

Sinus Tarsi – The Eye of the Foot and its Anatomical Contradictions

Atanas Katsarov

Institute of Experimental Morphology, Pathology and Anthropology with Museum, Bulgarian Academy of Sciences, Sofia, Bulgaria

*Corresponding author e-mail: zanasko@gmail.com

The descriptive anatomy of the tarsal sinus, canal and ligaments has been a matter of debate until today because of many inconsistencies in the description and nomenclature of the sinus tarsi ligaments. It is generally believed that the subtalar ligamentous structures consist of the cervical ligament (CL), the interosseous talo-calcaneal ligament (ITCL), the anterior capsular ligament (ACaL), and 3 roots of the inferior extensor retinaculum (IER). The importance of intrinsic subtalar ligaments in relation to the subtalar joint stability is growing more and more for the last years.

Key words: sinus tarsi, tarsal sinus, subtalar, coxa pedis, talus, calcaneus, foot

As a part of the subtalar joint sinus tarsi is an anatomically determined cavity surrounded by the bony surfaces of the talus (proximal) and calcaneus (distal), dividing the subtalar joint into anterior and posterior sections [4].

Due to its anatomy, it is specifically depicted in imaging studies of the foot and is known as the ‘eye of the foot’ or ‘bullet hole’. The scope of this article is firstly to discuss the variations in the ligamentous structures of the tarsal sinus of the foot, the functional relationships between them in the light of clinical practice and the different names under which they are found in the literature (**Fig. 1**).

The posterior subtalar joint or just subtalar joint is ovoid in shape and is formed between the relatively concave posterior facet of the talus and the convex posterior facet of the calcaneus, while the anterior subtalar joint includes the head of the talus, the middle and anterior facets of the calcaneus, and the navicular bone, i.e. is the talocalcaneonavicular joint. Together they form coxa pedis. The anterior and posterior departments are united in a single functional complex and therefore are often called the peritalar complex [24].

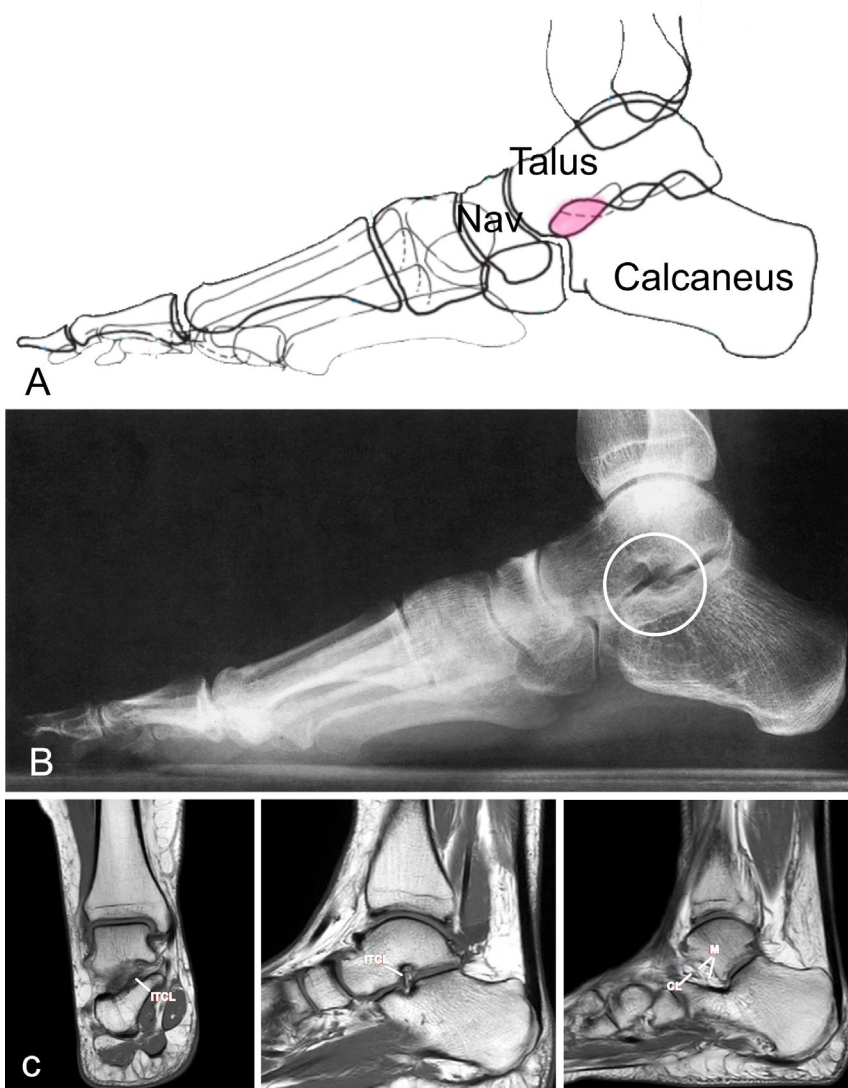


Fig. 1. Tarsal sinus (eye of the foot) A. Schematic presentation of the bones forming the subtalar joint and sinus tarsi, Nav – os naviculare.; B. X-ray imaging (lateral view) of the tarsal sinus. C. MRI of the subtalar joint, sinus tarsi and ligaments – ITCL – Interosseal talocalcaneal ligament, CL – Cervical ligament, M – Medial root of the inferior extensor retinaculum (IER)

The posterior subtalar joint has both intra-capsular and extra-capsular ligamentous supports. The intra-capsular ligamentous supports include the posterior talo-calcaneal ligament, lateral talo-calcaneal ligament and anterior capsular ligament of the posterior subtalar joint. The extra articular ligamentous supports include the calcaneo-fibular ligament, superficial deltoid ligament and the interosseous talo-

calcaneal and cervical ligaments [10]. The inferior extensor retinaculum also imparts stability to the posterior subtalar joint. One of the variabilities present medial talocalcaneal ligament is extra-articular and provides ligamentous support to the posterior subtalar joint.

The longitudinal axis of the canal is deviated about 45 degrees from the calcaneus. The sinus tarsi space is filled with connective and fatty tissue that contribute to the stability and overall proprioception of the ankle and serves as a substrate for numerous mechanoreceptors and free nerve endings that, along with ligaments and muscles, provide nociceptive and proprioceptive information about foot and ankle movement [4,17,1].

The sinus has a conical shape and a wider part is located antero-laterally. In the direction from anterior-lateral to posterior-medial, the surface of the sinus narrows to an almost transverse cylindrical space, the so-called tarsal canal. It ends behind the level of the sustentaculum tali of the talus.

A number of variations in subtalar joint articular facet anatomy are known, including medial extension of the articular surfaces to involve the posterior margin of the sustentaculum and the antero-inferior margin of the posteromedial process of the talus [8] (**Fig. 2**)

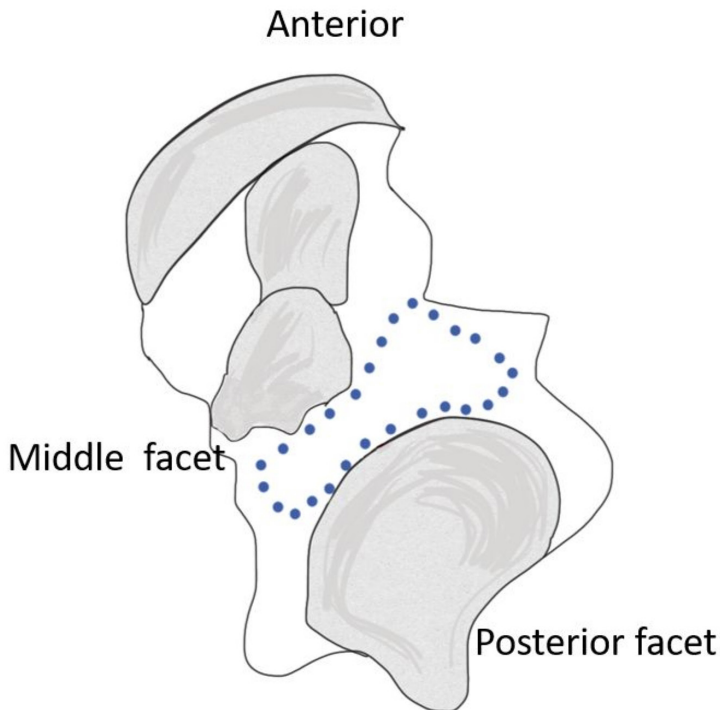


Fig. 2. Tarsal sinus and tarsal canal projection (cranial view) (From Irgit, K., Katsarov, A. Flexible Progressive Collapsing Foot Deformity Is There Any Role for Arthroereisis in the Adult Patient?, Foot and Ankle Clinics, 2021., With permission)

In addition to fatty and connective tissue, the sinus contains branches of the peroneal and posterior tibial arteries, which anastomose in the sinus and a branch of the superficial peroneal nerve – the cutaneous dorsolateral nerve [7].

Proprioceptive nerve endings are responsible for perceiving the spatial arrangement of both body parts and the whole body. As part of the sensorimotor system, they maintain the properly functioning position of the bones involved in the joints.

In addition to the structures listed, the tarsal canal contains the reinforced synovial capsule of the posterior subtalar joint and the talocalcaneonavicular joint, as well as the following ligaments.

The most medial of them is the interosseous talocalcaneal ligament (ITCL) or interosseous ligament (IL), which can also be found in the literature as the talocalcaneal ligament or Ligament of the tarsal canal or Axial ligament or Cruciate ligament of the tarsus [23] or as “Hedge” ligament of Farabeuf [11] or Oblique astragalo-calcaneal ligament [20] (**Fig. 3**). The ITCL is a vertical ligament significantly thinner than the ATFL, CFL, and CL, with its attachments parallel to the tarsal canal [15]. Several anatomical variants are observed – band type, fan type, and multiple type [13].

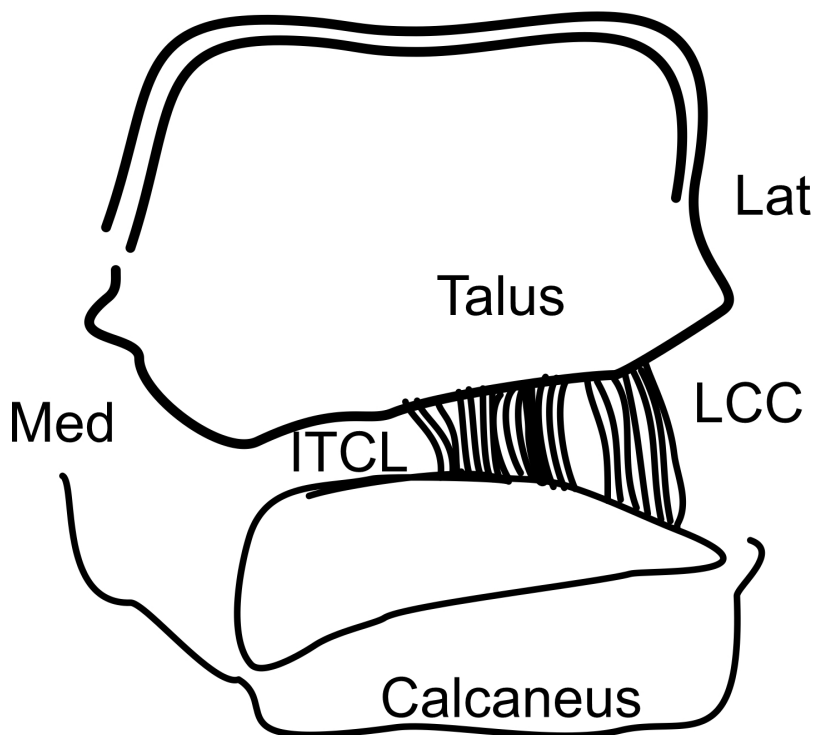


Fig. 3. Interosseous talocalcaneal ligament and lateral calcaneal component of the medial root (posterior view). Med – medial, Lat – lateral, ITCL – Interosseous talocalcaneal ligament, LCC – lateral calcaneal component of the medial root.

The ITCL together with the Anterior capsular ligament (AcaL) form the ITCL – AcaL complex, whose role is to maintain the apposition of the subtalar joint and perform eversion and inversion [2, 15]

The Cervical ligament (CL) (**Fig. 1**) known as Ligament of Fick [23] or Cervical talocalcaneal ligament [11] or External talocalcaneal ligament [20] or Oblique talocalcaneal ligament [16] or Anterolateral talo-calcaneal ligament [19]; Anterior capsular ligament known as Posterior capsular ligament [9] or Ligament of the anterior capsule of the posterior talocalcaneal joint [21] or Anterior talo-calcaneal ligament [16], is located in the sinus tarsi and is similar in size to the ATFL and CFL [18]. In the neutral position, the CL passes from the anterosuperior and medial aspect of the talus to the posteroinferior and lateral aspect of the calcaneus.

In inversion, CL is stretched in a vertical position, while in eversion CL is stretched in a horizontal position. Unlike the CFL, which is not stretched during fore-aft translation, the CL stays stretched. According to Yamaguchi et al, the CL is the fibrous part of the capsule of the talocalcaneonavicular joint [25].

The ACaL is a vertically located, rectangular bundle and corresponds to a thickened part of the anterior articular capsule of the posterior facet of the calcaneus [18, 24].

ACaL is often seen as ITCL or as a second band of ACaL. This is not clearly described in the literature and should be interpreted with caution [12]. ACaL insertion sites are located primarily in the sinus tarsi, but often extend into the tarsal canal. The ACaL and ITCL taken together have been called Farabeuf’s “hedge” ligament because they are wide and short and lie in the same direction [11] (**Fig. 4**).

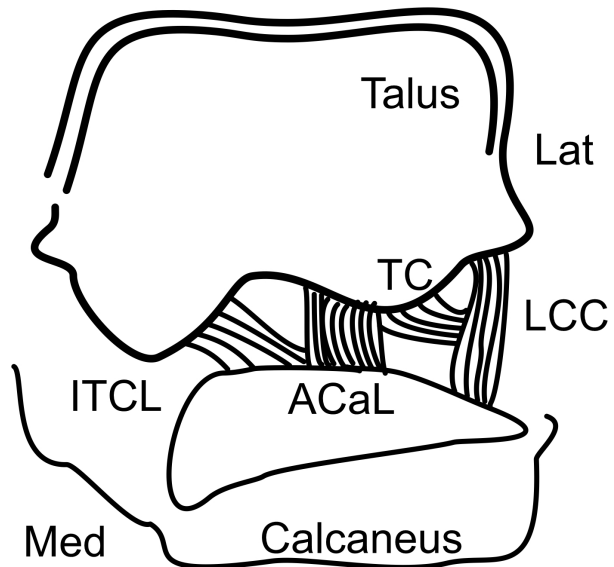


Fig. 4. Anterior capsular ligament and interosseous talocalcaneal ligament (posterior view). While the ACaL ran vertically, the ITCL ran obliquely. The ITCL had a large insertion area on the calcaneus. Med – medial, Lat – lateral, ITCL – Interosseous talocalcaneal ligament, LCC – lateral calcaneal component of the medial root, ACaL – anterior capsular ligament, TC – talar component.

Going deeper into the canal, it is found that the synovial tissues, including the inferior extensor retinaculum (IER) are those that divide the subtalar joint into two – the posterior talocalcaneal facet and the anteriorly fused anterior and middle talocalcaneal facets [25]

The extensor retinaculum (IER) covers 3 layers in depth, from back to front:

the anterior articular capsule of the posterior talocalcaneal joint, the interosseous talocalcaneal ligament (ITCL), and the medial insertion of the inferior extensor retinaculum (IER), as well as the posterior capsule of the talocalcaneonavicular joint. The anterior capsule of the posterior talocalcaneal joint consists of fibrous and synovial tissues that intertwine with each other [25].

The roots of the inferior extensor retinaculum anchor the lateral stalk of the retinaculum to the calcaneus, limiting extensor tendon excursion and limiting ankle inversion.

The medial root of the inferior extensor retinaculum is located posterior and medial to the cervical ligament CL, attached to the calcaneus at the bottom of the medial sinus, often merging with the calcaneal attachment of the interosseous ligament [8].

Sarrafiyan noted that the medial root of the IER has 3 components (the medial calcaneal component, the talar component, and the lateral calcaneal component) [24].

Jotoku et al and Li et al. confirmed these findings and reported that the medial calcaneal component (MCC) and the talar component (TC) of the medial root displayed 3 distinct anatomical variations in their shape and attachments [3,9]. In Jotoku' study, the author described the blending of 1 type of MCC with the fibers of the ITCL to form a V-shaped structure in the tarsal sinus and canal. Based on this, he hypothesized that the MCC may transmit the force of the extensors to the ITCL. [3].

Unlike Jotoku et al, Li et al. found that the medial root of the IER diverged into 2 components rather than 3 [9].

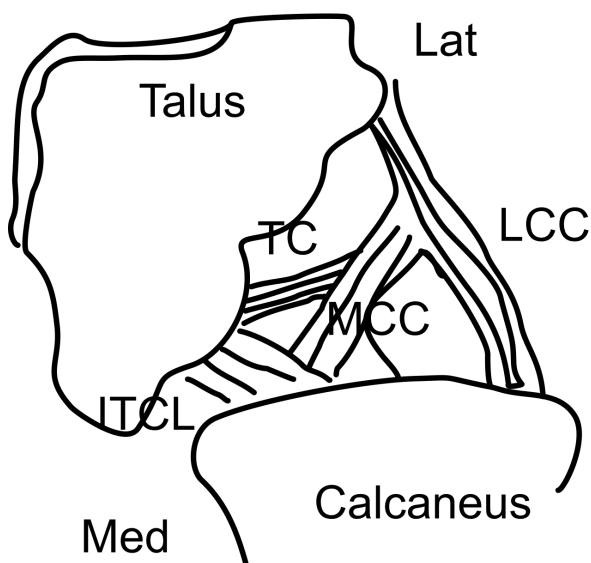


Fig. 5. Talar component of the medial root diverged from MCC (posterior view), Med – medial, Lat – lateral, ITCL – Interosseous talocalcaneal ligament, LCC – lateral calcaneal component of the medial root, TC – talar component, MCC – medial calcaneal component.

The intermediate root of the inferior extensor retinaculum also called the intermediary root, attaches to the calcaneus just behind the cervical ligament, passing anteriorly and superiorly over the medial edge of the extensor digitorum longus tendon [6].

The lateral root of the inferior extensor retinaculum was first described by Wood-Jones in 1944 as the “ligamentum frondiform”. Later, Cahill (1965) described its subtarsal location and divided the lateral root into three - lateral, intermediate, and medial [2].

This structure wraps around the lateral edge of the extensor digitorum tendon, fusing with the medial root to form a sling-like structure over the tendon. The lateral fibers extend posteriorly and laterally, attaching to the lateral cortex of the calcaneus or blending with the deep fascia [9].

Tarsal Canal Ligament is a short vertical ligament lying on the medial side of the tarsal canal just between the middle talocalcaneal facet and the lamina formed by the medial band of the medial root of the IER and the ITCL. Its presence in the population is about 60% [9].

The TCL forms a short, tight connection between the talus and the calcaneus. On its medial side is the sustentaculum tali, where some fibers of the TCL join those of the medial talocalcaneal ligament MTCL.

The middle subtalar joint is formed by the articular facet of sustentaculum tali of the calcaneus and the middle talar articular facet of the talus. The joint is next to the talo-navicular joint and could be found as the talo-navicular middle subtalar joint complex in the literature. Middle talar articular facet anatomy is relatively constant. Occasionally, the middle and anterior calcaneal and talar articular facets may be contiguous. The posterior capsule of the middle subtalar joint may be of variable thickness, occasionally being relatively thick, potentially mimicking a fibrous coalition or the interosseous talo-calcaneal ligament. The ITCL may be hypoplastic in the setting of a thick posterior capsule of the middle subtalar joint [10].

Anatomical knowledge of the tarsal canal and sinus is still unclear owing to the complexity of the ligamentous structures within them, particularly the relationship with the capsules of the subtalar joints [25].

Much of the ambiguity is due to the fact that in different studies, the authors use different and several names for individual ligaments and structures, as well as the very anatomical variation of the structures, their presence or absence in individual representatives of the human population.

The most important extrinsic ligaments are the CFL, which limits inversion, and deltoid ligament, which limits eversion. Some studies indicate that the anterior talofibular ligament (ATFL) has an indirect function in the stability of the subtalar joint [3].

Today, several recent publications support the hypothesis that the intrinsic subtalar ligaments play an important role in the stability of the subtalar joint [12]. It is believed that the ligament of the tarsal canal appears to maintain apposition of the talus and calcaneus in all positions.

References

1. **Akiyami, K., Y. Takakura, Y. Tomita, Y. K. Sugimoto, Y. Tanaka, S. Tamai.** Neurohistology of the sinus tarsi and sinus tarsi syndrome. – *J. Orthop. Sci.*, **4**, 1999, 299-303.
2. **Cahill, D. R.** The anatomy and function of the contents of the human tarsal sinus and canal. – *Anat. Rec.*, **153**, 1965, 1-17.
3. **Jotoku, T, M. Kinoshita, R. Okuda, M. Abe.** Anatomy of ligamentous structures in the tarsal sinus and canal. – *Foot Ankle Int.*, **27**(7), 2006, 533-538.
4. **Helgeson, K.** Examination and Intervention for Sinus Tarsi Syndrome. – *N. Am. J. Sports Phys. Ther.*, **4**(1), 2009, 29-37.
5. **Kelikian A. S., S. K. Sarrafian.** *Sarrafian's Anatomy of the Foot and Ankle: Descriptive, Topographical, Functional.* (Eds S. Kelikian) Philadelphia, Wolters Kluwer Health/ Lippincott Williams & Wilkins, 2011.
6. **Kjaersgaard-Andersen, P., J. O. Wethelund, P. Helmig, K. Søballe.** The stabilizing effect of the ligamentous structures in the sinus and canalis tarsi on movements in the hindfoot. An experimental study. – *Am. J. Sports Med.*, **16**(5), 1988, 512-516.
7. **Klein, M. A., A. M. Spreitzer.** MR imaging of the tarsal sinus and canal: normal anatomy, pathologic findings, and features of the sinus tarsi syndrome. – *Radiology*, **186**(1), 1993, 233-240.
8. **Lee, M. S., H. T. Harcke, S. J. Kumar, G. S. Bassett.** Subtalar joint coalition in children: new observations. – *Radiology*, **172**, 1989, 635-639.
9. **Li, S., Z-D. Hou, P. Zhang, H. Li, Z-H. Ding, Y-J. Liu.** Ligament structures in the tarsal sinus and canal. – *Foot Ankle Int.*, **34**(12), 2013, 1729-1736.
10. **Linklater, J., C. L. Hayter, D. V. Tse.** Anatomy of the subtalar joint and imaging of talocalcaneal coalition – *Skeletal Radiol.*, **38**, 2009, 437-449.
11. **Mabit, C., M. P. Boncoeur-Martel, J. M. Chaudruc, D. Valleix, B. Descottes, M. Caix.** Anatomic and MRI study of the subtalar ligamentous support. – *Surg. Radiol. Anat.*, **19**(2), 1997, 111-117.
12. **Michels, F., E. Vereecke, G. Matricali.** Role of the intrinsic subtalar ligaments in subtalar instability and consequences for clinical practice. – *Front. Bioeng. Biotechnol.*, **11**, 2023, 1047134.
13. **Michels, F., G. Matricali, E. Vereecke, M. Dewilde, F. Vanrietvelde, F. Stockmans.** The intrinsic subtalar ligaments have a consistent presence, location and morphology. – *Foot Ankle Surg.*, **27**(1), 2021, 101-109.
14. **Michels, F., S. Ozeki, S. W. Kong, G. Matricali, G.** Assessment of subtalar instability. – In: *Lateral ankle instability. An international approach by the ankle instability group.* First ed. (Eds. H. Pereira, S. Guillo, M. Glazebrook, M. Takao, J. Calder, N. Van Dijk, J. Karlsson), Berlin, Springer, 2021, 63-77.
15. **Michels, F., O. Taylan, F. Stockmans, E. Vereecke, L. Scheys, G. Matricali.** The different subtalar ligaments show significant differences in their mechanical properties. – *Foot Ankle Surg.*, **28**, 2022, 1014-1020.
16. **Mittlmeier, T., S. Rammelt.** Update on subtalar joint instability. – *Foot Ankle Clin.*, **23**, 2018, 397-413.
17. **Pisani, G., P. C. Pisani, E. Parino.** Sinus tarsi syndrome and subtalar joint instability. – *Clin. Pod. Med. Surg.*, **22**, 2005, 63-77.
18. **Sarrafian, S.** *Anatomy of the foot and ankle.* – In: *Descriptive, topographic, functional. 2nd Edn* (Eds: S. Sarrafian), Philadelphia, J. B. Lippincott, 1993, 113-217.
19. **Shellshear, J., N. Macintosh.** *Surveys of anatomical fields.* Sydney, Grahame Book Company, 1949.

20. **Smith, E. B.** Astragalo-Calcaneo-navicular joint. – *J. Anat. Physiol.*, **30**(3), 1896, 390-412.
21. **Stephens, M. M., G. J. Sammarco.** The stabilizing role of the lateral ligament complex around the ankle and subtalar joints. – *Foot Ankle*, **13**(3), 1992, 130-136.
22. **Tsao, L.** Sinus Tarsi Syndrome. – MRI Web Clinic, 2020, Available at: <https://radsourc.us/sinus-tarsi-syndrome/>**Viladot, A., J. C. Lorenzo, J. Salazar, A. Rodriguez.** The subtalar joint: Embryology and morphology. – *Foot Ankle*, **5**(1), 1984, 54-66.
23. **Wood-Jones, F.** The talocalcaneal articulation. – *Lancet*, **247**, 1944, 241-242.
24. **Yamaguchi, R., A. Nimura, K. Amaha, K. Yamaguchi, Y. Segawa, A. Okawa, K. Akita.** Anatomy of the Tarsal Canal and Sinus in Relation to the Subtalar Joint Capsule. – *Foot Ankle Int.*, **39**(11), 2018, 1360-1369.