REVIEW ARTICLE

CONTENTS

Tarsal tunnel syndrome in runners: diagnosis and return to physical activity – a review

Julia Szewczyk[1], Anna Szuciak[1], Kamila Mozga[1], Olga Synowiecka[1], Igor Rydzyk[1], Konrad Talarek[1], Michał Świta[1], Karolina Turżańska[2]

[1]STUDENT SCIENTIFIC ASSOCIATION AT THE DEPARTMENT OF REHABILITATION AND ORTHOPEDICS, MEDICAL UNIVERSITY OF LUBLIN, LUBLIN, POLAND

[2]DEPARTMENT OF REHABILITATION AND ORTHOPEDICS, MEDICAL UNIVERSITY OF LUBLIN, LUBLIN, POLAND

ABSTRACT

Aim: Tarsal Tunnel Syndrome (TTS) is a rare compressive neuropathy of the posterior tibial nerve, often undiagnosed but particularly relevant to runners due to the unique biomechanical demands of the sport. Running places repetitive stress on the foot and ankle, increasing susceptibility to nerve compression within the tarsal tunnel.

Materials and Methods: This review examines the anatomical structure of the tarsal tunnel, the etiology, and epidemiology of TTS, and highlights risk factors such as excessive pronation, high arches, and prior ankle injuries. Diagnosis relies on clinical assessments like the Tinel test, imaging techniques, and neurophysiological tests. Treatment ranges from conservative approaches, including orthoses, physical therapy, and nonsteroidal anti-inflammatory drugs (NSAIDs), to surgical interventions for nerve decompression, with emerging minimally invasive techniques gaining popularity. Rehabilitation is critical for restoring functionality and enabling runners to return to physical activity.

Conclusions: Comprehensive management of TTS, particularly for runners, involves a holistic approach encompassing prevention strategies, proper diagnosis, and individualized rehabilitation protocols. This review underscores the importance of increasing awareness of TTS among healthcare professionals and athletes to improve early detection, optimize treatment outcomes, and prevent recurrence.

KEY WORDS: tarsal tunnel syndrome, tibial nerve neuropathy, runners injuries, foot injuries, return to sport activity

Wiad Lek. 2025;78(3):584-590. doi: 10.36740/WLek/202447 DOI

INTRODUCTION

Over the last few decades, running has become one of the most popular sports. Despite the numerous health benefits of practicing this sport, it should be remembered that it is also associated with many injuries [1]. Runners often experience a variety of injuries, the most common of which are related to the knee, foot, and ankle. Patellofemoral pain syndrome (PFPS), iliac band friction syndrome (ITBFS), and patellar tendonitis are the predominant knee injuries, often resulting from biomechanical issues and overuse [2, 3]. Foot injuries such as plantar fasciitis are also common, accounting for 10% to 20% of all running injuries, with excessive loading and biomechanical abnormalities being significant contributing factors. Ankle injuries, including sprains, are common, accounting for 15% of all sports injuries, and often occur in runners due to repetitive impact and stress on the lower limbs [4, 5]. Additionally, injuries to the hip, pelvis, and thighs, such as muscle strains and tendinopathies, are noteworthy, often presenting diagnostic challenges and requiring a detailed history and physical examination for proper management [6]. Overuse injuries are particularly common in long-distance runners, with a high incidence of plantar fasciitis and other foot-related impairments [5]. The multifactorial nature of running-related injuries is evident, with factors such as previous injury history, training load, anatomical abnormalities, and running kinematics playing a significant role [7, 8]. Nerve injuries are a much rarer group of injuries. This group includes compression neuropathies of peripheral nerves. It is a rare condition that often goes undiagnosed [9]. A localized compressive neuropathy of the posterior tibial nerve or one of its related branches, either separately or together, is what is known as Tarsal Tunnel Syndrome (TTS). Runners are particularly susceptible to tarsal tunnel syndrome (TTS) due to the unique biomechanical demands of running, which can exacerbate conditions leading to the compression of the posterior tibial nerve within the tarsal tunnel. This group of athletes also often

experience trauma or micro-trauma to the ankle, which can cause adhesions or swelling in the tarsal tunnel, further compressing the nerve [10]. A thorough literature search was carried out utilizing well-known databases, including PubMed, Scopus, and Google Scholar, in order to create this review. The terms "tibial nerve neuropathy," "runners' injuries," "foot injuries," and "return to sport activity," which are associated with the diagnosis of tarsal tunnel syndrome, were employed. In order to find pertinent research, the search also included phrases associated with "imaging techniques," "risk factors," and "treatment methods." To guarantee that the most recent and relevant information was found, the search was restricted to articles published during the last ten years, as well as a few significant earlier publications. Forty scientific publications in all were chosen because they were of high substantive value in the context of the issues being considered and offered insightful information about the situation as outlined. These articles' contributions to the growth of our understanding of TTS and their possible therapeutic ramifications were carefully examined.

AIM

The aim of this review is to collect information on tarsal tunnel syndrome in order to determine the best diagnostic scheme and the possibility of returning to physical activity, especially in the group of runners.

MATERIALS AND METHODS

In July and August of 2024, a literature search was carried out. We used databases like PubMed and Web of Science. The search terms "tarsal tunnel syndrome," "tibial nerve neuropathy," "runner's injuries," "foot injuries," and "return to sport activity" were among those that were included. They were examined in the databases both separately and together. Articles that did not fit the subject criteria were eliminated after the titles and abstracts were reviewed since they had nothing to do with our work's focus on steppe isthmus syndrome and related diagnostic and therapeutic possibilities. To identify the most pertinent research studies and reviews, we thoroughly examined the remaining publications. The review was evaluated independently by two people. Scientific research on the diagnostic and therapeutic potential of tarsal tunnel syndrome as well as systematic and interventional reviews in this area were among the inclusion criteria. Key scientific works from earlier times were included in the search, which was restricted to scientific articles released between 2016 and 2024.

REVIEW AND DISCUSSION

ANATOMY

The tarsal canal is located posteroinferior to the medial malleolus. Medially, it is limited by the flexor retinaculum, and laterally, it is limited by the calcaneus and talus. Anterosuperior to the canal is the medial malleolus of the tibia, while its posteroinferior boundary is the calcaneus. Many important structures pass through the tarsal canal. These include three muscle tendons (flexor hallucis longus, flexor digitorum longus, and posterior tibialis), as well as an artery, vein, and posterior tibial nerve [11, 12]. This nerve is both motor and sensory, innervating the skin of the posterolateral side of the leg, the lateral aspect of the foot, and the sole of the foot. It shares the cutaneous innervation of the hind leg with the saphenous, superficial sagittal, sural, and medial calcaneal branches [13]. The tibial nerve, from which the posterior tibial nerve originates, originates from the roots of the L4-S3 spinal nerve and provides motor and sensory innervation to most of the posterior leg and foot, including branches such as the medial sural cutaneous nerve, medial calcaneal nerve, and medial and lateral plantar nerves (Fig. 1) [14].

ETIOLOGY AND EPIDEMIOLOGY

Tarsal tunnel syndrome can be caused by external and internal causes. The first group includes injuries, ill-fitting footwear, systemic diseases, and post-operative scars. The group of internal causes includes tendon sheath inflammation, osteophytes, ligament hypertrophy, varicose veins, ganglion cysts, tumors, and neuromas [9, 11]. It is classified as a rare disease by the Office of Rare Diseases Research of the National Institutes of Health, affecting approximately 1 in 1,500 people, with a slightly higher incidence in women (56%).

The typical patient profile includes adults, mainly women, aged 45 to 55 years, often with a history of weight gain, swelling, and joint hypermobility. TTS can be caused by a variety of factors, including trauma (17%), varicose veins (13%), talipes varus (11%), fibrosis (9%), and talipes valgus (8%), while 20-40% of cases have no discernible cause [15]. However, runners are among the groups particularly vulnerable to the occurrence of tarsal tunnel syndrome. High compliance in this group is related to biomechanical and overload factors. Excessive pronation and valgus of the foot while running lead to increased tension in the tarsal canal and, consequently, to compression of the posterior tibial nerve. Mechanical load on the foot while running can lead to micro-injuries and chronic inflammation, which are also conditions that can lead to compression of the

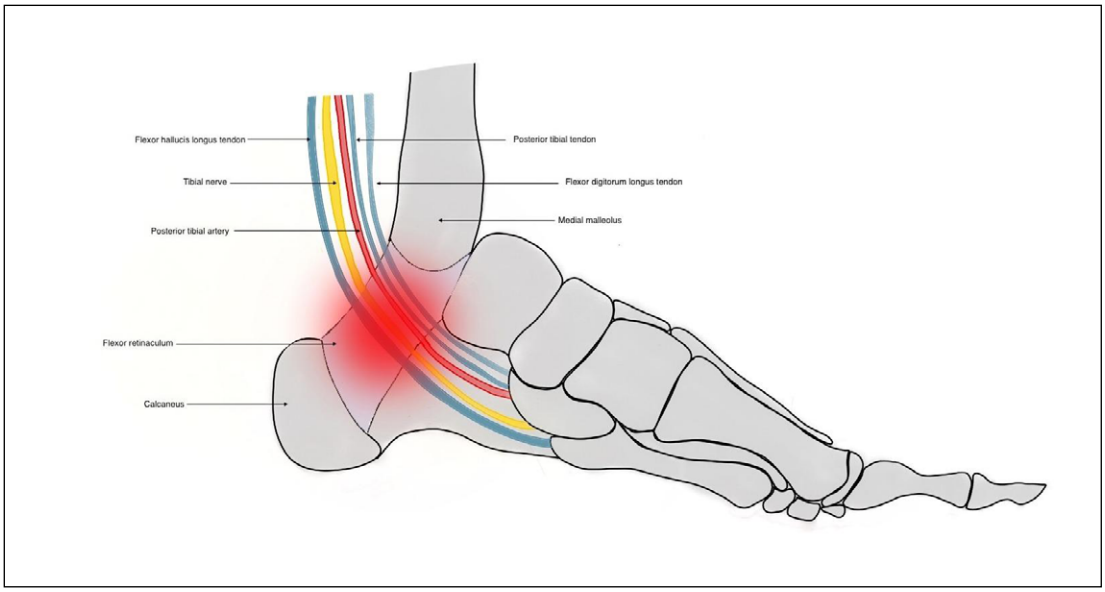

Fig. 1. Anatomy of the tarsal cannal.

tibial nerve. Risk factors also include biomechanical foot abnormalities such as high foot arches, muscle imbalance, and low tissue elasticity [16]. Runners are also exposed to other injuries, which may lead to the development of TTS. In a study, Foster et al. showed that ankle sprains may be a potential risk factor leading to tibial nerve compression. In a cohort with ankle sprains (n = 22,966), TTS occurred in 127 patients within 2 years of the sprain. Factors that increased the likelihood of TTS were female gender, increasing age, and the presence of metabolic syndrome. In addition, an ankle fracture associated with an ankle sprain decreased the chance of TTS [17].

SYMPTOMS

Tarsal tunnel syndrome is characterized by a range of symptoms primarily due to the compression of the tibial nerve or its branches within the tarsal tunnel, a fibro-osseous passage located on the medial side of the ankle beneath the flexor retinaculum [18]. Typical symptoms include pain, burning, tingling, and numbness of the plantar aspect of the foot and legs, which may sometimes extend to the medial distal calf [19, 20]. Patients often report sensory disturbances such as cold sensations, foreign body sensations such as walking on gravel, and plantar thickening [21]. Pain and paresthesia are usually aggravated by activities that increase tarsal tunnel pressure, such as prolonged standing or walking, and may be alleviated by rest [12].

DIAGNOSIS

One of the tests with relatively high sensitivity is the Tinel test. It involves proximal percussion of the nerve and is positive in the event of paresthesia in places innervated by this nerve. The test is performed by tapping the area above the tarsal tunnel, approximately 1-2 cm posterior to the medial malleolus and up to 1 cm above it. This test is simple to perform and significantly facilitates the diagnostic process of TTS, which is diagnosed based on the medical history and physical examination [22, 23].

A tibial nerve compression diagnosis can also be made based on the assessment of muscle mobility and strength. For this purpose, the dorsiflexion and eversion tests prove useful. The presence of pain or severe symptoms of paresthesia in this case may indicate TTS [9].

The most useful imaging methods include MRI and ultrasound. Magnetic resonance imaging helps identify cancerous lesions, bone spurs, and foot deformities. Please note that MRI findings should always be assessed in conjunction with clinical findings to avoid misdiagnoses [24, 25]. A study by Kim et al. examined the usefulness of using this method in preoperative planning. It has been shown that MRI can be effective for preoperative planning, especially when mass tumors are present, as well as when we are dealing with idopathic tarsal tunnel syndrome. However, the high cost of the method and its limited availability make it not the method of choice for every patient with suspected TTS [26].

Ultrasound is a method characterized by its high availability and low cost of examination. Fantino's study from 2014 demonstrated the effectiveness of ultrasound as a reliable method for assessing the tarsal canal, which significantly facilitates the confirmation of TTS. In 2021, Fantino et al. examined whether a cross-section of the tibialis muscle could be used to diagnose tibial nerve compression. It has been shown that patients

with tarsal tunnel syndrome have a significantly larger cross-section of the tibial nerve than patients in the control group. In 2023, Iborra et al. conducted a study examining whether the administration of lidocaine to the tibial nerve under ultrasound guidance can help in the diagnosis of TTS. The results showed that it can be an inexpensive and reliable method to facilitate the diagnosis of this pathology. Additionally, improved conduction after lidocaine administration may have a high predictive value for outcomes after surgical decompression [27-29].

Neurophysiological tests also have a place in the diagnosis of tarsal tunnel syndrome. One of the most common uses is EMG. Particular benefits of using this test include the ability to identify specific muscles affected by nerve damage. The test can be widely used in the case of neuropathies, including TTS, but it is mainly used to confirm the diagnosis and is not used as an independent test on the basis of which a diagnosis can be made [30].

TREATMENT

The diagnosis of TTS requires the doctor to select appropriate therapy. It depends largely on the etiology of the disease, the symptoms presented, and the severity of the disease. Depending on the above factors, non-invasive therapies and surgical treatments can be chosen [31].

The basic action taken in conservative treatment is to limit the load on the affected foot and rest. In situations where tibial nerve compression is caused by abnormal foot positioning while walking or running, foot orthoses are used. Physical therapy and kinesitherapy exercises, like gastrocnemius stretching, strengthening the weak muscles, and using medical longitudinal arch supports and heel or sole wedges to obtain neutral position of the foot, seem to be of key importance. They help relieve pain and increase muscle strength, which helps the affected foot move properly. Pharmacotherapy is also used in the treatment of TTS. Treatment with nonsteroidal anti-inflammatory drugs (NSAIDs) reduces pain and inflammation, while local anesthetics are particularly effective in the case of inflammatory processes and to relieve paresthesia and pain. Other forms of non-invasive treatment are also known, such as shock wave therapy or laser therapy, but the effectiveness of these methods has not been fully confirmed [32, 33].

Surgical treatment is the method of choice when conservative treatment options have been exhausted. The goal of surgical treatment is to release the tibial nerve in order to restore its proper function. The main methods are open dissection and decompression of the tibial nerve. This is the most common operation and is highly effective, but the risk of damaging the tarsal canal structure is relatively high. During this procedure, it is often necessary to remove pathological changes whose presence in the canal leads to nerve compression or increased pressure [34].

Minimally invasive methods are becoming more and more popular. Their main advantage is less tissue destruction, which means less pain and a faster recovery. One of such methods is acupotomy. It involves inserting a thin needle into the tarsal canal and using it to cut adhesions or tissues to decompress the nerve [35]. Subcutaneous endoscopic systems are also used to treat TTS; they enable better visualization of the tibial nerve and minimize intraoperative bleeding. However, they require extensive operator experience and cannot cope with larger changes that must be removed in a classic operation [36]. There are many benefits to using ultrasound in minimally invasive TTS surgery. Precise imaging of the structure in the tarsal canal means that this method is associated with fewer intra- and postoperative complications. However, it requires a long learning period to master and the availability of appropriate equipment to perform the procedure [37]. Minimally invasive methods are constantly gaining popularity and offer more and more advantages over traditional surgery. However, there is still a lack of high-quality research confirming the advantage of these methods over classical surgery, and their use is limited to a small number of centers.

REHABILITATION AND RETURN TO PHYSICAL ACTIVITY

Return to physical activity after TTS is closely related to the patient's condition before treatment and the form of therapy used. By using appropriate physiotherapy methods, scar tissue contractions can be prevented, and the joints affected by disease processes can be restored to normal ranges of motion [38]. Returning to running may be a distant goal that must be achieved gradually. Initially, the foot should be gradually loaded, and progress should be regularly assessed. Training intensity should be increased over a relatively long period of time to ensure smooth tissue adaptation. From the runner's perspective, it is extremely important to control the appropriate running technique and its biomechanical analysis in order to eliminate irregularities that may lead to the recurrence of TTS at the earliest possible stage. In order to prevent relapses, several important rules should be followed. Sports footwear should be selected carefully. It is necessary to introduce exercises that strengthen the muscles of the feet and

calves. Appropriate regeneration, including stretching and massages, also becomes crucial, which ensures better blood supply and elasticity of the tissues and prevents injuries [39]. Post-surgical rehabilitation focuses on restoring joint function and muscle strength through isometric exercises, lymphatic drainage techniques, and proprioception exercises. This multi-stage physiotherapy approach ensures the gradual return to full limb functionality and includes specific exercises to rebuild muscle strength and overall physical efficiency, particularly for patients aiming to return to sports [40].

CONCLUSIONS

Tarsal tunnel syndrome is a rare disease for which there are still no clear diagnostic and treatment criteria. It constitutes a significant diagnostic and therapeutic challenge in the population of runners, requiring a comprehensive approach. Effective management of this disease requires not only proper diagnosis and treatment but also the education of runners. TTS prevention among runners should focus on education regarding proper running technique, selecting appropriate footwear, and the importance of regeneration and strengthening exercises. As the popularity of amateur running increases, it becomes crucial to increase awareness of TTS among medical specialists, which may contribute to earlier detection, more effective treatment, and better prevention of this condition, enabling runners to safely return to sports activity and minimizing the risk of recurrence.

REFERENCES

1. Kakouris N, Yener N, Fong DTP. A systematic review of running-related musculoskeletal injuries in runners. J Sport Health Sci. 2021;10(5):513-522. doi:10.1016/j.jshs.2021.04.001 DOI
2. Cushman DM, Ross B, Denq W, Lippman J, Cummings K. Knee Injuries in Runners. In: Harrast MA (ed.).Clinical Care of the Runner. Elsevier, 2020, pp. 197-214. doi:10.1016/B978-0-323-67949-7.00018-5 DOI
3. Mellinger S, Neurohr GA. Evidence based treatment options for common knee injuries in runners. Ann Transl Med. 2019;7(S7):S249-S249. doi:10.21037/atm.2019.04.08 DOI
4. Deakins-Roche M, Fredericson M, Kraus E. Ankle and Foot Injuries in Runners. In: Clinical Care of the Runner. Elsevier; 2020:231-245. doi:10.1016/B978-0-323-67949-7.00020-3 DOI
5. Vijayan G, Murali Rajan K. Foot Impairments and Overuse Injuries in Long Distance Runners—A Prospective Study for the Prevalence. In: Rana NK, Shah AA, Iqbal R, Khanzode V (eds). Technology Enabled Ergonomic Design. Design Science and Innovation. Springer Nature Singapore; 2022, pp. 277-285. doi:10.1007/978-981-16-6982-8_25 DOI
6. Olafsen N, Simpson S. Hip, Pelvis, and Thigh Injuries in Runners. In: Harrast MA (ed.) Clinical Care of the Runner. Elsevier, 2020:181-195. doi:10.1016/B978-0-323-67949-7.00017-3 DOI
7. Burke A, Dillon S, O'Connor S, Whyte EF, Gore S, Moran KA. Aetiological Factors of Running-Related Injuries: A 12 Month Prospective "Running Injury Surveillance Centre" (RISC) Study. Sports Med – Open. 2023;9(1):46. doi:10.1186/s40798-023-00589-1 DOI
8. van der Worp MP, ten Haaf DSM, van Cingel R, de Wijer A, Nijhuis-van der Sanden MWG, Staal JB. Injuries in runners; a systematic review on risk factors and sex differences. PLoS One. 2015;10(2):e0114937. doi:10.1371/journal.pone.0114937 DOI
9. Tenforde AS, Yin A, Hunt KJ. Foot and Ankle Injuries in Runners. Phys Med Rehabil Clin N Am. 2016;27(1):121-137. doi:10.1016/j.pmr.2015.08.007 DOI
10. Fujihara, F. Tarsal Tunnel Syndrome. In: Isu T, Kim . (eds) Entrapment Neuropathy of the Lumbar Spine and Lower Limbs. Springer, Singapore, 2021. https://doi.org/10.1007/978-981-33-6204-8_13
11. Kiel J, Kaiser K. Tarsal Tunnel Syndrome. In: StatPearls. StatPearls Publishing; 2024. http://www.ncbi.nlm.nih.gov/books/NBK513273/ [Access: July 23, 2024]
12. Fortier LM, Leethy KN, Smith M, et al. An Update on Posterior Tarsal Tunnel Syndrome. Orthop Rev (Pavia). 2022;14(4):35444. doi:10.52965/001c.35444 DOI
13. Kennedy R, Nagpal A, Abd-Elsayed A. Posterior Tibial Nerve. In: Abd-Elsayed A, ed. Pain. Springer International Publishing; 2019, pp. 503-505. doi:10.1007/978-3-319-99124-5_111 DOI
14. Desai SS, Cohen-Levy WB. Anatomy, Bony Pelvis and Lower Limb: Tibial Nerve. In: StatPearls. StatPearls Publishing; 2024. http://www.ncbi.nlm.nih.gov/books/NBK537028/ [Access: July 25, 2024].
15. Martin D, Lui D, Rowan F, Benanni F, O'Grady P. Tarsal tunnel syndrome caused by giant cell tumour of the tendon sheath: case report with review of the literature. Eur Orthop Traumatol. 2013;4(4):281-284. doi:10.1007/s12570-013-0178-2 DOI
16. Jackson DL, Haglund BL. Tarsal tunnel syndrome in runners. Sports Med. 1992;13(2):146-149. doi:10.2165/00007256-199213020-00010 DOI
17. Foster KS, Greenlee TA, Young JL, Janney CF, Rhon DI. How Common is Subsequent Posterior Tibial Tendon Dysfunction or Tarsal Tunnel Syndrome After Ankle Sprain Injury? J Knee Surg. 2022;35(11):1181-1191. doi:10.1055/s-0042-1751246 DOI

18. Nocoń K. Tarsal tunnel syndrome. In: Radiopaedia.Org. Radiopaedia.org; 2021. doi:10.53347/rID-95424 https://radiopaedia.org/ [Access: July 23, 2024] DOI
19. Segura RP, Nirenberg MS. Prevalence of Obesity in High Tarsal Tunnel Syndrome: A Cross-Sectional Study. J Am Podiatr Med Assoc. 2023;113(4):22-056. doi:10.7547/22-056 DOI
20. Cohen BH. Tarsal Tunnel Syndrome. In: Eltorai AEM, Eberson CP, Daniels AH (eds). Essential Orthopedic Review. Springer International Publishing, 2018, pp.201-203. doi:10.1007/978-3-319-78387-1_91 DOI
21. Fujihara F. Tarsal Tunnel Syndrome. In: Isu T, Kim K (eds). Entrapment Neuropathy of the Lumbar Spine and Lower Limbs. Springer Singapore; 2021, pp. 85-92. doi:10.1007/978-981-33-6204-8_13 DOI
22. Rinkel WD, Castro Cabezas M, van Neck JW, Birnie E, Hovius SER, Coert JH. Validity of the Tinel Sign and Prevalence of Tibial Nerve Entrapment at the Tarsal Tunnel in Both Diabetic and Nondiabetic Subjects: A Cross-Sectional Study. Plast Reconstr Surg. 2018;142(5):1258-1266. doi:10.1097/PRS.0000000000004839 DOI
23. Ho T, Braza ME. Hoffmann Tinel Sign. In: StatPearls. StatPearls Publishing; 2024. http://www.ncbi.nlm.nih.gov/books/NBK555934/ [Access: July 23, 2024].
24. Lew JT, Stearns M. Tibial Neuropathy. In: StatPearls. StatPearls Publishing; 2024. http://www.ncbi.nlm.nih.gov/books/NBK582151/ [Access: July 23, 2024].
25. Koketsu K, Kim K, Tajiri T, et al. Ganglia-Induced Tarsal Tunnel Syndrome. J Nippon Med Sch. 2024;91(1):114-118. doi:10.1272/jnms.JNMS.2024_91-203 DOI
26. Kim K, Kokubo R, Isu T, et al. Magnetic Resonance Imaging Findings in Patients with Tarsal Tunnel Syndrome. Neurol Med Chir (Tokyo). 2022;62(12):552-558. doi:10.2176/jns-nmc.2022-0118 DOI
27. Fantino O. Role of ultrasound in posteromedial tarsal tunnel syndrome: 81 cases. J Ultrasound. 2014;17(2):99-112. doi:10.1007/s40477-014-0082-9 DOI
28. Fantino O, Bouysset M, Pialat JB. Can the axial cross-sectional area of the tibial nerve be used to diagnose tarsal tunnel syndrome? An ultrasonography study. Orthop Traumatol Surg Res. 2021;107(6):102630. doi:10.1016/j.otsr.2020.02.021 DOI
29. Iborra Á, Villanueva M, Barrett SL, Vega-Zelaya L. The role of ultrasound-guided perineural injection of the tibial nerve with a sub-anesthetic dosage of lidocaine for the diagnosis of tarsal tunnel syndrome. Front Neurol. 2023;14:1135379. doi:10.3389/fneur.2023.1135379 DOI
30. Scura D, García-López B. Electrodiagnostic Evaluation of Tarsal Tunnel Neuropathy. In: StatPearls. StatPearls Publishing; 2024. http://www.ncbi.nlm.nih.gov/books/NBK563278/ [Access: July 25, 2024].
31. Vij N, Kaley HN, Robinson CL, et al. Clinical Results Following Conservative Management of Tarsal Tunnel Syndrome Compared With Surgical Treatment: A Systematic Review. Orthop Rev (Pavia). 2022;14(3):37539. doi:10.52965/001c.37539 DOI
32. Kavlak Y, Uygur F. Effects of nerve mobilization exercise as an adjunct to the conservative treatment for patients with tarsal tunnel syndrome. J Manipulative Physiol Ther. 2011;34(7):441-448. doi:10.1016/j.jmpt.2011.05.017 DOI
33. Hudes K. Conservative management of a case of tarsal tunnel syndrome. J Can Chiropr Assoc. 2010;54(2):100-106.
34. Yunoki M. Analysis of Surgical Cases of Tarsal Tunnel Syndrome in Our Department: Case Series and Literature Review. Asian J Neurosurg. 2020;15(1):59-64. doi:10.4103/ajns.AJNS_257_19 DOI
35. Sun X, Zhou Q, Shi C, et al. Acupotomy for patients with tarsal tunnel syndrome: A protocol for systematic review and meta analysis. Medicine (Baltimore). 2020;99(39):e22369. doi:10.1097/MD.0000000000022369 DOI
36. Yoshida A, Okutsu I, Hamanaka I. Endoscopic tarsal tunnel syndrome surgery using the Universal Subcutaneous Endoscope system. Asia Pac J Sports Med Arthrosc Rehabil Technol. 2016;3:1-5. doi:10.1016/j.asmart.2015.09.001 DOI
37. Iborra A, Villanueva M, Sanz-Ruiz P. Results of ultrasound-guided release of tarsal tunnel syndrome: a review of 81 cases with a minimum follow-up of 18 months. J Orthop Surg Res. 2020;15(1):30. doi:10.1186/s13018-020-1559-1 DOI
38. O'Connor EJ. Rehabilitation Principles of the Injured Runner. In: Clinical Care of the Runner. Elsevier, 2020, pp. 101-112. doi:10.1016/B978-0-323-67949-7.00011-2 DOI
39. Krishnan S, Rani AMA, Kurappa LG, Paramasivam S. Fabrication of Parallel Mechanism Actuated by Pneumatic Artificial Muscle for Rehabilitation Therapy. In: Ibrahim RK, Porkumaran Kannan R, Mohd Nor N, Prabakar S (eds). International Conference on Artificial Intelligence for Smart Community. Vol 758. Lecture Notes in Electrical Engineering. Springer Nature Singapore; 2022, pp. 355-363. doi:10.1007/978-981-16-2183-3_34 DOI
40. Czamara A. Physiotherapeutic procedure after injuries of soft tissues of tarsal-crural joint. J Orthop Trauma Surg Relat Res. 2008;4(12):88-108.

CONFLICT OF INTEREST

The Authors declare no conflict of interest.

CORRESPONDING AUTHOR
Michał Świta
Student Scientific Association
at the Department of Rehabilitation and Orthopedics,
Medical University of Lublin
Lublin, Poland
e-mail: michal.swita10@gmail.com

ORCID AND CONTRIBUTIONSHIP
Julia Szewczyk: 0009-0008-5108-3172 A B D
Anna Szuciak: 0009-0002-0754-6682 A B D
Kamila Mozga: 0009-0000-9661-0396 B D
Olga Synowiecka: 0009-0004-4001-2054 B D
Igor Rydzyk: 0009-0002-8702-0356 B D
Konrad Talarek: 0009-0008-6501-168X B D
Michał Świta: 0009-0007-8426-9224 B D
Karolina Turżańska: 0000-0001-7359-9622 D E F

A – Work concept and design, B – Data collection and analysis, C – Responsibility for statistical analysis, D – Writing the article, E – Critical review, F – Final approval of the article

RECEIVED: 12.11.2024
ACCEPTED: 23.02.2025

CREATIVE COMMONS 4.0