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Ankle Sprain: A Common but Often Overlooked Injury - A Review of Causes, Treatment and Rehabilitation

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ABSTRACT

Introduction: Ankle sprains are a common injury affecting millions of people worldwide. While many cases are mild, they can lead to chronic joint instability, functional limitations and an increased risk of recurrence. Sprains most commonly involve the lateral ligaments of the joint, particularly ATFL, and in more complex cases, may also affect other structures, resulting in the high treatment costs.

Aim: The aim of this article is to present modern methods of diagnosis, treatment and rehabilitation of ankle sprains, including innovative therapies and technologies that support recovery.

Methods: A search of PubMed, Web of Science and Google Scholar was conducted. Included were randomized controlled trials, systematic review and meta-analyses of ankle sprain treatment and rehabilitation strategies.

Results: An ankle sprain, if not treated properly, can lead to chronic instability, functional limitations and the risk of recurrence. Early diagnosis, intervention are crucial. Modern therapeutic methods such as micro-needle knives, electroacupuncture and rehabilitation robots offer promising treatment options. Integration of traditional methods with innovative technologies can speed up rehabilitation, improve joint stability and reduce the risk of recurrence.

Conclusion: An ankle sprain, despite its initially mild nature,can lead to long term functional consequences. Early diagnosis and appropriate therapeutic intervention are crucial to minimise the risk of chronic instability and other complications. Modern diagnostic technologies and biological therapies are promising treatment options, accelerating the rehabilitation process and improving functional outcomes. However, these innovative methods require further research and verification of the reliability of the results obtained, as they are still in the early stages of development.

Keywords: Ankle sprain, diagnosis, treatment, rehabilitation, joint instability

INTRODUCTION

An ankle sprain is one of the most common musculoskeletal injuries. Even seemingly minor trauma can result in long-term consequences, including chronic pain, impaired range of motion and an increased risk of recurrence, which collectively affect millions of individuals each year. Moreover, according to research, half of all ankle sprains treated in American hospitals are not related to sport, indicating that this problem affects a much broader group of patients [1]. Despite the high prevalence of these injuries, their long-term effects are often underestimated, with chronic ankle instability (CAI) being one of the most frequent complications. Even when the range of motion is preserved, ankle sprains can lead to impairments in proprioception and balance, which increases the risk of repeated traumas and functional limitations. These findings emphasize the need for further research and a more comprehensive approach to the treatment [2,3]. Simultaneously, as the complexity of the injury increases, the expenses incurred by both patients and the healthcare system also rise. The mentioned costs encompass direct factors such as hospitalization, diagnostics, surgical treatment, and rehabilitation, along with indirect costs related to lost productivity and temporary work incapacity [4]. The aim of this study is to review contemporary issues related to the treatment and rehabilitation of ankle sprains. The article focuses on the modern diagnostic methods, effective therapeutic strategies and the prevention of recurrence of traumas. The discussed topics include injury classification, the consequences of sprains, innovative therapeutic approaches, the role of rehabilitation and the impact of chronic injuries on patients' quality of life. Another purpose of this paper is to provide a comprehensive overview of the current state of knowledge on the treatment of ankle sprains and to identify areas requiring further research in this field.

METHODOLOGY

The review aims to synthesize current research on the diagnosis, treatment and rehabilitation of ankle sprains, as well as their impact on long-term joint function and overall patient health. A literature search was conducted in the PubMed, Web of Science, and Google Scholar databases. The keywords used were: ankle sprain, diagnosis, rehabilitation, joint stability, treatment methods, biological therapies, modern rehabilitation technologies, and ankle pain. A total of 69 relevant publications were identified. The structure of the review allowed for the selection and synthesis of the results of the available studies. As a narrative review, the study does not include a formal assessment of methodological quality or meta-analysis. However, methodological diversity and significance of the analyzed materials were taken into account when interpreting the results.

LITERATURE REVIEW

Anatomical Structure, Mechanisms and Classification of Ankle Sprains

Ankle sprains are among the most common musculoskeletal harms. Their correct classification is crucial for accurate diagnosis, prognosis and optimal therapeutic strategy. Therefore, this chapter discusses the mechanisms of injury, the anatomical structures involved and the degree of soft tissue damage. The ankle joint is one of the most injury-prone joints in the body, particularly as a result of sprains, which can damage its stabilising structures. A crucial element responsible for maintaining the stability of the ankle joint is the ligament complex, which controls its mobility in various planes [5,6]. This structure includes the anterior talofibular ligament (ATFL), the calcaneofibular ligament (CFL) and the posterior talofibular ligament

(PTFL), which are the most commonly damaged during lateral sprains resulting from movements of the foot in the coronal and transverse planes [7]. The ATFL ligament is most often damaged during foot inversion combined with plantar flexion, while the CFL is damaged during excessive inversion, especially with dorsiflexion. Plantarflexion reduces the bone stability of the ankle joint, as the narrower part of the talus is then located in the acetabulum, which increases the joint's susceptibility to lateral forces [8].
PTFL injury is rare and usually accompanies severe, complete lateral sprains or fractures causing joint instability [9].

The next important complex is the tibiofibular syndesmosis complex , which consists of: the anterior inferior tibiofibular ligament (ATIFL), the posterior inferior tibiofibular ligament (PTIFL), the transverse ligament (TL) and the interosseous ligament (IO) [10]. High ankle sprains, though less common, account for 1-11% of all sprains and can lead to a significant joint instability and lower limb biomechanical dysfunction. The syndesmosis plays a crucial role in stabilizing the talocrural joint, maintaining the integrity of the joint mortise and the proper alignment of the talus under load [11]. At the same time, the medial side also ensures ankle joint stability, with the deltoid ligament being its key element. It is responsible for stabilisation in the superficial and deep layers, acting as an important joint stabiliser. Medial injuries occur in approximately 5% of isolated ankle sprains, but accompany as many as 40% of ankle fractures, which emphasises their clinical significance.

The cause of an ankle sprain may depend on many factors, and ligament damage can range from microscopic stretching to complete rupture. In order to determine the severity of the injury, predict the prognosis and select the appropriate treatment method, a classification system is used that distinguishes between three degrees.
I (mild)- microscopic ligament strain, slight pain, minimal swelling, no instability and ability to bear weight on the limb.
II (moderate)- partial ligament tear, moderate pain and swelling, slight instability and difficulty bearing weight on the foot.
III (severe) - complete ligament rupture (most often ATFL and CTL), severe pain, significant swelling, marked instability, often to bear weight on the limb and coexisting syndesmosis damage or minor avulsion fractures [13].

The Cascade of Pathophysiological Changes After Ankle Sprain

The swelling and restricted range of motion dominate in the initial phase of an ankle sprains. These factors are typically assessed by medical personnel subjectively. Physical examination remains one of the most reliable diagnostic methods, demonstrating a sensitivity of 96% and a specificity of 84%. Samer Mabrouk and co-workers introduced an innovative mobile diagnostic system that employs bioimpedance and motion sensors for the non-invasive monitoring of swelling and the condition of the ankle joint tissues following injury [14].

This system shows great potential for precise tracking of tissue regeneration processes and supporting decisions regarding treatment and rehabilitation. In addition, haematoma and pain often occur after ankle sprains. Interestingly, if these symptoms persist for more than two weeks, the risk of chronic complaints increases, which can last up to nine months after the injury [15]. Even minor injuries can trigger a cascade of biochemical changes within the joint, initiating a domino effect, as described by M.Dalmau-Pastor and co-workers. Microfractures of the cartilage on the dome of the talus occur frequently during inward inversion of the foot, disrupting the function of the ligaments and muscles, which subsequently leads to chronic instability and further injuries [16]. The peroneal tendons, which stabilize the rearfoot, can also be torn and eversion activated. These injuries often heal slowly and are often underdiagnosed, emphasizing the importance of thorough and appropriate rehabilitation [17].

All injuries associated with actual ligament laxity or excessive joint mobility, which can be confirmed through imaging or physical tests, are classified as mechanical ankle instability. However, attention should also be given to functional ankle instability (FAI), which is characterized by a subjective feeling of foot “wobbling” and deficits in neuromuscular control, despite the preserved integrity of the anatomical structures. FAI is particularly evident when walking on uneven terrain, running, or performing lateral movements and is associated with compensatory changes in the mechanics of the foot, hips and pelvis, as well as a significant slowing of gait and more cautious movement. This complication suggests that effective rehabilitation should address not only the ankle joint but also the entire movement patterns of the lower limb [18,19]. Functional ankle instability (FAI) results from several coexisting deficits: proprioception disorders [2], impaired ability to assess the position of the foot in space due to damaged joint and ligament receptors, neuromuscular control deficits [20], including slowed stabilisation reactions and weakness of the peroneal muscles and limited dynamic stabilisation, which makes it difficult to maintain balance when changing direction or running, increasing the risk of recurrent injuries [21].

Chronic complications of ankle sprains include both recurrent injuries and long-term joint dysfunction. Recurrent sprains are a consequence of functional and/or mechanical instability, often leading to the development of chronic ankle instability (CAI) [22]. Patients with chronic injuries also experience ankle degeneration (post-traumatic osteoarthritis),which can occur years later, especially as a result of repeated injuries or untreated sprains [23]. Long-term effects also include chronic pain in the lateral part of the joint, limited range of motion and overload of adjacent joints, such as the knee or hip, resulting from altered gaii biomechanics. This is why hip strengthening exercises can improve balance and function in patients with chronic ankle instability, counteracting the effects of altered gain biomechanics [24,25].

Diagnostic

Physical diagnosis plays a fundamental role in the early assessment of ankle ligament injuries, enabling rapid identification of the injury before imaging tests are performed. Basic tests include palpation of the ligaments, anterior drawer test, assessment of joint mobility, tenderness and weight-bearing capacity [26]. None of the tests simultaneously achieve high sensitivity and specificity (>90%). Palpation of the anterior talofibular ligament demonstrates high sensitivity (95–100%), while the anterior drawer test has low sensitivity (54%) and high specificity (87%). Palpation of the calcaneofibular ligament shows variable sensitivity (49–100%) and low specificity (26–79%) [27]. The accuracy of physical examinations increases when they are performed several days after the injury (approximately 5 days) and in combination with a thorough clinical interview. The simplicity and availability of the tests mean that they can be used in hospital, outpatient and sports settings, making them a key tool in the early diagnosis of ankle sprains [26].

Following palpation, the next diagnostic step is imaging, with X-ray (radiography) remaining the first-line diagnostic tool. The Ottawa Ankle Rules (OAR) are particularly useful in determining whether an X-ray is necessary to rule out fractures. These rules are based on criteria such as tenderness over specific bone points (e.g., 6 cm from the distal fibula, along the tibia, the navicular bone or the base of the fifth metatarsal), inability to bear weight on the affected limb (e.g., taking four steps) and other symptoms suggesting a fracture. The OAR has proven effective not only in adults but also in the pediatric population, reducing unnecessary radiographic orders, thereby minimizing radiation exposure and healthcare costs [28,29].

X-rays remain the primary tool for diagnosing fractures, but advanced imaging methods such as magnetic resonance imaging (MRI), computed tomography (CT) and ultrasonography are gaining importance in the assessment of soft tissue injuries of the ankle joint.
MRI is considered as the 'gold standard' in the diagnosis of ligament, cartilage and other soft tissue injuries, offering high sensitivity in detecting injuries, although due to its cost and time-consuming nature, it is mainly used in more complex cases [30]. MRI, especially in its three-dimensional (3D) and contrast-enhanced (MR Arthrography) versions, is becoming an increasingly advanced diagnostic method, enabling more precise assessment of micro-damage to ligaments and changes in joint cartilage structures [31]. Computed tomography, including cone beam computed tomography (CBCT), is an effective tool for assessing fractures, offering the advantage of reduced radiation exposure compared to traditional tomography [32]. The combination of computed tomography (CT) with single photon emission computed tomography (SPECT/CT) allows for the simultaneous assessment of anatomical structures and tissue function. SPECT/CT can complement traditional imaging, especially when CT or MRI do not provide sufficient information about inflammatory processes or changes in bone metabolism [34].

Ultrasonography, due to its speed, availability and low cost, is used in the diagnosis of ligament damage and can be useful in assessing whether patients require further diagnosis and, for example CT or MRI [35, 36, 37]. In addition, dynamic ultrasound examination, which involves assessing the joint during movement, can help detect damage that is not visible in standard static examinations [38]. Although USG is effective in diagnosing ligament damage, it has limited ability to assess deeper tissues such as cartilage or bone. For this reason, it is often used in combination with other imaging methods to obtain a more complete picture of structural damage to the ankle joint. Ultrasound is also helpful in monitoring the progress of treatment and rehabilitation [39]. Artificial intelligence (AI), including deep learning technologies, is becoming increasingly important in the diagnosis of ankle injuries, especially in the context of medical image analysis.

Thanks to automatic image segmentation, AI enables rapid and accurate detection of ligament damage, fractures and degenerative changes, significantly reducing diagnosis time and increasing the accuracy of results. Although image quality remains a challenge, the growing number of public databases is conducive to the development of this technology. The integration of AI with modern biomechanical systems that enable real-time motion monitoring opens up new possibilities for the prediction, prevention and treatment of ankle injuries, as well as allowing for more personalized healthcare [40,41,42].

Treatment

The main goal of early treatment after an ankle sprain is to reduce pain and swelling of soft tissues. In clinical practise, the RICE protocol (rest, ice, compression and elevation) is often used in the acute phase of injury, especially in the first 48-72h hours after injury, but the available scientific data do not provide clear evidence confirming the effectiveness of this method as a standalone intervention [43,44]. Non-steroidal anti-inflammatory drugs (NSAIDs) are commonly used to treat ankle sprains because they effectively relieve pain and swelling [45]. In the acute phase, their short-term use is justified as it helps to alleviate symptoms, speeding up rehabilitation and improving patient comfort [46]. In cases where NSAIDs are contraindicated, paracetamol or opioids are used as alternatives, which relieve pain but do not have an anti-inflammatory effect [47].

Functional treatment involves stabilising the ankle joint while maintaining controlled movement, which promotes a faster return to activity and reduces swelling, whereas immobilisation completely restricts movement, providing full protection for the ligaments but potentially leading to joint stiffness [48]. Although clinical studies suggest the superiority of functional treatment in terms of faster return to activity and less need for rehabilitation, a meta-analysis conducted by Vichez-Cavazos and colleagues found no significant differences between functional treatment and immobilisation in terms of pain and joint function. The choice of method should therefore be tailored to the individual, taking into account patient comfort, the risk of complications and the extent of the injury [49].

Surgery is recommended when, after 3-6 months of conservative treatment, the symptoms of chronic lateral ankle instability (CLAI) persist and imaging tests confirm changes in the joint. Surgery should also be considered in cases of concomitant osteochondral damage to the talus requiring repair of cartilage and bone tissue and damage to the ATFL and CFL ligaments requiring reconstruction to restore joint stability [50]. Depending on the extent of the damage, various surgical techniques are used to treat ankle instability. Standard anatomical repair according to Broström involves attaching the ATFL and CFL ligaments to the fibula, which ensures long-term joint stability. Modifications to this procedure, such as the Gould and Karlsson techniques, further strengthen the ligaments, improving the durability of the repair. In cases of more severe damage, reconstruction using autologous or allogeneic grafts are performed, restoring the anatomical structure of the joint. Non-anatomical reconstructions, e.g. using the peroneus brevis tendon, are less commonly used due to the limitation of range of motion. Alternatively, arthroscopic ligament repair is a minimally invasive method, reducing the risk of complications and shortening recovery time [51,52,53].

Biological therapies for treating ankle sprains, such as platelet- rich plasma (PRP) stem cells, hyaluronic acid and physiotherapy techniques, are gaining importance in clinical practice [54]. PRP accelerates the healing of ligaments and soft tissues, reducing pain and inflammation [55]. Stem cells support the regeneration of damaged tissues, improving joint stability. Hyaluronic acid improves joint lubrication, supporting cartilage regeneration and reducing pain [56]. Physiotherapy therapies, such as shock wave and ultrasound, accelerate repair processes [57,58]. Gene therapy, although still in the research phase, promises further possibilities for stimulating ligament and cartilage regeneration [59].

Rehabilitation

Rehabilitation after an ankle sprain aims to restore proper joint function and improve the patient's quality of life. Rehabilitation programmes include activities designed to increase joint mobility, strengthen muscles and reduce the risk of recurrence of injury [60]. However, the results of therapy can be ambiguous for several reasons. The observation period plays an important role- in the short term, patients may feel improvement without specialist rehabilitation, while the benefits of exercise only become apparent after several months. In addition, the diversity of injuries, the lack of standardized rehabilitation programmes and the subjective feelings of patients influence the interpretation of results, and methodological errors in studies can lead to contradictory conclusions [61]. Despite these limitations, rehabilitation remains a key element in returning to full fitness and preventing further injuries, as confirmed by numerous scientific reports [62]. Proprioceptive training is particularly important, as it improves the body's ability to detect changes in joint position and muscle tension in space. These types of exercises increase ankle stability, improve movement control and reduce the risk of recurrent sprains [63].

Virtual reality (VR)- based rehabilitation programmes show promising potential in the treatment of ankle injuries, offering a safe and effective approach. Nevertheless, there is a need for studies of higher methodological quality, as most of the available evidence is of low or moderate quality, which limits the certainty of the results and their application in clinical practice [64,65]. Ankle rehabilitation using robots, including Parallel Ankle Rehabilitation Robots (PARR) systems, is becoming an increasingly important therapeutic tool. Advanced technologies enable precise reproduction of ankle movements, supporting the rehabilitation process by improving proprioception, muscle strength and range of motion. Despite promising results obtained in studies on prototypes of these devices, further clinical research and optimisation of design and control strategies are necessary to fully exploit their potential in clinical practice [66].

Microneedle knife therapy (MNK) is an effective alternative or supplement to traditional physiotherapy in the treatment of acute ankle sprains. Compared to acupuncture, MNK offers faster and more effective release of tension in the superficial fascia, which translates into faster pain relief and improved joint function immediately after treatment. Although both methods produce similar results in the long term, MNK is more effective in the immediate post-injury phase, making it a valuable tool to support rehabilitation [67].
Acupuncture, and especially acupressure, is also an effective method of accelerating rehabilitation, reducing swelling, relieving pain and improving range of motion, which has a positive impact on patients' quality of life and supports the recovery process [68]. Electroacupuncture, which combines traditional acupuncture with the application of electrical current, is currently being developed as a treatment for acute ankle sprains. Research on this method focussed on comparing its effectiveness with placebo acupuncture and standard method such as rest and ice packs. Preliminary results indicate that electroacupuncture may reduce pain and swelling and support the restoration of foot function, making it a promising therapeutic tool in the rehabilitation of ankle sprains [69]

Discussion

In summary, ankle sprains are injuries that can have serious, long-term consequences for the patient's health, especially when not treated properly. Although most sprains are treated conservatively and effectively, it is crucial to provide patients with a comprehensive diagnosis, an individually tailored treatment plan and appropriate rehabilitation to minimise the risk of recurrence and long-term complications. Rehabilitation should include not only improving ankle function, but also comprehensive work on the entire biomechanics of the lower limb to restore the patient's full mobility.

At the same time, the development of new diagnostic technologies and therapies, such as biological therapies and artificial intelligence-assisted methods, offers hope for more precise and effective treatment. Groundbreaking approaches to prevention, such as proprioception training and the use of rehabilitation robots, can help reduce the number of injury recurrences and improve patients' quality of life. Despite significant advances in the treatment of ankle sprains, many questions remain unanswered, particularly in the context of chronic instability and the long-term effects of injuries. Therefore, it is necessary to continue research in these key areas to gain a better understanding of the effectiveness of therapies and to develop increasingly personalised approaches to treatment.

Finally, this article emphasises the importance of understanding the full nature of ankle sprains- not just an injury, but as a problem that, if not treated properly, can lead to chronic discomfort and significant limitations in the patient's functioning. I encourage further research to help optimize methods of diagnosis, treatment and rehabilitation, as well as to raise awareness among patients and health professionals.

Conclusion

Ankle sprains can lead to long-term issues like instability and functional limitations if not properly treated. Early diagnosis and modern therapies offer promising outcomes. Rehabilitation focused on proprioception is key to recovery and preventing recurrence. Ongoing research is needed to refine these approaches and better understand the long-term effects of ankle sprain. Comprehensive care is essential for optimal recovery and minimizing future risks.

AI

In the study, AI was used to improve the language of the manuscript, ensuring consistency and compliance with scientific standards. After using this tool, the authors reviewed and edited the content as necessary, taking full responsibility for the substantive content of the publication**.**

Author Contributions

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References

1. Herzog MM, Kerr ZY, Marshall SW, Wikstrom EA. Epidemiology of Ankle Sprains and Chronic Ankle Instability. J Athl Train. 2019;54(6):603-610. doi:10.4085/1062-6050-447-17
2. Alghadir AH, Iqbal ZA, Iqbal A, Ahmed H, Ramteke SU. Effect of Chronic Ankle Sprain on Pain, Range of Motion, Proprioception, and Balance among Athletes. Int J Environ Res Public Health. 2020;17(15):5318. Published 2020 Jul 23. doi:10.3390/ijerph17155318
3. Lin CI, Houtenbos S, Lu YH, Mayer F, Wippert PM. The epidemiology of chronic ankle instability with perceived ankle instability- a systematic review. J Foot Ankle Res. 2021;14(1):41. Published 2021 May 28. doi:10.1186/s13047-021-00480-w
4. Bielska IA, Wang X, Lee R, Johnson AP. The health economics of ankle and foot sprains and fractures: A systematic review of English-language published papers. Part 2: The direct and indirect costs of injury. Foot (Edinb). 2019;39:115-121. doi:10.1016/j.foot.2017.07.003
5. Bergman R, Shuman VL. Acute Ankle Sprain. In: StatPearls. Treasure Island (FL): StatPearls Publishing; August 2, 2025

6. Fong DT, Chan YY, Mok KM, Yung PS, Chan KM. Understanding acute ankle ligamentous sprain injury in sports. Sports Med Arthrosc Rehabil Ther Technol. 2009;1:14. Published 2009 Jul 30. doi:10.1186/1758-2555-1-14
7. Gibboney MD, Dreyer MA. Lateral Ankle Instability. In: StatPearls. Treasure Island (FL): StatPearls Publishing; May 23, 2023
8. Giesche F, Stief F, Groneberg DA, Wilke J. Effects of sport specific unplanned movements on ankle kinetics and kinematics in healthy athletes from systematic review with meta-analysis. Sci Rep. 2025;15(1):32476. Published 2025 Sep 12. doi:10.1038/s41598-025-18746-9
9. Gyftopoulos, S., Woertler, K. (2021). Ankle and Foot. In: Hodler, J., Kubik-Huch, R.A., von Schulthess, G.K. (eds) Musculoskeletal Diseases 2021-2024. IDKD Springer Series. Springer, Cham. https://doi.org/10.1007/978-3-030-71281-5_8
10. Yuen CP, Lui TH. Distal Tibiofibular Syndesmosis: Anatomy, Biomechanics, Injury and Management. Open Orthop J. 2017;11:670-677. Published 2017 Jul 31. doi:10.2174/1874325001711010670
11. Hermans JJ, Beumer A, de Jong TA, Kleinrensink GJ. Anatomy of the distal tibiofibular syndesmosis in adults: a pictorial essay with a multimodality approach. J Anat. 2010;217(6):633-645. doi:10.1111/j.1469-7580.2010.01302.x
12. Koris J, Calder JDF, Dalmau-Pastor M, Fernandez MA, Ramasamy A. Deltoid ligament injuries: A review of the anatomy, diagnosis and treatments. Knee Surg Sports Traumatol Arthrosc. 2024 Dec;32(12):3052-3064. doi: 10.1002/ksa.12274. Epub 2024 May 26. PMID: 38796726; PMCID: PMC11605033.
13. Petersen W, Rembitzki IV, Koppenburg AG, et al. Treatment of acute ankle ligament injuries: a systematic review. Arch Orthop Trauma Surg. 2013;133(8):1129-1141. doi:10.1007/s00402-013-1742-5
14. Mabrouk S, Whittingslow D, Inan OT. Robust Method for Mid-Activity Tracking and Evaluation of Ankle Health Post-Injury. IEEE Trans Biomed Eng. 2021;68(4):1341-1350. doi:10.1109/TBME.2020.3027477
15. Kilper A, Milani TL, Schütz L, et al. Ankle injury due to supination trauma: Potential factors worsening patient outcome. J Orthop. 2024;59:123-127. Published 2024 Nov 4. doi:10.1016/j.jor.2024.10.060
16. Dalmau-Pastor M, Calder J, Vega J, Karlsson J, Hirschmann MT, Kerkhoffs GMMJ. The ankle sprain and the domino effect. Knee Surg Sports Traumatol Arthrosc. 2024;32(12):3049-3051. doi:10.1002/ksa.12538

17. Little ZE, Kohls J, et al. Peroneal tendon injuries. Orthop Trauma. 2024;38(1):40-45. doi:10.1016/j.mporth.2023.11.007
18. Yin, Y., Lin, Q. & Wang, J. Randomized controlled trial on ankle biomechanics in the treatment of functional ankle instability with joint mobilization. Sci Rep 14, 22095 (2024). https://doi.org/10.1038/s41598-024-73646-8
19. Huang, D., Zhang, C., Song, W. et al. Gait variability and biomechanical distinctions in individuals with functional ankle instability: a case–control study based on three-dimensional motion analysis. Eur J Med Res 30, 493 (2025). https://doi.org/10.1186/s40001-025-02736-8
20. Evans T, Hertel J, Sebastianelli W. Bilateral deficits in postural control following lateral ankle sprain. Foot Ankle Int. 2004;25(11):833-839. doi:10.1177/107110070402501114
21. Doherty C, Bleakley C, Hertel J, Caulfield B, Ryan J, Delahunt E. Dynamic balance deficits in individuals with chronic ankle instability compared to ankle sprain copers 1 year after a first-time lateral ankle sprain injury. Knee Surg Sports Traumatol Arthrosc. 2016;24(4):1086-1095. doi:10.1007/s00167-015-3744-z
22. Hertel J, Corbett RO. An Updated Model of Chronic Ankle Instability. J Athl Train. 2019;54(6):572-588. doi:10.4085/1062-6050-344-18
23. Delco ML, Kennedy JG, Bonassar LJ, Fortier LA. Post-traumatic osteoarthritis of the ankle: A distinct clinical entity requiring new research approaches. J Orthop Res. 2017;35(3):440-453. doi:10.1002/jor.23462
24. Renstrom PA. Persistently Painful Sprained Ankle. J Am Acad Orthop Surg. 1994;2(5):270-280.
25. Yeum WJ, Lee MY, Lee BH. The Influence of Hip-Strengthening Program on Patients with Chronic Ankle Instability. Medicina (Kaunas). 2024;60(8):1199. Published 2024 Jul 24. doi:10.3390/medicina60081199
26. Beynon A, Le May S, Theroux J. Reliability and validity of physical examination tests for the assessment of ankle instability. Chiropr Man Therap. 2022;30(1):58. Published 2022 Dec 19. doi:10.1186/s12998-022-00470-0
27. Netterström-Wedin F, Matthews M, Bleakley C. Diagnostic Accuracy of Clinical Tests Assessing Ligamentous Injury of the Talocrural and Subtalar Joints: A Systematic Review With Meta-Analysis. Sports Health. 2022;14(3):336-347. doi:10.1177/19417381211029953

28. Carvalho MO, Marcolino HM, Daleffe MR. Ottawa Ankle Rules: A Reliable Clinical Instrument to Detect Fractures in Children and Adolescents. Rev Bras Ortop (Sao Paulo). 2025;60(1):s00441800938. Published 2025 Mar 4. doi:10.1055/s-0044-1800938
29. Seyhan AU, Ak R, Şimşek F, Ayvacı S, Açıkgöz O. The role of Ottawa ankle rules in geriatric emergency department visits. Geriatrik acil servis başvurularında Ottawa ayak bileği kurallarının rolü. Ulus Travma Acil Cerrahi Derg. 2024;30(4):271-275. doi:10.14744/tjtes.2024.39240
30. Jungmann PM, Lange T, Wenning M, Baumann FA, Bamberg F, Jung M. Ankle Sprains in Athletes: Current Epidemiological, Clinical and Imaging Trends. Open Access J Sports Med. 2023;14:29-46. Published 2023 May 22. doi:10.2147/OAJSM.S397634
31. Dai, M., Zhao, H., Sun, P. et al. Chronic ankle instability: a cadaveric anatomical and 3D high-resolution MRI study for surgical reconstruction procedures. Insights Imaging 15, 249 (2024). https://doi.org/10.1186/s13244-024-01824-3
32. Raheman FJ, Rojoa DM, Hallet C, et al. Can Weightbearing Cone-beam CT Reliably Differentiate Between Stable and Unstable Syndesmotic Ankle Injuries? A Systematic Review and Meta-analysis. Clin Orthop Relat Res. 2022;480(8):1547-1562. doi:10.1097/CORR.0000000000002171
33. Godoy-Santos AL, Bernasconi A, Bordalo-Rodrigues M, Lintz F, Lôbo CFT, de Cesar Netto C. Weight-bearing cone-beam computed tomography in the foot and ankle specialty: where we are and where we are going - an update. Radiol Bras. 2021;54(3):177-184. doi:10.1590/0100-3984.2020.0048
34. Ha S, Hong SH, Paeng JC, et al. Comparison of SPECT/CT and MRI in diagnosing symptomatic lesions in ankle and foot pain patients: diagnostic performance and relation to lesion type. PLoS One. 2015;10(2):e0117583. Published 2015 Feb 10. doi:10.1371/journal.pone.0117583
35. Szczepaniak J, Ciszkowska-Łysoń B, Śmigielski R, Zdanowicz U. Value of ultrasonography in assessment of recent injury of anterior talofibular ligament in children. J Ultrason. 2015;15(62):259-266. doi:10.15557/JoU.2015.0022
36. Ekinci S, Polat O, Günalp M, Demirkan A, Koca A. The accuracy of ultrasound evaluation in foot and ankle trauma. Am J Emerg Med. 2013;31(11):1551-1555. doi:10.1016/j.ajem.2013.06.008
37. Song JH, Moon JJ, Shin WJ, Ko KP. Use of a comprehensive systemic ultrasound evaluation in the diagnosis and analysis of acute lateral region ankle sprain. BMC

Musculoskelet Disord. 2023;24(1):517. Published 2023 Jun 23. doi:10.1186/s12891-023-06642-0

38. Cha SW, Bae KJ, Chai JW, Park J, Choi YH, Kim DH. Reliable measurements of physiologic ankle syndesmosis widening using dynamic 3D ultrasonography: a preliminary study. Ultrasonography. 2019;38(3):236-245. doi:10.14366/usg.1805
39. Kocsis K, Stubnya B, Váncsa S, et al. Diagnostic accuracy of ultrasonography in acute lateral ankle ligament injury: A systematic review and meta-analysis. Injury. 2024;55 Suppl 3:111730. doi:10.1016/j.injury.2024.111730
40. Ruitenbeek HC, Oei EHG, Visser JJ, Kijowski R. Artificial intelligence in musculoskeletal imaging: realistic clinical applications in the next decade. Skeletal Radiol. 2024;53(9):1849-1868. doi:10.1007/s00256-024-04684-6
41. Park C, Lee H, Kim M, Park C. Deep Learning-Based Segmentation in Musculoskeletal Imaging: A Review of Research Trends. J Korean Soc Radiol. 2025;86(5):587-607. doi:10.3348/jksr.2025.0013
42. Teoh YX, Alwan JK, Shah DS, Teh YW, Goh SL. A scoping review of applications of artificial intelligence in kinematics and kinetics of ankle sprains - current state-of-the-art and future prospects. Clin Biomech (Bristol). 2024;113:106188. doi:10.1016/j.clinbiomech.2024.106188
43. Tran K, McCormack S. Exercise for the Treatment of Ankle Sprain: A Review of Clinical Effectiveness and Guidelines. Ottawa (ON): Canadian Agency for Drugs and Technologies in Health; April 3, 2020.
44. Van den Bekerom MP, Struijs PA, Blankevoort L, Welling L, van Dijk CN, Kerkhoffs GM. What is the evidence for rest, ice, compression, and elevation therapy in the treatment of ankle sprains in adults?. J Athl Train. 2012;47(4):435-443. doi:10.4085/1062-6050-47.4.14
45. Struijs PA, Kerkhoffs GM. Ankle sprain: the effects of non-steroidal anti-inflammatory drugs. BMJ Clin Evid. 2015;2015:1115. Published 2015 Jul 28
46. van den Bekerom MPJ, Sjer A, Somford MP, Bulstra GH, Struijs PAA, Kerkhoffs GMMJ. Non-steroidal anti-inflammatory drugs (NSAIDs) for treating acute ankle sprains in adults: benefits outweigh adverse events. Knee Surg Sports Traumatol Arthrosc. 2015;23(8):2390-2399. doi:10.1007/s00167-014-2851-6
47. Gaddi D, Mosca A, Piatti M, et al. Acute Ankle Sprain Management: An Umbrella Review of Systematic Reviews. Front Med (Lausanne). 2022;9:868474. Published 2022 Jul 7. doi:10.3389/fmed.2022.868474

48. Kerkhoffs GM, Rowe BH, Assendelft WJ, Kelly K, Struijs PA, van Dijk CN. Immobilisation and functional treatment for acute lateral ankle ligament injuries in adults. Cochrane Database Syst Rev. 2002;(3):CD003762. doi:10.1002/14651858.CD003762
49. Hazañas Ruiz S, Gálvez Alcaraz L, Cepas Soler JA. Estabilización funcional frente a inmovilización ortopédica en el esguince de tobillo grado I-II (leve) [Functional stabilization versus orthopedic immobility in grade-I-II (mild) ankle sprain]. Aten Primaria. 1999;23(7):425-428.
50. Song Y, Li H, Sun C, et al. Clinical Guidelines for the Surgical Management of Chronic Lateral Ankle Instability: A Consensus Reached by Systematic Review of the Available Data. Orthop J Sports Med. 2019;7(9):2325967119873852. Published 2019 Sep 23. doi:10.1177/2325967119873852
51. Camacho LD, Roward ZT, Deng Y, Latt LD. Surgical Management of Lateral Ankle Instability in Athletes. J Athl Train. 2019;54(6):639-649. doi:10.4085/1062-6050-348-18
52. Acevedo JI, Mangone P. Arthroscopic brostrom technique. Foot Ankle Int. 2015;36(4):465-473. doi:10.1177/1071100715576107
53. Hunt KJ, Griffith R. Open Brostrom for Lateral Ligament Stabilization. Curr Rev Musculoskelet Med. 2020;13(6):788-796. doi:10.1007/s12178-020-09679-z
54. Hogan MV, Scott DM, Canton SP, LaBaze D, Yan AY, Wang JH. Biologic therapies for foot and ankle injuries. Expert Opin Biol Ther. 2021;21(6):717-730. doi:10.1080/14712598.2021.1866534
55. Frey E, Brown CD, Tripp B. Effectiveness of Platelet-Rich Plasma in Reducing Pain and Increasing Function After Acute Lateral Ankle Sprain: A Critically Appraised Topic. J Sport Rehabil. 2024;33(7):558-561. Published 2024 Jul 12. doi:10.1123/jsr.2023-0425
56. Petrella RJ, Petrella MJ, Cogliano A. Periarticular hyaluronic acid in acute ankle sprain. Clin J Sport Med. 2007;17(4):251-257. doi:10.1097/JSM.0b013e3180f6169f
57. Ammendolia A, de Sire A, Lippi L, et al. Cryo plus Ultrasound Therapy, a Novel Rehabilitative Approach for Football Players with Acute Lateral Ankle Injury Sprain: A Pilot Randomized Controlled Trial. Sports (Basel). 2023;11(9):180. Published 2023 Sep 9. doi:10.3390/sports11090180
58. Rhim HC, Shin J, Kang J, et al. Use of extracorporeal shockwave therapies for athletes and physically active individuals: a systematic review. Br J Sports Med. 2024;58(3):154-163. Published 2024 Feb 7. doi:10.1136/bjsports-2023-107567
59. Müller SA, Todorov A, Heisterbach PE, Martin I, Majewski M. Tendon healing: an overview of physiology, biology, and pathology of tendon healing and systematic review

of state of the art in tendon bioengineering. Knee Surg Sports Traumatol Arthrosc. 2015;23(7):2097-2105. doi:10.1007/s00167-013-2680-z

60. Lewis SR, Pritchard MW, Parker R, et al. Rehabilitation for ankle fractures in adults. Cochrane Database Syst Rev. 2024;9(9):CD005595. Published 2024 Sep 23. doi:10.1002/14651858.CD005595.pub4
61. Wagemans J, Bleakley C, Taeymans J, et al. Exercise-based rehabilitation reduces reinjury following acute lateral ankle sprain: A systematic review update with meta-analysis. PLoS One. 2022;17(2):e0262023. Published 2022 Feb 8. doi:10.1371/journal.pone.0262023
62. Moreira V, Antunes F. Entorses do tornozelo: do diagnóstico ao tratamento perspectiva fisiátrica [Ankle sprains: from diagnosis to management. the physiatric view]. Acta Med Port. 2008;21(3):285-292.
63. Rivera MJ, Winkelmann ZK, Powden CJ, Games KE. Proprioceptive Training for the Prevention of Ankle Sprains: An Evidence-Based Review. J Athl Train. 2017;52(11):1065-1067. doi:10.4085/1062-6050-52.11.16
64. Elaraby AER, Shahien M, Jahan AM, Etoom M, Bekhet AH. The Efficacy of Virtual Reality Training in the Rehabilitation of Orthopedic Ankle Injuries: A Systematic Review and Meta-analysis. Adv Rehabil Sci Pract. 2023;12:11795727231151636. Published 2023 Feb 7. doi:10.1177/11795727231151636
65. Dong M, Zhou Y, Li J, et al. State of the art in parallel ankle rehabilitation robot: a systematic review. J Neuroeng Rehabil. 2021;18(1):52. Published 2021 Mar 20. doi:10.1186/s12984-021-00845-z
66. Alvarez-Perez MG, Garcia-Murillo MA, Cervantes-Sánchez JJ. Robot-assisted ankle rehabilitation: a review. Disabil Rehabil Assist Technol. 2020;15(4):394-408. doi:10.1080/17483107.2019.1578424
67. Lu SW, Lang BX, Liu JN, et al. Comparative Efficacy of Micro-Needle-Knife Therapy and Acupuncture in Acute Ankle Sprains: A Randomized Controlled Trial. Med Sci Monit. 2024;30:e944157. Published 2024 May 25. doi:10.12659/MSM.944157
68. Zhao M, Gao W, Zhang L, et al. Acupressure Therapy for Acute Ankle Sprains: A Randomized Clinical Trial. PM R. 2018;10(1):36-44. doi:10.1016/j.pmrj.2017.06.009
69. Chen L, Hu Q, Gao H, Tang D. The Clinical Effect of Electroacupuncture Combined with Surround Needling in the Treatment of Acute Lateral Ankle Sprain Based on Musculoskeletal Ultrasound Imaging Technology: A Protocol for a Single-Centre, Randomized, Controlled Trial. J Pain Res. 2025;18:2467-2478. Published 2025 May 15. doi:10.2147/JPR.S517109