surface of the medial cuneiform | Deep fibular nerve | Dorsiflexion and inversion of the foot |
| Extensor hallucis longus | Distal aspect of the fibula and interosseous membrane | Distal phalanx of the first toe | Deep fibular nerve | Extension of the big toe and assists in dorsiflexion of the foot at the ankle |
| Extensor digitorum longus | Inferior aspect of lateral tibial condyle, anterior surface of the interosseous membrane and medial face of fibula | Distal phalanges of the second through fifth toes | Deep fibular nerve | Extension of toes and dorsiflexion of ankle |

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