

Inferior tibiofibular joint (tibiofibular syndesmosis) — own studies and review of the literature

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Abstract: The study was carried out on 50 human lower legs obtained during autopsies. The anatomy of the joint was studied using classical anatomical description methods. Based also on literature we have reviewed the current knowledge on the inferior tibiofibular joint.

Key words: tibiofibular syndesmosis, inferior tibiofibular joint, anatomy.

Introduction

The history of the studies on the mysteries of the structure of the human body is quite long. Hipocrates of Kos compiled information on the human body collected by ancient Greek scientists. He described the structure of human alimentary tract, trachea, bronchi and lobes of the lungs. He managed to make some observations on the circulatory system — his studies concentrated around the role of the heart valves and the hypothesis that heart obtains nutrients from the lungs. He stated that blood is created in the liver and the spleen, and next it flows across the body through the vessels, which he called “flebes”.

Some remarks on the anatomy of the human body, including the cardiovascular system, were made by Aristotle. He reported on 8 pairs of the ribs in humans, and the heart is consisted of 3 ventricles, while all vessels and nerves originate from the heart. According to him the brain was an organ which produced a mucus.

Unquestionable authority from ancient times until the middle of the 16th century was Claudius Galen. He described cranial nerves, distinguished veins from the arteries, and proved that these last contain blood not the air. Regarding the physiology Galen postulated that the work of the heart and the pulse are results of “pulsation power” — during a systole heart pushes the venous blood peripherally, while during the diastole the blood returns back to the heart. Blood is produced in the liver, and cleaned in the spleen. Despite numerous observations, Galen made lots of mistakes, mostly because his anatomical studies were based on animal dissections. His anatomy was an anatomy of a hybrid, not a human.

It is obvious that only the human dissections let to paint human body in a realistic way. In 15th century Leonardo da Vinci made one of the first dissections in a hospital in Firenze. Although after a conflict with a pope he continued his studies, at least officially, on animals.

Andreas Vesalius was a pioneer of a modern anatomy, who based his knowledge on self-made human dissections. As a first in the world he impeached Galen’s descriptions, who’s authority was so valuable that even visible mistakes were treated as anatomic dogmas. A milestone in gross anatomy became a textbook on anatomy published in 1543 “*De humani corporis fabrica libri septem*”. This book contained over 200 anatomical illustrations.

The next milestone in medicine was a description of systemic circulation given by William Harvey (1578–1657). His work “*Excercitation anatomica de motu cordis et sanguinis in animalibus*” was edited in 1628.

The further progress in morphological sciences was possible thank to invention of optic microscope, since the next step was description of capillaries made by Malpighi.

Also several Polish scientists contributed to development of morphological sciences — i.e. L. Bierkowski, K.L. Teichmann *et al.*

The next who significantly improved the quality of studies over the human vascular system was B. Adachi, who studied mainly variability and is widely known for his monograph on vascular system in Japanese based on hundreds of autopsies.

Evolution of erect position of the body

One of the main features which differ human being from other living creatures is an erect position of the body and two-feet transposition. Man as the only one, accepted permanently vertical posture, what allowed to release upper limbs from postural and locomotion functions. This enabled application of hands to another tasks.

Process of changing the posture took around 30 million years, so was quite slow and occurred during evolution. Long-lasting process required numerous adaptation changes not only in lower limbs. During evolution foot remained the only part of the human body to contact with the ground. This is why foot is subjected to pressure which results from the role they play — i.e. drive of the body and balance maintenance [1]. The weight of the body is carried thank to specific arrangement of the foot bones, which comprise bones of tarsus, metatarsus and phalanges. Tarsus consists of calcaneus, talus, and localized anteriorly navicular, cuboid and three cuneiform. Five metatarsals are located anterior to the tarsals. Phalanges are anterior to metatarsals. Given above bones are arranged so that they form characteristic concavity, which causes elasticity of the foot. There are five longitudinal and few transverse arches. Three medial longitudinal arches run through cuneiform bones and navicular to the talus. Two lateral arches course through the cuboid to the calcaneus. Posterior support of foot is calcaneal tuberosity, while anterior are heads of I and V metatarsals [2].

General characteristic of skeleton of free lower limb

Bones creating the girders of free lower limb comprise: femur, tibia, fibula, tarsals, metatarsals and phalanges.

Femur creates skeleton of the thigh; tibia and fibula — of the calf, while remaining bones form skeleton of foot. Tibia and fibula parallel themselves (tibia is medial and fibula lateral). Femur articulates with hip bone by hip joint, and with tibia by knee joint (which includes also the largest sesamoid bone of the body: patella).

Proximal ends of leg bones are united by superior tibiofibular synovial joint, while distal ends join by inferior tibiofibular joint. Interosseous borders are connected by interosseous membrane. Distal ends of leg bones are united with tarsus (in fact with talus) by ankle (talocrural) joint. This joint acts as uniaxial hinge joint. Head of the joint is located on trochlea tali (divided into superior, lateral and medial parts); socket is composed of inferior articular surface of tibia and articular surfaces of medial and lateral malleoli. In classical, anatomical description this joint is strengthened by medial (deltoid) ligament composed of anterior, lateral and posterior parts: anterior and posterior talo-fibular and calcaneofibular ligaments. Movements which occur here are: plantar and dorsal flexion.

Definition and forms of syndesmoses

Syndesmosis is a compact connective tissue joint which united skeletal elements and is commonly strengthened by ligaments. Syndesmoses can be divided into: fibrous, elastic, sutures, and gomphosis. In fibrous joints connections are composed of collagen fibers of different length (i.e. interosseous membrane of leg or forearm). Main component of

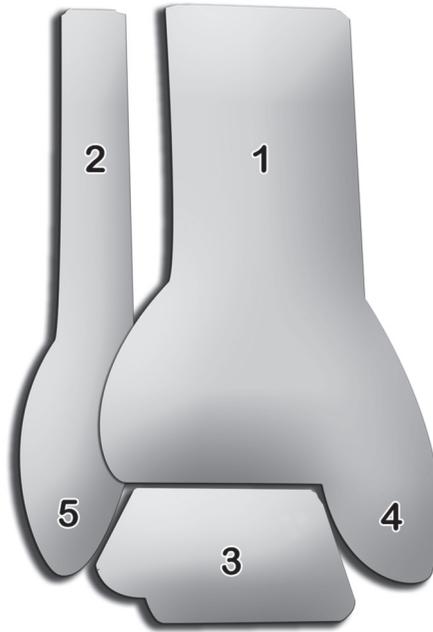


Fig. 1. Right talocrural joint (anterior view). 1 — tibia; 2 — fibula; 3 — talus; 4 — medial malleolus; 5 — lateral malleolus.

elastic joint are elastic fibers, which look yellowish (i.e. ligamenta flava between adjacent vertebral arches). In sutures, two bony margins are united by strong layer of connective tissue, which is about 0.5 mm thick. Depending on the shape of articular surfaces one can distinguish: plane sutures, squamous, and serrate. A quite specific type of syndesmosis is a gomphosis, which is a method thank to which the root of the tooth is mounted to the wall of the dental alveolus. A subdivision of gomphosis is schindylesis where sharp margin of one bone is inserted into a groove of another (i.e. connection between sphenoid rostrum and wings of vomer).

Material and methods

50 legs of 25 females and 25 males who died because of causes not associated with any leg diseases, stained in 10% solution of formaldehyde were dissected. The skin was gently removed by incision made along the anterior border of tibia, descending to the dorsum of foot. Next anterior group of leg muscles were exposed by incision made in the crural fascia. Subsequently tibialis anterior, extensor hallucis longus and extensor digitorum longus were separated from interosseous membrane of leg to make it visible, as well as the inferior tibiofibular joint. Next the gentle dissection of the joint was performed using magnifying glasses, what enabled to distinguish the ligaments and the articular

surfaces. The results were documented photographically. The study was approved by Ethical Committee (KBET 167/B/2009).

Results and discussion

Inferior tibiofibular joint is a fibrous connection located between fibular notch of lower tibial end and the medial aspect of distal end of tibia. We have confirmed that this syndesmosis is strengthened by two quite strong fibrous bands — anterior and posterior tibiofibular ligaments. However our findings confirmed also the studies performed by Bartoniczek [3], who distinguished three ligaments which strengthened inferior tibiofibular joint: anterior and posterior tibiofibular ligaments and an interosseous tibiofibular ligament.

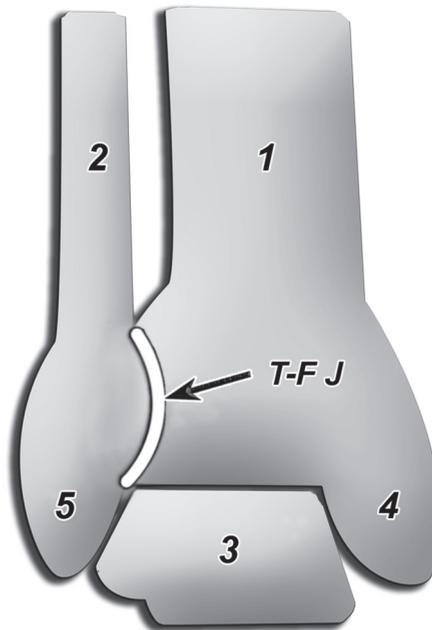


Fig. 2. Schematic drawing presenting right tibiofibular joint (anterior view). 1 — tibia; 2 — fibula; 3 — talus; 4 — medial malleolus; 5 — lateral malleolus; TF-J — inferior tibiofibular joint.

We have found the following ligaments:

- Anterior tibiofibular ligament (described by Golano *et al.* in 2010 [4] as anteroinferior tibiofibular ligament). It is consisted of three parts, usually separated by conglomerate of connective tissue (fibro-adipose). Its highest portion was relatively the shortest. Middle part of the joint was the most resistant to stretching, while the lowest part was the longest and the thinnest. The last portion seemed to be the most separated

from remaining bands by fibro-adipose tissue. Between the bands of a ligament one could see branches of the fibular artery [4]. The described ligament ran obliquely toward the distal end of fibula, lateral — at the angle of 25–35° with respect to the transverse plane. Next it ran posteriorly at the angle 55–70° with respect to the sagittal plane. It was trapezoid in shape. Our findings agreed with another studies [5]. The ligament originated from the eminence located on the anterior surface of distal end of tibia (the eminence, described by Ebraheim *et al.* in 1998 [5], mentioned also by Golano *et al.* [4] as anterior tubercle of distal end of tibia). The ligament inserted to anterior aspect of distal end of fibula (mostly lateral malleolus). The fibular insertion is referred to as anterior tubercle of fibula.

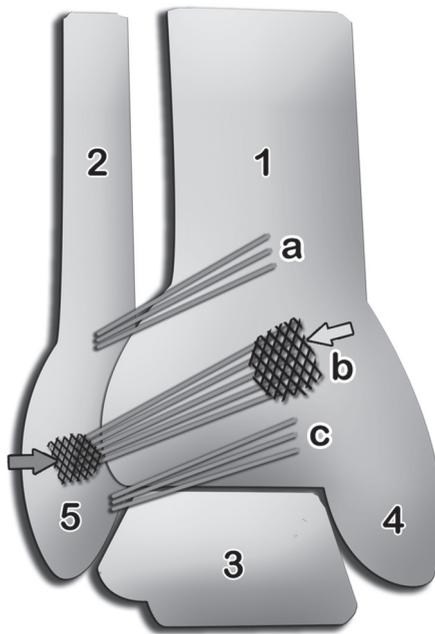


Fig. 3. Schematic drawing of joints of the distal end of the leg (anterior view). Arrows indicate origin and insertion of anterior tibiofibular ligament. 1 — tibia; 2 — fibula; 3 — talus; 4 — medial malleolus; 5 — lateral malleolus; a — upper portion of the ligament; b — middle portion of the ligament; c — inferior portion of the ligament; arrows : anterior tibial tubercle; and anterior fibular tubercle.

Posterior tibiofibular ligament (named by Golano *et al.* [4] postero-inferior tibiofibular ligament) was a strong and compact structure which arose from the posterior margin of the fibular notch of tibia. It seemed to be composed of two independent portions: superficial and deep. Superficial part begun on the posterior margin of the lateral malleolus and turned medially to posterior tubercle of tibia. Deep portion was cony-shaped and begun on the lateral malleolar fossa. Next it ran toward the tibia, to its posterior margin. It is reported that it could even reach the medial ankle [4]. Profound part is

referred by some authors to as transverse portion (inferior transverse ligament) [4, 6]. This part ran to lateral malleolar fossa. During its course it ran almost transversely at the angle about 15–20° with respect to the horizontal plane. It was continued by interosseous tibiofibular ligament which is located immediately above. Strong inferior margin of the posterior tibiofibular ligament filled the angle between posterior margin of tibia and lateral ankle, adhering to talar trochlea [5].

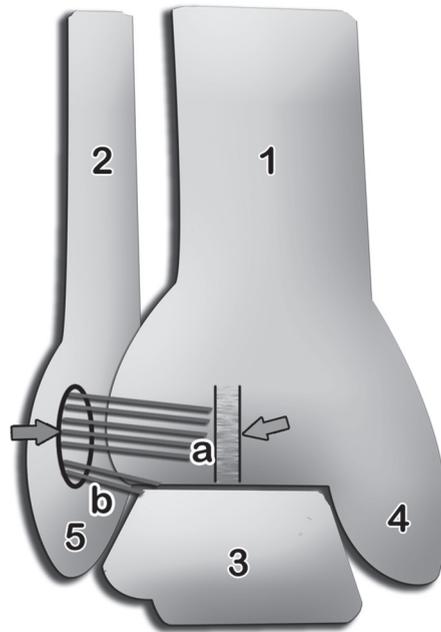


Fig. 4. Schematic drawing of distal end of the left lower limb (posterior view). Arrows indicate origin and insertion of posterior tibiofibular ligament. 2 — tibia, 2 — fibula; 3 — talus; 4 — medial ankle; 5 — lateral ankle; a — posterior tibiofibular ligament; b — inferior transverse ligament; arrows: groove for tendon of flexor hallucis longus tendon; and medial malleolar fossa.

Interosseous tibiofibular ligament — its structure resembled a network of fibers which extended between fibular notch of tibia and medial surface of distal end of fibula. Fibers of this ligament ran usually from tibia, lateral and anteriorly, and reached the distal end of fibula. One could distinguish in this ligament group of fibers located in the anterior portion which ran reversely. The fibers which attached to tibia most distally, at the level of eminence described by Ebraheim *et al.* [5] as anterior tubercle, descended straight toward fibula and attached to it immediately above the talocrural joint. The described ligament was a compact structure, composed of short fibers which together with adipose tissue and minute branches of fibular artery joined tibia and fibula [3]. At the level of inferior tibiofibular joint this ligament could be considered as continuation of the interosseous membrane of the leg [4, 6, 7].

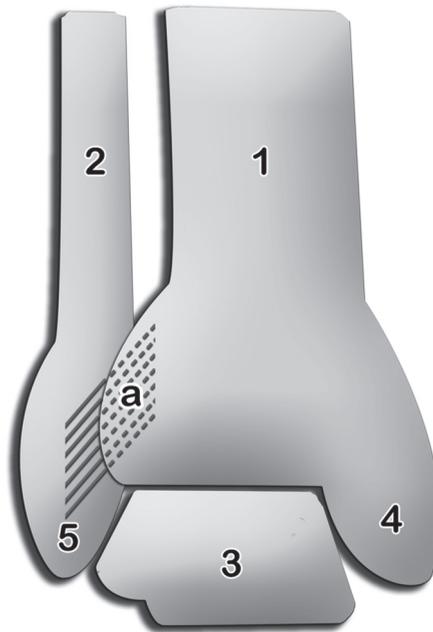


Fig. 5. Schematic drawing of the distal end of right lower limb (postero-medial view) — attachment of the interosseous tibiofibular ligament. 1 — tibia; 2 — fibula; 3 — medial ankle; 4 — lateral ankle; 5 — talus; a — interosseous tibiofibular ligament.

Certain authors distinguish additionally the so called transverse inferior tibiofibular ligament, which is also described as inferior portion of posterior tibiofibular ligament. In most of the reports this element is not considered to be separate, but following some sources, i.e. Hermans *et al.* [8], Ebraheim *et al.* [5] it is postulated that it is independent. This ligament may be of different shape. In our studies its mean length was 36.60 ± 9.40 mm. It originated from lateral malleolar fossa, slightly below posterior tibiofibular ligament. Usually it arose from posteroinferior margin of fibular notch of tibia, but sometimes could reach even the area of medial malleolar fossa. This is why its shape was poorly defined [5].

Conclusions

Distal ends of tibia and fibula quite compactly adhere. Inferior tibiofibular joint is then characterized by little movement. Actually it enables only slight lateral deviation of lateral and medial malleoli. It occurs especially during dorsal flexion. Fibula is then elastically united with tibia by inferior tibiofibular joint, what in association with the superior tibiofibular joint enables its plastic deviations and secures it against fractures.

Conflict of interests

None declared.

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