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Vascular density of inferior tibiofibular joint — cadaveric experimental study

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Abstract: The study was carried out on 50 human lower legs obtained during autopsies (KBET: 122.6120.315.2016). 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 blood supply considering the important clinically aspect — vascular density. Authors of this paper postulate relatively low vascular density of the region described and potential worse condition for healing in case of injury or after surgical procedures performed. We also postulate that ligament screws should be positioned with special respect to time limit which enables proper healing of the syndesmosis.

Key words: tibiofibular syndesmosis, inferior tibiofibular joint, blood supply, anterior tibial artery, posterior tibial artery.

Introduction

Inferior tibiofibular joint is an important structure which stabilizes junction of the leg and foot bones [1, 2]. A precise study on the anatomy of the region of inferior tibiofibular syndesmosis is essential and valuable for proper diagnosis and treatment of traumas in this region, which seem to be the most common causative factor of

acute pain in this area. Besides the chronic pain accompanies most commonly the phenomenon of loosening of the ligaments [3].

Profound knowledge on the variability and possible sources of blood supply, topography of neighboring bone structures and soft tissues, enables to eliminate the risk of the arteries and veins during performing surgical procedures. Current literature does not consider deeply information on variability of the blood supply of lateral malleolar region, as well as it does not regard almost at all the blood supply of the inferior tibiofibular joint directly. Awareness of the fact that certain anatomical variants of vascularization of the inferior tibiofibular joint exist is of special clinical importance in every day clinical practice. 85% of traumas in the malleolar region are mostly luxations of the lateral ankle — this is right here where the bony and soft tissue structures which are more subjected to lesions, more frequently than on the medial side [4].

Vast majority of the authors concentrate on the anatomy of large blood vessels of the shin. Most of publications consider popliteal, anterior and posterior tibial, and fibular arteries, which give rise to main arterial trunks running in the lateral malleolar region and vicinity of the inferior tibiofibular joint. However there is not current data on the fates of these branches. This is why the problem presented in our studies seems to be meaningful. Only McKeon *et al.* (2012) [5] describe the vascularization of the inferior tibiofibular join. They carried out the studies on 25 pairs of the adult lower limb (all together 50 limbs). They have amputated them below the knee and injected fibular, anterior and posterior tibial arteries with ink mixed with latex (Ward Blue Latex) to make visible the blood supply of the ligaments of the ankle region. 6% solution of sodium hypochloride was applied to remove soft tissues. The composition of the bones, ligaments and blood vessels remained untouched.

Lesions of the lateral malleolar region may lead to numerous complications, this is the reason why the studies on the anatomical composition of this region should be undertaken. Healing of the luxation and subluxation of the ankle may result in the ankle instability, what may cause elongation of the ligaments responsible for joint stabilization. Also the contact surface of two adhering bones may be decreased. All this may lead to instability and premature ossification of the superior ankle joint. The knowledge on the blood supply of the inferior tibiofibular joint (which is a strong connection between distal ends of the shin bones) and awareness of the existence of many variations according to the model of junction and course of minute blood vessels should be a facility in the treatment process, among other through the avoidance of potential lesions of small vascular structures. Distal end of fibula is lower than distal end of tibia, probably this is why most of the lesions affects the lateral ankle [4]. It all makes the main reason why the subject of this paper concentrates on this type of lesions. Authors of many articles pay much attention to lesions of the lateral ankle and inferior tibiofibular joint itself [6–17]. A relatively common joint instability as

a consequence of the lesion cause also injury to the inferior tibiofibular joint. When the limb subjected to trauma is externally rotated, fibular fracture occurs usually below the level of the tibiofibular interosseous ligament and it does not involve it [18, 19].

Materials and methods

The study was carried out on 50 adult lower limbs, males and females, aged 35–76 obtained during autopsies or routine anatomical dissection. Department of Forensic Medicine; Department of Anatomy UJ CM). The study was approved by a Local Ethical Committee — KBET: 122.6120.315.2016. We have studied only these limbs which did not show macroscopically any signs of pathologies with special respect to the vascular system.

Thus obtained material was divided into four age groups:

- Group I included limbs of individuals aged 35–46
- Group II included limbs of individuals aged 47–56
- Group III included limbs of individuals aged 57–66
- Group IV included limbs of individuals aged 67–76

Most of the limbs were from the individuals aged 57–66 — 23 examples (46% of studied amount — see Table 1).

Limbs of three males and one female were disqualified because of visible necrotic changes in the studied region.

Table 1. Age groups (I—IV).

Group (age)	Number of limbs		%
	left	right	
I (35–46)	3	2	10.00
II (47–56)	4	3	14.00
III (57–66)	11	12	46.00
IV (67–76)	8	7	30.00
Total	26	24	100.00

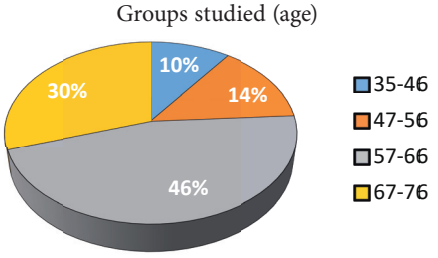

Fig. 1. Subdivision of the material studied.

Majority of the material obtained were female limbs. 31 limbs (62%) were female, while 19 (38%) were male.

The lateral malleolar region was gently dissected to make visible the main supplying vessels — fibular, anterior and posterior tibial vessels, their branches and tributaries. It was necessary to cut the fibula (lower 1/3 of its length) and separate it from its bed to see the inferior tibiofibular joint. Thus obtained specimens were evaluated histologically and dyed with hematoxylin and eosin to estimate vascular density [20].

Table 2. Distribution of the specimens.

Gender	Number of limbs	%
Female	31	62.00
Male	19	38.00
Total	50	100.00

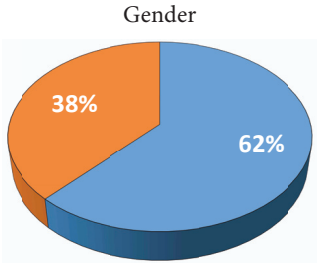

Fig. 2. Amount of female and male limbs in the material studied.

Three samples were taken from the inferior tibiofibular joint — from its apical, central and basal portions (Fig. 3).

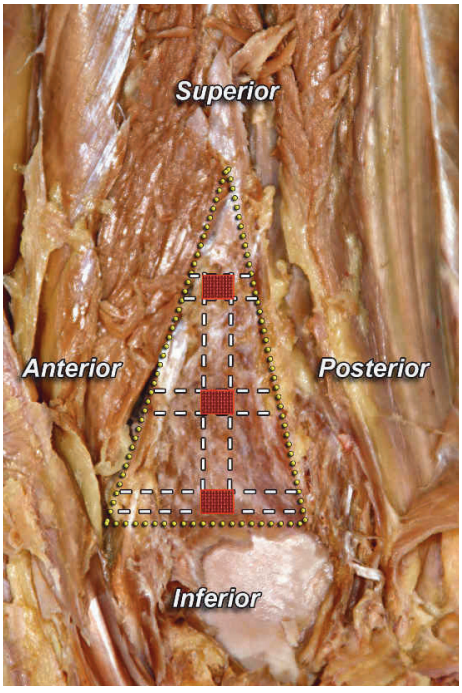

Fig. 3. Sagittal section showing the localization of the tibiofibular joint and scheme of sample obtaining.

A series of slides was prepared in Department of Pathology (Head: prof. Dariusz Adamek), cut at right angles to the longitudinal axis of the syndesmosis, according to the most probable course of the blood vessels, obtaining the transverse sections. Thus obtained specimens were dehydrated in ethyl alcohol and immersed in sodium benzoate, benzene and paraffin. Next the specimens were cut into slides 4 μm thick and dyed with hematoxylin and eosin. Next the material was studied under the microscope using magnifications between 5 and 40 ×. Specimes were subsequently photographed under a magnification 40 × and analyzed in the program ImageJ (authors: Wayne, Rasband) [21, 22].

The proportion of the fibrous connective and fat, the lumina of blood vessels was analyzed tissue with respect to the surface of the whole specimen in a visual field. An average value was taken after evaluation of the whole surface.

Results

Studying the vascular density of the inferior tibiofibular joint we have estimated the ratio of the fibrous connective tissue to the fat tissue and the lumina of the blood vessels in a specimen. The results are seen in Table 3.

We have noticed that vascular density is dependent on the type of blood supply and independent on the age.

Table 3. Fibrous connective tissue ratio to the fat tissue and the lumina of blood vessels.

Type of blood supply	Fibrous connective tissue (%)	Fat tissue (%)	Lumina of blood vessels (%)
IA	65.00	18.00	4.5
IB	55.00	35.00	4.2
IIA	44.00	47.00	5.0
IIB	51.00	42.00	6.6
III	85.00	11.00	3.7
Total	60.00	30.60	4.8

Obtained results indicate that vascular density of the inferior tibiofibular joint is significantly low (4.8%), what may be indicative for low potential of its healing. Special attention should be paid to longer stabilization of the joint i.e. after trimalleolar fracture with subsequent lesion of the syndesmosis. Iatrogenic "mechanical silence" may help in healing proces. We have performer also Pearson's correlation between the age of the studied individuals and blood supply of the joint, but we did not see positive correlation ($p > 0.05$).

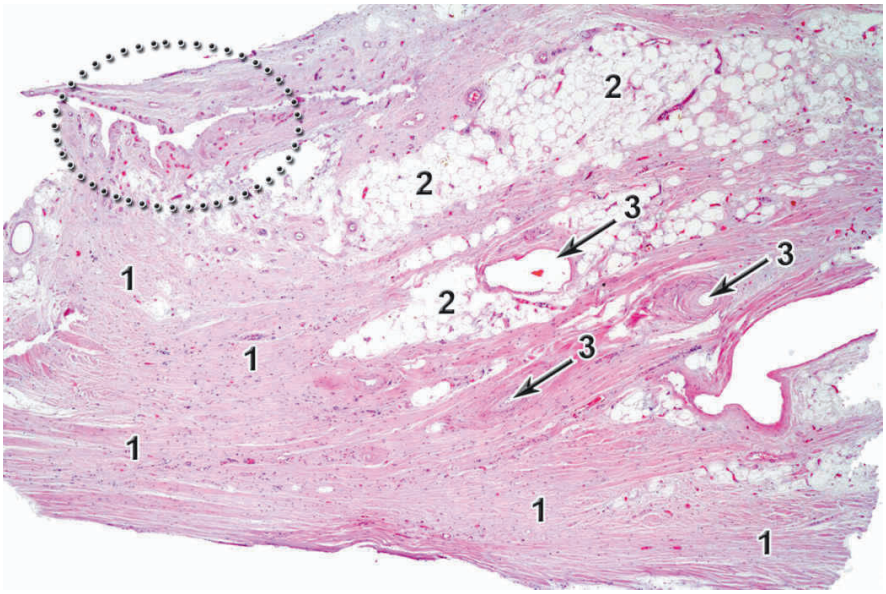

Fig. 4. Localization of minute blood vessels within the inferior tibiofibular joint. HE staining. Magnification 40 ×. Female 58 years old, right lower limb — specimen stained in formaldehyde solution. 1 — fibrous connective tissue; 2 — fat tissue; 3 — blood vessels. Surrounded area — visible numerous blood vessels (red dots).

Discussion

Many authors studies blood supply of the lower limb. Some of them examined vascular anatomy of foot [23–31]. Current literature includes the studies on the caliber of arteries of the lower limb, i.e. fibular, anterior tibial and posterior tibial arteries [32, 33], as well about the anastomoses between these vessels. There is still a question however what is the value of such studies performer on embalmed bodies with special respect to such measurements. There is however minimal amount of papers dealing with the blood supply of the lateral malleolar region with special attention to the vascularization of the inferior tibiofibular syndesmosis [34]. Numerous authors however concentrate on the anatomy of the malleolar region [4, 35–37], with special respect paid to clinical implications, lesions of this region and their epidemiology [38].

The are no data on the measurements of the vascular density within the tibiofibular joint. Our results indicate that it seems to be rather sparse (4.8%) (4.8%). It may suggest that a potential of healing in this region is relatively low. Form another hand however it may indicate a prolonged immobilization necessity (i.e. application of a “ligamentous” screw) especially after the fractures with subsequent lesion of the inferior tibiofibular joint.

The knowledge on the sources of blood supply of tibiofibular syndesmosis is clinically important — w special attention to orthopedic surgeons who operate in the region of the distal tibial and fibular ends. Inappropriately inserted and placed screw may injure blood vessels which supply the joint and delay healing process or increase the risk of other potential complication (i.e. postoperative calcifications).

References

1. *Mróz I., Kurzydło W., Bachul P., Jaworek J., Konarska M., Bereza T., Walocha K., Mazur M., Kuniewicz M., Depukat P., Mizia E., Chmielewski P., Warchoł Ł.*: Inferior tibiofibular joint (tibiofibular syndesmosis) — own studies and review of the literature Fol Med Cracov. 2015; 4: 71–79.
2. *Mróz I., Kielczewski S., Pawlicki D., Kurzydło W., Bachul P., Konarska M., Bereza T., Walocha K., Kaythampillai L.N., Depukat P., Pasternak A., Bonczar T., Chmielewski P., Mizia E., Skrzat J., Mazur M., Warchoł Ł., Tomaszewski K.*: Blood vessels of the shin — anterior tibial artery — anatomy and embryology — own studies and review of the literature. Fol Med Cracov. 2016; 1: 33–47.
3. *Golanó P., Vega J., de Leeuw P.A.J., Malagelada F., Manzanares M.C., Goötzens V., van Dijk C.N.*: Anatomy of the ankle ligaments: a pictorial essay. Knee Surg Sports Traumatol Arthrosc. 2010; 18 (5): 557–569.
4. *Ebraheim N.A., Lu J., Yang H., Rollins J.*: The fibular incisure of the tibia on CT scan: a cadaver study. Foot ankle 1998; 19: 318–321.
5. *McKeon K.E., Wright R.W., Johnson J.E., McCormick J.J., Klein S.E.*: Vascular anatomy of the tibiofibular syndesmosis. J Bone Joint Surg [Am]. 2012; 94: 931–938.
6. *Bandy W.D., Strong L., Roberts T., Dyer R.*: False aneurysm a complication following an inversion ankle sprain: a case report. J Orthop Sports Phys Ther. 1996; 23 (4): 272–279.
7. *Dong L., Li F., Jiang J., Zhang G.*: Transplantation of fibula with vascular pedicle for fusion of ankle in leprotic drop-foot. Indian J Lepr. 2000; 72 (4): 431–436.
8. *Golec E., Peszko J., Karuś A.*: Patomechanika złamań kostek goleni. Kwart Ortop. 1995; 3: 13–16.
9. *Golec E.*: Kliniczna i radiologiczna ocena pourazowej, mechanicznej niestabilności stawu skokowo-goleniowego. Kwart Ortop. 2001; 3: 177–181.
10. *Golec E., Widawski A.*: Przednio-boczny zespół zderzeniowy, a ocena przewlekłej, pourazowej niestabilności stawu skokowo-goleniowego. Chir Narz Ruchu Ortop Pol. 2001; 66: 377–386.
11. *Golec E.*: Odległa ocena kliniczna i radiologiczna stabilności stawu skokowo-goleniowego po ostrym urazowym uszkodzeniu aparatu więzadłowo-torebkowego. Chir Narz Ruchu Ortop Pol. 2002; 67: 357–364.
12. *Golec E.*: Następstwa otwartych złamań kostek goleni — obraz radiologiczny, a odległe wyniki czynnościowe. Kwart Ortop. 2003; 3: 146–149.
13. *Golec E., Wiśniowski J.*: Radiologiczna ocena porównawcza wyznaczania pourazowej, mechanicznej, przedniej niestabilności stawu skokowo-goleniowego sposobem Zwippa i metodą własną. Kwart Ortop. 2004; 3: 16.7–170.
14. *Golec E., Nowak S., de Lubicz-Jaworowski M.*: Chronic instability talocrural joint after tibiofibular syndesmosis traumatic injuries. Chir Narządów Ruchu Ortop Pol. 2005; 70 (4): 255–259.
15. *Kozień M.S., Lorkowski J., Szczurek S., Hładki W., Trybus M.*: Computer simulation of the isolated lesion of tibiofibular an syndesmosis using the finite element method. Przegl Lek. 2008; 65 (1): 50–53.
16. *Penera K., Manji K., Wedel M., Shofler D., Labovitz J.*: Ankle syndesmotic fixation using two screws: risk of injury to the perforating branch of the peroneal artery. J Foot Ankle Surg. 2014; 53 (5): 534–538.
17. *Ward N.J., Wilde G.P., Jackson W.F., Walker N.*: Compartment syndrome following ankle sprain. J Bone Joint Surg Br. 2007; 89 (7): 953–955.

18. *Pankovich A.M.*: Fractures of the fibula at the distal tibiofibular syndesmosis. Clin Orthop Relat Res. 1979; 143: 138–147.
19. *Scurran B.L.*: Foot and Ankle Trauma. Chapter 28, Ankle Fractures by Gumann G. Churchill Livingstone 1990, New York, pp. 579–625.
20. *Walocha J.A., Szczepański W., Miodoński A.J., Gorczyca J., Skrzat J., Bereza T., Ceranowicz P., Lorkowski J., Stachura J.*: Application of acrylic emulsion Liquitex R (Binney and Smith) for the preparation of injection specimens and immunohistochemical studies — an observation. Folia Morphol. 2003; 62 (2): 157–161.
21. *Mizia E., Tomaszewski K.A., Lis G.J., Goncerz G., Kurzydło W.*: The use of computer-assisted image analysis in measuring the histological structure of the human median nerve. Folia Morphol (Warsz). 2012; 71 (2): 82–85.
22. *Mizia E., Tomaszewski K.A., Rutowicz B., Konopka T., Pasternak A., Walocha J.A.*: Computer-assisted assessment of the histological structure of the human sural nerve. Folia Morphol. 2014; 73 (3): 292–297.
23. *Ali M.W., Mohajir A.M.*: Dorsalis pedis artery: Variations and clinical significance. J Indian Med Assoc. 1996; 94: 417–418.
24. *Bailleul J.P., Olivez P.R., Mestdagh H., Vilette B., Depreux R.*: Anatomie descriptive et topographique de l'artere dorsale du pied. [Descriptive and topographical anatomy of the dorsal artery of the foot]. Bull Assoc Anat (Nancy). 1984; 68: 15–25.
25. *Gelberman R.H., Mortensen W.W.*: The arterial anatomy of the talus. Foot Ankle. 1983; 4 (2): 64.
26. *Huber J.F.*: The arterial network supplying the dorsum of the foot. Anat Rec. 1941; 80: 373–391.
27. *Mulfinger G.L., Trueta J.*: The blood supply of the talus. J Bone Joint Surg Br. 1970; 52 (1): 160–167.
28. *Perlinzski L.*: Variation of the course and the division of dorsalis pedis artery in man. Folia Morphol. 1981; 40: 141–148.
29. *Petersen W.J., lankes J.M., Paulsen F.*: The arterial supply of the lesser metatarsal heads: a vascular injection study in human cadaver. Foot Ankle. 2002; 8 (2): 81.
30. *Salvi G.*: Sull' arteria dorsal pedis. Atti della societa Toscana di scienze naturally, process verbali. 1898; 12.
31. *Senior H.D.*: An interpretation of the recorded arterial anomalies of the human leg and foot. J Anat. 1919; 53: 130–171.
32. *Szpinda M.*: Compensating crural anastomoses in chronic critical limb ischaemia. Folia Morphol. 2005; 64 (1): 17–21.
33. *Szpinda M.*: External diameters of the crural arteries in patients with chronic critical limb ischaemia. Folia Morphol. 2005; 64 (4): 315–320.
34. *Taser F., Shafiq Q., Ebraheim N.A., Yeasting R.A.*: Enlarged perforating branch of peroneal artery and extra crural fascia in close relationship with the tibiofibular syndesmosis. Surg Radiol Anat. 2006; 28: 108–111.
35. *Bartonicek J.*: Anatomy of the tibiofibular syndesmosis and its clinical relevance. Surg Radiol Anat. 2003; 25: 379–386.
36. *Golanó P., Vega J., de Leeuw P.A.J., Malagelada F., Manzanares M.C., Goötzens V., van Dijk C.N.*: Anatomy of the ankle ligaments: a pictorial essay. Knee Surg Sports Traumatol Arthrosc. 2010; 18 (5): 557–569.
37. *Hermans J.J., Beumer A., De Jong T.A.W., Kleinrensink G.J.*: Anatomy of the distal tibiofibular syndesmosis in adults: a pictorial essay with a multimodality approach. Journal of Anatomy. 2010; 217: 633–645.
38. *Golec E.*: Epidemiologia uszkodzeń urazowych stawu skokowo-goleniowego. Kwart Ortop. 2000; 4: 232–236.