The foot, Anatomy notes

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Abstract

The foot has 28 bones, 30 joints, and more than 100 muscles, ligaments, and tendons. These structures work together to carry out two main functions: weight-bearing and propulsion. Plus, the foot must be flexible to adapt to uneven surfaces and remain stable. In this article, we briefly illustrate the anatomy of the foot and its various structures.

Keywords: Foot, Anatomy

BONES

The skeleton of the foot consists of a group of seven proximal bones, the tarsus, which continues forward with the five metatarsal bones which articulate with the phalanges. The set of these three parts constitutes an elongated bony system, rather squat posteriorly that flattens anteriorly due to the parallel arrangement of the metatarsals and the phalanges. The embryonic rotation of the lower limb bud causes the thumb to be lateral in hand and the medial big toe in the foot.

Those of the tarsus are seven short or irregular bones organized in two series, one proximal, the astragalus and the calcaneus, one distal, the scaphoid, the cuboid, and the three cuneiform bones (medial, intermediate and lateral).

The astragalus or talo is an irregularly cuboid bone interposed between the bones of the upper leg, the heel at the bottom and behind and the scaphoid forward. There can be distinguished three portions: a back body, a front head and a neck, located between the previous. As a whole, six faces are described in the astragalus: upper, lower, medial, lateral, posterior and anterior.

The upper face is entirely occupied by the trochlea, a transverse hemicylindrical relief, wider forward than backwards, crossed by a sagittal throat covered with cartilage that continues on the articular faces for the two malleoli, medial and lateral.

The lower face has three articular facets for the calcaneus: the front and the middle contiguous and flat, the rear (behind and laterally) concave in the sagittal sense, transversely flat, separated from the other two by a deep groove.

The medial and lateral faces have articular surfaces arranged on a plane close to the sagittal

one that relates to the inner surfaces of the two malleoli, respectively, tibial and fibular.

The posterior face is vertically divided into two parts by a sagittal groove intended for the passage of the insertion tendon of the long flexor muscle of the big toe.

The front face is occupied by the head, a portion of the sphere that enters into articulation with the scaphoid. It has a continuous cartilaginous coating with that of the anterior calcaneal articular face.

The talo is located at the top of the posterior tarsus and distributes the body weight over the entire foot; through its superior articular surface, the astral trochlea articulated with the bimalleolar clamp, it distributes the mechanical stresses in three directions; backwards, towards the heel (the massive tuberosity of the calcaneum) through the rear astragalus-calcaneal joint; forward and medially, in the direction of the inner arch of the plantar vault , through the astragalus-hull articulation; forward and sideways, in the direction of the outer arch of the plantar vault, through the anterior astragalus-calcaneal articulation.

The talo does not have muscular insertions: all the muscles of the leg that are inserted on the foot pass to him to bridge: for this, the astragalus is said "caged" bone.

The calcaneus is the most voluminous bone of the tarsus, with the major axis oriented in the anteroposterior direction. It is located under the astragalus, which does not completely cover it but leaves free the rear portion. It describes six faces: the upper one has three facets for the astragalus, of which the rear is the largest, cone-shaped segment with an oblique axis laterally and forward, while the front and middle articular facets are smaller, flat and approach each other at an obtuse angle. The medium articular facet, which is located on the sustentaculum tali is separated from the posterior by the groove of the calcaneum above which the sulcus of the Talo fits symmetrically: in this way, the so-called sinus of the tarsus forms between the two bones.

The lower face, irregular, has two tuberosities, one anterior and one posterior; on the latter, two tubercles are described, the medial and the lateral.

On the lateral side, there are two grooves intended for the passage of the tendons of the lateral peronier muscles, long and short. The medial face is characterized by the presence of a long shower in which run tendons, vessels and nerves that from the back face of the leg lead to the sole of the foot and a small apophysis that protrudes medially, the sustentaculum tali.

The front face has a saddle joint surface for the homologous surface of the cuboid. The back face corresponds to the projection of the heel; at the bottom is wrinkled for the insertion of the calcaneal tendon.

The cuboid is an irregularly cubic bone located in the outer part of the foot in front of the heel, laterally to the scaphoid and third cuneiform, behind the fourth and fifth metatarsals. The upper face is wrinkled and not articular; The plantar is crossed by an oblique groove for the tendon of the long peronier muscle. Behind the groove is the tuberosity of the cuboid. The lateral face is narrow and concave, and the furrow of the long peronier extends there; the medial one is more extended; it has a facet joint for the third bone cuneiform and, sometimes, a smaller facet for the scaphoid. The posterior surface (proximal facet), convex-concave, corresponds to the homologous face of the calcaneum, with which it is articulated. The anterior (distal) surface is divided into two facets that articulate with the bases of the fourth and fifth metatarsal bones.

The scaphoid (or navicular) is a bone shaped like a flattened disk or spaceship, placed in front of the head of the astragalus, behind the row of the three cuneiform, medially to the cuboid. It has a front and a rear face, two margins, upper and lower and two ends, medial and lateral. The back face is concave and welcomes the head of the astragalus; The front, convex overall, has three flat veneers for the three cuneiform.

The medial extremity is characterized by a prominent tuberosity, on which the main tendon of the posterior tibial muscle is inserted.

The cuneiform bones are three and have the form of triangular prisms.

They are distinguished in the middle-lateral sense with the name of the first cuneiform or medial, second cuneiform or intermediate and third cuneiform or lateral.

The medial cuneiform is the most voluminous; it is articulated forward with the first metatarsal and laterally with the second cuneiform and the second metatarsal bone. The sharp part of the wedge is facing upwards. On the medial, non-particular face, the anterior tibial muscle is inserted.

The intermediate cuneiform is distinguished from the other two by being shorter. The sharp margin is facing down and articulates on the

sides with its homologues, forward with the second metatarsal. The lateral cuneiform is arranged as the intermediate: anteriorly, it makes contact with the base of the third metatarsal, the medial face has an articular facet for the second cuneiform and one for the second metatarsal, and the lateral face is articulated with the cuboid and thick, forward, with the fourth metatarsal.

The metatarsal consists of five small mid-lateral numbered bones, the metatarsal bones, arranged between the proximal phalanges and the distal series of the tarsal bones. The first metatarsal bone is the largest and squat; the second is the longest and thinnest. Each one describes a triangular and concave prismatic body with three faces (dorsal, tibial and fibular), three margins (plantar, tibial and fibular) and two ends. The proximal extremities or bases are equipped with flat facets, which articulate with the bones of the second tarsal series (tarsometatarsal joints) and with the metatarsal bones close (intermetatarsal joints).

The distal extremities (heads) are rounded and have convex articular surfaces housed in the joint cavities of the proximal phalanges. On the plantar surface of the first metatarsal is the ridge for the insertion of the tendon of the long peronier muscle. The proximal end of the fifth metatarsal presents relief for the insertion of the tendon of the short peronier muscle.

The phalanges of the foot form the skeleton of the fingers. They are aligned one after the other, in a number of three for each finger, except for the first, which has only two. They are indicated, next distally, as first, second and third phalanges. Being long bones, they show a body (or diaphysis) and two ends (or epiphysis), back and front. The phalanges of the foot are similar to those of the hand but less developed, especially in length, with the exception of those of the big toe.

The sesamoid bones, included in the tendons and near the joints, may be numerous. Two are almost constant: they are found in the double tendon of the short flexor muscle of the big toe, in relation to the plantar facets of the head of the first metatarsal and inserted in the metatarsal phalanx joint.

Considering the skeleton of the foot as a whole, the ground support is realized through three bony points that correspond to the calcaneal tuberosity and to the head of the first and fifth metatarsals. These three points can be joined by three arches (plantar arches), two longitudinal (internal and external) and one transverse.

JOINTS

The ankle and the joints of the foot allow a movement characterized by three axes and three degrees of freedom:

- on the transverse axes, the flexural-extension movements (dorsal and plantar flexion, respectively) are carried out;
- movements of abduction and adduction are carried out on the sagittal axes;
- internal and external rotation movements shall be carried out on the longitudinal axis.

The inversion of the foot comes from the contemporary supination and adduction, subversion from the contemporary pronation and abduction.

The joints of the foot play a dual role: in addition to providing the degrees of freedom adapt it to the roughness of the ground, changing its shape and thus establishing between the ground and the leg a system of shock absorbers that gives the pitch elasticity, balance and looseness.

Tarsic or Talo-crural tibial joint

It is a trochlea joint (angular ginglymus) that connects the leg to the foot. The tibia, fibula and astragalus contribute to its formation. The joint surfaces of the leg bones form a mortar joint for the astral trochlea.

The means of union are represented by a joint capsule reinforced by ligaments. The fibrous part of the capsule is inserted on the edges of the tibiofibular mortar and the articular surface of the astragalus, extending forward also on the part of the neck of this bone. Especially in this front portion, the capsule is thin and loose, while it is thickened on the sides due to the presence of ligaments. The medial or deltoid ligament detaches from the apex of the malleolus, expanding into four bundles, two anterior, one medium and one posterior; the lateral ligament, as a whole, less robust than the medial, is formed by three distinct bundles in front, middle and rear.

The articulation allows mainly bending and extension movements; in plantar flexion are also possible laterality movements around a vertical axis, otherwise limited by the lateral portions of the mortar.

Intra-tarsic joints

Lower joint

The astragalus articulates with the underlying calcaneus through two articulations: the one

behind (astragalus-calcaneal articulation) and the other front, to which the navicular (astragalus-calcaneum- navicular articulation) also concurs. Between these two joints is interposed the interosseous astragalus-calcaneal ligament, a robust fibrous bundle that occupies the sinus of the tarsus.

The astragalus-calcaneal articulation is a trochoid that occurs between the posterior articular faces of the Talo and calcaneum. The joint capsule is reinforced by the anterior, posterior and medial Talo- calcaneal ligaments.

The Talo-calcaneo-navicular joint is an enarthrosis; the hemispherical head of the Talo and the anterior and medial tarsal joints for the calcaneum articulate with a concavity formed forward from the talar articular face of the navicular bone and behind from the talar articular face of the calcaneum, joint to each other by the robust calcaneo-navicular ligament plantar. The joint capsule is reinforced by the dorsal and lateral Talo-navicular ligaments and the medial bundle of the bifurcated ligament (also called a Y or key ligament).

Calcaneo-cuboid joint

It is placed laterally to the previous one with which it has in common the bifurcated ligament. It is a saddle joint reinforced by the lateral beam of the Y-ligament, by the dorsal and plantar calcaneum- cuboid ligaments.

The astragalo-calcaneo-navicular articulation and the calcaneo-cuboidal draw an interline joint (of the Chopart) that, observed on the back of the foot, describes an Italic S oriented transversely with two curves, medial and lateral, concave posteriorly and anteriorly respectively.

Navicular-cuboid joint

It is an arthrody that occurs between the lateral face of the navicular bone and the medial face of the cuboid bone. Its articular capsule is reinforced by the navicular-cuboid ligaments dorsal and plantar.

Naviculum-cuneiform joint

It consists of the juxtaposition of three arthrodies between the anterior face of the navicular bone and the posterior faces of the three cuneiform bones contained in a single joint cavity. The capsule is reinforced by the naviculum-cuneiform dorsal and plantar ligaments.

Intercuneiform articulations

They are two arthrodies between the lateral face of the first cuneiform and the medial one of the second and between the lateral face of the second cuneiform and the medial one of the third cuneiform. The joint capsule of each joint is reinforced by the dorsal and plantar inetercuneiform ligament.

Wedge-cuboid joint

It is an arthrody that occurs between the lateral face of the third cuneiform and the medial face of the cuboid bone. The joint capsule is reinforced by the dorsal and plantar wedge-cuboid ligament.

Tarsus-metatarsal joint

It is established between the distal articular facets of the three cuneiform bones that articulate with the bases of the first three metatarsals and between the distal facet of the cuboid that articulates with the bases of the fourth and fifth metatarsals. The set of these articular relationships draws the so-called tarso-metatarsal articulatory line of the Lisfranc. The common fibrous capsule is reinforced by the dorsal, plantar and interosseous tarsal-metatarsal ligaments.

Intermetatarsal joints

The bases of the second, third, fourth and fifth metatarsals are articulated through arthrodies, held together by a capsule reinforced by dorsal, plantar and interosseous ligaments. A fibrous tape, the transverse ligament, is stretched plantarly from the head of the first to that of the fifth metatarsal bone.

Metatarsal-phalangeal joints

Each metatarsal head (a condyle flattened transversely) articulates with the glenoid cavity of the proximal epiphysis of the first phalanx. Each capsule is reinforced by collateral and medial ligaments. They are condyloarthrosis that allows extension and bending movements. In the joint game of the metatarsal-phalanx of the big toe, there are also two small sesamoid bones.

Interphalangeal joints

Two in each finger, one in the big toe, the interphalangeal joints are trochlea joints reinforced each by capsule and collateral, lateral and medial ligaments.

The ligamentous apparatus of the foot is completed

with the long plantar ligament, which originates on the plantar side of the calcaneum and widens distally up to the bases of the metatarsal bones (the calcaneum-cuboid ligament can be considered part of it) and with short plantar ligaments, which form a deeper ligament plane along with the plantar calcaneum-navicular ligament.

MUSCLES

The muscles of the lower limb that intervene in the movements of the ankle and foot joint are those of the leg and the intrinsic ones of the foot.

In the leg they are arranged in three compartments: front, side and rear.

The muscles of the foot are divided into dorsal and plantar; The latter, in turn, are distinguished in medial, lateral and intermediate.

Front leg muscles

Anterior tibial ***(Tibialis anterior)***

It is the most robust and medial of the anterior muscles. It originates from the lateral condyle and the upper third of the lateral face of the tibia body and the upper third of the interosseous membrane of the leg. It passes deeply to the transverse ligaments and crusaders of the leg wrapped in its own synovial sheath. It is inserted in correspondence of the medial outline of the foot, on the first cuneiform and at the base of the first metatarsal. He flexes the foot dorsally, adduces it and rotates medially.

Long extender of the big toe ***(Extensor hallucis longus)***

It originates from the middle third of the medial face of the fibula body and the interosseous membrane of the leg. His tendon passes deeply to the transverse ligaments and crusaders of the leg wrapped in its own synovial sheath. It joins the tendon of the short extensor of the big toe and is inserted in part on the dorsal face of the proximal phalanx but especially on the base of the distal phalanx of the first finger. It extends the big toe; it flexes dorsally and rotates the foot medially, adduced.

Long finger extender

It originates from the lateral condyle of the tibia, the interosseous membrane of the leg, the head and the upper three-quarters of the body of the fibula. The insertion tendon, wrapped by its own synovial sheath, passes deeply to the transverse and crusader ligaments of the leg, is carried laterally on the back of the foot and is divided into four portions that are reached the last four fingers, respectively. Each portion is divided in turn into three tendon ribbons, of which the central one is inserted at the base of the second phalanx, while the other two converge, bringing it to the base of the second phalanx. It extends the last four fingers, extends the foot on the leg (dorsal flexion) and rotates it externally.

Anterior peronier or third peronier ***(Peroneus tertius)***

It arises from the middle part of the body of the fibula and the interosseous membrane of the leg. It frequently fuses its fleshy bundles with those of the long extensor. It is inserted at the base of the fifth metatarsal bone. She flexes her foot dorsally and pronates it.

Lateral leg muscles

Long peronier ***(Peroneus longus)***

Gives the shape to the side surface of the leg. It originates from the antero-lateral portion of the head of the fibula, the upper third of the face and the lateral margin of the same bone, as well as the lateral condyle of the tibia, the crural fascia and the surrounding intermuscular septa. The muscle bundles are carried vertically down; they continue in a long insertion tendon which, wrapped in its own sheath, goes deeply to the posterior fibular retinal, runs behind the malleolus reaching the sole of the foot that crosses obliquely to go on the tuberosity of the first metatarsal bone, on the medial cuneiform and at the base of the second metatarsal.

It flexes the foot, abduces it and rotates it laterally. It also helps to make the plantar concavity more evident.

Peronier short ***(Peroneus brevis)***

It is deeper than the long and arises from the middle third of the body of the fibula. Its tendon first runs in the sheath of the long peronier then provides a sheath of its own, passes behind the lateral malleolus and leads forward and under the sole of the foot, fitting on the tuberosity of the fifth metatarsal. Abduce the foot and rotate it laterally.

Hind leg muscles

Triceps of the sura ***(Triceps surae)***

It is a large and powerful fleshy mass developed

in man as a result of the acquisition of the erect station. It is formed by three heads, two superficial that together forms the gastrocnemius muscle and one deep, the soleus muscle. The medial head of the gastrocnemius (medial twin) is born with a large tendon flattened by the posterior face of the femur, above the medial condyle; the lateral head (lateral twin) originates with a smaller tendon from the posterior face of the femur above the lateral condyle, sometimes from the epicondyle. The two heads converge at the bottom, and the muscle fibres melt on a large aponeurosis that gradually narrows, receiving from its deep surface the tendon of the soleus muscle. This is how the calcaneal tendon (of Achilles) is formed, which is inserted on the back face of the heel.

The soleum originates from the popliteal line of the posterior face of the tibial body, the tendon arch of the soleus and the posterior face of the head and body of the fibula. Its muscular abdomen is covered dorsally by a thick aponeurotic plate that is continued in the heel tendon in the middle third of the leg.

The action of the sural triceps on the foot is that of flexing it plantarly. It has a very important action in walking, jumping and lifting the body on the tip of the feet. Finally, it contributes to the flexion of the leg on the thigh.

Plantar ***(Plantaris gracilis)***

It is a rudimentary and inconstant muscular bundle that arises from the femur above its lateral condyle, is dorsally placed with respect to the popliteal muscle and, at its lower margin, it continues with a long and thin tendon that runs between gastrocnemius and soleus that inserts itself or merging with the Achilles tendon on the back face of the heel. Assists the action of sural triceps.

Long flexor of the fingers ***(Flexor digitorum longus)***

It is the most medial muscle of the deep layer of the hind leg muscles. It originates from the posterior face of the tibia body below the popliteal line. It is brought down and medially: the insertion tendon passes behind the medial malleolus wrapped in a synovial sheath, and in the sole of the foot is divided into four divergent heads that lead to the last four fingers and attach to the base of the respective third phalanges after crossing an eyelet of the corresponding tendon of the flexor short of the fingers.

Flex the foot raised from the ground, flexing the second and third phalanx of the last four fingers. The foot resting on the ground and under load is synergistic to the intrinsic muscles of the foot to keep the fingers in close contact with the ground.

Posterior tibial ***(Tibialis posterior)***

It is the deepest of the posterior loggia originates from the posterior face of the tibia body, below the popliteal line, the interosseous membrane and the medial face of the fibula body. The tendon, covered by its own synovial membrane, rotates behind the medial malleolus and inserts on the tubercle of the navicular bone and on the first cuneiform bone. Adduces and rotates the foot medially and assists the plantar flexion of the ankle joint. Contributes to the lifting of the medial longitudinal arch of the foot.

Long flexor of the big toe ***(Flexor allucis longus)***

It arises from the lower two-thirds of the posterior face of the fibula body and the interosseous membrane. Wrapped by its own sheath, it passes through the groove that is dug on the back face of the astragalus and on the medial face of the heel. In the sole of the foot is lateral to the tendon of the flexor along the fingers which gives a slender beam to the tendon of the second and sometimes third finger. It is inserted on the plantar face of the base of the second phalanx of the big toe after having passed between the two sesamoid bones included in the tendon of the short flexor. Flex your big toe.

Dorsal muscles of the foot

Short extender of the big toe ***(Extensor hallucis brevis)***

It comes from the heel and fits on the dorsal face of the base of the first phalanx of the big toe, which extends.

Short extender of fingers ***(Extensor digitorum brevis)***

It comes from the heel, side to the origin of the short extensor muscle of the big toe. It is composed of three fleshy ventri followed by three tendons; on the dorsal face of the first phalanx of the second, third and fourth fingers join the respective tendon of the long extensor muscle of the fingers, which the short extensor assists in the extension movement.

Plantar muscles of the foot of the medial loggia

Abductor of the big toe ***(Adbuctor hallucis brevis)***
It originates from the medial end of the calcaneal tuberosity and is inserted on the medial contour of the base of the first phalanx of the big toe. Abduce and flex the big toe.

Short flexor of the big toe ***(Flexor hallucis brevis)***
It originates from the plantar faces of the second and third cuneiform. It fits on the medial and lateral contours of the base of the first phalanx of the big toe. Flex your big toe.

Adductor of the big toe ***(Adbuctor hallucis brevis)***
It originates from the plantar surface of the cuboid bone and the bases of the third and fourth metatarsals.
It is inserted on the lateral contour of the base of the first phalanx of the big toe. Adduces and flexes the big toe.

Plantar muscles of the foot of the lateral loggia

Abductor of the fifth finger ***(Adbuctor quinti digiti)***
It originates from the lateral extremity of the tuberosity of the calcaneum, it is inserted on the base of the first phalanx of the fifth finger, which abduces and flexes.

Short flexor of the fifth finger ***(Flexor quinti digiti brevis)***
It originates from the base of the fifth metatarsal bone and is inserted at the base of the first phalanx of the fifth toe, which flexes.

Opponent of the fifth finger ***(Opponent digiti minimi)***
It originates from the calcaneum-cuboid ligament and is inserted on the lateral contour of the fifth toe of the foot, which it adduces.

Intermediate plantar muscles of the foot

Flexor short of the fingers ***(Flexor brevis digitorum)***
It originates from the tuberosity of the calcaneum, and it is divided into four fleshy lacerations whose tendons split to form an eyelet crossed by the tendon of the flexor muscle along the fingers and are inserted on the plantar face of the base of the second phalanx of the last four toes. Flex the second phalanx of the last four fingers.

Square of the plant (Quadratus plantae)
It originates from the lower face of the calcaneum and ends on the lateral contour of the tendon of the flexor muscle along the fingers. It prevents the adductive action that the flexor muscle along the fingers would have on the fingers themselves due to the obliquity of its tendon.

Lumbricals muscles ***(Lumbricales pedis)***
They are four; they arise from the contiguous tendons of the flexor muscle along the fingers, with the exception of the first, the most medial, which originates exclusively from the medial margin of the tendon intended for the second finger. From the beginning, they move forward and end on the medial side of the proximal end of the first phalanx of the last four fingers and on the tendons of the extensor muscle along the fingers. The lumbricals muscle flex the first phalanges and extend the second and third phalanges of the last four toes.

Interosseous plantar muscles ***(Interossei plantaris)***
They are three, arise from the medial contour of the last three metatarsal bones and are inserted on the medial margin of the base of the first phalanx of the corresponding finger. They're showing off the last three toes.

Interosseous dorsal muscles ***(Interossei dorsali)***
They occupy the dorsal part of the four intermetatarsal spaces. They originate from the faced faces of the metatarsal bones and are inserted at the base of the proximal phalanges. The first dorsal interosseous leads to the medial margin of the proximal phalanx of the second finger, while the tendons of the second, third, and fourth dorsal interosseous go to the lateral margin of the proximal phalanx of the second, third, and fourth fingers respectively. The third and fourth also send a slender expansion to the tendon of the stretching muscle along the fingers.
The first and second dorsal interosseous muscles move the second toe medially and lateral respectively; the third and fourth dorsal interosseous muscles move the third and fourth toes away from the median axis of the foot. The interosseous dorsal muscles also flex the proximal phalanx of the second, third, and fourth toes, extending the other two phalanges.

FASCIAL SYSTEM

In the back of the foot are the superficial and deep dorsal bands and the fascia of the short extensor muscle of the fingers.

In the plantar region, the plantar aponeurosis is superficially extended; at the level of the skeletal plane is the deep plantar fascia.

Plantar aponeurosis (or superficial plantar fascia) occupies the surface plane of the plant below the subcutaneous layer. Three parts are distinguished, the medial, the intermediate and the lateral, which cover the three corresponding groups of plantar muscles.

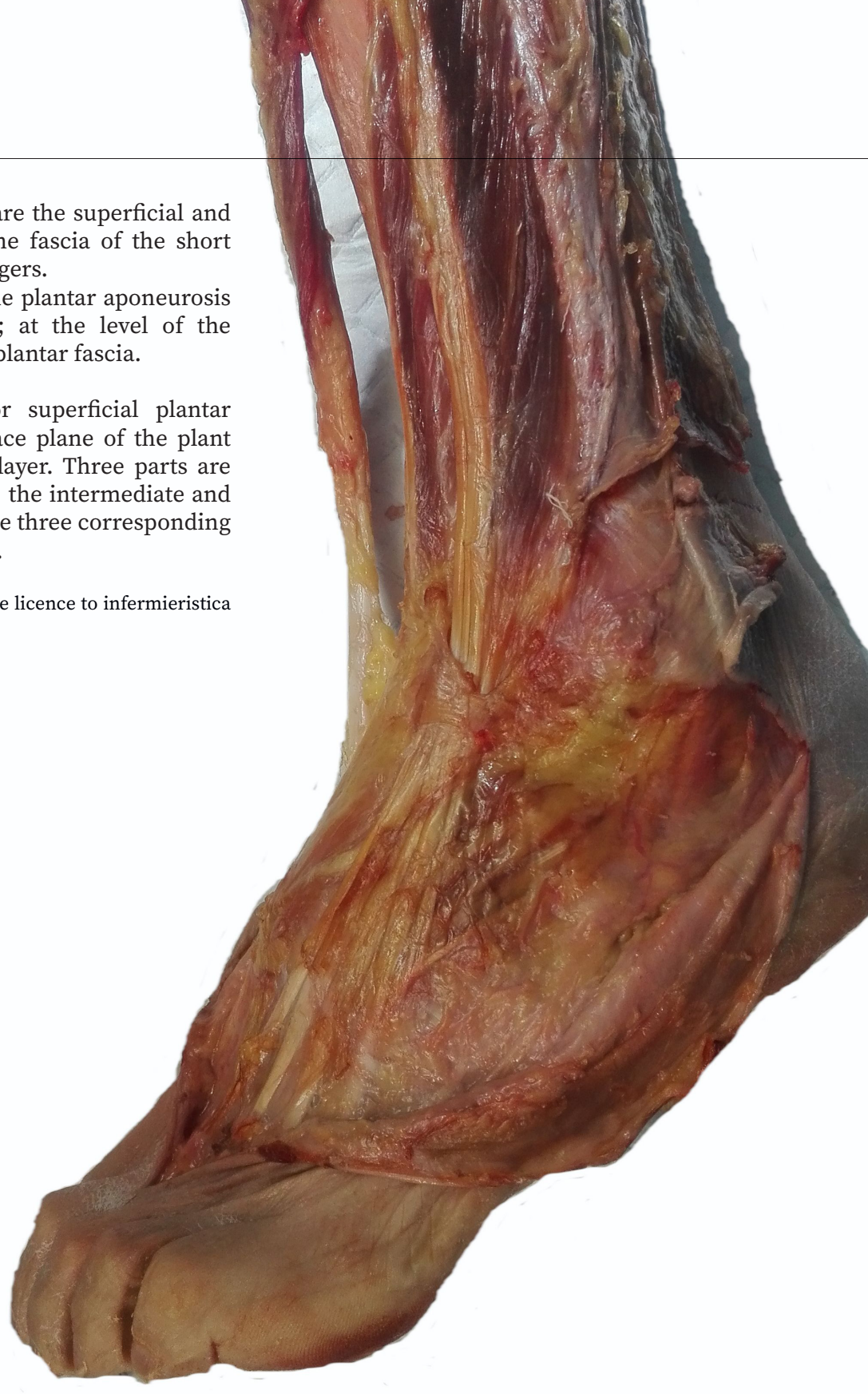

FIGURE LEGEND
Dissection by Veltro and Paternostro
Thanks to ICLO, Verona

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