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JOURNAL OF THE Foot & Ankle IFA

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Stormy times

Much more rapidly than anticipated, we have observed the submission of manuscripts to the ***Journal of the Foot and Ankle*** that have been predominantly produced with the assistance of Artificial Intelligence (AI).

This observation stems primarily from the diligent work of our editorial board, which is committed to providing constructive and collaborative reviews rather than merely selective evaluations. This editorial philosophy obliges each reviewer to engage deeply with the manuscripts, working alongside the authors to improve not only the structural formalities of a scientific paper but also the clarity and precision of the language. In doing so, reviewers decisively influence the quality of the final product, thereby enhancing the dissemination of ideas and results, and facilitating the incorporation of new knowledge into daily practice.

However, this task has increasingly become exhausting—and at times nearly unmanageable—when confronted with lengthy, complex texts that are clearly inflated by the use of AI. Such manuscripts are often riddled with thematic confusion, inconsistent insertions attempting to establish non-existent correlations, and a troubling duplication—or even multiplication—of papers on similar topics that overlap in an abnormal and unacceptable manner.

The same phenomenon has been identified in high-volume preprint platforms, where the participation of so-called "paper mills" and AI-based tools has significantly increased the proportion of LLM-generated manuscripts, reaching figures as high as **10% in the biological sciences** and **22% in computer science**.

The "symptoms" of AI-driven manuscripts may be summarized as follows:

1. **Overreliance on technology** – texts produced without the rigor of conventional scientific methodology;
2. **Stereotyped writing** – instead of advancing knowledge, such texts contribute to increased "noise" within scientific fields;
3. **Authorship opacity** – lack of transparency regarding the role of AI in manuscript production;
4. **Fabricated claims** – due to AI "hallucinations" that introduce false data and references;
5. **Rapid dissemination of misinformation** – amplified by modern preprint publication systems;
6. **An "arms race" between AI authors and AI detectors** – which may generate false positives and unfairly penalize legitimate authors.

The central concern, therefore, lies in the undeniable risk of disseminating low-quality studies that circulate misleading or false information, thereby severely undermining the trustworthiness of scientific output.

In our ongoing efforts to index the ***Journal of the Foot and Ankle***, we now face an additional challenge. Stricter differentiation between authentic manuscripts and those generated by AI will be indispensable, as it represents the only viable means of safeguarding the integrity—and the very survival—of this journal.

References

1. Watson T. AI content is tainting preprints: how moderators are fighting back. Nature. 2025;644(8077):590-1. https://doi.org/10.1038/d41586-025-02469-y
2. Liang W, Zhang Y, Wu Z, Lepp H, Ji W, Zhao X, et al. Quantifying large language model usage in scientific papers. Nat Hum Behav. 2025. https://doi.org/10.1038/s41562-025-02273-8

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Systematic Review

Osteochondral lesions of the talus: diagnostic and therapeutic approaches in orthopedics

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Abstract

Objective: Evaluate the diagnostic and therapeutic approaches currently employed in the management of osteochondral lesions of the talus, with an emphasis on technological advances and regenerative therapies.

Methods: This review was conducted based on the PRISMA guidelines and included 16 studies published between 2010 and 2024, selected from the PubMed, Scopus, Web of Science, and Embase databases.

Results: Advanced imaging techniques, such as magnetic resonance imaging with T2 mapping and three-dimensional computed tomography, are fundamental for early diagnosis and surgical planning. Conservative approaches, such as immobilization and physiotherapy rehabilitation, have demonstrated efficacy in providing symptomatic relief for minor lesions; however, they present limitations in tissue regeneration and the long-term maintenance of joint function. Conventional surgical procedures, including microfractures and subchondral perforation, were associated with initial functional improvements but with a risk of progressive degeneration of the reparative fibrocartilage. Regenerative therapies, such as autologous and allogeneic osteochondral transplantation, as well as the use of mesenchymal stem cells and bioactive scaffolds, have shown potential in restoring hyaline cartilage and preserving the joint, particularly in complex and refractory lesions. Despite technological and therapeutic advances, challenges persist, including the standardization of protocols, high costs, and limited accessibility to emerging therapies. Additionally, a meta-analysis was not possible to perform due to the heterogeneity of the included studies, which encompassed both randomized clinical trials and observational studies.

Conclusion: Integrated and individualized therapeutic strategies are crucial for optimizing clinical outcomes, preserving joint functionality, and enhancing the quality of life for patients with osteochondral lesions of the talus.

Level of evidence I; Systematic Review.

Keywords: Lesion; Talus; Diagnostic imaging; Technological development.

Introduction

Osteochondral lesions of the talus (OLT) represent a significant diagnostic and therapeutic challenge in orthopedic practice, given their complexity and the functional role of the talus in the ankle joint. These lesions, often related to acute trauma or repetitive microtrauma, compromise the integrity of the cartilage and the underlying bone, which can progress to chronic pain, joint instability, and progressive degeneration. Although they are more prevalent in young and active individuals, the functional impact of these lesions can be severe in any age group, making it difficult to restore joint mobility fully[1].

An early and accurate diagnosis is essential to prevent the progression of osteochondral damage. Clinical examination, although relevant, is often insufficient to determine the extent of lesions, requiring the use of advanced imaging tests. Imaging techniques such as magnetic resonance imaging (MRI) and computed tomography (CT) have distinguished

Study performed at the Hospital Santo Antônio /Obras Sociais Irmã Dulce, Salvador, Bahia, Brazil.

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themselves for their ability to characterize the depth, stability, and impairment of adjacent structures, thereby assisting in therapeutic planning. However, gaps remain in the standardization of diagnostic criteria and the evaluation of response to treatment[2].

Therapeutic approaches vary widely, ranging from conservative strategies such as immobilization and rehabilitation to surgical interventions, which may include microfractures, autologous osteochondral transplantation, and tissue engineering techniques. Choosing the optimal technique is influenced by multiple factors, including the patient's age, the extent of injury, the level of physical activity, and the presence of biomechanical changes in the ankle. Despite recent advances in surgical technologies and biomaterials, the literature reports varied results, with success rates that depend on rigorous treatment selection and adherence to rehabilitation[3].

In addition, OLTs are often associated with joint comorbidities, including ligament instability and reactive synovitis, which can complicate clinical management. Such conditions require a multidisciplinary approach to ensure functional recovery and minimize the risk of recurrences. In this context, research in regenerative therapies, such as the use of mesenchymal stem cells and bioactive scaffolds, has shown promising potential in restoring osteochondral tissue and improving long-term clinical outcomes[4].

Given the clinical relevance and functional impact of OLT, healthcare professionals must understand the diagnostic and therapeutic nuances associated with these lesions. The integration of technological advances and ongoing scientific research are indispensable for optimizing management protocols, improving patient outcomes, and reducing the burden associated with long-term complications.

The objective of this study is to evaluate the diagnostic and therapeutic approaches currently employed in the management of osteochondral lesions of the talus, with an emphasis on technological advances and regenerative therapies. In addition, identify the clinical and radiological factors that influence the choice of treatment, as well as discuss the outcomes related to different orthopedic management strategies.

Methods

This systematic literature review adhered to the principles established for systematic reviews, as outlined in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, prioritizing the scope and relevance of the included sources.

The search was conducted in the PubMed, Scopus, Web of Science, and Embase databases, covering publications between 2010 and 2024, with the inclusion of studies without language restriction. The descriptors used were selected based on Health Sciences Descriptors (DeCS) and Medical Subject Headings (MeSH), including the terms "osteochondral lesions of the talus," "diagnostic imaging," "therapeutic approaches," "ankle injuries" and "orthopedic management." The combination of terms was performed using Boolean operators ("AND" and "OR") to ensure a comprehensive and specific search.

Original articles, systematic reviews, meta-analyses, and relevant clinical studies addressing the diagnosis and treatment of OLT were included. Inclusion criteria were: (i) studies involving patients with a confirmed diagnosis of OLT; (ii) articles describing imaging techniques used in the diagnosis (MRI and CT); and (iii) research that presented therapeutic interventions, both conservative and surgical. Studies focusing exclusively on lesions of other joints, isolated case reports, and articles that did not provide full text were excluded (Figure 1).

The screening process was performed in two stages. Initially, two independent reviewers evaluated the titles and abstracts of the retrieved articles to verify their eligibility based on the defined criteria. Subsequently, the full texts of the selected studies were analyzed to confirm their inclusion. Disagreements were resolved by consensus or by consultation with a third reviewer.

Data from the included articles were extracted and organized. The analysis was qualitative, focusing on the identification of technological advances, limitations of current methods, and gaps in the literature that require further investigation. Whenever possible, the levels of evidence and the methodological quality of the studies were highlighted, using the GRADE system for critical evaluation.

As a limitation, it was not possible to perform a meta-analysis due to the inclusion of observational studies and randomized and non-randomized clinical trials. However, the findings of this systematic review make a significant contribution to the understanding of best practices in the management of OLT and provide support for future clinical research.

Results and Discussion

The 16 studies included in this qualitative analysis address a range of therapeutic strategies and techniques for the treatment of OLT, reflecting the diversity of clinical and surgical approaches available[5-20]. Investigations range from comparisons between conservative and surgical treatments, such as the study by Acar and Çevik (2025)[7], to the evaluation of new techniques, including the use of autologous osteochondral transplants and minimally invasive therapies (Wei et al., 2023)[11]. In addition, several studies evaluate the effectiveness of techniques such as bone marrow stimulation by arthroscopy (Arshad et al., 2022)[17], the induced matrix of chondrogenesis (Migliorini et al., 2022)[15], and the retrograde approach to OLT (Faldini et al., 2023)[13]. The analysis also includes research investigating the role of imaging in injury management (Khan et al., 2024)[9], the evaluation of healing indicators (Kim et al., 2022)[21], and the impact of chronic ankle instability on osteochondral lesions (Feng et al., 2022)[18]. Evidence extracted from these studies will be detailed below, providing critical insights into the effectiveness of treatments and future directions for managing OLT.

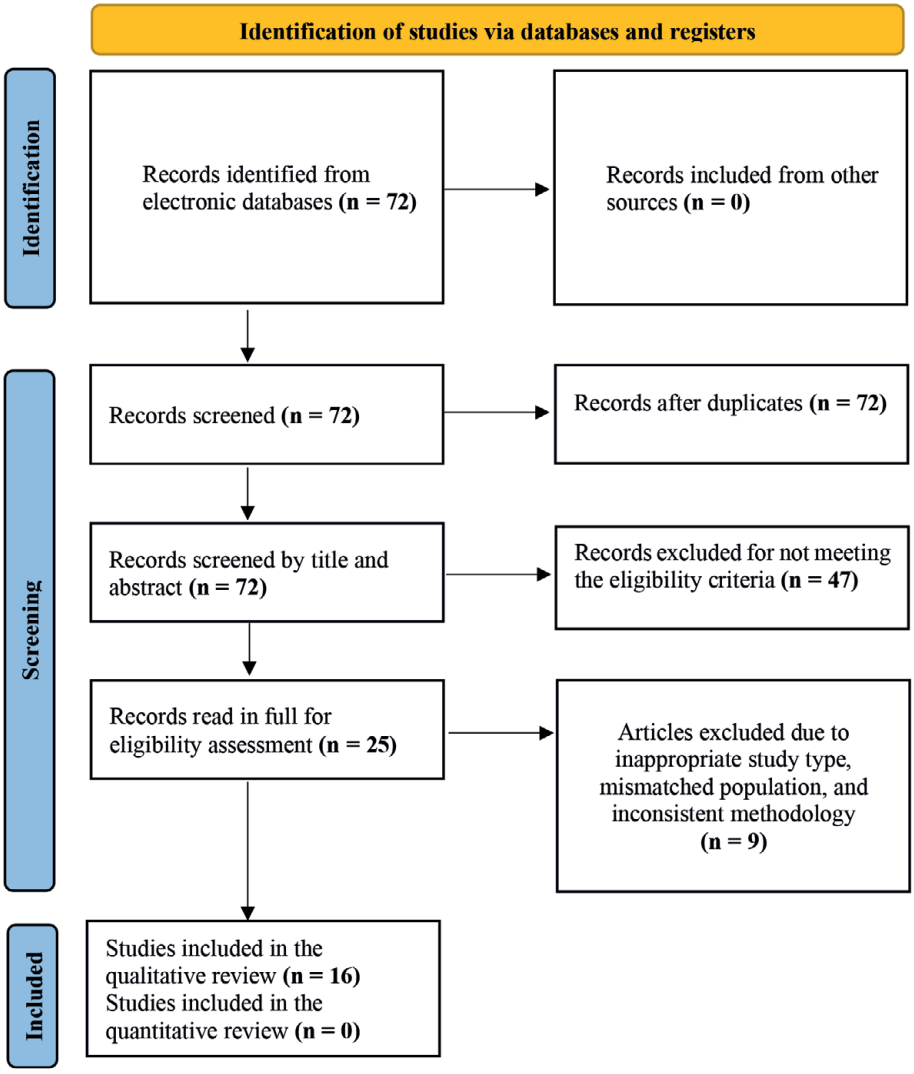

Figure 1. PRISMA flow diagram.

Advances in diagnostic imaging methods

Imaging diagnostic techniques have played a crucial role in the identification and characterization of OLT, enabling an accurate and personalized approach. Magnetic resonance imaging was highlighted as the gold standard tool due to its high sensitivity and specificity in evaluating osteochondral structures. Studies such as Khan et al. (2024)[9] have described the importance of MRI in the diagnosis, planning, and management of OLT, emphasizing its superiority in differentiating affected structures. Butler et al. (2024)[8] reinforced this perspective by associating the presence of a hypertrophic distal fascicle of the anterior tibiofibular ligament with a high rate of osteochondral lesions, demonstrating the relevance of imaging in the evaluation of predisposing anatomical factors.

Computed tomography remains an essential tool, especially for the analysis of subchondral bone and lesion morphology. Wei et al. (2023)[11] highlighted its role in the detailed evaluation of cystic lesions, favoring the selection of appropriate surgical interventions. Likewise, Walther et al. (2023)[12] analyzed its application in the classification and conservative diagnosis of OLT, highlighting the need for multimodal approaches. Migliorini et al. (2022)[15] have explored MRI using advanced techniques, including T2 mapping and T1-weighted images with specific contrast (dGEMRIC), which enable the early quantification of cartilaginous changes, promoting more accurate detection before significant clinical manifestations.

Regarding minimally invasive treatments, virtual arthroscopy emerges as a promising innovation. Arshad et al. (2022)[17] described its effectiveness in simulating direct arthroscopic

vision, optimizing the assessment of joint integrity without the need for invasive procedures. In addition, ultrasound has emerged as a complementary method in post-treatment follow-up, enabling the dynamic monitoring of changes in the soft tissue around the joint, as reported by Feng et al. (2022) [18] in cases of chronic ankle instability.

Advances in imaging technology have also facilitated the development of automated artificial intelligence systems, which assist in the detection and classification of OLT, optimizing diagnosis and reducing subjectivity in medical interpretation. Weber et al. (2021)[20] discussed the impact of these tools on therapeutic planning, emphasizing the need for large-scale clinical validation to consolidate their routine use. Kim et al. (2021)[21] showed the benefit of MRI in the evaluation of postoperative outcomes, confirming its applicability in the follow-up of intraarticular treatments.

Overall, advances in diagnostic imaging methods have allowed not only a deeper understanding of the pathogenesis of OLT but also greater accuracy in diagnosis and therapeutic planning, especially in complex and refractory cases. The integration of these technologies into clinical practice has the potential to enhance patients' functional outcomes and overall quality of life.

Performance of conservative interventions

Conservative interventions for the management of OLTs are often indicated in cases of lesser severity, especially in stable and limited-sized lesions. These strategies aim to relieve symptoms, reduce the progression of joint damage, and restore ankle function without the need for surgical intervention. Among the main approaches are temporary immobilization, the use of orthoses, modification of activities, and physiotherapy rehabilitation programs focused on muscle strengthening and biomechanical rebalancing.

The reviewed studies indicated that immobilization and joint load reduction are effective in alleviating pain and controlling initial inflammation, particularly in patients with a recent history of trauma. Kim et al. (2022)[14] reported that immobilization may provide initial symptomatic relief in young patients with osteochondritis dissecans of the talus; however, its long-term effectiveness remains a subject of debate. Walther et al. (2023)[12] reviewed conservative treatment modalities and highlighted that, although immobilization can alleviate initial symptoms, its effectiveness is limited in cases involving larger lesions.

Physiotherapy, when performed in a structured and personalized manner, has shown improvement in ankle mobility and muscle strength, contributing to more consistent functional recovery. Walther et al. (2023)[12] discussed the role of physical therapy in functional ankle stabilization, indicating that targeted protocols can optimize joint biomechanics and reduce overload in vulnerable areas. In addition, Faldini et al. (2023)[13] reported that conservative approaches are more effective when combined with measures that promote joint rebalancing and muscle strengthening.

Although conservative approaches are often effective for symptom relief, their ability to promote significant tissue regeneration is limited. Wei et al. (2023)[11] suggest that, in the absence of regenerative or surgical treatment, degenerative changes may progress, especially in lesions involving the subchondral bone. In addition, biomechanical factors such as ankle misalignment and ligament instability can compromise results, highlighting the importance of a comprehensive diagnosis before opting for this approach.

More recent conservative approaches include intraarticular infiltration of hyaluronic acid and corticosteroids, which have shown positive results in pain control and short-term functional improvement. Weber et al. (2021)[20] reported that these therapies may provide temporary symptomatic relief, but evidence of their impact on the long-term preservation of articular cartilage remains inconclusive.

In summary, conservative interventions represent an initial approach in selected cases of OLT, particularly when lesions are small and joint instability is absent. However, it is important to highlight that there is no robust scientific evidence to prove the effectiveness of these modalities in tissue repair or prevention of lesion progression. Thus, its use is primarily aimed at symptomatic control, with limited prognostic impact. The unpredictability of the clinical evolution of patients treated exclusively with conservative approaches requires caution when selecting this approach and reinforces the need for continuous monitoring through clinical and imaging reassessments.

Effectiveness of conventional surgical techniques

Conventional surgical techniques remain widely used in the management of OLT, especially in cases refractory to conservative treatment or in unstable and symptomatic lesions. Among the most used procedures are microfractures, subchondral perforation, and curettage, whose objective is to promote the formation of repair tissue in an attempt to restore, albeit partially, joint function. Migliorini et al. (2022)[15] highlighted that the microfracture technique, by inducing the migration of mesenchymal cells to the lesion site, presented satisfactory results in small lesions, usually less than 1.5 cm^2, providing significant pain relief and functional recovery in the short-term.

However, the limitation of fibrocartilage formation, which has biomechanical properties inferior to those of hyaline cartilage, has been identified as a critical factor that can compromise the durability of results, especially in young or physically active patients. Arshad et al. (2022)[17] reinforced this limitation, indicating that progressive degeneration can occur over time, leading to the need for complementary treatments.

Subchondral perforation, a technique similar to microfractures, has shown comparable effectiveness in relieving symptoms; however, it is associated with a higher risk of thermal injury during the procedure, unlike microfractures, which do not involve this type of complication, as highlighted

by Feng et al. (2022)[18]. Curettage, in turn, has been used as a complement in cases involving loose osteochondral fragments, allowing the removal of devitalized tissues and the preparation of the articular bed for additional interventions, as reported by Kim et al. (2021)[21].

Another limitation of conventional techniques is their reduced effectiveness in larger lesions or cases of significant subchondral bone involvement. In such situations, progression to advanced techniques, such as osteochondral transplants or the use of biological matrices, is often necessary to enhance clinical and functional outcomes. Wei et al. (2023)[11] described that, in lesions greater than 1.5 cm^2, the conventional approach had a lower long-term success rate, while more advanced techniques showed additional benefits in tissue regeneration.

In summary, conventional surgical techniques remain a valid and widely accessible therapeutic approach for the initial management of OLT. Despite the limitations regarding tissue regeneration, these techniques have a favorable profile of safety, simplicity, and effectiveness in the short-term and are widely used in less complex lesions. Currently, these interventions, such as microfractures, subchondral perforations, and curettages, are performed almost exclusively arthroscopically, as the open approach is no longer recommended in modern orthopedic practice due to the higher risk of morbidity and poorer functional recovery. The choice of technique should be based on criteria such as lesion size, joint stability, and the patient's clinical profile, ensuring a personalized and effective approach.

Advances in regenerative therapies and osteochondral transplants

Regenerative therapies and osteochondral transplants represent significant advances in the management of OLT, especially in cases refractory to conservative and conventional approaches. These strategies aim to restore joint integrity through regeneration of hyaline cartilage or direct replacement of injured tissue, offering more lasting and effective solutions for extensive or complex lesions. Wei et al. (2023)[11] highlighted that these approaches improve joint functionality by reducing the progression of osteochondral degeneration.

Autologous osteochondral transplantation (mosaicplasty) is a promising technique in which osteochondral cylinders are removed from non-supportive areas of the joint and transferred to the lesion site. Migliorini et al. (2022)[15] indicated that this approach provides excellent tissue integration, with hyaline cartilage formation and sustained long-term clinical improvement. However, challenges such as limitations in graft size and the potential for morbidity at the donor site still need to be considered.

Allogeneic osteochondral transplantation, in turn, has emerged as a valuable option due to its potential for treating larger lesions without the restrictions associated with donor sites. This technique maintains the preservation of joint congruency and enables the replacement of viable osteochondral tissue, especially in lesions involving large areas of the talus. Weber et al. (2021)[20] described advances in graft preservation techniques to increase cell viability. However, success rates remain unsatisfactory, and the indication of this type of procedure continues to be widely questioned in the literature. Additionally, the risks of immune rejection and the limited availability of viable donors represent significant challenges to their adoption in clinical practice.

Regenerative therapies, including the use of mesenchymal stem cells and growth factors, have shown promise in stimulating tissue regeneration. Clinical trials analyzed by Arshad et al. (2022)[17] demonstrated that intraarticular application of stem cells derived from bone marrow or adipose tissue can promote the formation of hyaline cartilage, in addition to improving functional parameters and reducing pain. Similarly, the use of three-dimensional bioactive matrices, such as collagen scaffolds or biomaterials, is effective in supporting tissue repair, promoting cell organization and structural regeneration.

Although advances in regenerative therapies and osteochondral transplants represent a milestone in the approach to OLT, challenges remain, including the standardization of protocols, high costs, and the need for long-term studies to assess the durability of results. However, these strategies offer promising prospects for significantly improving patients' clinical outcomes and quality of life, especially in cases where traditional approaches are insufficient[21].

Functional outcomes and quality of life

The functional outcomes and quality of life of patients with OLT are directly related to the choice and effectiveness of the therapeutic approach, as well as to the initial severity of the lesion. Recent studies demonstrate that successful interventions, whether conservative, conventional surgical, or advanced, are associated with significant improvements in joint mobility, pain relief, and recovery from daily activities. Walther et al. (2023)[12] reviewed the effects of conservative interventions, showing initial functional improvement but highlighting the limitations in the long-term preservation of the joint.

Patients treated with conservative interventions, such as physical therapy and joint infiltrations, often report short-term functional improvement, especially in cases of minor lesions. However, the absence of effective tissue repair may limit long-term gains, with recurrence of symptoms and progressive joint impairment in some cases. Feng et al. (2022)[18] reported that although physiotherapy can improve mobility and muscle strengthening, patients with extensive lesions have higher rates of failure in conservative treatment. On the other hand, conventional surgical treatments, such as microfractures and subchondral perforations, are more effective in relieving pain and restoring joint function, although results may be inferior in patients with extensive lesions. Migliorini et al. (2022)[15] showed that patients undergoing microfractures had

significant improvement in joint function scores but had an increased risk of fibrocartilage degeneration over time.

Advances in regenerative techniques and osteochondral transplants have shown a positive impact on functional outcomes, particularly in patients with complex lesions. Osteochondral transplantation, both autologous and allogeneic, has been associated with the restoration of normal biomechanical patterns in the ankle, resulting in a significant reduction in pain and an improvement in the ability to perform physical activities. Studies indicate that autologous osteochondral transplantation has success rates greater than 85% in the long term; however, minor symptoms may persist, and late deterioration may occur. Similarly, the use of bioactive stem cells and scaffolds has demonstrated potential for regenerating hyaline cartilage, promoting superior functional outcomes and greater long-term preservation of the joint, as noted by Arshad et al. (2022)[17].

Regarding quality of life, standardized assessment instruments, such as the American Orthopaedic Foot & Ankle Society (AOFAS) ankle-hindfoot score and the Short Form 36 Health Survey Questionnaire (SF-36), indicate that most patients experience considerable improvement following successful interventions. For example, studies have shown that patients undergoing arthroscopy-assisted micro-perforations had a mean increase of 22.5 points in the AOFAS score after the surgical procedure. This improvement is associated not only with symptom relief but also with the re-establishment of functional independence and the resumption of leisure and work activities. Kim et al. (2021) [21] reinforced that patients undergoing regenerative therapies demonstrated higher scores in these instruments compared to conventional approaches.

Despite therapeutic advances, certain factors continue to negatively impact functional outcomes and quality of life, including advanced age, large lesions, and associated comorbidities. Weber et al. (2021)[20] emphasized that individualization of treatment, longitudinal follow-up, and the use of multimodal approaches are essential to optimize clinical outcomes and provide broader functional and psychosocial recovery for patients with OLT.

Final considerations

Osteochondral lesions of the talus represent a significant challenge in orthopedic practice due to their anatomical location, wide clinical variability, and functional impact. Proper management of these lesions depends on a multidisciplinary approach that integrates advanced diagnostic methods, therapeutic interventions, and careful longitudinal follow-up.

Advances in imaging methods, such as high-resolution MRI and CT with three-dimensional reconstruction, have enhanced diagnostic accuracy, enabling the earlier identification of lesions and more detailed surgical planning. These advances have contributed to more accurate stratification of patients and the selection of personalized therapeutic strategies.

In the therapeutic field, although conservative approaches are still used in specific contexts, they are not considered effective pillars in the management of OLT. They are most often employed as transitional strategies in situations where more definitive interventions are not feasible. Conventional surgical techniques, on the other hand, remain a reference in cases of less complex lesions. On the other hand, advances in regenerative therapies and osteochondral transplants offer more promising prospects, with the potential to at least partially restore articular cartilage and improve functional outcomes and quality of life, particularly in cases of extensive or refractory lesions. Still, the widespread adoption of these techniques faces significant limitations, including high costs, resource scarcity, and a lack of standardization in protocols.

Despite significant advances, gaps remain in understanding the evolution of OLT, particularly regarding the progression of joint degeneration and the factors that influence long-term therapeutic outcomes. Future research should focus on optimizing treatment protocols, benchmarking different techniques, and developing biomaterials and cell therapies that promote tissue regeneration more efficiently.

We believe that the integrated approach of OLT, combining early diagnosis, innovative therapies, and personalized care, is fundamental to minimizing the functional impact and improving the quality of life for patients. Continued advancement in clinical and scientific knowledge is essential to develop more effective, safe, and accessible strategies for managing these complex lesions.

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References

1. Prado MP, Kennedy JG, Raduan F, Nery C. Diagnosis and treatment of osteochondral lesions of the ankle: current concepts. Rev Bras Ortop. 2016;51:489-500.
2. Ribeiro LFS. Estudo Retrospetivo para Caracterização de Artroscopias Eletivas para Tratamento de Osteocondrose Dissecante num Hospital de Referência em Portugal [dissertação]. Lisboa: Universidade de Lisboa; 2023.
3. Coelho BAL. Efeito imediato da mobilização de tornozelo na amplitude de dorsiflexão em cadeia cinética fechada em mulheres com dor patelofemoral: um ensaio clínico aleatorizado [tese]. São Paulo: Universidade de São Paulo; 2019.
4. Souza FT. Análise da influência de um calçado flexível e desprovido de salto sobre a mecânica da marcha e a carga articular de indivíduos com osteoartrite de joelho [tese]. São Paulo: Universidade de São Paulo; 2010.
5. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ. 2021;372:n71.
6. Tang X, Han X, Fu H, Shen Y, Zhang D, Guo Q, et al. Comparative study of arthroscopic autologous cancellous bone grafting and medial malleolar osteotomy combined with autologous periosteal iliac bone grafting for the treatment of osteochondral lesions of the talus. J Orthop Surg Res. 2025;20(1):60.
7. Acar A, Çevik HB. Clinical and radiological comparisons of isolated posterior malleolar fractures treated surgically and conservatively. Eur J Trauma Emerg Surg. 2025;51(1):12.
8. Butler JJ, Randall GW, Dalmau-Pastor M, Lin CC, Schoof L, Kennedy JG. A hypertrophic distal fascicle of the anterior tibiofibular ligament is associated with a high rate of osteochondral lesions of the talus. Knee Surg Sports Traumatol Arthrosc. 2024;32(9):2452-62.
9. Khan I, Ranjit S, Welck M, Saifuddin A. The role of imaging in the diagnosis, staging, and management of the osteochondral lesions of the talus. Br J Radiol. 2024;97(1156):716-25.
10. Rikken QGH, Favier BJC, Dahmen J, Stufkens SAS, Kerkhoffs GMMJ. Open lift-drill-fill-fix for medial osteochondral lesions of the talus: surgical technique. Oper Orthop Traumatol. 2024;36(2):132-44.
11. Wei Y, Guo H, Sun N, Tang Z, Ding J, Zeng C. Autologous Costal Osteochondral Transplantation for Cystic Osteochondral Lesions of the Talus: Feasible and Effective. Orthop Surg. 2023;15(11): 2985-92.
12. Walther M, Gottschalk O, Madry H, Müller PE, Steinwachs M, Niemeyer P, et al. Etiology, Classification, Diagnostics, and Conservative Management of Osteochondral Lesions of the Talus. 2023 Recommendations of the Working Group "Clinical Tissue Regeneration" of the German Society of Orthopedics and Traumatology. Cartilage. 2023;14(3):292-304.
13. Faldini C, Mazzotti A, Artioli E, Ruffilli A, Barile F, Zielli SO, et al. A novel retrograde technique for ankle osteochodral lesions: the sub-endo-chondral regenerative treatment (secret). Musculoskelet Surg. 2023;107(3):337-43.
14. Kim HW, Park KB, Kim CW, Lee KY, Park H. Healing Predictors of Conservative Treatment for Juvenile Osteochondritis Dissecans of the Talus. Clin J Sport Med. 2022;32(6):e635-43.
15. Migliorini F, Schenker H, Maffulli N, Eschweiler J, Lichte P, Hildebrand F, et al. Autologous matrix induced chondrogenesis (AMIC) as revision procedure for failed AMIC in recurrent symptomatic osteochondral defects of the talus. Sci Rep. 2022;12(1):16244. .
16. Saxena A, Maffulli N, Jin A, Isa E, Jaswal J, Allen R. Outcomes of Talar Osteochondral and Transchondral Lesions Using an Algorithmic Approach Based on Size, Location, and Subchondral Plate Integrity: A 10-Year Study on 204 Lesions. J Foot Ankle Surg. 2022;61(3):442-7.
17. Arshad Z, Aslam A, Iqbal AM, Bhatia M. Should Arthroscopic Bone Marrow Stimulation Be Used in the Management of Secondary Osteochondral Lesions of the Talus? A Systematic Review. Clin Orthop Relat Res. 2022;480(6):1112-25.
18. Feng SM, Chen J, Ma C, Migliorini F, Oliva F, Maffulli N. Limited medial osteochondral lesions of the talus associated with chronic ankle instability do not impact the results of endoscopic modified Broström ligament repair. J Orthop Surg Res. 2022;17(1):69.
19. Geyer S, Mattes J, Petersen W, Imhoff AB, Achtnich AE. Arthroscopic one-step matrix-assisted bone marrow stimulation for the treatment of osteochondral defects of the talus. Oper Orthop Traumatol. 2022;34(4):295-302.
20. Weber CD, Kerkhoffs G, Dahmen J, Arbab DU, Kobbe P, Hildebrand F, et al. [Osteochondral lesions of the talus: Individualized approach based on established and innovative reconstruction techniques]. Unfallchirurg. 2021;124(4):319-32. German.
21. Kim JH, Gwak HC, Park DH, Lee CR, Jung SH, Kim JG, et al. Second-look arthroscopic findings and clinical outcomes after management of intra-articular lesions in acute ankle fractures with arthroscopy. Foot Ankle Surg. 2021;27(7):799-808.

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Systematic Review

Impact of immobilization time on the recovery of ankle function after Achilles tendon rupture

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Abstract

Objective: To analyze the impact of immobilization time on the recovery of ankle function after Achilles tendon fracture.

Methods: Studies published between 2013 and 2023, extracted from databases including PubMed, Scopus, Web of Science, Embase, and Cochrane Library, were included.

Results: The analysis revealed that protocols with immobilization of 0-2 weeks resulted in better recovery of range of motion, muscle strength, and greater patient satisfaction, without a significant increase in complication rates or re-ruptures. In contrast, immobilization of 4-6 weeks was associated with greater joint stiffness and delayed return to sports activities.

Conclusion: The findings reinforce the benefits of early mobilization after Achilles tendon rupture and reinforce the need for a more individualized approach.

Level of Evidence I; Systematic Review.

Keywords: Achilles tendon; Immobilization; Functional rehabilitation.

Introduction

Achilles tendon rupture is among the most common tendon injuries in adults, especially in individuals aged 30-50 who engage in recreational sports activities. The Achilles tendon is the strongest and thickest in the human body, playing a critical role in walking, running, and jumping. Its rupture can lead to significant functional impairment, impacting the patient's mobility and quality of life. Treatment can be surgical or conservative, and both involve immobilization time to support tendon healing and reduce complications[1].

The ideal immobilization time after injury remains controversial in the orthopedic literature. Traditional protocols recommend prolonged immobilization to protect the scar structure and avoid excessive stress at the injury site, while recent approaches suggest that short immobilization reduces muscle atrophy, preserves range of motion (ROM), and improves functional recovery without increasing the risk of re-rupture[2].

The choice of immobilization time can influence residual muscle strength, proprioception, and timeline to return to functional activities. Prolonged immobilization is associated with adverse effects, including calf muscle weakness, shortening, and joint stiffness, which can compromise ankle biomechanics and increase the risk of further injury. Conversely, insufficient immobilization time may result in inadequate tendon healing and an increased risk of re-rupture. Given this scenario, a better understanding of the effects of immobilization time on the recovery of ankle function is required[3].

The objective of this study is to analyze the impact of immobilization time on the recovery of ankle function after Achilles tendon rupture, comparing different immobilization times in terms of muscle strength, ROM, proprioception, timeline to return to functional activities, and re-rupture rates. The findings may optimize rehabilitation protocols, helping to define the ideal immobilization time to maximize functional recovery and minimize associated complications.

Study performed at Hospital do Servidor Público Municipal de São Paulo, São Paulo, SP, Brazil.

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Methods

This integrative review synthesized evidence from different study designs to provide a comprehensive analysis of immobilization time and its impact on the recovery of ankle function after Achilles tendon rupture. The review was conducted in six stages: (1) problem identification; (2) definition of inclusion and exclusion criteria; (3) database search; (4) critical evaluation of methodological quality; (5) data analysis and synthesis; and (6) results presentation.

The question, formulated according to the PICO framework, was: What is the impact of immobilization time on the recovery of ankle function after Achilles Tendon rupture?

'Short immobilization' was defined as 0-2 weeks, and 'prolonged immobilization' as 4-6 weeks. Early functional rehabilitation protocols include, but are not limited to, short immobilization times and the early initiation of controlled exercises to regain mobility and strength, which differs from strategies that focus solely on reducing immobilization time.

Inclusion criteria were studies published between 2013 and 2023, in English, Portuguese, or Spanish, that evaluated the effect of immobilization time on recovery of ankle function after Achilles tendon rupture. Eligible designs included randomized clinical trials, cohort studies, systematic reviews, and meta-analyses. Exclusion criteria included opinion articles, case reports, narrative reviews without defined methodology, and studies lacking functional outcomes.

Searches were conducted in PubMed, Scopus, Web of Science, Embase, and the Cochrane Library databases, using both controlled and uncontrolled terms combined with Boolean operators (AND, OR). Main terms were: 'Achilles tendon rupture', 'ankle immobilization', 'functional recovery', 'early mobilization', 'rehabilitation', 'range of motion', 'muscle strength', and 're-rupture risk'.

Among the identified articles, 15 were screened based on title and abstract, 13 underwent full-text review, and only three strictly met the inclusion criteria, as described in Figure 1. Despite the small number, the selection prioritized methodological quality, assessed using the PEDro scale for randomized clinical trials, the Newcastle-Ottawa for observational studies, and the AMSTAR-2 checklist for systematic reviews. Although Mayer et al.[4] was included, despite methodological limitations, due to its unique focus on functional outcomes not addressed by the other articles.

The small sample size and methodological heterogeneity limit the generalizability of the results; however, the critical appraisal enables the identification of consistent trends and knowledge gaps that are essential for refining clinical protocols and guiding future research.

Results

Three studies met the inclusion criteria, evaluating the impact of immobilization time on recovery of ankle function after Achilles tendon rupture[4-6]. A retrospective study involving 266 patients divided into four immobilization groups (0, 2, 4, and 6 weeks) showed that shorter immobilization time (0-2 weeks) resulted in earlier return to light sports ($p < 0.001$), faster recovery of ROM, and improved single-leg jump performance, without significant differences in complication rates[5].

A meta-analysis of ten randomized controlled trials, including 570 patients, compared early functional rehabilitation to traditional plaster immobilization. Early functional rehabilitation was associated with a faster return to pre-injury sports levels in five of six studies, with higher patient satisfaction (OR = 3.13; 95% CI: 1.30-7.53; $p = 0.01$), and no significant increase in major complications ($p = 0.21$). Dynamometry and anthropometry measurements favored functional rehabilitation in the first 6-12 postoperative weeks; however, these differences became negligible by six months[6].

Mayer et al.[4] investigated muscle imbalances between the dorsiflexors and plantarflexors after conservative and accelerated treatment of Achilles tendon ruptures. Prolonged immobilization was associated with muscle loss, joint stiffness, and atrophy, while short mobilization preserved functional outcomes and mitigated these adverse effects.

Patients undergoing short immobilization time returned to light sports after a mean of 12 weeks, compared with 16 weeks in the prolonged immobilization ($p < 0.001$). ROM

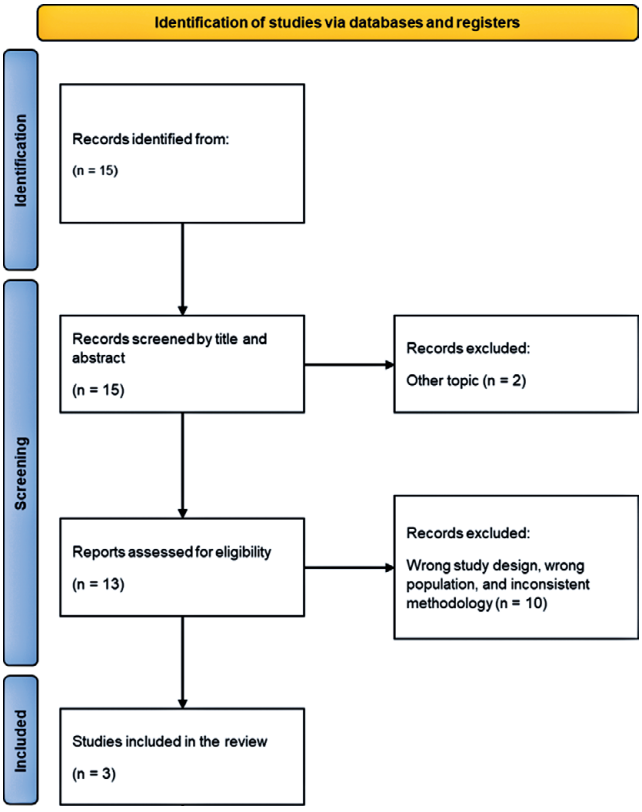

Figure 1. PRISMA flowchart.

recovery reached 90% of the contralateral side at eight weeks in short immobilization, compared to 12 weeks in prolonged immobilization ($p < 0.001$)[4-6].

Single-leg jump height reached 80% of the unaffected side at 14 weeks in the short immobilization groups, compared with 20 weeks in prolonged immobilization ($p < 0.001$). Patient satisfaction was also higher, with 85% rating the outcomes as good or excellent, compared with 70% in traditional immobilization (OR = 3.13; 95% CI: 1.30-7.53; $p = 0.01$)[4-6].

No significant difference was found in re-rupture rates among the groups ($p = 0.21$). After 12 months, patients undergoing early rehabilitation showed a 4.19% lower Limb Symmetry Index – Heel-Rise Work (LSI-HRW; $p = 0.041$). Complication rates, including superficial infections and deep vein thrombosis, were similar between protocols, with no statistically significant differences[4-6].

Mean scores on the American Orthopedic Foot and Ankle Society and Achilles tendon rupture scales were significantly higher in the short immobilization groups during the first 12 postoperative weeks ($p < 0.001$). No significant difference was found in return to work rates between the early functional rehabilitation and traditional immobilization groups ($p = 0.060$)[4-6].

No significant difference was found in the return to sports among the groups ($p = 0.306$). Dynamometry and anthropometry measurements favored functional rehabilitation in the first 6-12 postoperative weeks; however, these differences became negligible by six months. After 12 months, patients in early rehabilitation again showed a 4.19% lower LSI-HRW compared with traditional immobilization[4-6].

Discussion

The analysis showed that postoperative immobilization time has a significant impact on the recovery of ankle function after Achilles tendon rupture. Short immobilization was associated with a faster return to light sports (mean 12 vs. 16 weeks; $p < 0.001$), aligning with evidence that early functional rehabilitation improves mobility without compromising tendon healing[7-9].

The ROM was also more rapidly restored in short immobilization protocols, reaching 90% of the contralateral ROM at eight weeks, whereas in prolonged immobilization, it was observed only at 12 weeks ($p < 0.001$). Recent studies have shown that early mobilization promotes better restructuring of collagen fibers, contributing to the recovery of ankle function[10,11].

Muscle strength was significantly higher in the early functional rehabilitation groups. Single-leg jump height, an important indicator of muscle strength and coordination, reached 80% of the unaffected side in 14 weeks in the short immobilization groups, whereas in the prolonged immobilization groups, it took 20 weeks ($p < 0.001$). These findings are corroborated by studies that indicate that early use of the lower limb reduces the negative impact of muscle atrophy and improves biomechanical function[12,13].

Patient-reported outcomes were superior in the short rehabilitation group, with 85% of participants rating their results as good or excellent, compared to 70% in the prolonged immobilization group (OR = 3.13; 95% CI: 1.30-7.53; $p = 0.01$). These findings are consistent with the literature, which reports higher satisfaction and reduced psychological distress when early mobilization is employed[14].

One major concern regarding early mobilization is the risk of re-rupture; however, the included studies found no significant differences between short and prolonged immobilization ($p = 0.21$). These findings are consistent with meta-analytic evidence indicating that early functional rehabilitation does not increase re-rupture rates when applied properly. Likewise, complication rates, including superficial infections and deep vein thrombosis, were comparable across groups, supporting the safety of shorter immobilization protocols[15,16].

Long-term outcomes, including the LSI-HRW, showed that after 12 months, patients undergoing early rehabilitation had a 4.19% lower rate compared to prolonged immobilization ($p = 0.041$). These findings reinforce the effectiveness of early mobilization in preserving muscle function and preventing chronic sequelae[17].

Conclusion

The findings of this review reinforce the importance of early functional rehabilitation in ankle recovery after Achilles tendon rupture. The reduction in immobilization time, especially for periods of up to two weeks, is associated with a faster recovery of ROM, single-leg jump height, and muscle strength, in addition to providing greater patient satisfaction without increasing the risk of complications.

The analyzed literature suggests that more dynamic rehabilitation protocols, instead of prolonged immobilization, can optimize functional outcomes and accelerate the return to daily and sports activities. However, the choice of rehabilitation regimen should be individualized, considering factors such as age, pre-injury activity level, and associated comorbidities.

Although the results are promising, further studies are required with greater methodological rigor and long-term follow-up to validate the findings and establish more robust guidelines for managing Achilles tendon rupture. Thus, new research may contribute to a continuous refinement of rehabilitation protocols, ensuring better prognoses and quality of life for patients affected by this injury.

Authors' contributions: Each author contributed individually and significantly to the development of this article: YVF *(https://orcid.org/0009-0008-2541-8020) Conceived and planned the activities that led to the study, conducted the bibliographic review, formatted the article, participated in the review process, and approved the final version; JVGF *(https://orcid.org/0009-0003-6644-9281) Conceived and planned the activities that led to the study, interpreted the study results, participated in the review process, and approved the final version; VVSR *(https://orcid.org/0009-0001-0051-433); LSCS *(https://orcid.org/0009-0000-4450-6626) Contributed to the organization and analysis of data, assisted in writing and formatting the manuscript, participated in the review process, and approved the final version; data collection, statistical analysis. All authors read and approved the final manuscript. *ORCID (Open Researcher and Contributor ID).

References

1. Ganestam A, Kallemose T, Troelsen A, Barfod KW. Increasing incidence of acute Achilles tendon rupture and a noticeable decline in surgical treatment from 1994 to 2013: a nationwide registry study of 33,160 patients. Knee Surg Sports Traumatol Arthrosc. 2016;24(12):3730–7.
2. Seow D, Islam W, Randall GW, Azam MT, Duenes ML, Hui J, et al. Lower re-rupture rates but higher complication rates following surgical versus conservative treatment of acute Achilles tendon ruptures: a systematic review of overlapping meta-analyses. Knee Surg Sports Traumatol Arthrosc. 2023;31(10):3528–40.
3. Wu Y, Lin L, Li H, Zhao Y, Liu L, Jia Z, et al. Is surgical intervention more effective than non-surgical treatment for acute Achilles tendon rupture? A systematic review of overlapping meta-analyses. Int J Surg. 2016;36(Pt A):305–11.
4. Mayer A, Frasson VB, Ott R, Fortuna RO, Vaz MA. Desequilíbrios musculares entre flexores dorsais e plantares do tornozelo após tratamento conservador e acelerado da ruptura do tendão calcâneo. Fisioter Pesqui. 2010;17(2):108–13.
5. Liu X, Dai TJ, Li BL, Li C, Zheng ZY, Liu Y. Early functional rehabilitation compared with traditional immobilization for acute Achilles tendon ruptures: a meta-analysis. Bone Joint J. 2021;103-B(6):1021–30.
6. McCormack R, Bovard J. Early functional rehabilitation or cast immobilisation for the postoperative management of acute Achilles tendon rupture? A systematic review and meta-analysis of randomised controlled trials. Br J Sports Med. 2015;49(20):1329–35.
7. Wu Y, Mu Y, Yin L, Wang Z, Liu W, Wan H. Complications in the management of acute Achilles tendon rupture: a systematic review and network meta-analysis of 2060 patients. Am J Sports Med. 2019;47(9):2251–60.
8. Westin O, Nilsson Helander K, Grävare Silbernagel K, Samuelsson K, Brorsson A, Karlsson J. Patients with an Achilles tendon re-rupture have long-term functional deficits and worse patient-reported outcome than primary ruptures. Knee Surg Sports Traumatol Arthrosc. 2018;26(10):3063–72.
9. Lu J, Liang X, Ma Q. Early functional rehabilitation for acute Achilles tendon ruptures: an updated meta-analysis of randomized controlled trials. J Foot Ankle Surg. 2019;58(5):938–45.
10. De la Fuente C, Peña y Lillo R, Carreño G, Marambio H. Prospective randomized clinical trial of aggressive rehabilitation after acute Achilles tendon ruptures repaired with Dresden technique. Foot (Edinb). 2016;26:15–22.
11. Barfod KW, Nielsen F, Helander KN, Mattila VM, Tingby O, Boesen A, et al. Treatment of acute Achilles tendon rupture in Scandinavia does not adhere to evidence-based guidelines: a cross-sectional questionnaire-based study of 138 departments. J Foot Ankle Surg. 2013;52(5):629–33.
12. Manent A, López L, Corominas H, Santamaría A, Domínguez A, Llorens N, et al. Acute Achilles tendon ruptures: efficacy of conservative and surgical (percutaneous, open) treatment – a randomized, controlled, clinical trial. J Foot Ankle Surg. 2019;58(6):1229–34. Erratum in: J Foot Ankle Surg. 2020;59(4):874.
13. Gatz M, Driessen A, Eschweiler J, Tingart M, Migliorini F. Open versus minimally-invasive surgery for Achilles tendon rupture: a meta-analysis study. Arch Orthop Trauma Surg. 2021;141(3):383–401.
14. Zou J, Mo X, Shi Z, Li T, Xue J, Mei G, et al. A prospective study of platelet-rich plasma as biological augmentation for acute Achilles tendon rupture repair. Biomed Res Int. 2016;2016:9364170.
15. Sharaby MMF, Abouheif MM, El-Mowafi H. Prospective randomized controlled study on an innovative mini-open technique versus standard percutaneous technique to avoid sural nerve injury during acute Achilles tendon repair. Tech Foot Ankle Surg. 2021;20(2):57–63.
16. Myhrvold SB, Brouwer EF, Andresen TKM, Rydevik K, Amundsen M, Grün W, et al. Non-operative or surgical treatment of acute Achilles' tendon rupture. N Engl J Med. 2022;386(15):1409–20.
17. Park YH, Kim W, Choi JW, Kim HJ. Absorbable versus nonabsorbable sutures for the Krackow suture repair of acute Achilles tendon rupture: a prospective randomized controlled trial. Bone Joint J. 2022;104-B(7):938–45.

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Review

Comparison of Chevron and Scarf osteotomies in hallux valgus correction: Functional and radiographic outcomes

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Abstract

Objective: To compare the functional and radiographic outcomes between Chevron and Scarf osteotomies in hallux valgus correction.

Method: A systematic review was conducted in the PubMed/MEDLINE, SciELO, Lilacs, and Embase databases from 2004 to 2024. Inclusion criteria included clinical trials and observational studies that directly compared both techniques.

Results: Both osteotomies showed similar effectiveness in improving functional scores (AOFAS) and correcting hallux valgus and intermetatarsal valgus angles. Chevron osteotomy was more indicated in mild to moderate deformities, while Scarf osteotomy showed greater stability and versatility in severe deformities.

Conclusion: Both osteotomies are effective, with specific advantages. The surgical choice must be individualized.

Level of Evidence Level I; Systematic Review.

Keywords: Hallux valgus; Osteotomy; Orthopedic procedures; Radiography.

Introduction

Hallux valgus deformity is one of the most prevalent deformities of the forefoot, characterized by progressive lateral deviation of the hallux and medial prominence of the head of the first metatarsal[1]. This condition affects predominantly women, being associated with genetic factors, chronic use of inappropriate footwear, and biomechanical changes of the foot. Although the classical literature mentions conservative treatment as an initial approach, in specialized orthopedic practice, most symptomatic cases evolve directly to surgical, given the progressive nature of the deformity and the functional limitation. To date, more than one hundred osteotomy techniques have been described for hallux valgus correction, varying according to the degree of deformity and anatomical characteristics of the patient[2].

Among the most used techniques are distal Chevron osteotomy and Scarf diaphyseal osteotomy, both aiming to correct the intermetatarsal angle (IMA) and hallux valgus angle (HAV), in addition to restoring the biomechanical alignment of the first ray and improving clinical symptoms[3]. Chevron osteotomy, which is simpler to perform, is traditionally indicated for mild to moderate deformities, while Scarf osteotomy, which is more versatile and technically demanding, allows for greater angular correction and is often used in moderate to severe cases[4].

However, there is still controversy in the literature regarding the superiority of one technique over another in terms of clinical, functional, and radiographic outcomes. Comparative analysis between these surgical methods is fundamental to support clinical decision-making, improve therapeutic outcomes, and reduce complication rates or recurrences[5].

In this context, the objective of this study is to compare the functional and radiographic outcomes of Chevron and Scarf osteotomies in hallux valgus correction, to provide scientific support to guide the choice of the most appropriate procedure according to the degree of deformity and anatomical characteristics of the patient.

Study performed at Hospital Alvorada Moema, Sao Paulo, SP, Brazil.

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Methods

This systematic review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The research question was defined based on the acronym PICO, where: P (population) = patients with hallux valgus; I (intervention) = Chevron osteotomy; C (comparison) = Scarf osteotomy; and O (outcomes) = postoperative functional and radiographic results.

Search strategy

A systematic search was conducted in the PubMed/MEDLINE, Scopus, Web of Science, Embase, and Cochrane Library databases, including publications between January 2004 and December 2024. Controlled (MeSH) and uncontrolled descriptors were used, combined by Boolean operators, with the following strategy: ("Hallux Valgus" OR "Bunion") AND ("Chevron Osteotomy" OR "Distal Metatarsal Osteotomy") AND ("Scarf Osteotomy") AND ("Functional Outcome" OR "Radiographic Outcome").

Inclusion and exclusion criteria

Primary randomized controlled trials (RCTs), prospective and retrospective comparative studies, published in English, Portuguese, or Spanish, that directly compared Chevron and Scarf osteotomies in patients diagnosed with hallux valgus, presenting functional outcomes—such as the American Orthopaedic Foot & Ankle Society (AOFAS) score, Visual Analog Scale (VAS), and the 36-Item Short Form Health Survey (SF-36)—and/or radiographic outcomes, including the IMA, metatarsophalangeal angle (MPA), and distal metatarsal articular angle (DMAA), were included.

Studies were excluded if they did not directly compare the two osteotomy techniques, assessed only a single osteotomy in isolation, involved modified techniques lacking a standardized description, presented duplicate data, or were published as abstracts, letters to the editor, review articles, or studies involving animals.

Study selection and data extraction

Two independent reviewers screened titles and abstracts, followed by a full-text read of potentially eligible articles. Disagreements were resolved by consensus or by consultation with a third reviewer. The extracted data included: author, year of publication, type of study, sample characteristics, surgical technique used, follow-up time, functional assessment instruments, radiographic parameters, and main outcomes.

Methodological quality assessment

The quality of the included studies was assessed using the Cochrane Risk of Bias (RoB 2.0) tool for randomized clinical trials and the Newcastle-Ottawa Scale for observational studies.

Data synthesis

Data were organized in descriptive tables and qualitative analysis was performed, comparing the main functional and radiographic outcomes between the techniques. When applicable, the possibility of meta-analysis was considered, provided that the data presented statistical and methodological homogeneity.

Results

This systematic review included six comparative clinical studies, three randomized controlled trials (RCTs), and three retrospective studies, totaling 507 feet submitted to hallux valgus correction. Of these, 261 were operated using Chevron osteotomy and 246 the Scarf osteotomy[6-12]. The studies were mostly conducted in Europe and Asia, with a mean follow-up time ranging from 12 to 48 months. Most participants were women, aged between 36 and 55 years, reflecting the typical epidemiological profile of the deformity.

Regarding functional outcomes, there was a significant improvement in the postoperative scores of both groups, with a mean increase of more than 30 points in the AOFAS score. The meta-analysis demonstrated a weighted mean difference (WMD) of only 0.75 points between techniques (95% CI: -5.32 to 6.82; p = 0.81), indicating the absence of functional superiority of one technique over the other. Similar results were observed for the VAS for pain, with a mean reduction of more than 4 points in both groups. Patient satisfaction, evaluated in three studies, was high (> 85% satisfaction) regardless of the technique used[6,9-10].

In radiographic parameters, the HVA correction was slightly more effective with Chevron osteotomy, which presented a mean correction of 16.2° vs. 14.1° in Scarf osteotomy. This difference was statistically significant (WMD = -1.94°; 95% CI: -2.65 to -1.29; p < 0.00001). On the other hand, the IMA showed similar corrections between the groups, with a mean difference of -0.44° (95% CI: -1.10 to 0.22; p = 0.19), which is not statistically significant. The DMAA was also evaluated in four studies, and although both techniques promoted satisfactory correction, interindividual variations prevented robust statistical conclusions[6,8,11].

As for postoperative complications, the overall rate was low in both groups. There was no statistically significant difference in the total incidence of adverse events (RR = 1.22; 95% CI: 0.65 to 2.27; p = 0.53). The most frequent complications included superficial infection, residual pain, and intolerance to the synthetic material. Scarf osteotomy showed a slightly higher frequency of pain at the site in longer follow-ups, although without a relevant functional impact. None of the techniques presented cases of avascular necrosis or need for digital amputation. The reoperation rate was less than 2% in both groups[7,10,12].

It should be noted that the analysis could have been enhanced with the evaluation of the preoperative angles. The presence of higher angular values, indicative of more pronounced deformities, in cases treated with Scarf osteotomy

could possibly explain a lower functional or radiographic performance compared to Chevron osteotomy. In this sense, the absence of preoperative values may have biased the results, favoring the Chevron technique, often reserved for less severe deformities. This methodological limitation raises the need for a more careful analysis of the surgical indication criteria to avoid disproportionate comparisons between techniques applied to different severity profiles. Perhaps this reflection should be considered by the authors in future reviews or discussions on the data presented[6-12].

The analysis of the methodological quality of the studies, using the RoB 2.0 tool for RCTs and the Newcastle-Ottawa scale for observational studies, indicated a low risk of bias in most of the included publications. The consistency of findings and the statistical homogeneity across the analyzed studies strengthen the reliability and validity of the conclusions presented in this review.

Discussion

This systematic review demonstrated that both Chevron and Scarf osteotomy are effective techniques in hallux valgus correction, promoting significant functional and radiographic improvement. Several studies show that both techniques provide improvement in functional scores, such as AOFAS, without statistically significant differences between groups, as evidenced by Clemente et al.[13] and Ferreira et al.[14] in recent systematic reviews.

Radiographic analysis demonstrated a slight advantage of Chevron osteotomy in HVA correction, as reported by Ma et al.[4], whose meta-analysis indicated that this technique has greater angular correction capacity in mild to moderate deformities. This superiority may be related to the greater predictability of the Chevron technique and its direct effect on angular deformity, as also described by Kuliński et al.[15] in a comparative radiographic study.

On the other hand, Scarf osteotomy demonstrates relevant biomechanical advantages, such as greater contact surface between fragments, greater stability, and the possibility of multiplanar corrections, and is often indicated in moderate to severe deformities. Studies such as Ye et al.[16] and Castioni et al.[17] confirm their effectiveness in more complex cases, including a lower recurrence rate in the medium term. Even so, meta-analyses as of Peng et al.[5] indicate that, in the outcomes related to the IMA correction, there is no statistically significant difference between the techniques.

Regarding safety, both techniques presented similar results. The complication rate was low in all studies reviewed, the most frequent being residual pain and intolerance to the synthetic material. Torrent et al.[18] and Tay et al.[19], when analyzing minimally invasive variants of the techniques, also did not identify significant differences in the incidence of adverse events.

In this context, for those who consider that Scarf osteotomy is preferably applied to more intense and complex deformities, obtaining results comparable to those of Chevron osteotomy, both in terms of angular correction and complications, can be interpreted as a relevant clinical advantage. After all, achieving the same success rates with greater biomechanical and technical requirements may suggest Scarf's practical superiority in more complex scenarios.

The proposal to expand the indications for Chevron osteotomy to cases of moderate hallux valgus, as suggested by Lai et al.[1], should be interpreted with caution. Although the study indicates similar functional and radiographic results between the percutaneous Chevron technique and the open Scarf osteotomy in selected populations, this matching may not reflect the biomechanical complexity involved in moderate deformities. The attempt to extend the applicability of a technique originally indicated for mild deformities, without proper stratification of severity, may compromise the external validity of the results and lead to misinterpretations about the real effectiveness of the Chevron osteotomy in these cases. This evidence reinforces the importance of considering individual variables, such as the degree of deformity, the presence of joint changes, age, and functional demand.

On the other hand, Scarf osteotomy remains the preferred technique in more severe deformities, especially when there is a need for more complex corrections or the presence of significant biomechanical instability, as indicated by Kakwani et al.[20], who highlighted the feasibility of its application even in scenarios of high surgical complexity.

Ferreira et al.[14] and Tay et al.[19] demonstrated that the choice between the Chevron and Scarf osteotomies should consider objective anatomical and clinical criteria, especially the degree of deformity and the complexity of the necessary correction, in addition to the surgeon's familiarity with each procedure. Similarly, while the importance of postoperative follow-up and adherence to functional rehabilitation is well recognized in clinical practice, these factors were not systematically evaluated in the included studies, thereby limiting the ability to draw more definitive conclusions on their impact.

It is important to emphasize that, although the included studies present good methodological quality, limitations such as heterogeneity in the selection criteria, variations in follow-up times, and absence of blinding in some trials should be considered in the interpretation of the findings. Future investigations with robust methodology, larger sample, and long-term evaluation are essential to consolidate current evidence and guide more accurate conduct[21].

Conclusion

The comparison between Chevron and Scarf osteotomies in hallux valgus correction showed that both techniques are effective in improving functional and radiographic outcomes, promoting pain relief, structural realignment, and recovery of foot function, although they have been applied in deformities of different severity. Chevron osteotomy showed satisfactory performance in cases of mild to moderate deformities, with shorter surgical time and less complex surgical technique.

Scarf osteotomy, in turn, was mainly used in more severe deformities and is considered technically more demanding. Its apparent advantages, greater versatility, mechanical stability, and multiplanar correction capability, should be interpreted with caution, as direct comparisons between techniques applied to deformities of differing severity may limit the validity of such conclusions.

Although the analyzed studies do not show clear superiority between the techniques regarding the postoperative function or the magnitude of the angular correction, this equivalence raises questions. If both techniques promote similar angular corrections, the Chevron osteotomy, often applied in less severe cases, may, in practice, demonstrate greater relative effectiveness. On the other hand, Scarf osteotomy, used in more severe deformities, starts from a more challenging point of correction. The comparative analysis of the absolute postoperative angles between the groups could better clarify this issue and provide more robust subsidies for the individualized surgical choice, considering the severity of the deformity, the anatomical characteristics of the patient, and the experience of the surgeon.

Thus, both osteotomies remain viable and effective options for the surgical treatment of hallux valgus, and it is up to the surgeon to choose the most appropriate technique based on specific clinical criteria, such as the degree of deformity, anatomical characteristics of the foot, and the surgical complexity involved. New randomized clinical trials with greater methodological reliability and validity, and prolonged follow-up are recommended to improve surgical decision-making and therapeutic protocols.

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References

1. Lai MC, Rikhraj IS, Woo YL, Yeo W, Ng YCS, Koo K. Clinical and radiological outcomes comparing percutaneous chevron-Akin osteotomies vs open scarf-Akin osteotomies for hallux valgus. Foot Ankle Int. 2018;39(3):311-7.
2. Smith SE, Landorf KB, Butterworth PA, Menz HB. Scarf versus chevron osteotomy for the correction of 1–2 intermetatarsal angle in hallux valgus: a systematic review and meta-analysis. J Foot Ankle Surg. 2012;51(4):437-44.
3. Jeuken RM, Schotanus MG, Kort NP, Deenik A, Jong B, Hendrickx RP. Long-term follow-up of a randomized controlled trial comparing scarf to chevron osteotomy in hallux valgus correction. Foot Ankle Int. 2016;37(7):687-95.
4. Ma Q, Liang X, Lu J. Chevron osteotomy versus scarf osteotomy for hallux valgus correction: a meta-analysis. Foot Ankle Surg. 2019;25(6):755-60.
5. Peng YN, Peng YH, Chen CP. Chevron osteotomy and scarf osteotomy for hallux valgus angle and intermetatarsal angle correction: a systematic review and meta-analysis of randomized controlled trials. J Orthop Surg Res. 2024;19(1):566.
6. Deenik AR, Pilot P, Brandt SE, van Mameren H, Geesink RGT. Scarf Versus Chevron Osteotomy in Hallux Valgus: a Randomized Controlled Trial in 96 patients. Foot Ankle Int. 2007;28(5):537-41.
7. Mahadevan D, Lines S, Hepple S, Winson I, Harries W. Extended plantar limb (modified) chevron osteotomy versus scarf osteotomy for hallux valgus correction: a randomized controlled trial. Foot Ankle Surg. 2016;22(2):109-13.
8. Deenik A, van Mameren H, de Visser E, de Waal Malefijt M, Draijer F, de Bie R. Equivalent correction in Scarf and Chevron Osteotomy in moderate and severe Hallux Valgus: a Randomized Controlled Trial. Foot Ankle Int. 2008;29(12):1209-15.
9. Lee M, Walsh J, Smith MM, Ling J, Wines A, Lam P. Hallux valgus correction comparing percutaneous chevron/Akin (PECA) and open scarf/Akin osteotomies. Foot Ankle Int. 2017;38(8):838-46.
10. Jeuken RM, Schotanus MG, Kort NP, Deenik A, Jong B, Hendrickx RP. Long-term follow-up of a Randomized Controlled Trial comparing scarf to Chevron Osteotomy in Hallux Valgus correction. Foot Ankle Int. 2016;37(7):687-95.
11. Elshazly O, Abdel Rahman AF, Fahmy H, Sobhy MH, Abdelhadi W. Scarf versus long chevron osteotomies for the treatment of hallux valgus: a prospective randomized controlled study. Foot Ankle Surg. 2019;25(4):469-77.
12. Bia A, Guerra-Pinto F, Pereira BS, Corte-Real N, Oliva XM. Percutaneous osteotomies in hallux valgus: a systematic review. J Foot Ankle Surg. 2018;57(1):123-30.
13. Clemente P, Mariscal G, Barrios C. Distal chevron osteotomy versus different operative procedures for hallux valgus correction: a meta-analysis. J Orthop Surg Res. 2022;17(1):80.
14. Ferreira GF, Borges VQ, Moraes LVM, Stéfani KC. Percutaneous Chevron/Akin (PECA) versus open scarf/Akin (SA) osteotomy treatment for hallux valgus: a systematic review and meta-analysis. PLoS One. 2021;16(2):e0242496.
15. Kuliński P, Tomczyk Ł, Pawik Ł, Olech J, Morasiewicz P. Radiographic

outcomes of hallux valgus deformity correction with chevron and scarf osteotomies. J Foot Ankle Surg. 2023;62(4):676-82.

16. Ye W, Liu Y, Liu W, Li X, Fei Y, Gao X. Comparison of the clinical outcomes of scarf and chevron osteotomy for hallux valgus deformity: a meta-analysis of randomized controlled trials. J Orthop Surg Res. 2019;14(1):66. Preprint: https://doi.org/10.21203/rs.2.16117/v1
17. Castioni D, Fanelli D, Gasparini G, Iannò B, Galasso O. Scarf osteotomy for the treatment of moderate to severe hallux valgus: analysis of predictors for midterm outcomes and recurrence. Foot Ankle Surg. 2020;26(4):439-44.
18. Torrent J, Baduell A, Vega J, Malagelada F, Luna R, Rabat E. Open vs minimally invasive scarf osteotomy for hallux valgus correction: a randomized controlled trial. Foot Ankle Int. 2021;42(8):982-93.
19. Tay AYW, Goh GS, Koo K, Yeo NEM. Third-generation minimally invasive chevron-Akin osteotomy for hallux valgus produces similar clinical and radiological outcomes as scarf-Akin osteotomy at 2 years: a matched cohort study. Foot Ankle Int. 2022;43(3):321-30.
20. Kakwani R, Hutt N, Townshend D, Murty A, Kakwani M, Pujol A, et al. Feasibility Study for COSMIC Study - Comparing Open SCARF Osteotomy and Minimally Invasive Chevron Osteotomy for Hallux Valgus Correction. Foot Ankle Orthop. 2024;9(4):2473011424S00288.
21. Fukushi JI, Tanaka H, Nishiyama T, Hirao M, Kubota M, Kakihana M, et al. Comparison of outcomes of different osteotomy sites for hallux valgus: a systematic review and meta-analysis. J Orthop Surg (Hong Kong). 2022;30(2):10225536221110473.

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Review

Return to sport after hallux valgus surgery in athletes: Current evidence

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Abstract

Objective: To present evidence regarding the different surgical techniques for hallux valgus and their impact on return to sports.

Methods: A search was conducted in PubMed, Embase, MEDLINE, and Google Scholar databases. The inclusion criteria were articles involving case series published in English from 1995 through January 2025. The exclusion criteria were articles addressing hallux rigidus, traumatic deformity, sesamoid pathology, and review articles. Studies that did not describe the athlete's level of play and the type of sport were also excluded.

Results: Eight studies on the surgical correction of hallux valgus in "athletes" published to date were identified. Current evidence supports Chevron osteotomy for mild to moderate deformities and Scarf osteotomy for moderate to severe deformities, both resulting in low recovery time. Metatarsophalangeal arthrodesis has demonstrated up to 96% patient satisfaction in sport-related activities.

Conclusion: Chevron and scarf osteotomies are effective surgeries for athletes with minor deformities. For severe hallux valgus, there is no clear consensus, but metatarsophalangeal arthrodesis appears to demonstrate a good result. Further studies are required to document activity levels and return to sport to help guide treatment.

Level of evidence I; Systematic Review.

Keywords: Athletes; Return to sport; Hallux valgus; Patient satisfaction.

Introduction

Hallux valgus (HV) is a common deformity that affects up to one-third of the population and is typically asymptomatic[1]. It occurs more frequently in women, especially following the introduction of high heels and pointed-toed shoes in the 1950s[1].

This condition is characterized by a multiaxial deformity in which the first metatarsal is in varus, the hallux is in valgus, and the first ray is in pronation. This deformity makes the medial region of the forefoot more prominent, which can lead to pain, particularly when wearing tight-fitting shoes. In addition, hallux valgus compromises first ray function, disrupts the gait pattern, and alters plantar pressure during different stages of walking[2].

Initial management typically involves the use of wide, firm-soled footwear. Although toe separators and various orthoses have been described, they have shown limited success. When conservative management fails, surgical intervention is considered. The literature reports over 100 surgical techniques, each with varying results[2].

Athletes are not exempt from this condition, with a higher prevalence in women. Hallux valgus in athletes can manifest as simple pain while wearing running shoes, a loss of strength during propulsion, transfer injuries, or even a decrease in overall athletic performance. Although repetitive trauma is considered a contributing factor, its exact impact remains unclear[3,4].

Currently, there are few targeted studies in the literature that address the return to sport following hallux valgus surgery. The objective of this review is to present evidence regarding the different surgical techniques for hallux valgus and their impact on return to sports.

Study performed at the Clínica Alemana, Santiago, Chile.

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Biomechanics of the first ray in sports and hallux valgus

The first ray bears approximately 30% of the load in the stance phase; therefore, a dysfunctional first ray, whether due to hallux valgus or another pathology, leads to a global foot malfunction, resulting in various conditions[5].

During running and jumping activities, the force on the first metatarsophalangeal (MTP) joint can reach up to 400% of body weight, in contrast to normal walking, where the force is around 80%[6-8]. For this reason, it is crucial to maintain a healthy and congruent MTP joint.

It is well-documented that in patients with hallux valgus, pressure in the forefoot is shifted from the first ray to the central rays[9,10]. After corrective surgery, the loads should theoretically normalize or eventually return to the first ray. However, studies are inconsistent due to small sample sizes and varying techniques.

Considering this, Wong et al.[11] conducted a systematic review in 2023, including studies with pre- and post-surgical podographic analyses. They analyzed 26 studies involving 857 operated hallux valgus cases. Overall, the results showed that a postoperative decrease in hallux plantar pressure, suggesting a tendency for increased transfer metatarsalgia. The study heterogeneity and the techniques used are reported as a significant limitation. These findings contradict expected outcomes; therefore, no adequate conclusions can be drawn.

Surgical intervention for hallux valgus in athletes

As previously stated, multiple surgical options are available for the treatment of HV. Currently, there is no consensus on which procedure is optimal for athletes. Surgical approaches are often similar to those used in non-athletic patients, intending to achieve the same goals: correcting the MTP angle, restoring joint congruence, and positioning the metatarsal head above the sesamoid complex. In cases of mild hallux valgus, distal osteotomies are preferred, whereas proximal osteotomies are favored for moderate hallux valgus due to their greater corrective potential. In athletes, it is also crucial to consider functionality, as the required range of motion varies depending on the sport. One of the most debated issues among surgeons is MTP arthrodesis, as it induces joint stiffness, which may adversely affect athletic performance[12].

The definition of 'athlete' in the published literature is highly variable. This distinction is significant, as the expectations regarding surgery and outcomes can differ significantly between high-performance and amateur athletes.

Methods

A literature review was conducted by two researchers, primarily in the MEDLINE, PubMed, Embase, Google Scholar, and Scopus databases to search for the following terms: "hallux valgus," "bunion," "athlete," "surgery," "sport," and "physical activities." Several searches were performed using combinations of the terms, such as "hallux valgus", "athlete", "surgery and bunion," and "sports." Twenty-six articles were found; eight met the inclusion and exclusion criteria. The inclusion criteria were articles involving case series published in English from 1995 through January 2025. Exclusion criteria were articles addressing hallux rigidus, traumatic deformity, sesamoid pathology, and review articles. Studies that did not describe the athlete's level of play and the type of sport were also excluded. Figure 1 shows the flowchart of the search.

They were further divided into categories: distal osteotomies, proximal osteotomies, MTP, and tarsometatarsal arthrodesis. The outcomes of the procedures were carefully reviewed by the authors. The eight included studies are summarized in Table 1. The objective of gathering this information was to describe the findings in the selected prior publications in a narrative fashion with an emphasis on the different surgical techniques.

Results

Distal osteotomies

Within this category, all papers involving the use of any distal osteotomy were reviewed. The most common technique reported in the literature is Chevron osteotomy, followed by Scarf osteotomy. The Chevron osteotomy offers several advantages, including an inherently stable bone cut that facilitates an early return to daily activities.

Giotis et al.[13] describe a case series including 33 patients (42 feet) with mild to moderate hallux valgus surgically treated using Chevron and Akin osteotomies. Outcomes were evaluated using the American Orthopaedic Foot and Ankle Society (AOFAS) score, pain levels, cosmetic results, and mobility. The AOFAS score improved from a baseline mean of 47 points to 96 points. Range of motion did not vary significantly, 90% reported no pain, and 95% of cases rated the cosmetic outcome as excellent. All athletes returned to their sport within 12 weeks postoperatively and regained their preoperative performance level within six months.

Saxena et al.[14] define athletes as individuals participating in sports for at least six hours per week, including school-selected, university-level, or those running at least 25 miles per week. Patients returned to non-competitive sports within a mean of 8.9 weeks. However, the study did not specify findings regarding competitive sports. The authors conclude that the procedure is straightforward and reproducible; although it may lead to shortening of the first ray.

Regarding the Scarf technique, Ciechanowicz et al.[15] analyzed 79 patients with a mean age of 55 years over a three-year follow-up. Sixty-seven percent of the patients maintained their sports level, and 24% reported an improvement. The sports evaluated included running, functional training, skiing, and volleyball. The mean return to sports after surgery was approximately 15 weeks.

Proximal osteotomies

In general, proximal osteotomy is considered for moderate to severe hallux valgus. The reason is based on that "the

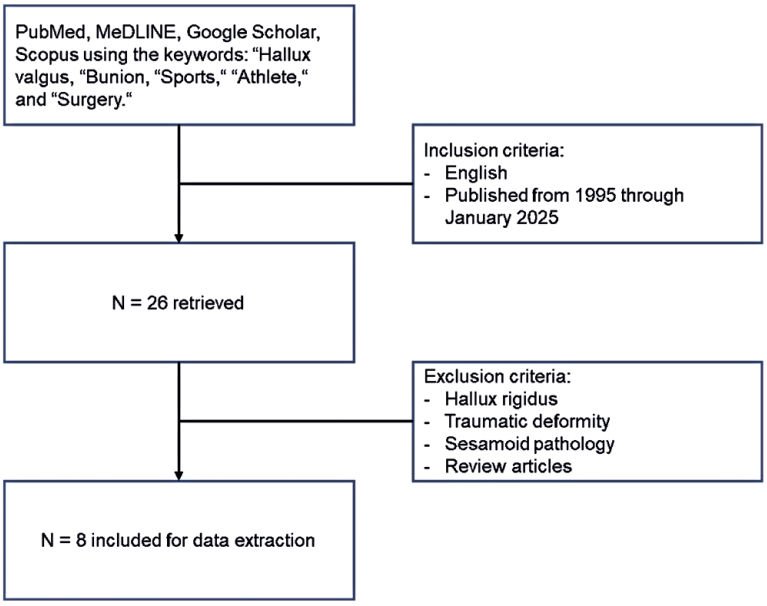

Figure 1. Flowchart of the review.

Table 1. Summary of evidence

Study	Procedure	Design	Patients	Follow-up	Results
Giotis et al. (2016)	Chevron	Prospective	33 (42 feet)	32 months	40/42 pain free
Saxena (2000)	Ludloff	Retrospective	12 (14 feet)	48 months	Return to sport 8.9 weeks*
Ciechanowicz et al. (2020)	Scarf	Retrospective	79	36 months	67% RTS and 24% increase of sport level
Saxena and St Louis (2013)	Ludloff	Prospective	112 (119 feet)	75 months	100% RTS
Macmahon et al. (2016)	Lapidus	Retrospective	48	2.8 years	80% RTS
McInnes and Bouché (2001)	Lapidus	Retrospective	25 (32 feet)	39 months	30% RTS
Da Cunha et al. (2019)	MTP arthrodesis	Prospective	50	5,1 years	96% RTS
Thong et al. (2024)	MTP arthrodesis	Retrospective	58	5,3 years	From 4.26 to 5.29 hours weekly

MTP: Metatarsophalangeal; RTS: return to sport. * It does not specify the sport level, only return to sport.

closer the osteotomy is to the base of the first metatarsal, the greater the lever arm and power of correction." Furthermore, proximal osteotomies facilitate sagittal plane correction; however, they are typically less stable than distal techniques. The Ludloff osteotomy is among the classical approaches in this category. To date, there are no studies demonstrating outcomes regarding sports reintegration related to these procedures; only an older study by Saxena et al (1997)[16], which assessed 12 patients (14 feet) treated with the Ludloff technique. Early weight-bearing was allowed at 3 weeks postoperatively, resulting in a mean return to sports at 3.6 months. All participants successfully resumed their sporting activities.

Tarsometatarsal arthrodesis

Among the procedures in this subgroup, the Lapidus technique is the most classically described, which entails arthrodesis of the first metatarsal with a medial wedge. This procedure allows for correction of deformities in the sagittal, coronal, and even rotational planes. Technically, it is more demanding since it requires simultaneous control of three planes and can result in shortening of the first ray.

McMahon et al.[17] demonstrated that the modified Lapidus technique—excluding arthrodesis between the base of the second to the first metatarsal—is a viable option for athletic patients. In their retrospective study with a mean follow-up of 2.8 years, 48 athletes with first ray hypermobility were evaluated. Overall, 81% of patients were satisfied with the surgery, and 80% managed to return to their previous sport. Two self-administered postoperative questionnaires were evaluated: the Foot and Ankle Outcome Score (FAOS) and a self-reported sports questionnaire. A total of 15% of complications were reported, ranging from hematomas to transfer metatarsalgia. Another study by McInnes and Bouché in 2001[18] assessed Lapidus surgery in 25 athletes

with a follow-up of 39 months. In contrast to the McMahon et al. study, only 30% returned to their previous sport, with a higher complication rate.

Metatarsophalangeal arthrodesis

Metatarsophalangeal arthrodesis has been employed for many years to treat severe hallux valgus, especially when associated with degenerative changes. The fusion of the first metatarsal with the proximal phalanx allows for significant corrections; however, the major drawback is the loss of joint motion, resulting in rigidity. Consequently, its use in athletes remains controversial.

Brodsky et al.[19] observed the effects of MTP joint arthrodesis on gait. Gait analysis was performed in 23 patients with a mean age of 58.0 ± 9.5 years preoperatively and at least one year postoperatively. The results showed increased maximum ankle propulsion power and single-limb stance time in the operated limb, along with a decrease in stride length, concluding that MTP joint arthrodesis leads to objective improvements in propulsion power, foot weight-bearing capacity, and gait stability.

Da Cunha et al.[20] conducted a prospective study with 50 patients, with a mean follow-up of 5.1 years. The patients participated in 22 different sports (one in three engaged in more than 10 hours per week) and underwent surgery at a mean age of 49 years. Sports included swimming, running, cycling, and trekking. Forty-four percent managed to return to their sport six months postoperatively, achieving peak performance between nine to 12 months. Additionally, 96% of patients reported satisfaction with the surgery outcome regarding their return to sports.

Thong et al.[21] assessed 58 patients with a mean age of 54 years (ranging from 18 to 59 years) with a follow-up of 5.3 years. Weekly sports activity increased from 4.26 to 5.29 hours postoperatively, with 52% participating in high-intensity sports such as tennis, running, triathlon, basketball, and soccer, without any change in sports intensity.

Discussion

The most appropriate surgery for hallux valgus for athletes remains unknown. The current evidence is limited, and studies that cover different registration systems and sports are not comparable. Furthermore, all surgical techniques appear to affect foot biomechanics. Therefore, it is not possible to provide a definitive recommendation on which surgery to perform for each athlete.

It is noteworthy that most studies on hallux valgus report "return to activities" using various scoring systems; however, they are quite ambiguous regarding the specific sport, lacking detailed records, which immediately disqualifies most studies for this review.

One of the most extensively analyzed studies was conducted by Da Cunha et al[20]. They conducted a long-term follow-up and applied standardized and validated scales such as the FAOS, analyzing different sports disciplines. A noted limitation of the study is that although it separates sports into high and low intensity, it does not account for high-performance or professional athletes.

Regardless of the surgical technique chosen, it is recommended to implement some physical activities, such as low-impact sports, during early rehabilitation to avoid complications such as muscle atrophy and stiffness, among others. Impact activities may be reintroduced once radiographic evidence of consolidation is confirmed.

One of the limitations of our study is the narrative review design, as no meta-analysis was conducted, which would have been ideal to strengthen the conclusions; however, current limited evidence precludes such an analysis. Additionally, there is a lack of consistent definitions regarding athlete classification, particularly the distinction between amateur and high-performance athletes.

Despite these limitations, we believe that return to sport outcome should be considered in future prospective studies. It is important to specify results by type of sport, given that the physical demands differ significantly. It appears reasonable to hypothesize that if osteotomies can be performed without sacrificing joints, they should be the first option in sports requiring preserved ankle and foot mobility.

On the other hand, with the growing trend of minimally invasive surgery, which theoretically should have accelerated recovery times and less pain, such procedures should be considered as a treatment alternative for athletes. Currently, a directed review of studies published up to 2024 reports multiple scores such as MOXFQ and EQ-5D; however, they do not report on sports reintegration or return to play[22-25].

Conclusion

Athletes are equally susceptible to hallux valgus as the sedentary population; however, the treatment approach must be different. A tailored assessment that considers the patient's functional demands and expectations is essential to guide optimal surgical decision-making. Chevron and scarf osteotomies are effective surgeries for athletes with minor deformities, leading to relatively early return to sports and low complication rates. For severe hallux valgus, there is no clear consensus, but metatarsophalangeal arthrodesis appears to demonstrate a good sports reintegration rate without function alteration, despite evident biomechanical alterations. Further studies regarding hallux valgus and athletes are required, especially in minimally invasive surgery and a proper definition of "athlete".

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References

1. Coughlin MJ, Jones CP. Hallux valgus: demographics, etiology, and radiographic assessment. Foot Ankle Int. 2007;28(7):759-77.
2. Hecht PJ, Lin TJ. Hallux valgus. Med Clin North Am. 2014;98(2): 227-32.
3. Baxter DE. Treatment of bunion deformity in the athlete. Orthop Clin North Am. 1994;25(1):33-9.
4. Hockenbury RT. Forefoot problems in athletes. Med Sci Sports Exerc. 1999;31(7 Suppl):S448-58.
5. Suárez EM. Kinematic and kinetic analysis of human gait. Rev Pie Tobillo. 2003;17(1):29-37.
6. Kennedy JG, Collumbier JA. Bunions in dancers. Clin Sports Med. 2008;27(2):321-8.
7. Mann R. Bunion deformity in the elite athlete. In: Porter DA, Schon LC, eds. Baxter's. The Foot and Ankle in Sports. 2nd ed, Mosby Elsevier Wilkins, Philadelphia, PA. 1994:435-43.
8. Saxena A, McCammon D. The Ludloff osteotomy: a critical analysis. J Foot Ankle Surg. 1997;36(2):100-5; discussion 159-60.
9. Hofmann UK, Götze M, Wiesenreiter K, Müller O, Wünschel M, Mittag F. Transfer of plantar pressure from the medial to the central forefoot in patients with hallux valgus. BMC Musculoskelet Disord. 2019;20(1):149.
10. Galica AM, Hagedorn TJ, Dufour AB, Riskowski JL, Hillstrom HJ, Casey VA, Hannan MT. Hallux valgus and plantar pressure loading: the Framingham foot study. J Foot Ankle Res. 2013;6(1):42.
11. Wong DW, Cheung JC, Zhao JG, Ni M, Yang ZY. Forefoot Function after Hallux Valgus Surgery: A Systematic Review and Meta-Analysis on Plantar Load Measurement. J Clin Med. 2023; 12(4):1384.
12. Fournier M, Saxena A, Maffulli N. Hallux Valgus Surgery in the Athlete: Current Evidence. J Foot Ankle Surg. 2019;58(4):641-3.
13. Giotis D, Paschos NK, Zampeli F, Giannoulis D, Gantsos A, Mantellos G. Modified Chevron osteotomy for hallux valgus deformity in female athletes. A 2-year follow-up study. Foot Ankle Surg. 2016;22(3):181-5.
14. Saxena A. Return to athletic activity after foot and ankle surgery: a preliminary report on select procedures. J Foot Ankle Surg. 2000;39(2):114-9.
15. Ciechanowicz D, Kozłowski J, Kołodziej Ł, Kromuszczyńska J. Return to Physical Activities after Scarf Osteotomy for Hallux Valgus. Ortop Traumatol Rehabil. 2020;22(2):95-106.
16. Saxena A, St Louis M. Medial locking plate versus screw fixation for fixation of the Ludloff osteotomy. J Foot Ankle Surg. 2013; 52(2):153-7.
17. MacMahon A, Karbassi J, Burket JC, Elliott AJ, Levine DS, Roberts MM, et al. Return to Sports and Physical Activities After the Modified Lapidus Procedure for Hallux Valgus in Young Patients. Foot Ankle Int. 2016;37(4):378-85.
18. McInnes BD, Bouché RT. Critical evaluation of the modified Lapidus procedure. J Foot Ankle Surg. 2001;40(2):71-90.
19. Brodsky JW, Baum BS, Pollo FE, Mehta H. Prospective gait analysis in patients with first metatarsophalangeal joint arthrodesis for hallux rigidus. Foot Ankle Int. 2007;28(2):162-5.
20. Da Cunha RJ, MacMahon A, Jones MT, Savenkov A, Deland J, Roberts M, et al. Return to Sports and Physical Activities After First Metatarsophalangeal Joint Arthrodesis in Young Patients. Foot Ankle Int. 2019;40(7):745-52.
21. Thong YJ, Davies BM, Bedi H. Return to activities in younger individuals (<60 yrs) undergoing first metatarsophalangeal joint arthrodesis. J Foot Ankle Surg. 2025;64(2):192-6.
22. Lewis TL, Robinson PW, Ray R, Dearden PMC, Goff TAJ, Watt C, et al. Five-Year Follow-up of Third-Generation Percutaneous Chevron and Akin Osteotomies (PECA) for Hallux Valgus. Foot Ankle Int. 2023 Feb;44(2):104-17.
23. Lewis TL, Lau B, Alkhalfan Y, Trowbridge S, Gordon D, Vernois J, et al. Fourth-Generation Minimally Invasive Hallux Valgus Surgery With Metaphyseal Extra-Articular Transverse and Akin Osteotomy (META): 12 Month Clinical and Radiologic Results. Foot Ankle Int. 2023;44(3):178-91.
24. Lewis TL, Ray R, Gordon DJ. Minimally invasive surgery for severe hallux valgus in 106 feet. Foot Ankle Surg. 2022;28(4):503-9.
25. Lewis TL, Ray R, Miller G, Gordon DJ. Third-Generation Minimally Invasive Chevron and Akin Osteotomies (MICA) in Hallux Valgus Surgery: Two-Year Follow-up of 292 Cases. J Bone Joint Surg Am. 2021;103(13):1203-11.

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Review

Lymphedema and lower limb edema: what do foot and ankle orthopedists need to know? A narrative review

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Abstract

Objective: To review in the literature updates on lymphedema and differential diagnoses of lower limb edema for foot and ankle orthopedists.

Methods: This is a narrative review, and the search was conducted on the PubMed and SciELO databases, using established keywords. Articles published in the last 15 years were included. The research question was "What do foot and ankle orthopedists need to know about lymphedema and lower limb edema?"

Results: Lymphedema is one of the causes of chronic lower limb edema, characterized by excessive lymphatic fluid in the interstitial medium due to impaired lymphatic drainage. It can be classified as primary or secondary lymphedema, with trauma being one of the most important etiologies of the latter. The diagnosis of this condition is primarily clinical, typically established through a thorough medical history and physical examination. Complementary examinations can evaluate indirect signs of lymphedema or direct signs of lymphatic dysfunction through lymphoscintigraphy. The differential diagnosis of chronic lower limb edema is challenging, and venous, cardiac, and traumatic etiologies, as well as lipedema, should be considered.

Conclusion: A thorough clinical examination, combined with appropriately indicated diagnostic tests such as lymphoscintigraphy, is essential for the differential diagnosis of chronic lower limb edema—a common finding in orthopedic clinical practice.

Level of Evidence V; Narrative review.

Keywords: Lymphedema; Diagnosis; Diagnosis, differential; Foot; Ankle.

Introduction

Chronic edema is defined as swelling that persists for more than three months and involves one or more of limbs, hands or feet, upper body (chest/chest wall, shoulders, and back), lower body (buttocks and abdomen), genitals (scrotum, penis and vulva), head, neck or face[1,2]. The body area most affected is the lower limbs, whose edema is observed in 96.4% of the population studied[1,3].

Lymphedema is an often underdiagnosed and neglected condition. Chronic lower limb edema should be carefully investigated, regarding the duration of the condition (acute or chronic), unilateral or bilateral involvement, and the presence of associated symptoms, such as skin changes and pain—symptoms that foot and ankle specialists encounter in daily practice. In this context, the diagnostic approach relies on an adequate clinical examination and, sometimes, on informative complementary examinations[4].

Given the high prevalence of chronic edema reported by patients in daily foot and ankle orthopedists' practice, the objective of this narrative review is to search the literature for updates on lymphedema and differential diagnoses of lower limb edema.

Methods

This study was based on the fundamental steps for conducting a narrative review. The literature search was performed between October 2024 and March 2025 on the PubMed and Scielo electronic databases, including articles

Study performed at Universidade Federal de Alfenas, Faculdade de Medicina, Alfenas, MG, Brazil.

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published in the last 15 years. The terms used in the DeCS/MeSH in Portuguese and English were: Linfedema (Lymphedema), Pé (Foot), Tornozelo (Ankle), Membros Inferiores (Lower limbs) Diagnóstico (Diagnosis), Diagnóstico Diferencial (Differential Diagnosis), Epidemiologia (Epidemiology) e Patologia (Pathology). The Boolean operators AND and OR were used. The studies were selected in a non-systematic manner based on the critical analysis of the authors, and those articles that contributed meaningfully to addressing the research question were selected: "What do foot and ankle orthopedists need to know about lymphedema and lower limb edema?". The most recent publications with the highest level of evidence were prioritized.

Results and discussion

Twenty-six articles met the established inclusion criteria and were included in the review.

Definition

Lymphedema is the manifestation of edema in one or more segments of the body caused by excessive lymphatic fluid in the interstitial medium due to impaired lymphatic drainage[5]. In addition to lymphatic impairment, notable features include the involvement of inflammatory factors, deposition of fibroadipose tissue, and expansion of adipose tissue[6]. In most cases, lymphedema is a chronic condition that worsens without treatment, predisposes patients to infections, and negatively affects the patient's quality of life[5].

When this condition results from congenital abnormalities in the structural or functional development of the lymphatic system, it is classified as primary lymphedema. In contrast, when it arises secondary to trauma, obstruction, infection, or any other form of injury to the lymphatic system, it is defined as secondary lymphedema[7].

Etiology

Primary lymphedema

Primary lymphedema is due to mutations in several genes involved in the initial formation of lymphatic vessels, their growth, and development. This form of lymphedema may be present from birth or develop later in life[5].

To date, mutations in 28 genes have been identified as causally linked to primary lymphedema. However, these genetic alterations are found in fewer than 30% of cases. Most of the implicated mutations affect genes encoding proteins involved in the lymphatic vascular development pathway, for example, vascular endothelial growth factor C (VEGF-C) or vascular endothelial growth factor receptor 3 (VEGFR-3)[8].

Secondary lymphedema

In developed countries, the main precipitating factors of lymphedema are related to lymphadenectomy and radiotherapy for cancer treatment[9]. In developing countries, lymphatic system infections, such as filariasis, are the most prevalent etiologies of lymphedema[7].

In filariasis, infection by the larvae *Wuchereria bancrofti*, *Brugia malayi,* and *Brugia timori* occurs through the bite of a female mosquito. Once the larvae reach the regional lymphatic vessels, they act both directly and via secreted products, leading to the destruction of lymphatic tissues and unidirectional valves. This results in impaired contractility and dilation of the lymphatic vessels[10].

Trauma is another important cause of secondary lymphedema. The energy involved in orthopedic trauma, which causes bone and soft tissue injuries, is responsible for damaging the lymphatic pathways and promoting chronic lymphedema. The severity of lymphedema is directly related to the extent of lymphatic system damage, which generates activation of the inflammatory cascade, infiltration of immune cells, fibrosis, and accumulation of adipose tissue. On the other hand, the presence of lymphedema in traumatized extremities can delay wound and fracture healing. Thus, the diagnosis of lymphedema, whether coexisting or trauma-induced, should be addressed by orthopedic surgeons aiming to achieve successful surgical outcomes[11,12].

Epidemiology

The LIMPRINT study[1], conducted in 2019, to date, is the largest epidemiological study on the subject and investigated the presence of lymphedema in patients admitted to ward beds of six hospitals in five countries (Denmark, France, the United Kingdom, Australia, and Ireland). A total of 3,401 patients were evaluated, of whom 38% were diagnosed with lymphedema. The main risk factors associated with the condition included advanced age, morbid obesity, heart failure, venous insufficiency, limited lower limb mobility, and neurological deficits. About 96.4% of patients with lymphedema involved the lower limbs, most of them below the knee. As for the cause of hospitalization, the main one is cellulite, responsible for 68.1% of cases[1].

Clinical presentation

Lymphedema can be unilateral or bilateral, with two-thirds of cases being unilateral. In cases of secondary lymphedema, laterality depends on the underlying cause[1]. Patients who have lower limb lymphedema complain of a feeling of heaviness, dull pain, and discomfort in the legs and ankles, especially at the end of the day. Such symptoms are nonspecific and common among several conditions associated with lower limb edema[13].

The main clinical sign on physical examination in cases of lymphedema is edema. Initially, it is soft, becoming hardened and associated with skin changes as the disease progresses. Lymphedema usually begins on the back of the foot or hand and progresses cranially. In addition to the back, the extremities are affected by edema. Hypoplastic and concave nails may be present in cases of primary lymphedema[14].

The International Society of Lymphology (ISL) defined in its consensus, published in 2020, the clinical stages of lymphedema, which summarize the signs found on physical examination as the disease progresses. Stages I, II, and III were defined, and an earlier stage, stage 0, was recognized, in which, despite an impaired lymphatic system, subtle changes in fluid and tissue composition and subjective symptoms, no evident swelling is apparent. Next, there is a description of the clinical findings of each stage. It is important to emphasize that several stages may coexist in the same limb, corresponding to different lymphatic areas[15].

Mild lymphedema

In Stage I, or mild lymphedema, there is an accumulation of interstitial fluid with a higher protein content compared to venous edema. The swelling is typically mild, resolves with limb elevation, and has a soft, dough-like consistency. At this stage, lymphedema may be mistaken for other causes of lower limb edema, such as congestive heart failure or chronic venous insufficiency[4,13,14].

Moderate lymphedema

In Stage II, or moderate lymphedema, adipocyte hypertrophy occurs in response to persistent fluid accumulation in the interstitial space. At this stage, the edema does not resolve with limb elevation and becomes non-soft due to skin thickening. As the condition progresses, there is continued deposition of fibroadipose tissue and further thickening of the overlying skin.

Severe lymphedema

In stage III, or severe lymphedema, there is greater evidence of fibrous tissue deposition in the interstitial space and trophic skin changes such as acanthosis, increased thickness, and verrucous lesions.

Initially, the skin develops a dimpled, *peau d'orange texture, which,* as it progresses, becomes hardened, hyperkeratotic, and leathery in texture. As the condition progresses, lymphostatic elephantiasis may develop, characterized by the presence of hyperkeratotic verrucous lesions[13]. These changes contribute to the appearance of the pathognomonic sign of chronic lymphedema—Stemmer's sign—defined by the inability to pinch a skin fold at the base of the second toe.

In chronic and severe lymphedema, the presence of skin fissures increases the risk of trophic changes associated with secondary infections and ulcerations. Patients may present with recurrent episodes of cellulitis, lymphangitis, impetigo, and clear fluid leakage, known as lymphorrhea[13]. Non-healing ulcers in lymphedema warrant investigation for malignant transformation, particularly the development of lymphangiosarcoma[14].

Diagnostic

The diagnosis of lymphedema is primarily clinical. A thorough medical history and physical examination revealing typical characteristics can confirm the diagnosis, especially if there is a classical etiology present. Edema following lymph node resection, a history of trauma, absence of a systemic cause for generalized edema, and skin changes typically associated with lymphedema strongly support the diagnosis[14]. However, according to Jayaraj et al.[16], classical clinical signs of lymphedema were present in only 17% of cases confirmed by lymphoscintigraphy, highlighting their limited reliability.

Several imaging tests evaluate the anatomy and function of peripheral and central lymphatic vessels. These tests can evaluate the lymphatic vessels directly, observing their anatomical or functional changes, or indirectly evaluate lymphatic impairment by identifying consequences of lymphatic dysfunction, such as interstitial fibrosis[17].

The investigation usually begins with a venous ultrasound to exclude causes of edema[15]. Although duplex ultrasound cannot visualize lymphatic vessels—only lymph nodes and blood vessels—it plays an important role in identifying dermal and subcutaneous alterations associated with lymphedema[17]. The dermis may show changes in echogenicity due to increased collagen fiber deposition, while the subcutaneous tissue often exhibits fat tissue hyperplasia and hypertrophy, which disrupts the normal echogenic line patterns observed on ultrasound[18].

Computed tomography and magnetic resonance imaging of limbs affected by lymphedema can be useful in identifying indirect signs of the disease. Edema acquires a characteristic marked by honeycomb distribution, reflecting fluid accumulation around fibrotic and adipose tissue. These imaging modalities also aid in identifying potential causes of lymphedema, such as extrinsic compression of the lymphatic system by tumors. Furthermore, magnetic resonance imaging can provide valuable features that assist in distinguishing lymphedema from other causes of swelling, such as chronic venous insufficiency.

Although the diagnosis of lymphedema is primarily clinical and does not require lymphatic imaging, evaluating the anatomy and function of the lymphatic system can confirm the diagnosis, determine the disease stage, and guide treatment planning and follow-up. Currently, lymphoscintigraphy is considered the gold standard imaging modality for diagnosing lymphedema. The procedure involves intradermal injection of technetium-99m-labeled sulfur colloid into the second and third interdigital spaces of the feet, followed by serial imaging using a scintigraphic camera to track lymphatic flow from the feet toward the thoracic region[4].

Differential diagnosis

Peripheral edema is a common clinical finding and may be indicative of a wide range of underlying conditions. As such, the differential diagnosis is often broad. A thorough clinical history is essential at the outset of the diagnostic process, including information on the chronicity and laterality of symptoms, associated manifestations, concurrent skin changes, and current medication use[20].

Causes of lower limb edema can be local or systemic. Among the most common systemic causes are congestive heart failure, renal failure, hypoalbuminemia, and protein-losing nephropathy. Local etiologies include primary and secondary lymphedema, lipedema, deep vein thrombosis, and chronic venous disease[20].

One of the main differential diagnoses of lymphedema is chronic venous disease (CVD), as it produces a bilateral chronic edema in the ankle and sole of the foot with characteristics similar to those of lymphedema[20]. Clinical suspicion typically arises in patients presenting with soft, pitting, reddish edema, predominantly affecting the leg, particularly the medial aspect of the ankle and calf. The diagnosis can be confirmed through lower limb venous Doppler ultrasound or by assessing the ankle-brachial index[21]. However, despite being a differential diagnosis, the relationship between CVD and lymphedema has been studied. Up to 30% of CVD cases have associated lymphatic system involvement. Some authors have used the term phlebolymphedema to characterize this mixed involvement[22].

Edema of cardiac origin usually begins in the pre-tibial region, in some severe cases reaching proximal regions of the lower limb. When the patient acquires a supine position, there may be sacral edema. The skin is shiny, often associated with symptoms of stasis dermatitis, and edema is soft[23]. In chronic cases, edema may harden, although it occurs less frequently than in cases whose etiology is venous insufficiency[24].

Lipedema is a chronic disease characterized by increased adipose tissue in the limbs, which occurs mainly in women. A family history of lipedema is common, with approximately 60% of patients reporting an affected first-degree relative. Current evidence suggests an autosomal dominant inheritance pattern with incomplete penetrance[25]. Patients relate the onset of the condition to periods of hormonal variation, such as adolescence, pregnancy, and menopause. In this type of swelling, the hands and feet are not affected, and the adipose hypertrophy is bilateral and symmetrical. Stemmer's sign, positive in lymphedema, is often negative in lipedema. Symptoms such as pain disproportionate to pressure and touch, feeling of heaviness and tension in the affected limbs, a marked tendency to form bruises, worsening of symptoms over the days, hypothermia of the skin, telangiectasia, and visible veins around the fat deposits are associated. When clinical examination is not sufficient to differentiate the case with lymphedema, imaging tests such as lymphoscintigraphy may be requested to evaluate changes in the lymphatic system[26].

Edema of traumatic origin

Trauma is a common cause of acute lower limb edema, with swelling resulting from capillary injury, inflammatory response, or hematoma formation. Evaluation begins with a history consistent with trauma, and subsequent management is individualized based on the mechanism and severity of the injury, which may range from contusions and sprains to fractures[20].

The Morel-Lavallée injury or closed degloving is an uncommon cause of acute, subacute, or even chronic lower limb edema. Injury most commonly occurs in high-velocity trauma through the shear mechanism, where the deep fascia separates from the skin and superficial fascia. This mechanism has also been reported to occur in direct lower limb trauma, especially in athletes, and rarely in abdominoplasties and liposuction. Although it can affect any region of the lower limbs, it most commonly occurs in proximal areas. Due to its delayed onset—often days after trauma—and prolonged course, it is frequently misdiagnosed as chronic edema[27]. However, it has been identified that patients who have suffered from circumferential dehiscence in the lower limbs have a high probability of developing lymphedema. Thus, in addition to being a differential diagnosis, the Morel-Lavallée injury is also one of the possible etiologies of secondary lymphedema[28].

Conclusion

Orthopedic surgeons frequently face the challenge of differentiating causes of chronic lower limb edema in clinical practice. Given the increasing prevalence of lymphedema, lymphatic drainage dysfunction should always be considered in the diagnostic process. Characteristic clinical manifestations, a history of predisposing conditions, and appropriate imaging studies are essential for accurate diagnosis. In this context, the identification of orthopedic conditions associated with lymphedema contributes to improved therapeutic strategies and prognostic outcomes.

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References

1. Quéré I, Palmier S, Norregaard S, Pastor J, Sykoroca M, Dring E, et al. LIMPRINT: estimation of the prevalence of lymphoedema/ chronic oedema in acute hospital in in-patients. Lymphat Res Biol. 2019;17(2):135-40.
2. Rockson S. The impact of LIMPRINT. Lymphat Res Biol. 2019;19(5):409–10.
3. Moffatt C, Keeley V, Franks P, Rich A, Pinnington L. Chronic oedema: a prevalent health care problem for UK health services. Int Wound J. 2016;14(5):772-81.
4. Gasparis A, Kim P, Dean S, Khilnani N, Labropoulos N. Diagnostic approach to lower limb edema. Phlebology. 2020;35(9):650-5.
5. Brouillard P, Witte M, Erickson R, Damstra R, Becker C, Quéré I, et al. Primary lymphoedema. Nat Rev Dis Primers. 2021;7(1):1-20.
6. Duhon B, Phan T, Taylor S, Crescenzi R, Rutkowski J. Current mechanistic understandings of lymphedema and lipedema: tales of fluid, fat and fibrosis. Int J Mol Sci. 2022;23(12):6621.
7. Dayan JH, Ly CL, Kataru RP, Mehrara BJ. Lymphedema: pathogenesis and novel therapies. Annu Rev Med. 2018;69(1):263-76.
8. Rockson S. Advances in lymphedema. Circ Res. 2021;128(12):2003–16.
9. Bernas M, Thiadens S, Stewart P, Granzow J. Secondary lymphedema from cancer therapy. Clin Exp Metastasis. 2022;39(1):239-47.
10. Lourens GB, Ferrell DK. Lymphatic filariasis. Nurs Clin North Am. 2019;54(2):181-92.
11. Liao C, Kuruvilla A, Krajewski A. A scoping literature review of post-traumatica lymphedema: Where are we now? J Plast Reconstr Aesthet Surg. 2022;75(7):2387-440.
12. Thomas C, Le J, Benson E. Managing Lymphedema in Fracture Care: Current Concepts and Treatment Principles. J Am Acad Orthop Surg. 2020;28(18):737-41.
13. Grada A, Phillips T. Lymphedema: pathophysiology and clinical manifestations. J Am Acad Dermatol. 2017;77(6):1009-20.
14. Bittar S, Simman R, Lurie S. Lymphedema: a practical approach and clinical update. Wounds. 2020;32(3):86-92.
15. Executive Committee of the International Society of Lymphology. The diagnosis and treatment of peripheral lymphedema: 2020 Consensus Document of the International Society of Lymphology. Lymphology. 2020;53(1):3-19.
16. Jayaraj A, Raju S, May C, Pace N. The diagnostic unreliability of classic physical signs of lymphedema. J Vasc Surg Venous Lymphat Disord. 2019;7(6):890-7.
17. O'Donnell Jr T, Rasmussen J, Sevick-Muraca E. New diagnostic modalities in the evaluation of lymphedema. J Vasc Surg Venous Lymphat Disord. 2017;5(2):261-73.
18. Suehiro K, Morikage N, Murakami M, Yamashita O, Ueda K, Samura M, et al. Subcutaneous tissue ultrasonography in legs with dependent edema and secondary lymphedema. Ann Vasc Dis. 2014;7(1):21-7.
19. Wiser I, Mehrara B, Coriddi M, Kenworthy E, Cavalli M, Encarnacion E, et al. Preoperative Assessment of Upper Extremity Secondary Lymphedema. Cancers (Basel). 2020;1(12):125.
20. Patel H, Skok C, DeMarco A. Peripheral edema: evaluation and management in primary care. Am Fam Physician. 2022;106(5): 557-64.
21. Trayes K, Studdiford J, Pickle S, Tully A. Edema: diagnosis and management. Am Fam Physician. 2013;88(2):102-10.
22. Saleem T. Phlebolymphedema: unraveling the connection. J Vasc Surg Venous Lymphat Disord. 2022;10(6):1417.
23. Stöberl C. Differential diagnosis of leg edema. Wien Med Wochenschr. 2016;166(9–10):278-86. German
24. Schellong S, Wollina U, Unger L, Machetanz J, Stelzner C. Leg swelling. Internist (Berl). 2013;54(11):1261-72.
25. Forner-Cordero I, Szolnoky A, Forner-Cordero A, Kelmény L. Lipedema: an overview of its clinical manifestations, diagnosis and treatment of the disproportional fatty deposition syndrome – systematic review. Clin Obes. 2012;2(3–4):86-95.
26. Kruppa P, Georgiou I, Biermann N, Prantl L, Klein-Weigel P, Ghods M. Lipedema: pathogenesis, diagnosis, and treatment options. Dtsch Arztebl Int. 2020;117(22–23):396-403.
27. Yang Y, Tang T. The Morel-Lavallée lesion: review and update on diagnosis and management. Orthop Surg. 2023;15(10):2485-91.
28. Mello D, Assef J, Hellene-Jr A. Avaliação linfocintilográfica da circulação linfática em pacientes vítimas de desenluvamentos circunferenciais dos membros inferiores. Rev Col Bras Cir. 2022; 49:e20222981.

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Original Article

Adequate and safe operative fixation of ankle fractures by residents and orthopedic trauma surgeons

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Abstract

Objective: Investigate surgical outcomes of patients with ankle fractures operated on by residents and orthopedic trauma surgeons.

Methods: Retrospective cohort study including all adult patients surgically treated for ankle fracture from 2016 to 2020 in regional hospitals in the Netherlands. Data regarding patient demographics, fracture characteristics, and treatment characteristics were collected from patient medical records.

Results: Patient demographics and fracture characteristics were similar for patients who underwent surgery by residents compared to those operated on by orthopedic trauma surgeons. There was no significant difference in postoperative complications, revision surgeries (2.8% vs. 4.7%), surgery duration (60.0 minutes vs. 54.0 minutes), or quality of life for residents compared to orthopedic trauma surgeons. Differences were seen in surgical treatment, with external fixation (2.2% vs. 5.2%), medial screw fixation (21.4% vs. 28.5%), and dorsal plate fixation (21.4% vs. 28.5%) being significantly more often used in patients operated on by surgeons. Logistic regression showed that primary surgeon being a resident or orthopedic trauma surgeon was not a predictor for complications.

Conclusion: Outcomes after surgical fixation of ankle fractures are comparable for residents and orthopedic trauma surgeons. Careful selection of patients combined with an appropriate level of supervision is necessary for residents to develop their skills without putting patients at risk.

Level of evidence: Level II, Prognostic study, Retrospective study.

Keywords: Surgical education; Professional competence; Ankle fractures; Treatment outcome; Postoperative complications.

Introduction

The ultimate goal of any surgical residency program is to prepare the resident to function as a qualified surgeon[1]. Adequate surgical experience in the operating room is a critical factor in the development of technical skills and surgical judgment[1,2]. Residents still predominantly train under the apprenticeship model, where they perform progressively complex surgeries under the supervision of an attending surgeon[3]. As residents advance in their training, more responsibility for independent action is granted in direct patient care, surgeries, and in supervising junior residents[1,4]. However, it is important that this is done in a safe environment, without increasing the risk of complications for patients.

There have been several studies comparing surgical outcomes between surgeons and residents[3]. A study by Abson et al.[5] showed that there was no difference in surgical outcomes found in closed reduction of pediatric distal radius fractures in a comparison of procedures performed by residents and attending surgeons. Additionally, another study found that resident involvement did not independently increase the risk of complications in the surgical treatment of lower extremity injuries[6].

Study performed at the Radboudumc, Nijmegen, The Netherlands.

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To date, only a limited number of studies have investigated the impact of surgical resident involvement on outcomes following open reduction and internal fixation (ORIF) of ankle fractures. Studies specifically on this topic originate from Israel and the United States. These studies show that resident involvement does not immediately affect complication rates. So far, no studies have been done on this topic in the European continent, despite well-known differences in residency training programs, as well as in surgical practice[7,8]. In conclusion, the aim of this study is to investigate surgical outcomes of patients with ankle fractures comparing those operated on by residents and those attended by orthopedic trauma surgeons.

Methods

Study design

A retrospective cohort study was conducted to assess surgical outcomes in ORIF of ankle fractures comparing the performance of residents and orthopedic trauma surgeons. Participating teaching hospitals were two level 1 trauma centers and two level 2 trauma centers in the Netherlands. Ethical approval was obtained from local medical ethics committees.

All patients aged 18 years old or older with an ankle fracture surgically treated at one of the four participating hospitals from August 1st, 2016, to April 31st, 2020, were included in this study. Patients under the age of 18 and patients with pilon fractures were not included. Patients were divided into two groups based on the primary surgeon responsible for their treatment. One group consisted of patients treated by an orthopedic trauma surgeon as primary surgeon; the other, of patients treated by a resident with assistance and direct supervision of an orthopedic trauma surgeon or without assistance and direct supervision of an orthopedic trauma surgeon, meaning the surgeon was available for consultation but not present in the operating room. In the Netherlands, the residency program takes at least six years for conclusion, or until the residency training director states the resident is completely competent as an orthopedic trauma surgeon. Residents can fulfill the orthopedic trauma residency requirements through an orthopedic or general surgery program, the latter being the most frequently chosen program. In the first four years of residency, residents complete the common trunk training, covering areas such as trauma surgery, vascular surgery, oncological surgery, and pediatric surgery. In the final two years, they specialize in the field of (orthopedic) trauma. Residents who performed ankle surgery with indirect supervision were senior residents (5th or 6th year). Follow-up was defined as time from surgery till last hospitalization or outpatient clinic appointment.

Study variables

A database was made by retrospectively extracting data from medical records of patients treated in participating hospitals. Data extracted from the records included patient, fracture and treatment characteristics. All data was managed using the online Castor Electronic Data Capture software.

Patient characteristics assessed were age, sex, body mass index (BMI), and the American Society of Anesthesiologists (ASA) classification. Fracture characteristics obtained were classified using the Weber[9] and Lauge-Hansen classifications[10]. It was further analyzed whether or not it was a compound fracture as per the Gustilo classification[11]. Analyses and classifications of fractures were performed by one of the medical researchers. In case of uncertainties, one of three trauma surgeons selected was consulted. Finally, data on primary surgeon (resident or orthopedic trauma surgeon), surgery time, and the type of fracture fixation performed were extracted from the medical records. After the surgical procedure, surgeons must point out the primary and secondary surgeon in an electronic health record, as well as in a surgical resident portfolio. The primary surgeon identification is based on the individual who took the lead during surgery or performed most operative steps, as discussed among attendings and/or residents. Anesthesiologists document the start time and the time the surgery ended by using the electronic health record.

Quality of life (QoL) was measured using the EQ-5D-3L questionnaire. Patients received this questionnaire by mail or e-mail. Where patients did not complete the questionnaire, either two reminders were sent via e-mail or contact was made via telephone, no more than three times. The EQ-5D-3L is a validated questionnaire used to measure QoL using five dimensions of health: mobility, self-care, daily activities, pain, and mood. Patients can indicate the extent to which they experience problems in each area: level 0 (no problems), level 1 (moderate problems), and level 2 (severe problems)[12].

Outcome variables

Primary outcome was the complication rate comparison between residents and orthopedic trauma surgeons. Secondary outcomes were the duration of surgery and frequency of revision operations.

Complications included infections, peripheral nerve damage, bleeding, malunion, nonunion, failure of osteosynthesis material, and revision surgery. The attending surgeon who performed or supervised the surgical treatment decided if revision surgery was necessary. Superficial wound infections were defined as those treated with oral antibiotics only. Wound infections treated with intravenous antibiotics and/or surgical debridement were defined as deep infections. Peripheral nerve damage was defined as the loss of sensibility in the ankle or foot persisting for three months after surgery. When a hematoma led to blood transfusion and/or surgery, it was defined as postoperative bleeding. Cases of malunion, nonunion, and failure of the osteosynthesis material were extracted from the medical records, being diagnosed by the attending surgeon who performed or directly or indirectly supervised the surgical treatment.

Statistical analysis

Data was analyzed using SPSS version 29.0.0.0, statistical significance was set as $p < 0.05$. Patient characteristics were analyzed using absolute and relative frequencies for categorial variables, and median with interquartile range (IQR) for continuous variables. Independent sample t-tests, chi-square tests, and Mann-Whitney U tests were used to determine significance of differences between the groups of patients operated on by surgeons and residents, respectively. Lastly, a logistic regression analysis was performed for complications, and a multivariate linear regression was performed for QoL.

Results

A total of 838 patients were included for analysis; 33.5% (n = 281) were operated on by a resident while under direct or indirect supervision of an experienced orthopedic trauma surgeon. Median follow-up duration was 20.0 weeks (IQR 12.0 to 42.0) and median time to fill the questionnaire in was 2.3 years (IQR 559.00 days to 1150.50 days). Table 1 describes the characteristics of patients; the majority of patients in both groups were females with a closed Weber B ankle fracture. No significant differences in patient and fracture characteristics were found between groups.

Table 2 compares surgical outcomes of procedures performed by surgeons and residents. Postoperative complication rates were similar for residents and orthopedic trauma surgeons (17.8% vs. 17.6%). Besides, no significant differences were found in the rate of revision surgery (2.8% vs. 4.7%) or the median duration of surgery (60.0 (40.0 to 74.0) minutes vs. 54.0 (40.0 to 76.0) minutes) when comparing residents with orthopedic trauma surgeons. Surgical technique was in some aspects significantly different in patients operated on by surgeons compared to

Table 1. Patient demographics and fracture characteristics compared by surgeons vs surgical residents

		Surgical residents (n = 281)	Surgeons (n = 557)	p-value
Sex	Male	124 (44.1%)	239 (42.9%)	0.737
	Female	157 (55.9%)	318 (57.1%)	
Median age in years (IQR)		50.00 (32.00 to 50.00)	56.00 (44.00 to 69.50)	0.511
ASA	1	102 (36.3%)	197 (35.4%)	0.922
	2	138 (49.1%)	269 (48.3%)	
	3	32 (11.4%)	66 (11.8%)	
	4	3 (1.1%)	9 (1.6%)	
	Missing	6 (2.1%)	16 (2.9%)	
Median BMI in kg/m² (SD)		26.60 (24.00 to 30.36)	26.56 (23.15 to 30.43)	0.977
Weber Classification	A	18 (6.4%)	38 (6.8%)	0.466
	B	205 (73.0%)	382 (68.6%)	
	C	56 (19.9%)	130 (23.3%)	
	Missing	2 (0.7%)	7 (1.3%)	
Lauge Hansen Classification	Supination exorotation			0.713
	Type 1	-	-	
	Type 2	39 (13.9%)	64 (11.5%)	
	Type 3	8 (2.8%)	20 (3.6%)	
	Type 4	144 (51.2%)	275 (49.4%)	
	Supination adduction	-	5 (0.9%)	
	Type 1	10 (3.6%)	26 (4.7%)	
	Type 2	9 (3.2%)	11 (2.0%)	
	Pronation exorotation Type 1	-	4 (0.7%)	
	Type 2	18 (6.4%)	36 (6.5%)	
	Type 3	40 (14.2%)	88 (15.8%)	
	Type 4	5 (1.8%)	11 (2.0%)	
	Pronation adduction Type 1	-	1 (0.2%)	
	Type 2	5 (1.8%)	10 (1.8%)	
	Type 3	3 (1.1%)	6 (1.1%)	
	Missing			
Gustilo Classification	Closed fracture	270 (96.1%)	528 (94.8%)	0.369
	1	3 (1.1%)	7 (1.3%)	
	2	5 (1.8%)	7 (1.3%)	
	3	-	12 (2.2%)	
	Unknown/missing	3 (1.1%)	3 (0.5%)	

ASA: American Society of Anesthesiologists; IQR: Interquartile range; SD: Standard deviation; BMI: Body mass index.

those operated on by residents as primary surgeon: external fixation was used more often (2.2% vs. 5.2%, p = 0.019), medial fixation was more often done with screws (21.4% vs. 28.5%, p = 0.018), and dorsal plate fixation was performed more often (2.1% vs. 4.5%, p = 0.041). There were no significant differences in any domain of the EQ-5D-3L between patients operated on by surgeons and those operated on by residents.

A logistic regression analysis was performed correcting for the patient's sex, age, ASA classification, and fracture classification (i.e. Weber and Gustilo, Table 3). It showed that resident or orthopedic trauma surgeon as primary surgeon was not a predictor for complications (p = 0.803). In this model, sex (OR = 0.666, CI 0.457 to 0.971) and open fractures (OR = 2.571, CI 1.251 to 5.286) were significant predictors for complications. Lastly, a multivariate linear regression analysis was performed to assess QoL, which showed that resident or orthopedic trauma surgeon as primary surgeon was not a predictive factor for QoL (Table 4).

Only a relatively small number of patients (n = 54) underwent ORIF by a resident with indirect supervision of a surgeon. This subcategory was analyzed separately, and results can be found in Tables 5, 6, 7 and 8. In short, there were no statistically significant differences in revision surgery rates or in the median duration of surgery. Multivariate analysis also showed no statistically significant difference for residents under direct or indirect supervision compared to orthopedic trauma surgeons.

Table 2. Surgical outcomes compared by surgeons vs surgical residents

		Surgical residents (n = 281)	Surgeons (n = 557)	p-value
Median duration of surgery in minutes (IQR)		60.0 (40.0 to 74.0)	54.0 (40.0 to 76.0)	0.062
External fixation	Temporary	3 (1.1%)	26 (4.7%)	**0.019**
	Final fixation	3 (1.1%)	3 (0.5%)	
Lateral fixation	One-third tubular plate	195 (69.4%)	392 (70.4%)	0.511
	Fixed angle screw fixation	30 (10.7%)	52 (9.3%)	0.580
	Intramedullary fixation	-	4 (0.7%)	0.151
	Lag screw	144 (51.2%)	303 (54.4%)	0.261
Medial fixation	One-third tubular plate	8 (2.8%)	24 (4.3%)	0.283
	Fixed angle screw fixation	2 (0.7%)	3 (0.5%)	0.768
	Intramedullary fixation	2 (0.7%)	9 (1.6%)	0.271
	Screw fixation	60 (21.4%)	159 (28.5%)	**0.018**
	Screws and K-wire	59 (21.0%)	120 (21.5%)	0.791
	Metal cerclage compression wiring	6 (2.1%)	12 (2.2%)	0.968
	Vicryl cerclage compression wiring	9 (3.2%)	19 (3.4%)	0.852
Dorsal fixation	Screw fixation AP	12 (4.3%)	16 (2.9%)	0.471
	Screw fixation PA	7 (2.5%)	15 (2.7%)	0.641
	One-third tubular plate	6 (2.1%)	25 (4.5%)	**0.041**
	Intramedullary fixation	-	1 (0.2%)	0.448
	Other	1 (0.4%)	2 (0.4%)	0.909
Complications	None	229 (81.5%)	457 (82.0%)	0.845
	Nerve damage	2 (0.7%)	3 (0.5%)	0.757
	Hemorrhage	-	1 (0.2%)	0.478
	Malunion	1 (0.4%)	2 (0.4%)	0.995
	Non-union	4 (1.4%)	9 (1.6%)	0.834
	Superficial infection	32 (11.4%)	53 (9.5%)	0.392
	Deep infection	11 (3.9%)	25 (4.5%)	0.703
	Failure of osteosynthesis	-	5 (0.9%)	0.111
Revision surgery		8 (2.8%)	26 (4.7%)	0.219
EQ-5D (N patients reporting problems)	Mobility	83 (42.3%)	195 (49.2%)	0.234
	Selfcare	12 (6.1%)	27 (6.8%)	0.781
	Daily activities	56 (28.6%)	133 (33.7%)	0.452
	Pain	105 (53.6%)	230 (58.4%)	0.159
	Mood	47 (24.1%)	97 (24.7%)	0.915
	VAS (median, IQR)	80.00 (70.00 to 90.00)	80.00 (70.00 to 88.00)	0.915

IQR: Interquartile range; AP: Anteriorposterior; PA: Posterioranterior; VAS: Visual analog scale.

Discussion

In our study, we found that surgical residents can perform an adequate and safe operative fixation of ankle fractures. Neither the complication rate nor the median duration of surgery differed between residents and orthopedic trauma surgeons. This applied to both direct and indirect supervision of the surgical resident. Critical judgment of orthopedic trauma surgeons regarding the degree of supervision required by surgical residents performing operative treatment of ankle fractures is of paramount importance. Findings from this study suggest that more challenging fractures requiring an external fixator or a dorsal approach were more often operated by orthopedic trauma surgeons. These are complicated procedures which require careful consideration regarding the ability of surgical residents.

Our findings are consistent with those of a study by Tenenbaum et al.[13] that showed comparable complication rates for both resident involvement and no resident

Table 3. Logistic regression analysis

		Odds ratio (Exp B)	p-value	95% Confidence interval
Sex	Male	RC		
	Female	0.666	**0.034**	0.457 to 0.971
Age	< 40 years	RC		
	> 40 years	1.489	0.072	0.965 to 2.297
Experience	Trauma surgeon	RC		
	Surgical resident	1.050	0.803	0.717 to 1.537
ASA Classification	ASA 1	RC		
	ASA 2	0.903	0.634	0.592 to 1.376
	ASA 3	1.540	0.141	0.866 to 2.737
	ASA 4	1.936	0.315	0.533 to 7.037
Weber Classification	Weber A	RC		
	Weber B	1.845	0.177	0.759 to 4.482
	Weber C	2.151	0.106	0.849 to 5.445
Gustilo Classification	Closed	RC		
	Open	2.571	**0.010**	1.251 to 5.286

ASA: American Society of Anesthesiologists; RC: Reference category.

Table 4. Multivariable linear regression analysis of quality of life

		Standardized Beta	p-value	95% Confidence interval for B
Sex	Male	RC		
	Female	-0.087	0.036	-0.070 to -0.002
Age	< 40	RC		
	> 40	0.004	0.931	-0.035 to 0.038
Experience	Trauma surgeon	RC		
	Surgical resident	0.004	0.923	-0.032 to 0.035
ASA Classification	ASA 1	RC		
	ASA 2	-0.092	0.038	-0.072 to -0.002
	ASA 3	-0.231	< 0.001	-0.211 to -0.097
	ASA 4	-0.197	< 0.001	-0.595 to -0.254
Weber Classification	Weber A	RC		
	Weber B	0.188	0.009	0.021 to 0.146
	Weber C	0.171	0.015	0.016 to 0.152
Gustilo Classification	Closed	RC		
	Open	-0.098	0.027	-0.171 to -0.010
Complications	No	RC		
	Yes	-0.157	< 0.001	-0.120 to -0.039

ASA: American Society of Anesthesiologists; RC: Reference category.

involvement. Louie et al.[14] also showed comparable complication rates, stating that resident involvement was not an independent risk factor for overall complications. Our study found sex and compound fractures to be an independent risk factors for postoperative complications, Louie et al.[15] additionally identified higher age as a risk factor for overall complications. Gross et al., in a study from the US on resident involvement in foot and ankle surgery, stated that resident involvement was not independently associated with 30-day mortality or 30-day overall morbidity. However, Gross et al. reported more postoperative complications in the resident group, noting they treated sicker and more complex patients.

Table 5. Patient demographics and fracture characteristics compared by surgeons, surgical residents with direct and indirect supervision

		Surgical residents, direct supervision (n = 227)	Surgical residents, indirect supervision (n = 54)	Surgeons (n = 557)	p-value
Sex	Male	101 (44.5%)	23 (42.6%)	239 (42.9%)	0.915
	Female	126 (55.5%)	31 (57.4%)	318 (57.1%)	
Median age in years (IQR)		50.00 (30.00 to 63.00)	49.00 (39.50 to 66.00)	51.00 (33.00 to 63.00)	0.773
ASA	1	83 (36.6%)	19 (35.2%)	197 (35.4%)	0.834
	2	107 (47.1%)	31 (57.4%)	269 (48.3%)	
	3	28 (12.3%)	4 (7.4%)	66 (11.8%)	
	4	3 (1.3%)	0 (0.0%)	9 (1.6%)	
	Missing	6 (2.6%)	0 (0.0%)	16 (2.9%)	
Median BMI in kg/m^2 (IQR)		26.52 (24.00 to 30.41)	27.00 (24.12 to 30.41)	26.46 (23.10 to 30.43)	0.950
Weber Classification	A	14 (6.2%)	4 (7.4%)	38 (6.8%)	0.792
	B	165 (72.7%)	40 (74.1%)	382 (68.6%)	
	C	46 (20.3%)	10 (18.5%)	130 (23.3%)	
	Missing	2 (0.9%)	-	7 (1.3%)	
Lauge Hansen Classification	**Supination exorotation**				0.901
	Type 1	0 (0.0%)	0 (0.0%)	0 (0.0%)	
	Type 2	33 (14.5%)	6 (11.1%)	64 (11.5%)	
	type 3	7 (3.1%)	1 (1.9%)	20 (3.6%)	
	type 4	113 (49.8%)	31 (57.4%)	275 (49.4%)	
	Supination adduction	0 (0.0%)	0 (0.0%)	5 (0.9%)	
	Type 1	8 (3.5%)	2 (3.7%)	26 (4.7%)	
	Type 2	7 (3.1%)	2 (3.7%)	11 (2.0%)	
	Pronation exorotation	0 (0.0%)	0 (0.0%)	4 (0.7%)	
	Type 1	17 (7.5%)	1 (1.9%)	36 (6.5%)	
	Type 2	31 (13.7%)	9 (16.7%)	88 (15.8%)	
	Type 3	3 (1.3%)	2 (3.7%)	11 (2.0%)	
	Type 4	0 (0.0%)	0 (0.0%)	1 (0.2%)	
	Pronation adduction	5 (2.2%)	0 (0.0%)	10 (1.8%)	
	Type 1	3 (1.3%)	0 (0.0%)	6 (1.1%)	
	Type 2				
	Type 3				
	Missing				
Gustilo Classification	Closed	219 (96.5%)	51 (94.4%)	528 (94.8%)	0.866
	1	2 (0.9%)	1 (1.9%)	7 (1.3%)	
	2	4 (1.8%)	1 (1.9%)	7 (1.3%)	
	3	0 (0.0%)	0 (0.0%)	12 (2.2%)	
	Missing	2 (0.9%)	1 (1.9%)	3 (0.5%)	
EQ-5D (n patients reporting problems)	Mobility	66 (42.0%)	17 (43.6%)	195 (49.2%)	0.568
	Selfcare	11 (7.0%)	1 (2.6%)	27 (6.9%)	0.825
	Daily activities	42 (26.8%)	14 (35.9%)	133 (33.7%)	0.581
	Pain	83 (52.9%)	22 (56.4%)	230 (58.4%)	0.038
	Mood	35 (22.4%)	12 (30.8%)	97 (24.7%)	0.639
	VAS (median, IQR)	80.00 (70.00 to 90.00)	79.00 (64.75 to 86.00)	80.00 (70.00 to 88.00)	0.541

IQR: Interquartile range; VAS: Visual analog scale; BMI: Body mass index.

Table 6. Surgical outcomes compared by surgeons, surgical residents with direct and indirect supervision

	Surgical residents, direct supervision (n = 227)	Surgical residents, indirect supervision (n = 54)	Surgeons (n = 557)	p-value
Median duration of surgery in minutes (IQR)	60.0 (40.0 to 64.0)	57.0 (37.4 to 73.0)	54.0 (40.0 to 76.0)	0.165
Complications				
None	189 (83.3%)	40 (74.1%)	457 (82.0%)	0.284
Nerve damage	1 (0.4%)	1 (1.9%)	3 (0.5%)	0.450
Hemorrhage	-	-	1 (0.2%)	0.777
Malunion	-	1 (1.9%)	2 (0.4%)	0.119
Non-union	3 (1.3%)	1 (1.9%)	9 (1.6%)	0.936
Superficial infection	24 (10.6%)	8 (14.8%)	53 (9.5%)	0.434
Deep infection	9 (4.0%)	2 (3.7%)	25 (4.5%)	0.928
Failure of osteosynthesis	-	-	5 (0.9%)	0.282
Revision surgery	4 (1.8%)	4 (7.4%)	26 (4.7%)	0.083

IQR: Interquartile range.

Table 7. Logistic regression analysis

		Odds ratio (Exp B)	p-value	95% Confidence interval for B
Sex	Male	RC		
	Female	0.667	***0.035***	0.457 to 0.972
Age	< 40	RC		
	> 40	1.460	0.88	0.945 to 2.255
Experience	Surgical resident	RC		
	Trauma surgeon	0.619	0.154	-0,320 to 1.197
	Supervision of surgeon on surgical resident	0.573	0.129	0.280 to 1.175
Weber Classification	Weber A	RC		
	Weber B	1.857	0.172	0.764 to 4.517
	Weber C	2.168	0.103	0.855 to 5.494
ASA-classification	ASA 1	RC		
	ASA 2	0.900	0.624	0.590 to 1.373
	ASA 3	1.576	0.122	0.885 to 2.806
	ASA 4	2.016	0.288	0.553 to 7.347
Gustilo Classification	Closed			
	Open	2.550	**0.011**	1.238 to 5.249

ASA: American Society of Anesthesiologists; RC: Reference category.

Table 8. Complications divided by Lauge-Hansen classification

		Lauge-Hansen classification						p-value
		SE2	SE4	SA2	PE3	PE4	PA3	
Complications	Nerve damage	1 (1.0%)	3 (0.7%)	0 (0.0%)	0 (0.0%)	1 (0.8%)	0 (0.0%)	1.000
	Hemorrhage	1 (1.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0.853
	Malunion	0 (0.0%)	1 (0.2%)	0 (0.0%)	0 (0.0%)	1 (0.8%)	0 (0.0%)	0.319
	Non-union	1 (1.0%)	5 (1.2%)	1 (2.8%)	0 (0.0%)	2 (1.6%)	3 (20.0%)	**< 0.001**
	Superficial infection	6 (5.8%)	50 (12.0%)	4 (11.1%)	5 (9.6%)	13 (10.2%)	1 (6.7%)	0.798
	Deep infection	3 (2.9%)	17 (4.1%)	2 (5.6%)	5 (9.6%)	8 (6.3%)	1 (6.7%)	0.812
	Failure of osteosynthesis	0 (0.0%)	3 (0.7%)	0 (0.0%)	0 (0.0%)	3 (2.3%)	0 (0.0%)	0.872

Both Louie et al. and Gross et al. did not detail whether the resident was involved as the primary or secondary surgeon.

These findings comply with those of other studies regarding trauma surgery, as Abson et al.[5], who showed no significant difference in achieving fracture reduction or in the re-displacement of pediatric distal radius fractures when comparing residents and attending surgeons.

The present study found sex and open fractures as significant predictive factors for complications. This also aligns with another study investigating the influence of open ankle fractures on complications, which suggests that these fractures lead to more complications[16]. Further, Lorente et al.[17] stated that sex impacted functional outcomes and QoL in patients with ankle fracture.

Based on results from the present study, it is not possible to determine the patient profile or type of operative approach of ankle fractures that are optimal and safe to be performed by surgical residents. This was also the conclusion of the systematic review by D'Souza et al.[3], which described a large heterogeneity among different surgical specialties and, therefore, in results, which prevents generalizing the findings to specific clinical contexts. Careful case selection by the orthopedic trauma surgeon can challenge surgical residents appropriately and develop their skills without putting patients at risk. This is also supported by the overall complication rate found in the present study, which was not significantly different for surgical residents and orthopedic trauma surgeons and similar to complication rates found in the literature[18-20].

A strength of this study is that it is a multicenter study involving both academic and non-academic hospitals. Another strength is that this is the first European study to assess the resident involvement in treating ankle fractures, demonstrating that this system of residency involvement is safe and, therefore, effective.

Some limitations of this study should be considered. Due to its retrospective design, data are based on what was documented in medical records of patients. For example, the primary surgeon is identified through chart review, but interpretations of resident involvement can vary among surgeons. Another point is that long-term complications, such as osteoarthritis, were not considered; however, by including QoL, the follow-up period is extended to 2.3 years. Assuming that osteoarthritis leads to a lower QoL, a significant difference would be expected if one of the groups had a higher prevalence of osteoarthritis. Additionally, this study was conducted in the Netherlands, on a Dutch residency program, so findings may not be directly comparable to those of countries using different residency programs. Also, this database did not provide specific information on the year residents were in when performing the surgery. As aforementioned, residents who performed surgeries without direct supervision concern 5th- or 6th-year residents. The content and level of challenge of the individual cases are difficult to define. Nonetheless, the "proof of concept" remains valid, namely, that it is safe to gradually give residents more independence and that the surgeon should assess the resident competency level.

Conclusion

According to the findings of our study, surgical fixation of ankle fractures by surgical residents as the primary surgeon appears to be safe when compared to those performed by orthopedic trauma surgeons. Duration of the surgery, number of revision surgeries, and postoperative complications were similar for surgical residents and orthopedic trauma surgeons. We advise careful case selection and appropriate level of supervision in order to allow surgical residents to develop their skills without putting patients at risk. Future research should be done on differences in patient-reported outcome measures.

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References

1. Kazaure HS, Roman SA, Sosa JA. The resident as surgeon: an analysis of ACS-NSQIP. J Surg Res. 2012;178(1):126-32.
2. Kairys JC, McGuire K, Crawford AG, Yeo CJ. Cumulative operative experience is decreasing during general surgery residency: a worrisome trend for surgical trainees? J Am Coll Surg. 2008;206(5):804-11; discussion 811-3.
3. D'Souza N, Hashimoto DA, Gurusamy K, Aggarwal R. Comparative Outcomes of Resident vs Attending Performed Surgery: A Systematic Review and Meta-Analysis. J Surg Educ. 2016; 73(3):391-9.
4. Fallon WF Jr, Wears RL, Tepas JJ 3rd. Resident supervision in the operating room: does this impact on outcome? J Trauma. 1993;35(4):556-60; discussion 560-1.
5. Abson S, Williams N, Inglis M, Antoniou G, Cundy P. Resident Versus Attending Surgeons in Achieving and Maintaining Fracture Reduction in Pediatric Distal Radius Fractures. J Pediatr Orthop. 2016;36(5):478-82.
6. Mitchell PM, Gavrilova SA, Dodd AC, Attum B, Obremskey WT, Sethi MK. The impact of resident involvement on outcomes in orthopedic trauma: An analysis of 20,090 cases. J Clin Orthop Trauma. 2016;7(4):229-33.
7. Whewell H, Brown C, Gokani VJ, Harries RL, Global Surgical Training Requirements Project Collaborators. Variation in training requirements within general surgery: comparison of 23 countries. BJS Open. 2020;4(4):714-23.
8. Schijven MP, Reznick RK, ten Cate OT, Grantcharov TP, Regehr G, Satterthwaite L, et al. Transatlantic comparison of the competence of surgeons at the start of their professional career. Br J Surg. 2010;97(3):443-9.
9. Fonseca LLD, Nunes IG, Nogueira RR, Martins GEV, Mesencio AC, Kobata SI. Reproducibility of the Lauge-Hansen, Danis-Weber, and AO classifications for ankle fractures. Rev Bras Ortop. 2017;53(1):101-6.
10. LAUGE-HANSEN N. Ligamentous ankle fractures; diagnosis and treatment. Acta Chir Scand. 1949;97(6):544-50.
11. Yim GH, Hardwicke JT. The Evolution and Interpretation of the Gustilo and Anderson Classification. J Bone Joint Surg Am. 2018;100(24):e152.
12. EuroQol. EQ-5D-3L: EuroQol Research Foundation; 1990. Available from: https://euroqol.org/information-and-support/euroqol-instruments/eq-5d-3l/.
13. Tenenbaum SA, Shenkar Y, Fogel I, Maoz O, Balziano S, Barzilai Y, et al. Ankle fracture surgery performed by orthopaedic residents without supervision has comparable outcomes to surgery performed by fellowship trained orthopaedic surgeons. Arch Orthop Trauma Surg. 2024;144(6):2511-8.
14. Louie PK, Schairer WW, Haughom BD, Bell JA, Campbell KJ, Levine BR. Involvement of Residents Does Not Increase Postoperative Complications After Open Reduction Internal Fixation of Ankle Fractures: An Analysis of 3251 Cases. J Foot Ankle Surg. 2017;56(3):492-6.
15. Gross CE, Chang D, Adams SB, Parekh SG, Bohnen JD. Surgical resident involvement in foot and ankle surgery. Foot Ankle Surg. 2017;23(4):261-7.
16. Simske NM, Audet MA, Kim CY, Vallier HA. Open ankle fractures are associated with complications and reoperations. OTA Int. 2019;2(4):e042.
17. Lorente A, Pelaz L, Palacios P, Benlloch M, de la Rubia Ortí JE, Barrios C, et al. Predictive Factors of Functional Outcomes and Quality of Life in Patients with Ankle Fractures: A Systematic Review. J Clin Med. 2024;13(5):1188.
18. Zaghloul A, Haddad B, Barksfield R, Davis B. Early complications of surgery in operative treatment of ankle fractures in those over 60: a review of 186 cases. Injury. 2014;45(4):780-3.
19. Cammas C, Ancion A, Detrembleur C, Tribak K, Putineanu D, Cornu O. Frequency and risk factors of complications after surgical treatment of ankle fractures: a retrospective study of 433 patients. Acta Orthop Belg. 2020;86(3):563-74.
20. Macera A, Carulli C, Sirleo L, Innocenti M. Postoperative Complications and Reoperation Rates Following Open Reduction and Internal Fixation of Ankle Fracture. Joints. 2018;6(2):110-5.

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Original Article

Outcomes of plated metatarsophalangeal joint fusions without transarticular screw fixation

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Abstract

Objective: Evaluate the outcomes of metatarsophalangeal (MTP) arthrodesis performed with plate-only fixation.

Methods: A retrospective observational study was conducted on 68 patients submitted to MTP arthrodesis with plate fixation between June 2021 and December 2023. The primary outcome measure was the Patient-Reported Outcomes Measurement Information System (PROMIS) Physical Function (PF) score, evaluated preoperatively and postoperatively in patients who received a locking-compression plate or locking plate. Secondary outcomes included complication rates and the duration of follow-up.

Results: The mean patient age was 64.0 years, with a body mass index of 28.5 kg/m^2. The minimal clinically important difference of PROMIS-PF scores was achieved by 30.9% of patients. The complication rates were low, with no cases of malunion and only 2 (2.9%) nonunions. Patients who received a locking-compression plate had higher postoperative PROMIS-PF scores compared to the locking plate group (46.4 vs. 42.3, p = 0.038), and a greater percentage of these patients experienced improvement in PROMIS-PF postoperatively (71.4% vs. 42.5%, p = 0.035).

Conclusions: Both locking-compression and locking plates for MTP joint arthrodesis without transarticular screws are effective, with a low complication rate. These outcomes were comparable to those of prior studies evaluating screw-only and plate and screw fixation constructs. Longer follow-up studies are required to enable direct comparison of outcomes across the alternative arthrodesis techniques.

Level of Evidence III; Retrospective, Case-control study.

Keywords: Metatarsophalangeal joint; Arthrodesis; Postoperative complication; Bone plates; Patient Reported Outcome Measures.

Introduction

First metatarsophalangeal (MTP) joint arthrodesis is a surgical procedure commonly performed to alleviate pain and improve function in patients with severe arthritis or hallux rigidus[1,2]. These conditions often result in significant discomfort and impaired mobility, severely affecting patients' quality of life[3]. The primary goal of first MTP arthrodesis is to provide pain relief and restore functional ability by permanently achieving arthrodesis, thereby eliminating motion and reducing inflammation and pain[4].

Traditionally, first MTP arthrodesis has utilized screw fixation, either alone or combined with plates, due to its simplicity and reliability[5]. However, the emerging practice of using plate fixation alone, without transarticular screws, is gaining popularity at our institution and may offer comparable outcomes. Previous studies have similarly found functional and patient satisfaction improvements with plate and screw methods, prompting a reevaluation of the necessity and cost-effectiveness of transarticular screws[6-9]. Locking plates provide enhanced stability by creating a fixed plate-screw

Study performed at the Luminis Health Anne Arundel Medical Center, Annapolis, MD, USA.

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construct that is more rigid and advantageous, especially with softer bone. The objective of this study is to evaluate the patient-reported and clinical outcomes of patients submitted to first MTP arthrodesis using locking or locking-compression dorsal plates without a transarticular compression screw. We hypothesized that patients submitted to plate-only fixation would experience outcomes similar to those previously described in patients submitted to screw-only or plate and screw fixation. This study examined a retrospective cohort of 68 patients, focusing on improvements in physical function as measured by the Patient-Reported Outcomes Measurement Information System (PROMIS) Physical Function (PF) scores, complication rates, and the overall efficacy and safety of the procedure. Understanding these outcomes is essential for refining surgical techniques and improving patient care in those suffering from severe first MTP joint conditions.

Methods

Study population

This study was exempt from review by the institutional review board because it was a retrospective review of existing medical records. A retrospective observational study of 68 patients submitted to first MTP arthrodesis with low-profile locking MTP plates (Low Profile Titanium Pre-Contoured Plate, Arthrex Inc., Naples, FL, USA) or locking-compression MTP plates (MaxForce MTP Plate, Arthrex Inc., Naples, FL, USA) from June 2021 to December 2023 was performed. Surgeries were performed by three board-certified orthopedic surgeons with fellowship training in foot and ankle surgery. All patients underwent plate-only fixation without the use of a transarticular compression screw. Patients were excluded from the study if they did not complete the PROMIS-PF survey at baseline and at least once postoperatively.

Operative technique

The most commonly used approach for first MTP arthrodesis was the dorsal longitudinal incision, medial to the extensor hallucis longus tendon over the hallux MTP joint[1]. However, in cases where there was significant dorsal scarring of the hallux, a medial incision was used as an alternative. Sharp dissection was performed down through the skin and subcutaneous tissue, and the capsule was incised in line with the skin incision. This approach ensures adequate exposure of the joint while minimizing trauma to the surrounding tissues.

Joint preparation

Subperiosteal dissection and release of the collateral ligaments were performed to allow proper positioning of the cup and cone reamers from the Arthrex hallux MTP arthrodesis plating system (Arthrex, Inc., Naples, FL, USA). The spherical cup-and-cone articular surface preparation technique, known for its precision and reliability, was employed in this procedure. While alternative techniques, such as peg and socket configurations or planar cuts, are available and well-documented, the cup-and-cone method was selected for its superior alignment and surface matching[1,10]. Reaming was performed to the level of bleeding subchondral bone, and additional fenestration of the first metatarsal head and the base of the proximal phalanx was accomplished using Kirschner-wire drill holes.

Fixation technique

For fixation, either an Arthrex arthrodesis locking or locking-compression plate was chosen at the surgeon's discretion and provisionally secured to the bone with BB-Taks (Arthrex, Inc., Naples, FL, USA). In the locking plates, the distal part of the plate was then fixed securely, followed by the placement of a proximal compression screw. In the locking-compression plates, the distal end was secured with multiple locking screws, and a compression jig was used to compress through the MTP joint arthrodesis site. Bone reamings are utilized as graft material to enhance the fusion process in both cohorts. Notably, no transarticular screws were used in any of these cases.

Independent variables

The independent variables of interest included age, body mass index (BMI), race, American Society of Anesthesiologists (ASA) score, history of rheumatoid arthritis, prior MTP surgery, hallux rigidus grade, additional procedures performed, and plate type.

Outcome measures

The outcomes of interest were baseline PROMIS-PF, postoperative PROMIS-PF, improvement in PROMIS-PF, achievement of the minimal clinically important difference (MCID) between baseline and postoperative PROMIS-PF achievement, malunion, nonunion, reoperation, and duration of follow-up. The PROMIS-PF is a validated tool used to assess patients' self-reported physical abilities and health status, providing a standardized way to gauge the effectiveness of medical interventions. The PROMIS-PF MCID was defined as a 5-point improvement from baseline, using the ½ standard deviation method, in alignment with prior studies[11,12].

Statistical analysis

Descriptive statistics were performed to evaluate the demographics, surgeries performed, and outcomes for all MTP arthrodesis patients. For all descriptive statistics, the data were presented as mean ± standard deviation or n (%). Univariate analysis, including Chi-square testing for categorical measures and 2-sided independent samples t-testing for continuous measures, was performed to compare outcomes between locking and locking-compression plates. Statistical analysis was performed in RStudio (Boston, MA, USA), and statistical significance was assessed at $p < 0.05$.

Results

The patients' mean age was 64.0 ± 10.8 years, with a BMI of 28.5 ± 5.4 kg/m^2. Only six patients (1.0%) were not white, and only five (7.4%) had a history of rheumatoid arthritis. Most patients had an ASA score of 2 (69.1%) or 3 (26.5%), and 15 (22.1%) had a prior first MTP surgery, 13 (86.7%) of which were a bunionectomy or cheilectomy. Additionally, five patients (7.4%) had a hallux rigidus grade of 2, 41 (60.3%) had a grade of 3, and 22 (32.4%) had a grade of 4. An Arthrex Maxforce locking-compression plate was used in 28 (41.2%) MTP arthrodesis, and 19 (27.9%) of patients had additional procedures performed (Table 1).

Preoperatively, the mean PROMIS-PF score was 42.8 ± 6.1, and postoperatively, the mean PROMIS-PF score was 44.0 ± 7.6. Additionally, 37 (53.6%) patients saw improvement in PROMIS-PF scores postoperatively, while 21 (30.9%) achieved MCID. There were no patients with a malunion postoperatively, and only two (2.9%) had a nonunion postoperatively. Three (4.3%) patients had a reoperation. The mean follow-up was 13.8 months (median 12 months) after surgery (Table 2).

Table 3 details the patients with nonunion and reoperation. All patients had pre-contoured locking Arthrex plates, and none were MaxForce locking-compression plates. Two male patients, aged 71 and 79, experienced nonunion with no evidence of hardware loosening or failure on computed tomography (CT) scans. The 71-year-old patient's condition was complicated by an autoimmune disorder, and it is questionable if the nonunion was aseptic or septic. The 79-year-old patient displayed hardware loosening without signs of infection. Three patients required reoperation due to different etiologies. The 71-year-old male, with advanced hallux rigidus (grade 4), underwent hardware removal due to nonunion. The CT scans confirmed that there was no hardware loosening or failure, and no signs of infection were observed. The other two patients, females aged 55 and 37, both underwent hardware removal due to persistent pain despite achieving successful fusion. Both showed no signs of hardware failure or loosening on their CT scans.

Table 1. Patient characteristics and surgery details

Measure	All patients (n = 68)
Age	64.0 ± 10.8
BMI	28.5 ± 5.4
Non-white race	6 (1.0)
ASA score	
1	2 (2.9)
2	47 (69.1)
3	3 (26.5)
4	1 (1.5)
Rheumatoid arthritis	5 (7.4)
Prior MTP surgery	15 (22.1)
Bunionectomy/Cheilectomy	13 (86.7)
Arthroplasty/Hemiarthroplasty	2 (13.3)
Hallux rigidus grade	
2	5 (7.4)
3	41 (60.3)
4	22 (32.4)
Additional procedures performed	19 (27.9)
Locking plate	28 (41.2)

Data are expressed as mean ± SD or n (%). ASA: American Society of Anesthesiologists; BMI: Body mass index (kg/m2); MTP: Metatarsophalangeal.

Discussion

This study demonstrates that first MTP joint arthrodesis using plate-only fixation without a transarticular screw improved the patient-reported physical function and comparable outcomes as previously reported using screw-only and plate and screw fixation. The plate-only procedure exhibited a low complication rate, with no instances of malunion and a 2.9% nonunion rate, which underscores the efficacy and safety of plate-only first MTP arthrodesis. Additionally, the reoperation rate was relatively low at 4.3%. In comparison to patients treated with locking plates, those receiving locking-compression plates reported higher levels of physical function postoperatively and were more likely to report improvement on the PROMIS-PF survey—further, none of the patients receiving a locking plate experienced complications.

The 2.9% nonunion rate observed in our study is in alignment with prior studies reporting nonunion rates of 0% to 23% after first MTP arthrodesis[13-16]. In a systematic review of 2,800 primary and revision first MTP arthrodesis, an overall nonunion rate of 5.4% and implant removal rate of 8.5% was reported[17]. Kumar et al.[13] found a 98% fusion rate with plate and screw methods, and other studies have shown a 1.5%-3.7% nonunion rate in hallux rigidus fusion with plate and compression screw[14]. Our study contributes to this body of evidence by demonstrating that plate-only fixation, without the use of transarticular screws, achieves comparable results, providing surgeons with flexibility in choosing the method best suited to their patients' needs. Nonunion and reoperation after first MTP joint arthrodesis are influenced

Table 2. Patient-reported and clinical outcomes

Outcome	All patients (n = 68)
Baseline PROMIS-PF	42.8 ± 6.1
Postop PROMIS-PF	44.0 ± 7.6
Improved PROMIS-PF postoperatively	37 (53.6)
Achieved PROMIS-PF MCID postoperatively	21 (30.9)
Malunion	0 (0.0)
Nonunion	2 (2.9)
Reoperation	3 (4.3)
Follow-up months	13.8 ± 10.5

Data are expressed as mean ± SD or n (%). PROMIS: Patient-Reported Outcomes Measurement Information System; PF: Physical function; MCID: Minimal clinically important difference.

Table 3. Details of patient complications

Patient Age/Sex	Plate type	Hallux rigidus grade	Arthritis grade	Etiology of outcome	Patient risk factors
Nonunion					
71 y.o. Male	Low profile Titanium standard Pre-contoured (Locking)	4	4	CT shows no hardware loosening or failure Questionable aseptic versus septic Autoimmune disorder	Elevated BMI Smoker
79 y.o. Male	Low profile Titanium standard Pre-contoured (Locking)	3	3	CT showing hardware loosening No signs of infection	Elevated BMI Smoker
Reoperation					
71 y.o. Male	Low profile Titanium standard Pre-contoured (Locking)	4	4	Hardware removal due to nonunion CT shows no hardware loosening or failure No signs of infection	Elevated BMI Smoker
55 y.o. Female	Low profile Titanium petite Pre-contoured (Locking)	2	2	Hardware removal due to pain No hardware loosening or failure Successful fusion	None
37 y.o. Female	Low profile Titanium petite Pre-contoured (Locking)	2	2	Hardware removal due to pain No hardware loosening or failure Successful fusion	None

BMI: Body mass index; CT: Computed tomography.

by a range of patient-specific and surgical factors. Key modifiable risk factors significantly associated with nonunion after foot and ankle arthrodesis include a higher BMI, tobacco use, diabetes mellitus, thyroid dysfunction, parathyroid disease, and vitamin D abnormalities[18]. Specifically, higher body weight and increased preoperative hallux valgus angle slightly raised the likelihood of nonunion in first MTP arthrodesis[19]. Nonunion is also more frequently reported among males, those with comorbidities, higher grades of osteoarthritis, and greater postoperative dorsiflexion of the great toe[20]. Patients with inflammatory diseases can achieve successful fusion; however, they may take longer to achieve clinical and radiographic union compared to patients without inflammatory disease[21]. Surgical factors such as moderate to severe hallux valgus and under-correction of more than 25 degrees at the first MTP joint significantly increased the risk of nonunion or delayed union[22]. Diabetes further heightened nonunion rates, underscoring the need for careful management of diabetic patients undergoing surgery[23]. Finally, postoperative residual hallux valgus deformity was an independent risk factor for nonunion, highlighting the importance of achieving proper alignment during surgery[24].

Multiple previous studies have evaluated the benefits of first MTP arthrodesis for pain relief, functional improvement, and patient-reported outcomes[3,7]. In the study by Dayton et al.[25], 98.3% of patients were able to walk at a normal pace postoperatively, and 95% reported that loss of motion in their big toe did not affect their daily function after MTP arthrodesis. Another study of 60 patients by Chraim et al.[26] highlighted that 90% of patients were either satisfied or very satisfied after treating their hallux rigidus with fusion at a mean follow-up of 47 months. Even patients with a history of cheilectomy, who tend to have worse physical function both preoperatively and postoperatively, can achieve similar improvements in PROMIS scores compared to patients without such a history[27]. Various factors may influence these results; Andrews et al.[28] found that resilience, as measured by the Brief Resilience Scale, independently affects patient-reported outcomes, including PROMIS-PF scores. In our study, similar results were observed in patient-reported outcomes. Across the population, patients presented with relatively high levels of preoperative physical function, as demonstrated by a mean PROMIS-PF score of 42.8, which is within one standard deviation of the general adult population normative value of 50[29]. This is in alignment with a prior study reporting mean baseline PROMIS-PF scores of 44.4 in patients undergoing primary first MTP arthrodesis[27]. Given the high levels of baseline function in the population and the relatively short follow-up period, we observed modest improvements in PROMIS-PF scores postoperatively, with approximately 54% of patients reporting improvement. Notably, patients treated with locking-compression plates demonstrated higher postoperative PF scores and higher rates of improvement than those receiving locking plates—an observation that, to our knowledge, has not been previously reported. In light of this trend and the finding that no patients in the locking-compression plate group experienced postoperative complications or reoperations, our data suggest there may be a slight benefit to using locking-compression plates in plate-only MTP arthrodesis constructs.

Alternative methods of arthrodesis, such as the use of fully threaded compression screws and low-profile locking plates, have been compared in terms of biomechanical properties. One study indicated that fully threaded compression

screws had similar plantar gapping and load-to-failure compared to low-profile locking plates, but with significantly more stiffness[26], which may contribute to poorer patient satisfaction. However, when comparing low-profile contoured locking plates with single intraarticular compression screws, patients suffered from greater stiffness in the screw group[30], further defending the performance of plate-only arthrodesis. In general, studies have shown no clinical difference in time to fusion, fusion rates, or biomechanical differences between plate and screw techniques[30,31]. However, the choice between locking and non-locking plates remains a contested issue. Locking plates are designed to provide greater stability and may reduce the risk of hardware failure. Non-locking plates, while offering flexibility during bone healing, may present a higher risk for complications in certain patient populations. Haimes et al.[16] performed a comparison of non-locking semi-tubular plates and pre-contoured locking plates and found no significant difference in revision rates, questioning the necessity of more expensive locking plates. Hunt et al.[11], however, found that locked titanium plates resulted in a higher nonunion rate compared to non-locking stainless steel plates in patients without rheumatoid arthritis. Additionally, Bass and Serikonda[32] found higher fusion rates with locking plates in males, although overall fusion rates did not differ significantly between the two plate types. Although the majority of patients may achieve similar results with either type of plate, certain patient populations may benefit from a personalized selection. A unique aspect of our study is the evaluation of compression vs. traditional plates within the locking plate category. Our data suggest that locking compression plates might be associated with fewer complications compared to traditional locking plates without compression when not using a transarticular screw. Further research is needed to evaluate outcome differences between these alternative locking plate systems, especially given the increased cost of locking compression plates.

The primary limitation of this study is its small sample size, which may affect the statistical power and generalizability of the findings. The retrospective nature of the study also introduces potential biases, such as selection bias and recall bias, which can impact the accuracy and reliability of the results. Additionally, the study was conducted at a single institution, limiting the applicability of the results to broader populations. Furthermore, only patients completing both pre- and postoperative PROMIS surveys were included, adding to selection bias. Moreover, the time to follow-up was variable across the population, and no minimum follow-up period was required, potentially biasing both the clinical and patient-reported outcomes observed. These factors should be considered when interpreting the findings, and future research should include larger, multicenter cohorts to validate these results and enhance their generalizability.

Conclusion

Patients undergoing first MTP arthrodesis using plate-only fixation without a transarticular screw experienced low complication rates, including a 2.9% nonunion rate and a 4.3% reoperation rate. These outcomes were comparable to previous studies evaluating screw-only and plate and screw fixation constructs, demonstrating the safety of the plate-only approach. Longer follow-up studies are required to enable direct comparison of outcomes across the alternative arthrodesis techniques.

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References

1. Koutsouradis P, Savvidou OD, Stamatis ED. Arthrodesis of the first metatarsophalangeal joint: The "when and how". World J Orthop. 2021;12(7):485-94.
2. LaCoste KL, Andrews NA, Ray J, Harrelson WM, Shah A. First Metatarsophalangeal Joint Arthrodesis: A Narrative Review of Fixation Constructs and Their Evolution. Cureus. 2021;13(4):e14458.
3. Bergin SM, Munteanu SE, Zammit GV, Nikolopoulos N, Menz HB. Impact of first metatarsophalangeal joint osteoarthritis on health-related quality of life. Arthritis Care Res (Hoboken). 2012;64(11):1691-8.
4. Rammelt S, Panzner I, Mittlmeier T. Metatarsophalangeal Joint Fusion: Why and How? Foot Ankle Clin. 2015;20(3):465-77.
5. Sidhu VS, Kim CJ, Pedowitz DI, Pagliaro AJ, Fuchs D, O'Neil JT, et al. Screw Only Fixation vs Plate Fixation For 1st MTPJ Arthrodesis: A Comparative Retrospective Study. Foot Ankle Orthop. 2023; 8(4):24730114235S00406.
6. Filomeno P, López J. Republication of "First Metatarsophalangeal Joint Arthrodesis: Functional Outcomes Using 2 Different Fixation Techniques. Is More Expensive Better?". Foot Ankle Orthop. 2023; 8(3):24730114231193424.
7. DeSandis B, Pino A, Levine DS, Roberts M, Deland J, O'Malley M, et al. Functional Outcomes Following First Metatarsophalangeal Arthrodesis. Foot Ankle Int. 2016;37(7):715-21.
8. Gross CE, Bei C, Gay T, Parekh SG. A Short-Term Retrospective of First Metatarsophalangeal Joint Arthrodesis Using a Plate With PocketLock Fixation. Foot Ankle Spec. 2015;8(6):466-71.
9. Goucher NR, Coughlin MJ. Hallux metatarsophalangeal joint arthrodesis using dome-shaped reamers and dorsal plate fixation: a prospective study. Foot Ankle Int. 2006;27(11):869-76.
10. Curtis MJ, Myerson M, Jinnah RH, Cox QG, Alexander I. Arthrodesis of the first metatarsophalangeal joint: a biomechanical study of internal fixation techniques. Foot Ankle. 1993;14(7):395-9.
11. Hung M, Bounsanga J, Voss MW, Saltzman CL. Establishing minimum clinically important difference values for the Patient-Reported Outcomes Measurement Information System Physical Function, hip disability and osteoarthritis outcome score for joint reconstruction, and knee injury and osteoarthritis outcome score for joint reconstruction in orthopaedics. World J Orthop. 2018;9(3):41-9.
12. Norman GR, Sloan JA, Wyrwich KW. Interpretation of changes in health-related quality of life: the remarkable universality of half a standard deviation. Med Care. 2003;41(5):582-92.
13. Kumar S, Pradhan R, Rosenfeld PF. First metatarsophalangeal arthrodesis using a dorsal plate and a compression screw. Foot Ankle Int. 2010;31(9):797-801.
14. Chien C, Alfred T, Freihaut R, Pit S. First Metatarsophalangeal Joint Arthrodesis in Hallux Valgus Versus Hallux Rigidus Using Cup and Cone Preparation Compression Screw and Dorsal Plate Fixation. Cureus. 2017;9(10):e1786.
15. Hoveidaei AH, Roshanshad A, Vosoughi AR. Clinical and radiological outcomes after arthrodesis of the first metatarsophalangeal joint. Int Orthop. 2021;45(3):711-9..
16. Haimes MA, Roberts MS, Bougioukas L, Michelson JD. Analysis of the Costs and Complications of First Metatarsophalangeal Joint Arthrodesis Comparing Locked and Non-locked Plate Fixation Constructs. J Am Acad Orthop Surg. 2023;31(21):e1012-e1020.
17. Roukis TS. Nonunion after arthrodesis of the first metatarsal-phalangeal joint: a systematic review. J Foot Ankle Surg. 2011; 50(6):710-3.
18. Moore KR, Howell MA, Saltrick KR, Catanzariti AR. Risk Factors Associated With Nonunion After Elective Foot and Ankle Reconstruction: A Case-Control Study. J Foot Ankle Surg. 2017; 56(3):457-62.
19. Füssenich W, Seeber GH, van Raaij TM, van Lingen CP, Zuurmond RG, Stevens M, et al. Factors Associated With Nonunion in Arthrodesis of the First Metatarsophalangeal Joint: A Multicenter Retrospective Cohort Study. Foot Ankle Int. 2023;44(6):508-15.
20. Weber C, Yao D, Schwarze M, Andersson K, Andric V, Kinkelin M, et al. Risk Analysis of Nonunion After First Metatarsophalangeal Joint Arthrodesis. Foot Ankle Spec. 2021;14(2):120-5.
21. Mayer SA, Zelenski NA, DeOrio JK, Easley ME, Nunley JA 2nd. A comparison of nonlocking semitubular plates and precontoured locking plates for first metatarsophalangeal joint arthrodesis. Foot Ankle Int. 2014;35(5):438-44.
22. Molloy A, Butcher C, Mason L. Risk Factors for Non-union in First MTPJ Arthrodesis. Foot Ankle Orthop. 2018;3(3).
23. Kachooei AR, Raikin SM, Daniel JN. Factors Influencing the Nonunion Rate Following First Metatarsophalangeal Joint Arthrodesis. Foot Ankle Orthop. 2022;7(1):24730114215S00035.
24. Weigelt L, Redfern J, Heyes GJ, Butcher C, Molloy A, Mason L. Risk Factors for Nonunion After First Metatarsophalangeal Joint Arthrodesis With a Dorsal Locking Plate and Compression Screw Construct: Correction of Hallux Valgus Is Key. J Foot Ankle Surg. 2021;60(6):1179-83.
25. Dayton M, Dayton P, Togher CJ, Thompson JM. What Do Patients Report Regarding Their Real-World Function Following Triplane Metatarsophalangeal Joint Arthrodesis for Hallux Valgus? J Foot Ankle Surg. 2023;62(5):905-11.
26. Chraim M, Bock P, Alrabai HM, Trnka HJ. Long-term outcome of first metatarsophalangeal joint fusion in the treatment of severe hallux rigidus. Int Orthop. 2016;40(11):2401-8.
27. Rajan L, Kim J, An T, Mizher R, Srikumar S, Fuller R, et al. Effect of Prior Cheilectomy on Outcomes of First Metatarsophalangeal Joint Fusion for Treatment of Hallux Rigidus. Foot Ankle Orthop. 2022;7(3):24730114221119740.
28. Andrews N, Tran S, Young S, Halstrom J, Ray J, Littlefield Z, et al. Impact of Resilience on Patient Reported Outcome of First Metatarsophalangeal Arthrodesis. Osteology. 2022;2(2): 87-98.
29. Brodke DJ, Saltzman CL, Brodke DS. PROMIS for Orthopaedic Outcomes Measurement. J Am Acad Orthop Surg. 2016;24(11):744-9.
30. Fuld RS 3rd, Kumparatana P, Kelley J, Anderson N, Baldini T, Younger ASE, et al. Biomechanical Comparison of Low-Profile Contoured Locking Plate With Single Compression Screw to Fully Threaded Compression Screws for First MTP Fusion. Foot Ankle Int. 2019;40(7):836-44.
31. Sharma H, Bhagat S, Deleeuw J, Denolf F. In vivo comparison of screw versus plate and screw fixation for first metatarsophalangeal arthrodesis: does augmentation of internal compression screw fixation using a semi-tubular plate shorten time to clinical and radiologic fusion of the first metatarsophalangeal joint (MTPJ)? J Foot Ankle Surg. 2008;47(1):2-7.
32. Bass EJ, Sirikonda SP. 1st metatarsophalangeal joint fusion: A comparison of non-union and gender differences between locking and non-locking plating systems. Foot (Edinb). 2015;25(4):195-9.

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Original Article

Perception of quality of life in patients with diabetic foot

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Abstract

Objective: Investigate the factors that influence the perception of quality of life in patients with diabetic feet, with and without ulcers in the lower limbs.

Methods: An observational cross-sectional study in 50 adult patients with type 1 and 2 diabetes mellitus, where sociodemographic, clinical, and treatment data were collected, and the Neuropathy Specific Quality Of Life (NEUROQOL) questionnaire was applied, which consists of 35 items that evaluate six domains related to quality of life. Comparisons were performed using appropriate statistical tests, considering the significance of $p < 0.05$.

Results: The mean age was 70 years, with 13 patients having a history of amputations, and 18 had foot ulcers. The domains significantly affected were sensorimotor symptoms, limitations in daily activities, interpersonal problems, and emotional distress. Patients with amputations or ulcers had higher scores, indicating poorer quality of life. Physical activity was associated with significantly better scores in several domains.

Conclusion: Patients with diabetic foot complications, such as amputations or ulcers, had a poorer quality of life, especially in the domains related to functionality and emotional well-being. Physical activity proved to be a relevant protective factor. Preventive and therapeutic strategies that promote mobility, health education, and adequate clinical management can contribute to improving the quality of life in individuals with diabetic feet.

Level of Evidence IV; Therapeutic studies - investigating the results of treatment; Case series.

Keywords: Diabetes Mellitus; Diabetic foot; Quality of life.

Introduction

Diabetes mellitus (DM) is defined as a heterogeneous metabolic disorder with hyperglycemia as its main aspect. Its main causes are disorders in insulin secretion or its effect, and it may even be a combination of both. The prevalence of diabetes is currently approximately 540 million people worldwide, and the estimate for 2045 is 783.2 million[1,2].

Among the many complications of DM, foot-related changes are particularly significant. Diabetic foot results from the neurological and vascular alterations caused by DM. The resulting loss of muscle mass and changes in bone structure lead to areas of excessive pressure on the feet, which are further exacerbated by skin dryness and impaired local circulation, delaying healing. This combination of factors creates an ideal environment for foot ulcer development, which, if not properly managed, can progress and require amputation as a life-saving measure[3].

Many patients experience a significantly poorer quality of life when they have foot problems caused by DM. Understanding the multifaceted aspects of the condition becomes important for both patients, in terms of strengthening their physical and mental health, and for health professionals, to promote a treatment more appropriate to the individual needs of each patient[4].

The objective of this study is to investigate the factors that influence the perception of quality of life in patients with diabetic feet, with and without ulcers in the lower limbs, in outpatient follow-up in a university hospital.

Study performed at the Universidade Federal do Paraná, Curitiba, Paraná, Brazil.

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Methods

This is a cross-sectional observational study with a quantitative and qualitative approach. The target population consisted of 50 adult patients of both sexes with a confirmed diagnosis of DM type 1 or 2, followed at the Diabetic Foot Outpatient Clinic and the Medical Outpatient Service Three (SAM 3) of the Complexo Hospital de Clínicas da Universidade Federal do Paraná (CHC-UFPR). The study was approved by the Institutional Review Board under the number 78151524.6.0000.0096.

Data collection was performed from May to November 2024. The data collected from the questionnaires were recorded in an electronic database and stored for five years, as recommended by Resolution 466/12 of the National Health Council.

Inclusion criteria were age ≥ 18 years, any race/ethnicity/sex, with or without ulcers in the lower limbs, and a signed Informed Consent Form (ICF). The exclusion criteria were non-diabetic patients, diabetic patients < 18 years, patients who had some physical or mental condition that prevented them from answering the questionnaires, and those who did not agree to participate in the study.

Data collection involved the application of the Neuropathy Specific Quality of Life (NEUROQOL) questionnaire, which was created by Vileikyte et al.[5] and later translated into Portuguese and validated by Xavier et al.[6].

The NEUROQOL has adequate internal consistency (Cronbach's Alpha Coefficient 0.94), consisting of 35 items that allow participants to answer how often and with what intensity foot problems affect their quality of life in relation to six domains: pain, loss/reduction of sensitivity, diffuse sensorimotor symptoms, limitations in activities in daily life, interpersonal issues and emotional distress. The final two items on the scale assess, respectively, the impact of foot problems on overall quality of life and overall quality of life rating. Depending on the type of question, an "X" is marked on a scale of 1 to 5, where 1 represents "never" or "not at all" and 5 represents "very or very much." After selecting the response for a given item, participants are also asked to indicate how much the content of this item represents a nuisance or how important it is on a scale of 1 to 3, with the answers 1 = not at all, 2 = little, and 3 = a lot. To obtain the weighted scores of each item of the respective domains, the value obtained in each item (1-5) is multiplied by the value attributed to the corresponding nuisance/importance (1-3). This multiplication provides the degree of impact for each item within the instrument. The total values for each domain are calculated as the mean of the weighted items of the respective domains and can vary from 1 to 15; that is, the highest value corresponds to a poorer quality of life.

In addition, structured interviews were conducted to collect sociodemographic, clinical, and treatment information. The questionnaire was applied during patient care at the outpatient clinic, in a private room, in the presence of the nurse responsible for the area, and, when present, a companion. Patients were informed about all stages, objectives, benefits, and risks of the study and invited to participate in the study by signing the ICF.

For the descriptive analysis of quantitative variables, means, standard deviations, median, minimum, and maximum values were used. Categorical variables were described by absolute frequency and percentage. Regarding the questions with Likert scale response options (categorical variables), comparisons were made using Fisher's exact test or the Chi-square test. To compare the groups defined by demographic and clinical variable classifications, the scores of the NEUROQOL questionnaire domains (ranging from 1 to 15) were analyzed using the non-parametric Mann-Whitney test. P values < 0.05 were considered statistically significant. Data were analyzed using the IBM SPSS Statistics v. 29.0.0 (Armonk, NY: IBM Corp).

Results

The mean age was 70 years (± 10.6), the minimum 40 years, and the maximum 95 years. The mean time since diagnosis was 26 years (± 13.2), and 44 (88%) of patients had a follow-up time in the outpatient clinic of more than 24 months. Twenty-seven (54%) patients were female, 39 (78%) white, nine (18%) brown (*pardo*) and two (4%) black. As for marital status, 25 (50%) were married, 22 (44%) were divorced or widowed, and three (6%) were single. Regarding schooling, 26 (52%) had incomplete elementary school, 12 (24%) completed high school, five (10%) completed higher education, four (8%) completed elementary school, two (4%) had incomplete high school and one (2%) had no formal education. Thirty (60%) patients had monthly family income between one and three minimum wages, while 12 (24%) received more than three minimum wages and eight (16%) received up to one minimum wage. Regarding lifestyle at the time of the interview, 37 (74%) patients did not engage in physical activity, 28 (56%) denied being smokers, and 30 (60%) did not consume alcohol.

Forty-one (83.7%) patients with DM type 2 and nine (18%) patients with DM type 1 were identified. The self-reported mean capillary glycemia was 153.6 (± 51.2). Among the associated illnesses, systemic arterial hypertension was predominant in 42 (84%) patients, followed by dyslipidemia in 41 (82%) patients. Regarding the lesions, 38 (76%) patients had four or more non-ulcerated lesions, the most common being nail dystrophy (Figure 1) and calcaneal hyperkeratosis (Figure 2). In addition, 18 (36%) patients had ulcers (Figure 3), and 13 (26%) patients had some amputation (Figure 4).

Regarding mobility, 35 (70%) patients walked without assistance, eight (16%) required assistance to walk, and seven (14%) used a wheelchair.

The assessment of quality of life by domains is presented in Table 1.

At the end of the questionnaire, the patients answered two questions about overall quality of life (questions 28 and 29). The frequencies and percentages of patient's responses to these two final questions are presented in Table 2.

Figure 1. A 68-year-old female patient with DM type 2, insulin-dependent, presenting with toenail deformities associated with nail dystrophy.

Figure 2. A 76-year-old female patient with DM type 2, on metformin and dapagliflozin (Forxiga®), presenting with calcaneal hyperkeratosis.

From the responses obtained for each of the demographic and clinical variables analyzed, as well as for the domain scores and the overall score, the null hypothesis that the scores are the same for all variable classifications was tested against the alternative hypothesis that the scores differ. Among all analyses, three variables stood out: amputation, physical activity, and ulcer, in which statistically significant differences were found in the quality of life domains ($p < 0.05$).

The results showed a significant difference between patients with and without amputation in the domains of limitations in daily activities, interpersonal problems, emotional distress, and overall quality of life. In these domains, it was observed that the mean scores were higher for patients with amputation, indicating a poorer quality of life for this group (Table 3).

Figure 3. A 69-year-old male patient with DM type 2, on metformin and dapagliflozin (Forxiga®), presenting an ulcer in the plantar region of the left hallux (3A) and left calcaneal region (3B).

Patients who did not practice physical activity had worse scores in sensorimotor symptoms, limitations in daily activities, interpersonal problems, emotional distress, and overall quality of life (Table 4). Their mean scores were higher in all domains, indicating poorer quality of life; however, this difference was not statistically significant in pain and loss/reduction of sensitivity domains.

Figure 4. A 60-year-old female patient, DM type 2, insulin-dependent, with several years of evolution, presenting with gangrene of the right second toe (4A) and postoperative status (4B).

Table 1. Quality of life scores by domains and overall assessment

Domain	n	Mean	Median	Minimum	Maximum
Pain	50	4.8	4.1	1	15
Loss/reduction of sensitivity	50	5.2	3.7	1	15
Sensorimotor symptoms	50	9.3	9.7	4.7	15
Limitations in daily activities	50	8.2	9.0	1	15
Interpersonal problems	50	8.0	8.6	1	15
Emotional distress	50	5.5	4.8	1	13
Overall	50	6.3	6.4	1.6	12

*Higher values indicate poorer quality of life, ranging from 1 to 15.

Table 2. Overall quality of life

Questions	Classification	n	%
Question 28 Overall, my foot problems greatly decreased my quality of life	Very much	13	26%
	Very	12	24%
	Moderately	8	16%
	A little	8	16%
	Not at all	9	18%
Question 29 Overall, I rate my quality of life as:	Excelent	3	6%
	Very good	5	10%
	Good	23	46%
	Fair	16	32%
	Poor	3	6%

*Percentages represent the perception of quality of life related to diabetic foot (response 28) and the overall perception of quality of life (response 29).

On the other hand, patients with ulcers had worse scores in sensorimotor symptoms, limitations in daily activities, interpersonal problems, emotional distress, and overall quality of life (Table 5).

Table 3. Association of amputation and quality of life

Domain*	Amputation	n	Mean	Median	Minimum	Maximum	p*
Pain	No	37	5.0	4.6	1	15	
	Yes	13	4.1	3.6	1.6	8	0.413
Loss/reduction of sensitivity	No	37	4.8	3.7	1	14	
	Yes	13	6.3	5	1	15	0.657
Sensorimotor symptoms	No	37	8.8	9	4.7	15	
	Yes	13	10.5	10.7	4,7	15	0.100
Limitations in daily activities	No	37	6.8	7.5	1	15	
	Yes	13	12.2	15	3	15	0.001
Interpersonal problems	No	37	6.8	6.5	1	15	
	Yes	13	11.6	12	5.8	15	0.001
Emotional distress	No	37	4.9	4	1	13	
	Yes	13	7.0	7.9	2	13	0.046
Overall	No	37	5.8	5.4	1.6	12	
	Yes	13	7.6	7.4	4.5	10.3	0.025

*Higher values indicate poorer quality of life, ranging from 1 to 15; Mann-Whitney non-parametric test, $p < 0.05$.

Table 4. Association of physical activity and quality of life

Domain*	Physical activity	n	Mean	Median	Minimum	Maximum	p*
Pain	No	37	5.1	4.4	1	15	
	Yes	13	3.8	3.7	1	7.3	0.232
Loss/reduction of sensitivity	No	37	5.8	4.7	1	15	
	Yes	13	3.3	2	1	10.3	0.296
Sensorimotor symptoms	No	37	10	10.3	4.7	15	
	Yes	13	7.2	6.3	4.7	15	0.008
Limitations in daily activities	No	37	9.4	9	1	15	
	Yes	13	4.7	2.5	1	12	0.003
Interpersonal problems	No	37	9.4	10.8	1	15	
	Yes	13	4.3	3	1	10.3	< 0.001
Emotional distress	No	37	6.5	6.6	1	13	
	Yes	13	2.4	2	1	7.4	< 0.001
Overall	No	37	7.1	7.4	2.1	12	
	Yes	13	3.9	3.3	1.6	6.4	< 0.001

*Mann-Whitney non-parametric test, $p < 0.05$.

Table 5. Association of ulcer and quality of life

Domain	Ulcer	n	Mean	Median	Minimum	Maximum	p*
Pain	No	32	4.9	4.3	1	15	
	Yes	18	4.5	4	1	11.3	0.746
Loss/reduction of sensitivity	No	32	4.3	3.7	1	14	
	Yes	18	6.8	5.5	1	15	0.411
Sensorimotor symptoms	No	32	8.4	7.8	4.7	15	
	Yes	18	10.7	10.3	4.7	15	0.025
Limitations in daily activities	No	32	7	7.5	1	15	
	Yes	18	10.3	12.3	1	15	0.026
Interpersonal problems	No	32	7	7	1	15	
	Yes	18	9.9	11.3	1	15	0.028
Emotional distress	No	32	4.8	4	1	13	
	Yes	18	6.7	7.9	1	13	0.048
Overall	No	32	5.7	5.5	1.6	12	
	Yes	18	7.4	7.4	2	12	0.036

*Mann-Whitney non-parametric test, $p < 0.05$.

Discussion

Studies show that most diabetic patients with foot ulcers are between 50 and 79 years old, and advanced age and long time living with diabetes increase the risk of foot complications, including amputations[7,8]. A study conducted in South Korea revealed that patients of low socioeconomic status with diabetic foot ulcers had significantly higher rates of amputation and mortality[9].

Our study revealed a patient profile consistent with the literature: older individuals (mean age of 70 years) with a long-standing diagnosis (mean of 26 years), predominance of type 2 DM (83.7%), low socioeconomic status (38 patients with family income up to three minimum wages) and educational status (31 patients until complete elementary school), high number of foot injuries (38 patients with four or more injuries) and prolonged follow-up at the outpatient clinic (44 patients with more than 24 months of follow-up).

A 2019 systematic review identified 31 studies using questionnaires related to diabetes, validated for Brazilian Portuguese, that covered various populations and areas of interest. Specifically, regarding quality of life, seven questionnaires were identified[10]. The NEUROQOL questionnaire used in this study stands out for being directed at people who present signs and symptoms of peripheral diabetic neuropathy, marking the first documented application in Brazilian studies following the validation of its translation version.

In the study by Xavier et al.[6] (2011), which translated the NEUROQOL questionnaire, the first application of this questionnaire was conducted to verify its properties. The evaluation included 50 patients with a mean age of 56 years and low education, a different pattern from the original study performed in North America and the United Kingdom in these aspects. Thus, it was found that the questionnaire had properties that allowed it to be used as a valid instrument. However, due to the variety of cultures and realities in the different regions of Brazil, it would be necessary to conduct a second phase to confirm the questionnaire's ability to evaluate patients.

The results of the questionnaires used in this study showed a significant impact on the patient's quality of life, particularly in domains related to sensorimotor symptoms, limitations in daily activities, interpersonal problems, and emotional distress. This impact was more evident among patients with amputations, foot ulcers, and lack of physical activity.

Studies indicate that diabetic patients in need of amputation report emotional distress, economic stress, body image disorders, reduced mobility, and physical limitations that often lead to loss of independence[11,12], which can indirectly affect their interpersonal relationships. In line with evidence from previous studies, the results of this study indicate that patients with amputations due to diabetic complications had higher scores in most domains of the quality of life questionnaire. There was statistical significance in four of the six domains analyzed: sensorimotor symptoms, limitations in daily activities, interpersonal problems, and emotional distress, as well as the overall assessment, indicating poorer quality of life in these patients.

Regarding foot ulcers, the study by Byrnes et al.[13] (2024) provides a detailed analysis of the relationship between diabetic foot ulcers and quality of life. This multicenter cross-sectional study evaluated health-related quality of life in patients with various health conditions related to diabetic foot ulcers, including those with healed, uninfected, infected, hospitalized, and amputated ulcers. Among the patients participating in the study, it was observed that all health conditions related to diabetic foot ulcers resulted in a significant reduction in quality of life, with the greatest reductions noted in patients with infected ulcers. The data from our study corroborate these results, as the 18 (36%) patients with foot ulcers had poorer quality of life. These patients had higher scores in the domains related to sensorimotor symptoms, limitations in daily activities, interpersonal problems, emotional distress, and overall assessment compared to patients without ulcers.

The practice of physical activity has a positive impact on the quality of life of people with diabetic foot, as shown by several studies. International guidelines recommend exercise programs targeting the foot and ankle in individuals at risk of developing the disease, with evidence of improvements in the functionality of these regions and in gait biomechanics[14]. In addition, higher exercise volumes are associated with benefits such as improved plantar microcirculation and reduced plantar tissue stiffness, without increasing the risk of ulcers[15]. Among the patients in our study, only 13 (26%) practiced regular physical activity, and these individuals had lower scores in all domains of the quality of life questionnaire, suggesting that their quality of life was better than those who did not practice physical activity, which agrees with the data in the literature.

As a limitation of our study, it is worth noting that the application of the NEUROQOL questionnaire was challenging for the patient population treated at the outpatient clinic due to the complexity of some questions, particularly those related to the concept of quality of life. This factor may explain the results observed in the last two questions of the instrument. Although most participants indicated that foot problems greatly decreased their quality of life (question 28), they still rated their overall quality of life as good (question 29).

The present study reinforces the importance of deepening knowledge about the quality of life in patients with diabetic foot, emphasizing the need for personalized interventions to mitigate the negative impacts of diabetic foot on overall health and well-being. Other relevant correlations, which were not explored in this study, can be investigated in future studies.

Conclusion

Our study demonstrated that the quality of life of diabetic patients treated at the diabetic foot outpatient clinic of

CHC-UFPR is significantly affected by diabetes-related complications, such as ulcers and amputations. These complications are associated with deterioration in functional and emotional well-being domains, including sensorimotor symptoms, limitations in daily activities, and emotional distress.

Furthermore, the lack of physical activity was identified as a significant risk factor negatively impacting multiple domains of quality of life. These findings reinforce the importance of interventions that promote mobility and health education, highlighting the protective role of physical activity in managing patients with diabetic foot.

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References

1. Petersmann A, Müller-Wieland D, Müller UA, Landgraf R, Nauck M, Freckmann G, et al. Definition, Classification and Diagnosis of Diabetes Mellitus. Exp Clin Endocrinol Diabetes. 2019;127(S 01):S1-S7.
2. Sun H, Saeedi P, Karuranga S, Pinkepank M, Ogurtsova K, Duncan BB, et al. IDF Diabetes Atlas: Global, regional and country-level diabetes prevalence estimates for 2021 and projections for 2045. Diabetes Res Clin Pract. 2022;183:109119. Erratum in: Diabetes Res Clin Pract. 2023;204:110945.
3. BRASIL. Manual do pé diabético: estratégias para o cuidado da pessoa com doença crônica [Internet]. Ministério da Saúde: Secretaria de Atenção à Saúde; 2016 [cited 2023 Aug 20]. Available from: http://www.as.saude.ms.gov.br/wp-content/uploads/2016/06/manual_do_pe_diabetico.pdf.
4. Coffey L, Mahon C, Gallagher P. Perceptions and experiences of diabetic foot ulceration and foot care in people with diabetes: A qualitative meta-synthesis. Int Wound J. 2018;16(1):183-210.
5. Vileikyte L, Peyrot M, Bundy C, Rubin RR, Leventhal H, Mora P et al. The development and Validation of a Neuropathy - and Foot Ulcer-Specific Quality of Life Instrument. Diabetes Care. 2003;26(9):2549-55.
6. Xavier ATF, Foss MC, Junior WM, dos Santos CB, Onofre PTBN, Pace AE . Cultural adaptation and validation of the Neuropathy - and Foot Ulcer – Specific Quality of Life instrument (NeuroQol) for Brazilian Portuguese - Phase 1. Rev. Latino-Am. Enfermagem. 2011;19(6):1352-61.
7. Yao Y, Chen L, Qian Y. Age Characteristics of Patients With Type 2 Diabetic Foot Ulcers and Predictive Risk Factors for Lower Limb Amputation: A Population-Based Retrospective Study. J Diabetes Res. 2024;2024:2380337.
8. Al-Rubeaan K, Al Derwish M, Ouizi S, Youssef AM, Subhani SN, Ibrahim HM, et al. Diabetic foot complications and their risk factors from a large retrospective cohort study. PLoS One. 2015;10(5):e0124446.
9. Ha JH, Jin H, Park JU. Association between socioeconomic position and diabetic foot ulcer outcomes: a population-based cohort study in South Korea. BMC Public Health. 2021;21(1):1395.
10. Bottino LG, Madalosso MM, Garcia SP, Schaan BD, Teló GH. Diabetes-Specific Questionnaires Validated in Brazilian Portuguese: A Systematic Review. Arch Endocrinol Metab. 2020;64(2):111-20.
11. Pedras S, Vilhena E, Carvalho R, Pereira MG. Quality of Life Following a Lower Limb Amputation in Diabetic Patients: A Longitudinal and Multicenter Study. Psychiatry. 2020;83(1):47-57.
12. McDonald S, Sharpe L, Blaszczynski A. The psychosocial impact associated with diabetes-related amputation. Diabet Med. 2014; 31(11):1424-30.
13. Byrnes J, Ward L, Jensen S, Sagoo M, Charles D, Mann R, et al. Health-related quality of life in people with different diabetes-related foot ulcer health states: A cross-sectional study of healed, non-infected, infected, hospitalised and amputated ulcer states. Diabetes Res Clin Pract. 2024;207:111061.
14. van Netten JJ, Sacco ICN, Lavery L, Monteiro-Soares M, Paton J, Rasmussen A, Raspovic A, et al. Clinical and biomechanical effectiveness of foot-ankle exercise programs and weight-bearing activity in people with diabetes and neuropathy: A systematic review and meta-analysis. Diabetes Metab Res Rev. 2024;40(3):e3649.
15. Ren W, Duan Y, Jan YK, Ye W, Li J, Liu W, et al. Effect of Exercise Volume on Plantar Microcirculation and Tissue Hardness in People With Type 2 Diabetes. Front Bioeng Biotechnol. 2021;9:732628.

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Original Article

Translation, cultural adaptation, and validation of the AOFAS lesser metatarsophalangeal-interphalangeal scale into Brazilian Portuguese

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Abstract

Objective: Translate, culturally adapt, and evaluate the reproducibility of the American Orthopaedic Foot and Ankle Society (AOFAS) lesser metatarsophalangeal-interphalangeal scale into Brazilian Portuguese.

Methods: The AOFAS and SF-36 questionnaires were applied to 50 patients with lesser toes deformity. The methodology followed the criteria defined by Reichenheim & Moraes for translation and cultural adaptation of questionnaires.

Result: The intraclass correlation coefficient (ICC) across the domains was 0.96, and Cronbach's alpha was 0.80, both indicating excellent reliability. The scores of the first and second evaluations were 70.72 and 72.36, respectively, with high interobserver agreement and overlapping confidence intervals. Spearman's correlation analysis also yielded a correlation coefficient of 96%, indicating strong agreement among the applications of the test.

Conclusion: According to the established criteria, the translation and cultural adaptation of the questionnaire were conducted effectively, with very high interobserver agreement, and can be safely reproduced in Brazilian Portuguese.

Level of evidence IV; Case series.

Keywords: Toes; Questionnaires; Translation; Validation.

Introduction

Lesser toe deformities, including hammer, claw, and overlapping toes, affect more than 50% of patients evaluated in foot and ankle surgery services, resulting in pain, functional limitations, and considerable psychosocial repercussions[1,2].

Although minimally invasive corrective procedures have advanced in the last decade, the heterogeneity of techniques and success criteria makes it difficult to compare studies and clinical-surgical decision-making[3].

Lesser toe deformity, although often perceived as secondary, deserves attention due to its significant impact on the patient's quality of life[4]. Adequate treatment should be recommended in each case, and, for better results, a standardized instrument is essential to evaluate postoperative outcomes and achieve a universal comparison standard[5]. Additionally, a standardized criterion facilitates the development of new treatments within the subspecialty, allowing for a consistent approach among practitioners.

Study performed at the Faculdade de Medicina do ABC, Santo André, SP, Brazil.

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Faced with the demand for a model that helps compare the patient's quality of life, the American Orthopaedic Foot and Ankle Society (AOFAS) published a questionnaire that evaluates pain, function, and specific alignment of the lesser toes on a scale from 1 to 100. This questionnaire aims to quantify the impact of the disease on quality of life, monitor responses to treatment, compare interventions in clinical trials, and support evidence-based health policies[6]. Several cultures are validating this questionnaire to systematize the results of the studies and create better standardization of them[7,8]. Although an excellent questionnaire, it does not have translation and cultural validation into Portuguese for lesser toe deformity.

Foot and ankle pathologies directly influence the patient's quality of life and, in many cases, can generate disability, especially in older people and women. Thus, scoring exactly the benefits of each surgical technique to equalize and rationalize the choice becomes an essential task.

The objective of this study is to translate, culturally adapt, and evaluate the reproducibility of the AOFAS lesser metatarsophalangeal/interphalangeal (MTP/IP) scale questionnaire (Table 1) into Brazilian Portuguese, following the COSMIN protocols[9]. By providing a validated version, the aim is to facilitate multicenter research, assist in the selection of evidence-based surgical techniques, and, above all, improve the postoperative follow-up of patients with lesser toe deformities.

Methods

Study design and ethical approval

This is a study of translation, cross-cultural adaptation, and evaluation of the psychometric properties of the AOFAS lesser MTP/IP scale in Brazilian Portuguese. The study was approved by the Institutional Review Board under the number 285506820.6.0000.5442, following all its requirements. Thus, all participants signed free and informed consent forms.

Sample size

To estimate the test-retest reliability using the intraclass correlation coefficient (ICC), an expected ICC of 0.90, an acceptable minimum of 0.75, α = 0.05, and power of 80% were considered. According to the method of Walter et al.[10], a minimum of 46 subjects is required; we recruited 50 consecutive patients to compensate for potential losses. This number falls under Browne's recommendations for pilot/validation studies[10,11].

Study population (inclusion criteria)

Adults over 18 years with outpatient follow-up and clinical-radiographic diagnosis of symptomatic lesser toes deformity (hammer, claw, or overlap) under treatment in a tertiary hospital between 2023 and 2024 were included. Patients who did not have any impairment to answer the questionnaire and those who were using immobilizers or victims of acute trauma were excluded from the study (Figure 1). During the study, there were no exclusions or loss of follow-up in the reapplication of the questionnaires.

Table 1. AOFAS Lesser Metatarsophalangeal-Interphalangeal Scale

None	40
Mild, occasional	30
Moderate, daily	20
Severe, almost always present	0
Function (45 points)	
Activity limitations	
No limitations	10
No limitation of daily activities, limitation of recreation activities	7
Limited daily and recreational activities	4
Severe limitation of daily and recreational activities	0
Footwear requirements	
Fashionable, conventional shoes, no insert required	10
Comfort footwear, shoe insert	5
Modified shoes or brace	0
MTP joint motion (dorsiflexion plus plantarflexion)	
Normal or mild restriction (75° or more)	10
Moderate restriction (30° - 74°)	5
Severe restriction (less than 30°)	0
IP joint motion (plantarflexion)	
No restriction	5
Severe restriction (less than 10°)	0
MTP-IP stability (all directions)	
Stable	5
Definitely unstable or able to dislocate	0
Callus related to lesser MTP-IP	
No callus or asymptomatic callus	5
Callus, symptomatic	0
Alignment (15 points)	
Good, lesser toes well aligned	15
Fair, some degree of lesser toe malalignment observed, no symptoms	8
Poor, severe malalignment, symptoms	0
Total	100

Grading: Excellent=90-100points, Good = 75-89 points; Fair= 60-74 points; Poor =<60 points. AOFAS: American Orthopaedic Foot and Ankle Society.

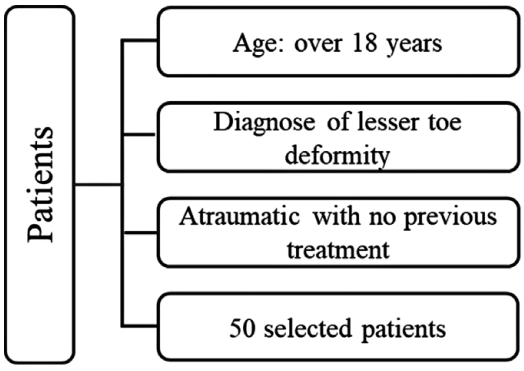

Figure 1. Patient selection.

Questionnaire translation and adaptation process

The process followed the COSMIN protocol, as described by Reichenheim and Moraes[9].

Direct translation: The questionnaire was translated by two independent Brazilian translators, who were aware of the objective of the study, ensuring that the translation was not only literal but also considered the context in which it would be applied. The disagreements would be resolved by a third translator-moderator, producing a consensual version. However, we did not observe significant divergences in translations.

Back-translation: After this step, two independent American translators were hired to perform the back-translation of the questionnaire, blind to the objective of the study, to minimize any tendency to accept an inadequate translation.

Expert committee: A team formed by for foot and ankle specialists, two physiotherapists, and an independent translator evaluated the patients' understanding of the questions and answers, to validate the translation processes (semantic, idiomatic, conceptual, and cultural equivalence) and the application of the questionnaire among Brazilian patients. This committee reached the final version of the translation (Table 2).

Instruments

Lesser MTP/IP scale, which consists of nine domains totaling 100 points: pain (40), function (10), footwear requirements (10), MTP amplitude (dorsiflexion and plantar flexion) (10), IP amplitude (plantar flexion) (5), MTP/IP amplitude (all directions) (5), calluses associated with hallux MTP/IP (5) and alignment (15).

Score interpretation is as follows: poor (< 60 points), fair (60-74 points), good (75-89 points), and excellent (90-100 points).

Application

The test was applied to 50 patients by two orthopedic examiners, specialized in foot and ankle, and submitted again 14 days later by one of the same examiners; thus, it was possible to obtain the interobserver and ICC.

These steps are illustrated in a flowchart for better understanding (Figure 2).

The 36-Item Short Form (SF-36) questionnaire (Quality of life), a validated Brazilian version, was used to obtain a correlation and measurement, which evaluates eight categories based on physical and emotional characteristics. This questionnaire consists of 36 items that evaluate functional capacity, physical aspects, pain, general health, vitality, social, emotional, and mental health[12].

Assessment of psychometric properties

The data obtained after the interviews were entered into Microsoft Excel software and subjected to statistical analysis to determine reliable correlation parameters. The significance level was set at 5%. For the statistical analysis, the R software (version 4.3.2, with the IRR and cart packages) was used.

Initially, a descriptive analysis was performed on all study variables. Qualitative variables were presented in terms of both their absolute and relative values, while quantitative variables were presented in terms of their central tendency and dispersion values. To guide the choice of sample similarity test, the Shapiro-Wilk test was used, which yielded values below 0.00001 for all variables, suggesting that the differences in the variables do not follow a normal distribution. Therefore, the Wilcoxon test was applied to compare the first

Table 2. Final questionnaire in Brazilian Portuguese - AOFAS Lesser Metatarsophalangeal-Interphalangeal Scale

Dor (40 pontos)	
Ausente	40
Leve, ocasional	30
Moderada, diária	20
Intensa, quase sempre presente	0
Função (45 pontos)	
Limitação das atividades	
Sem limitação	10
Sem limitação das atividades da vida diária, limitação das atividades do laser	7
Limitação das atividades da vida diária e do laser	4
Limitação grave das atividades da vida diária e do laser	0
Requisitos para calçados	
Calçados da moda, convencionais, sem palmilha	10
Calçados confortáveis, com palmilha 5	5
Calçados adaptados ou órtese 0	0
Amplitude da MTF (dorsiflexão e flexão plantar)	
Normal ou com restrição leve (75° ou mais)	10
Restrição moderada (30°–74°)	5
Restrição grave (menos de 30°)	0
Amplitude da IF (flexão plantar)	
Sem restrição	5
Restrição grave (menos de 10°)	0
Estabilidade da MTF/IF (todas as direções)	
Estável	5
Definitivamente instável ou passível de deslocar	0
Calos associados à MTF-IF do hálux	
Sem calos ou calo assintomático	5
Calo, sintomático	0
Alinhamento (15 pontos)	
Bom, dedos menores alinhados	15
Regular, observa-se certo grau de desalinhamento dos dedos menores, assintomático	8
Ruim, desalinhamento grave, sintomático	0
Total	100

Resultado: Excelente =90-100pontos; Bom= 75-89 pontos; Razoável:60-74 pontos; Ruim= ou < que 60 pontos. MTF:metatarsofalangeana/ IF: interfalangeana. MTF-IF: Metatarso-falangeana.

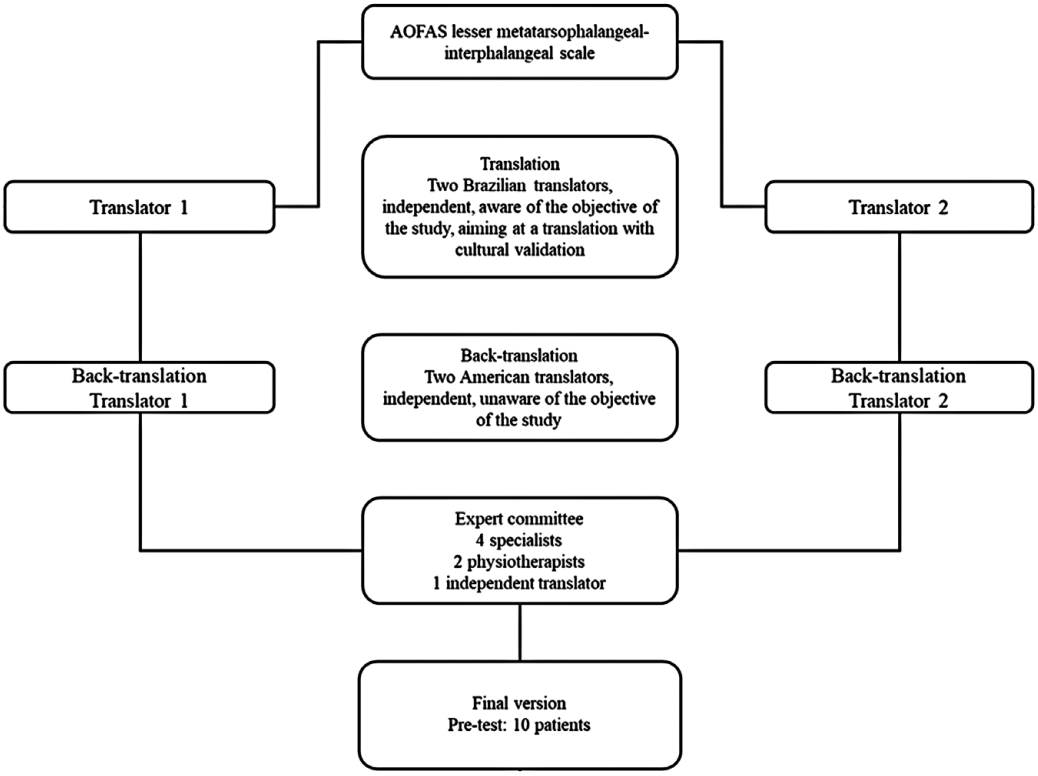

Figure 2. Questionnaire application flow chart.

and second values of each AOFAS domain, as it is a non-parametric test more suitable for our data.

To evaluate the correlation between the SF-36 and AOFAS domains, Spearman's correlation coefficient was used in both the first and second evaluations.

The ICC was used to evaluate the first and second AOFAS agreements for each domain, with their respective 95% confidence interval.

Results

The questionnaire was applied to 50 patients. Table 3 shows the descriptive analysis of the variables: age, sex, and diagnosis. The results show that most patients were women over 50 years with a diagnosis of lesser toe deformity associated with hallux valgus.

Table 4 shows the mean with standard deviation, the ICC coefficient with a 95% confidence interval, and the significance level. An excellent ICC was observed in all domains, with a total ICC of 0.96 (95% CI, 0.93-0.98). It is worth noting that the ICC is widely recognized as one of the most reliable metrics to assess the consistency and homogeneity of repeated measurements, as it encompasses both aspects. Regarding internal consistency, Cronbach's alpha for the total score was 0.80 (95% CI, 0.74-0.85), classified as "good," indicating adequate homogeneity among the domains. Values above 0.70 are generally considered acceptable for group-level comparisons, thereby reinforcing the instrument's reliability.

Table 3. Descriptive analysis

Variables	Total
Age (Years)	
Mean (SD)	66.5 (16.587)
Minimum-Maximum	18 - 85
Sex (N (%))	
Female	46 (92)
Male	4 (8)
Diagnosis (N (%))	
Hallux valgus	43 (86)
Others	7 (14)

SD: Standard deviation.

Table 5 shows the comparison of the first and second AOFAS results for each domain. The results showed no significant differences between the first and second evaluations, as determined by the Wilcoxon test, in each domain ($p > 0.05$). The variable "alignment" did not show any difference between the first and second evaluations, indicating high agreement between the samples in this domain. Therefore, we did not present the Wilcoxon test for this variable.

Table 4. Intraclass correlation coefficient analysis – AOFAS questionnaire

Domain	Pre Mean (SD)	Post Mean (SD)	ICC (95%CI)	p-value
Pain	28.2 (9.83)	29.2 (9)	0.93 (0.87; 0.96)	< 0.0001
Function	8.66 (2.27)	8.6 (2.28)	0.98 (0.97 – 0.99)	< 0.0001
Footwear requirements	6.3 (2.43)	6.5 (2.53)	0.92 (0.86 – 0.95)	< 0.0001
MTP amplitude	7.9 (3.36)	8.1 (3.18)	0.95 (0.92-0.97)	< 0.0001
IP amplitude	3.9 (2.09)	3.9 (2.09)	0.88 (0.8 – 0.93)	< 0.0001
MTP/IP amplitude	4.3 (1.75)	4.4 (1.93)	0.93 (0.87; 0.96)	< 0.0001
Calluses	2.9 (2.49)	3.1 (2.45)	0.92 (0.86 – 0.95)	< 0.0001
Alignment	8.56 (4.56)	8.56 (4.56)	1	
Total	70.72 (20.56)	72.36 (18.42)	0.96 (0.93-0.98)	< 0.0001

MTP: Metatarsophalangeal; IP: Interphalangeal; MTP/IP: Metatarsophalangeal-interphalangeal; 95%CI: 95% confidence interval; SD: Standard deviation; ICC: Intraclass correlation coefficient.

Table 5. Comparison between the first and second AOFAS questionnaire

	1st	2nd	p-value
Pain			0.08
Mean	28.2 (25.41-30.99)	29.2 (26.64-31.76)	
Standard deviation	9.83	9	
Minimum-maximum	0-40	0-40	
Function			1
Mean	8.66 (8.01-9.31)	8.6 (7.95-9.25)	
Standard deviation	2.27	2.28	
Minimum-maximum	0-10	0-10	
Footwear requirements			0.345
Mean	6.3 (5.61-6.99)	6.5 (2.53-5.78)	
Standard deviation	2.43	2.53	
Minimum-maximum	0-10	0-10	
MTP amplitude			0.345
Mean	7.9 (6.94-8.86)	8.1 (7.2-9)	
Standard deviation	3.36	3.18	
Minimum-maximum	0-10	0-10	
IP amplitude			1
Mean	3.9 (3.31-4.49)	3.9 (3.31-4.49)	
Standard deviation	2.09	2.09	
Minimum-maximum	0-5	0-5	
MTP/IP amplitude			1
Mean	4.3 (3.8-4.8)	4.4(3.85-4.95)	
Standard deviation	1.75	1.93	
Minimum-maximum	0-5	0-10	
Calluses			0.345
Mean	2.9 (2.19-3.61)	3.1(2.4-3.8)	
Standard deviation	2.49	2.45	
Minimum-maximum	0-5	0-5	
Alignment			
Mean	8.56 (7.26-9.86)	8.56(7.26-4.56)	
Standard deviation	4.56	4.56	
Minimum-maximum	0-15	0-15	
Total			0.031
Mean	70.72 (64.88-76.56)	72.36 (67.13-77.59)	
Standard deviation	20.56	18.42	
Minimum-maximum	9-100	9-100	

MTP: Metatarsophalangeal; IP: Interphalangeal; MTP/IP: Metatarsophalangeal-interphalangeal; 95%CI: 95% confidence interval; ICC: Intraclass correlation coefficient; p-value referent to Wilcoxon test

Table 6 shows the Spearman correlation analysis of the first and second AOFAS for each domain. A direct proportional correlation was observed between the first and second evaluations in each AOFAS domain.

Discussion

Injuries to the lesser toes often receive less attention in clinical research, yet they are of fundamental importance due to their significant impact on patients' lives[13]. Although the hallux is mainly responsible for support, the lesser toes are fundamental for distributing the load and total accommodation of the feet[14]. Treatments with limited results can lead to changes in the quality of life for patients and those with disabilities.

The definition of the best approach for each patient depends on instruments that assess progress and results over time, considering the patient's perspective, specifically, in foot pathologies, which have a significant impact on the patient's activities of daily living. With the numerous new techniques available, having a reliable comparison system allows for better choices and results[15].

The AOFAS scale is widely used to evaluate outcomes after treatment of ankle and foot injuries. Considering that the patient's perspective is essential for this evaluation, translation and cultural adequacy become crucial to maintaining the reliability of the results[16].

Literal translation is a possibility, but cross-cultural adaptation is crucial to ensure and facilitate accurate understanding and more reliable results.

It is important to mention that the AOFAS consists of an instrument that is subdivided into hindfoot and ankle, midfoot, hallux, and smaller toes. Translations and cultural adaptations into other languages are still lacking; however, the AOFAS hindfoot and ankle and AOFAS hallux are already available in Portuguese[5,17].

Our study had a predominantly female population (92%), with a mean age of 66.5 years, and 86% of the cases were related to hallux valgus. The data obtained agrees with the literature. Most atraumatic deformities of the lesser toes are related to hallux valgus, a pathology that is 2.3 times more common in women. In addition, since the lesser toe deformity is a pathology often secondary to hallux valgus, the mean age of the study may be higher than the age of diagnosis of hallux valgus[18].

The ICC evaluation showed extremely close agreement and a high reliability coefficient in the demonstrated tests. The high agreement between the examiners indicates that the questionnaire is prepared in a clear, objective, and easy-to-understand manner, both among researchers and patients.

The validation and cultural adaptation protocol follows a well-defined flowchart to ensure the quality and applicability of the translation process. These sequential steps ensure that different researchers found similar results when interviewing the same participant, which was achieved in our study.

When applying the questionnaire for the second time, the same researcher obtains results comparable to those from the first application for the same patient under the same evaluation conditions. According to the ICC criterion, all evaluated domains exhibit extreme agreement. In the Wilcoxon criterion, we observed a slight change in the evaluation of the pain domain, which is known to be a more subjective criterion.

The Persian language study published in 2018 for hindfoot and ankle is a good example showing reliability in the test-retest measured by the ICC of 0.853 ($p < 0.001$) and Pearson's correlation coefficient between AOFAS and SF-36, which validates and provides reliability to the translation process and cultural validation of the questionnaire in the studied population[19].

Conclusion

Our data contribute to demonstrating the importance of an evaluation instrument that allows comparisons to be made regarding the indicated treatments, thereby standardizing the evaluation and facilitating the development

Table 6. Spearman correlation of the first and second AOFAS for each domain

	Pain	Function	Footwear requirements	MTP amplitude	IP amplitude	MTP/IP amplitude	Calluses	Alingnment	Total
Pain	0.95**	0.5**	0	0.45**	0.12	0.34*	0.42**	0.14	0.78**
Function	0.55**	0.97**	-0.07	0.48**	0.25	0.64**	0.1	0.21	0.61**
Footwear requirements	-0.01	0.01	0.92**	0.11	0.3*	0.27	0.35*	-0.04	0.23
MTP amplitude	0.41**	0.54**	0.25	0.96**	0.51**	0.6**	0.47**	0.25	0.69**
IP amplitude	0.03	0.35*	0.33*	0.55**	0.88**	0.6**	0.38**	0.4**	0.47**
MTP/IP amplitude	0.37**	0.63**	0.34*	0.5**	0.48**	0.94**	0.4**	0.34*	0.59**
Calluses	0.36**	0.12	0.51**	0.44**	0.33*	0.38**	0.92**	0.32*	0.68**
Alignment	0.02	0.22	0.09	0.23	0.24	0.24	0.25	1**	0.4**
Total	0.71**	0.54**	0.29*	0.61**	0.42**	0.5**	0.65**	0.45**	0.96**

MTP: Metatarsophalangeal; IP: Interphalangeal; MTP/IP: Metatarsophalangeal-interphalangeal.

of new therapeutic approaches. Our study found very high interobserver agreement, demonstrating that the translation of the AOFAS lesser metatarsophalangeal-interphalangeal scale into Brazilian Portuguese can be used for clinical evaluations and studies aimed at comparing the quality of life of patients during treatment.

Authors' contributions: Each author contributed individually and significantly to the development of this article: TAA *(https://orcid.org/0000-0002-3008-7069) Interpreted the results of the study, formatting of the article, and wrote the article; BRM *(https://orcid.org/0000-0002-5306-2972) Conceived and planned the activities that led to the study, and bibliographic review; HCC *(https://orcid.org/0009-0000-6104-4064) Bibliographic review and performed data collection; AMS *(https://orcid.org/0000-0002-3067-3279) Performed data collection; FCLS *(https://orcid.org/0000-0003-4925-8101) Performed data collection; ADPF *(https://orcid.org/0000-0001-5808-1788) Performed data collection; FCPFF *(https://orcid.org/0000-0002-8907-0472) Participated in the review process; DRCN *(https://orcid.org/0000-0003-0227-2440) Participated in the review process; TRN *(https://orcid.org/0009-0001-0282-5001) Statistical analysis; RSB *(https://orcid.org/0000-0002-2870-2261) Participated in the review process. All authors read and approved the final manuscript. *ORCID (Open Researcher and Contributor ID).

References

1. Kim KC, Schmidt E, de Carvalho KAM, Lalevee M, Mansur N, Dibbern K, et al. Prevalence of midfoot arthritis and lesser toe deformities. Foot Ankle Surg. 2024;30(5):423-31.
2. Menz HB, Lord SR. Foot pain impairs balance and functional ability in community-dwelling older people. J Am Podiatr Med Assoc. 2001;91(5):222-9.
3. Mattingly AS, Chen MM, Divi V, Holsinger FC, Saraswathula A. Minimally Invasive Surgery in the United States, 2022: Understanding Its Value Using New Datasets. J Surg Res. 2023;281:33-6.
4. Katsambas A, Abeck D, Haneke E, van de Kerkhof P, Burzykowski T, Molenberghs G, et al. The effects of foot disease on quality of life: results of the Achilles Project. J Eur Acad Dermatol Venereol. 2005;19(2):191-5.
5. Rodrigues RC, Masiero D, Mizusaki JM, Imoto AM, Peccin MS, Cohen M, et al. Translation, cultural adaptation and validation of the "American Orthopaedic Foot and Ankle Society (AOFAS) Ankle-Hindfoot Scale." Acta Ortop Bras. 2008;16(2):107-11
6. Kitaoka HB, Alexander IJ, Adelaar RS, Nunley JA, Myerson MS, Sanders M. Clinical rating systems for the ankle-hindfoot, midfoot, hallux, and lesser toes. Foot Ankle Int. 1994;15(7):349-53.
7. Leigheb M, Janicka P, Andorno S, Marcuzzi A, Magnani C, Grassi F. Italian translation, cultural adaptation and validation of the "American Orthopaedic Foot and Ankle Society's (AOFAS) ankle-hindfoot scale". Acta Biomed. 2016;87(1):38-45.
8. Kostuj T, Krummenauer F, Schaper K, Stief F, Zettersten K, Baums MH, et al. Analysis of agreement between the German translation of the American Foot and Ankle Society's Ankle and Hindfoot Scale (AOFAS-AHS) and the Foot Function Index in its validated German translation by Naal et al. (FFI-D). Arch Orthop Trauma Surg. 2014;134(9):1205-10.
9. Reichenheim ME, Moraes CL. Operacionalização de adaptação transcultural de instrumentos de aferição usados em epidemiologia. Revi Saúde Pública. 2007;41(4):665-73.
10. Walter SD, Eliasziw M, Donner A. Sample size and optimal designs for reliability studies. Stat Med. 1998;17(1):101-10.
11. Browne RH. On the use of a pilot sample for sample size determination. Stat Med. 1995;14(17):1933-40.
12. Ciconelli RM, Ferraz MB, Santos W, Meinão I, Quaresma MR. Brazilian-Portuguese version of the SF-36. A reliable and valid quality of life outcome measure. Rev Bras Reumatol. 1999; 39(4):143-50
13. Mann TS, Nunes GA. Rheumatoid Deformities of the Lesser Toes. Foot Ankle Clin. 2024;29(4):629-44.
14. Del Vecchio JJ, Dalmau-Pastor M. Anatomy, Biomechanics, and Pathogenesis of the Lesser Toes Deformities. Foot Ankle Clin. 2024;29(4):557-69.
15. Cordier G, Nunes GA. Minimally Invasive Advances: Lesser Toes Deformities. Foot Ankle Clin. 2020;25(3):461-78.
16. Molano Castro JD, Sardoth Álvarez R, Franco Betancur A, Vargas Montenegro GE. Translation, Cultural Adaptation, and Validation of the American Orthopedic Foot and Ankle Society Scale in Patients With Hallux Valgus in Colombia. J Foot Ankle Surg. 2023;62(3):511-18.
17. Miranda BR de, Loures PF, Azevedo Degani R, Emboz JNM, Oliveira LZ, Freitas ADP de, et al. Translation of AOFAS Hallux Metatarsophalangeal- Interphalangeal Scale into Portuguese. J Foot Ankle. 2024;18(1):95-100.
18. Mann R. Mann's Surgery of the Foot and Ankle. 9th ed. Philadelphia: Elsevier; 2014.
19. Vosoughi AR, Roustaei N, Mahdaviazad H. American Orthopaedic Foot and Ankle Society ankle-hindfoot scale: A cross-cultural adaptation and validation study from Iran. Foot Ankle Surg. 2018;24(3):219-23.

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Original Article

The bright side of high-heeled shoes

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Abstract

Objective: Wearing high heels is a common practice, especially among urban women, and is part of the social and professional environment for many people. Research on the subject often focuses on the harmful health effects of high heels, including discomfort and pain, musculoskeletal disorders, and foot deformities. Since few studies have assessed the subjective effects of high heels, the objective of this study was to investigate why people wear them or not.

Methods: A cross-sectional, quantitative study was conducted using an online self-administered questionnaire that covered the participants' profiles and reasons they wear or do not wear high heels. The convenience sample consisted of skeletally mature cisgender and transgender women aged ≥ 18 years. Data were collected between November 2023 and March 2024.

Results: A total of 1100 responses were obtained, with a final sample of 801 participants. The variables significantly associated with wearing high heels were age, education, profession, approximate family income, and nutritional status. The reasons for wearing high heels included aesthetics (~80%), feeling more beautiful (63%), better professional appearance (54%), and improved self-esteem (47%).

Conclusion: Most participants wear high heels for aesthetic reasons, and more than half of those reported feeling more beautiful and feeling more professionally dressed. Although most participants who wear high heels experience pain (66%), there are still good subjective reasons to continue wearing them. Among those who reported not wearing high heels, the main reason was foot pain or discomfort.

Level of evidence II; Cross-sectional, quantitative study.

Keywords: Deformities, Foot; Pain; Motivation.

Introduction

The act of wearing shoes has a long history and is widespread throughout the world. The use of high heels, mainly by women, is now commonplace in social and professional settings. It is estimated that approximately 59% of women wear high-heeled shoes for varying amounts of time (1 to 8 hours) daily[1].

Studies have often associated high-heeled shoes with painful symptoms and lower limb problems. When walking in high heels, stride length, balance, and muscular efficiency are altered, which can lead to disorders in the feet, ankles, knees, and lumbar spine, and can cause pain and muscle fatigue[2,3]. A study evaluating ten years of medical records in hospital emergency rooms in the United States found an overall high-heeled-related injury rate of 7.32 per 100,000 women, mainly involving foot or ankle sprains, with the highest rate among young adult women (20-29 years old)[4].

However, other studies have found that wearing high heels benefits women, including improved posture, elegance due to a secondary increase in lumbar curvature, and, consequently, greater attractiveness[5-8]. Another study demonstrated that daily and prolonged use (≥ 8 hours) has a protective effect on pelvic floor function[7].

High heels are thus associated with both negative and positive health and well-being outcomes. No study, however, has evaluated the profile of women who wear high heels

Study performed at Hospital Moinhos de Vento, Porto Alegre, RS, Brazil.

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or their reasons behind it, despite the plethora of disorders associated with this habit. Therefore, the objective of this study is to identify who uses this type of footwear and the reasons behind their use.

Methods

Study design and population

This cross-sectional study collected data through an online self-report questionnaire. Participants accessed the questionnaire through a public link disseminated in the involved institution's internal network and the social network of each author. Data were collected between November 2023 and March 2024. Participants were included only after providing written informed consent. This study was approved by the Institutional Review Board.

Skeletally mature (≥ 18 years of age) cisgender and transgender women who wear high heels or not were included. Individuals identifying as male, those who did not complete the questionnaire, and those under 18 years of age were excluded.

Variables

The study outcome was the use or non-use of high heels. The exposure variables were frequency of use, heel type, and reasons for use. The covariates, also used to outline the population demographics including sex (cisgender/transgender women), age (categorized into quartiles: 18-33, 34-41, 42-50, > 50 years), race (self-reported and categorized as: White/Asian, Black, Mixed/indigenous), education (categorized as ≤ high school, incomplete university, complete university, or graduate school), nutritional status according to body mass index (weight/height^2): underweight (< 18.5 kg/m^2), normal weight (18.5 to 25 kg/m^2), overweight (25 to < 30 kg/m^2); obese (≥ 30 kg/m^2) and height (short: < 1.60 m; medium: 1.60 to 1.70 m; tall: > 1.70 m)[9].

The REDCap-HMV platform was used for data collection, storage, and management[10,11].

Statistical analysis

Categorical data were presented as absolute and relative frequency, while continuous variables were described using the mean (Standard deviation (SD)) or the median and interquartile range, depending on the data distribution. The chi-square test was used to determine the association between the variables of interest. When an association between the variables was identified, analysis of standardized residuals was performed. The significance level was set at 5%. All analyses were performed in RStudio 4.3.11.

Results

The final sample consisted of 801 participants. The majority were cisgender women (95.93%), primarily between 18 and 33 years old (27.58%), White (88.18%), and with a graduate degree (57.64%) (Table 1). The mean age at which they began wearing high heels was 14.7 years (SD, 2.77).

Overall, 583 participants (73%) reported wearing high heels, and the characteristics associated with their use were: age 34-41 years ($p < 0.001$), income levels ($p < 0.001$), higher education level ($p < 0.001$), and normal weight ($p < 0.001$). However, age > 50 years ($p < 0.001$), lower education level ($p = 0.0031$), retirement ($p = 0.0289$), and overweight ($p < 0.001$) were associated with not wearing high heels (Table 2). Regarding height, it was observed that 75% of short women have the habit of wearing high heels, compared to 73.8% of women of average height and 67.9% of women of tall height.

Table 2 presents the user profile and their reasons for wearing high heels. Most participants wear high heels at least once a week (52.58%), alternate between low and high heels (40.76%), and prefer square heels (43.92%). Most participants wear high heels for aesthetic reasons (79.76%) and 21% to look taller. A significant percentage (63.46%) reported feeling more beautiful, 54.20% reported feeling more professionally dressed, and 16% felt happier with this item of clothing. Improved self-esteem and attractiveness were reported by 47% and 41.6% of the participants, respectively. Only 1.5% responded that they use high heels to protect their feet. An interesting fact is that 19.5% of the participants work or have worked in a company that recommended the use of high heels. Among the total, 37% responded that they have felt embarrassed at a social event for not wearing high heels. There was no difference in the habit of wearing high heels between cis women (551/755) and trans women (23/32) ($p > 0.999$). However, 66.67% reported that wearing high heels causes pain, while 63% continue wearing them nonetheless. Among those who reported not wearing high heels, the main reason was foot pain or discomfort (69.72%), and 18.8% reported fear of ankle sprains (Table 3).

Discussion

Our study examined the shoe-wearing habits of women who wear high-heeled shoes and those who do not, as well as their reasons for doing it. The main sociodemographic variables associated with wearing high heels were age 34-41 years, a high education level, and a normal body mass index. The main reasons for wearing high heels were aesthetic and professional requirements, while the main reasons for not wearing them were foot pain or discomfort.

The fact that retired women do not wear heels may be due to their distance from the professional world and its dress standards. Overweight women may have greater difficulty wearing high heels, possibly due to greater discomfort from overloading the forefoot.

We also found that the mean age of first high-heeled shoe use was in adolescence (14.7 years), before reaching skeletal maturity, possibly due to improved self-esteem, and feeling happier, more beautiful, and attractive. However, early initiation of high-heel use can be harmful to health, as it can

Table 1. Overall participants' characteristics.

Variables	Total (N = 801)	Wear high heels (N = 583)	Does not wear high heels (N = 218)	p-value
Sex				
Woman - cisgender	755/787 (95.93)	551/574 (95.99)	204/213 (95.77)	> 0.999
Woman - transgender	32/787 (4.07)	23/574 (4.01)	9/213 (4.23)	
Age category				
18-33 years	214/776 (27.58)	163/569 (28.65)	51/207 (24.64)	< 0.001
34-41 years	181/776 (23.32)	147/569 (25.83)*	34/207 (16.43)	
42-50 years	192/776 (24.74)	146/569 (25.66)	46/207 (22.22)	
> 50 years	189/776 (24.36)	113/569 (19.86)	76/207 (36.71)*	
Race				
White	701/795 (88.18)	508/578 (87.89)	193/217 (88.94)	0.871
Black	26/795 (3.27)	20/578 (3.46)	6/217 (2.76)	
Mixed	68/795 (8.55)	50/578 (8.65)	18/217 (8.29)	
Education level				
≥ High School	59/798 (7.39)	31/582 (5.33)	28/216 (12.96)*	0.0031
University – incomplete	86/798 (10.78)	66/582 (11.34)	20/216 (9.26)	
University – complete	193/798 (24.19)	141/582 (24.23)	52/216 (24.07)	
Graduate degree	460/798 (57.64)	344/582 (59.11)	116/216 (53.70)	
Profession				
Retired	22/627 (3.51)	11/464 (2.37)	11/163 (6.75)*	0.0289
Exact and Earth Sciences	38/627 (6.06)	30/464 (6.47)	8/163 (4.91)	
Health Sciences	271/627 (43.22)	202/464 (43.53)	69/163 (42.33)	
Applied Social Sciences	214/627 (34.13)	162/464 (34.91)	52/163 (31.90)	
Linguistics, Literature, and Arts	27/627 (4.31)	16/464 (3.45)	11/163 (6.75)	
Civil service	22/627 (3.51)	20/464 (4.31)*	2/163 (1.23)	
Other	33/627 (5.26)	23/464 (4.96)	10/163 (6.13)	
Nutritional status				
Underweight	10/776 (1.29)	5/565 (0.88)	5/211 (2.37)	< 0.001
Normal weight	416/776 (53.61)	330/565 (58.41)*	86/211 (40.76)	
Overweight	227/776 (29.25)	158/565 (27.96)	69/211 (32.70)*	
Obese	123/776 (15.85)	72/565 (12.74)	51/211 (24.17)	
Height				
Short	205/779 (26.32)	154/570 (27.02)	51/209 (24.40)	0.3021
Medium	440/779 (56.48)	325/570 (57.02)	115/209 (55.02)	
Tall	134/779 (17.20)	91/570 (15.96)	43/209 (20.57)	

*Group with an association.

lead to postural disorders, including forward head posture, lumbar hyperlordosis, pelvic anteversion, and valgus knee[6].

The reasons for wearing high heels included aesthetic, professional, self-esteem, and attractiveness issues, which align with a study of Brazilian students who also described positive feelings from wearing high-heeled shoes, such as increased sensuality, power, elegance, and femininity[12]. The positive feelings associated with the use of high heels may explain why most women continue wearing them despite the pain[8,12].

In contrast, 27.21% of our respondents did not wear heels, either due to foot pain or discomfort, or due to fear of ankle sprains. It is not surprising, given that the association between high heels and foot deformities has been described[13,14].

This study has notable strengths, including the significant number of participants and the pioneering nature of the research in identifying the subjective benefits of wearing high heels as a non-drug therapy that can cause happiness and improve self-esteem. As with many other habits, moderation seems to be the best recommendation regarding high-heeled

Table 2. Characteristics of participants who wear high heels.

Variable	Total (N = 583)
Frequency of high heel use	
Rarely/ Only special events	171/582 (29.38)
≥ 1 a month	105/582 (18.04)
1-3 times a week	148/582 (25.43)
> 3 times a week	158/582 (27.15)
Heel height	
≤ 4 cm	173/579 (29.88)
> 5 cm	170/579 (29.36)
Both	236/579 (40.76)
Heel type	
Stiletto	78/576 (13.54)
Square	253/576 (43.92)
Platform	31/576 (5.38)
> 1 of the above	214/576 (37.15)
Reasons for using high heels	
To be taller	122/583 (20.93)
For aesthetic reasons	465/583 (79.76)
For comfort	35/583 (6.00)
Professional requirement	160/583 (27.44)
For foot protection	9/583 (1.54)
Feeling when wearing high heels	
Prettier	370/583 (63.46)
Happier	93/583 (15.95)
More attractive	243/583 (41.68)
Higher self-esteem	275/583 (47.17)
Feel more professional	316/583 (54.20)
No influence other than height	28/583 (4.80)

Table 3. Characteristics of participants who do not wear high heels.

Variable	Total (N = 801)
Reasons for not wearing high heels	
I don't think they're pretty	8/801 (1.00)
They are uncomfortable	152/801 (18.98)
I'm afraid of twisting my ankle	41/801 (5.12)
My spouse is my height or shorter	12/801 (1.50)
Other	60/801 (33.33)
Wearing high heels is painful	
Yes	386/579 (66.67)
No	193/579 (33.33)
I wear high heels despite the pain	
Yes	242/384 (63.02)
No	142/384 (36.98)

shoes. Our results contribute to understanding the reasons for the continued use of high-heeled shoes, despite their potential to cause discomfort or pain.

However, some study limitations must be acknowledged, including the use of a self-selection sampling technique and the online-only dissemination and completion of the questionnaire, which may have led to selection bias and prevented the generalization of the results to the general population.

Conclusion

Women who wear high heels are mainly young, have higher education and income levels, and most wear them for aesthetic reasons, because they feel prettier, more attractive, more professionally dressed, and with increased self-esteem. Although high-heel-related pain is quite prevalent, it is insufficient to outweigh the subjective benefits. Among those who reported not wearing high heels, the main reason was foot pain or discomfort.

Authors' contributions: Each author contributed individually and significantly to the development of this article: PIFV *(https://orcid.org/0009-0008-7949-2402), and PBZR *(https://orcid.org/0000-0002-1774-073X), and LHB *(https://orcid.org/0000-0002-2299-8452), and MMDS *(https://orcid.org/0000-0002-4291-1684), and JAVS *(https://orcid.org/0000-0002-6321-9566) Conceived and planned the activities that led to the study, interpreted the results of the study, participated in the review process, data collection, bibliographic review, formatting of the article; MPVS *(https://orcid.org/0000-0002-0177-8338) Conceived and planned the activities that led to the study, data collection, bibliographic review; KMS *(https://orcid.org/0000-0003-1697-1584) Conceived and planned the activities that led to the study, interpreted the results of the study, data collection, statistical analysis, formatting of the article; KNT *(https://orcid.org/0009-0005-6884-6832) Concieved and planned the activities that led to the study, bibliographic review. All authors read and approved the final manuscript. *ORCID (Open Researcher and Contributor ID).

References

1. Di Sipio E, Piccinini G, Pecchioli C, Germanotta M, Iacovelli C, Simbolotti C, et al. Walking variations in healthy women wearing high-heeled shoes: Shoe size and heel height effects. Gait Posture. 2018;63:195-201.
2. Wiedemeijer MM, Otten E. Effects of high heeled shoes on gait. A review. Gait Posture. 2018;61:423-30.
3. Cronin NJ, Barrett RS, Carty CP. Long-term use of high-heeled shoes alters the neuromechanics of human walking. J Appl Physiol. 2012;112(6):1054-8.
4. Moore JX, Lambert B, Jenkins GP. Epidemiology of high-heel shoes injuries in U.S. Women: 2002 to 2012. J Foot Ankle Surg. 2015;54(4):615-19.
5. Meskó N, Őry F, Csányi E, Juhász L, Szilágyi G, Lubics O, et al. Women walk in high heels: Lumbar curvature, dynamic motion stimuli and attractiveness. Int J Environ Res Public Health. 2021;18(1):299.
6. Silva AM, de Siqueira GR, da Silva GA. Implications of high-heeled shoes on body posture of adolescents. Rev Paul Pediatr. 2013;31(2):265-71.
7. Wang Y, Shi C, Jiao W, Yu W, Shi G, Zheng J. Wearing high heels with an appropriate height is protective for pelvic floor function. Transl Androl Urol. 2021;10(6):2493-9.
8. Lewis DMG, Russell EM, Al-Shawaf L, Ta V, Senveli Z, Ickes W, et al. Why women wear high heels: Evolution, lumbar curvature, and attractiveness. Front Psychol. 2017;8:1875.
9. Instituto Brasileiro de Geografia e Estatística (IBGE) [Internet]. Rio de Janeiro: Características Étnico-raciais da População Classificações e Identidades; 2013. [atualizado 2013; citado 2024 Set 13]. Disponível em: https://biblioteca.ibge.gov.br/visualizacao/livros/liv63405.pdf
10. Harris PA, Taylor R, Minor BL, Elliott V, Fernandez M, O'Neal L, et al. The REDCap consortium: Building an international community of software platform partners. J Biomed Inform. 2019;95:103208.
11. Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG. Research electronic data capture (REDCap)--a metadata-driven methodology and workflow process for providing translational research informatics support. J Biomed Inform. 2009;42(2):377-81.
12. Brito, GA. Uma análise acerca da Hegemonia dos sapatos de saltos altos ao longo da História. In: 9º colóquio de Moda-Fortaleza (CE); 2013; Fortaleza. Fortaleza: Silo.Tips; 2017. [citado 2025 May 29] Disponível em: https://silo.tips/download/uma-analise-acerca-da-hegemonia-dos-sapatos-de-saltos-altos-ao-longo-da-historia
13. Barnish MS, Barnish J. High-heeled shoes and musculoskeletal injuries: a narrative systematic review. BMJ Open. 2016;6(1):e010053.
14. Cronin, NJ. The effects of high heeled shoes on female gait: a review. J Electromyogr Kinesiol. 2014;24(2):258-63.

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Original Article

Clinical outcomes of proximal medial gastrocnemius release in the treatment of non-insertional Achilles tendinopathy

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Abstract

Objective: To evaluate the outcomes of proximal medial gastrocnemius release (PMGR), a procedure with relatively low morbidity, in the treatment of non-insertional Achilles tendinopathy.

Methods: Twelve patients diagnosed with non-insertional Achilles tendinopathy, confirmed by clinical examination and nuclear magnetic resonance imaging, and refractory to conservative treatment, were treated with PMGR. Five patients had bilateral involvement, totaling 17 tendons treated.

Results: After a mean follow-up of 32 months, the mean American Orthopaedic Foot and Ankle score increased from 62.1 preoperatively to 90.2 at last follow-up. The mean pain score on the visual analog scale decreased from 6.7 preoperatively to 1.9 at last follow-up. While some patients experienced residual pain, it was milder than preoperative pain in all cases, and all participants reported satisfaction after the treatment.

Conclusion: Despite the small sample size and short follow-up period, the results were promising. As PMGR is a relatively simple procedure compared to tendon reconstruction techniques, it may be an attractive alternative treatment for this common and disabling disorder.

Evidence Level: III; Type of Study: Retrospective study.

Keywords: Achilles tendon; Gastrocnemius muscle; Tendinopathy; Tendon release; Minimally invasive surgical procedures.

Introduction

The Achilles tendon, or calcaneal tendon, is the strongest tendon in the human body. Due to its critical role in gait, it is frequently affected by tendinosis[1]. It is estimated that up to 6% of the population will experience calcaneal tendon issues during their lifetime[2]. Non-insertional Achilles tendinopathy is characterized by degenerative and inflammatory histological changes, typically located 2-6 cm from the calcaneal insertion[3]. Contributing factors include shortening of the posterior chain, especially the gastrocnemius, as shown by the Silfverskiöld test. Gastrocnemius contracture is associated not only with Achilles tendinopathy but also with several lower extremity disorders[4-6]. Once tendinosis is established, it can severely impair gait and physical activity, leading to a sedentary lifestyle and its related consequences[7].

The optimal treatment remains a matter of debate. Current functional rehabilitation protocols, which primarily involve stretching exercises, yield inconsistent results and typically require a long period before noticeable clinical improvement occurs, posing a significant challenge for patient adherence. When conservative treatment fails, surgical intervention is indicated. Several techniques have been described, including tenoplasty with resection of the degenerated tissue, with or without tendon transfer reinforcement[8-11].

Study performed at the Hospital Moinhos de Vento, Porto Alegre, RS, Brazil.

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Open surgical techniques for tendinosis have shown reasonable success; however, they typically require non-weight-bearing and immobilization periods ranging from two to six weeks[10,12-15]. Proximal medial gastrocnemius release (PMGR) is a relatively simple procedure, performed under sedation and local anesthesia through a 15-20 mm incision in the posterior knee region, which does not require postoperative immobilization or non-weight-bearing of the operated limb. Some authors have described its success in the treatment of several foot and ankle disorders, including Achilles tendinopathy[16-27].

Studies have shown that medial gastrocnemius release in the calf region can alleviate ankle pain and improve function with an increase in ankle dorsiflexion range of motion. However, some reports indicate a potential for reduced strength, which makes PMGR at the level of the popliteal fossa a relatively safer alternative[28-33].

The objective of this study is to evaluate the outcomes of PMGR in improving pain and function in patients with non-insertional Achilles tendinopathy and gastrocnemius contracture.

Methods

A retrospective, observational, analytical study using medical records of adult patients submitted to PMGR for the treatment of non-insertional Achilles tendinopathy. This study was approved by the Institutional Review Board, and all research and methods were performed following the STROBE guidelines.

A convenience sample of 12 patients submitted to PMGR for non-insertional Achilles tendinopathy from January 2018 to June 2024 was analyzed. Inclusion criteria were age over 18 years, lack of improvement after at least six months of conservative treatment, clinical examination showing shortening of the posterior chain affecting the gastrocnemius (positive wrinkle sign in the Silfverskiöld test), and provision of written informed consent to participate in the study[34]. Exclusion criteria included the presence of systemic inflammatory disease or a history of prior surgery for non-insertional Achilles tendinopathy in the same lower extremity.

The sample included six female and six male patients, with a mean age of 58.5 years (range, 40-78) at the time of surgery. Three patients underwent surgery on the right side, four on the left side, and five bilaterally, totaling 17 operated feet. The mean postoperative follow-up was 23 months, ranging from six to 106 months.

Operative technique

After marking the surgical site with a surgical pen, the patient was placed in the prone position. Antisepsis was then performed on the posterior region of the knee to be operated on or both in cases requiring bilateral surgery. No tourniquet or prophylactic antibiotic therapy was used, and no anticoagulants were prescribed.

The center of the medial fovea of the popliteal region was marked with a dot, and a transverse incision of 15-20 mm was made 10 mm lateral to this point. Subcutaneous tissue was bluntly dissected, and the fascia was opened transversely to expose the proximal insertion of the medial gastrocnemius. A hook retractor or Mixter forceps was used to pull the tendon, further exposing its tendinous portion, which was then cut with a #15 or #12 scalpel blade (Figure 1). Hemostasis was performed as required. The subcutaneous fascia was closed with 3-0 Vicryl, and the skin with 4-0 Vicryl Rapide. The wound was closed using Steri-Strips only. No immobilization was used.

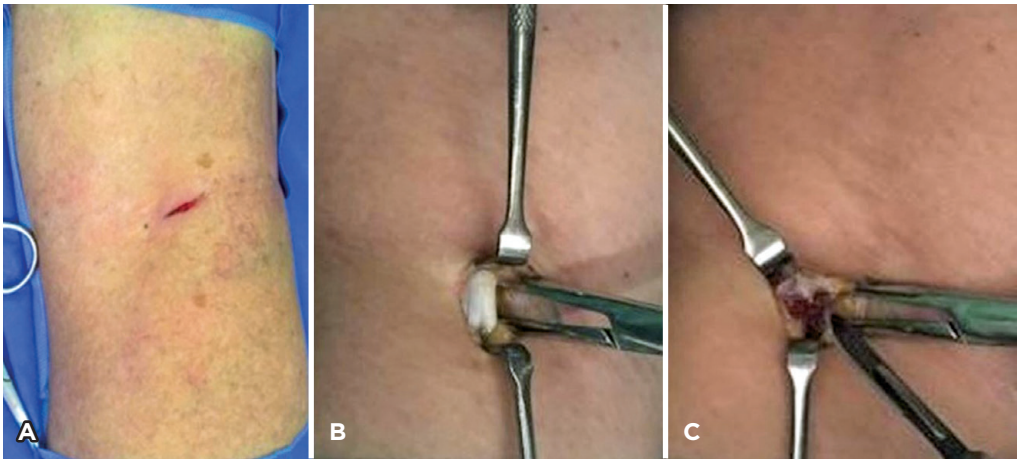

Figure 1. (A) Central marking on the medial fovea with a surgical pen. (B) Exposure of the gastrocnemius tendon with a Mixter forceps. (C) Final appearance after release of only the fascia, white fibers, of the medial gastrocnemius.

Postoperative protocol

The procedure was conducted in an outpatient setting. Postoperatively, patients were permitted to bear weight on the operated limb(s) as tolerated, initially using crutches. Patients were reassessed at 7 and 14 days, when a rehabilitation program was initiated, focusing on gait training and exercises to stretch the posterior chain.

All patients were reassessed regularly. Data were collected preoperatively and at the last postoperative assessment through an online questionnaire and in-person clinical evaluations and compared for all patients.

The American Orthopaedic Foot and Ankle Society (AOFAS) hindfoot scale, translated and validated for Portuguese, was used to conduct a functional assessment of the foot, evaluating patient-reported pain and function. The score ranges from 0 to 100, with 0 representing the worst and 100 the best possible outcome. Pain was assessed using the visual analog scale (VAS), and patient satisfaction with the surgery was measured using the question: "How satisfied are you with the surgery performed?" with answers of very satisfied, satisfied with some reservations, or dissatisfied.

Statistical analysis

Statistical analysis was performed using R version 4.3.1, with the RStudio interface version 2023.09.1+494. The Shapiro-Wilk test indicated that the data were not normally distributed; therefore, the results were compared using the medians in the Wilcoxon test.

Results

Over a mean follow-up period of 23 months, the mean AOFAS score increased from 62.1 preoperatively to 90.2 postoperatively, representing a mean improvement of 28.1. Pain levels, as measured by the VAS, showed a mean improvement of 4.8, decreasing from a mean preoperative score of 6.7 to a postoperative mean of 1.9. No patient was dissatisfied with the outcome of the procedure. No cases of superficial or deep infection, nerve injury, deep vein thrombosis, or suture dehiscence were observed.

Descriptive analysis

Figure 2 shows boxplots of the AOFAS and VAS score distributions before and after the intervention. The lines inside the boxes represent the medians for each group, and the interquartile ranges (IQR) are defined by the upper and lower quartiles. The increase in AOFAS scores and the decrease in VAS scores after the intervention suggest clinical improvement.

Table 1 shows the number and percentage for each category of the 'side' variable, as well as the median (IQR) for the numerical variables.

The median AOFAS increased by 21.5 points from preoperative to postoperative measurements, while the VAS decreased by 6 points. To assess the statistical significance, two Wilcoxon tests were conducted, as detailed below.

Hypothesis testing

The Wilcoxon test results, comparing pre- and postoperative scores, are shown in Table 2. The observed p-values (both < 0.05) indicate statistically significant differences in both AOFAS and VAS scales, suggesting a relevant change in scores following the intervention. These statistically significant improvements in scale responses reflect a notable reduction in pain after the operation.

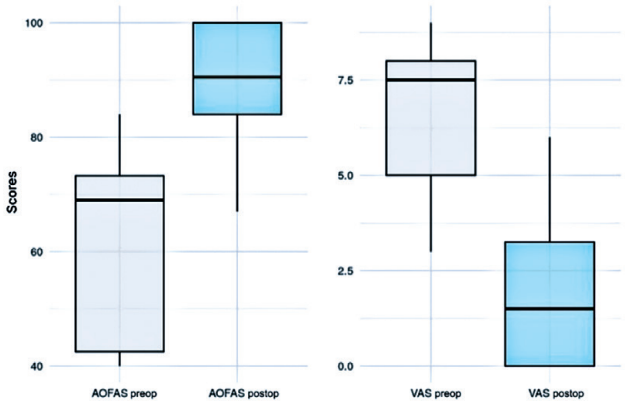

Figure 2. Boxplot of the pre- and postoperative scores.
AOFAS: American Orthopaedic Foot and Ankle Society; VAS: Visual analog scale.

Table 1. Description of database variables

Variable	n = 12
Side, n (%)	
Bilateral	5 (41.67)
Right	3 (25.00)
Left	4 (33.33)
AOFAS preoperative, median (IQR)	69 (42.50-73.25)
VAS preoperative, median (IQR)	7.5 (5-8)
AOFAS postoperative, median (IQR)	90.5 (84-100)
VAS postoperative, median (IQR)	1.5 (0-3.25)
Follow-up (months), median (IQR)	23 (10.75-36.5)

AOFAS: American Orthopaedic Foot and Ankle Society; IQR: Interquartile range; VAS: Visual analog scale.

Table 2. Wilcoxon test results

Scale	p
AOFAS	0.00218
VAS	0.00216

AOFAS: American Orthopaedic Foot and Ankle Society; VAS: Visual analog scale.

Discussion

Proximal medial gastrocnemius release is particularly effective in patients with gastrocnemius contracture confirmed on clinical examination and non-insertional tendinopathy. This aligns with the findings of our study, in which we used the surgical technique described by Barouk[35]. Tallerico et al.[32] reported excellent results in the treatment of insertional Achilles tendinopathy with gastrocnemius recession, noting that patients without spurs appear to achieve better results than patients with spurs. Gurdezi et al.[16] observed more significant improvement in non-insertional tendinopathy compared to insertional tendinopathy treated with isolated PMGR and also highlighted that PMGR might be less effective in patients without gastrocnemius contracture[6,31,32].

Maffulli and Kader[13] suggest that the benefits of PMGR arise from the reduced tensile stress on the Achilles tendon following the release, which can reverse pathological changes, decrease local inflammation, and support healing. Restoring ankle dorsiflexion and reducing tensile stress on the Achilles tendon are key factors for enhancing function, and PMGR not only alleviates pain but also restores muscle strength and function without compromising ankle biomechanics[6,12,13,18].

In our study, the median preoperative VAS score was 7.5 (IQR 5-8), decreasing to 1.5 (IQR 0-3.25) postoperatively. This represents a 6-point reduction on the VAS scale, indicating a significant improvement in pain after the intervention. This pain reduction aligns with the findings of Gurdezi et al.[16], who reported a median VAS reduction from 7.8 to 0.4 in patients with non-insertional tendinopathy.

The AOFAS score showed a median improvement of 21.5 after the procedure, increasing from a preoperative median of 69 to a postoperative median of 90.5. This improvement aligns with the findings of Gurdezi et al.[16], who reported a mean increase of 29% in the AOFAS score, from 61.8 to 91.2, in patients with non-insertional tendinopathy treated with PMGR.

Gentchos et al.[24] reported complete pain resolution following gastrocnemius recession at the calf level (Strayer procedure) for Achilles tendinopathy refractory to prolonged conservative treatment. Duthon et al.[17] also noted significant improvements in the AOFAS score after gastrocnemius release at the calf level for non-insertional Achilles tendinopathy. However, although a more distal release at the calf level may achieve gastrocnemius lengthening, it also carries a higher risk of reduced plantar flexion strength and impaired performance, which may be particularly risky for athletes[17,24,31].

Patient satisfaction was assessed using a satisfaction index, with 100% of patients being either very satisfied or satisfied with their results. This high satisfaction rate aligns with the findings of Gurdezi et al.[16], who also reported a high satisfaction rate (6 out of 9 patients) after PMGR. The absence of postoperative immobilization facilitates faster recovery and earlier return to activities, contributing to this high degree of patient satisfaction[16,18].

The results of our study, along with the reviewed literature, suggest that PMGR is an effective technique for the treatment of non-insertional Achilles tendinopathy, leading to improvements in both pain and function scores[5-27]. PMGR is a minimally invasive technique with low morbidity compared to traditional open surgical treatments, such as open Achilles tendon debridement. Open procedures are associated with higher complication rates due to the approach, the required immobilization, and the extended recovery period[10-15,30]. The incision in PMGR, made at the proximal insertion of the Achilles tendon, reduces the risk of complications related to wound healing, especially in patients with comorbidities such as diabetes or vascular insufficiency[16,25].

The main limitations of our study include the small sample size, the relatively short follow-up period, and the absence of a comparative treatment group. However, the results observed with PMGR are compelling. Given its minimally invasive nature and low complication rate, PMGR appears to be an excellent alternative and potentially the primary surgical option for managing non-insertional Achilles tendinopathy.

Conclusion

The results of our study, along with the reviewed literature, suggest that PMGR is a safe and effective treatment for non-insertional Achilles tendinopathy. The significant improvements observed in pain (VAS) and function (AOFAS) scores, alongside a 100% patient satisfaction rate, highlight the potential of PMGR for patients with gastrocnemius contracture who have not responded to conservative treatment.

Authors' contributions: Each author contributed individually and significantly to the development of this article: JAVS *(https://orcid.org/0000-0002-6321-9566) Cconceived and planned the activities that led to the study, interpreted the results of the study, participated in the review process, performed the surgeries, data collection, statistical analysis, bibliographic review, survey of the medical records, formatting of the article, and clinical examination; GEP *(https://orcid.org/0009-0007-8918-932X) Cconceived and planned the activities that led to the study, interpreted the results of the study, participated in the review process, data collection, bibliographic review, and formatting of the article; DP *(https://orcid.org/0009-0007-1220-7665) Interpreted the results of the study, participated in the review process, data collection, bibliographic review, and formatting of the article. All authors read and approved the final manuscript. *ORCID (Open Researcher and Contributor ID).

References

1. O'Brien M. The anatomy of the Achilles tendon. Foot Ankle Clin. 2005;10(2):225-38.
2. Morton, DJ. The human foot: its evolution, physiology and functional disorders. New York: Columbia University Press; 1935.
3. Kujala UM, Sarna S, Kaprio J. Cumulative incidence of Achilles tendon rupture and tendinopathy in male former elite athletes. Clin J Sport Med. 2005;15(3):133-5.
4. Jastifer JR, Marston J. Gastrocnemius contracture in patients with and without foot pathology. Foot Ankle Int. 2016;37(11):1165-70.
5. Cychosz CC, Phisitkul P, Belatti DA, Glazebrook MA, DiGiovanni CW. Gastrocnemius recession for foot and ankle conditions in adults: Evidence-based recommendations. Foot Ankle Surg. 2015; 21(2):77-85.
6. DiGiovanni CW, Kuo R, Tejwani N, Price R, Hansen ST Jr, Cziernecki J, et al. Isolated gastrocnemius tightness. J Bone Joint Surg Am. 2002;84(6):962-70.
7. Battery L, Maffulli N. Inflammation in overuse tendon injuries. Sports Med Arthrosc Rev. 2011;19(3):213-7.
8. Feilmeier M. Noninsertional Achilles tendinopathy pathologic background and clinical examination. Clin Podiatr Med Surg. 2017; 34(2):129-36.
9. Magnussen RA, Dunn WR, Thomson AB. Nonoperative treatment of midportion Achilles tendinopathy: a systematic review. Clin J Sport Med. 2009;19(1):54-64.
10. Pearce CJ, Tan A. Non-insertional Achilles tendinopathy. EFORT Open Rev. 2017;1(11):383-90.
11. Aicale R, Tarantino D, Maffulli N. Non-insertional Achilles tendinopathy: State of the art. In: Canata GL, d'Hooghe P, Hunt KJ, Kerkhoffs GMMJ, Longo UG, editors. Sports injuries of the foot and ankle: A focus on advanced surgical techniques. Berlin: Springer Berlin Heidelberg;2019. p. 359-67.
12. Maffulli N, Aicale R. Update on non-insertional Achilles tendinopathy. Fuß Sprunggelenk. 2019;17(4):248-56.
13. Maffulli N, Kader D. Tendinopathy of tendo achillis. J Bone Joint Surg Br. 2002;84(1):1-8.
14. Jarin I, Bäcker HC, Vosseller JT. Meta-analysis of noninsertional Achilles tendinopathy. Foot Ankle Int. 2020;41(6):744-54.
15. Paavola M, Orava S, Leppilahti J, Kannus P, Järvinen M. Chronic Achilles tendon overuse injury: complications after surgical treatment. An analysis of 432 consecutive patients. Am J Sports Med. 2000;28(1):77-82.
16. Gurdezi S, Kohls-Gatzoulis J, Solan MC. Results of proximal medial gastrocnemius release for Achilles tendinopathy. Foot Ankle Int. 2013;34(10):1364-9.
17. Duthon VB, Lübbeke A, Duc SR, Stern R, Assal M. Noninsertional Achilles tendinopathy treated with gastrocnemius lengthening. Foot Ankle Int. 2011;32(4):375-9.
18. Chimera NJ, Castro M, Manal K. Function and strength following gastrocnemius recession for isolated gastrocnemius contracture. Foot Ankle Int. 2010;31(5):377-84.
19. Laborde JM, Weiler L. Achilles tendon pain treated with gastrocnemius-soleus recession. Orthopedics. 2011;34(4):289-91.
20. Bull PE, Malloy McCoy AM, Thompson M, McGann MR, Berlet GC. The medial gastrocnemius release: A safe and effective alternative for treatment of isolated gastrocnemius contracture. Foot Ankle Orthop. 2022;7(1):24730114215S00123.
21. Arshad Z, Al Shdefat S, Iqbal AM, Bhatia M. Gastrocnemius release is an effective management option for Achilles tendinopathy: a systematic review. Knee Surg Sports Traumatol Arthrosc. 2022;30(12):4189-97.
22. White CJ, Seyed-Safi P, Ieong E, Rudge B. Gastrocnemius release in the treatment of Achilles tendinopathy: A systematic review. Indian J Orthop. 2024;58(5):470-83.
23. Molund M, Lapinskas SR, Nilsen FA, Hvaal KH. Clinical and functional outcomes of gastrocnemius recession for chronic Achilles tendinopathy. Foot Ankle Int. 2016;37(10):1091-7.
24. Gentchos CE, Bohay DR, Anderson JG. Gastrocnemius recession as treatment for refractory Achilles tendinopathy: a case report. Foot Ankle Int. 2008;29(6):620-3.
25. Saxena A, Widtfeldt A. Endoscopic gastrocnemius recession: preliminary report on 18 cases. J Foot Ankle Surg. 2004;43(5):302-6.
26. Kiewiet NJ, Holthusen SM, Bohay DR, Anderson JG. Gastrocnemius recession for chronic noninsertional Achilles tendinopathy. Foot Ankle Int. 2013;34(4):481-5.
27. Maffulli N, Del Buono A. Release of the medial head of the gastrocnemius for Achilles tendinopathy in sedentary patients: a retrospective study. Int Orthop. 2015;39(1):61-5.
28. Busquets R, Sanchez-Raya J, Sallent A, Maled I, Duarri G. Proximal medial gastrocnemius release: Muscle strength evaluation. Foot Ankle Surg. 2020;26(7):828-32.
29. DiLiberto FE, Nawoczenski DA, Tome J, DiGiovanni BF. Patient reported outcomes and ankle plantarflexor muscle performance following gastrocnemius recession for Achilles tendinopathy: A prospective case-control study. Foot Ankle Surg. 2020;26(7):771-6.
30. Rush SM, Ford LA, Hamilton GA. Morbidity associated with high gastrocnemius recession: retrospective review of 126 cases. J Foot Ankle Surg. 2006;45(3):156-60.
31. Chimenti RL, Cychosz CC, Hall MM, Phisitkul P. Current concepts review update: Insertional Achilles tendinopathy. Foot Ankle Int. 2017;38(10):1160-9.
32. Tallerico VK, Greenhagen RM, Lowery C. Isolated gastrocnemius recession for treatment of insertional Achilles tendinopathy: A pilot study. Foot Ankle Spec. 2015;8(4):260-5.
33. Pinney SJ, Sangeorzan BJ, Hansen ST Jr. Surgical anatomy of the gastrocnemius recession (Strayer procedure). Foot Ankle Int. 2004;25(4):247-50.
34. Sanhudo JAV, Canuto GM. Wrinkle sign for the Silfverskiöld test. J Foot Ankle. 2021;15(2):188-90.
35. Barouk P. Technique, indications, and results of proximal medial gastrocnemius lengthening. Foot Ankle Clin. 2014;19(4):795-806.

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Original Article

Management of ankle fractures in diabetic patients: case series of seven patients

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Abstract

Objectives: To evaluate the effectiveness and safety of retrograde intramedullary nailing with antibiotic-impregnated cement in the management of ankle fractures in diabetic patients with peripheral neuropathy, focusing on postoperative outcomes.

Methods: This study included seven diabetic patients with traumatic ankle fractures and peripheral neuropathy. Postoperative data collection was performed, focusing on evaluating fracture healing through radiographic evidence, time to achieve full weight-bearing, and any complications, including infection, wound dehiscence, or the need for additional surgical intervention.

Results: Regarding postoperative complications, among seven diabetic patients with ankle fractures, only one patient developed a medial foot ulcer. Four patients achieved full weight-bearing without pain within five months, and no cases of delayed union, malunion, or nonunion were recorded.

Conclusions: Orthopedic surgeons face challenges treating ankle fractures in diabetic patients due to high morbidity and mortality rates. Our case series demonstrated that the minimally invasive tibiotalocalcaneal option may reduce infection risk and require fewer operations, with only one postoperative complication and no intraoperative issues.

Level of evidence IV; Case series.

Keywords: Ankle fractures; Arthrodesis; Peripheral vascular disease; Diabetes mellitus.

Introduction

Ankle fractures in diabetic patients are challenging. Most diabetic patients have existing peripheral neuropathy, arthropathy, vasculopathy, or poor bone quality, which makes fracture management difficult and controversial. Due to these pre-existing conditions in this population, high rates of nonunion, malunion, delayed union, or wound infections are anticipated[1]. These patients have a higher risk of complications than diabetic patients without pre-existing diabetes-related complications and non-diabetic patients[2]. Moreover, diabetic patients with high haemoglobin A1c (HbA1c) or uncontrolled blood glucose show poor prognosis even after receiving the appropriate management for their fracture[3].

The mainstream management of ankle fractures can be operative with either open reduction and internal fixation (ORIF), external fixation, or non-operative, depending on the type of fracture and the condition of surrounding soft tissues. For diabetic patients, non-operative treatment carries a significantly higher risk of complications when compared to operative one[4].

However, operative treatment itself is still controversial, with much ongoing research discussing surgical options and their outcomes for this population. One of the options that has been recently introduced is primary arthrodesis in the form of tibiotalocalcaneal (TTC) fusion, especially since most patients managed by fracture fixation already end with a fused ankle[5]. This approach also allows for a minimally invasive technique

Study performed at the King Salman Armed Forces Hospital, Tabuk, Saudi Arabia.

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to minimize the risk of infection, with evidence that this technique is associated with a lower number of operations when compared to other surgical management options[5]. This technique is well-documented in the literature, with previous studies showing that the use of antibiotic-coated intramedullary nails provides both mechanical stability and localized antibiotic delivery, significantly lowering the risk of postoperative infections[6]

Although TTC has promising outcomes, more studies are needed to provide better evidence regarding its advantages. According to our latest research, all available evidence to date is limited to case-series designs, which have provided good outcomes[7-9]. Similar studies have highlighted the importance of this approach, noting that TTC nailing has become an increasingly preferred method for managing complex ankle fractures in high-risk patients due to its ability to provide stable fixation and reduce the risk of infection[10].

However, no studies have been published in Saudi Arabia about this technique. The objective of this study is to show the postoperative outcomes and patients' satisfaction in our center as the first one in Saudi Arabia, to add evidence to the literature, and to help future researchers study larger data from different regions. Additionally, we describe a different surgical approach in an attempt to minimize the risk of infection.

Methods

This study has been approved by the Institutional Review Board (IRB) and Ethics Committee of our Institution, and the patients included in the study signed the Informed Consent form. The study was conducted at a tertiary care facility in Tabuk, Saudi Arabia. A consecutive series of nine diabetic patients was included who sustained traumatic ankle fractures and had peripheral neuropathy, with or without peripheral vascular disease (PVD). These patients, who were treated surgically between 2019 and 2023, were considered at high risk for postoperative infection if managed with classic treatment methods such as ORIF. Peripheral neuropathy was confirmed based on clinical examination (diminished monofilament sensation and absent ankle reflexes). PVD was identified using ankle-brachial index (ABI < 0.9). One patient with talus avascular necrosis (AVN) was excluded from the study based on the inclusion criteria. Additionally, during the follow-up period, one patient passed away due to an unrelated medical condition, giving the final data of seven patients with follow-up.

The inclusion criteria specifically targeted diabetic patients with peripheral neuropathy and/or PVD submitted to antibiotics-coated TTC nailing as a primary treatment for their ankle fractures. Any patient who did not meet these criteria was excluded.

Data collection

Collected data included patient demographics, comorbid conditions, HbA1c levels, presence of neuropathy, and PVD status. The mean age of patients was 65.2 years, with a range of 49-87 years, and the mean HbA1c was 8.3, with a range of 6.6-11.3.

Six patients sustained bimalleolar fractures, with or without dislocation, and one patient had a trimalleolar fracture dislocation.

Postoperative data collection focused on fracture healing, assessed via radiographic evidence, time to full weight-bearing, and any complications, such as infection, wound dehiscence, or the need for further surgical intervention.

Statistical analysis

Data analysis was performed using IBM SPSS Statistics version 27. Descriptive statistics were used to summarize the patient characteristics, surgical outcomes, and complications.

Surgical technique

The surgical procedure employed was retrograde intramedullary nailing with the application of antibiotic-impregnated cement. An approximately 4 cm incision was made on the plantar surface of the heel. Under fluoroscopic (C-arm) guidance, the entry point was identified at the central calcaneus in the anteroposterior view and between the anterior and middle thirds in the lateral view, aligning centrally with the tibial plafond and medullary canal.

Key steps of the procedure included incision of skin and subcutaneous tissues, preparation of the entry point using an entry reamer under C-arm guidance, passing through the calcaneus, talus, and distal tibia, insertion of a guide wire passing through the calcaneus and talus to the proximal tibia, measurement of the appropriate nail length under C-arm guidance, preparation of high viscosity polymethyl methacrylate cement at room temperature, mixed with 2 g of vancomycin and 2 g of ceftriaxone, and manual coating of a size 8 mm interlocking tibial nail to achieve a diameter of 12 to 13 mm, medullary reaming followed by insertion of the intramedullary tibial nail retrogradely through the calcaneal entry, placement of proximal and distal locking screws under C-arm guidance, with two distal screws, one in the talus and the most distal one in the calcaneus, and closure of the surgical site with appropriate washing and sterile dressing. The mean duration for the surgery was two hours.

Postoperative protocol

After surgery, all patients followed a standardized postoperative protocol to ensure optimal healing and minimize the risk of complications. This protocol was designed based on best practices reported in similar studies, where early mobilization and infection prevention were emphasized[11]. Immediately after surgery, patients were placed in a well-padded splint to maintain stability and reduce swelling. Weight-bearing was restricted for six weeks to allow for adequate bone healing. During this period, patients were instructed to keep the affected limb elevated, when possible,

to control oedema. At two weeks, patients returned for a surgical site wound check. At six weeks, radiographs were taken to assess the progression of bone healing. If the radiographs showed adequate healing, patients were transitioned to partial weight-bearing in a fracture boot, progressing to full weight-bearing as tolerated over the next several weeks. Pain management was tailored to each patient, with a focus on minimizing the use of opioids. Nonsteroidal anti-inflammatory drugs (NSAIDs) and acetaminophen were used as first-line treatments, with opioids reserved for breakthrough pain. Physical therapy was initiated around eight weeks postoperatively as part of the rehabilitation protocol, focusing on initiating weight-bearing and functional mobility. The rehabilitation process is critical, as noted in similar studies. Early initiation of physical therapy has been shown to improve outcomes and reduce the likelihood of long-term disability in patients recovering from complex ankle fractures[11].

Follow-up and outcomes measurement

Patients were followed up at intervals of two weeks, six weeks, three months, six months, and 12 months postoperatively. Clinical outcomes were primarily focused on subjective measures for each patient, as all included patients were neuropathic. The American Orthopaedic Foot and Ankle Society (AOFAS) Ankle-Hindfoot Score was also used for objective assessment. Additionally, patient satisfaction with the surgical treatment was evaluated using a Likert scale, which described five scenarios: very satisfied, somewhat satisfied, neither satisfied nor dissatisfied, somewhat dissatisfied, and very dissatisfied. Literature supports the use of these subjective measures, particularly in neuropathic populations, as patient-reported outcomes provide critical insights into the success of surgical interventions in complex cases[12].

Results

Overall, all seven patients had diabetes mellitus (DM) and diabetic neuropathy (Table 1). Four of them were males (57%), with a mean age of 65.5 years and a standard deviation of 12.95. Other comorbidities included hypertension (62.5%), dyslipidemia (25%), hypothyroidism (12.5%), ischemic heart disease (37.5%), and colon cancer (12.5%) (Table 1). The mean HbA1c level was 8.2 ± 1.6, with all patients having values ≥ 6.5.

Regarding fracture patterns, seven patients presented with traumatic closed ankle fractures: bimalleolar fractures (42.8%), bimalleolar fracture-dislocations (42.8%), and trimalleolar fracture-dislocations (14.4%). The mean operative time was two hours from entry to the operating room to transfer to the recovery room. At the two weeks follow-up, all patients had a surgical site inspection. Radiographs were obtained at six weeks. Subsequent evaluations were conducted at three months, six months, and 12 months. All patients were seen in person at least once after six months, with later follow-up data (up to four years) obtained either through in-person visits or structured phone interviews, depending on patient availability. Only one patient (14.4%) developed a postoperative medial foot ulcer complication. The patient is a 72-year-old female with diabetes, diabetic neuropathy, hypertension, and ischaemic heart disease; her HbA1c is 6.9, and she has encountered a closed trimalleolar fracture. No surgical complications such as superficial/deep infections, hardware failure were reported, and none of the patients required reoperation or further surgical intervention.

Regarding weight-bearing and mobility outcomes, two patients (25%) began partial weight-bearing at six weeks. Between three and six months postoperatively, six patients (85.6%) had achieved full weight-bearing without pain, and one patient (14.4%) was mobilizing with minimal pain. The time to achieve full weight-bearing ranged from three to six months (Table 3). At final follow-up, all patients were walking: five used a walking frame, one used a walker, and one walked independently. Patient satisfaction was assessed using a Likert scale. Six patients (85.6%) reported being very satisfied with the surgical outcome, while one patient (14.4%) reported being somewhat satisfied (Table 2). The mean AOFAS score was 76 ± 6.3. Radiographic evaluation at final follow-up showed that four patients (57%) had complete fracture union. The remaining three patients (43%) showed good callus formation but had not achieved full radiographic union at the time of their last follow-up imaging. However, none of these patients demonstrated clinical instability or required further intervention. No cases of delayed union, malunion, or nonunion were formally diagnosed. The mean hospital stay was 5.1 days (range: 3-14 days) (Table 3).

Table 1. Demographic characteristics of included patients

Patient	Age	Sex	Diagnosis	Open fracture	Comorbidities	HbA1c	Neuropathy
1	80	Male	Bimalleolar fracture	No	DM, HTN, Colon cancer	6.3	Yes
2	50	Male	Bimalleolar fracture	No	DM	9.3	Yes
3	87	Male	Bimalleolar fracture dislocation	No	DM, IHD, Hypothyroidism	7	Yes
4	49	Male	Bimalleolar fracture	No	DM, IHD	11.3	Yes
5	69	Female	Bimalleolar fracture dislocation	No	DM, HTN, Dyslipidemia	7.1	Yes
6	60	Female	Bimalleolar fracture dislocation	No	DM, HTN, Dyslipidemia	9.2	Yes
7	72	Female	Trimalleolar fracture dislocation	No	DM, HTN, IHD	6.9	Yes

HbA1C: Haemoglobin A1C; DM: Diabetes mellitus; HTN: Hypertension; IHD: Ischemic heart disease.

Table 2. Patients' postoperative follow-up and clinical outcomes

Patient	Post-op complications	Surgical complications	Need future surgery	Last post-op follow-up	Last follow-up radiograph	Satisfaction	AOFAS score
1	No	No	No	6 weeks	Good callus formation	Very Satisfied	73
2	No	No	No	6 weeks	Good callus formation	Very Satisfied	78
3	No	No	No	2 Years	United	Very Satisfied	69
4	No	No	No	6 Months	United	Very satisfied	86
5	No	No	No	3 Years	United	Very Satisfied	78
6	No	No	No	13 Months	United	Somewhat satisfied	65
7	Medial foot ulcer	No	No	5 Months	Good callus formation	Very Satisfied	80

AOFAS: The American Orthopaedic Foot and Ankle Society.

Table 3. Patients' pre- and postoperative characteristics and outcomes

Patient	Length of hospital stay (days)	Preinjury ambulatory level	Last follow-up ambulatory level	Time to full weight-bearing (months)	Current mobilization level
1	14	Cane	Walking Frame	5	**Non-painful full weight-bearing**
2	3	Walking with no assistance	Walking	3	**Non-painful full weight-bearing**
3	3	Cane	Walking frame	6	**Non-painful full weight-bearing**
4	3	Non-painful full weight-bearing	Walker	3	**Non-painful full weight-bearing**
5	5	Non-painful full weight-bearing	Walker	3	**Non-painful full weight-bearing**
6	4	Walker	Walking frame	4	Mobilising with minimal pain
7	4	Walking frame	Walking frame	5	**Non-painful full weight-bearing**

Discussion

Diabetes and its complications, especially diabetic peripheral neuropathy and PVD, make ankle fracture prognosis worse than that of those with ankle fractures without being diagnosed with diabetes or diabetic patients without complications[2]. Management options are still controversial, but there is evidence that operative management has better outcomes than nonoperative[4]. Many emerging studies show the effectiveness of operative options, depending on the type and stability of the fracture and the patient's diabetic control[2]. TTC arthrodesis is one of the discussed options that has shown good results. However, few studies applying TTC to diabetic patients have been published[7-9]. In non-diabetic patients, a study by Childress[13] suggested using arthrodesis when local soft tissues did not allow for standard incisions for open reduction and internal fixation, or when patients were marginally ambulatory or had medical comorbidities. He reported overall good outcomes using vertical trans-articular pin fixation for 92 patients with ankle fractures.

In our study, we present eight patients with diabetes and diabetic peripheral neuropathy, with a mean age of 65.5 years and a mean HbA1C of 8.2. Seven of them had traumatic closed ankle fractures without other associated injuries, and one had osteomyelitis in the form of an infected previous implant after an ankle fracture treatment. All of them underwent a primary TTC and were followed up until they could maintain full weight-bearing with minimal pain. It was decided for a primary TTC arthrodesis instead of starting with fixation, as this operation is less invasive and needs a shorter operation time than fixation, which will reduce the risk of wound infections, especially in those patient populations where wound healing is poor. Regarding the choice of antibiotics in cement preparation, we chose vancomycin and ceftriaxone as they are the preferred and most used in cement preparation, they provide broad-spectrum coverage, have thermoresistant properties, and are available in powder form[14].

Infection can occur easily[15], and the earlier weight-bearing time reduces non-ambulation-related complications[16]. Also, the fixation provided by arthrodesis allows for faster bone healing when compared to fixation with plates and screws[16], as the bone healing process is already compromised in our patients as a complication of diabetes[17].

Regarding postoperative outcomes, only one patient developed a medial foot ulcer, representing 12.5% of the total cases. This percentage is satisfactory when compared to previous studies; Ebaugh et al.[7] reported a postoperative complication rate of 18.5%, and Jani et al.[8] reported a rate of 25%. Although in other studies, some patients who underwent a primary TTC ended with other surgeries or amputations[7,9], none of our patients did, representing a limb salvage rate of 100%. One possible explanation in our opinion to these satisfactory outcomes besides our modification in

the surgical approach as provided in the methodology, is our inclusion criteria that focuses on diabetic patients with ankle fractures excluding those with Charcot arthropathy, this is different from the study by Grote et al.[18], who reported 15% of Charcot arthropathy among their patients, and from Ayoub[19] who primarily focused on treating patients with Charcot arthropathy. While we didn't specify the type of fracture as being open or closed as part of our inclusion criteria, all our included patients had a closed fracture, which again makes our results more satisfactory with fewer complications in comparison to similar studies[18].

It is difficult to compare limb salvage rates in ankle fractures managed by a primary TTC and ORIF because of the lack of strong evidence about primary TTC. However, evidence suggests that ORIF has a high limb salvage rate of 97.9%[20]. The decision to utilize TTC nailing was guided by multiple considerations. This technique is minimally invasive and time-efficient, offering the dual benefits of reduced operative duration and the capacity for sustained local delivery of high-concentration antibiotics. These advantages are particularly pertinent in immunocompromised patients, in whom the risk of infection is elevated, thereby enhancing the potential for successful limb salvage.

The AOFAS score was used to assess patients' clinical outcomes. Although most patients achieved relatively high scores, we recognize that this tool may not accurately reflect true functional status in this population. The AOFAS score has known limitations in terms of validity and reliability, particularly when applied to diabetic patients with peripheral neuropathy, who may have altered pain perception and different functional baselines compared to non-diabetic individuals. Nevertheless, we selected this scoring system due to its widespread use in the literature and the lack of validated outcome measures specifically designed for fusion procedures in patients with peripheral neuropathy[21].

The strengths of our study include a long postoperative follow-up period and the fact that all fractures were closed, which allowed for a logical and more precise comparison of the outcomes. However, our study also has many limitations, including the study design, as case series hold a high rate of bias, the small number of patients, and the lack of a reliable and valid clinical assessment score to assess our patients' satisfaction.

Conclusion

This case series suggests that primary TTC arthrodesis may be a viable treatment option for diabetic patients with peripheral neuropathy who sustain traumatic ankle fractures. The procedure was associated with limb salvage in all cases, minimal complications, and satisfactory functional outcomes, with most patients achieving full weight-bearing within five months. While these preliminary findings are encouraging, the small sample size and absence of a comparative group limit the generalizability of the results. Further studies with larger cohorts and comparative designs are needed to validate these outcomes.

For future research, we recommend including a higher number of patients and using a better study design, if possible, such as a cohort study design or clinical trials. For the clinical assessment, we recommend considering a new assessment tool to help assess patients with neuropathy or vasculopathy, for which the present tools cannot be fully trusted, despite being already low in reliability and validity measures.

Authors' contributions: Each author contributed individually and significantly to the development of this article: AA *(https://orcid.org/0009-0000-6228-2814) Conceived and planned the activities that led to the study, and performed the surgeries;YD *(https://orcid.org/0009-0008-9211-7463) Performed the surgeries and participated in the review process; MA *(https://orcid.org/0009-0008-7438-7064) Performed the surgeries and interpreted the results of the study; SF *(https://orcid.org/0000-0001-5265-1452) Interpreted the results of the study and participated in the review process; AA *(https://orcid.org/0009-0002-6593-339X) Data collection and clinical examination; HE *(https://orcid.org/0009-0005-6170-6570) Performed the surgeries and survey of the medical records; AM *(https://orcid.org/0009-0000-8175-2770) Frmatting of the article and discussion writing; DS *(https://orcid.org/0009-0007-2035-2408) Statistical analysis, bibliographic review, and final editing. All authors read and approved the final manuscript. *ORCID (Open Researcher and Contributor ID) iD.

Reference

1. Chaudhary SB, Liporace FA, Gandhi A, Donley BG, Pinzur MS, Lin SS. Complications of ankle fracture in patients with diabetes. J Am Acad Orthop Surg. 2008;16(3):159-70.
2. Wukich DK, Kline AJ. The management of ankle fractures in patients with diabetes. J Bone Joint Surg Am. 2008;90(7): 1570-8.
3. Liu J, Ludwig T, Ebraheim NA. Effect of the blood HbA1c level on surgical treatment outcomes of diabetics with ankle fractures. Orthop Surg. 2013;5(3):203-8.
4. Lovy AJ, Dowdell J, Keswani A, Koehler S, Kim J, Weinfeld S, et al. Nonoperative Versus Operative Treatment of Displaced Ankle Fractures in Diabetics. Foot ankle Int. 2017;38(3):255-60.
5. Vaudreuil NJ, Fourman MS, Wukich DK. Limb Salvage After Failed Initial Operative Management of Bimalleolar Ankle Fractures in Diabetic Neuropathy. Foot ankle Int. 2017;38(3):248-54.
6. Thonse R, Conway J. Antibiotic cement-coated interlocking nail for the treatment of infected nonunions and segmental bone defects. J Orthop Trauma. 2007;21(4):258-68.

7. Ebaugh MP, Umbel B, Goss D, Taylor BC. Outcomes of Primary Tibiotalocalcaneal Nailing for Complicated Diabetic Ankle Fractures. Foot ankle Int. 2019;40(12):138-7.
8. Jani MM, Ricci WM, Borrelli JJ, Barrett SE, Johnson JE. A protocol for treatment of unstable ankle fractures using transarticular fixation in patients with diabetes mellitus and loss of protective sensibility. Foot ankle Int. 2003;24(11):838-44.
9. Taylor BC, Hansen DC, Harrison R, Lucas DE, Degenova D. Primary Retrograde Tibiotalocalcaneal Nailing for Fragility Ankle Fractures. Iowa Orthop J. 2016; 36:75-8.
10. Lu V, Tennyson M, Zhou A, Patel R, Fortune MD, Thahir A, et al. Retrograde tibiotalocalcaneal nailing for the treatment of acute ankle fractures in the elderly: a systematic review and meta-analysis. EFORT open Rev. 2022;7(9):628-43.
11. SooHoo NF, Kominski GF. Cost-effectiveness analysis of total ankle arthroplasty. J Bone Joint Surg Am. 2004;86(11):2446-55.
12. Mauffrey C, McGuinness K, Parsons N, Achten J, Costa ML. A randomised pilot trial of "locking plate" fixation versus intramedullary nailing for extra-articular fractures of the distal tibia. J Bone Joint Surg Br. 2012;94(5):704-8.
13. Childress HM. Vertical transarticular pin fixation for unstable ankle fractures: impressions after 16 years of experience. Clin Orthop Relat Res. 1976;(120):164-71.
14. Herrera-Pérez M, Díaz-Fernández R, Rendón-Díaz D, Boluda-Mengod J, Pais-Brito JL, Tejero S. Tibiotalocalcaneal Fusion With Antibiotic Cement-Coated Nails for Refractory Deep Infection After Ankle ORIF. Foot Ankle Int. 2020;41(11):1391-7.
15. Greenhalgh DG. Wound healing and diabetes mellitus. Clin Plast Surg. 2003;30(1):37-45.
16. Balziano S, Baran I, Prat D. Hindfoot nailing without joint preparation for ankle fractures in extremely elderly patients: Comparison of clinical and patient-reported outcomes with standard ORIF. Foot ankle Surg. 2023;29(8):588-92.
17. Jiao H, Xiao E, Graves DT. Diabetes and Its Effect on Bone and Fracture Healing. Curr Osteoporos Rep. 2015;13(5):327-35.
18. Grote CW, Tucker W, Stumpff K, Birt MC, Horton GA. Primary arthrodesis for diabetic ankle fractures. Foot Ankle Orthop. 2020;5(1):2473011420908841.
19. Ayoub MA. Ankle fractures in diabetic neuropathic arthropathy: can tibiotalar arthrodesis salvage the limb? J Bone Joint Surg Br. 2008;90(7):906-14.
20. Manchanda K, Nakonezny P, Sathy AK, Sanders DT, Starr AJ, Wukich DK. A systematic review of ankle fracture treatment modalities in diabetic patients. J Clin Orthop Trauma. 2021;16:7-15.
21. Al-Mohrej OA, Petrisor B. Foot and Ankle Outcome Instruments: Missing the Target. Curr Rev Musculoskelet Med. 2023;16(6):246-54.

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Original Article

Ottawa Ankle Rules and their association with ligamentous or chondral injuries of the ankle: a prospective observational study

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Abstract

Objective: Evaluate the association between the Ottawa Ankle Rules (OAR) and the presence of ligamentous and chondral injuries identified on magnetic resonance imaging (MRI).

Methods: A prospective observational study was conducted in 48 patients who underwent clinical evaluation using the OAR with subsequent MRI assessment. Variables analyzed included patient age, gender, laterality, and presence of ligamentous or chondral injuries. Statistical analyses were performed using the Shapiro-Wilk test for normality, Student's t-test for age comparisons, and Pearson's chi-square test to assess associations between categorical variables.

Results: Mean age of patients was 41.06 years, ranging from 15 years to 82 years. Groups with positive and negative OAR results were homogeneous regarding age (p = 0.29), gender (p = 0.42), and laterality (p = 0.09). No significant association was found between a positive OAR and the presence of ligamentous injuries (p = 0.42) or chondral injuries (p = 0.83) on MRI.

Conclusion: The OAR were not associated with ligamentous or chondral injuries identified on MRI, suggesting their limitations in predicting these specific findings. Further studies are needed to develop a more accurate predictive model incorporating clinical and imaging parameters.

Level of Evidence IV; Prospective Observational; Case Series

Keywords: Ankle injuries; Ligaments; Cartilage; Ottawa Ankle Rule; Magnetic resonance imaging

Introduction

Ottawa Ankle Rules (OAR) are a well-established set of clinical guidelines designed to help clinicians determine the necessity of radiographic imaging in patients with acute ankle injuries[1]. Their primary objective is to reduce unnecessary radiographs while maintaining a high sensitivity for detecting clinically significant fractures. According to the OAR, ankle radiographs are recommended if patient meets one of the following criteria: (1) inability to bear weight immediately after the injury or in the emergency department for four steps, or (2) point tenderness over the posterior edge or tip of the lateral malleolus, medial malleolus, base of the fifth metatarsal, or navicular bone[2].

The effectiveness of the OAR have been validated across different populations, demonstrating a high sensitivity, ranging from 92% to 100%[3]. While the OAR effectively minimize cases of missed fractures, their low specificity can lead to false positives, increasing the number of radiographs

Study performed at the Instituto Vita, São Paulo, SP, Brazil.

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performed unnecessarily. The OAR use has been shown to reduce healthcare costs and patient wait times without compromising clinical outcomes[2]. These guidelines are applicable to both adults and children over the age of five and are widely used in emergency departments and sports medicine settings[3].

Despite the extensive validation of the OAR for guiding radiographic imaging, there is no direct evidence linking them to the use of magnetic resonance imaging (MRI) as primary diagnostic tool in the initial assessment of acute ankle injuries.

The American College of Radiology Appropriateness Criteria indicate that MRI is not typically the first-line imaging modality for acute ankle trauma, even when the OAR suggest the need for radiographs. Instead, MRI is primarily used in cases where occult fractures, ligamentous injuries, or chondral damage are suspected but not evident on initial radiographs[1].

While MRI offers superior soft tissue contrast and is highly accurate in detecting ligamentous or chondral injuries, its role in the initial evaluation of acute ankle trauma remains uncertain[4]. This raises the question of whether a positive OAR assessment correlates with an increased likelihood of ligamentous or chondral injuries on MRI.

The objective of this study is to evaluate the relationship between a positive OAR assessment and the presence of ligamentous and chondral injuries diagnosed through MRI in patients with acute ankle trauma.

Methods

Study design

This is a prospective observational study analyzing the association between the OAR and the presence of ligamentous or chondral injuries identified on MRI. The study was conducted at a single medical center, where all clinical evaluations and imaging studies were performed following standardized protocols.

Ethical approval

The study was approved by the local ethics committee and conducted in accordance with the Declaration of Helsinki and Good Clinical Practice guidelines. This study is reported following the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for observational studies[5].

Participants

Inclusion criteria were patients who were 15 years of age or older, had sustained an acute ankle trauma assessed using the OAR, and underwent MRI as part of the diagnostic evaluation. Two senior practitioners from the same healthcare center conducted patient evaluations, exercising autonomy in selecting diagnostic tests deemed most appropriate for the assessment of acute trauma. A third evaluator independently applied the OAR to patients, without any interaction or communication with the initial evaluators. Due to the private nature of the facility, MRI scans were highly accessible and feasible in such cases. Exclusion criteria included a history of previous ankle surgery or fracture, incomplete medical records or records missing imaging data, and MRI performed for reasons unrelated to acute trauma.

Data collection

Patient data were prospectively collected from electronic medical records, including demographic information, clinical findings based on the OAR, and MRI reports. The presence of ligamentous injuries (e.g., anterior talofibular ligament tears) or chondral lesions was recorded (Figure 1). The MRI interpretation was performed by board-certified radiologists following institutional imaging protocols.

Outcome measures

The primary outcome was the presence or absence of ligamentous and chondral injuries on MRI in patients with positive or negative OAR assessments. Additional variables included patient age and sex and the laterality of the injury.

Statistical analysis

Statistical analyses were conducted using the R software. Descriptive statistics, including mean and standard deviation, were calculated for continuous variables. The Shapiro-Wilk test was applied to assess the normality of age distribution. For group comparisons, Student's t-test was used for age, while Pearson's chi-square test was employed for categorical variables such as sex, laterality, and MRI findings. A p-value ≤ 0.05 was considered statistically significant. A post hoc power analysis was performed considering a moderate effect size ($W = 0.3$).

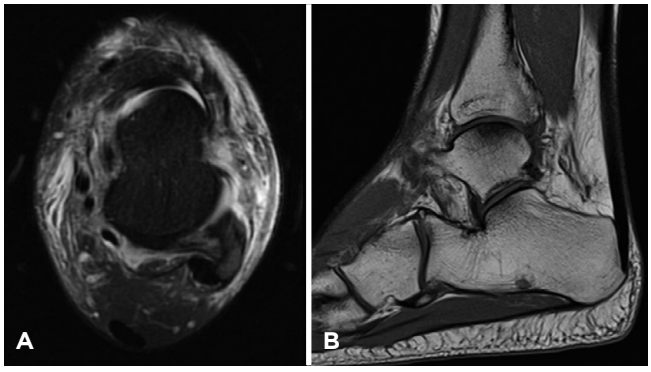

Figure 1. (A) Magnetic resonance imaging showing a ligamentous injury in an ankle trauma case. (B) Magnetic resonance imaging illustrating a chondral lesion in an ankle trauma case.

Results

The study included 48 patients with ages ranging from 15 years to 82 years (mean = 41.06 years). When analyzing age according to the OAR, mean age was 46.63 years and standard deviation (SD) was 15.41 in the negative test group, and 39.95 years (SD = 16.81) in the positive test group. However, this difference was not statistically significant (p = 0.29), indicating that age did not influence test positivity.

The sample consisted of 18 men (37.5%) and 30 women (62.5%), with no statistically significant differences between the positive and negative OAR groups (p = 0.4237). Regarding laterality, 23 patients (47.9%) had right-sided involvement, while 25 patients (52.1%) had left-sided involvement. In the negative test group, six patients had right-sided injuries, and two patients had left-sided injuries; in the positive test group, 17 patients had right-sided involvement, and 23 patients had left-sided involvement. There was no statistically significant association between laterality and the OAR result (p = 0.09).

These findings indicate that the groups with positive and negative OAR were homogeneous in terms of age, sex, and laterality.

OAR and MRI findings

Statistical analysis was performed to evaluate the relationship between a positive OAR and the presence of ligamentous or chondral injuries identified on MRI. The distribution of these findings is illustrated in Figure 2, which presents the proportion of ligamentous and chondral injuries among patients with positive and negative OAR results.

Chondral injuries

Among patients with a positive OAR result, 36 had no chondral injury, while four presented with a chondral lesion.

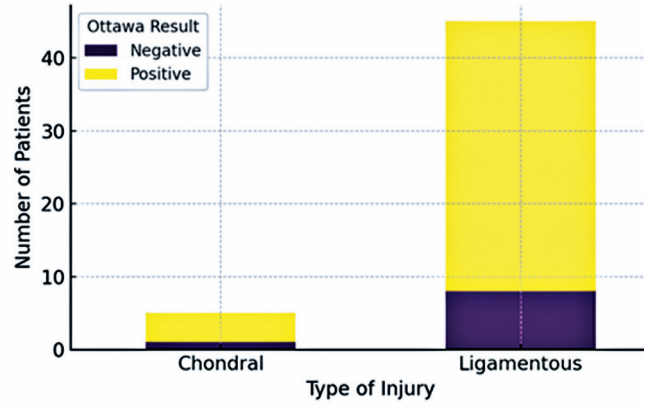

Figure 2. Association between the Ottawa Ankle Rules (OAR) and magnetic resonance imaging findings. The stacked bar chart represents the distribution of ligamentous or chondral injuries among patients with positive or negative OAR results.

In the negative OAR group, seven patients had no chondral injury, and one had a chondral lesion. There was no significant association between a positive OAR result and the presence of chondral injury (p = 0.83).

Ligamentous injuries

Among patients with a positive OAR result, three had no ligamentous injury, while 37 had ligamentous involvement. In the negative OAR group, eight patients had a ligamentous lesion. No significant association was observed between a positive OAR result and the presence of ligamentous injury (p = 0.42).

Discussion

The present study provides new insights into the relationship between the OAR and ligamentous or chondral injuries identified on MRI. While the OAR are widely used to determine the necessity of radiographs in acute ankle trauma, our findings suggest that soft tissue injuries are not well diagnosed by these rules. Findings suggest that a positive OAR result is not associated with a high likelihood of ligamentous or chondral injuries, reinforcing that the OAR should primarily be used to rule out fractures rather than to predict complex ankle pathologies.

The OAR have been extensively validated, demonstrating a high sensitivity (92%–100%) for detecting fractures, which makes them a valuable tool for reducing unnecessary radiographs and optimizing healthcare resources[2]. However, their low specificity (7.8%–68%) leads to a proportion of false positives that may result in some patients undergoing imaging that ultimately does not reveal fractures[6].

While previous studies have confirmed the effectiveness of the OAR in ruling out fractures, no prior research has investigated a direct link between OAR results and MRI findings. Our study contributes to filling this gap, as no significant association was found between positive OAR and the presence of ligamentous or chondral injuries.

Our findings align with previous literature, suggesting that, while the OAR are highly effective in reducing unnecessary radiographs, the rules do not necessarily correlate with other imaging modalities such as MRI[1].

Despite differences in specificity, alternative clinical decision rules, such as the Bernese Ankle Rules (BAR) and the Shetty Test (ST), have not demonstrated the same level of sensitivity as the OAR[7]. While the BAR offers higher specificity, their lower sensitivity limits their clinical utility. Similarly, the ST, which focuses on dynamic evaluation, has been found to be less reliable in emergency settings due to its lower sensitivity compared to the OAR[6].

Given the high sensitivity but low specificity of the OAR, it is not surprising that no significant association was found between a positive OAR result and the presence of ligamentous or chondral injuries. The OAR may underdiagnose a great sort of injuries that could be evidenced on MRI evaluation

and may lead to late diagnosis or sequelae. These findings align with previous literature, which emphasizes the OAR as a reliable screening tool for fractures but not necessarily for more complex injuries involving ligaments and cartilage[8].

Limitations

This study has some limitations that should be considered. Its design may introduce selection bias, as only patients who underwent MRI were included, a potential overrepresentation of cases with more severe symptoms may exist. Additionally, the sample size, while adequate for initial analysis, may not have been large enough to detect smaller but clinically meaningful associations. A post hoc power analysis was performed considering a moderate effect size (W = 0.3). With 48 patients included and an alpha level of 0.05, estimated statistical power was approximately 54.7%. Although below the conventional 80% threshold, this level of power is considered acceptable.

The lack of functional outcome assessment limits the ability to determine the clinical relevance of MRI-detected ligamentous and chondral injuries, as some may be asymptomatic while others, with persistent pain, may have no visible abnormalities.

Finally, being a single-center study, findings may not be fully generalizable to different healthcare settings, where variations in clinical protocols, physician experience, and MRI availability could influence the applicability of results. Future multicenter studies with larger and more diverse populations are needed to confirm these findings.

Interpretation

Findings suggest that, while the OAR remain an essential tool for fracture exclusion, these rules do not reliably predict ligamentous or chondral injuries detected on MRI. This reinforces their well-established role in guiding the use of radiographs in acute ankle trauma but highlights the need for additional clinical judgment when evaluating soft tissue injuries.

Future research should focus on refining predictive models that integrate clinical findings, imaging features, and patient-reported symptoms to improve the decision-making in acute ankle injuries. Additionally, further studies incorporating long-term functional outcomes could provide valuable insights into the clinical relevance of MRI-detected injuries.

Generalizability

Although the OAR have been widely validated in various populations and healthcare settings, findings of this study should be interpreted considering its limitations. Differences in MRI utilization across institutions and the homogeneity of the study population may affect the generalizability of results, particularly in settings where MRI is not routinely used for acute ankle trauma. Variations in clinician experience, imaging availability, and institutional protocols could also influence how the OAR are applied and their association with MRI findings. Despite these factors, this study reinforces the primary role of the OAR as a fracture screening tool rather than a predictor of ligamentous or chondral injuries.

Developing a more comprehensive predictive model that incorporates clinical findings, imaging parameters, and patient-reported symptoms should be addressed in future studies. Expanding this research across multiple centers with larger and more diverse populations will help determine the broader applicability of these findings.

Conclusion

The OAR were not associated with ligamentous or chondral injuries identified on MRI, suggesting limitations in predicting these specific findings. Further studies are needed to develop a more accurate predictive model incorporating clinical and imaging parameters.

Authors' contributions: Each author contributed individually and significantly to the development of this article: MCMD *(https://orcid.org/https://orcid.org/0000-0001-6572-1771) Conceived and planned the activities that led to the study, bibliographic review, formatting of the article, wrote the article; MPMD *(https://orcid.org/0000-0002-2846-3280) Data collection, bibliographic review, survey of the medical records; MVPF *(https://orcid.org/0000-0002-2320-9769) Conceived and planned the activities that led to the study, bibliographic review, survey of the medical record; MFF *(0000-0002-6219-0407) Conceived and planned the activities that led to the study, participated in the review process; GFNS *(https://orcid.org/0000-0003-2717-3609) Bibliographic review, formatting of the article; ADB *(https://orcid.org/0000-0002-5991-1701) Participated in the review process, formatting of the article; RGP *(https://orcid.org/0000-0002-6064-2027) Conceived and planned the activities that led to the study, interpreted the results of the study, participated in the review process; GFF *(https://orcid.org/0000-0001-8032-3077) Interpreted the results of the study, statistical analysis, bibliographic review, formatting of the article, wrote the article. All authors read and approved the final manuscript. *ORCID (Open Researcher and Contributor ID).

References

1. Expert Panel on Musculoskeletal Imaging; Smith SE, Chang EY, Ha AS, Bartolotta RJ, Bucknor M, Chandra T, et al. ACR Appropriateness Criteria® Acute Trauma to the Ankle. J Am Coll Radiol. 2020;17(11S):S355-66.
2. Martin RL, Davenport TE, Fraser JJ, Sawdon-Bea J, Carcia CR, Carroll LA, et al. Ankle Stability and Movement Coordination Impairments: Lateral Ankle Ligament Sprains Revision 2021. J Orthop Sports Phys Ther. 2021;51(4):CPG1-80.
3. Gomes YE, Chau M, Banwell HA, Causby RS. Diagnostic accuracy of the Ottawa ankle rule to exclude fractures in acute ankle injuries in adults: a systematic review and meta-analysis. BMC Musculoskelet Disord. 2022;23(1):885.
4. Kaminski TW, Hertel J, Amendola N, Docherty CL, Dolan MG, Hopkins JT, et al. National Athletic Trainers' Association position statement: conservative management and prevention of ankle sprains in athletes. J Athl Train. 2013;48(4):528-45.
5. von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP; STROBE Initiative. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. J Clin Epidemiol. 2008;61(4):344-9.
6. Ak R, Kurt E, Bahadırlı S, Semih Çakır M, Bilgü AS, Kurt ŞZE. The Comparison of Ottawa Ankle Rules and Shetty test performances in foot-ankle trauma patients visited to the emergency department. Injury. 2022;53(6):2287-91.
7. Derksen RJ, Knijnenberg LM, Fransen G, Breederveld RS, Heymans MW, Schipper IB. Diagnostic performance of the Bernese versus Ottawa ankle rules: Results of a randomised controlled trial. Injury. 2015;46(8):1645-9.
8. Ellenbogen AL, Rice AL, Vyas P. Retrospective comparison of the Low Risk Ankle Rules and the Ottawa Ankle Rules in a pediatric population. Am J Emerg Med. 2017;35(9):1262-5.

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Original Article

Risk factors for calcaneal fracture-related infection in open reduction and internal fixation: a retrospective cohort

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Abstract

Objective: To identify independent risk factors for calcaneal fracture-related infection (FRI) in open reduction and internal fixation (ORIF).

Methods: Retrospective and observational study using data extracted from the TriNetX international platform, including patients of both sexes with a confirmed diagnosis of calcaneal fracture submitted to surgical treatment with ORIF, with a 1-year follow-up. An adjusted multiple logistic regression test was used to identify independent variables, and the Kaplan-Meier and Log-Rank tests were used to assess disease-free survival.

Results: In total, 2,830 patients with a mean age of 50 years (SD ± 15) were evaluated, most of them men, 1,788 (63.8%). One hundred eighty-one patients had FRI within one year after surgical treatment. The following variables were independent risk factors for FRI: smoking [OR 1.8 (CI 0.02;0.06), p = 0.0001], alcohol abuse [OR 1.6 (CI 1.0;2.6), p = 0.045], chronic kidney disease [OR 2.23 (CI 1.13;4.39), p = 0.017], overweight [OR 2.8 (CI 1.34;5.89), p = 0.004], fall from height [OR 2.18 (CI 1.47;3.25), p = 0.0001] and open fracture [OR 2.13 (CI 1.07;4.23), p = 0.026].

Conclusion: Smoking, alcohol abuse, chronic kidney disease, overweight, fall from height, and open fracture were independent risk factors for infection.

Level of evidence II, observational study.

Keywords: Infections; Surgical wound infection; Heel bone; Bone fractures; Risk factors.

Introduction

Calcaneal fracture-related infection (FRI) can occur in up to 25% of open reduction and internal fixation (ORIF) procedures, resulting in restrictions on ambulation and occupational limitations with a substantial loss of quality of life[1].

Calcaneal fractures are the most frequent tarsal lesions[2] and the second most common among foot bones, although they represent only 2% of fractures in adults[3]. In addition to the aforementioned functional disability, FRI has a high cost to the public health system, as the patient requires several additional surgical interventions, making the treatment costly, with values that reach up to five times the value of the initial treatment[4].

Risk factors for infection can be modifiable and non-modifiable, and most are related to the patient's clinical comorbidities, lifestyle, and surgical management of the fracture[5]. Other factors are associated with the perioperative period, such as the management of open fractures following the appropriate protocols, fracture stabilization, prolonged hospitalization, and soft tissue involvement, which hinder the fracture consolidation process that, in the natural history of

Study performed at Hospital Alemão Oswaldo Cruz, Sao Paulo, SP, Brazil.

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the disease, can have osteomyelitis and even amputation as an outcome[5,6].

Information on these risk factors for calcaneal ORIF infection is restricted in the literature. Therefore, the objective of this study is to identify independent risk factors for calcaneal fracture-related infection in open reduction and internal fixation.

Methods

Study design

This is a multicenter, observational, retrospective cohort study and cross-sectional analysis of men and women diagnosed with calcaneal fractures submitted to surgical correction with ORIF and evolved to FRI. The data was extracted from the international collaborative real-world evidence platform TriNetX, an international health research network that is updated weekly with data recorded in electronic medical records. This network comprises Healthcare Organizations (HCOs), including academic centers, specialized medical centers, and hospitals. In Brazil, the data are centralized at the DataLab for Innovation, Research, and Education of Hospital Alemão Oswaldo Cruz (HAOC) in Sao Paulo, which operates as a TriNetX hub institution in the country. TriNetX complies with the Health Insurance Portability and Accountability Act (HIPAA). This retrospective study is exempt from informed consent. The revised data are a secondary analysis of existing data, do not involve intervention or interaction with human subjects, and are de-identified under the HIPAA Privacy Rule standards.

The data used in this study were collected on December 31, 2024. At the time of data consultation, 2,830 patients were included in the TriNetX database. This study used a retrospective cohort design, reviewing electronic medical records from January 1, 2020 to January 1, 2023. Selected through ICD-10: S92.0. All included patients had at least 1-year follow-up after the initial event, were ≥ 18 years old, and underwent surgical treatment for calcaneal fracture with ORIF. Age < 18 years, fracture of more than one surgical site, FRI after 1-year follow-up, percutaneous fixation, pseudarthrosis, refractures, and patients submitted to arthrodesis were excluded from the study.

The variables collected were divided as follows: variables related to the patient; addressing the demographic characteristics of sex, mean age, race, comorbidities (identified by ICD-10)[7], and clinical conditions of the patient; related to the perioperative period, with information on fracture characteristics, trauma information, and fracture classification. For ORIF, the use of plate and screws and direct access routes to the fracture was considered, such as the access route of the tarsal sinus and the extended lateral.

Outcomes analyzed

Prevalence and risk factors for FRI in patients with calcaneal fractures submitted to surgical treatment with ORIF up to 1-year follow-up. The outcome of FRI was selected using the following ICD-10 codes: T81.4, T84.6, T84.60XA, and T84.6.

Sample size calculation and statistical analysis

The sample size calculation was developed in conjunction with the local Statistics and Epidemiology Laboratory. The expected event ratio and odds ratio data for the initial estimated calculation were used. The level of statistical significance adopted in the analysis was 5% (0.05). The two-sided test of significance was used. Continuous variables were expressed as mean ± standard deviation (SD), as they presented normal distribution. Analyses comparing these variables between infected and uninfected groups were performed using the unpaired Student's t-test. To test for normality, the Shapiro-Wilk test was used. The distributions of categorical variables were expressed as frequencies and percentages, and the respective comparisons were performed using the χ^2 test or Fisher's exact test, as appropriate. The analysis of the outcomes was conducted based on the time to occurrence of the primary event, as well as event-free survival and osteomyelitis curves, using the Kaplan-Meier method. The Log-rank test was used for statistical significance between the distribution curves. The statistical programs used were the R system and SPSS Statistics version 19.0, in addition to four programs or language tools intrinsic to the TriNetX platform system.

Results

Overall, 38,842 patients with calcaneal fractures were evaluated for inclusion in the study. Of these patients, 36,012 (92.7%) were excluded: 32,312 underwent non-surgical treatment, 1,517 were > 18 years, and 2,183 underwent percutaneous surgical treatment, totaling 196 patients in the final analysis. The mean age was 50 years (SD ± 15), with a majority of men, 1,788 (63.8%). During the evaluated period, 181 patients were diagnosed with FRI, resulting in an overall rate of 6.83% within 1-year follow-up (Figure 1).

Of the variables analyzed, those that presented statistical significance of FRI were smoking (p < 0.0001), alcohol abuse (p < 0.016), systemic arterial hypertension (p < 0.001), chronic kidney disease (p <0.002), overweight (p <0.01), grade I obesity (p < 0.0005), fall from a height greater than 3 meters (p < 0.0001), open fracture (p < 0.0001), intra-articular fracture (p < 0.0001), serum albumin < 3.5 g/dL (p < 0.0001), serum protein dosage less than 6 g/dL (p < 0.0001) and Hb1Ac between 5.7%-6.4% (< 0.0001). There was no statistical difference in relation to demographic data (Table 1).

However, in the multivariate analysis of risk factors for FRI, only the variables smoking, alcohol abuse, chronic kidney disease, overweight, fall from height, and open fracture were statistically significant. Some variables were almost twice as likely to develop infection, including smoking [OR 1.8 (CI 0.02;0.06)], alcohol abuse [OR 1.6 (CI 1.0;2.6)], and systemic arterial hypertension [OR 1.4 (CI 1.09;2.01)]. Chronic kidney disease [OR 2.23 (CI 1.13;4.39)], overweight [OR 2.8 (CI

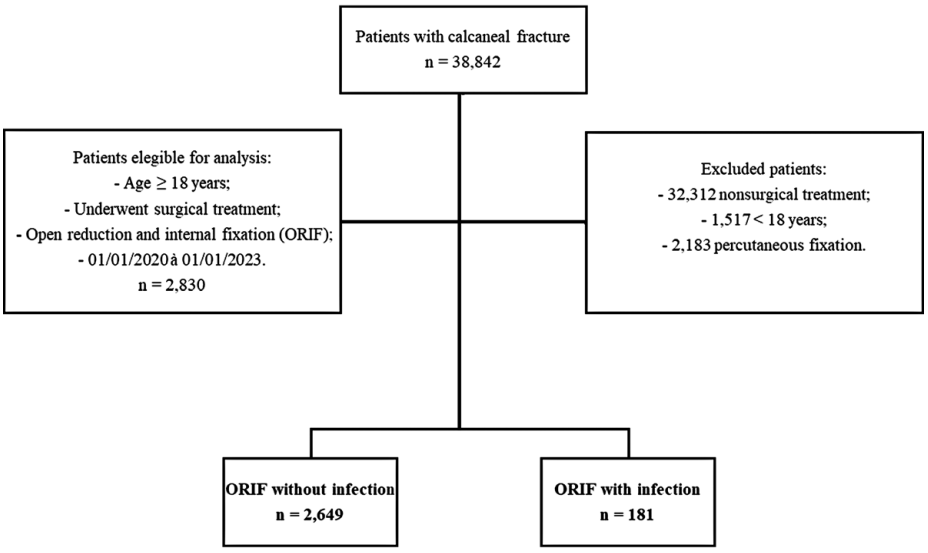

Figure 1. Algorithm for selecting the patients involved in the study.

Table 1. Risk factors for infection according to univariate analysis.

	Variables	With infection (n = 181)			Without infection (n = 2,649)			p-value
	Demographic data	(Mean ± SD)		% cohort[a]	(Mean ± SD)		% cohort[a]	
ICD-10	Age	46.4 ± 14.3	181	100%	46.9 ± 15.3	2.649	100%	0.65
	Men		121	66.85%		1.667	62.93%	0.28
	Women		51	28.18%		824	31.11%	0.40
	Race							
	White		132	72.93%		1.793	67.69%	0.14
	Black		16	8.84%		299	11.28%	0.31
	Unknown		21	11.60%		357	13.48%	0.47
	Comorbidities							
F17.2	Smoking		73	40.33%		716	27.03%	0.0001
F10	Alcoholism		26	14.37%		238	8.99%	0.016
I10	SAH[b]		64	35.36%		648	24.46%	0.001
E08-E13	Diabetes Mellitus		23	12.71%		228	8.61%	0.06
N18	Chronic kidney disease		13	7.18%		100	3.78%	0.02
	BMI[c] (Kg/m^2)	26.4 ± 7.13	133	73.48%	27.3 ± 5.98	1.658	62.59%	
	25-29.9		70	38.67%		787	29.71%	0.0111
	30-34.9		47	25.97%		424	16.01%	0.0005
	35-40		11	6.08%		185	6.98%	0.6422
	Fracture							
W13	Fall from high (> 3 m)		30	16.58%		176	6.64%	0.0001
S92.06	Intraarticular fracture		100	55.25%		1.070	40.39%	0.0001
S92.009A	Closed fracture		49	27.07%		641	24.20%	0.38
S92.009B	Open fracture		10	5.53%		31	1.17%	<0.0001
	Exams							
	Serum Albumin	3.7 ± 0.724	102	56.35%	4.04 ± 0.619	1.208	45.60%	< 0.0001
	< 3.5 g/dL		57	31.49%		356	13.44%	< 0.0001
	Serum protein	6.72 ± 1.06	94	51.93%	6.98 ± 2.19	1.142	43.11%	0.26
	< 6.0		36	19.89%		281	10.61%	< 0.0001
	HbA1c[d]	5.96 ± 1.5	59	32.60%	6.04 ± 1.77	593	22.39%	0.7314
	5.7-6.4%		21	11.60%		196	7.40%	0.0398
	> 6.5%		13	7.18%		119	4.49%	0.0968

% cohort: Percentage of sample in cohort; SAH[b]: Systemic arterial hypertension; BMI[c]: Body mass index, HbA1c[d]: Glycated Hemoglobin.

1.34;5.89)], fall from height [OR 2.18 (CI 1.47;3.25)], and open fracture [OR 2.13 (CI 1.07;4.23)] presented a two-fold higher adjusted odds ratio (Table 2).

In the survival analysis to evaluate the osteomyelitis outcome between the groups, statistically significant events were observed in the group of patients who evolved with infection (Figure 2).

Discussion

Open reduction and internal fixation in calcaneal fractures are challenging for the orthopedic surgeon, as there is a peculiar local anatomy and poor soft tissue envelopment in this area[8,9]. In our study, the overall infection rate was 6.83% and the prevalence was 7.49%. Our data are similar to the literature, which reports a prevalence of 9.7% and an incidence of 7.7% in closed fractures, and up to 45% in open fractures[10]. However, data were reduced in relation to the retrospective study by Lian Ding et al.[11], with an incidence of 17.8% in its cohort of 490 patients

Classically, the risk analysis of the FRI is related to the patient, the fracture, and the surgical procedure[12]. Modifiable lifestyle factors are important in preventing infection[13]. Among these factors, smoking and alcohol abuse can influence the outcome of infection and even delay the consolidation of fixed fractures[14]. In our study, patients who had the habit of smoking were 1.8 times more likely to become infected during surgical treatment. Although the evidence remains contradictory[15,16]. On the other hand, patients with alcohol abuse were 1.6 times more likely than those who did not use alcohol chronically. They are important factors in the rehabilitation of patients submitted to surgery and can be controlled during the perioperative period.

Indeed, the acute nature of fractures limits the ability to modify risk factors for FRI, particularly comorbidities. Nonetheless, these factors should be optimized to provide a more favorable window of opportunity for surgical intervention[17]. Complications of ankle and foot fractures correlated with chronic kidney disease are poorly described in the literature; however, the presence of this risk factor may increase the incidence of infection by three- to fourfold[18]. A similar statistically significant association was observed in this cohort, which may be linked to a secondary complication arising from diabetes progression.

Obesity is recognized as a modifiable risk factor for FRI, and it was statistically significant in our study. Although there are controversies about the relationship between obesity and FRI in other fracture sites[19,20], it is consistently associated with complications and infections in orthopedic procedures[21,22], as confirmed by studies with statistical significance, even in paired analysis[22]. In our sample, patients identified as overweight had a higher probability of the outcome investigated. However, an important finding is that morbid obesity did not correlate with infection outcome as reported in the literature, presenting a divergent pattern.

In lower limb orthopedic procedures, glycemic control and diabetes management are essential due to the high complication rates[23]. In this context, however, our study found no significant association between diabetes and infection, which contrasts with existing literature. Diabetes is known to impair immune cell function, thereby compromising both innate and adaptive immune responses[24]. On the other hand, the study by Endara et al. [25] showed a significant association between glycemic uncontrol and infection at the surgical wound incision. This discrepancy between our series and the literature may be related to the age group of young adults, the type of trauma, or even the reduced number of diabetic patients.

The role of open fractures and high-energy trauma is also well established in the literature for an outcome of FRI, and the risk of infection increases proportionally to the severity classification of the open fracture[26,27]. In our results, patients classified as open fracture had a risk probability twice as high as patients with closed fracture, corroborating the studies in the literature.

Suffering soft tissue envelopment due to trauma energy can impair osteosynthesis [27]. Our study corroborates this correlation by demonstrating an association between high-energy trauma—especially falls from height (greater than 3 meters)—and FRI's. In cases of extensive soft tissue involvement, some surgeons postpone the definitive surgical procedure to improve edema and reduce local hematoma[28]. However, there are controversies about the delay of calcaneal

Table 2. Multivariate analysis of independent risk factors associated with the infection

Variables	Odds ratio Adjusted	95% CI	p-value
Smoking	1.816	(0.021, 0.065)	0.0001
Alcoholism	1.624	(1.007, 2.618)	0.045
Chronic kidney disease	2.237	(1.137, 4.399)	0.017
Overweight	2.815	(1.345, 5.889)	0.004
Fall from high (>3 m)	2.189	(1.470, 3.258)	0.0001
Open fracture	2.133	(1.076, 4.231)	0.026

Figure 2. Kaplan-Meier survival curve for osteomyelitis considering fracture-related infection. TRINETX Database: 163 cases (Yes 92 cases, No 71 cases).

surgery for soft tissue improvement. As demonstrated by Abidi et al.[29], this delay increased the wound healing time by approximately 2.6 times.

Studies related to the prevention and mitigation of risk factors emphasize the need to consolidate and develop early intervention strategies following the diagnosis of FRI to prevent pseudarthrosis and osteomyelitis[26-29]. In our series, the survival analysis showed a high risk of osteomyelitis in patients with FRI.

Over the last decade, there has been growing concern about the need to understand the RFIs in various clinical scenarios, particularly in relation to the peculiarities of anatomical location, fracture patterns, types of implants, and access routes[29,30]. This study reinforces the need for improvement and stratification of studies on FRI, addressing the intrinsic characteristics of fracture location.

This study has several limitations. Initially, the retrospective nature of the study introduces an unavoidable selection bias, which relies on the accuracy and quality of medical records to populate the platform database. There is limited information on other factors described in the literature, such as the type of implants, use of previous external fixation, identification of microorganism, and access route used in surgical treatment. Patient-specific covariates (smoking, alcohol abuse, drug use, and medical comorbidities) depended primarily on the patient's report, and some of them might not be willing to disclose these coexisting bad habits and diseases.

Conclusion

Smoking, alcohol abuse, chronic kidney disease, overweight, fall from height, and open fracture were identified as risk factors predicting FRI. Indeed, the holistic view in the perioperative surgical approach helps to identify and mitigate risk factors for infection. We believe that the study provides evidence that will help prevent infection in calcaneal osteosyntheses. Future randomized controlled trials are needed to mitigate contributing factors to infection.

Author's contributions: Each author contributed individually and significantly to the development of this article: ECSS *(https://orcid.org/0000-0001-5018-3923) Conceived and planned the activities that led to the study, wrote the article, participated in the review process, approved the final version; interpreted study results, participated in the review process; and participated in the review process; CDF *(https://orcid.org/0000-0002-6649-2066) Interpreted study results, participated in the review process; ROAF *(https://orcid.org/0009-0008-8466-8900) Interpreted study results, participated in the review process; SMFF *(https://orcid.org/0009-0001-4712-6159) Interpreted study results, participated in the review process; FDPR *(https://orcid.org/0009-0007-9143-1162) Interpreted study results, participated in the review process; DAS *(https://orcid.org/0009-0008-8395-8797) Interpreted study results, participated in the review process; MLSK *(https://orcid.org/0009-0009-9003-0863) Interpreted study results, participated in the review process; EAP *(https://orcid.org/000-001-60088671) Interpreted study results, participated in the review process; DLR *(https://orcid.org/0000-0003-0183-8641) Interpreted study results, participated in the review process. All authors read and approved the final manuscript. *ORCID (Open Researcher and Contributor ID).

References

1. Hu JS, Huang CB, Mao SM, Fang KH, Wu ZY, Zhao YM. Development of a nomogram to predict surgical site infection after closed comminuted calcaneal fracture. BMC Surg. 2022;22(1):313.
2. Mitchell MJ, McKinley JC, Robinson CM. The epidemiology of calcaneal fractures. Foot (Edinb). 2009;19(4):197-200.
3. Thomas L, Mcnaughton G. Spontaneous Avulsion Fracture Of The Calcaneus In A Non-Diabetic Patient. Scott Med J. 2006;51(3):1-3.
4. Metsemakers WJ, Moriarty TF, Morgenstern M, Marais L, Onsea J, O'Toole RV, et al. The global burden of fracture-related infection: can we do better? Lancet Infect Dis. 2024;24(6):e386-93.
5. Backes M, Schepers T, Beerekamp MS, Luitse JS, Goslings JC, Schep NW. Wound infections following open reduction and internal fixation of calcaneal fractures with an extended lateral approach. Int Orthop. 2014;38(4):767-73.
6. Buijs MAS, van den Kieboom J, Sliepen J, Wever KLH, van Breugel JM, Hietbrink F, et al. Outcome and risk factors for recurrence of early onset fracture-related infections treated with debridement, antibiotics and implant retention: Results of a large retrospective multicentre cohort study. Injury. 2022;53(12):3930-7.
7. World Health Organization. The ICD-10 classification of mental and behavioural disorders: clinical descriptions and diagnostic guidelines. Geneva: World Health Organization; 1992.
8. Hao D, Chen C, Wang D, Yin Y. [Non-operation related risk factors of wound complications of calcaneal fractures using lateral extensive L-shaped incision]. Zhongguo Xiu Fu Chong Jian Wai Ke Za Zhi. 2013;27(1):30-5. Chinese.
9. Paryavi E, Stall A, Gupta R, Scharfstein DO, Castillo RC, Zadnik M, et al. Predictive model for surgical site infection risk after surgery for high-energy lower-extremity fractures: development of the risk of infection in orthopedic trauma surgery score. J Trauma Acute Care Surg. 2013;74(6):1521-7.
10. Wang H, Pei H, Chen M, Wang H. Incidence and predictors of surgical site infection after ORIF in calcaneus fractures, a retrospective cohort study. J Orthop Surg Res. 2018;13(1):293.
11. Ding L, He Z, Xiao H, Chai L, Xue F. Risk factors for postoperative wound complications of calcaneal fractures following plate fixation. Foot Ankle Int. 2013;34(9):1238-44.

12. Santos EC, Prebianchi S, Santos IN, Kurihara MN, Dell'Aquila A, Finelli C, et al. Prior use of antibiotics and immunosuppression are risk factors for fracture-related infection during the COVID-19 pandemic period: a Brazilian prospective cohort study. BMC Musculoskelet Disord. 2022;23(1):535.
13. Ovaska MT, Mäkinen TJ, Madanat R, Vahlberg T, Hirvensalo E, Lindahl J. Predictors of poor outcomes following deep infection after internal fixation of ankle fractures. Injury. 2013;44(7):1002-6.
14. Jerjes W, Ramsay D, Stevenson H, Yousif A. Effect of chronic heavy tobacco smoking on ankle fracture healing. Foot Ankle Surg. 2024;30(4):343-8.
15. Alt V, Giannoudis PV. Musculoskeletal infections: A call for papers to continue the battle against this devastating global challenge. Injury. 2021;52(11):3187-8.
16. Smolle MA, Leitner L, Böhler N, Seibert FJ, Glehr M, Leithner A. Fracture, nonunion and postoperative infection risk in the smoking orthopaedic patient: a systematic review and meta-analysis. EFORT Open Rev. 2021;6(11):1006-19.
17. Metsemakers W-J, Handojo K, Reynders P, Sermon A, Vanderschot P, Nijs S. Individual risk factors for deep infection and compromised fracture healing after intramedullary nailing of tibial shaft fractures: A single centre experience of 480 patients. Injury. 2015;46(4):740-5.
18. Sinkler MA, Pennacchio CA, Kotchman HM, Vallier HA. Association of Chronic Kidney Disease and Complications Following Acute Torsional Ankle Fracture. Foot Ankle Int. 2022;43(12):1569-76.
19. Shaath MK, Lim PK, Andrews R, Chip Routt ML. Morbid obesity and short-term complications following acetabular fracture surgery: A comparative cohort study. Injury. 2020;51(11):2622-7.
20. Qi H, Duan W, Jia R, Wang S, An M, Long Y. Risk factors for surgical site infection after patellar fracture surgery in the elderly. J Orthop Surg Res. 2024 Dec 18;19(1):830. doi: 10.1186/s13018-024-05335-1. PMID: 39695794; PMCID: PMC11657550.
21. Bai Y, Zhang X, Tian Y, Tian D, Zhang B. Incidence of surgical-site infection following open reduction and internal fixation of a distal femur fracture: An observational case-control study. Medicine (Baltimore). 2019;98(7):e14547.
22. Janghala A, Niknam K, Freshman R, Cogan CJ, Zhang AL, Lansdown D. Effect of Obesity on Short- and Long-Term Complications After Ankle Fracture Fixation. J Orthop Trauma. 2024;38(9):e312-7.
23. Zhao D, Liang GH, Pan JK, Zeng LF, Luo MH, Huang HT, et al. Risk factors for postoperative surgical site infections after anterior cruciate ligament reconstruction: a systematic review and meta-analysis. Br J Sports Med. 2023;57(2):118-28.
24. Trevelin SC, Carlos D, Beretta M, da Silva JS, Cunha FQ. Diabetes Mellitus and Sepsis: A Challenging Association. Shock. 2017;47(3):276-87.
25. Endara M, Masden D, Goldstein J, Gondek S, Steinberg J, Attinger C. The role of chronic and perioperative glucose management in high-risk surgical closures: a case for tighter glycemic control. Plast Reconstr Surg. 2013;132(4):996-1004.
26. Foster AL, Moriarty TF, Trampuz A, Jaiprakash A, Burch MA, Crawford R, et al. Fracture-related infection: current methods for prevention and treatment. Expert Rev Anti Infect Ther. 2020;18(4):307-21.
27. You DZ, Schneider PS. Surgical timing for open fractures: Middle of the night or the light of day, which fractures, what time? OTA Int. 2020;3(1):e067.
28. Abidi NA, Dhawan S, Gruen GS, Vogt MT, Conti SF. Wound-healing risk factors after open reduction and internal fixation of calcaneal fractures. Foot Ankle Int. 1998;19(12):856-61.
29. Marais LC, Zalavras CG, Moriarty FT, Kühl R, Metsemakers WJ, Morgenstern M. The surgical management of fracture-related infection. Surgical strategy selection and the need for early surgical intervention. J Orthop. 2023;50:36-41.
30. Metsemakers WJ, Morgenstern M, McNally MA, Moriarty TF, McFadyen I, Scarborough M, et al. Fracture-related infection: A consensus on definition from an international expert group. Injury. 2018;49(3):505-10.

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Original Article

A comparison of foot pain and dynamic stability among flat and heeled footwear users in undergraduate female medical students

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Abstract

Objective: To compare foot pain and dynamic stability among flat and heeled footwear users in undergraduate medical students, raising awareness about the importance of appropriate footwear for improving health and stability.

Methods: This analytical cross-sectional study targeted 305 undergraduate female medical students to assess foot pain and dynamic stability. Participants were selected using a convenience sampling technique and pre-specified inclusion/exclusion criteria. Foot pain was measured using a 100 mm visual analog scale, with validity (0.76 to 0.84) and reliability (0.66 to 0.77). Dynamic stability was assessed using the four square step test (FSST), which showed excellent test-retest reliability (ICC = 0.92). The sample size was calculated using Yamane's formula, resulting in 305 participants.

Results: The study showed that 68.9% of participants had a normal body mass index, with 33.8% reporting no foot pain, while 56.1% experienced mild pain, and 10.2% severe pain. The ANOVA test revealed a significant increase in stability test times with higher heels (flat: 6.62s, low: 7.39s, high: 8.91s, $F = 68.880$, $p < 0.001$), and the Kruskal-Wallis test (Non normally distributed data) showed increased pain with higher heels ($p = 0.001$). The most common pain areas were the heels (38%) and the arch (27.9%), highlighting the negative impact of heel height on both pain and dynamic stability.

Conclusion: The study indicates that elevated heel heights substantially exacerbate foot discomfort and hinder dynamic balance when compared to flat shoes among female undergraduate medical students.

Level of evidence III; Analytical Cross-sectional Study.

Keywords: Postural Balance; Foot pain, shoes; Pain measurement; Medical students.

Introduction

Footwear has been used by humans for centuries. Soon after its invention, it gained huge popularity because it served a very important function of protecting the foot. Cultural differences also influence the styles. Footwear comes in a variety of sizes, shapes, and heel heights. High heels with pointed toes have been associated with elegance and a symbol of fashion in females, while flat footwear has been associated with comfort. The elegance associated with high-heeled footwear also brings lower back pain, due to increased curvature of the spine, disturbance of bone alignment, and leg pain; as well as increased weight on the foot and instability[1].

Different footwear, specifically different heel heights [0 cm (flat), 4 cm (low), 7 cm (medium), and 10 cm (high)], can have a significant influence on stability as higher heels raise the center of gravity and shift it away from the base of support[2]. In a static position, the condition for stability is that the center of gravity must pass through the base of support. During walking or other movements, 'dynamic

Study performed at School of Allied Health Sciences, CMH Lahore Medical College & Institute of Dentistry, Lahore Cantt, and Lahore, Pakistan.

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stability' is required, defined as the ability of an individual to control body position and balance during movement or when shifting from a dynamic position to a static position. Both the center of gravity and the base of support are actively moving in dynamic conditions; for the prevention of falls, it is essential to maintain balance in these conditions[3].

Walking down a curved path or changing directions rapidly requires more balance compared to walking in a straight line. Therefore, for testing dynamic stability, the four square step test (FSST) will be used, as this test combines rapid stepping with changing directions simultaneously[4]. While wearing proper footwear can protect from a wide range of injuries, wearing improper footwear, on the other hand, is the leading cause of various health problems and has been strongly associated with foot pain[5]. Approximately 24% to 30% of the adult population suffers from foot pathologies and pain[6].

Women tend to be at a higher risk of foot pain compared to men, due to the use of high heels[5]. The Visual Analogue Scale (VAS) will be used to assess foot pain, as this scale has been used to measure pain, quality of life, and anxiety since the 1920s[6]. The test typically consists of a 100 mm horizontal line with endpoints ranging from "no pain" to the "worst pain possible"[7]. For participants who report foot pain, the specific location of the foot pain will also be assessed[8].

A correlational study was conducted by Rajalaxmi et al.[9] in 2017, involving 100 male and female students, to investigate the correlation of habitual footwear with balance and foot pain among physiotherapy students. The study consisted of two groups: Group A, which included 50 males (A1, shoes with heels; A2, shoes without heels), and Group B, which included 50 females (B, flat slippers; B2, high-heeled slippers). The participants were assessed using the star excursion balance test and the foot function index. The results showed a significant difference in scores between the two groups. Group B2 had more pain, and Group A2 had better balance. These results conclude that wearing heeled footwear affected balance and caused more foot pain. A comparative study performed by Kaur and Chitkara in 2020 evaluated the impact of high heels on dynamic stability in young females by comparing habitual and non-habitual heel users. The dynamic stability of the 60 participants was assessed using the FSST. The results showed that non-habitual heel users had more dynamic stability and a lower chance of developing foot abnormalities compared to habitual heel users[10].

A study conducted by Fatima et al.[11] in 2022 evaluated the association between foot pain and high-heeled shoes in working women. The study consisted of 285 office workers and school teachers. The data were collected using the foot health status questionnaire (a 0-100 point scoring scale). The results showed a very high prevalence of foot pain (94.6%) among high-heeled shoe users. Previous studies have explored the link between foot pain and balance in high-heeled and flat footwear users, but without specifying heel height, and primarily among physical therapy students. No research has been conducted on this topic in Pakistan. This study aims to compare foot pain and dynamic stability among flat and heeled footwear users in undergraduate medical students, raising awareness about the importance of appropriate footwear for improving health and stability.

Methods

This study was approved by the Institutional Review Board, and written informed consent was obtained from all participants before their inclusion in the study. The study was conducted according to STROBE guidelines.

This analytical cross-sectional study was conducted at C.M.H Lahore Medical College and IOD, Lahore, focusing on undergraduate female medical students. Participants were recruited through a convenience sampling method, with eligibility criteria including being over 18 years old, maintaining good health, and habitually wearing either heeled footwear (for at least 2-3 hours, 2-3 days per week) or flat footwear. Exclusion parameters encompassed individuals with congenital or acquired musculoskeletal anomalies, foot injuries, trauma, obesity (Body mass index (BMI $\geq$ 30)), pregnancy, or reliance on assistive devices. The sample size was calculated using Yamane's formula, resulting in 305 participants from a population of 900, with a 0.05 marginal error[12,13].

Data acquisition involved measuring foot pain using a 100 mm VAS, where participants indicated their pain intensity along a continuum from no discomfort (rightmost point) to excruciating pain (leftmost point). The VAS exhibited robust validity (0.76-0.84) and moderate-to-good reliability (0.66-0.77)[7,14]. Additionally, individuals experiencing foot pain were able to pinpoint the precise location of discomfort using a foot diagram. Dynamic stability was evaluated through the FSST, which required participants to navigate a cross-patterned arrangement of squares swiftly and accurately, avoiding balance disturbances, missteps, or falls. Each participant completed the test twice, with the superior performance time recorded for analysis. The FSST demonstrated outstanding test-retest reliability (ICC = 0.92)[15]. Data were analyzed using SPSS version 26. Descriptive statistics were reported as frequencies and percentages for categorical variables, and means ± standard deviation for continuous variables. Normality was assessed using the Kolmogorov–Smirnov and Shapiro–Wilk tests. Between-group differences in test performance time were analyzed using one-way ANOVA followed by Tukey's post-hoc test. VAS scores across heel height categories were compared using the Kruskal–Wallis test followed by Bonferroni-adjusted pairwise comparisons. The significance level was set at $p < 0.05$.

Results

The study, conducted in 305 participants, revealed significant findings regarding heel height, foot pain, and dynamic stability. The sample consisted of two age groups: 18–21 years (59%) and 22–25 years (41%). Most participants were classified within the normal BMI range (68.9%), followed by 17.4% who were underweight and 13.8% who were overweight (Table 1).

Regarding footwear preferences, 47.21% preferred flat heels, 41.97% opted for medium heels, and 10.82% wore high heels. The VAS showed that 33.8% of participants reported no pain, while 56.1% experienced mild pain, 89.8% moderate pain, and 10.2% severe pain. One participant reported the worst imaginable pain. Pain location indicated that the heels (38%) and the arch (27.9%) were the most affected areas, followed by the ball of the foot (21.6%) and the toes (11.8%). While 66.6% of participants did not avoid wearing heels due to concerns about pain, 33.4% indicated that pain influenced their decision to wear heels.

Dynamic stability was assessed using a stability-related test, and the results showed a significant impact on heel height ($F = 68.880$, $p < 0.001$). Flat-heel users had the shortest test times (6.62 seconds), followed by low-heel users (7.39 seconds) and high-heel users (8.91 seconds) (Table 2). Tukey's post-hoc comparisons confirmed that the differences in stability test times between all heel height groups were statistically significant ($p < 0.001$), indicating that increased heel height compromised dynamic stability (Table 3). The normality of the data was assessed using the Shapiro-Wilk test, which indicated that VAS pain scores were not normally distributed across heel height groups ($p < 0.05$). Consequently, the Kruskal-Wallis test, a non-parametric alternative to ANOVA, was used to analyze pain levels across heel heights (Table 4). This test revealed significant differences in VAS scores by heel height ($p = 0.001$) (Figure 1). Pairwise comparisons with Bonferroni correction further confirmed that higher heels were associated with significantly greater pain than flats and low heels.

Overall, the findings demonstrate a clear inverse relationship between heel height and comfort and dynamic stability. High heels were associated with increased foot pain, particularly in

Table 1. Demographics characteristics of participants (n = 305)

Variable	Categories	N (%)
Age group (Years)	18-21	180 (59.00)
	22-25	125 (41.00)
BMI (Kg/m²)	Underweight (< 18.5)	53 (17.40)
	Normal (18.5-24.5)	210 (68.90)
	Overweight (25-29.5)	42 (13.80)
Heel height (cm)	Flat	144 (47.21)
	Low	128 (41.97)
	High	33 (10.82)
Pain distribution (VAS)	No pain	103 (33.4%)
	Mild pain	68 (22.3%0
	Moderate pain	103 (33.8%)
	Severe pain	30 (9.8%)
	Worst pain imaginable	1 (0.30%)
FSST (Sec)	Balanced (< 6.4)	104 (34.1%)
	Unbalanced (6.4 and Above)	201 (65.9%)

BMI: Body mass index; FSST: Four square step test; Heel height classification: Flat (0 cm), Medium (2-5 cm), High (>5 cm); Percentages are calculated based on the total sample size (N = 305); Cumulative percent represents the progressive sum of participants experiencing each pain category; The FSST showed 34.1% balanced and 65.9% unbalanced among 305 participants.

Table 2. Pairwise comparison of heel heights (cm)

Sample 1- Sample 2	Test statistic	Std. error	Std. test statistic	p-value	Adj. Sig.
Flat (< 0.8) - Low (0.8-4)	-19.937	10.499	-1.899	0.058	0.173
Flat (< 0.8) - High (> 4)	-62.458	16.681	-3.744	0.000	0.001
Low (0.8-4) - High (> 4)	-42.521	16.874	-2.520	0.012	0.035

$p < 0.05$ is considered statistically significant; Adj. Sig: Adjusted significance, values account for multiple comparisons to reduce the risk of Type I error; Negative test statistics indicate a higher mean difference in the second group compared to the first.

Table 3. Post-hoc tests showing multiple comparisons

	(I) Heel height (cm)	(J) Heel height (cm)	Mean Difference	p-value
Tukey HSD	Flat (< 0.8)	Low (0.8-4)	-.77898*	< 0.001*
		High (> 4)	-2.29580*	0.001*
	Low (0.8-4)	High (> 4)	-1.51681*	0.001*

$p < 0.05$ is considered statistically significant; Tukey HSD: Honestly Significant Difference tests was performed for post-hoc multiple comparisons of heel height groups; Negative mean differences indicate higher test performance time in the second group compared to the first.

Table 4. Analysis of variance (ANOVA) for test performance time among different footwear groups

	Test performing time (Second)				
	Sum of squares	df	Mean square	F	p- value
Among the groups	150.654	2	75.327	68.880	< 0.001*
Within groups	330.265	302	1.094		
Total	480.919	304			

df: Degrees of freedom; A statistically significant difference (*$p < 0.001$) was observed in test performance time across different footwear groups; The four square step test was used to measure dynamic stability; Higher F-values indicate significant variance between groups.

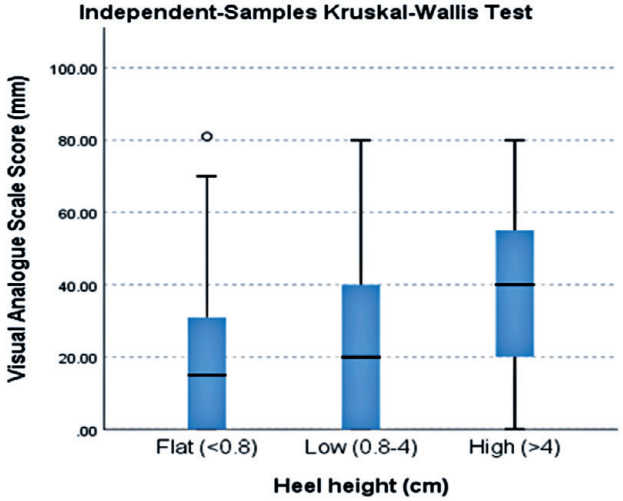

Figure 1. Pain scores across various heel heights.

the heel and arch regions, and impaired stability, as evidenced by longer test times. In contrast, flat shoes provided better outcomes for pain and dynamic stability, making them a more ergonomic choice for extended wear.

Discussion

The discussion on high-heeled versus flat footwear highlights differences in aesthetics, comfort, and practicality. High heels are often chosen for their elegance and formal appeal, but are associated with significant physical strain, including impaired balance, foot pain, and altered posture. In contrast, flat footwear offers better comfort and dynamic stability, making it more suitable for extended wear.

This study evaluated the effects of high heels on dynamic stability using the FSST. The results showed that flat footwear users (0.8 cm) had better dynamic stability than high-heel users (> 5 cm), similar to the findings of Kaur and Chitkara[10], who reported greater stability in non-habitual heel users compared to habitual users. Likewise, Rajalaxmi et al.[9] observed that wearing heels adversely affected balance and increased foot pain, findings consistent with this study.

Kahile M et al.[16] demonstrated a significant correlation between heel height and pain, where higher heels were associated with an increased prevalence of heel pain. This corroborates the results of our study, which identified heel pain as the most significant complaint among high-heeled users. Similarly, Joshi et al.[17] observed that heel height negatively impacted dynamic balance, lumbar lordosis, and core muscle strength using the Y-balance test, aligning with the current findings. Randal et al.[18] further supported this, noting significant static and dynamic balance impairments with increasing heel heights.

Additionally, Fatima et al.[11] found a 96% prevalence of foot pain among women wearing high heels, with the majority experiencing mild to moderate pain, which aligns with our study's observation of increased foot discomfort in high-heeled users. Kumar et al.[19] reported that wearing high heels, compared to flat footwear, significantly impaired balance and stability dynamics, as evidenced by altered kinetic parameters. These results align with the current study's findings, which demonstrated a decline in dynamic stability with increasing heel height.

In summary, high-heeled footwear significantly impairs dynamic stability, balance, and foot comfort, with higher heel heights exacerbating these effects. Flat footwear provides better stability and comfort, making it a more practical option for prolonged wear. These findings emphasize the importance of carefully considering biomechanical and ergonomic factors when selecting footwear to promote optimal function and musculoskeletal health.

Study limitations

- Employing convenience sampling from a single academic setting restricts the broader applicability of the findings;
- The cross-sectional nature of the study reflects relationships at a single time point and does not permit conclusions regarding causality;
- Foot discomfort ratings obtained through the VAS may be subject to recall inaccuracies and personal differences in pain interpretation;
- It was not feasible to fully regulate all potential confounding variables, such as variations in daily physical activity, prior injuries, and differences in footwear use.

Practical implications

- Educating undergraduate students, particularly females, on the adverse effects of high heels can promote healthier footwear choices;
- Integrating foot health education into medical curricula can equip future healthcare professionals to counsel patients on footwear-related risks;
- Encouraging the use of flat or low-heeled shoes for prolonged standing or walking can help minimize foot pain and enhance stability;
- Universities and workplaces can implement guidelines or campaigns to promote ergonomic footwear and reduce balance-related injuries.

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References

1. Nadeem I, Kashif M, Mushtaq S, Hussain R, Naseem N, Darain H, et al. High heels and low back pain in young female students. Int J Pathol. 2018;16(2):87-91.
2. Chen Y, Li JX, Wang L. Influences of heel height on human postural stability and functional mobility between inexperienced and experienced high heel shoe wearers. PeerJ. 2020;8:e10239.
3. Park DJ, Lee KS, Park SY. Effects of two foot-ankle interventions on foot structure, function, and balance ability in obese people with pes planus. Healthcare (Basel). 2021;9(6):667.
4. Renganathan G, Kurita Y, Ćuković S, Das S. Foot biomechanics with emphasis on the plantar pressure sensing: A review. In: Revolutions in Product Design for Healthcare: Advances in Product Design and Design Methods for Healthcare. 2022. p. 115-41.
5. Branthwaite H, Chockalingam N. Everyday footwear: An overview of what we know and what we should know on ill-fitting footwear and associated pain and pathology. Foot (Edinb). 2019;39:11-4.
6. Zeng Z, Liu Y, Hu X, Li P, Wang L. Effects of high-heeled shoes on lower extremity biomechanics and balance in females: A systematic review and meta-analysis. BMC Public Health. 2023;23(1):726.
7. Modarresi S, Lukacs MJ, Ghodrati M, Salim S, MacDermid JC, Walton DM. A systematic review and synthesis of psychometric properties of the numeric pain rating scale and the visual analog scale for use in people with neck pain. Clin J Pain. 2022;38(2):132-48.
8. Mahnoor M, Maqsood Q, Sumrin A. The association of back pain and its functional limitations with wearing heels among working women and its therapeutic management. Int J Multidiscip Res Growth Eval. 2021;2(4):392-400.
9. Rajalaxmi V, Lakshmi S, Kamatchi K, Jayson JC, Devika E. Correlation between high heel vs. flat footwear with balance and foot pain in physiotherapy students. J Liaquat Univ Med Health Sci. 2018;17(4):255-9.
10. Kaur N, Chitkara E. Effect of high heels on dynamic stability in young females: A comparative study. Indian J Basic Appl Med Res. 2020;9(3):302-8.
11. Fatima S, Riaz U, Sadia A, Khalid M, Jamal A, Ilyas T. Association Between Foot Pain and High Heeled Shoes in Working Women: Association between Foot Pain and High Heeled Shoes. PBMJ. 2022;5(5):49-53.
12. Kothari CR. Research methodology: Methods and techniques. New Delhi: New Age International; 2004.
13. Cochran WG. Sampling techniques. New York: John Wiley & Sons; 1977.
14. Streiner DL, Norman GR, Cairney J. Health measurement scales: a practical guide to their development and use. Oxford: Oxford University Press; 2024.
15. Shirley Ryan Ability Lab. Rehabilitation measure: Four square step test. 2018. Available from: https://www.sralab.org/rehabilitation-measures/four-square-step-test
16. Kahile M, Deshmukh N, Neve C, Padwal AM, Khedkar SS, Muley P. Prevalence of foot pain and its correlation with various heel heights among health care professionals. NeuroQuantology. 2022;20(14):1489-94.
17. Joshi G, Pathak H, Bagade V, Naidu S. The effect of heel height on balance, lumbar lordosis and core muscle strength among young healthy Indian females. Indian J Physiother Occup Ther. 2023;17(1):45-50.
18. Randall RL. The Effects of Elevated Shoe Heights on Static and Dynamic Balance in Healthy Younger Women [Internet]. Physical Therapy Scholarly Projects. 2001;362. Available from: https://commons.und.edu/pt-grad/362
19. Kumar SD, Sandhu K, Pal M. Effect of wearing high heel and flat footwear on balance and stability dynamics: A kinetic study. Indian Journal of Physiology and Pharmacology. 2024;68(2):157-63.

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Original Article

Modified Lapidus procedure with a single screw and staple: A comparative analysis

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Abstract

Objective: The primary objective of the study is to review the fusion rate associated with a single screw and staple construct in Lapidus bunionectomy, and to compare the complication rates, fusion outcomes, and radiographic results with those of other common fixation methods.

Methods: Eighty-four bunionectomies met study criteria; in 24 cases, a single screw and staple construct was used, while 28 used a screw and locking plate, and 32 used two crossing screws. Although group matching was attempted, a greater body mass index was observed in the screw and locking plate group (p = 0.006).

Results: The minimum follow-up was 12 months (mean, 31.4 months), and the primary outcome was fusion rate. Union rates were achieved in 95.8% for the single screw and staple fixation (23/24), 92.8% for the screw and locking plate (26/28), and 93.8% for crossing screws (30/32) without a statistically significant difference (p = 0.474). The single screw and staple group achieved significantly (p = 0.012) earlier radiographic and clinical union, at 11.7 (+ 1.86) weeks, compared to crossing screw (13.2 + 2.39 weeks) and screw and locking plate (13.5 + 1.69 weeks) groups. There were no significant differences in final first intermetatarsal angle (p = 0.403), hallux valgus angle (p = 0.153), or complication rates (p = 0.386) among the fixation methods.

Conclusion: Our study shows that a single screw and staple construct is a viable option for Lapidus bunionectomy, demonstrating faster union time and maintained deformity correction with an acceptable complication rate. However, further research is required to validate the advantages and disadvantages of specific surgical implants.

Level of evidence III; Retrospective Case-control Study.

Keywords: Hallux valgus; Fracture fixation, internal; Bone screws; Bone nails.

Introduction

Hallux valgus is one of the most common pathologies encountered by a foot and ankle specialist. After failure of conservative treatments, deformity correction can be accomplished by a variety of techniques. One conventional procedure is the first tarsometatarsal joint (TMTJ) arthrodesis[1,2]. This method has become increasingly popular over the past century, following its expansion by Paul Lapidus in 1934[1-3]. Now eponymous with Dr. Lapidus, the TMTJ fusion (or Lapidus procedure) has progressed considerably from its original description[4]. The modern discourse regarding Lapidus bunionectomy has focused on minimal bony resection, anatomic reduction in all planes, robust internal fixation, and early mobilization[4,5].

Recent evidence has noted lower recurrence rates and similar fusion rates with tri-planar correction. There are numerous radiographic parameters reported to determine correction and potentially limit long-term recurrence[3-5]. However, accurate and sustained correction may be independent of the type of fixation and secondary to intraoperative technique

Study performed at Scripps Healthcare, San Diego, CA, USA.

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and anatomic reduction[5-7]. Regardless, the release of novel orthopedic instrumentation and implants for Lapidus bunionectomies has continued at a steady pace[8,9].

Historically, there have been a plethora of fixation constructs for first TMTJ arthrodesis[1,3,6-8]. The most common fixation method in the literature appears to be crossing screw fixation[7,10,11]. Other techniques have been described, including Kirschner wire augmentation[12], various plating[13], endosseous fixation[14], and staples[15]. The senior authors' technique involves the hybrid use of a screw and staple. Biomechanical studies have emphasized the ability of nitinol staples to apply and maintain compression across a first TMTJ fusion site[16]. To our knowledge, a single screw and staple construct has not been evaluated in the literature. The primary objective of the study is to review the fusion rate associated with a single screw and staple construct in Lapidus bunionectomy, and to compare the complication rates, fusion outcomes, and radiographic results with those of other common fixation methods.

Methods

This study was approved by the Institutional Review Board. Patient data was de-identified and retrospectively reviewed. A total of 445 first TMTJ arthrodesis procedures were identified at our regional healthcare system from April 2016 to April 2023.

Inclusion criteria consisted of patients submitted to their first TMTJ arthrodesis for hallux valgus, with a minimum clinical follow-up of 12 months and radiographic follow-up of at least six months. For all surgeons, a Lapidus was considered primarily if a patient had an intermetatarsal angle (IMA) greater than 13 degrees and any subjective evidence of medial column instability. Exclusion criteria included patients younger than 18 years of age, those undergoing lower extremity reconstructive surgery, or patients undergoing midfoot or rearfoot bony procedures at the time of their Lapidus bunionectomy. Implant type(s) were determined by operative notes and plain film radiographs. Central metatarsal osteotomy was performed sparingly but completed for long second rays based on the metatarsal parabola. And proximal phalanx osteotomy was completed if there was residual deformity at the hallux after modified Lapidus.

One author routinely utilizes a single screw and staple construct for Lapidus bunionectomies. The senior author's cases, which include either a dorsomedial locking plate or crossing screws, were used for comparison. Operative technique was otherwise similar for both. This included a standard dorsomedial approach. A soft tissue lateral release followed by meticulous joint preparation with rasp, curettage, and 2.0 mm drill bit fenestration. Deformity reduction was completed manually, with the assistance of a Weber clamp in all cases. The hardware used for the former's cases included a cannulated 4.0 mm headless compression screw positioned in a "beam" fashion to capture the plantar medial cuneiform, and a nitinol staple, placed medially if dissection allowed, typically 15 mm by 15 mm (Figures 1 and 2). The latter utilized a cannulated 3.5 mm compression screw and 5-hole locking plate placed dorsomedially with 2.5 mm screws or a crossing screw construct with two 3.7 mm solid-headed compression screws (Figure 3).

Figure 1. Anteroposterior and lateral views of a standard single screw and staple construct.

A chart review was conducted by researchers not involved in the index surgery and blinded to patient outcomes. Demographic data, including patient comorbidities based on the International Classification of Diseases (ICD-9), were recorded and are presented in Table 1. Radiographic parameters were calculated as described by Lamm et al.[17], both preoperatively and at the latest radiographic follow-up. Intermetatarsal angle of 1-2 metatarsals, hallux valgus angle (HVA), and the lateral axis of talar neck and first metatarsal (Meary's angle) were collected via an electronic picture archiving communication system (Intellispace Enterprise, Philips, Amsterdam, Netherlands). Union was defined as osseous bridging of at least three cortices in addition to an absence of clinical symptomatology. Complications were recorded and

Figure 2. Anteroposterior and lateral views of the standard crossing screw construct.

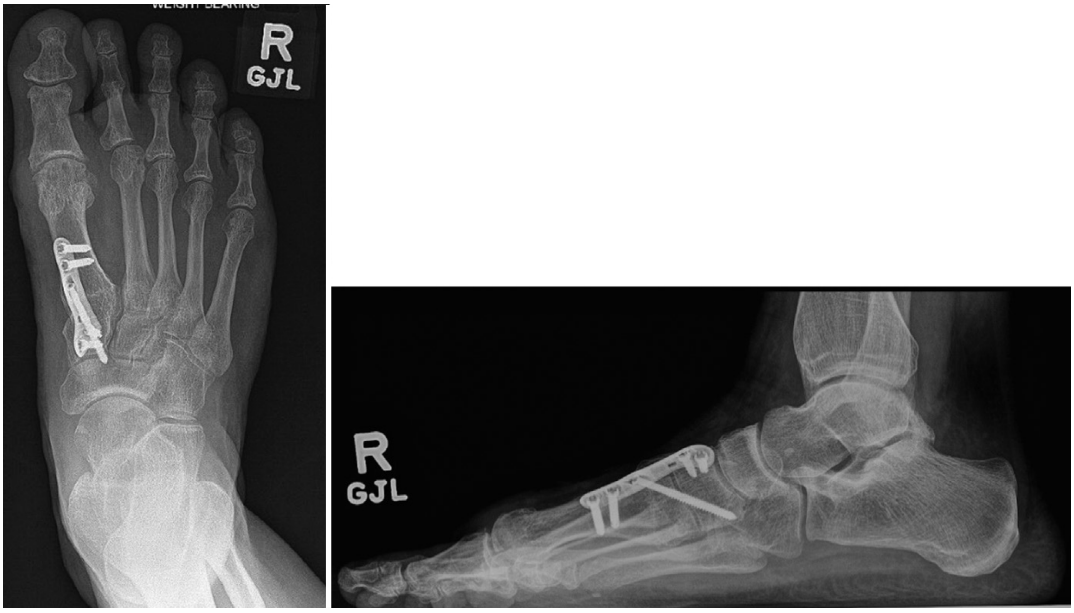

Figure 3. Anteroposterior and lateral views of the screw and locking plate construct.

deemed major if they required a return to the operating room and/or persisted for more than three months. Complications were considered minor if they were resolved with conservative care within three months. The chart review was conducted by co-investigators not involved in patient care. A radiographic review was performed while the clinician was blinded to the clinical outcome.

Postoperative protocol

All patients were placed in a non-weight-bearing splint for two weeks postoperatively. Afterward, all patients were placed in a controlled ankle motion boot and continued non-weight-bearing for four weeks. At which point they progressed to weight-bearing in a controlled ankle motion boot for 2-4 weeks, followed by a return to regular shoe gear.

Statistics

Normality tests were completed using the Shapiro-Wilk test. Only age was found to be normally distributed; therefore, analysis of variance was used to compare ages. Nominal variables were compared using the Chi-squared test. Kruskal-Wallis tests were used for nonparametric quantitative data as three fixation types were compared. The Wilcoxon test was used to compare pre- and postoperative radiographic measurements within groups. The Alpha error was set at 5%, and results lower were deemed significant. A power calculation was performed, and a sample size of 220 patients was estimated for 80% statistical power. However, the final sample size was 84 cases. Statistical analysis was completed using SPSS version 26.0 (IBM Corporation, Armonk, NY).

Results

Seventy-five patients, involving 84 feet, met the inclusion criteria for analysis. Twenty-four Lapidus bunionectomies were completed with a screw and a staple construct. One of these was completed with two screws and one staple. Twenty-eight cases were completed with a lag screw and locking plate, and 32 cases were completed with two crossing screws.

Among the groups, there were no significant differences in age, laterality, tobacco use, vitamin D, or diabetes mellitus. The lag screw and locking plate group had a significantly greater body mass index (BMI) ($p = 0.006$). Comparison of demographic features is seen in Table 1. Overall, the median age was 58 (SD + 14.2, range: 19-78). Mean follow-up was 31.4 months (SD + 4.13). Mean BMI was 27.4 (SD + 5.7, range: 18.5 - 45.6). Female patients comprised 89.7% of the patients, and left feet were 56.7% of cases. Regardless of implant specifics, all radiographic parameters showed significant improvement from preoperative measurements to the latest follow-up ($p < 0.001$). Union was achieved in 11.7 weeks (SD + 1.86) in the single screw and staple group, 13.2 weeks (SD + 2.39) in the crossing screw group, and 13.5 weeks (SD + 1.69) in the screw and locking plate group. The difference between the single screw and staple group and the others was statistically significant ($p = 0.012$), but not between the crossing screw and locking plate groups ($p = 0.485$).

The union rate was 95.8% for the single screw and staple group (23/24), 92.8% for the screw and locking plate group (26/28), and 93.8% for the crossing screws group (30/32) (Table 2). Seven superficial wounds occurred, three each in the locking plate and crossing screw groups, and one in the

Table 1. Patient demographics and risk factors among groups.

Variable	Screw and staple (n = 24)	Crossing screws (n = 32)	Screw and locking plate (n = 28)	p-value
Mean age (± SD)	58.4 (± 11.5)	51.1 (± 16.9)	57.2 (± 11.2)	0.210
BMI (± SD)	26.1 (± 4.6)	25.5 (± 4.4)	30.8 (± 6.5)	0.006*
Female (%)	19 (79.2%)	28 (87.5%)	25 (89.3%)	0.148
Laterality, right (%)	14 (58.3%)	14 (43.75%)	12 (42.9%)	0.315
Current tobacco use (%)	1 (4.2%)	0	0	0.191
Former tobacco (%)	0	4 (12.5%)	3 (10.7%)	
Diabetes mellitus	1 (4.2%)	1 (3.1%)	1 (3.6%)	0.910
Follow up, months (± SD)	31.4 (± 4.27)	30.7 (± 3.95)	32.1 (± 4.30)	0.414

BMI: Body mass index; SD: Standard deviation. *Statistically significant.

Table 2. Comparison of outcomes and complications among groups.

		Screw and staple (n = 24)	Crossing screws (n = 32)	Screw and locking plate (n = 28)	p-value
Complications	Minor	1 (4.2%)	3 (9.4%)	3 (10.7%)	0.386
	Major	2 (8.3%)	2 (6.3%)	3 (10.7%)	0.474
Adjunctive procedures	2nd metatarsal Weil osteotomy	3 (12.5%)	4 (12.5%)	2 (7.1%)	1.0
	Akin osteotomy	4 (16.6%)	4 (12.5%)	2 (7.1%)	1.0
Fusion rate (nonunions)		95.8% (1)	93.8% (2)	92.9% (2)	0.474
Time to union (weeks, mean)		11.7*	13.2	13.5	0.012

*Statistically significant.

single screw and staple group. One hardware removal was required in the locking plate and crossing screw groups. All-cause complication rate was 17.9%, with nonunions accounting for 33.3% (5/15) overall and 71.4% (5/7) of major complications. Three of the five nonunions were symptomatic. Two underwent revision arthrodesis, one each in the locking plate and crossing screw groups. Preoperative HVA was significantly greater in the single screw and staple group ($p = 0.004$). Otherwise, all pre- and postoperative radiographic measurements did not show significant differences among groups, as demonstrated in Table 3 ($p > 0.15$).

Discussion

Several studies have compared fixation methods in Lapidus arthrodesis[13,14,18-21]. Barp et al.[18] reviewed 147 Lapidus procedures with either crossing solid screws, locking plates with a separate compression screw, or locking plates with an integrated compression screw. They found a 7.3% lower risk of nonunion with the integrated locking system ($p = 0.0056$), and a 12.1% greater risk of hardware removal, which was not statistically significant ($p = 0.963$). The groups were matched, although no radiographic parameters were reported. In a recent review, Heifner et al.[21] found no significant differences between crossing screw and plate constructs. This study did not focus on union rates, which are notoriously difficult across graft wedges. Other studies have also emphasized higher union rates with a screw and plate construct[19,20].

On the other hand, results of staple fixation for hallux valgus correction have been infrequent. Mallette et al.[15] in 2014 demonstrated their results using a two-staple construct for Lapidus bunionectomies. They had a 44% overall complication rate out of their 36 cases. Painful hardware accounted for half of these complications. This has not been the experience of the senior author, and painful hardware is found in 7.5% of patients postoperatively. Postoperatively, one hardware removal was required (5.3%) compared to 22.8% of cases reported by Mallette et al[15]. It remains unclear whether dorsal versus medial staple orientation across the TMTJ impacts symptomatic prominence. In our study, staples were placed as medially as possible, given the soft tissue constraints, and no association was found between the type of fixation and complications ($p = 0.386$).

An advantage of staple fixation is the greater residual bone volume for additional fixation. This can play a role when there is limited space for an intermetatarsal (IM) or intercuneiform screw. An additional screw in this instance is common to increase rigidity or address intercuneiform instability[22,23]. A suture button device could also be used, with a lower risk of cutting through screw threads compared to a staple[15]. In our study, one patient received an IM screw in the single screw and staple group, three in the crossing screw group, and none in the locking plate group. Previous reports have demonstrated the increased rigidity with a transverse screw[4,22-24]. This intercuneiform or IM screw may also provide more confidence in early weight-bearing. Also, neither of the senior authors routinely deploys a transverse screw. Rather, if there is a minor intraoperative loss in correction after hardware placement, transverse fixation is then applied between the cuneiforms or the first and second metatarsal bases. Naturally, the method of fixation is dependent on the surgeon's preference and experience.

The one difference across our treatment groups was BMI ($p = 0.006$). The mean BMI for the locking group was 4.7 and 5.3 greater than the single screw and staple and crossing screw groups, respectively. Whether this is clinically relevant remains to be seen. Some data have shown no discrepancies in union rates between similar variances in BMI[7]. It is assumed that surgeons select more robust hardware for patients with higher BMI. Therefore, the difference in BMI may be due to surgeon selection and is a potential source of bias. Contemporary literature has supported the use of a compression screw and locking plate for overweight patients due to the increased biomechanical strength[4,5,7,24]. However, Aiyer et al.[23] demonstrated the significant contact area and contact force of staple fixation across the first TMTJ. They found that the contact force and area with a single staple were greater than with a crossing screw or claw plate ($p < 0.05$). And while the single staple also performed similarly to a crossing screw in plantar gapping ($p < 0.01$), the crossing screw was the superior construct compared to four-point bending at all levels of displacement ($p < 0.001$). The authors consider the continuous interfragmentary compression afforded by the properties of nitinol as a reason for the quicker time to union in the staple group. Unfortunately, a precise biomechanical measurement of the stiffness, contact area, and peak loads of the single screw and staple construct was not determined. In vitro biomechanical testing is certainly needed in addition to this clinical report.

Other limitations of our study are those intrinsic to a retrospective review with a small sample size. Follow-up was short and likely inadequate to evaluate the latent loss of deformity correction. Patients with concomitant midfoot or rearfoot procedures were excluded to curb heterogeneity.

Table 3. Radiographic comparison among groups.

		Screw and staple (n = 24)	Crossing screws (n = 32)	Screw and locking plate (n = 28)	p-value
IMA (degrees)	Preoperative	13.55 (±2.2)	13.48 (±4.0)	15.1 (±4.5)	0.411
	Postoperative	7.1 (±1.4)	6.7 (±2.6)	7.9 (±3.6)	0.403
HVA (degrees)	Preoperative	38.0 (±9.9)	27.6 (±9.7)	30.3 (±10.8)	0.004*
	Postoperative	18.8 (±4.4)	15.0 (±7.6)	13.8 (±9.0)	0.153

IMA: Intermetatarsal angle; HVA: Hallux valgus angle. *Statistically significant.

Inclusion of such cases would have bolstered the sample size. All operative techniques were biased to the surgeon's preference. Preferences go beyond hardware and include methods of joint preparation and reduction. However, cases were consecutive and techniques did not change over time. Furthermore, fixation constructs varied evenly for each surgeon. The cases were reviewed by researchers who were not involved in the surgical cases and were blinded to patient outcome. Additionally, computed tomography was not routinely used to assess union. A case was defined as union only if both radiographic parameters were met and the patient remained asymptomatic. True pseudoarthrosis rate may be greater than reported, albeit asymptomatic. Radiographic measurements are susceptible to detection bias. All measurements were standardized and calculated on the same system, with researchers blinded to the clinical outcome.

Lastly, an increasingly important issue in healthcare is value-based care[25]. The present data demonstrates equivalent outcomes and complications for crossing screws as screw and staple. This is despite a standard fully threaded screw being less expensive than a nitinol staple[26]. Future cost-benefit analyses should be conducted to justify the higher prices of implants. One factor that needs to be considered is operating room time and efficiency.

Conclusion

Our study shows that a single screw and staple construct is a viable option for Lapidus bunionectomy. The single screw and staple group achieved combined radiographic and clinical union at 11.7 weeks, compared to 13.2 and 13.5 weeks in the crossing screw and locking plate groups, respectively ($p = 0.012$). The single screw and staple group also maintained deformity correction with an acceptable overall complication rate. The union rate across all fixation groups was 94.05%, which is comparable to the contemporary literature[7,11,27]. Further research is required to validate the advantages and disadvantages of specific surgical implants.

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References

1. Lapidus PW. Operative correction of the metatarsus varus primus in hallux valgus. Surg Gynecol Obstet. 1934;58:183-91.
2. Galois L. History of surgical treatments for hallux valgus. Eur J Orthop Surg Traumatol. 2018;28(8):1633-9.
3. Symeonidis PD, Anderson JG. Original and modified Lapidus procedures: proposals for a new terminology. J Bone Joint Surg 2021;103(4):e15.
4. Dujela MD, Langan T, Cottom JM, DeCarbo WT, McAlister JE, Hyer CF. Lapidus Arthrodesis. Clin Podiatr Med Surg. 2022;39(2):187-206.
5. Li S, Myerson MS. Evolution of thinking of the Lapidus procedure and fixation. Foot Ankle Clin 2020;25(1):109-26.
6. Wang B, Manchanda K, Lalli T, Wukich DK, Liu GT, Raspovic K, et al. Identifying Risk Factors for Nonunion of the Modified Lapidus Procedure for the Correction of Hallux Valgus. J Foot Ankle Surg. 2022;61(5):1001-6.
7. Prissel MA, Hyer CF, Grambart ST, Bussewitz BW, Brigido SA, DiDomenico LA, e al. A Multicenter, Retrospective Study of Early Weightbearing for Modified Lapidus Arthrodesis. J Foot Ankle Surg. 2016;55(2):226-9.
8. Liu GT, Chhabra A, Dayton MJ, Dayton PD, Duke WJ, Farber DC, et al. One- and Two-Year Analysis of a Five-Year Prospective Multicenter Study Assessing Radiographic and Patient-Reported Outcomes Following Triplanar First Tarsometatarsal Arthrodesis With Early Weightbearing for Symptomatic Hallux Valgus. J Foot Ankle Surg. 2022;61(6):1308-16.
9. Chaparro F, Cárdenas PA, Butteri A, Pellegrini MJ, Carcuro G, Ortiz C. Minimally invasive technique with intramedullary nail for treatment of severe hallux valgus: clinical results and surgical technique. J Foot Ankle. 2020;14(1):3-8.
10. DeVries JG, Granata JD, Hyer CF. Fixation of first tarsometatarsal arthrodesis: a retrospective comparative cohort of two techniques. Foot Ankle Int. 2011;32(2):158-62.
11. King CM, Richey J, Patel S, Collman DR. Modified lapidus arthrodesis with crossed screw fixation: early weightbearing in 136 patients. J Foot Ankle Surg. 2015;54(1):69-75.
12. Basile P, Cook EA, Cook JJ. Immediate weight bearing following modified lapidus arthrodesis. J Foot Ankle Surg. 2010;49(5):459-64.

13. Cottom JM, Rigby RB. Biomechanical comparison of a locking plate with intraplate compression screw versus locking plate with plantar interfragmentary screw for Lapidus arthrodesis: a cadaveric study. J Foot Ankle Surg. 2013;52(3):339-42.
14. King CM, Doyle MD, Castellucci-Garza FM, Lyon L, Richey J, Patel S, Collman DR. Addressing Transverse Plane Instability in the Modified Lapidus Arthrodesis: A Comparative Study of Screw Versus Suture and Button Fixation Device Technique. J Foot Ankle Surg. 2022;61(5):979-85.
15. Mallette JP, Glenn CL, Glod DJ. The incidence of nonunion after Lapidus arthrodesis using staple fixation. J Foot Ankle Surg. 2014; 53(3):303-6.
16. Russell NA, Regazzola G, Aiyer A, Nomura T, Pelletier MH, Myerson M, et al. Evaluation of Nitinol Staples for the Lapidus Arthrodesis in a Reproducible Biomechanical Model. Front Surg. 2015;2:65.
17. Lamm BM, Stasko PA, Gesheff MG, Bhave A. Normal Foot and Ankle Radiographic Angles, Measurements, and Reference Points. J Foot Ankle Surg. 2016;55(5):991-8.
18. Barp EA, Erickson JG, Smith HL, Almeida K, Millonig K. Evaluation of Fixation Techniques for Metatarsocuneiform Arthrodesis. J Foot Ankle Surg. 2017;56(3):468-73.
19. Gutteck N, Wohlrab D, Zeh A, Radetzki F, Delank KS, Lebek S. Comparative study of Lapidus bunionectomy using different osteosynthesis methods. Foot Ankle Surg. 2013;19(4):218-21.
20. Saxena A, Nguyen A, Nelsen E. Lapidus bunionectomy: Early evaluation of crossed lag screws versus locking plate with plantar lag screw. J Foot Ankle Surg. 2009;48(2):170-9.
21. Heifner JJ, Materón SR, Zhang L, Giovanni TPS. Union Rates With the Use of Structural Allograft in Lapidus Arthrodesis: A Comparison Between Two Fixation Constructs. J Foot Ankle Surg. 2023;62(1):91-5.
22. Jones JM, Schleunes SD, Vacketta VG, Philp FH, Hentges MJ, McMillen RL, et al. First Tarsometatarsal Joint Arthrodesis for Hallux Valgus With and Without Intermetatarsal Screw Fixation: A Comparison of Correction and Maintenance of Correction. J Foot Ankle Surg. 2022;61(6):1255-62.
23. Aiyer A, Russell NA, Pelletier MH, Myerson M, Walsh WR. The Impact of Nitinol Staples on the Compressive Forces, Contact Area, and Mechanical Properties in Comparison to a Claw Plate and Crossed Screws for the First Tarsometatarsal Arthrodesis. Foot Ankle Spec. 2016;9(3):232-40.
24. Ehredt DJ Jr, Kawalec J, Ligas C, Seidel J, Benson B, Reiner MM, et al. The Lapidus Arthrodesis: Examining the Effect of the Metatarsal Base Transfixion Screw. J Foot Ankle Surg. 2021;60(2):333-8.
25. Gray M. Value based healthcare. BMJ. 2017;356:j437.
26. Wagner E, Ortiz C, Torres K, Contesse I, Vela O, Zanolli D. Cost effectiveness of different techniques in hallux valgus surgery. Foot Ankle Surg. 2016;22(4):259-64.
27. Donnenwerth MP, Borkosky SL, Abicht BP, Plovanich EJ, Roukis TS. Rate of nonunion after first metatarsal-cuneiform arthrodesis using joint curettage and two crossed compression screw fixation: a systematic review. J Foot Ankle Surg. 2011;50(6):707-9.

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Technical Tips

Modified posterolateral approach for fixation of posterior malleolar fractures associated with distal tibiofibular syndesmosis injury: A surgical technique

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Abstract

Posterior malleolar fractures are challenging to treat in ankle injuries and, when not treated properly, can lead to unfavorable results, especially if associated with syndesmosis injury. Posterior access approaches (posterolateral and posteromedial) are recommended for reduction and adequate fixation of the posterior malleolus; however, they usually do not allow direct visualization of the syndesmosis, one of the main prognostic factors in the treatment of these injuries. We present a modified posterolateral approach that enables direct visualization of the syndesmosis, in addition to the use of syndesmosis fixation implants integrated with lateral implants when associated with a lateral malleolar fracture.

Level of evidence IV; Case series.

Keywords: Ankle fractures; Ankle joint; Ankle injuries.

Introduction

Posterior malleolar fractures are present in up to 44% of ankle fractures[1], are a challenge in the treatment of ankle injuries, and when not properly treated can lead to tibiotarsal instability, degenerative arthropathy, and poor long-term results[2-4], especially when the injury is associated with distal tibiofibular syndesmosis[5].

Access to concomitant fractures and injuries involving the posterior malleolus can be challenging due to the local anatomy and morphology, as well as the reduction and fixation of these injuries[6]. In the literature, there are two main approaches to addressing the posterior malleolus fragments: the posterolateral approach, used in more than 60% of cases, and the posteromedial approach (conventional and modified)[7]. The choice between these approaches is primarily based on tomographic findings, which are considered essential for assessing the pattern and size of fragments and are a mandatory assessment in bimalleolar and trimalleolar ankle fractures[6,8,10].

This conduct differs from previous definitions that advocated the indirect reduction of the posterior malleolus through ligamentotaxis and its fixation with percutaneous cannulated anteroposterior screws[11]. The main limitation of percutaneous reduction in dorsal decubitus is that when indirect reduction of the posterior malleolus is not adequate, the traditional lateral approach to the lateral malleolus does not allow access to the posterior fragment, which can cause harm to the patient since non-anatomical reduction functions as a predictive factor for progression to osteoarthritis and poor results[12,13].

However, the posterolateral approach, as classically described by Gatellier[8], despite being a good resource for anatomical reduction and adequate fixation of the posterior malleolus, demonstrates limitations in evaluating stability

Study performed at the Universidade Federal de São Paulo–UNIFESP, Escola Paulista de Medicina, São Paulo, SP, Brazil.

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and direct reduction of the distal tibiofibular syndesmosis, thereby impairing adequate treatment of associated injuries.

In 2020, Kummer et al.[14] presented a cadaveric study of the anterior extension of the posterolateral approach for anterior visualization of the syndesmosis, named PAMELA. Based on this scenario, we present the clinical use of the modified posterolateral approach that provides access to the posterior malleolus and its direct reduction, combined with access to the lateral malleolus and its fixation with posterior or lateral implants, direct visualization of the anterior distal tibiofibular syndesmosis and anterolateral tibial fragments (Tillaux-Chaput), all through the same access.

Methods

A technique description of the modified posterolateral approach for fixation of posterior malleolar fractures associated with distal tibiofibular syndesmosis injury. The method was applied by the authors on a multicenter basis from 2015 to 2025 for the treatment of posterior malleolar fractures with intracisural involvement, except for those classified as Bartoníček type 3[4], in which a posteromedial approach is preferable.

The postoperative protocol followed was the same as that used for fractures treated with the traditional posterolateral approach. After surgery, patients were immobilized with a cast splint, and the surgical wound was evaluated one week after the procedure. Suture removal occurred at the end of the third week, when all patients were referred for physiotherapy sessions to relieve pain and increase range of motion. The patients were released to perform progressive partial weight-bearing, using a boot-type immobilizer orthosis, after six weeks postoperatively. Release to full weight-bearing occurred after eight weeks if signs of bone consolidation were present on postoperative radiographs.

This study was approved by the Institutional Review Board, and informed consent forms were obtained from the patients.

Surgical technique

After the anesthesia, the patient is placed in the prone position, with a pad beneath the ankle to support the foot and another under the trunk and pelvis to protect the patient's chest and face. We recommend using a tourniquet for easy viewing and access.

The incision is made longitudinally in the posterolateral region of the ankle, halfway between the lateral edge of the calcaneal tendon and the posterior edge of the lateral malleolus, previously marked with a surgical pen (Figure 1). The incision is curved from the distal edge of the lateral malleolus to the anterior, about 1cm away from it, towards the base of the fourth metatarsal (Figure 2), which allows visualization of the anterior distal tibiofibular syndesmosis and/or anterolateral malleolus fragments (Figure 3). If necessary, it can also be expanded proximally, with a slight inclination toward the anterior, especially in cases involving complex fibular fractures with long oblique patterns, which facilitates exposure and reduction. To reduce the risk of postoperative skin complications, during this step, the skin and subcutaneous tissue are lifted in a single layer, with no divulsion between them.

Following the skin incision, careful attention must be given to at-risk neurovascular structures, particularly the sural nerve and the small saphenous vein, which are located lateral to the calcaneal tendon (Figure 4). The posterior fascia of the leg is opened medially to the fibular tendons, exposing the flexor hallucis longus. After medial retraction of the flexor hallucis longus muscle, protecting the deep posterior neurovascular bundle, the posterior malleolus and the fracture

Figure 1. Preoperative surgical marking of the traditional posterolateral approach at the midpoint between the lateral malleolus and the lateral edge of the calcaneal tendon.

Figure 2. Modified posterolateral approach with anterior extension towards the base of the fourth metatarsal.

apex are identified. At this moment, if there is no impact component of the joint surface, the anatomical reduction of the metaphysis allows satisfactory joint reduction (Figure 5). Then, through a lateral window to the peroneal tendons, the lateral malleolus is medially separated and reduced and fixed with lateral implants, as performed in the traditional lateral or posterolateral approach. Still in the prone position, access to the medial malleolus is performed. Internal rotation of the limb or knee flexion allows for access and reduction of a medial malleolus fracture without altering the patient's decubitus position.

Following malleolar fixation, the anterolateral tissues of the ankle are retracted, preserving the ligamentous structures. This provides a direct view of the distal tibiofibular joint, allowing for anatomical reduction and proper fixation using position screws or a suture-button system. This anterolateral extension of the posterior approach also allows for visualization and fixation of anterolateral tibial fractures, as well as complete and adequate treatment of quadrimalleolar fractures[15].

Figure 3. Modified posterolateral approach allowing direct visualization of the anterior region of the syndesmosis.

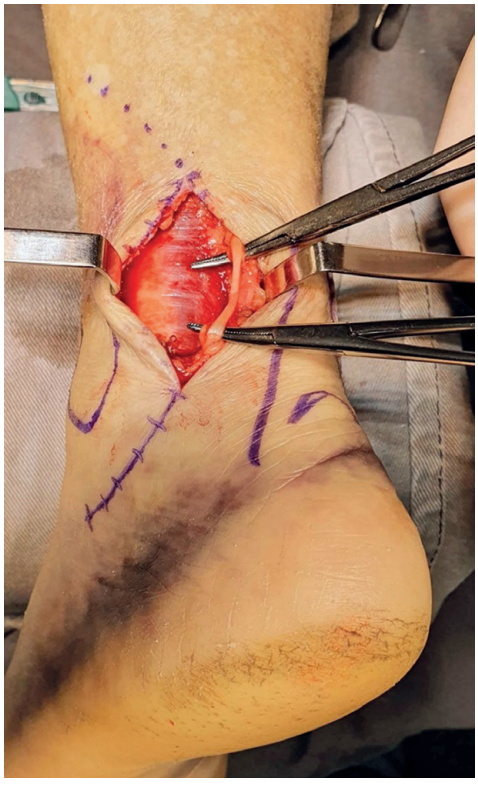

Figure 4. Posterolateral approach with emphasis on sural nerve dissection in its anatomical path under the surgical wound.

Results

The modified posterolateral approach allowed not only direct and anatomical reduction of the posterior malleolus but also visualization of the adequate reduction of the syndesmosis and its flexible fixation using a suture-button system without the need for an additional lateral approach and with a lower risk of inadequate reduction and fixation compared to the percutaneous technique for the treatment of distal tibiofibular syndesmosis injuries.

During the 10-year period of this study, minor complications, such as superficial skin necrosis and wound dehiscence, both of which occurred without the need for additional surgical

Figure 5. Intraoperative fluoroscopy demonstrating reduction and fixation of the posterior malleolus associated with fixation of the distal tibiofibular syndesmosis.

intervention, were observed at a frequency consistent with the data in the literature[16].

It is believed that the wide elevation of the skin flap, combined with the delicate retraction of the incision edges, helps minimize soft tissue trauma, thereby reducing the incidence of phlebitis and wound edge maceration. Moreover, no cases of postoperative pain higher than expected levels for the surgical treatment of ankle fractures were observed.

Although the technique allows for direct visualization of the syndesmosis and accurate evaluation of reduction parameters, there was an isolated case of reduction loss in a patient submitted to rigid fixation. Osteosynthesis review was necessary and, even after a new surgical intervention with arthroscopic guidance, the patient evolved with implant failure and severe post-traumatic arthrosis 12 months after the primary surgical procedure (Figure 6).

Discussion

A posterior malleolar fracture is a severe ankle injury that requires careful and complex treatment. It is essential to perform a detailed tomographic evaluation in all cases of isolated posterior malleolar fractures, as well as in bimalleolar and trimalleolar ankle fractures, to define treatment, surgical approach, and appropriate fixation methods.

Figure 6. Postoperative radiographic of surgical reintervention of a patient undergoing modified posterolateral approach demonstrating implant failure and early advanced tibiotarsal arthrosis.

Inadequate treatment of this injury can lead to long-term complications such as post-traumatic arthritis, tibiotarsal instability, and chronic ankle pain. These complications can result in significant limitations in the patient's daily and sports activities, in addition to substantial economic impact, particularly among the economically active population.

In addition to posterior malleolar fractures, it is important to properly evaluate and treat associated injuries, such as those involving the distal tibiofibular syndesmosis and the lateral ligament complex of the ankle. Neglecting these injuries can lead to unfavorable clinical and radiological outcomes, requiring additional surgeries to treat neglected concomitant injuries and resulting in longer treatment time and functional rehabilitation.

The surgical approach described above was previously published in a cadaveric study by Kummer et. al.[14] in 2020. The authors used a single extended posterolateral incision to expose the posterior, lateral, and anterolateral aspects of the ankle joint, presenting in detail the anatomical findings of each region and delimiting safe zones of dissection of the structures.

The need for meticulous dissection during the posterolateral approach is highlighted to prevent neurovascular injuries. The sural nerve, located superficially in the subcutaneous tissue just below the cutaneous incision, and the saphenous vein are the first structures at risk in the posterolateral approach to the ankle. When access is extended towards the tarsal sinus, the nerve becomes susceptible to injuries due to traction or divulsion, which reinforces the importance of a delicate technique and the systematic identification of these elements throughout the surgical path.

During the dissection of the deep posterolateral planes, there is still a risk of injury to the tibial nerve and the posterior tibial vascular bundle. Careful removal of the tissues and proper use of the window between the flexor hallucis longus tendon (distended medially) and the fibular tendons allows access to the posterior tibial surface with a substantial reduction in the risk of iatrogenic damage.

The objective of the technical modification of the posterolateral approach is to ensure accurate visualization and reduction of the distal tibiofibular joint, which may include Tillaux-Chaput and anterolateral ankle fractures. Anatomical fixation using position screws or a suture-button system promotes adequate stability of the syndesmosis, aiding in healing and preventing long-term complications. In addition, direct reduction of the posterior malleolus decreases the risk of poor reduction and unfavorable clinical outcomes[17].

Regarding lateral malleolar fixation, traditionally, when approaching the ankle through the posterolateral region, implants are placed at the back of the fibula, providing shear strength in Lauge-Hansen (Supination external rotation) injury patterns and greater resistance to torsional failure in Weber B fractures[16], especially in osteoporotic bones[15].

However, the implant's posterior position in the lateral malleolus can result in tendinitis of the fibular tendons as a postoperative complication due to the constant friction

between the synthetic material and these tendons[15,18]. Furthermore, this position prevents the use of syndesmosis position screws and suture-button systems integrated with a plate.

On the other hand, the presence of a well-developed skin and subcutaneous tissue flap capable of covering the implants placed on the lateral aspect of the fibula, along with incision and suture away from the most prominent area of these implants, allows for safe implant placement. This reduces the risk of local skin complications and enhances the biomechanical advantages of the construct.

Finally, it is important to emphasize that the ideal treatment for posterior malleolar fracture must be individualized, considering the specific characteristics of the injury as established by Arrondo et al., Bartoníček et al., and Haraguchi et al.[2,4,9], where they correlate the tomographic findings of injury pattern, fragment size, and distal tibiofibular joint involvement with the most indicated surgical access.

Conclusion

The modified posterolateral surgical approach presents advantages in the treatment of posterior malleolar fractures and syndesmosis injuries. This technique allows direct visualization of the reduction and fixation of the distal tibiofibular syndesmosis, potentially reducing the risk of complications associated with poor reduction of ankle fractures. However, additional studies comparing this approach with the conventional posterolateral approach are needed, especially regarding local skin complication rates, healing time, and functional recovery.

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References

1. Ahn J, Kim S, Lee JS, Woo K, Sung KS. Incidence of Peroneal Tendinopathy After Application of a Posterior Antiglide Plate for Repair of Supination External Rotation Lateral Malleolar Fractures. J Foot Ankle Surg. 2016;55(1):90-3.
2. Arrondo GM, Joannas G. Complex Ankle Fractures: Practical Approach for Surgical Treatment. Foot Ankle Clin. 2020;25(4):587-95.
3. Bartonícek J, Rammelt S, Kostlivy K, Vanecek V, Klika D, Tresl I. Anatomy and classification of the posterior tibial fragment in ankle fractures. Arch Orthop Trauma Surg. 2015;135(4):505-16.
4. Bartoníček J, Rammelt S, Tuček M, Naňka O. Posterior malleolar fractures of the ankle. Eur J Trauma Emerg Surg. 2015;41(6):587-600.
5. Büchler L, Tannast M, Bonel HM, Weber M. Reliability of radiologic assessment of the fracture anatomy at the posterior tibial plafond in malleolar fractures. J Orthop Trauma. 2009;23(3):208-12.
6. Buscharino B, Moretti RG, Hungria JOS, Christian RW, Mercadante M, Raia F, et al. Biomechanical Study: Resistance Comparison of Posterior Antiglide Plate and Lateral Plate on Synthetic Bone Models Simulating Danis-Weber B Malleolar Fractures. Rev Bras Ortop. 2013;48(3):221-7.
7. Drijfhout van Hooff CC, Verhage SM, Hoogendoorn JM. Influence of fragment size and postoperative joint congruency on long-term outcome of posterior malleolar fractures. Foot Ankle Int. 2015;36(6):673-8.
8. Gatellier, J. The juxtoretroperoneal route in the operative treatment of fractures of the malleolus with posterior marginal fragments. Surg., Gynec. & Obst. 1931; 52:67-70.
9. Haraguchi N, Haruyama H, Toga H, Kato F. Pathoanatomy of Posterior Malleolar Fractures of the Ankle. J Bone Joint Sur. 2006;88(5):1085-92.
10. Horisberger M, Valderrabano V, Hintermann B. Posttraumatic ankle osteoarthritis after ankle-related fractures. J Orthop Trauma. 2009;23(1):60-7.
11. Irwin TA, Lien J, Kadakia AR. Posterior malleolus fracture. J Am Acad Orthop Surg. 2013;21(1):32-40.
12. Jaskulka RA, Ittner G, Schedl R. Fractures of the posterior tibial margin: their role in the prognosis of malleolar fractures. J Trauma.1989;29(11):1565-70.
13. Kimball JS, Ruckle DE, Rajfer RA, Johnson JP. Anatomic Analysis of a Percutaneous Fixation Technique for the Posterior Malleolus Using Posterior-to-Anterior-Directed Cannulated Screws: A Cadaveric Study and Technique Description. J Am Acad Orthop Surg Glob Res Rev. 2021;5(2).
14. Kummer A, Cadas H, Crevoisier X. Posterior to anterior malleolar extended lateral approach to the ankle (PAMELA): a cadaveric anatomic study. Arch Orthop Trauma Surg. 2021;141(3):427-35.
15. Rammelt S, Bartoníček J, Kroker L, Neumann AP. Surgical Fixation of Quadrimalleolar Fractures of the Ankle. J Orthop Trauma [Internet]. 2021;35(6):e216-22.
16. Milton, Berkes MB, Lazaro LE, Sculco PK, Helfet DL, Lorich DG. Complications Following Treatment of Supination External Rotation Ankle Fractures Through the Posterolateral Approach. Foot & Ankle International. 2013;34(4):523-9.
17. McDaniel WJ, Wilson FC. Trimalleolar fractures of the ankle. An end result study. Clin Orthop Rel Res. 1977;(122):37-45.
18. Ramos LS, Gonçalves HM, Freitas A, Oliveira MP, Lima DMS, Carmargo WS. Evaluation of the Reproducibility of Lauge-Hansen, Danis-Weber, and AO Classifications for Ankle Fractures. Rev Bras Ortop. 2021;56(3):372-8.

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Technical Tips

Glomus tumor of the hallux: a technical tip and narrative review

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Abstract

Glomus tumors are benign and rare neoplasms, with few cases reported in the lower extremities. This study describes a case of glomus tumor in the hallux, with an atypical location, detailing the surgical resection technique employed and its excellent clinical outcome. A narrative review related to the incidence, clinical characteristics, and therapeutic options for this benign tumor.

Level of Evidence V; Therapeutic Study; Expert Opinion.

Keywords: Glomus tumor; Neoplasms; Hallux; Lower extremity.

Introduction

Originally described by Wood in 1812 and named by Mason in 1924[1], the glomus tumor is a benign neuromyoarterial neoplasm[2-4]. This clinical condition can occur throughout the body surface but is more commonly found in the extremities and the pre-coccygeal region, representing approximately 1.5% of distal soft tissue neoplasms[2,3].

The glomus body has the main function of thermoregulating the region where it is located[1-3,5]. Its anatomical structure is composed of an afferent artery, an arteriovenous anastomosis[4,6] of the Sucquet-Hoyer canal, an intraglomerular reticulum[1], and a modified smooth muscle cell capsule[2,5,6]. The regulation of blood pressure within this anatomical structure enables thermoregulation. Thus, it has three main components[1,2,5]: the glomus cell (derived from a modified musculature of cuboidal cells), the blood vessels, and smooth muscle cells.

The pathophysiology involves the proliferation of one of these components, leading to glomus tumor formation. Traumatic or infectious events may play a role[3]; however, the etiology remains incompletely understood[4].

Its classification is based on the proportion of hyperplasia components[1] and includes solid glomus tumors, glomangiomas, and glomangiomyomas. Solid types are the most common, representing 75% of cases, followed by glomangiomas (20%) and glomangiomyomas (5%)[5,6].

Approximately 75% of glomus tumors occur in the hands, particularly in the subungual region, and are more frequently reported in women[1,3,5,7]. However, they are not exclusive to females. When located in other regions, such as the subungual area of the toes, they are more commonly observed in men, as illustrated in this technical report[2,5].

Due to the rarity of glomus tumors in the feet, whether subungual or intraosseous, diagnosis is often delayed[5,8].

This case report and technical tip describe a case of glomus tumor of the hallux, with an atypical location and excellent clinical result, and provide a narrative review of this pathology.

Study performed at the Hospital Israelita Albert Einstein, São Paulo,SP, Brazil.

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Case report

A 40-year-old male patient reported severe pain on contact at the base of the left hallux nail and sensitivity to cold, with symptoms persisting for three years. At the initial physical examination, the patient had severe pain on compression at the base of the nail and in the nail matrix of the left hallux (Love test), without irradiation or pain around the area.

The clinical aspect raised the suspicion of a glomus tumor, prompting load-bearing radiographs (Figure 1A) and contrast-enhanced magnetic resonance imaging (MRI). While radiographs showed no abnormalities, MRI revealed a 2.5 mm contrast-enhancing nodular lesion in the central portion of the nail matrix of the affected hallux (Figure 1B and C), supporting the initial diagnosis of a glomus tumor.

Following a shared decision-making process between the medical team and the patient, surgical resection of the lesion was performed, followed by anatomopathological analysis.

Description of the surgical technique

The surgical procedure began with pre-anesthetic marking of the lesion based on the specific location of the pain. (Figure 2A). This was followed by spinal anesthesia, exsanguination of the left lower limb, and inflation of a pneumatic tourniquet at the proximal thigh to 280 mmHg.

Two small incisions were made at the proximal nail fold to isolate the eponychium, which was sutured with Vicryl to preserve the tissue and allow clear visualization of deeper structures. The nail was then carefully detached from its bed, exposing the nail matrix (Figure 2B-D).

A tumor impression measuring approximately 3 mm was identified on the nail matrix (Figure 2E-F), then the nail matrix was sectioned, revealing the tumor (Figure 2G-H). Complete excision of the lesion was then performed using an *en bloc* technique (Figure 2I); the specimen was subsequently sent for histopathological analysis. The nail matrix was sutured with 5-0 Monocryl (Figure 2J), and the nail was repositioned and stabilized using 3-0 nylon sutures in simple cardinal points, allowing the nail to function as a biological dressing (Figure 2K).

Anatomopathological analysis confirmed the diagnosis. The patient was followed for two years, during which there was complete resolution of pain in the immediate postoperative period and no recurrence of symptoms or lesion. Six weeks after surgery, the nail detached and was gradually replaced by new growth, reaching an almost normal appearance by the two-year mark (Figure 3).

Discussion

Although glomus tumors are well documented in the upper extremities, reports of their occurrence in the lower limbs are rare[2], likely due to the low prevalence of these tumors in the foot region[7]. They have also been identified in anatomical locations not typically containing glomus bodies. One hypothesis suggests that such tumors may arise from other perivascular cells capable of differentiating into glomus cells, as described in cases involving atypical anatomical sites[5,6].

Glomus tumors most commonly occur between the ages of 20 and 40, with a lower incidence in children and the elderly. They typically present as solitary lesions, while multiple lesions are less frequent and more often seen in young males[5,8]. Due to the limited number of reported cases involving the foot, no definitive conclusions can be drawn regarding sex distribution in this anatomical location[3].

This condition presents with a varied clinical spectrum. The classic symptom triad includes cold sensitivity, intense paroxysmal pain, and tenderness to palpation[1,3,5,8,9]. Although common, these symptoms are not mandatory for diagnosis. Solid glomus tumors, for instance, present with pain in approximately 80% of cases and cold sensitivity in 63%, whereas multiple glomus tumors are often painless[5].

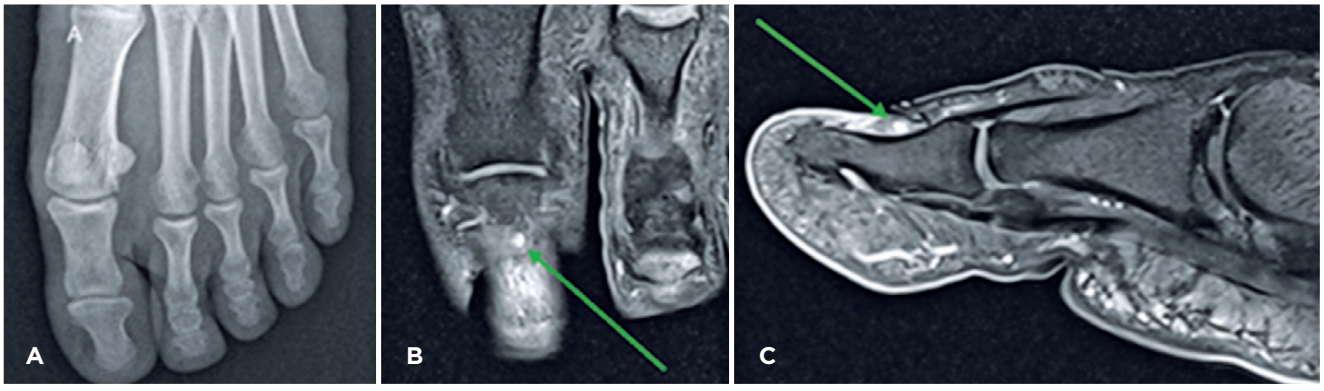

Figure 1. A) Anteroposterior radiograph of the left foot under load. B) Coronal T2-weighted magnetic resonance imaging with contrast showing a hyperintense lesion. C) Sagittal T2-weighted magnetic resonance imaging with contrast demonstrating enhancement in the central portion of the hallux nail matrix, measuring approximately 2.5 mm.

The symptomatology of this neoplasm is associated with the transformation of glomus cells into oval and round forms[6], often accompanied by mast cells at the lesion site[4]. Although the exact mechanism of pain is not fully understood, it is believed to involve the release of substance P peptide by peripheral nerves in response to cold stimuli[2,5], along with other mediators secreted by surrounding mast cells[4].

In addition to pain, clinical signs may include nail deformities with bluish discoloration[4] and a well-circumscribed protrusion[2,3]. Patients may also report difficulty wearing shoes, pain unresponsive to analgesics, and radiation of discomfort to areas adjacent to the lesion.

Discomfort is typically triggered by tactile stimulation at the tumor site but may progress to spontaneous pain that

Figure 2. A) Preoperative lesion demarcation. B) Planned incisions at the proximal nail fold. C) Exposure of the eponychium. D) Detachment of the nail from the entire bed. E, F) Visualization of the tumor impression relative to the nail matrix and measurement of lesion size. G, H) Identification and demarcation of the lesion. I) Excised glomus tumor. J) Suture of the nail matrix. K) Nail repositioned and stabilized in its original bed.

Figure 3. Clinical image of the foot in the late postoperative period under load. A) Dorsal view. B) Front View.

persists at rest. Additional features can include edema and either inflammatory or non-inflammatory changes of the eponychium[2], which may be mistaken for onychocryptosis.

There are reports of symptom variation with temperature changes[6], typically associated with cold sensitivity[2-4]. Pain may present as diffuse over the nail bed or as sharp and localized, caused by stimulation with a pointed object[4,8]. This is known as the Love test[3,5,8], which demonstrates 100% sensitivity but 0% specificity[2].

Another diagnostic method is Hildreth's sign, which involves the disappearance of pain or a negative Love test after applying a tourniquet above systolic pressure to the affected limb[3,8]. This sign is particularly valuable in cases involving foot or toe tumors[5], with reported sensitivity ranging from 77% to 92% and specificity between 91% and 100%, depending on the vascular nature of the lesion[2,5].

In cases with inconclusive clinical findings or when further investigation is required, imaging methods such as ultrasound or MRI can be highly valuable[1,2,4,5,9]. On ultrasound, glomus tumors typically appear as hypoechogenic lesions, and Doppler imaging may reveal hypervascularization in the affected area[5].

Magnetic resonance imaging offers greater diagnostic accuracy, especially in cutaneous glomus tumors[5]. In cases with high clinical suspicion, MRI is a valuable tool for both diagnosis and surgical planning[5]. Glomus tumors typically appear as well-defined lesions with low signal intensity on T1-weighted images and high signal intensity on T2-weighted images[1-3,5,8], as shown in Figures 1 and 2. Due to their vascular etiology, these tumors often enhance with gadolinium-based contrast agents[1,4,5]. However, not all glomus tumors exhibit detectable changes on MRI[1,8].

Other diagnostic tools include radiography, which may reveal semispherical erosions with well-defined margins[2]. When correlated with high clinical suspicion, such findings can be observed in 30% to 60% of cases, reflecting tumor growth[2].

Once a glomus tumor is diagnosed, surgical excision is the treatment of choice[2-6,9]. This approach typically provides rapid relief of pain and other associated symptoms.

Although alternative treatments, such as sclerotherapy and the use of argon or carbon dioxide lasers, exist, typically for superficial and deep lesions, respectively[5], they are rarely employed. Additionally, indomethacin has been reported to alleviate tumor-related symptoms after ten days of treatment[2].

The primary goal of surgical treatment is complete symptom resolution. However, recurrence, though rare, may occur due to incomplete excision or the development of a new lesion. Moreover, meticulous surgical technique and precise repositioning of the nail onto its original bed, without injuring the matrix, are crucial for achieving optimal aesthetic outcomes.

Conclusion

A thorough understanding of the anatomical, pathophysiological, and epidemiological aspects of glomus tumors, combined with early imaging-based diagnosis and the application of appropriate surgical techniques, enables excellent postoperative clinical outcomes.

Authors' contributions: Each author contributed individually and significantly to the development of this article: MCA *(https://orcid.org/0009-0005-2501-5537) Conceived and planned the activities that led to the study, wrote the paper, and participated in the reviewing process; SHV *(https://orcid.org/0009-0001-8135-493X) Searched for bibliographic review, interpreted the results of the study, and participated in the reviewing process; LPD *(https://orcid.org/0000-0002-7951-5634) Interpreted the results of the study and participated in the reviewing process; LPH *(https://orcid.org/0000-0003-3829-983X) Interpreted the results of the study and participated in the reviewing process; ALGS *(https://orcid.org/0000-0002-6672-1869) Participated in the reviewing process; ASOJ *(https://orcid.org/0000-0002-7348-4697) Conceived and planned the activities that led to the study, wrote the paper, and participated in the reviewing process. All authors read and approved the final manuscript. *ORCID (Open Researcher and Contributor ID).

References

1. Seo JH, Lee HS, Kim SW, Jeong JJ, Choi YR. Subungual glomus cell proliferation in the toe: a case report. J Foot Ankle Surg. 2014;53(5):628-30.
2. Polo C, Borda D, Poggio D, Asunción J, Peidro L. Glomus tumor of the hallux. Review of the literature and report of two cases. Foot Ankle Surg. 2012;18(2):89-93.
3. Pater TJ, Marks RM. Glomus tumor of the hallux: case presentation and review of the literature. Foot Ankle Int. 2004;25(6):434-7.
4. Horst F, Nunley JA. Glomus tumors in the foot: a new surgical technique for removal. Foot Ankle Int. 2003;24(12):949-51.
5. Lui TH, Mak SM. Glomus tumor of the great toe. J Foot Ankle Surg. 2014;53(3):360-3.
6. Gombos Z, Fogt F, Zhang PJ. Intraosseous glomus tumor of the great toe: a case report with review of the literature. J Foot Ankle Surg. 2008;47(4):299-301.
7. Kreel L, Thornton A, Pardy BJ. Glomus tumour of the hallux: diagnosis by Doppler-shift ultrasound and digital subtraction angiography. Postgrad Med J. 1986;62(729):647-51.
8. Koo SWK, Koo KOT. Glomus Tumor of the Left Second Toe Distal Phalanx: A Case Report and Review of Literature. J Orthop Case Rep. 2024;14(7):14-9.
9. Nishikawa DRC, Duarte FA, Saito GH, Santos IS, Filho VM, Mendes AAM, et al. Subungual Glomus Tumor of the Hallux: a Report of 4 Cases. Foot Ankle Spec. 2023:19386400231206285.

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Case Report

Decellularized human dermis vs. standard care in two diabetic foot ulcers: A comparative case report

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Abstract

Objective: To describe healing trajectories in two neuropathic diabetic foot ulcer cases—one treated with decellularized human dermis (DHD) and one with moist wound management (MWM).

Methods: After a two-week optimization period, two adults with long-standing diabetes and plantar ulcers were managed weekly for 12 weeks. Case 1 received a single 4 × 4 cm DHD graft combined with non-adherent dressings, and case 2 received gauze-based MWM alone. Wound area was quantified using digital planimetry.

Results: Case 1 achieved an 80% area reduction by week 4 and achieved full epithelialization at week 8. Case 2 showed a 7.8% area reduction by week 2, a transient 21.6% area increase between weeks 3 and 5, and reached 68.6% reduction by week 12 without closure. No adverse events occurred.

Conclusion: The results of our study suggest that DHD may accelerate closure compared with standard care. Due to the small sample size, randomized controlled studies with longer follow-up are essential.

Level of Evidence V; Case report.

Keywords: Diabetic foot; Wound healing; Foot ulcer; Treatment outcome.

Introduction

Diabetic foot ulcers account for up to 80% of diabetes-related amputations[1]. Decellularized human dermis (DHD) preserves extracellular-matrix architecture and angiogenic growth factors that support granulation tissue formation[2]. Cohort studies report faster closure with dermal matrices, but direct comparisons with moist wound management (MWM) remain scarce. Therefore, the objective of this case report is to describe the healing trajectories of two neuropathic ulcers—one managed with DHD and one with standard MWM.

Case description

Case 1 was treated with DHD. A 61-year-old man with type 2 diabetes for 20 years (HbA1c 7.2%) presented with an eight-week plantar ulcer beneath the first metatarsal head. The wound measured 2.3 × 2.0 cm (area 4.6 cm^2; depth 0.3 cm) and was classified as Wagner grade 2 with a negative probe-to-bone test. Comorbidities included sensory neuropathy and controlled hypertension; ankle-brachial index was 0.85; serum albumin was 3.9 g/dL; and there was no renal impairment. After debridement and optimization, a single fenestrated 4 × 4 cm DHD graft was applied, covered with a non-adherent dressing, and off-loaded in an OSSUR CAM walker.

Case 2 was treated with MWM. A 67-year-old man with type 2 diabetes for 15 years (HbA1c 8.5%) presented with a 10-week plantar ulcer at the fifth metatarsal base measuring 2.8 × 2.2 cm (6.2 cm^2; depth 0.4 cm) and was classified as Wagner grade 2, probe-to-bone negative. Comorbidities included neuropathy, hypertension, and dyslipidemia; ankle-brachial index was 0.92; serum albumin was 3.4 g/dL. Following identical debridement, the wound was managed with gauze-based MWM and the same off-loading device. Baseline cultures were negative, and duplex scanning showed adequate pedal flow in both patients.

Study performed at Axentra Bio, Phoenix & Scottsdale, Arizona, USA.

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Methods

Adults ≥ 18 years with neuropathic diabetic foot ulcers measuring 1-10 cm^2 in surface area, present for ≥ eight weeks, and unresponsive to standard hydrogel therapy, regular debridement, and off-loading were eligible. Additional enrolment criteria required an ankle-brachial index > 0.70 (or toe pressure > 40 mm Hg), no clinical infection, no critical limb ischemia, and no severe malnutrition or uncontrolled hyperglycemia.

Both patients completed a two-week optimization phase to stabilize glycemic control and perfusion status. After surgical debridement, case 1 received a single fenestrated 4 × 4 cm DHD graft plus non-adherent dressing, and case 2 received MWM with sterile gauze alone. Off-loading was identical (OSSUR CAM walker).

Wounds were photographed and measured weekly for 12 weeks using Silhouette digital planimetry (Aranz Medical). The primary outcome was the percentage reduction in ulcer surface area; secondary outcomes were time to complete epithelialization and the incidence of adverse events.

Results

Weekly planimetry revealed distinct healing trajectories. Case 1 achieved a 46.7% area reduction by week 3, 80% by week 4, and complete epithelialization at week 8 (Figure 1). Case 2 showed a 7.8% reduction by week 2, a transient 21.6% area increase between weeks 3 and 5, and a 68.6% reduction by week 12 without closure (Figure 2). A side-by-side line graph summarizing the weekly percentage change is presented in Figure 3. These clinical results are consistent with findings presented in our institutional research poster, which documented an 80% surface area reduction by week four and complete closure by week eight using DHD therapy. The congruence between real-world outcomes and poster data reinforces the reproducibility and practical effectiveness of DHD in managing chronic diabetic foot ulcers.

Discussion

Comparison with the literature

Our findings align with Zelen et al.[5], who reported a median six-week closure with dermal matrices, but differ from Greaves et al.[4], who observed slower contraction under gauze.

Mechanistic rationale

Decellularized human dermis supplies a collagen scaffold rich in basic fibroblast growth factor and vascular endothelial growth factor (VEGF), which may explain earlier granulation.

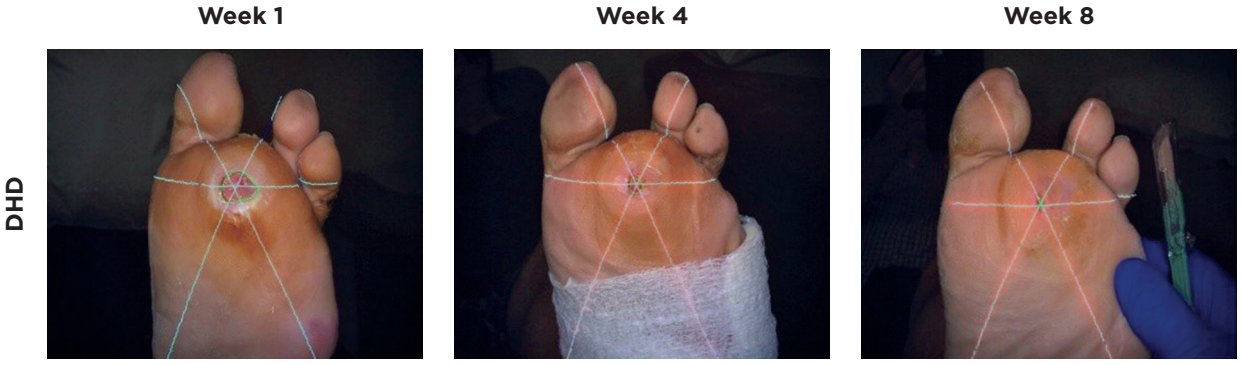

Figure 1. Sequential wound photographs, Case 1 (DHD): baseline (week 0), week 4 (80% reduction), and week 8 (closure).

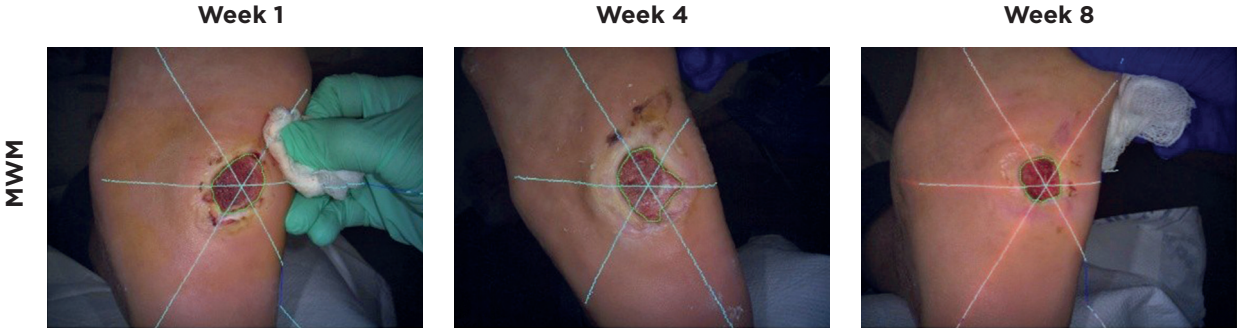

Figure 2. Sequential wound photographs, Case 2 (MWM): baseline, week 4 (area increase), and week 12 (68.6% reduction).

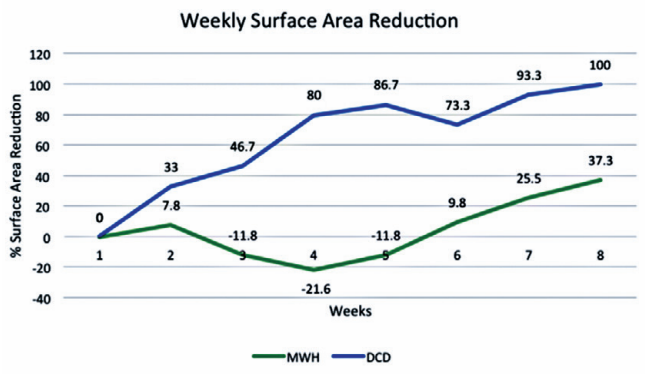

Figure 3. Line graph showing percentage wound-area reduction over 12 weeks for DHD vs. MWM treatments.

Clinical context and mechanistic insight

Multiple studies support the clinical utility of acellular dermal matrix (ADM) grafts. A systematic review by Guo et al.[2] reported higher overall healing rates with ADM products, while a multicenter randomized trial by Zelen et al.[5] showed faster wound closure and improved cost-effectiveness compared with standard care. Biologically, DHD retains collagen I/III, laminin, and angiogenic cytokines such as VEGF and platelet-derived growth factor, properties that accelerate fibroblast migration, neovascularization, and keratinocyte re-epithelialization[3,4].

Economic and digital considerations

Although a single DHD graft is more expensive than gauze, economic modelling by Zelen et al.[5] indicates overall cost savings through fewer clinic visits and shorter healing times. Digital planimetry (Silhouette) provided reproducible area measurements but requires staff training and controlled lighting; future work should assess its cost-utility across varied settings.

Limitations

This study is inherently limited by its small sample size and observational design, which restricts generalizability. The absence of long-term follow-up data precludes assessment of recurrence rates or durability of closure. Although digital wound assessment tools such as Silhouette™ enhance measurement accuracy, their clinical utility may vary based on user proficiency and resource availability. These limitations underscore the need for larger, controlled studies to validate the observed outcomes.

Conclusion

The synthesis of clinical data, mechanistic insights, economic evaluations, and advanced diagnostic technologies substantiates DHD's superiority over standard wound management for diabetic foot ulcers. The findings support the early adoption of DHD as a frontline modality in diabetic foot ulcers management, moving it from salvage to standard therapy. Its integration has the potential to reduce limb loss, lower hospital readmission rates, and alleviate the economic burden of chronic wounds. Future randomized multicenter studies with longer follow-up are essential to confirm these outcomes and guide evidence-based standardization of care.

Authors' contributions: Each author contributed individually and significantly to the development of this article: JAB *(https://orcid.org/0009-0001-5434-9158) Clinical management and data acquisition; KV *(https://orcid.org/0009-0005-1280-0800) Study design, manuscript drafting, and correspondence; KSP *(https://orcid.org/0009-0003-3787-5177) Literature review and critical revisions. All authors read and approved the final manuscript. *ORCID (Open Researcher and Contributor ID).

References

1. Armstrong DG, Boulton AJM, Bus SA. Diabetic Foot Ulcers and Their Recurrence. N Engl J Med. 2017;376(24):2367-75.
2. Zhang X, Chen X, Hong H, Hu R, Liu J, Liu C. Decellularized extracellular matrix scaffolds: Recent trends and emerging strategies in tissue engineering. Bioact Mater. 2021;10:15-31.
3. Greaves NS, Lqbal SA, Morris J, Benatar B, Alonso-Rasgado T, Baguneid M, et al. Acute cutaneous wounds treated with human decellularised dermis show enhanced angiogenesis during healing. PLoS One. 2015;10(1):e0113209. Erratum in: PLoS One. 2015;10(3):e0121503.
4. Greaves NS, Benatar B, Baguneid M, Bayat A. Single-stage application of a novel decellularized dermis for treatment-resistant lower limb ulcers: positive outcomes assessed by SIAscopy, laser perfusion, and 3D imaging, with sequential timed histological analysis. Wound Repair Regen. 2013;21(6):813-22.
5. Zelen CM, Gould L, Serena TE, Carter MJ, Keller J, Li WW. A prospective, randomised, controlled, multi-centre comparative effectiveness study of healing using dehydrated human amnion/chorion membrane allograft, bioengineered skin substitute or standard of care for treatment of chronic lower extremity diabetic ulcers. Int Wound J. 2015;12(6):724-32.

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Case Report

Adipose mesenchymal stem cells in ankle osteoarthritis: a case report

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Abstract

Ankle osteoarthritis, mostly of traumatic origin, compromises the mobility and quality of life of patients. Conventional treatment includes physical therapy and infiltrations, while advanced cases require arthrodesis or arthroplasty. In this context, mesenchymal cells from adipose tissue emerge as a promising alternative. We report the case of a 43-year-old patient with advanced ankle osteoarthritis treated with micro-fragmented adipose tissue (MFAT) infiltration using Lipogems® technology. The procedure resulted in significant improvement in pain and joint function in the first three months, followed by partial regression at six months. The findings corroborate previous studies, suggesting transient efficacy and indicating that more advanced cases may have a limited response. Further research with larger samples and longer follow-up is needed to elucidate the therapeutic potential of this approach.

Level of evidence V; Case report.

Keywords: Osteoarthritis; Ankle; Mesenchymal stem cells; Arthritis; Bone fracture.

Introduction

Ankle osteoarthritis causes significant pain and dysfunction. The main etiology is traumatic, in up to 70% of cases, and conservative treatment involves a series of diverse treatments, ranging from completely conservative options, such as lifestyle modification, physical therapy, physiotherapy, and rehabilitation, to interventional treatments such as joint infiltrations with corticosteroids or orthobiologics. When the progression is severe, surgeries such as arthrodesis or arthroplasty become necessary, with impacts on the patient's mobility[1,2].

Facing the need for less invasive alternatives, joint micro-fragmented adipose tissue (MFAT) infiltration has been studied. The Lipogems® system uses autologous adipose tissue, allowing a minimally invasive procedure with local trophic potential, in addition to a paracrine effect in modulating the inflammatory environment of osteoarthritis. The literature presents studies with a high level of evidence, mainly for knee osteoarthritis, but there is a lack of data on its application to the ankle. We report a case of ankle osteoarthritis treated with this therapy[1,2].

Case report

The study was approved by the Institutional Review Board under the number 52440821.5.0000.0068.

We report the case of a 43-year-old female patient on the date of the procedure performed in March 2023. Her body mass index at the time was 29.01 kg/m^2.

The patient suffered torsional trauma of the right ankle in 2013, with a trimalleolar fracture. She had surgery to malleolar osteosynthesis without fixation of the posterior malleolus. She evolved with pain in the late postoperative period, and in 2015, two years later, she had the material removed, due to medical advice.

Study performed at the Instituto de Ortopedia e Traumatologia do Hospital das Clínicas da Faculdade de Medicina da Universidade de São Paulo, São Paulo, SP, Brazil.

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After these procedures, she started experiencing chronic pain with progressive worsening in the region, associated with symptoms of disproportionate pain and allodynia (painful symptoms in the affected region even with stimuli that commonly do not cause pain). The patient was submitted to five sessions of joint infiltration with hyaluronic acid for pain control, with minimal partial response. Due to the unsatisfactory response, she underwent ankle arthroscopy for synovectomy and exostectomy in 2020, with no improvement in the clinical status.

On physical examination, she presented with great restriction of movement, compatible with advanced tibiotalar osteoarthritis, as verified in imaging exams. A severe degenerative arthropathy of the tibiotalar joint was found, classified by Kellgren and Lawrence as type 4 (Figures 1-3).

First, we advised a new application of hyaluronic acid, this time with high-density solution (2 MegaDaltons) associated with sorbitol, performed in two sessions. During this period, the patient reported improvement and regression of up to 70% of the pain symptoms. Afterwards, due to the condition of allodynia and complex regional pain, diagnosed according to the Budapest criteria[3], desensitization treatment was initiated with radial shockwave, in six sessions, with complete regression of the allodynia condition.

After six months, new treatment possibilities were discussed with the patient, since the partial result of pain control was achieved. An MFAT infiltration was performed in the operating room on March 15, 2023.

Surgical procedure

Adipose tissue was collected from the abdomen under local anesthesia and sedation, using the technique proposed by the Lipogems® material. Approximately 100 mL of subcutaneous fat tissue from the abdominal region, below the umbilical scar, was processed, generating 10 mL of MFAT, of which 6 mL was infiltrated into the tibiotalar joint under ultrasound guidance. The procedure was performed in a surgical environment, with discharge of the patient on the same day and postoperative guidelines including analgesia and restriction of physical activities for one week (Figures 4-8).

Results

Initially, the patient presented with strong pain in the first postoperative days, requiring analgesics such as tramadol and non-steroidal anti-inflammatory drugs, in addition to the use of crutches in the first three days. After the fifth postoperative day, the patient was able to resume her daily living activities. In the immediate postoperative period, there was also a complaint of a moderate amount of serous fluid leaving the donor region, which was resolved within 48 hours with daily dressing changes. The patient did not present any aesthetic complaint in the donor region.

The patient was re-evaluated at six weeks, three months, and six months. After the first two weeks, she reported a great improvement in symptoms, which was verified objectively using the visual analog pain scale (VAS) and the

Figure 1. T2-weighted resonance image with signs of bone edema in the tibiotalar joint and degenerative joint clamping. Examination of August 2022.

Figure 2. T1-weighted resonance image. In the red arrow, a hypointensity signal in the region of the posterior malleolus is observed, sequelae of a posterior malleolus fracture not previously fixed. Examination of August 2022.

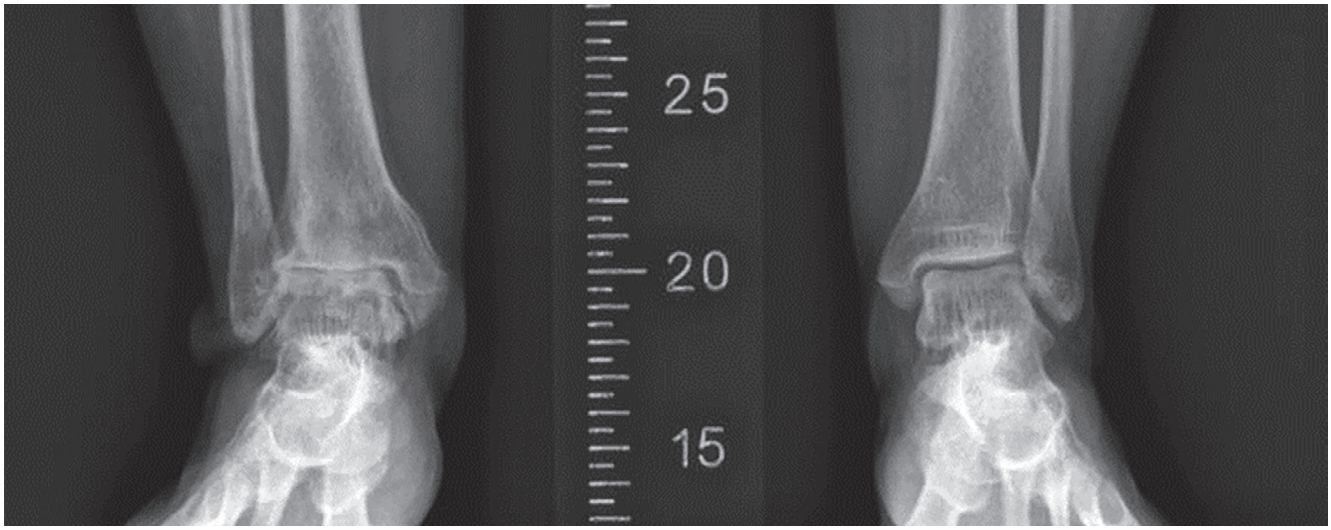

Figure 3. Radiographs showing the asymmetry of the tibiotarsal joints and degenerative osteoarthritis in the right joint.

Figure 4. Patient positioning and gowning for a surgical procedure.

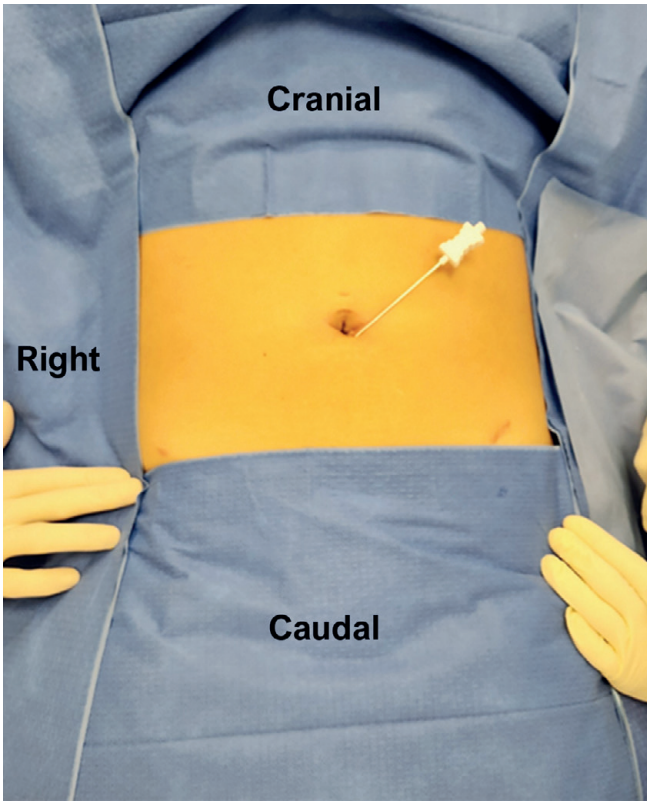

Figure 5. Entry point for preparation and collection of micro-fragmented material.

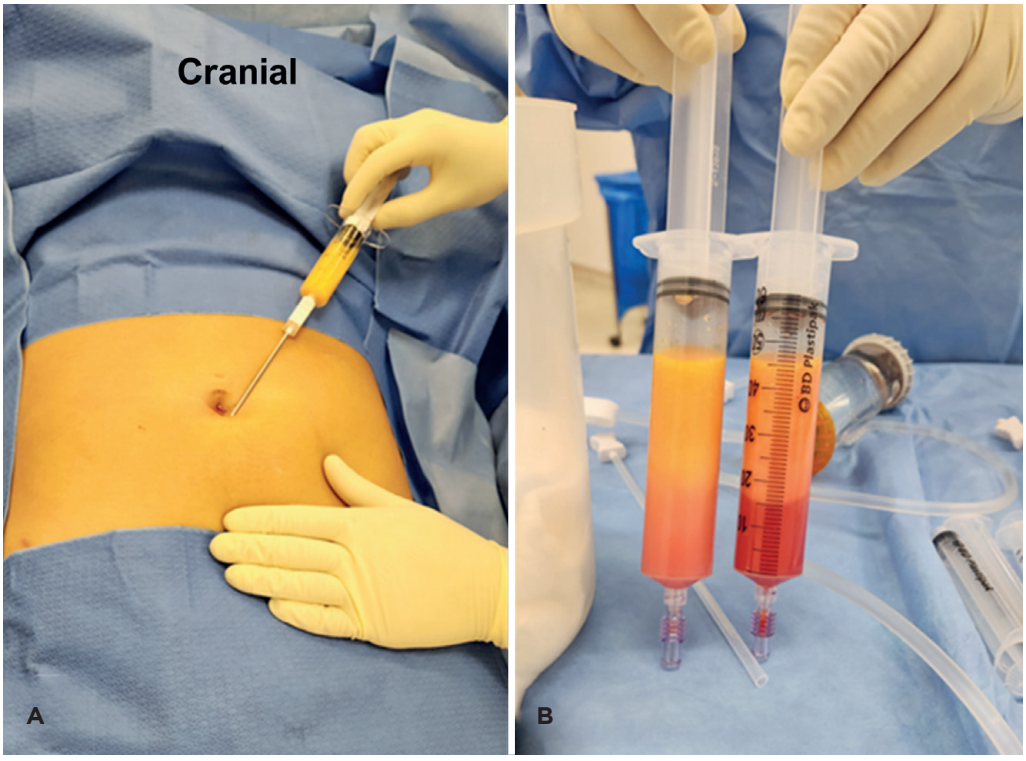

Figure 6. (A) Collection of micro-fragmented adipose tissue with a "vaclock" syringe (B) Total content collected without filtering.

Figure 7. Micro-fragmented tissue processing system and syringe filled with the final filtered and fragmented contents.

Figure 8. Tibiotalar intrarticular injection of micro-fragmented adipose tissue under direct visualization with ultrasound.

functional questionnaire of the American Society of Foot and Ankle Orthopedics (AOFAS). Also, gait, mobility, and range of motion (ROM) of the ankle were evaluated. The test results were entered in Table 1.

Throughout the follow-up, the patient was very satisfied with the results. When asked, at the end of six months, she reported 80% improvement in pain compared to the pre-procedure.

Discussion

Niazi et al.[4], performed MFAT infiltration in a 39-year-old male patient with Takakura grade 4 tibiotalar osteoarthritis—obliteration of the joint space with full tibiotalar contact. The volume infiltrated in the procedure is not reported. The patient was instructed to wear an orthopedic boot and a partial weight-bearing with crutches for two weeks. The authors found pain improvement on VAS from 9 to 1 at the end of six months of follow-up, in addition to complete improvement in nocturnal pain and at rest. There was also a statistically significant improvement in functional scores, and there was no report of any complications.

These findings differ from our study. Our patient similarly presented with osteoarthritis secondary to the trauma sequelae, with less severe evolution than the case reported by Niazi et al[4]. The patient was not instructed to immobilize or remove weight-bearing. This was only instructed in the first three days due to strong disproportionate pain. We consider that this pain was due to the capsular distension performed during the procedure, since approximately 6 mL was infiltrated into a joint with severe synovial constriction. Draeger et al.[5], reported that intrarticular infiltration in the ankle should not exceed 16-30 mL. In our case, we did not reach this volume, but perhaps due to the surgical history and previous involvement, even a smaller volume was not initially tolerated by our patient.

Table 1. Data collected on the day of surgery and at six weeks, three months, and six months.

	Day of surgery	Six weeks postoperative	Three months postoperative	Six months postoperative
VAS at the moment of interview	0	3	2	1
VAS at the moment of crises	7	5	4	7
AOFAS	68/100	78/100	70/100	67/100
ROM right ankle	19	23	21	36
ROM left ankle	70	66	63	64

VAS: Visual analog scale; AOFAS: The American Society of Foot and Ankle Orthopedics; ROM: Range of motion.

Natali et al.[6] performed infiltration with Lipogems® in 31 patients with moderate ankle osteoarthritis, with a total of 5 mL of infiltrated volume and 24 months of follow-up. The authors found good results, with no serious adverse events, but with the return of symptoms after 12 months of follow-up. This also differs from the findings in our study, as after about three months, our patient already had a partial return of symptoms. We consider that the patient with more advanced joint osteoarthritis could present less lasting results.

In our study, we found in the collected data that the patient presented an improvement in the AOFAS and VAS score, especially in the short-term follow-up, up to three months, including a significant clinical difference, as reported by Chen et al[7]. At the six-month follow-up, these scores returned to a similar level as at baseline. Still, the patient was subjectively better compared to before the procedure, with up to 80% improvement in symptoms in her routine. These findings also differ from Niazi et al.[4], who found sustained improvement in his patient with more advanced degenerative disease even after six months of the procedure.

In another study, Shimozono et al.[8], performed an infiltration with 5 mL of Lipogems® into the ankle of patients after arthroscopic debridement. Similar to our findings, the authors found an improvement in symptomatology and decreased pain in functional scores, but not sustained after six months. This suggests that MFAT may show a decrease in its benefits over time. In addition, patients with less severe osteoarthritis had better results, suggesting that advanced cases are not good candidates for the procedure.

Most previous studies focused on harvesting bone marrow material to consolidate corrective osteotomies in the case of advanced osteoarthritis with angular deviation. However, these collections typically involve multiple surgical procedures and extended treatments[8-10]. This can become a bias, as outcomes may reflect the combined effects of several interventions rather than the results of a single procedure[6]. In our case, a single surgical procedure was performed.

In our study, we verified the use of MFAT, collected through the Lipogems® kit. The product has a good safety profile for use in patients. Abdominal collection is safe and has not brought any aesthetic damage in our case. Objectively, symptoms and pain improvement was maintained for three months. After this initial period, the scores returned to a level similar to the preoperative period. As future perspectives, we consider that new studies using larger samples, interventions using a control group, and randomization are important to verify the real potential of these therapies and the best treatment options before a radical surgical intervention.

There was a favorable initial response from our patient in the initial postoperative period, but it was not sustained at the end of three and six months of follow-up. Our findings showed the failure of this therapy to control symptoms in the medium and long term.

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References

1. Godoy-Santos AL, Ranzoni L, Teodoro WR, Capelozzi V, Giglio P, Fernandes TD, et al. Increased cytokine levels and histological changes in cartilage, synovial cells and synovial fluid after malleolar fractures. Injury. 2017;48 Suppl 4:S27-S33.
2. Godoy-Santos AL, Fonseca LF, de Cesar Netto C, Giordano V, Valderrabano V, Rammelt S. Ankle osteoarthritis. Ver Bras Ortop. 2021;56(6):689-96.
3. Bullen M, Lang C, Tran P. Incidence of Complex Regional Pain Syndrome I Following Foot and Ankle Fractures Using the Budapest Criteria. Pain Med. 2016;17(12):2353-9.
4. Niazi NS, Niazi NS, Wong J, Pillai A. Autologous Micro Fragmented Adipose Cells Therapy for Subtalar Joint Osteoarthritis – Case Report and Review of Literature. SN Compr Clin Med. 2021;1-3.
5. Draeger RW, Singh B, Parekh SG. Quantifying normal ankle joint volume: An anatomic study. Indian J Orthop. 2009;43(1):72-5.
6. Natali S, Screpis D, Farinelli L, Iacono V, Vacca V, Gigante A, et al. The use of intra-articular injection of autologous micro-fragmented adipose tissue as pain treatment for ankle osteoarthritis: a prospective not randomized clinical study. Int Orthop. 2021;45(9):2239-44.
7. Chen C, Li Z, Zhang Y, Zhou H, Li Y, He W, et al. What's the clinical significance of VAS, AOFAS, and SF-36 in progressive collapsing foot deformity. Foot Ankle Surg. 2024;30(2):103-9.
8. Shimozono Y, Dankert JF, Kennedy JG. Arthroscopic Debridement and Autologous Micronized Adipose Tissue Injection in the Treatment of Advanced-Stage Posttraumatic Osteoarthritis of the Ankle. Cartilage. 2021;13(1_suppl):1337S-43S.
9. Hernigou P, Guissou I, Homma Y, Poignard A, Chevallier N, Rouard H, et al. Percutaneous injection of bone marrow mesenchymal stem cells for ankle non-unions decreases complications in patients with diabetes. Int Orthop. 2015;39(8):1639-43.
10. Angthong C, Kunkanjanawan H. Ankle synovium-derived mesenchymal stem cells for the treatment of osteochondral lesion of the talus: a novel cell harvesting technique and clinical applications. Eur Rev Med Pharmacol Sci. 2020;24(16):8273-80.

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Case Report

Association of bilateral trans-syndesmotic lesion with logsplitter and syndesmosis instability with high ankle sprain in a young patient: a case report

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Abstract

Dislocated fractures of the ankle are frequently associated with ligament injuries; between 20% and 45% of injuries of the distal tibiofibular syndesmosis occur in 6% to 16% of patients without associated fracture. These lesions can occur by different mechanisms: abduction, external rotation and dorsiflexion (Danis-Webber C), pronation and external rotation Lauge-Hansen and by vertical shearing, the latter being little described in the literature. Clinical presentation includes pain, edema, instability, restricted dorsiflexion, and functional limitation support and gait. The most characteristic symptom is pain over the tibiofibular ligaments. On physical examination, diagnostic suspicion is based on the presence of pain, edema, ecchymosis, and deformity at the ankle level. Diagnostic tests include different clinical signs, conventional and stress radiography, computed tomography, magnetic resonance imaging and fluoroscopy under anesthesia, in some cases), arthroscopy, and intraoperative clinical tests. We present the clinical case of a 21-year-old female patient with right ankle dislocated fracture and bilateral injury of the distal tibiofibular syndesmosis following axial trauma to the lower limbs after a fall from a height of six meters.

Level of evidence V; Case report.

Keywords: Ankle joint; Fracture dislocation; Ankle.

Introduction

Dislocated fractures of the ankle are associated with injuries of the distal tibiofibular syndesmosis, which can also occur in isolation, with or without osteochondral injuries, causing chronic pain, stiffness, and post-traumatic osteoarthritis. Depending on the trauma and type of fracture, syndesmosis injuries occur in 10%–15% of cases of Weber A fractures; in 17%–39%, of Weber B fractures; and in 21%–36%, of Weber C fractures[1,2]. The Lauge-Hansen classification describes the progression of bone and ligamentous injuries according to the trauma mechanism, fracture pattern, and the associated soft tissue injuries[3]. Injuries to the syndesmosis usually result from abduction, external rotation, and dorsiflexion of the ankle[4].

Tibiofibular syndesmosis is a fibrous joint stabilized by four ligaments: anterior inferior tibiofibular ligament (AITFL), which joins the tibia and distal fibula obliquely; posterior inferior tibiofibular ligament (PITFL), with a triangular arrangement between the tibial malleolus and fibula; interosseous ligament (IOL), which acts as a spring during dorsiflexion; and transverse ligament (TL), which joins the malleolar fossa of the fibula to the distal tibia. Together, they resist axial, rotational, and translational forces[5].

Clinical presentation of dislocated fractures includes pain, edema, instability, restricted dorsiflexion, and functional limitation during support and gait, with classic pain over the AITFL and PITFL[6]. These are associated with edema,

Study performed at the ESE Hospital Universitario San Rafael de Tunja, Boyacá, Colombia.

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ecchymosis, and deformity in the ankle. Clinical assessment is performed through the following tests:

- Compression test (squeeze test): compression of the proximal tibia and fibula; positive if it causes pain in the ankle, with sensitivity of 30% and specificity of 88%–93%.
- Pain on palpation over the AITFL: Sensitivity of 92% and specificity of 79%.
- Cotton test: lateral and medial force is applied to the talus with the ankle in neutral position; positive if translation is greater than that of the contralateral ankle, with sensitivity of 29% and specificity of 68%.
- Frick test: External rotation and forced dorsiflexion of the ankle with the knee flexed to 90º; positive if there is pain, with sensitivity of 30%–71% and specificity of 85%[5-7] (Figure 1).

Radiological diagnosis is made by means of anteroposterior (AP), lateral, and mortise radiographs in 20° internal rotation, as well as of stress radiographs in external rotation, varus and valgus, to evaluate the stability of the syndesmosis. The following are assessed: the tibiofibular clear space (TFCS), the distance between the lateral edge of the posterior malleolus and the medial edge of the fibula (less than 3 mm in AP and mortise), the tibiofibular overlap (TFO), the distance between the medial edge of the fibula and the lateral edge of the anterior tibial tubercle (greater than 6 mm in AP or > 2 mm in mortise), the medial clear space (MCS), and the distance between the lateral edge of the medial malleolus and the medial edge of the talus (≤ 3 mm)[2].

Computed axial tomography, more sensitive and specific than radiography, allows the evaluation of the MCS and intra-articular fractures of the tibia, fibula, and posterior malleolus.

Figure 1. Diagnostic tests; **A** Cotton test: lateral and medial force is applied to the talus with the ankle in neutral position; Positive if translation is greater than that of the contralateral ankle. **B** Frick test: xternal rotation and forced dorsal flexion of the ankle with the knee flexed to 90º; positive if there is pain. **C** Kleiger test: in seated position, with the knee hanging in 90º, ankle relaxed; positive if there is pain at the site of the interosseous membrane, or medially. **D** Crossed-leg test: lower leg over the contralateral knee with the weight of the foot hanging. **E** Squeeze test: proximal fibula is compressed against the tibia to assess the integrity of the bone interosseous membrane and syndesmotic ligaments; pain occurs with fracture or diastasis and test is considered positive. **F** Fibula translation test: patient is positioned in a side-lying position, tibia is stabilized, and fibula is gently translated anteriorly and posteriorly – test is repeated on both legs. Anteroposterior mobilization of the fibula. A positive test produces pain over the anterior and posterior tibiofibular ligaments and interosseous membranes.

It also enables analyzing the tibiofibular line, which measures the distance between the center of the tibia and the cortices of the fibula; the angles between tangential lines of the tibial cortices; the medial edge of the fibula; and the morphology of tibial incisura breadth and depth and correlation with the fibula[1]. These measurements are compared with the contralateral extremity.

The ideal method to evaluate syndesmosis bony or chondrogenic lesions and the PITFL, AITFL, and IOL is MRI, with a sensitivity of 91% and specificity of 100%[7].

Pre- or intraoperative fluoroscopy includes the modified otton test, which detects an opening of > 2 mm, and the forced external rotation test (Frick test), diagnostic if the opening is ≥ 5 mm[8]. Syndesmosis instability is questioned and confirmed by arthroscopy. A complete joint examination needs to be carried out in search of associated injuries, such as medial instability, lateral instability, loose bodies, and osteochondral lesions. Upon finding such conditions, surgical treatment is necessary[9].

Case presentation

A 21-year-old female patient who had a six-meter fall while climbing presented with pain, deformity, edema, and functional limitation in the right ankle, in addition to pain and edema in the left ankle.

On admission, patient presented pain, ecchymosis, and deformity in the right ankle, with mild edema in the left ankle. Radiographs showed logsplitter injury (Lauge-Hansen, Weber C) and normal left ankle (Figure 2). Closed reduction and immobilization with posterior splint were performed on the right ankle (Figure 2 C), and bulky bandage was performed on the left ankle. Control radiograph showed adequate reduction. The CT scan showed residual lateral tibiotalar subluxation and increased MCS, indicating open reduction and internal fixation of the fibula with trans-syndesmotic fixation.

Given the persistence of pain and edema in the left ankle, a control radiograph showed an increase in the MCS. Fluoroscopy showed instability, and the CT scan confirmed this finding (Figure 3).

Open reduction of the right foot neck dislocation was performed, and the cotton test confirmed a syndesmosis lesion. Tibiofibular osteosynthesis with trans-syndesmotic fixation was performed using a minimally invasive technique (a distal and proximal incision is made, locating the subfascial platting without opening the fracture site). Fluoroscopy and stress tests of the left foot under anesthesia evidenced a compromised distal tibiofibular syndesmosis, and fixation was performed with two trans-syndesmotic screws (Figure 4). Control radiograph confirmed adequate fixation and reduction of the bilateral tibiotalar subluxation (Figure 5). Patient was discharged with analgesia, immobilization, and walking with crutches, without joint load. After two weeks, she tolerated standing with full mobility and support according to pain. Functional recovery, edema management, and proprioceptive reeducation were achieved through physical therapy. At 12 weeks, the osteosynthesis material was removed with adequate radiological control (Figures 6).

Figure 2. A Left lower limb admission radiograph. **B** Right lower limb admission radiograph.**C** Right lower limb postproduction.

Discussion

Syndesmosis lesions are frequently misdiagnosed or undetected. Suspicion is increased when he mechanism of injury is accompanied by diffused ankle pain, as in case of pain in both ankles[6].

Initial suspicion includes pain in the anterior external part of the leg with edema, ecchymosis, instability, and radiating pain on compression in the proximal part of the limb. Tests such as ankle valgus stress test, Frick test, squeeze test, and hook test are performed, with different sensitivities and

Figure 3. Axial, sagittal, and coronal evaluation with three-dimensional CT reconstruction allows determining the relationship between the tibial and distal fibula, as well as determining the size, breadth, and depth of the sigmoid cavity, its relationship with the fibula, and the presence of occult fractures, specifically posterior malleolus and osteochondral lesions that can be confirmed in the MRI.

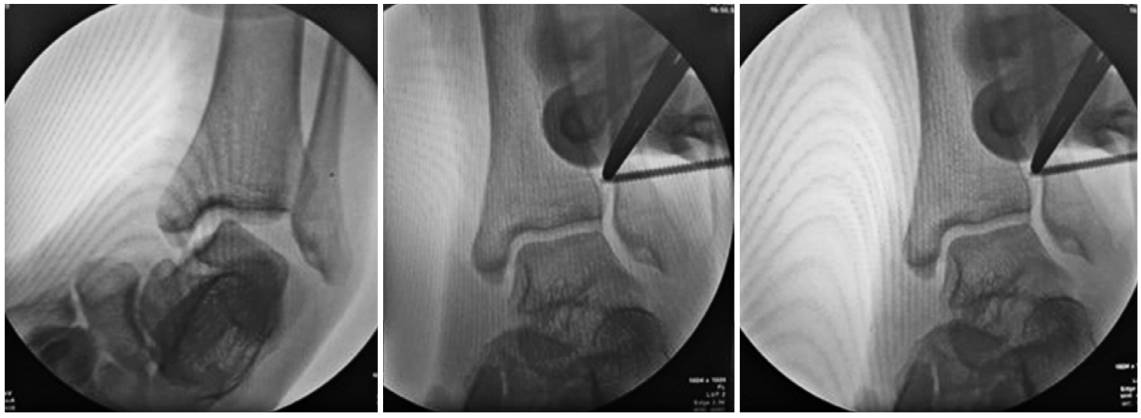

Figure 4. Intraoperative fluoroscopy assessment under anesthesia, left lower limb.

specificities[10]. In the case presented in this study, physical examination showed edema, ecchymosis, and deformity in the ankle, which increased the diagnostic suspicion.

As many of the tests performed were positive, next step were imaging studies. Mortise (20° internal rotation), AP, and lateral radiographs allow evaluation of the tibia-fibula relationship, detecting fractures and displacements. Supportive, stress, and intraoperative fluoroscopic radiographs confirm the diagnosis. In this case, the right ankle radiograph allowed diagnosis, but the persistence of pain in the left ankle and the lack of CT findings led to an intraoperative stress test which confirmed the diagnosis.

Computed tomography allows evaluating the sigmoid cavity of the fibula, the tibiofibular congruence, and the size of the Chaput tubercle, as well as verifying the postoperative reduction[8]. The standard for diagnosing lesions of syndes-

Figure 5. A Postoperative right foot neck anteroposterior and lateral views. **B** Postoperative left foot neck anteroposterior view.

Figure 6. Control radiograph at 12 weeks. **A** Front and right foot neck. **B** Left foot neck.

mosis is MRI, especially for the anteroinferior (100% sensitivity, 94% specificity) and posteroinferior (100% sensitivity and specificity) tibiofemoral ligaments[7].

Lesions of the syndesmosis can be treated conservatively or surgically. Grade I lesions are treated with immobilization for six weeks, followed by rehabilitation. High ankle sprain tends to be slower and more painful, requiring significantly more time for proper recovery. Grade II and Grade III injuries require surgical treatment, which includes closed or open reduction and transitional fixation of the syndesmosis. The combination of dislocation with trans-syndesmotic lesions is an indication for surgery. The use of trans-syndesmotic screws is standard, although complications such as loosening and the need for additional intervention may occur. Dynamic implants such as endobuttons allow a less rigid fixation, favoring physiological movement without compromising stability, although they may present complications with the suture[11]. Endobuttonsprovid a reliable fixation without restricting movement, being as effective as screws[11]. Despite its advantages, for cost-effectiveness issues, endobutton fixation is not our first choice to perform dynamic stabilization.

Postoperative care includes removal of osteosynthesis material between weeks 8 and 12, joint load restriction, assisted passive and active mobility, lymphatic drainage, edema management, and proprioceptive reeducation, as well as muscle strengthening and stretching for adequate rehabilitation[11].

Syndesmosis injuries and high-grade knee sprains have frequently been associated with syndesmosis instability, generally being underdiagnosed. The syndesmotic ligament injury instability parameters guide the decision-making between operative and nonoperative treatment. Clinical diagnosis has limited evidence, clinical test shows low accuracy, and radiologic test has low sensitivity, interobserver correlation, and specificity. Both CT and MRI have more sensitivity and specificity in diagnostics. Intraoperative stress views and arthroscopy confirm lesions, associated injuries, such as medial instability and lateral instability, loose bodies, and osteochondral lesions. Conditions, surgical treatment. Advancements in clinical assessment and imaging diagnosis are necessary for obtaining a correct diagnosis when injury and instability are suspected. Better understanding of anatomykinematics, and mechanism of injury is necessary to determine the best treatment. The choice of implant depends on the configuration of the injury and syndesmotic behavior; surgical stabilization is ideal in different planes, setting the tibiofibular interactions to conditions close to the native state.

It is important to evaluate the influence of industry in inducing the use of dynamic endobutton fixation versus trans-syndesmotic screw fixation. We believe that prospective and multicenter controlled clinical studies analyzing the advantages of each with a larger sample size are needed. The understanding of vertical shear as a mechanism of trauma is insufficient and requires greater knowledge and dissemination.

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Authors' contributions: Each author contributed individually and significantly to the development of this article: FYSA *(https://orcid.org/0000-0003-0105-9349) Conceived and planned the activities that led to the study, clinical examination, participated in the revision process and approved the final version. LBC *(https://orcid.org/0000-0002-9997-2795) Advised the methodological part of the case report, participated in the review process. MVMP *(https://orcid.org/0009-0008-6102-9241) Performed informed consent signature, bibliographic review, data collection participated in the writing of the article. CMAL *(https://orcid.org/0009-0004-9102-0257) Participated in the writing of the article and bibliographic review. ACNS *(https://orcid.org/0009-0001-3947-3871) Bibliographic review, formatting of the article. All authors read and approved the final manuscript. *ORCID (Open Researcher and Contributor ID).

References

1. Lawson KA, Ayala AE, Morin ML, Latt LD, Wild JR. Republication of "Ankle Fracture-Dislocations: A Review". Foot Ankle Orthop. 2023;8(3):24730114231195058.
2. Cornu O, Manon J, Tribak K, Putineanu D. Traumatic injuries of the distal tibiofibular syndesmosis. Orthop Traumatol Surg Res. 2021;107(1S):102778.
3. Yin Z, Wang Z, Ge D, Yan J, Jiang C, Liang B. Treatment of a high-energy transsyndesmotic ankle fracture: A case report of "logsplitter injury". Medicine (Baltimore). 2020;99(9):e19380.
4. Vohra R, Singh A, Thorat B, Patel D. Instability of the distal tibiofibular syndesmosis. J Orthop Surg (Hong Kong). 2023;31(2):10225536231182349.
5. Hao KA, Vander Griend RA, Nichols JA, Reb CW. Intraoperative Assessment of Reduction of the Ankle Syndesmosis. Curr Rev Musculoskelet Med. 2022;15(5):344-52.
6. Kang L, Helms E, Broadhead M. Bilateral ankle syndesmosis injury: a rare case report. Orthop Rev (Pavia). 2022;14(4):35494.

7. Netterström-Wedin F, Bleakley C. Diagnostic accuracy of clinical tests assessing ligamentous injury of the ankle syndesmosis: A systematic review with meta-analysis. Phys Ther Sport. 2021;49:214-26.
8. Liu J, Valentine D, Ebraheim NA. Management of Syndesmosis Injury: A Narrative Review. Orthop Res Rev. 2022;14:471-5.
9. Barbachan Mansur NS, Godoy-Santos AL, Schepers T. High-Ankle Sprain and Syndesmotic Instability: How Far Have We Come with Diagnosis and Treatment? Foot Ankle Clin. 2023;28(2):369-403.
10. Chun DI, Cho JH, Min TH, Park SY, Kim KH, Kim JH, et al. Diagnostic Accuracy of Radiologic Methods for Ankle Syndesmosis Injury: A Systematic Review and Meta-Analysis. J Clin Med. 2019; 8(7):968.
11. Mutschler M, Naendrup JH, Pfeiffer TR, Jaecker V, Arbab D, Shafizadeh S, et al. Current status of the management of isolated syndesmotic injuries in Germany. Arch Orthop Trauma Surg. 2023; 143(4):2019-26.

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Letter to the Editor

From industry to academia: A leading orthopedic CEO's journey into research

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As a child, I never dreamt of feet. I never considered their importance or complexity. I certainly never said, "One day I will grow up and improve people's ability to walk." And yet, I find myself in a place where I am inspired every day to seek answers, think creatively, and improve lives. Today, I can say with confidence and childlike wonder: my purpose is feet.

I grew up in a Portuguese household with three amazing siblings, the youngest of whom was born with spina bifida. Our family was close-knit, and I spent much of my childhood by my sister's side. Through her, I experienced life with a disability—the longing to blend in, the silent resilience of wanting to feel "normal." I remember taking her trick-or-treating in a basket on a three-wheeled bike so she could share in the joy of childhood. I dreamt, even then, of finding a cure. I never imagined I would spend my career trying to create solutions that might fulfill that dream—not just for her, but for countless others.

I didn't become a doctor—a minor disappointment to my loving Portuguese mother—but I did become an engineer. And I fell in love with the world of orthopedics through sales. I explored hips, knees, spine, and sports medicine, but it was foot and ankle that captured my heart. The field was young, diverse, and underdeveloped—with over 100 indications and very limited data. I remember being asked for 10-year follow-up data and thinking, "We are lucky to have any data at all."

The foot itself is a miracle of biomechanics. From the plantar fascia controlling arches and force vectors to the interplay between rigid and flexible columns—we understand so little about something so fundamental. Every day, I learn more, and every day I am more convinced that I have found the purpose I never knew I needed. This is bigger than any financial goal. I know I can help.

I vividly recall a conversation with Dr. Michael Houghton about syndesmotic reduction. He described how subtle and tactile the procedure is—how you rely on a 1 mm overlap and "feel" the tilt of the talus. Years later, finite element modeling at the University of Virginia quantified what he described: a deviation of less than 1 mm alters pressure in the talar gutter enough to initiate arthritis. It confirmed what I already believed—this field needs precision, clarity, and innovation.

In 2010, I co-founded Paragon 28 with Lee Rosenthal in his basement in Birmingham, Alabama. We didn't fully grasp the scale of what we were building. Understandably, our wives were not thrilled when we announced we were quitting our jobs and investing our life savings in a dream. At the time, Foot & Ankle was growing at 9–10% annually—an anomaly in orthopaedics—and larger companies took notice. But to many of them, it was just a growth opportunity. That offended me. I walked trade show floors seeing the same recycled ideas. Changing anodization color or screw diameter by 1 mm and calling it innovation? That is not what transforms patient care.

We believed our market deserved better—and that conviction built one of the most effective Foot & Ankle companies in the industry. A company built on research first, without a product in mind. Research that would drive the next generation of understanding. We cared deeply about leaving a legacy of transforming an entire segment.

By 2019, we crossed $100 million in revenue—a milestone that required us to evolve. What got us there would not get us to the next $100 million. We conducted a surgeon survey that made one thing clear: innovation was not yet changing lives. We asked ourselves hard questions. Would outcomes with our "cool" solutions actually outperform k-wires? That was the moment we committed to enabling technologies—

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pre-op planning, navigation, robotics, sensors, and AI—to truly improve outcomes.

And we wondered: Why do 10 patients with similar deformities, comorbidities, and procedures have such different outcomes? Psychology matters, yes—but so does biomechanical variation. We believed AI could help us understand those differences.

In 2020, I attended a presentation titled *Exponential Growth* by Salim Ismail, former Head of Brickhouse—Yahoo's internal incubator for innovation—at an Ernst & Young conference. His core message stuck with me: every five years, technology doubles in capability and halves in cost.

Today, we can segment CT and MRI scans to sub-millimeter precision, identifying nuanced deformity classifications that once went unnoticed. We can analyze bone density and begin mapping its implications for soft tissue function and gait. The human body is dynamic—its tissues and structures continually adapting to load, stress, and change.

With these capabilities, we are finally equipped to ask—and answer—questions we had not yet known to pose. This data-driven lens may guide not only the future of foot and ankle care, but the broader goal of improving lives every single day.

To do this, we needed resources—beyond what private equity or friends and family could provide. This was the moment we decided to go public. It was time to accelerate our ability to do more and commit more to the purpose of helping define this space—through research, development, and more advanced tools.

On October 15, 2021, we took Paragon 28 public on the NYSE—a pivotal step toward investing in technologies that would shape the future. We embraced a mindset we called the 15/45 Rule: spend 15 minutes celebrating, and 45 minutes asking how to improve. That ethos drove our culture, self-awareness, and constant evolution.

Going public gave us the capital—but it also pulled my focus away from where I believed I could have the greatest impact. Nearly 25% of my time was spent with investors and analysts, explaining our "why." At times, I felt like the message of patient outcomes wasn't what they were there to hear.

On January 28, 2025, we announced our merger with Zimmer Biomet. It wasn't an exit—it was a transition. Another evolution in our journey. One that would allow us to recommit to innovation, deepen our investment in enabling technologies, and—most importantly—refocus our time and energy on patient outcomes. The public markets gave us growth capital, but this merger gives us freedom: to think bigger, move faster, and ask harder questions.

I have always believed—and I hope my colleagues know—that I care deeply about patients. I care as much, if not more, than many people directly in their line of care. I have never let profit compromise purpose. I have always said we would publish results even when they contradict our own technologies. I want to see through the marketing and biases and find real answers. I want to do research that guides the future of our exciting space.

But in 2022, I experienced a moment that changed me. I was invited to speak on a bunion panel. One surgeon declined, stating that if I was on stage, he would not participate—because I was not a doctor. It stung. But it also fueled me. I decided I would go to medical school and earn my PhD.

In late 2024, I was accepted at PhD Program at the University of São Paulo School of Medicine in Brazil with project entitled: "Weight Bearing Computed Tomography Assessment of Deformity Patterns in Hallux Valgus. Development of a Multi-Modal Neural Network Capable to Cluster the Different Types of Hallux Valgus Deformity Patients."

I am here to prove—through action—that I care deeply, that I am committed to advancing knowledge, and that I will never stop fighting to improve lives. I want to help patients walk pain-free. I want to help them simply feel normal again.

This is my purpose.

Feet.

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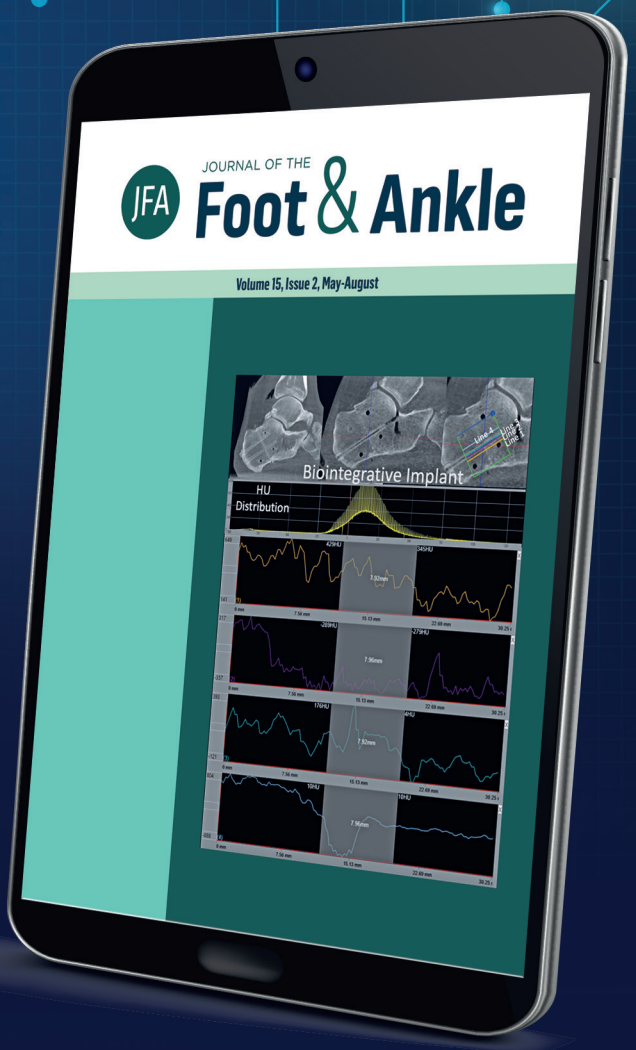

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