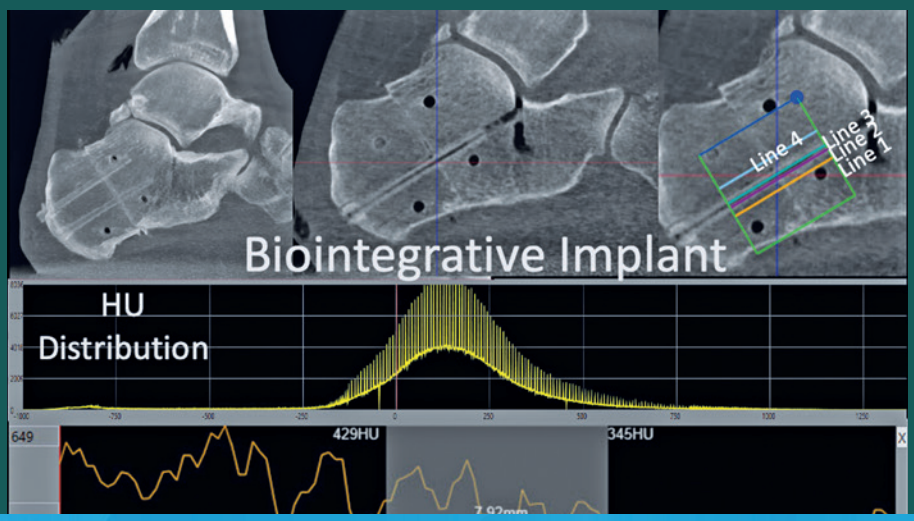
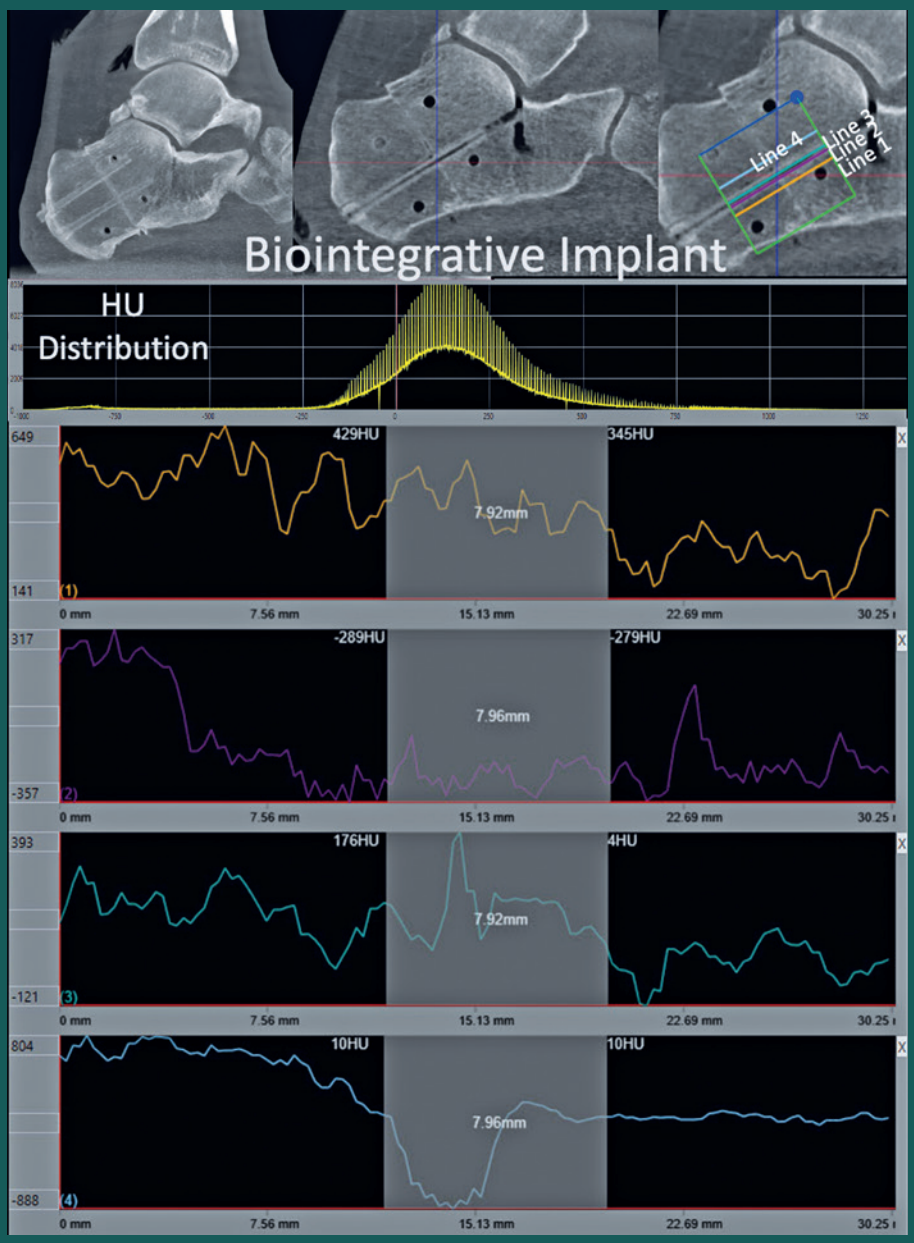
JOURNAL OF THE
JFA Foot & Ankle

Volume 15, Issue 2, May-August



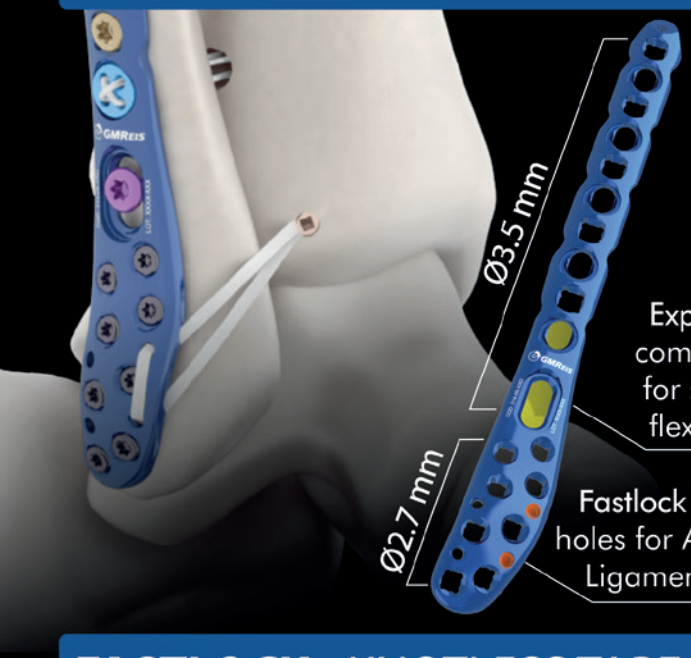
JOURNAL OF THE
JFA
Foot & Ankle

Volume 15, Issue 2, May-August



NEW VERSALOCK ANATOMIC DISTAL FIBULA PLATE

GMREIS
Qualidade para Vida
Calidad para Vida Quality for Life الجودة للحياة



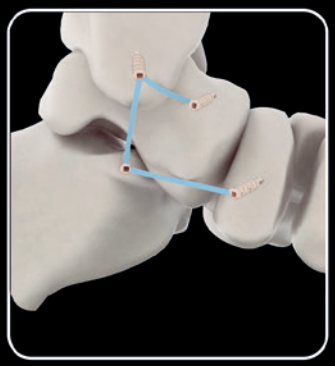
LOOKING FOR FOOT & ANKLE SOLUTIONS?

VARIABLE ANGLE LOCKING PLATES

FASTLOCK - KNOTLESS TAPE LOADED ANCHORS

ILA - INTERNAL LIGAMENT AUGMENTATION

ILA - ATFL



ILA - DELTOID + SPRING LIGAMENTS

FASTBRIDGE - DOUBLE ROW TECHNIQUE

FASTBRIDGE - ACHILLES TENDON REPAIR

EXPERT - FLEXIBLE FIXATION

EXPERT KNOTLESS DUAL FOR SYNDESMOSIS INSTABILITY

EXPERT KNOTLESS FOR SYNDESMOSIS INSTABILITY

MINI EXPERT FOR LISFRANC INSTABILITY

DISCOVER GMREIS

Contact Us: gmreis.com
marketingdigital@gmreis.com.br

JOURNAL OF THE
JFA Foot & Ankle

Volume 15, Issue 2, May-August

The Journal of the Foot & Ankle (eISSN 2675-2980) is published quarterly in April, August, and December, with the purpose of disseminating papers on themes of Foot and Ankle Medicine and Surgery and related areas. The Journal offers free and open access to your content on our website. All papers are already published with active DOIs.

EDITORIAL TEAM

ASSOCIATED SOCIETIES

Argentina
Sociedad Argentina de Medicina y Cirugía de Pie y Pierna
http://www.samecipp.org.ar/

Bolivia
Sociedad Boliviana de Medicina y Cirugía del Tobillo y Pie
http://www.sbolot.org/

Brazil
Brazilian Association of Medicine and Surgery of the Ankle and Foot
http://www.abtpe.org.br/

Chile
Comité de Tobillo y Pie de la Sociedad Chilena de Ortopedia y Traumatologia (SCHOT)
http://www.schot.cl/

Colombia
Capítulo de Pie y Tobillo de la Sociedad Colombiana de Cirugía Ortopedia y Traumatología (SCCOT)
http://www.sccot.org.co/

Mexico
Sociedad Mexicana de Pie y Tobillo
https://www.facebook.com/smpieytobillo/

Peru
Capítulo Peruano de Cirugía del Pie y Tobillo (CAPPiTO) – Sociedad Peruana de OyT
http://www.spotrauma.org/

Portugal
Sociedade Portuguesa de Ortopedia e Traumatologia (SPOT)
http://www.spot.pt/

Uruguay
Sociedad de Ortopedia y Traumatologia del Uruguay – Comité Uruguayo de Estudios del Pie (CUEP)
http://www.sotu.org.uy/

Venezuela
Capítulo de Tobillo y Pie de la Sociedad Venezolana de Cirugía Ortopédica y Traumatología (SVCOT)
http://www.svcot.org.ve/

JOURNAL OF THE Foot & Ankle
eISSN 2675-2980

https://jfootankle.com/JournalFootAnkle jfootankle@jfootankle.com

JOURNAL OF THE
JFA Foot & Ankle

Volume 15, Issue 2, May-August

Contents

DOI: https://doi.org/10.30795/jfootankle.2021.v15.1559

JOURNAL OF THE Foot & Ankle IFA

The efficient and disciplined path to the indexing of Latin American journals in PubMed

DR. GILBERTO LUIS CAMANHO, PHD

BRAZIL

FULL PROFESSOR, DEPARTMENT OF ORTHOPEDICS AND TRAUMATOLOGY, SCHOOL OF MEDICINE, UNIVERSIDADE DE SÃO PAULO, SÃO PAULO, SP, BRAZIL.

In 1997, the US National Library of Medicine (NLM) developed an Internet search system for publications in the medical field based on the MEDLINE database, PubMed.

PubMed was established in 1966 and has more than 32 million citations in 5400 American journals from 80 countries around the world, offering users multiple ways to search for these publications. They can be searched by title, by field, by author, by diagnosis, or a multitude of other ways.

This search tool is offered as a free service by NLM and has completely changed information systems in the medical field worldwide, making the electronic publication of scientific papers possible and desirable.

The vast majority of these publications are originally from the MEDLINE database of NLM, but there are other publication sources.

Belonging to PubMed makes the publication, the authors, the institution, and the research itself accessible without restrictions.

There is currently a large number of requirements to include a journal in PubMed. Some are of a legal nature, such as the International Standard Serial Number (ISSN), others refer to journal publication frequency (at least 25 peer-reviewed articles published), and some refer to the quality and type of articles (minimum number of original studies, case reports, etc.).

With the online publication of a large number of journals, PubMed is able to classify journals into more restricted categories – for example, accepting journals devoted exclusively to surgical techniques.

The requirements are published and easily accessible, but Latin American journals have great difficulty in getting indexed. In the field of orthopedics in Latin America, the Brazilian Orthopaedic Journal (RBO), Acta Ortopédica Brasileira, and Revista Mexicana de Ortopedia y Traumatología are the only ones indexed.

Assessments are conducted by third-party assessors who place great value on some points, about which we were able to learn through RBO's indexing process.

1. Publisher

Publishers with an international reach are more valued, as they already have established contracts and methods.

2. Publication frequency

From 20 to 25 issues of the journal are usually analyzed, as well as publication time (how long the journal has been published) and the regularity of publications.

3. Citations by peers

Frequency with which authors cite studies published in the applicant journal in the manuscript they are submitting for publication in the journal in question.

4. Streamlined and qualified editorial staff

"Latin" editorial boards with a large number of members are viewed with reservation. Having members from other countries in the editorial board is a valued resource, but they should confirm their participation when questioned.

5. Diversity of authors regarding the origin of publications

Assessors check whether there are authors from various origins, and not always the same authors being frequently cited.

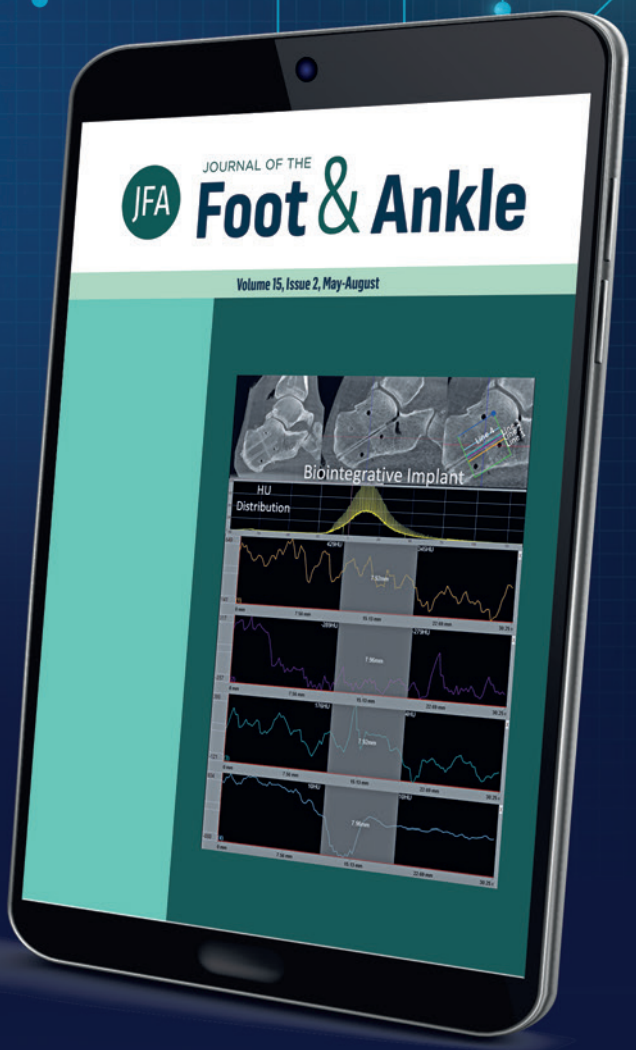
6. Indexing in other databases (eg, LILACS)

Even though the database is a regional one, the assessors will consider that the journal has already been through other assessments.

7. A recommendation made from an international author to the board of directors of PubMed's orthopedics field has considerable weight.

Getting indexed is a long way to go. However, as in any path to improvement, the process will provide parallel gains for the journal and its authors.

The Journal of the Foot & Ankle (eISSN 2675-2980) is published quarterly in April, August, and December, with the purpose of disseminating papers on themes of Foot and Ankle Medicine and Surgery and related areas. The Journal offers free and open access to your content on our website. All papers are already published with active DOIs.



ASSOCIATED SOCIETIES

Argentina
Sociedad Argentina de Medicina y Cirugía de Pie y Pierna
http://www.samecipp.org.ar/

Bolivia
Sociedad Boliviana de Medicina y Cirugía del Tobillo y Pie
http://www.sbolot.org/

Brazil
Brazilian Association of Medicine and Surgery of the Ankle and Foot
http://www.abtpe.org.br/

Chile
Comité de Tobillo y Pie de la Sociedad Chilena de Ortopedia y Traumatologia (SCHOT)
http://www.schot.cl/

Colombia
Capítulo de Pie y Tobillo de la Sociedad Colombiana de Cirugía Ortopedia y Traumatología (SCCOT)
http://www.sccot.org.co/

Mexico
Sociedad Mexicana de Pie y Tobillo
https://www.facebook.com/smpieytobillo/

Peru
Capítulo Peruano de Cirugía del Pie y Tobillo (CAPPiTO) – Sociedad Peruana de OyT
http://www.spotrauma.org/

Portugal
Sociedade Portuguesa de Ortopedia e Traumatologia (SPOT)
http://www.spot.pt/

Uruguay
Sociedad de Ortopedia y Traumatologia del Uruguay – Comité Uruguayo de Estudios del Pie (CUEP)
http://www.sotu.org.uy/

Venezuela
Capítulo de Tobillo y Pie de la Sociedad Venezolana de Cirugía Ortopédica y Traumatología (SVCOT)
http://www.svcot.org.ve/

This and other publications are available at
https://jfootankle.com/JournalFootAnkle/index
or by QR Code:

Follow us
@journalofthefootandankle
https://jfootankle.com/JournalFootAnkle
jfootankle@jfootankle.com

DOI: https://doi.org/10.30795/jfootankle.2021.v15.1562

Original Article

Implant-related artifacts around metallic and bio-integrative screws: a CT scan 3D Hounsfield unit assessment

Christian VandeLune[1], Tutku Tazegul[1], Samuel J Ahrenholz[1], Caleb Iehl[1], Victoria Vivtcharenko[1], Eli Schmidt[1], Kevin N Dibbern[1], Hee Young Lee[1], Matthieu Lalevee[1], Nacime Salomão Barbachan Mansur[1], César de César Netto[1]

1. Department of Orthopedics and Rehabilitation, University of Iowa, Carver College of Medicine, Iowa City-IA, USA.

Abstract

Objective: To assess the degree of implant-related artifacts (IRA) around metallic and bio-integrative (BI) cannulated screws using Hounsfield units (HU) on computed tomography (CT). Our hypothesis was that BI implants would demonstrate significantly decreased IRA around the inserted screws.

Methods: In this cadaveric CT imaging study, we used 2 below-knee specimens. Medial displacement calcaneal osteotomy was performed, and the specimens were fixed with either metallic or BI screws. HU values were measured over 4 different lines that crossed the osteotomy position.

Results: The mean HU value was decreased in the BI implants compared to the metallic ones in 3 different positions: near the screw, directly over the screw, and inside the screw cannula. At the line placed 1 cm dorsal to the screw, the HU value for the metallic screw was lower than that for the BI screw.

Conclusions: We found metallic implants to demonstrate significantly increased HU values in regions close to the implant and significantly decreased values 1 cm away from the implant, when compared to the BI screw. The decreased HU values 1 cm away from the implant could be due to a shielding effect of the surrounding bone, hindering the assessment of union and healing. BI implants represent an alternative to decrease these IRA effects.

Level of Evidence III; Case Control Study.

Keywords: Osteotomy; Calcaneus; Metals; Radiography; Tomography, x-ray computed.

Introduction

Assessment of bone healing in osteotomies, fractures, and fusions has challenged orthopedic surgeons over the years[1,2]. Accurate bone visualization is important since healing parameters are used to determine postoperative protocols and the need for surgical revision[3,4]. Normally, both clinical and radiographic findings are the basis of this evaluation, as pain, site mobility, implant failure, and bone bridging are subjectively combined to support a decision towards union or nonunion[5,6].

Computed tomography (CT) is widely regarded as the gold-standard imaging method when appraising bone healing[7,8]. When opposing bone surfaces have contiguous trabeculation or calcific density, union is characterized in that particular area[7,9]. To estimate the rate of bone healing, the amount of bone bridging is divided by the total contact surface[9]. Although a cut-off percentage for general ossification has not yet been established, when considering arthrodesis, values above 70% are usually designated as complete unions, and values between 33 and 69% are designated as partial unions[6,10]. Bone bridging above 25-49% in hindfoot and ankle arthrodesis has been correlated to good functional outcomes[11].

Study performed at Department of Orthopedics and Rehabilitation, University of Iowa, Carver College of Medicine, Iowa City-IA, USA.

Correspondence: César de César Netto. Department of Orthopaedic and Rehabilitation. University of Iowa, Carver College of Medicine. 200 Hawkins Dr, John Pappajohn Pavillion (JPP). Room 01066, Lower Level. Iowa City, IA, 52242. United States. **E-mail:** cesar-netto@uiowa.edu. **Conflicts of Interest:** none. **Source of funding:** none. **Date received:** July 12, 2021. **Date accepted:** July 14, 2021. **Online:** August 31, 2021.

How to cite this article: VandeLune C, Tazegul T, Ahrenholz SJ, Iehl C, Vivtcharenko V, Schmidt E, et al. Implant-related artifacts around metallic and bio-integrative screws: a CT scan 3D Hounsfield unit assessment. J Foot Ankle. 2021;15(2):95-9.

Implant-related artifacts (IRA) represent a significant limitation in bone and soft tissue imaging evaluations[12,13]. When assessing bone healing through conventional CT, IRA may hinder a proper and complete judgment of bridging[2,9]. Metallic implants are the standard in foot and ankle surgery but are recognized as significant sources of IRA[14]. Absorbable and bio-integrative (BI) implants are attractive options for bone fixation when postoperative CT imaging is likely, particularly in procedures with a higher risk of nonunion. However, literature comparing the severity of IRA when using metallic or BI implants is scarce. The objective of this study was to compare the degree of IRA when using metallic vs BI cannulated screws. Our hypothesis was that BI implants would demonstrate significantly decreased IRA around the inserted screws when assessed by Hounsfield units (HU) on CT.

Methods

Design

This cadaveric, case-control study was performed at the Orthopedic Functional Research Imaging Laboratory (OFIRL), University of Iowa. Institutional Review Board approval was obtained (IRB# 202012422).

Sample

Two fresh-frozen cadaveric lower legs obtained from knee disarticulations were used. Specimens had no deformity and were thawed for 36 hours before experimental preparation[15].

Surgical procedure

All surgical procedures were performed by a fellowship-trained foot and ankle orthopedic surgeon with more than 10 years of experience. Using a 5cm traditional oblique lateral heel approach, medial displacement calcaneal osteotomies were performed on both specimens. A cut in the safe zone of the calcaneal tuberosity was done perpendicular to the lateral wall of the calcaneus and displaced medially by 10 mm[16]. It was then provisionally fixed with two parallel Kirschner wires under fluoroscopic guidance. Positioning and placement were checked in multiple planes. The wires were used for drilling and countersinking for a set of 4.0mm cannulated headless screws.

One specimen received two 4.0mm standard cannulated metallic (titanium) screws (Wright Medical®), while the other received two 4.0mm cannulated BI fiber screws (OSSIO®). The BI screw is composed of 50% mineral fibers (silica, magnesium, calcium, sodium oxide, boron trioxide, phosphorus) and 50% polymer (poly [l-lactide-co-d, l-lactide])[17]. A hand screwdriver was used to place both sets of screws, and their placement was continuously monitored fluoroscopically during the procedure.

Cadaveric model

Cadavers were placed in an external frame after preparation of the proximal tibia. An 80 lb (356 N) axial load was applied to the construct. Muscle forces were applied to simulate a double-legged stance with the tibia approximately perpendicular to the floor. The tension of each muscle group was set relative to the peak contractile tension of the triceps surae's strength, work percentage, and cross-sectional area. Muscle forces were then decreased proportionally to reflect axial loading to half body weight on each leg. The muscle forces applied to each tendon were: posterior tibial tendon (PTT), 40 N; flexor digitorum longus (FDL), 22 N; flexor hallucis longus (FHL), 22 N; peroneus brevis and peroneus longus combined, 35 N; and Achilles tendon, 200 N.

Weight-Bearing CT (WBCT) measurement technique

WBCT scans were performed with a cone-beam CT lower extremity scanner (HiRise; CurveBeam, LLC, Warrington, PA, USA). Raw multiplanar de-identified data were converted into sagittal, coronal, and axial plane images and evaluated using dedicated software (CubeVue™, CurveBeam, LLC, Warrington, PA, USA). Assessments were performed by another board-certified foot and ankle surgeon with more than 10 years of experience who had experience with the dedicated software. The overall HU distribution within a 3D cube of 30mm edge length was assessed. Additionally, within the cube, 4 linear projections were selected to sample the entire set of HU values along that line. Each line was parallel to the screws and crossed the osteotomy site. Line 1 was placed in close proximity to the screw (within 1cm), Line 2 was placed directly over the screws, Line 3 was placed inside the screw cannula, and Line 4 was placed dorsal to the implant by 1cm. The HU values on these lines were measured across the entire length of the line. Additionally, an 8 mm segment of each line as it crossed the osteotomy was selected (Figure 1).

Statistical analysis

For each measurement, data were evaluated for normality using the Shapiro-Wilk test, and descriptive statistics were obtained (mean, median, interquartile range [IQR], 95% confidence interval values). The average HU value for each line was compared between metallic and BI implanted specimens by t-tests/Wilcoxon analyses, and p-values ≤ 0.05 were considered significant. The JMP Statistical Software (SAS Institute®) was used for the analysis.

Results

The specimen with metallic screws was found to have significantly higher HU values for lines 1, 2, and 3 when compared to the BI screw specimen. Values were significantly increased when considering both the entire line inside the 3D cube as well as the selected 8 mm line segment across the calcaneal osteotomy. When considering Line 1 (close to the screw), the metallic implant had higher HU values (entire, 7.26; selected, -5) when compared to BI (entire, -159; selected, -249). For Line 2 (over the top of the screw), the metallic implant was found to have higher HU values (entire, 4.84; selected, 6286) and the BI had lower values (entire, 108; selected, 151.2), as seen in figure 2. Line 3 (inside the cannula) was also found to have increased HU values for the metallic implant (entire, 1664; selected, 198.7) compared to the BI one (entire, 144; selected, -277.7). However, across Line 4 (1cm away from the implant), HU values were significantly decreased around the metallic implant (entire, -49: selected, -110) compared to the BI implant (entire, 178.5; selected, 221), as seen in figure 3.

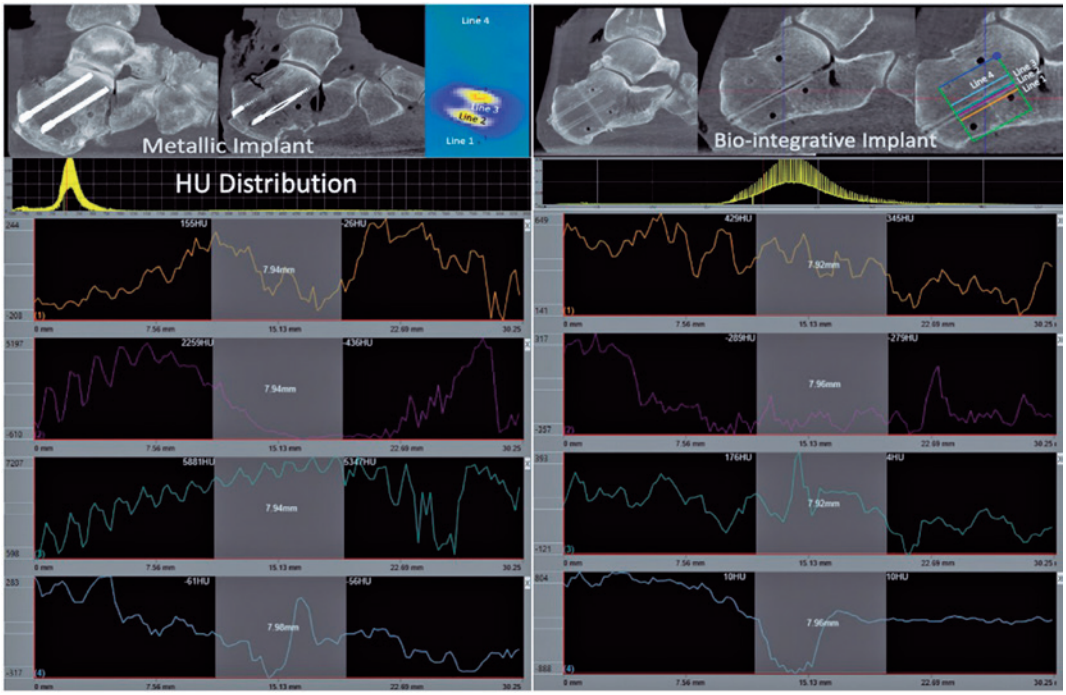


Figure 1. The left column shows data on the metallic implant and the right column, on the bio-integrative implant. Hounsfield unit distribution across Line 1 is represented by the yellow line, its distribution on Line 2 is shown by the purple line, that on Line 3, by the teal line, and that on Line 4, by the light blue line. The highlighted box 7.94mm across the graph shows the "selected" line segment.

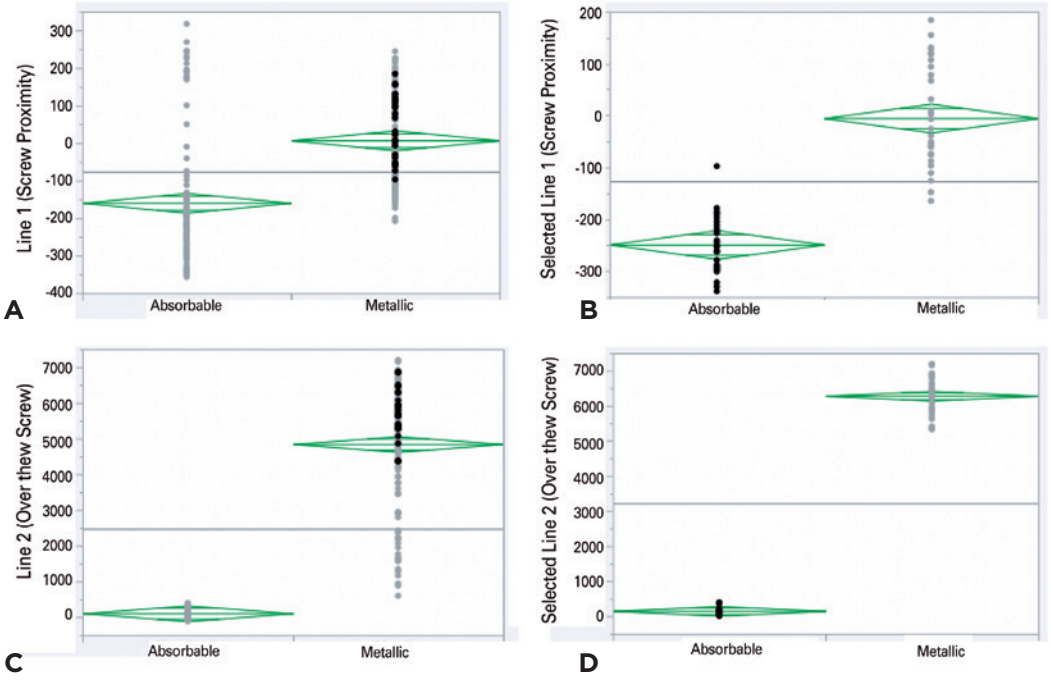


Figure 2. Line 1 Hounsfield unit values for the whole line (A) and the selected line segment (B). Line 2 values for the whole line (C) and the selected line segment (D).

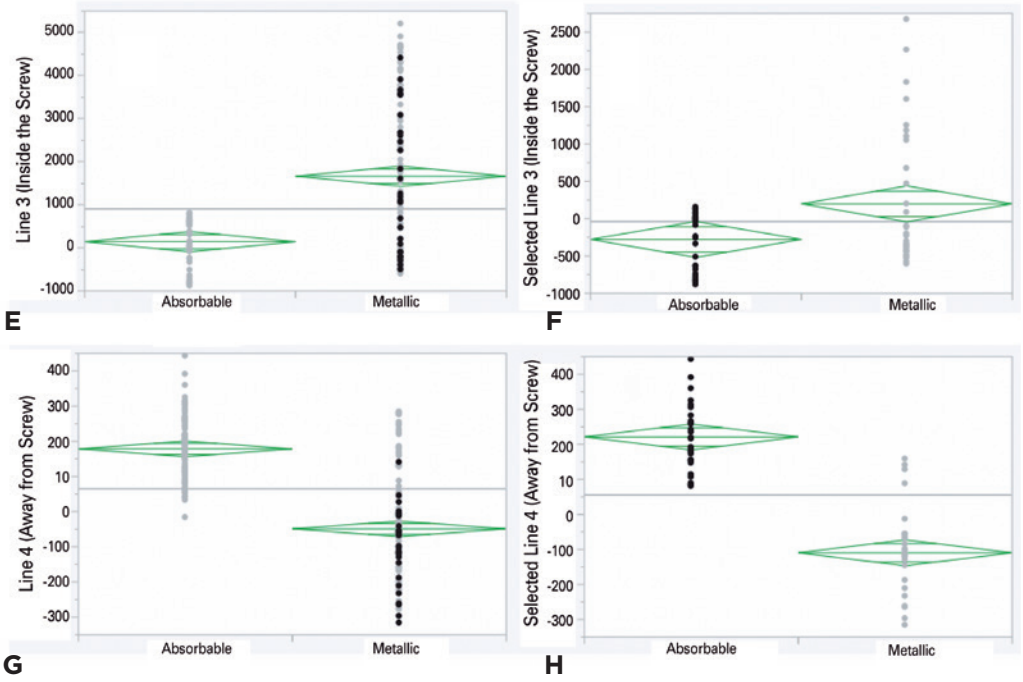


Figure 3. Line 3 Hounsfield unit values for the whole line (E) and the selected line segment (F). Line 4 values for the whole line (G) and the selected line segment (H).

Discussion

Our cadaveric study demonstrated that BI implants significantly reduced HU values in 3 different planes across a calcaneal osteotomy: close to the screw, directly over the screw, and inside the screw cannula. Interestingly, HU values 1 cm away from the metallic screw (Line 4) were lower than those around the BI screw. This is potentially due to a beam hardening artifact, which might concentrate HU adjacent to the metal and shield the surrounding cancellous bone from being accurately reconstructed.

When assessing postoperative CT images for bone healing and the presence of nonunion, accurate diagnosis depends on having a clear scan close to the implant, as it crosses the osteotomy line. Historically, the lack of non-metallic implant options has led to IRA reduction through dual-energy CT scanners and post-CT imaging algorithms[18]. Metal artifact reduction software (MARS) uses algorithms that aim to reduce the effect of beam hardening and photon starvation around the implant. While these methods can reduce IRA, allowing the surrounding tissue to be better visualized, they can also add streak artifacts close to the implant and are associated with data loss[19,20]. BI implants have the possibility to remove the need for special CT protocols/software when imaging temporary hardware by reducing IRA[21]. This could also lead to better scan quality around the implant, while saving resources on imaging and processing.

Recently, other non-metallic implant options have been used surgically in the form of biodegradable, magnesium screws[21]. They have been shown to have significantly reduced IRA on postoperative CT scans and have similar efficacy to metallic implants[22]. However, when magnesium is broken down in the body, hydrogen gas is released into the surrounding tissue. The gas does not cause clinical symptoms or affect fracture healing, but can be seen radiographically[21,22]. More studies are needed to compare IRA when using magnesium and BI implants.

Some clear limitations of this study are the small number of specimens used and lack of implant diversity. This was a pilot study, and sample sizing and power analyses were not performed. Procedures that require more hardware in closer proximity might show differences in IRA reduction. In addition, the procedure was done on cadaveric specimens and HU measurements were completed immediately after; therefore, the change in IRA once the BI screws were allowed to integrate was not tested. Furthermore, the lack of a pre-osteotomy WBCT scan makes it difficult to assess the effect of BI screws on IRA. For a better assessment of IRA with BI screws, a pre-osteotomy HU assessment should be performed. No biomechanical testing was performed either. Surgeries and readings were each performed by different professionals, but only one surgeon and one reader were involved. WBCT and the software used for the assessments are not widely available, which could affect the study's reproducibility.

Conclusions

In this study, we compared IRA around metallic and BI implants used to stabilize medial displacement calcaneal osteotomies. We found metallic implants to demonstrate significantly increased HU values close to the implant and significantly decreased values 1 cm away from the implant. This could be due to a shielding effect on the surrounding cancellous bone. These characteristics could potentially hinder the assessment of bone density quality and bone healing. Additional clinical studies are needed to confirm and expand our findings.

Authors' contributions: Each author contributed individually and significantly to the development of this article: CV *(https://orcid.org/0000-0002-7797-6111) Wrote the manuscript, participated in the review process, formatted the article, made figures, approved final version; TT *(https://orcid.org/0000-0002-3802-3422) Participated in the review process and formatted article; SJA *(https://orcid.org/0000-0002-5486-9858) Formatted the article, collected the data; CI *(https://orcid.org/0000-0003-1434-2725) Formatted the article, collected the data; VV *(https://orcid.org/0000-0002-1574-3793) Bibliographic review, data collection; ES *(https://orcid.org/0000-0002-6922-5238) Bibliographic review, data collection; HYL *(https://orcid.org/0000-0003-4179-9501) Bibliographic review, data collection; ML *(https://orcid.org/0000-0001-5058-8867) Bibliographic review, data collection; KND *(https://orcid.org/0000-0002-8061-4453) Participated in the review process, formatted the article; NSBM *(https://orcid.org/0000-0003-1067-727X) Participated in the review process, formatted the article, approved the final version; CCN *(https://orcid.org/0000-0001-6037-0685) Conceived and planned the activities that led to the study, participated in the review process, approved the final version, performed the surgeries. All authors read and approved the final manuscript. *ORCID (Open Researcher and Contributor ID).

References

1. Yamagishi M, Yoshimura Y. The biomechanics of fracture healing. J Bone Joint Surg Am. 1955;37(5):1035-68.
2. Krause F, Younger AS, Baumhauer JF, Daniels TR, Glazebrook M, Evangelista PT, et al. Clinical Outcomes of Nonunions of Hindfoot and Ankle Fusions. J Bone Joint Surg Am. 2016;98(23):2006-16.
3. Gagne OJ, Veljkovic AN, Glazebrook M, Penner M, Wing K, Younger ASE. Agonizing and Expensive: A Review of Institutional Costs of Ankle Fusion Nonunions. Orthopedics. 2020;43(4):e219-e24.
4. Ziegler P, Friederichs J, Hungerer S. Fusion of the subtalar joint for post-traumatic arthrosis: a study of functional outcomes and non-unions. Int Orthop. 2017;41(7):1387-93.
5. Wilson FC Jr, Fay GF, Lamotte P, Williams JC. Triple arthrodesis. A study of the factors affecting fusion after three hundred and one procedures. J Bone Joint Surg Am. 1965;47:340-8.
6. Coulomb R, Hsayri E, Nougarede B, Marchand P, Mares O, Kouyoumdjian P, et al. Do clinical results of arthroscopic subtalar arthrodesis correlate with CT fusion ratio? Orthop Traumatol Surg Res. 2019;105(6):1125-9.
7. Coughlin MJ, Grimes JS, Traughber PD, Jones CP. Comparison of Radiographs and CT Scans in the Prospective Evaluation of the Fusion of Hindfoot Arthrodesis. Foot Ankle Int. 2006;27(10):780-7.
8. Cerrato RA, Aiyer AA, Campbell J, Jeng CL, Myerson MS. Reproducibility of Computed Tomography to Evaluate Ankle and Hindfoot Fusions. Foot Ankle Int. 2014;35(11):1176-80.
9. Dorsey ML, Liu PT, Roberts CC, Kile TA. Correlation of Arthrodesis Stability with Degree of Joint Fusion on MDCT. AJR Am J Roentgenol. 2009;192(2):496-9.
10. Jones CP, Coughlin MJ, Shurnas PS. Prospective CT scan evaluation of hindfoot nonunions treated with revision surgery and low-intensity ultrasound stimulation. Foot Ankle Int. 2006;27(4):229-35.
11. Glazebrook M, Beasley W, Daniels T, Evangelista PT, Donahue R, Younger A, et al. Establishing the Relationship Between Clinical Outcome and Extent of Osseous Bridging Between Computed Tomography Assessment in Isolated Hindfoot and Ankle Fusions. Foot Ankle Int. 2013;34(12):1612-8.
12. Kumar NM, de Cesar Netto C, Schon LC, Fritz J. Metal Artifact Reduction Magnetic Resonance Imaging Around Arthroplasty Implants: The Negative Effect of Long Echo Trains on the Implant-Related Artifact. Invest Radiol. 2017;52(5):310-6.
13. Kosmas C, Hojjati M, Young PC, Abedi A, Gholamrezanezhad A, Rajiah P. Dual-layer spectral computerized tomography for metal artifact reduction: small versus large orthopedic devices. Skeletal Radiol. 2019;48(12):1981-90.
14. De Cesar Netto C, Schon LC, Da Fonseca LF, Chinanuvathana A, Stern SE, Fritz J. Metal artifact reduction MRI for total ankle replacement sagittal balance evaluation. Foot Ankle Surg. 2019;25(6):739-47.
15. Sands A, White C, Blankstein M, Zderic I, Wahl D, Ernst M, et al. Assessment of ankle and hindfoot stability and joint pressures using a human cadaveric model of a large lateral talar process excision: a biomechanical study. Medicine (Baltimore). 2015;94(11):e606.
16. Talusan PG, Cata E, Tan EW, Parks BG, Guyton GP. Safe Zone for Neural Structures in Medial Displacement Calcaneal Osteotomy: A Cadaveric and Radiographic Investigation. Foot Ankle Int. 2015;36(12):1493-8.
17. Štalc J, Cicchinelli LD, Miller S, Richter M. Fiber-reinforced fixation implant for proximal interphalangeal joint arthrodesis shows implant bio-integration at 1-year follow-up. Foot Ankle Surg. 2021:S1268-7731(21)00134-X.
18. Kasparek MF, Töpker M, Lazar M, Weber M, Kasparek M, Mang T, et al. Dual-energy CT and ceramic or titanium prostheses material reduce CT artifacts and provide superior image quality of total knee arthroplasty. Knee Surg Sports Traumatol Arthrosc. 2019;27(5):1552-61.
19. Bolstad K, Flatabø S, Aadnevik D, Dalehaug I, Vetti N. Metal artifact reduction in CT, a phantom study: subjective and objective evaluation of four commercial metal artifact reduction algorithms when used on three different orthopedic metal implants. Acta Radiol. 2018;59(9):1110-18.
20. Giantsoudi D, De Man B, Verburg J, Trofimov A, Jin Y, Wang G, et al. Metal artifacts in computed tomography for radiation therapy planning: dosimetric effects and impact of metal artifact reduction. Phys Med Biol. 2017;62(8):R49-R80.
21. Sonnow L, Könneker S, Vogt PM, Wacker F, von Falck C. Biodegradable magnesium Herbert screw - image quality and artifacts with radiography, CT and MRI. BMC Med Imaging. 2017;17(1):16.
22. Acar B, Kose O, Unal M, Turan A, Kati YA, Guler F. Comparison of magnesium versus titanium screw fixation for biplane chevron medial malleolar osteotomy in the treatment of osteochondral lesions of the talus. Eur J Orthop Surg Traumatol. 2020;30(1):163-73.

DOI: https://doi.org/10.30795/jfootankle.2021.v15.1539

Original Article

Mobilization protocol and early postoperative weight-bearing in transyndesmal ankle fractures

Diego Yearson[1,2,3], **Ignacio Melendez**[1,2], **Federico Anain**[1,2], **Santiago Siniscalchi**[1,2], **Juan Drago**[1,2,3]

1. Sanatorio de la Trinidad Ramos Mejía, Ramos Mejía, Buenos Aires, Argentina.
2. Sanatorio Trinidad Palermo, CABA, Buenos Aires, Argentina.
3. CLIMBA, CABA, Buenos Aires, Argentina.

Abstract

Objective: To disseminate a rehabilitation protocol with early mobilization and ambulation, with no external supports, reducing the time until full weight-bearing and providing greater postoperative comfort.

Methods: We prospectively assessed a series of 68 patients, with level of evidence IV, mean age of 33.3 years. We performed open reduction with ankle lateral approach (Kocher) and internal fixation with an interfragmentary compression screw and a one-third locked tubular plate for neutralization. All patients were subjected to a rehabilitation protocol with early mobilization and weight-bearing.

Results: No fracture displacements were observed on the postoperative radiographic controls, neither loosening nor ruptures of implants. There was no need to change rehabilitation guidelines either due to pain or to other subjective limitation.

Conclusion: We can state that early joint mobilization and controlled progressive support, with appropriate osteosynthesis, resulting in an early return to everyday activities, both work and sports ones.

Level of Evidence IV; Therapeutic Studies; Case Series.

Keywords: Fractures, bone; Ankle; Range of motion, articular; Early ambulation; Electrophoretic mobility shift assay.

Introduction

Ankle fractures compromise both bone and ligament structures. According to the AO classification, which is based on that of Weber, these fractures belong to the 44 A, B or C group, according to the level at which fibula fracture is located with respect to syndesmosis; they are also subclassified into 1, 2 or 3, according to the involvement of one, two, or three malleoli or their equivalent ligaments. We have studied the 44-B1 group (transyndesmal fibula fracture with no medial or posterior involvement), the most frequent subtype among ankle fractures[1]. These fractures are mostly stable and can be conservatively treated with cast or plastic immobilizers (Figure 1) or treated with surgery. Conservative treatment is indicated in non-displaced fractures, in older patients[2,3] or with limited ambulation[4], in those with neurological or severe peripheral vascular disease, and in bedridden patients. Poor integumentary status may be also a conditioning in the choice for conservative treatment. Surgical indications are fractures with a displacement greater than 2mm in young patients, whether athletes or workers. One of the advantages of surgical treatment is postoperative rehabilitation protocol, with joint mobilization and early progressive weight-bearing, which allows for an earlier return to labor and sports activities.

Study performed at the Sanatorio de la Trinidad de Ramos Mejía, Ramos Mejía, Buenos Aires, Argentina.

Correspondence: Diego Javier Yearson. Calle Jose Antonio Maure, 2021, CABA – 1426, Buenos Aires, Argentina. **E-mail:** dyearson@intramed.net. **Conflicts of interest:** none. **Source of funding:** none. **Date received:** May 01, 2021. **Date accepted:** June 29, 2021. **Online:** August 31, 2021.

How to cite this article: Yearson D, Melendez I, Anain F, Siniscalchi S, Drago J. Mobilization protocol and early postoperative weight-bearing in transyndesmal ankle fractures. J Foot Ankle. 2021;15(2):100-4.

Classically, patients with this type of fractures are allowed to initiate weight-bearing after the fourth postoperative week, starting with two crutches and bearing from 30 to 50% of body weight[5,6]. Between the fifth and the sixth postoperative week, one crutch is removed (maintaining the one on the opposite side from the fractured ankle), which means loading 75% of body weight on the operated ankle, and full weight-bearing is achieved between the seventh and the eighth postoperative week.

Currently, fracture rehabilitation protocols tend to shorten recovery times so that patients can make an early return to their activities. The 44-B1 group is not only the most frequent type of ankle fracture but also predominates in young patients or athletes[7]. This reason, as well the scarce literature on the topic, led us to develop a new guideline on rehabilitation that meets the expectations of this group of patients.

The aim of this presentation is to disseminate a postoperative rehabilitation protocol in 44-B1 fractures, which reduces the usual time to initiate weight-bearing without external support in the postoperative period.

Methods

This study was approved by the institutional ethics committee and was conducted by our team of specialists in this disease with specific selection criteria and pre-established algorithms, following identical parameters.

The project was performed under the ethical standards that regulate investigation in humans, according to the National Personal Data Protection Act No. 25326 (Habeas Data Act) and Declaration of Helsinki in its latest version.

Figure 1. Image showing a 44-B1 fracture with no displacement that could be conservatively treated.

We retrospectively assessed a series of cases with level of evidence IV.

All operated patients were in a good general state, with no integumentary complications that could delay or complicate surgical indication. Exclusion criteria were patients older than 65 years of age, with limited ambulation or bedridden, patients with multiple trauma who could not be subjected to the proposed protocol due to other injuries, severe neurological diseases, osteoporosis, comminuted fractures that made it impossible to perform the osteosynthesis established in the protocol, and fractures not classified into the 44-B1 type (Table 1).

From November 2015 to November 2018, we operated on 68 patients with 44-B1 ankle fractures (49 men and 19 women). Surgical indications were fibula fractures with a displacement greater than 2mm and those in young patients, whether athletes or workers, with no deltoid ligament involvement.

The surgical technique used was open reduction with ankle lateral approach (Kocher) and internal fixation with an interfragmentary compression screw measuring

3.5mm in diameter and a one-third locked tubular plate for neutralization[8,9] (Figure 2). We used locked implants in all assessed patients included in the protocol, who systematically received 2 proximal locked screws and 2 distal locked screws[10-12]. Post-surgical immobilization was not used in any case, only wound coverage and elastic bandage.

Postoperative management (Table 2):

Day 7: initial postoperative follow-up. Wound healing. Household ambulation was allowed with crunches, without support. Ankle flexion and extension exercises were indicated according to patient's tolerance, with active and passive mobilization with elastic band if possible.

Day 15: removal of stitches, control radiography. Weight-bearing was initiated with two crutches according to tolerance (up to 50% of body weight). Ankle movements were intensified, including forced inversion and eversion. At this point, patients were expected to have at least 50% of mobility with regard to the contralateral ankle.

Table 1. Inclusion and exclusion criteria for patient selection

Inclusion criteria	>16 years old
	< 65 years old
	44-B1 fractures
Exclusion criteria	<16 years old
	>65 years old
	Limited ambulation or bedridden
	Severe neurological diseases
	Multiple trauma or impossibility to conduct the protocol
	Osteoporosis
	Comminuted fractures

Figure 2. Treatment of transyndesmal fibula fractures with locked plates.

Table 2. Rehabilitation guidelines during the first 4 postoperative weeks

Week	Mobilization (%)	Support (%)
1	No tolerance	0
2	>50	50
3	>70	75
4	>90	100

Day 21: weight-bearing progressed using a single crutch contralateral to the fractured ankle (up to 75% of the body weight). Kinesiological rehabilitation was started combining magnet therapy, ultrasound (US), and stationary bicycle; moreover, there

was an emphasis on improving ankle dorsiflexion up to at least 70% of normal range. Exercises for evertor strengthening were initiated.

Day 28: crutches were removed, prior control radiography. Proprioceptive exercises on unstable surfaces are allowed, with kinesiologic support. Expected mobility in this stage was around 90%.

After the fourth week, proprioceptive exercises and muscular strengthening were intensified with kinesiologic assistance. Jogging was allowed after the third month, and return to high-impact sports activities was allowed from the 5th to the 6th month.

Control radiographies were obtained at the immediate postoperative period and at days 15, 30, 60, and 90.

Results

In the 68 patients treated according to our protocol, we confirmed radiological signs of complete fibula union at 4 weeks in all cases, and no displacement or changes in fracture axis were observed in postoperative radiographic controls[13]; similarly, there were no cases of loosening or rupture of hardware. Four patients (5.88%) presented with focal wound dehiscence[14], without exposure of hardware, which in all cases was resolved with local treatment by successive dressings and oral antibiotic. No patient required a new intervention. One should bear in mind that these complications were not related to arthrosis in the long term[15].

Patients returned to their everyday and work activities (from home), with weight-bearing of 50% of body weight, at the end of the second postoperative week (day 15), whereas in-person work activities started 28 days after surgery, obviously

depending on the required activity. Complete weight-bearing without crutches was reached at the end of the 4th week, and the only limiting factor was local edema.

The return to sports activities was progressive and staggered, as mentioned before, starting with kinesiological rehabilitation with increased intensity up to the 4th week. The use of stationary bicycle was initiated between the 2nd and 3rd week, according to patient's tolerance, which was interchanged with a street bicycle after the 6th week, with no reported complications. As patients improved local edema, discomfort, muscle strength, and balance, jogging, sprint, and jumping exercises were started after the 3rd month. Only one patient suffered a mild sprain with no severe complications.

Discussion

The published literature on surgical treatment of ankle fractures usually addresses criteria, surgical approaches, indications, and isolated results, but there were no studies that present results according to variables in postoperative protocols.

In this paper, we assessed the most frequent subgroup of ankle fractures. In general, we observed a population of young active individuals whose main demand is returning to work and sports activities as early as possible[7]. No previous studies have described a specific postoperative protocol for this type of fracture.

A meta-analysis of 25 articles published in 2015 studied early mobilization and early weight-bearing as variables to consider in the treatment outcomes and concluded that none of these variables resulted in increased rates of complications.

In this series of articles, we found the study by Gul et al.[16], conducted in 2007, the first one to propose a protocol similar to that assessed in the present study:

immediate unprotected weight-bearing as tolerated did not increase the rate of perioperative complications, and mobilization from the immediate postoperative period associated with early weight-bearing as tolerated is the safest and most effective option for early functional recovery. They were the first authors to propose progressive weight-bearing with no external protection in the entire series. Studies published later reached similar conclusions[17].

Early mobilization and weight-bearing are associated with a faster recovery of range of motion, shortening the time for the resumption of previous activities without increasing complication rates[16]. These measures did not expedite definite return to work, but drastically improves quality of life until this return. Immobilization led to more soft tissue adhesions to implants, with hypertrophic healing, and greater postoperative edema[15,18].

Another meta-analysis published in *The Foot* in 2019[19] on the experience of 85 health centers in Great Britain divided cases into those with early weight-bearing, which started before 3 weeks after surgery, and delayed weight-bearing, which started after this period. Only 21% of patients performed unrestricted weight-bearing, but always with some external support. Conceptually, this experience was difference from that of our proposal, since it proposes early weight-bearing at the expenses of immediate mobilization, which, we emphasize, is key to short-term functional recovery.

Some studies recommend postponing early mobilization, stating that it increases infection rates and periarticular pain[20].

Conversely, early mobilization allows to progressively reach full weight-bearing, which is most difficult in patients who remained immobilized[18].

Furthermore, some studies did not show significant long-term differences with regard to motility and return to sports when comparing early and delayed support. Improvement in quality of life that implies in progressively disregarding prolonged postoperative immobilization and crutches since the second postoperative week does not have an impact on isolated functional outcomes[18].

It is important to identify patients with comorbidities such as diabetes or smokers, since it has been demonstrated that these factors increase the likelihood of wound dehiscence or infection. In our series, we excluded patients with comorbidities that could be a determinant in outcomes.

Although the present study did not present results for a control group, we believe that its results were satisfactory, considering that patients emphasized the postoperative comfort of allowing for weight-bearing with crutches and without external supports, with early joint mobilization, and follow-up assessment did not reveal any case with signs of loosening, loss in the reduction procedure, hardware fatigue, soft tissue injury requiring a second surgical procedure.

Although the study population is acceptable, the limitation of the study is the lack of a control group subjected to a postoperative protocol with another standard with the purpose of objectively demonstrating the observed benefits. Currently, we are working with the same age group and the same type of fracture, starting with early weight-bearing 72 hours after surgery, in an attempt to further expedite the time of functional recovery. The results of this analysis will be presented when allowed by the study population and by postoperative follow-up, but we have already made conclusions on the patients assessed in the present study, which could be used as a control group in further studies.

Conclusion

Based on the obtained results, we can state that our protocol is effective with regard to early mobilization and early support, that it is not necessary to immobilize patients, and that they can resume to their everyday activities, both work and sports ones, promptly.

Authors' contributions: Each author contributed individually and significantly to the development of this article: DY *(https://orcid.org/0000-0002-9542-6914) Conceived and planned the activities that led to the study, performed the surgeries and bibliographic review; IM *(https://orcid.org/0000-0002-9452-0175); Performed the surgeries, interpreted the results of the studie and data collection; FA *(https://orcid.org/0000-0001-6577-8911) Participated in the review process, clinical examination and formatting of the article; SS *(https://orcid.org/0000-0003-0432-8102) Bibliographic review, interpreted the results of the study and approved the final version; JD *(https://orcid.org/0000-0002-5733-6766) Participated in the review process, performed the surgeries and statistical analysis. All authors read and approved the final manuscript. *ORCID (Open Researcher and Contributor ID).

References

1. Michelson JD. Ankle fractures resulting from rotational injuries. J Am Acad Orthop Surg. 2003;11(6):403-12.
2. Tang YH, Zeng LR, Xin DW, Yue ZS, Hu ZQ, Xu CD. [Individual choice of distal fibula internal fixation for ankle fractures in elderly]. Zhongguo Gu Shang. 2016;29(12):1114-8.
3. Davis AT, Israel H, Cannada LK, Bledsoe JG. A biomechanical comparison of one-third tubular plates versus periarticular plates for fixation of osteoporotic distal fibula fractures. J Orthop Trauma. 2013;27(9):e201-7.
4. Lorente A, Palacios P, Lorente R, Mariscal G, Barrios C, Gandía A. Orthopedic treatment and early weight-bearing for bimalleolar ankle fractures in elderly patients: Quality of life and complications. Injury. 2020;51(2):548-53.
5. Smeeing DP, Houwert RM, Briet JP, Kelder JC, Segers MJ, Verleisdonk EJ, et al. Weight-bearing and mobilization in the postoperative care of ankle fractures: a systematic review and meta-analysis of randomized controlled trials and cohort studies. PLoS One. 2015;10(2):e0118320.

6. Dehghan N, McKee MD, Jenkinson RJ, Schemitsch EH, Stas V, Nauth A, et al. Early Weightbearing and Range of Motion Versus Non-Weightbearing and Immobilization After Open Reduction and Internal Fixation of Unstable Ankle Fractures: A Randomized Controlled Trial. J Orthop Trauma. 2016;30(7):345-52.
7. Simanski CJ, Maegele MG, Lefering R, Lehnen DM, Kawel N, Riess P, et al. Functional treatment and early weightbearing after an ankle fracture: a prospective study. J Orthop Trauma. 2006;20(2):108-14.
8. Eckel TT, Glisson RR, Anand P, Parekh SG. Biomechanical comparison of 4 different lateral plate constructs for distal fibula fractures. Foot Ankle Int. 2013;34(11):1588-95.
9. Bariteau JT, Blankenhorn BD, Lareau CR, Paller DJ, DiGiovanni CW. Biomechanical evaluation of mini-fragment hardware for supination external rotation fractures of the distal fibula. Foot Ankle Spec. 2013;6(2):88-93.
10. Gentile J, Taylor BC, Chan R, French B. Clinical Comparison of Minifragment Plates Versus Conventional Semitubular Plates for Fixation of Distal Fibula Fractures. HSS J. 2015;11(2):148-53.
11. Hallbauer J, Klos K, Rausch S, Gräfenstein A, Wipf F, Beimel C, et al. Biomechanical comparison of a lateral polyaxial locking plate with a posterolateral polyaxial locking plate applied to the distal fibula. Foot Ankle Surg. 2014;20(3):180-5.
12. Milner BF, Mercer D, Firoozbakhsh K, Larsen K, Decoster TA, Miller RA. Bicortical screw fixation of distal fibula fractures with a lateral plate: an anatomic and biomechanical study of a new technique. J Foot Ankle Surg. 2007;46(5):341-7.
13. Smeeing DPJ, Houwert RM, Briet JP, Groenwold RHH, Lansink KWW, Leenen LPH, et al. Weight-bearing or non-weight-bearing after surgical treatment of ankle fractures: a multicenter randomized controlled trial. Eur J Trauma Emerg Surg. 2020;46(1):121-30.
14. Thangarajah T, Prasad PS, Narayan B. Surgical site infections following open reduction and internal fixation of ankle fractures. Open Orthop J. 2009;3:56-60.
15. Höiness P, Engebretsen L, Strömsöe K. The influence of perioperative soft tissue complications on the clinical outcome in surgically treated ankle fractures. Foot Ankle Int. 2001;22(8):642-8.
16. Gul A, Batra S, Mehmood S, Gillham N. Immediate unprotected weight-bearing of operatively treated ankle fractures. Acta Orthop Belg. 2007;73(3):360-5.
17. Dehghan N, McKee MD, Jenkinson RJ, Schemitsch EH, Stas V, Nauth A, et al. Early Weightbearing and Range of Motion Versus Non-Weightbearing and Immobilization After Open Reduction and Internal Fixation of Unstable Ankle Fractures: A Randomized Controlled Trial. J Orthop Trauma. 2016;30(7):345-52.
18. Moseley AM, Beckenkamp PR, Haas M, Herbert RD, Lin CW; EXACT Team. Rehabilitation After Immobilization for Ankle Fracture: The EXACT Randomized Clinical Trial. JAMA. 2015;314(13):1376-85.
19. BONE Collaborative. Weight-bearing in ankle fractures: An audit of UK practice. Foot (Edinb). 2019;39:28-36.
20. Lin CW, Donkers NA, Refshauge KM, Beckenkamp PR, Khera K, Moseley AM. Rehabilitation for ankle fractures in adults. Cochrane Database Syst Rev. 2012;11:CD005595.

DOI: https://doi.org/10.30795/jfootankle.2021.v15.1567

Original Article

Functional and radiological assessment of total ankle replacement with Infinity prosthesis

Álvaro Santiago Guerrero Forero[1], **Ricardo Rodríguez Ciodaro**[1,2], **Carlos Castillo Forero**[3], **Claudia Caicedo Donoso**[1]

1. Hospital de San José Bogotá, Bogotá, Colombia.
2. Fundación Universitaria de Ciencias de la Salud Bogotá, Bogotá, Colombia.
3. Clínica de la Colina, Bogotá, Colombia.

Abstract

Objective: To present mid-term functional and radiological outcomes obtained with the use of Infinity prosthesis in Bogotá (Colombia).

Methods: This cross-sectional observational study selected consecutive patients subjected to total ankle replacement with the fourth generation Infinity prosthesis (Wright Medical Technology).

Results: Fifty-two patients with ankle arthrosis were followed for a mean period of 24 months, and the most frequently reported case of joint degeneration was trauma. Postoperative improvement was observed in perception of pain (visual analog scale increased from 8/10 to 2/10; p<0.0005), AOFAS functional scale (from 23 to 84.5; p < 0.0005), and range of motion (from 11° to 29°; p<0.0005). Similarly, radiological findings, implant positioning, and signs of loosening did not reveal implant failure.

Conclusions: The use of fluoroscopically navigated prostheses allows us to achieve predictable outcomes, with satisfactory mid-term clinical and imaging results.

Level of Evidence IV; Therapeutic Studies; Case Series.

Keywords: Arthrosis; Ankle; Joint prosthesis; Arthroplasty, replacement, ankle.

Introduction

For patients, end-stage tibiotalar joint arthrosis represents limited limb function and thus limitations in performing everyday activities (Figure 1). Ankle arthrodesis has been widely indicated as a therapeutic option that promotes pain control and allows for gait of enough quality for the performance of basic everyday tasks[1,2]. However, restricted tibiotalar range of motion generates overload on transtarsal and tarsometatarsal joints, which, in the mid and long term, leads to arthrosis of these joints (50% of patients present with changes related to hindfoot arthrosis the 8 years after disease onset, but at 20 years, all patients had developed joint degeneration)[3-8].

Therefore, in the last decade total ankle arthroplasty, associated with biomedical advances in implants, has become a technique to solve limitation secondary to end-stage ankle arthrosis[9,10], with the advantage of not restricting mobility and preventing the transfer of load to neighboring joints.

Total ankle arthroplasty has shown promising results in the current literature, in terms of durability and function; therefore, it is considered by many authors the gold standard for the treatment of end-stage tibiotalar arthrosis[11].

The aim of this study is to present the results obtained with the use of Infinity prosthesis over the last 4 years.

Methods

According to resolution 8430 of 1993 of the Ministry of Protection, the present study is considered an investigation that does not pose significant risks to patients (Resolution 8430 of 1993 of the Ministry of Health of the Republic of Colombia, Article 10 and 11), because it consisted of a review of information collected from a database of patients subjected to ankle joint replacement. Ethical guidelines were based on the Declaration of Helsinki as revised in 2013, especially on articles 22, which refers to the development of a research protocol, and article 24, which ensures the confidentiality of data from study participants.

Study performed at the Hospital de San José – Fundación de Ciencias de la Salud, Bogotá, Colombia.

Correspondence: Álvaro Santiago Guerrero Forero. Calle 10 Nº 18-75, 111711, Bogatá, Colombia. **E-mail:** satiagoguerrero@hotmail.com. **Conflicts of Interest:** Consultor Wright Medical Tecnology. **Source of funding:** none. **Date received:** July 26, 2021. **Date accepted:** July 30, 2021. **Online:** August 31, 2021.

How to cite this article: Guerrero Forero AS, Rodríguez Ciodaro R, Castillo Forero C, Caicedo Donoso C. Functional and radiological assessment of total ankle replacement with Infinity prosthesis. J Foot Ankle. 2021;15(2):105-9.

Figure 1. Thirty-six-year-old patient with history of ankle fracture. A) Clinical photos showing equinus deformity of 12°. B) X-ray of the right ankle with support.

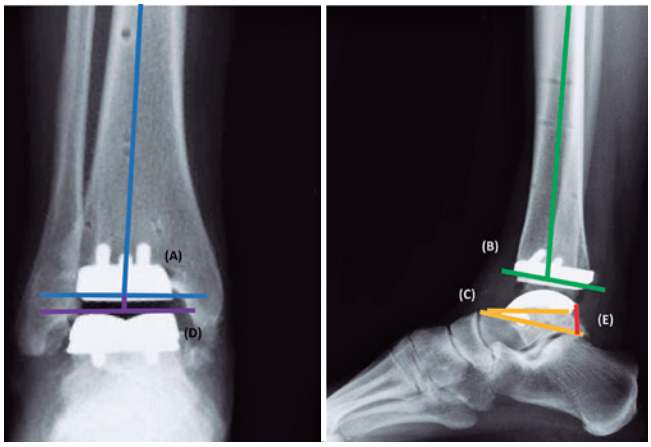


Figure 2. Radiographic parameters for the assessment of Infinity prosthesis (Wright Medical Technology) alignment. A) α angle in blue. B) β **angle** in green. C) Θ angle in orange. D) **Tibiotalar angle** in purple. E) **Distance "b"** in red.

Since the present investigation is a study without significant risks, the Research Ethics Committee of the research institution waived the requirement of obtaining written informed consent (Resolution 8430 of 1993 Ministry of Health of the Republic of Colombia – First Paragraph).

This is a cross-sectional observational study that selected consecutive patients subjected to total ankle replacement with fourth generation Infinity prosthesis, performed by the foot and ankle surgery team.

Pre- and immediate, four-week, six-month, and one-year postoperative radiographic images, obtained in the anteroposterior and lateral planes, were assessed through radiographic measurements according to the parameters described by Hintermann et al.[12-14] to evaluate misalignment and signs of wearing or loosening of prosthesis components (Figure 2):

- **Malalignment:** corresponds to measures that were not within the established ranges for α, β, and Θ angles;
- α **angle:** angle between the anatomical axis of the tibia and the joint surface of the tibial component of the prosthesis, in the coronal view, with a normal value of 90° (normal range [NR] 86-92);
- β **angle:** angle between the anatomical axis of the tibia and the joint surface of the tibial component of the prosthesis, in sagittal view, with a normal angle of 85° (NR 82-88);
- Θ **angle:** angle composed of the union of the line going through the anterior and posterior extremities of the talar component of the prosthesis (line A) and the line tangential to the upper edge of the navicular and the upper eminence of the posterior tuberosity of the calcaneus (line B), with a normal value of 20°;
- **Tibiotalar angle:** angle between the axis of the tibia and a line perpendicular to the talar dome. Negative values represent varus angulations, whereas positive ones represent valgus angulations.
- **Distance "a":** distance between the anterior extremity of the talar component of the prosthesis and line A, measured in millimeters;
- **Distance "b":** distance between the posterior extremity of the talar component of the prosthesis and line B, measured in millimeters.

Statistical analysis

This is a cross-sectional observational study that selected consecutive patients subjected to total ankle replacement with fourth generation Infinity prosthesis (Wright Medical Technology).

Data were collected on an Excel spreadsheet and then exported to the Stata® Software, version 14, for further analysis. Qualitative variables were reported using measures of absolute and relative frequency, and quantitative variables were reported using measures of central trend and dispersion, depending on data distribution: data with normal distribution are expressed as mean and standard deviation, whereas those with non-normal distribution are expressed as median and interquartile range (IQR).

Results

The present study evaluated the clinical-radiographic outcomes of patients subjected to total ankle replacement with Infinity prosthesis (Wright Medical Technology) due to end-stage arthrosis. Mean follow-up time was 24 months (9.5-55 months); mean age was 61 years (53-67 years). With regard to the operated side, 53.8% of interventions were performed on the right ankle, and 46.2% on the left ankle. The cause of arthrosis was post-traumatic in 61.9% of the cases, whereas 38.1% of the cases had another origin (rheumatoid arthritis, gout, and hemophilia) (Tables 1 and 2).

Table 1. Demographic data

Demographic data		
Variables		
Age, mean		61
Gender	Male	51%
	Female	49%
Race	White	98%
	Non-white	1%

Table 2. Distribution of cause and radiological findings

Characteristics of the prosthesis		
Variables		
Operated side	Right	53.84%
	Left	46.36%
Cause	Degenerative	38.10%
	Post-traumatic	61.40%
Periprosthetic cyst		0%
Talar subsidence		0%
Polyethylene wearing		0%
Associated surgery	None	80%
	Achilles tendon lengthening	9.62%
	Subtalar arthrodesis	1.92%
	Syndesmosis fixation	1.92%
	Calcaneal osteotomy	5.77%
Malleolus fracture	None	96.10%
	Lateral	1.92%
	Medial	1.92%
Wound complications	No complications	92.31%
	Necrosis of wound extremities	7.69%
	Extensive necrosis (implant)	0%
	Extensive necrosis (vascularized flap)	0%
	Infection	0%
Prosthesis failure		0%
Salvage		0%

A visual analog scale was used to assess pre- and postoperative pain, with a mean preoperative score of 8/10 (5-10) and a mean postoperative score of 2/10 (0-3), showing a statistically significant improvement ($p<0.0005$) (Table 3).

All patients were evaluated with the American Orthopaedic Foot and Ankle Society (AOFAS) for the ankle, with a mean preoperative score of 23 points (20-30.5), and a mean postoperative score of 84.5 points (80-90), showing a statistically significant improvement ($p<0.0005$).

Actual ankle range of motion, interpreted as the sweep angle from maximum active extension to maximum active flexion, had mean preoperative and postoperative values of 11 degrees (5-30) and 29 degrees (20-40), respectively, representing a statistically significant difference ($p<0.0005$).

Our study assessed the postoperative radiographic outcomes of patients subjected to total ankle replacement due to end-stage arthrosis. Control images were obtained at the postoperative immediate period and at three, six, and twelve postoperative months, in anteroposterior, lateral, and mortise views.

During follow-up, there were no signs of early loosening (periprosthetic radiolucent lines) or variation in angle measures suggesting subsidence of prosthetic components or polyethylene implant wearing.

Furthermore, the indication of procedures in parallel with arthroplasty was assessed; 80% of the cases did not require an associated surgical intervention. The most frequently indicated procedure was Achilles tendon lengthening, followed by calcaneal osteotomy. During follow-up, no patient required revision surgery.

Discussion

Infinity ankle prosthesis (Wright Medical Technology) is a fourth-generation implant characterized by low profile, fluo-

Table 3. Pre- and postoperative findings

Variable	Median	Minimum	Maximum	Interquartile range
Preoperative VAS	8	5	10	7 to 9
Postoperative VAS	2	0	3	1 to 2
Preoperative AOFAS score	23	13	40	20 to 30.5
Postoperative AOFAS score	84.5	80	92	80 to 90
Preoperative ROM	10	5	30	7.5 to 15
Postoperative ROM	28	20	40	25 to 30
Real preoperative mobility	1	0	3	1
Real postoperative mobility	30	20	40	30
Distance “a”	2	1	5	2
Distance “b”	4	2	6	4 to 5

AOFAS= American Orthopaedic Foot and Ankle Society; ROM= range of motion; VAS= visual analog scale

roscopically navigated, fixed-bearing device with a symmetrical condylar geometry that uses a resurfacing and fluoroscopic navigation system[15,16]. Since its use was initiated in 2013, this prosthesis has demonstrated satisfactory clinical and radiological outcomes. In Colombia, its use has increased since 2016, with favorable results, being even more used than arthrodesis as the therapeutic method in end-stage ankle arthrosis.

The rates of complications and revision of ankle prosthesis were considerably high compared to those observed in knee and hip arthroplasties, which has changed with the development of new generations of implants, in which fixation with tibial/talar pegs and resurfacing have reduced the effect of shear stress on implant components[16].

Cody et al.[17], Althoff et al.[18], and DeVries et al.[19] reported a rate of revision of 10%, whose more frequent causes were loosening of prosthetic components (3.8%) and deep infection (3.8%) in 159 ankles in a 20-month follow-up. However, in the same year, Penner et al.[9] published their two-year follow-up with Infinity prosthesis in 67 patients requiring total ankle arthroplasty. In this cohort, 3% of participants required prosthetic revision for aseptic loosening. Similarly, there was a significant improvement in the Foot Function Index and Ankle Osteoarthritis Scale functional scores ($p<0.0001$).

Rushing et al.[20], in turn, assessed 55 ankles over a follow-up time of up to 43 months, with a rate of prosthesis survivorship of 97% and a rate of revision 1.8%; moreover, radiolucency was observed in 34.5% of the ankles, of which 89.5% were not progressive. Improvement of angle deformity was achieved both in the coronal and sagittal planes ($p<0.001$ and $p<0.09$, respectively).

Saito et al.[16] reports a rate of revision surgery of 4.7% in a 25-month follow-up of a cohort of 64 patients (18), similar to the rates observed with other implants. Meanwhile, the United Kingdom National Joint Register found that only 1% of cases required revision of Infinity prosthesis in a 14-month follow-up[9,16-20].

In Latin America, a 2020 study by Nery et al.[3] reported successful outcomes in 26 patients subjected to arthroplasty with Infinity prosthesis, with a 100% rate of survivorship in the first year of follow-up, which is similar to the result found in our study, although the present study had a larger sample size and longer follow-up.

Prostheses with fluoroscopic navigation (Figure 3) enhance the accuracy of postoperative outcomes with regard to implant alignment; in 2018 King et al.[15] found, in a cohort of 20 patients with a 24-month follow-up, a deviation of 1.5° from 90° alignment to the anatomical axis of the tibia, which allows for a homogeneous distribution of body load that is translated in the preservation of implant components. Similarly, Saito et al.[16] reported improvement in tibiotalar coronal alignment with the use of a fluoroscopically navigated prosthesis, as shown by the maintenance of the prosthesis and consistent with the results observed in our radiological follow-up assessment.

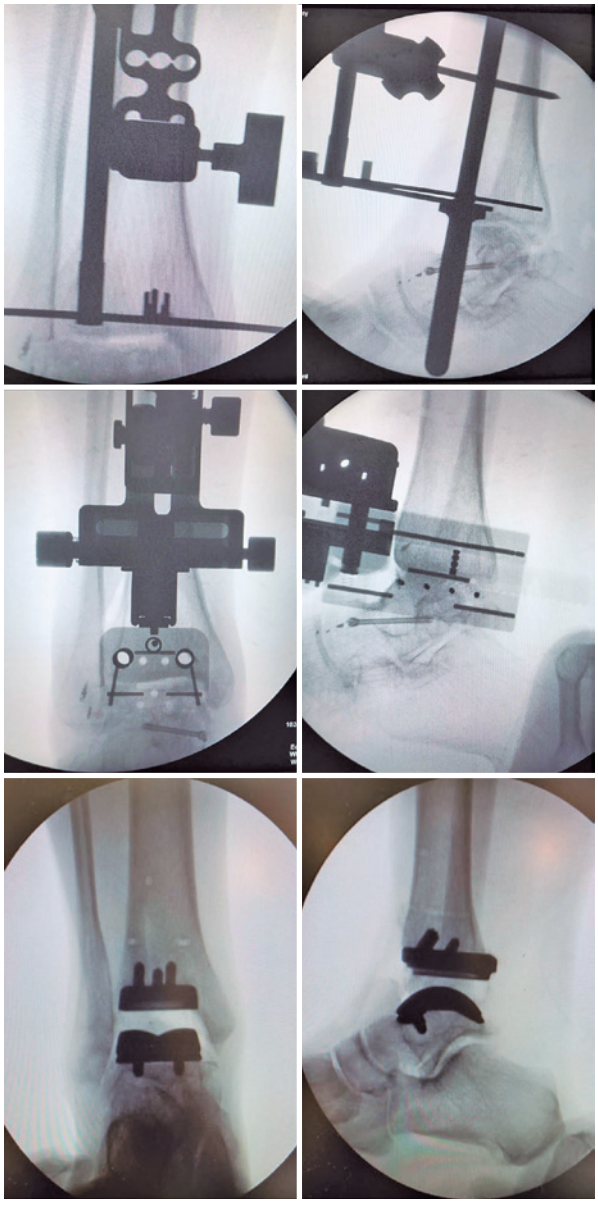


Figure 3. Fluoroscopic sequence of total ankle replacement with Infinity prosthesis (Wright Medical Technology).

General complications related to the use of this prosthesis are reported in up to 54% of the cases[15,16] and, in the cohort by Saito et al.[16], consisted mainly of impingement of the lateral groove. However, the most frequent complication in our sample was that involving soft tissues.

Conclusion

Total ankle replacement with Infinity prosthesis allows for a reproducible technique with satisfactory mid-term clinical and radiological outcomes. Thus, we consider that results for long-term prognosis are promising, but a longer patients' follow-up is required.

Authors' contributions: Each author contributed individually and significantly to the development of this article: ASGF *(https://orcid.org/0000-0003-0296-5263) Conceived and planned the activities that led to the study, participated in the review process, performed the surgeries, data collection, survey of the medical records, formatting of the article, clinical examination, approved the final version; RRC *(https://orcid.org/0000-002-3817-0609) Conceived and planned the activities that led to the study, participated in the review process, performed the surgeries, data collection, survey of the medical records, formatting of the article, clinical examination, approved the final version; CCF *(https://orcid.org/0000-0002-5197-4468) Performed the surgeries, data collection, survey of the medical records; CCD *(https://orcid.org/0000-0002-8049-3903) Interpreted the results of the study, participated in the review process, statistical analysis, bibliographic review, formatting of the article, clinical examination, approved the final version. All authors read and approved the final manuscript. *ORCID (Open Researcher and Contributor ID).

References

1. Escudero MI, Le V, Barahona M, Symes M, Wing K, Younger A, et al. Total Ankle Arthroplasty Survival and Risk Factors for Failure. Foot Ankle Int. 2019;40(9):997-1006.
2. Daniels TR, Younger AS, Penner M, Wing K, Dryden PJ, Wong H, et al. Intermediate-term results of total ankle replacement and ankle arthrodesis: a COFAS multicenter study. J Bone Joint Surg Am. 2014;96(2):135-42.
3. Nery C, Lemos AVKC, Ferreira Martins CEC, Baumfeld D. Brazilian Total Ankle Replacement Experience. Orthop Clin North Am. 2020; 51(2):293-302.
4. Wang H, Brown SR. The effects of total ankle replacement on ankle joint mechanics during walking. J Sport Health Sci. 2017;6(3):340-5.
5. Latham WC, Lau JT. Total Ankle Arthroplasty: An Overview of the Canadian Experience. Foot Ankle Clin. 2016;21(2):267-81.
6. Barg A, Wimmer MD, Wiewiorski M, Wirtz DC, Pagenstert GI, Valderrabano V. Total ankle replacement. Dtsch Arztebl Int. 2015; 112(11):177-84.
7. Besse JL, Colombier JA, Asencio J, Bonnin M, Gaudot F, Jarde O, et al. Total ankle arthroplasty in France. Orthop Traumatol Surg Res. 2010;96(3):291-303.
8. Prusinowska A, Krogulec Z, Turski P, Przepiórski E, Małdyk P, Księżopolska-Orłowska K. Total ankle replacement - surgical treatment and rehabilitation. Reumatologia. 2015;53(1):34-9.
9. Penner M, Davis WH, Wing K, Bemenderfer T, Waly F, Anderson RB. The Infinity Total Ankle System: Early Clinical Results With 2- to 4-Year Follow-up. Foot Ankle Spec. 2019;12(2):159-66.
10. Younger AS, Wing KJ, Glazebrook M, Daniels TR, Dryden PJ, Lalonde KA, et al. Patient expectation and satisfaction as measures of operative outcome in end-stage ankle arthritis: a prospective cohort study of total ankle replacement versus ankle fusion. Foot Ankle Int. 2015;36(2):123-34.
11. Nery C, Fernandes TD, Réssio C, Fuchs ML, Santos ALG, Ortiz RT. Total Ankle Replacement: Brazilian Experience with the HINTEGRA Prosthesis. Rev Bras Ortop. 2010;45(1):92-100.
12. Hintermann B, Valderrabano V, Dereymaeker G, Dick W. The HINTEGRA ankle: rationale and short-term results of 122 consecutive ankles. Clin Orthop Relat Res. 2004;(424):57-68.
13. Hintermann B. Surgical techniques. In: Total ankle arthroplasty: historical overview, current concepts and futures perspectives. 5th ed. New York: Springer-Verlang; 2005. p. 115-31.
14. Hintermann B, Valderrabano V, Knupp M, Horisberger M. [The HINTEGRA ankle: short- and mid-term results]. Orthopade. 2006; 35(5):533-45.
15. King A, Bali N, Kassam AA, Hughes A, Talbot N, Sharpe I. Early outcomes and radiographic alignment of the Infinity total ankle replacement with a minimum of two year follow-up data. Foot Ankle Surg. 2019;25(6):826-33.
16. Saito GH, Sanders AE, de Cesar Netto C, O'Malley MJ, Ellis SJ, Demetracopoulos CA. Short-Term Complications, Reoperations, and Radiographic Outcomes of a New Fixed-Bearing Total Ankle Arthroplasty. Foot Ankle Int. 2018;39(7):787-94.
17. Cody EA, Taylor MA, Nunley JA 2nd, Parekh SG, DeOrio JK. Increased Early Revision Rate With the INFINITY Total Ankle Prosthesis. Foot Ankle Int. 2019;40(1):9-17.
18. Althoff A, Cancienne JM, Cooper MT, Werner BC. Patient-Related Risk Factors for Periprosthetic Ankle Joint Infection: An Analysis of 6977 Total Ankle Arthroplasties. J Foot Ankle Surg. 2018;57(2):269-72.
19. DeVries JG, Derksen TA, Scharer BM, Limoni R. Perioperative Complications and Initial Alignment of Lateral Approach Total Ankle Arthroplasty. J Foot Ankle Surg. 2017;56(5):996-1000.
20. Rushing CJ, Kibbler K, Hyer CF, Berlet GC. The INFINITY Total Ankle Prosthesis: Outcomes at Short-Term Follow-up. Foot Ankle Spec. 2020:1938640020946199.

DOI: https://doi.org/10.30795/jfootankle.2021.v15.1563

Original Article

Minimally invasive chevron/akin osteotomy: radiographic outcomes

Kepler Alencar Mendes de Carvalho[1], Fernando Garnica Torrico[1], David Satiro Borges Pereira de Oliveira[1], André Donato Baptista[1]

1. Nossa Senhora do Pari Beneficent Association, São Paulo, SP, Brazil.

Abstract

Objective: To evaluate radiographic outcomes in patients undergoing minimally invasive Chevron/Akin osteotomy (MICA) for hallux valgus correction.

Methods: We have treated 31 patients (40 feet). Preoperative and postoperative hallux metatarsophalangeal angles (hallux valgus angles, HVA), intermetatarsal angles (IMA) between the first and second metatarsals, and distal metatarsal articular angles (DMAA) were followed up for 12 months.

Results: The mean age of the patients was 53.2 years. Mean preoperative HVA, IMA, and DMAA values were 28.85°, 15.38°, and 14.35°, respectively. The mean postoperative angles measured after 1 year were 10.60°, 7.95°, and 7.48°. Improvements in HVA, IMA, and DMAA values showed statistical relevance. There were no losses in angular parameters during follow-up.

Conclusion: The radiographic outcomes in patients undergoing MICA osteotomy for hallux valgus correction followed up for 12 months showed significant improvements and no recurrence of the deformity. Our results suggest that this technique is effective for correcting hallux valgus.

Level of Evidence III; Therapeutic Studies; Comparative Retrospective Study.

Keywords: Hallux valgus/surgery; Osteotomy; Radiography; Minimally invasive surgical procedures.

Introduction

Hallux valgus is a common deformity of the forefoot, characterized by lateral hallux deviation and medial deviation of the first metatarsal. Its overall prevalence is 23% among individuals aged 18 to 65 years and 35% in the older population (> 65 years old). It mainly affects women, with a prevalence of 30%, compared to 13% in men[1-3].

Pain in the hallux metatarsophalangeal region is a quite common symptom, which may result in limitation of daily activities and impaired quality of life[1,4-6]. Genetics is an important predictive factor for the disease, with nearly 68% of patients having familial inheritance. The use of inappropriate shoes, bone abnormalities, and excessive pronation of the foot are also among etiological factors[7,8].

Conservative treatment consists in wearing adequate shoes with wide and deep anterior chambers and low heels to minimize the patient's pain and progressive deformity[7].

In order to determine the severity of hallux valgus, we plotted the metatarsophalangeal angle (hallux valgus angle, HVA) and the intermetatarsal angle (IMA) on X-ray images. The HVA angle was plotted at the intersection of the lines along the long axis of the first metatarsal and the proximal phalanx of the hallux. The angle between the long axis of the first and second metatarsals was the IMA. Both angles were checked on anteroposterior radiographs of weight-bearing feet. The deformity was thus classified as: mild (HVA > 19° and IMA > 13°), moderate (HVA between 20° and 40° and IMA between 14° and 20°), and severe (HVA > 40° and IMA >

Study performed at Nossa Senhora do Pari Beneficent Association, São Paulo, SP, Brazil.

Correspondence: Képler Alencar Mendes de Carvalho. Rua Hannemann, 234 – Pari - 03031-040, São Paulo - SP, Brazil. **E-mail:** kepler.ortopedia@gmail.com.
Conflicts of Interest: none. **Source of funding:** none. **Date received:** July 13, 2021. **Date accepted:** July 22, 2021. **Online:** August 31, 2021.

How to cite this article: Carvalho KAM, Torrico FG, Oliveira DSBP, Baptista AD. Minimally invasive chevron/akin osteotomy: radiographic outcomes. J Foot Ankle. 2021;15(2):110-4.

20°)[7]. These radiographic angles have excellent correlations with clinical aspects[4,8]. The distal metatarsal articular angle (DMAA) is defined as the relationship between the distal articular surface and the longitudinal axis of the first metatarsal bone. The DMAA is considered a fundamental aspect to be evaluated while planning surgical corrections. To achieve total congruence of the metatarsophalangeal joint of the hallux, it is paramount to avoid or decrease the incidence of insufficient corrections or recurrences. In normal feet, this angle should not exceed 8º[7,9].

Minimally invasive surgery for correcting forefoot deformities has gained popularity worldwide in recent years. These techniques preserve soft tissues and reduce recovery time and morbidities associated with the disease process and surgical intervention[2,10,11].

The distal Chevron metatarsal osteotomy, first described in 1962, is a widely accepted technique used in the treatment of mild and moderate deformities. It shows satisfactory results in adult individuals of all age groups, promoting pain relief, restoration of function, and lasting correction of the deformity[4,10]. However, publications regarding its efficacy in severe deformities are still scarce in the literature[4].

With the advent of minimally invasive techniques for correcting hallux valgus, Vernois idealized the minimally invasive Chevron/Akin osteotomy (MICA) osteotomy[12]. In this technique, owing to less damage to soft tissues and metatarsal head vascularization, it is possible to laterally translate the capital fragment through up to 100% of the osteotomy contact area. This increases the potential to correct severe deformities when compared to the traditional open technique. In some cases, the contact between the proximal and distal portions of the first metatarsal is made only by the cortical bone[4]. The osteotomy is fixed with cortical screws, providing sufficient stability for mild or aggressive corrections[2,10,12,13].

Methods

This study was approved by the Research Ethics Committee registered at Plataforma Brasil under the Certificate of Presentation for Ethical Appreciation (CAAE number 35995820.5.0000.0068).

We operated on 31 patients (40 feet) using the MICA technique between June 2016 and January 2018. The exclusion criteria for patients in this study were peripheral sensitive neuropathy, symptomatic osteoarthritis with limited range of motion of the first metatarsophalangeal joint, and severe vascular disease.

Radiographic analysis

Pre- and postoperative weight-bearing anteroposterior (AP) view radiographs were performed. Radiographic data were recorded preoperatively and at the 6-month and 12-month follow-up visits. The analysis followed the trigonometric measurement model established for Chevron's osteotomy[14]. We evaluated the following radiographic parameters: HVA, DMAA, and IMA.

Surgical procedure

The surgical procedure consisted of a bunionectomy performed with 12 x 3.1 mm Wedge cutters, followed by percutaneous Chevron osteotomies with 20 x 2 mm Shannon burrs and Akin osteotomies performed with 12 x 2 mm Shannon burrs. Osteotomy fixation was done using 2 3.5 mm fully threaded cannulated screws or 4.5 mm headless compression screws (Figure 1). All surgical steps were performed under fluoroscopic control.

Results

We included 31 patients (40 feet) operated on using the MICA technique for hallux valgus correction. The mean age of the patients was 53.45 (± 2.25) years (ranging from 23 to 77 years) and 90% of them were women.

The mean preoperative HVA angle was 28.85° (± 10.42°). At the 6-month postoperative follow-up, the mean value was 10.78° (± 6.93°), and at the 12-month follow-up, it was 10.60° (± 6.65°) (Figure 2).

The mean preoperative IMA value was 15.38° (± 4.07°). At 6 months postoperative, the mean value was 8.11° (± 2.60°), and after 12 months, it was 7.95° (± 2.80°) (Figure 3).

Regarding the DMAA, the mean preoperative value was 14.35° (± 6.83°), after 6 months it was 7.75° (± 5.51°), and after 12 months, 7.48° (± 5.39°) (Figure 4).

As sample distributions for the HVA, DMAA, and IMA were not symmetrical, we opted for the Friedman test in our initial statistical evaluation. The test analyzed 3 paired segments (preoperative vs 6-month postoperative vs 12-month postoperative) to determine the statistically significant difference ($p<0.001$) between preoperative and postoperative measurements (Table 1).

Figure 1. A) Preoperative radiographic image. B) Radiographic image 12 months after surgery.

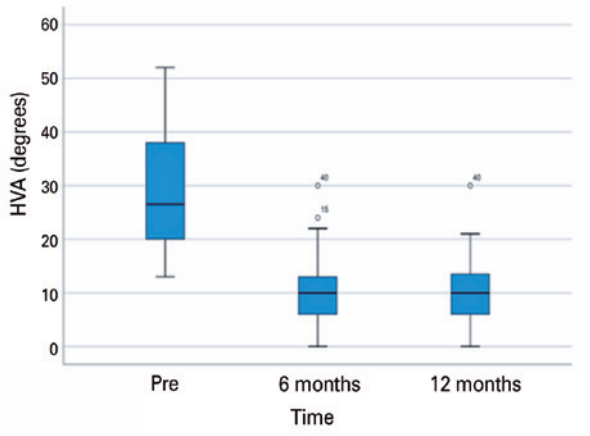


Figure 2. Radiographic parameters over time. Metatarsophalangeal angle (hallux valgus angle, HVA), (mean/standard deviation, in degrees).

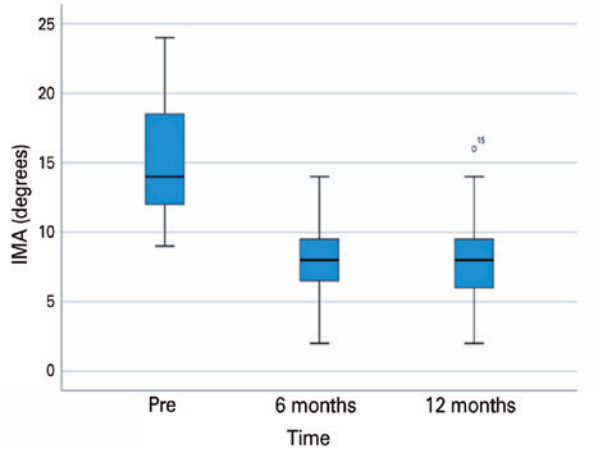


Figure 3. Radiographic parameters over time. Intermetatarsal angle (IMA) (mean/standard deviation, in degrees).

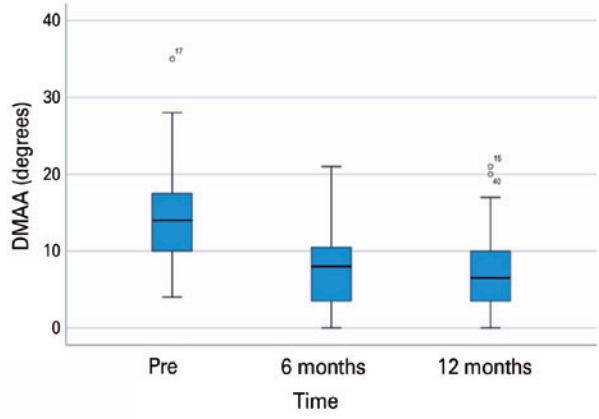


Figure 4. Radiographic parameters over time. Distal metatarsal articular angle (DMAA) (mean/standard deviation, in degrees).

Table 1. Friedman tests for 3 paired follow-ups (preoperative [pre-op] vs 6-month postoperative [post-op] vs 12-month postoperative).

	HVA	IMA	DMAA
	(Pre-op vs 6 months post-op vs 12 months post-op)		
N	40	40	40
Chi-squared	72.788	69.664	35.586
p value	p<0.001	p<0.001	p<0.001

DMAA: distal metatarsal articular angle; HVA: hallux valgus angle; IMA: intermetatarsal angle

Subsequently, the Wilcoxon test (matched pairs) was applied to verify at which point during the follow-up the statistically significant difference was found. We observed no differences in the HVA, DMAA, and IMA radiographic parameters from the 6-month to the 12-month follow-up (p=0.788). On the other hand, HVA, DMAA, and IMA improved significantly when comparing the preoperative values to the 6-month (p<0.001) and 12-month postoperative periods (p<0.001) (Table 2).

Discussion

There is an increasing interest in minimally invasive surgery techniques for the treatment of forefoot pathologies, especially hallux valgus. Some of the reported advantages include less aggression to soft tissues and vascularization[5,6]. However, there is still no consensus in the medical literature on the most effective technique to correct hallux valgus[6].

At our institution, the MICA osteotomy is the treatment of choice for most cases of mild, moderate, and severe hallux valgus deformities. We designed this study to assess radiographic parameters of patients undergoing this procedure and its effectiveness in the correction of hallux valgus deformities.

Following the trigonometric measurement model designed for Chevron's osteotomy[14], we assessed the following radiographic parameters: HVA, DMAA, and IMA between the first and second metatarsal.

The HVA is the angle formed between the line running along the diaphyseal axis of the proximal phalanx of the hallux and the mechanical axis of the first metatarsal. We considered values below 15° to be normal[7,14,15]. We recorded a mean preoperative HVA of 28.8°. At the 12-month postoperative evaluation, the mean value decreased to 10.6 degrees, denoting a statistically significant difference (p<0.01) and demonstrating a return of the HVA value to normal parameters.

The IMA is the angle formed between the lines that correspond to the first and second metatarsal axes. We considered normal values to be equal to or lower than 9°[7,14,15]. In our study, we found a mean preoperative IMA of 15.38°, and at the 12-month postoperative follow-up, the mean value decreased to 7.95°, denoting a statistically significant difference (p<0.01) and return of the IMA to normal angular parameters.

Table 2. Wilcoxon test assessing at what point during follow-up the statistically significant difference was found.

	Metatarsophalangeal angle			Intermetatarsal angle			Distal metatarsal articular angle		
	Pre-op vs PO 6m	PO6m vs PO 12m	Pre-op vs PO 12m	Pre-op vs PO 6m	PO6m vs PO 12m	Pre-op vs PO 12m	Pre-op vs PO 6m	PO6m vs PO 12m	Pre-op vs PO 12m
Z	-5.514[b]	-0.199[b]	-5.513[b]	-5.389[b]	-0.269[b]	-5.519[b]	-4.497[b]	-1.550[b]	-4.591[b]
p value	<0.001	0.842	<0.001	<0.001	0.788	<0.001	<0.001	0.121	<0.001

b. Based on positive posts.
Pre-op: preoperative; PO: postoperative; m: months.

Although the literature is still scarce about this theme, in a similar study evaluating HVA and IMA for this type of osteotomy[16], the authors found similar results for angular corrections comparing preoperative and postoperative measurements.

The DMAA represents the orientation of the articular surface of the first metatarsal head[17], measured between the line connecting the 2 extreme points of the distal articular surface of the first metatarsal bone and the line perpendicular to its diaphyseal axis. This angle should not exceed 8°. Although some authors suggest that an altered DMAA may be a secondary radiographic projection of a pronation deformity, this measure is still widely used and influences treatment decision making[7,17-19]. Osteotomies that produce lateral rotation in the axial plane can potentially worsen the DMMA, requiring additional procedures for its correction. As the percutaneous Chevron is a distal translational osteotomy, we did not observe this deleterious effect. To our knowledge, there are no studies to date that explain etiologic factors for increased DMAA in hallux valgus.

In most cases, the progression of hallux valgus is simultaneous with an unstable first tarsometatarsal joint, which causes medial deviation and pronation of the first metatarsal[17].

We recorded a mean preoperative DMMA of 14.35°. At the 12-month postoperative evaluation, this mean value decreased to 7°, denoting a statistically significant difference ($p<0.01$) and a return of the DMAA value to normal parameters. We did not intentionally care for the metatarsal pronation during the procedure, but we believe the lateral shift of the first metatarsal head itself promotes its correction.

This study's weaknesses include the small number of patients, its retrospective and non-randomized design, and the absence of clinical data. Although 2 experienced orthopedic surgeons performed all radiographic measurements, an unknown bias can affect the results of the study. In addition, the short follow-up and small sample group may be insufficient for us to reach relevant conclusions.

Conclusion

Many studies have suggested that hallux valgus is a three-dimensional deformity. Therefore, two-dimensional radiographic measurements may be insufficient to explain the complex nature of this deformity. The advent of three-dimensional imaging technologies, such as weight-bearing computed tomography scans, should bring us more accurate information about this complex deformity. Nevertheless, the radiographic parameters evaluated in this study showed that the MICA technique is effective in promoting satisfactory angular corrections that lasted for the 12-month follow-up.

Authors' contributions: Each author contributed individually and significantly to the development of this article: KAMC *(https://orcid.org/0000-0003-1082-6490) Conceived and planned the activities that led to the study, performed the surgeries, interpreted the results of the study, participated in the review process and approved the final version; FGT *(https://orcid.org/0000-0002-2127-6650) Data collection and interpreted the results of the study; DSBPO *(https://orcid.org/0000-0002-0201-9413) Data collection and interpreted the results of the study; ADB *(https://orcid.org/0000-0002-5991-1701) Performed the surgeries and approved the final version. All authors read and approved the final manuscript. *ORCID (Open Researcher and Contributor ID).

References

1. van Groningen B, van der Steen MC, Reijman M, Bos J, Hendriks JG. Outcomes in chevron osteotomy for Hallux Valgus in a large cohort. Foot (Edinb). 2016;29:18-24.
2. Silva RF, Baptista AD. Surgical treatment of moderate and severe hallux valgus: 30 cases undergoing surgery using the percutaneous Chevron technique. Sci J Foot Ankle. 2018;12(1):61-7.
3. Maffulli N, Longo UG, Marinozzi A, Denaro V. Hallux valgus: effectiveness and safety of minimally invasive surgery. A systematic review. Br Med Bull. 2011;97:149-67.
4. Lee KM, Ahn S, Chung CY, Sung KH, Park MS. Reliability and relationship of radiographic measurements in hallux valgus. Clin Orthop Relat Res. 2012;470(9):2613-21.
5. Palmanovich E, Myerson MS. Correction of moderate and severe hallux valgus deformity with a distal metatarsal osteotomy using an intramedullary plate. Foot Ankle Clin. 2014;19(2):191-201.
6. Cassinelli SJ, Herman R, Harris TG. Distal Metatarsal Osteotomy for Moderate to Severe Hallux Valgus. Foot Ankle Int. 2016;37(10):1137-45.
7. Nery CAS. Hallux valgus. Rev Bras Ortop. 2001;36(6):183-200.

8. Cohen JC, Richardson G, Fernandes RMP. Surgical treatment of moderate to severe hallux valgus with distal chevron osteotomy associated with distal soft tissue release. Rev ABTPé. 2010;4(2): 97-106.
9. Nery CAS, Apostólico Netto A, Benevento M, Réssio C. Radiographic Evaluation of the Hallux Valgus: Population Study of New Angular Parameters. Acta Ortop Bras. 2001;9(2):41-8.
10. Brogan K, Voller T, Gee C, Borbely T, Palmer S. Third-generation minimally invasive correction of hallux valgus: technique and early outcomes. Int Orthop. 2014;38(10):2115-21.
11. Jowett CRJ, Bedi HS. Preliminary Results and Learning Curve of the Minimally Invasive Chevron Akin Operation for Hallux Valgus. J Foot Ankle Surg. 2017;56(3):445-52.
12. Vernois J, Redfern DJ. Percutaneous Surgery for Severe Hallux Valgus. Foot Ankle Clin. 2016;21(3):479-93.
13. Redfern D, Perera AM. Minimally invasive osteotomies. Foot Ankle Clin. 2014;19(2):181-9.
14. Nery CAS. [Chevron osteotomy for the treatment of hallux valgus – Part 1 – Clinical-radiological and trigonometric evaluation]. Rev Bras Ortop. 1995;30(6):385-92.
15. Hardy RH, Clapham JC. Observations on hallux valgus; based on a controlled series. J Bone Joint Surg Br. 1951;33(3):376-91.
16. 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.
17. Lee SY, Chung CY, Park MS, Sung KH, Ahmed S, Koo S, Kang DW, Lee KM. Radiographic Measurements Associated With the Natural Progression of the Hallux Valgus During at Least 2 Years of Follow-up. Foot Ankle Int. 2018;39(4):463-70.
18. Coughlin MJ, Carlson RE. Treatment of hallux valgus with an increased distal metatarsal articular angle: evaluation of double and triple first ray osteotomies. Foot Ankle Int. 1999;20(12):762-70.
19. Lee KM, Ahn S, Chung CY, Sung KH, Park MS. Reliability and relationship of radiographic measurements in hallux valgus. Clin Orthop Relat Res. 2012;470(9):2613-21.

DOI: https://doi.org/10.30795/jfootankle.2021.v15.1537

Original Article

Clinical and functional outcomes of tarsal coalition resection to correct rigid flat foot

Rodrigo Guimarães Huyer[1], **Mário Sérgio Paulillo Cillo**[1], **Carlos Daniel Cândido Castro Filho**[1], **Hallan Douglas Bertelli**[1], **Marcelo Morelli Girondo**[1], **Armando Bortolatto Neto**[1]

1. Orthopedics and Traumatology Departament PUC-Campinas, Campinas, SP, Brazil.

Abstract

Objective: This study used the AOFAS score to assess the clinical functional results of patients who underwent tarsal coalition resection.

Methods: This was a retrospective case series of patients who underwent tarsal coalition resection to correct rigid flat foot. Clinical and functional assessment was performed with the AOFAS score before and 6 months after surgical treatment. Descriptive analysis was performed for 7 patients (11 operated feet) using measurements of position and dispersion (mean, standard deviation, minimum, median and maximum value) for continuous variables and frequency tables (absolute and relative) for categorical variables.

Results: The mean patient age was 10 years, 7 months, and the majority (71.43%) were male. The most affected joint was the calcaneonavicular. The right side was affected in 54.55% of the cases. The most frequent type of coalition was osseous (81.82% of the cases). The mean pre- and postoperative AOFAS scores were 32.7 and 70.2 points, respectively, which was a significant increase.

Conclusion: The increased scores after coalition resection was considered the main change between the two assessments. Thus, it can be concluded that in rigid flat feet without severe hind- or forefoot deformities for which conservative treatment failed, bar resection should be the surgical procedure of choice.

Level of Evidence IV; Therapeutic Studies; Case Series.

Keywords: Tarsal coalition; Tarsal bones; Flatfoot; Subtalar joint.

Introduction

Tarsal coalition, a bone pathology that occurs in less than 1% of the population[1], is characterized as a bony, cartilaginous or fibrous connection between two or more bones of the hind- and/or midfoot. It is the main cause of rigid flat foot in children. Although many patients are asymptomatic, others complain of foot pain, functional limitations, and ankle sprains[2-4]. Symptom onset is related to the ossification process: ossification occurs in the calcaneonavicular coalition and the talocalcaneal joint at 8-12 and 12-16 years of age, respectively[5]. Clinical diagnosis can be complemented by radiographic examinations, which should include an oblique view. Magnetic resonance imaging and computed tomography can be useful complementary methods in the diagnostic process. Conservative treatment initially involves behavioral and lifestyle recommendations, non-steroidal anti-inflammatory drugs, and insoles[6,7]. Immobilization with or without a cast is another conservative treatment option. Surgical treatment includes bar resection and, when the coalition compromises a large joint surface, arthrodesis.

Surgical treatment is recommended for symptomatic tarsal coalition, since it can more efficiently restore normal foot function[8] and avoids the unsatisfactory results of immobilization[3], in addition to preventing sequelae by eliminating the cause of the pathology[8,9]. However, some authors recommend conservative treatment for symptomatic coalitions, whether calcaneonavicular[10-13] or talocalcaneal[7-8,10-12,14-16].

The present study assessed the functional clinical results of resecting tarsal coalition in patients with symptomatic rigid flat foot, comparing American Orthopedic Foot and Ankle Society (AOFAS) scores before and after the procedure[17].

Study performed at the Orthopedics and Traumatology Departament PUC-Campinas, Campinas, SP, Brazil.

Correspondence: Marcelo Morelli Girondo. Rua Alberto Cerqueira Lima, 29, Apto. 171B, Taquaral - 13076-010, Campinas, SP, Brazil. **E-mail:** girondomarcelo@gmail.com.
Conflicts of interest: none. **Source of funding:** none. **Date received:** May 20, 2021. **Date accepted:** July 05, 2021. **Online:** August 31, 2021.

How to cite this article: Huyer RG, Cillo MSP, Castro Filho CDC, Bertelli HD, Girondo MM, Bortolatto Neto A. Clinical and functional outcomes of tarsal coalition resection to correct rigid flat foot. J Foot Ankle. 2021;15(2):115-9.

Methods

This retrospective clinical study, which was approved by the institutional ethics committee, included 7 patients (11 feet) who underwent tarsal coalition resection to treat rigid flat foot. The following data were collected from our institution's database and stored for further evaluation: age at the time of surgery, sex, type of coalition (determined at the time of surgery: fibrous, cartilaginous, or osseous), affected joint (talocalcaneal or calcaneonavicular), complementary diagnostic methods in addition to physical examination, and the symptoms presented. Valente's classification for flat foot (to grade 3) was used to indicate tarsal coalition resection. All patients had moderate deformities and showed no signs of joint degeneration or arthrosis.

The AOFAS scoring system was developed as a standardized method for clinical and functional assessment of different parts of the foot, enabling better pathological analysis and therapeutic planning. The ankle and hindfoot scale, which totals 100 points, consists of nine items in three categories: pain (40 points), functional aspects (50 points) and alignment (10 points). The AOFAS scale was applied during the preoperative period and again 6 months after tarsal coalition resection. The results were compared using statistical methods. All patients were followed for at least 12 months.

The patients and feet were descriptively analyzed by measures of the central position and dispersion (mean, standard deviation, and minimum, median, and maximum values) for continuous variables and frequency tables (absolute and relative) for categorical variables.

Generalized estimating equations were used to study AOFAS scores over time. The estimates were calculated using maximum likelihood models for control, without assuming independence between subjects or within-subject variability. The values were transformed into ranks due to their non-normal distribution.

A significance level of 5% was used for the statistical tests.

Results

The patients were classified according to age, sex, type of coalition, affected joint, laterality, and complementary diagnostic methods.

The patients' mean age was 10.7 years and 71.43% were male. The most frequent complementary diagnostic method was radiography (57.14% of the cases), followed by an association of radiography and computed tomography (42.86%).

Of the orthopedic lesions 54.55% were in the right lower limb and 45.45% were in the left lower limb. Osseous coalition was the most frequent type (81.82% of the patients), followed by cartilaginous (18.18%); none of the coalitions were fibrous. The calcaneonavicular and talocalcaneal joints were affected in 54.55% and 45.45% of the cases, respectively (Table 1).

The mean pre- and postoperative AOFAS scores were 32.7 and 70.2, respectively, which was a significant increase. We consider this the main effect of the change between the two assessments (Table 2 and Figure 1).

The relationship between sex, age, and affected joint in the pre- and postoperative periods was also analyzed. Among female patients, the mean pre- and postoperative AOFAS scores were 23.0 and 78.5 points, respectively, while for males, they were 34.9 and 68.3 points, respectively. There was no significant difference in pre/post score change between the sexes (Table 3 and Figure 2).

Table 1. General descriptive analysis

Age					
n	Mean	SD	Min.	Median	Max.
7	10.7	2.4	7.0	11.0	14.0

Sex			
		Cumulative	
Sex	Frequency	Percent	Frequency
Female	2	28.57	2
Male	5	71.43	7

Type of coalition (fibrous, cartilaginous, osseous)			
		Cumulative	
Coalition	Frequency	Percent	Frequency
Cartilaginous	2	18.18	2
Osseous	9	81.82	11

Affected joint (TC, CN)			
		Cumulative	
JOINT	Frequency	Percent	Frequency
CN	6	54.55	6
TC	5	45.45	11

Complementary diagnostic method			
		Cumulative	
Diagnostic method	Frequency	Percent	Frequency
Radiography	4	57.14	4
Radiography + CT	3	42.86	7

Laterality			
		Cumulative	
Laterality	Frequency	Percent	Frequency
Right foot	6	54.55	6
Left foot	5	45.45	11

CN: calcaneonavicular; CT: computed tomography; TC: talocalcaneal.

Table 2. Descriptive analysis and comparison of AOFAS scores between assessments

Variable	N	Mean	SD	Min.	Median	Max.
AOFAS_PRE	11	32.7	19.1	10.0	38.0	55.0
AOFAS_POST	11	70.2	13.2	51.0	77.0	83.0

P=**0.0259** (GEE); significant increase in postoperative score
The operated side was considered as a control factor (repeated measure with missing data) and the main effect was the pre/post score change.
GEE: generalized estimating equation; SD: standard deviation.

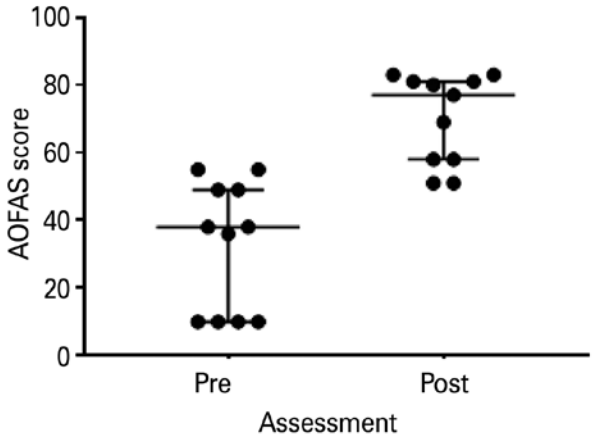


Figure 1. AOFAS score dispersion in each assessment. The bars represent the median and the interquartile interval. There was significant difference between the assessments in general (p=0.0259 EEG).

Table 3. Descriptive analysis and comparison of AOFAS scores between the sexes

Sex	Variable	N	Mean	SD	Min.	Median	Max.
Fem.	AOFAS_PRE	2	23.0	18.4	10.0	23.0	36.0
	AOFAS_POST	2	78.5		77.0	78.5	80.0
Male	AOFAS_PRE	9	34.9	19.6	10.0	38.0	55.0
	AOFAS_POST	9	68.3		51.0	69.0	83.0

P=0.3863 (GEE). There was no significant difference in pre/post score change between the sexes.
The operated side was considered as a control factor (repeated measure with missing data), and pre/post change and sex were considered effects.
GEE: generalized estimating equation.

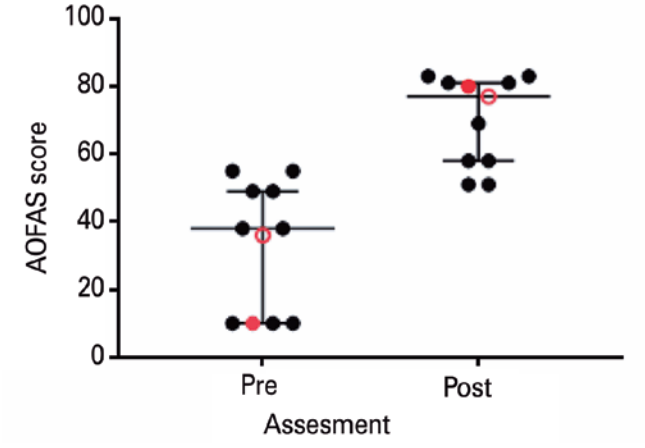


Figure 2. Dispersion of the AOFAS score in each assessment. The bars represent the medians and interquartile intervals in general. The red marks represent women. There was no significant difference between genders in each assessment (p=0.3863 EEG).

The mean pre- and postoperative AOFAS scores of patients diagnosed with a talocalcaneal tarsal coalition were 36.8 and 68.8, respectively. In patients whose calcaneonavicular joint was affected, the mean pre- and postoperative scores were 29.3 and 71.3, respectively. There was no significant difference in pre/post score change between the affected joints (Table 4 and Figure 3). There was also no significant relationship between age and pre/post score change (Table 5).

Table 4. Descriptive analysis and comparison of the AOFAS scores between the affected joints

Joint	Variable	N	Mean	SD	Min.	Median	Max.
CN	AOFAS_PRE	6	29.3	22.3	10.0	23.0	55.0
	AOFAS_POST	6	71.3	11.5	58.0	73.0	83.0
TC	AOFAS_PRE	5	36.8	16.0	10.0	38.0	49.0
	AOFAS_POST	5	68.8	16.3	51.0	80.0	81.0

P=0.6537 (GEE). There was no significant difference in pre/post score change between the affected joints.
The operated side was considered as a control factor (repeated measure with missing data), and pre/post change and joint type were considered effects.
CN: calcaneonavicular; GEE generalized estimating equation; TC: talocalcaneal.

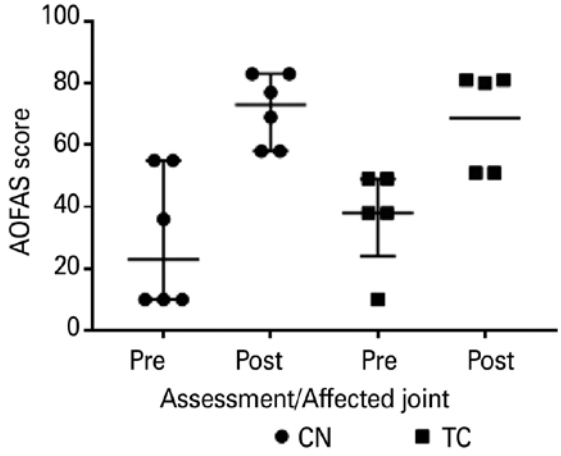


Figure 3. Dispersion of AOFAS score in each time and affected joint. The bars represent the median and interquartile intervals in each of the affected joints. There was no significant difference between de assesments for each of the affected joints. (p=0.6537 EEG).

Table 5. GEE results on the relationship between age and AOFAS score

P=0.0592 (GEE). There was no significant relationship between pre/post score change and age.

The operated side was considered as a control factor (repeated measure with missing data), and pre/post change and age were considered effects.

Discussion

The main goal of tarsal coalition treatment is symptom relief and a biomechanically stable foot that does not cause functional impairment. According to the literature, as well as our results, when patients are managed according to a treatment flowchart, good results almost always occur.

In a recent study on conservative treatment for tarsal coalitions, Shirley et al.[18] found that it can have a positive effect on pain, as well as the prevention or postponement of surgical treatment for symptomatic cases. Although the results of conservative treatment cannot be compared with those of our study, from a treatment point of view, conservative treatment should not be ruled out and may produce good results. In the patients in our study, surgery was indicated because conservative treatment failed. Therefore, a good relationship with the patient's parents and making sure they understand the treatment process is an important part of the approach at our clinic. As pain complaints increase in frequency and intensity, the treatment strategy should be changed to bar resection.

Scranton[19] re-evaluated 14 patients (23 tarsal coalitions) who had been treated conservatively after a mean of 3.9 years (2.2 to 9.5 years) of treatment. Five feet in 3 patients were asymptomatic after plaster cast immobilization, 4 feet underwent triple arthrodesis, and 14 feet underwent coalition resection after immobilization failed to resolve the symptoms. As in our study, non-response to conservative treatment was an indication for resection. In addition, the author considered a coalition smaller than half of the area of the affected joint and no arthrosis in the affected joint (mainly talocalcaneal coalition) as indications for surgery. Considering all forms of treatment, the results were good in 13 feet and satisfactory in the other 10. For the present study, we chose bar resection for all patients, and the surgical results are based on an early appropriate diagnosis, considering patient age and light clinical deformity (hindfoot valgus and forefoot abduction). In coalition cases involving severe deformities of the forefoot and hindfoot, calcaneal osteotomies are a more common treatment. Our group views isolated subtalar arthrodesis and double or triple joint remodeling as exceptional and salvage surgical treatments.

Also using bar resection, Kumar et al.[14] found excellent results in 8 feet, good results in 8 feet, and poor results in 1 foot (due to recurrent tarsal coalition). The types of coalition identified in the preoperative exams were confirmed during surgery, and the type of coalition did not influence the surgical outcome. These results demonstrate the effectiveness of tarsal coalition resection, especially after conservative treatment fails.

Gonzalez et al.[15] obtained excellent or good results in 77% of patients they treated with bar resection. In 3 of the patients who reported unsatisfactory results during follow-up, symptom improvement occurred by the end of follow-up and their final results was considered good. The best results were observed in patients who had a cartilage coalition and were under 16 years of age at the time of surgery. In our study, osseous coalition was the most frequent type (81.82% of patients), followed by cartilaginous (18.18%); there were no fibrous coalitions. There were no significant differences between coalition types in AOFAS score improvement. As in the literature, the most affected joint in our study was the calcaneonavicular (54.55% of the cases), followed by the talocalcaneal (45.45%).

Takakura et al.[20] compared surgical and conservative treatment in 29 patients (36 feet) whose tarsal coalition was diagnosed using computed tomography as a complementary method. A total of 33 tarsal coalition resections and 3 arthrodeses were performed. The follow-up time averaged 5.3 years (2.25 to 11.2 years). The resection results were excellent in 24 feet and good in 7, with 2 treatment failures. The arthrodesis results were good in all 3 feet.

In 2009 and 2016, Hamel[21,22] evaluated 24 resections of talocalcaneal coalitions in 22 patients. After 21.2 months of follow-up, complete symptom remission occurred in 17 patients. Five others still had pain, although it had improved, and 2 of these were lost to follow-up.

In our study, patients' mean age was 10.7 years and 71.43% were male. Our mean follow-up time was 2.44 years (1.33-3.58). The most frequent preoperative complementary diagnostic method was isolated radiography (57.14% of the cases), followed by an association of radiography and computed tomography (42.86%).

Our small sample size can be considered a major limiting factor.

Due to the mean increase in AOFAS score between the pre- and postoperative periods, we can conclude that the results were good. The significant increase in postoperative scores must be considered an effect of the surgery.

Conclusion

As in the other cited studies, we found that bar resection should be the surgical procedure of choice in rigid flat feet without severe hindfoot or forefoot deformities that are refractory to conservative treatment.

Authors' contributions: Each author contributed individually and significantly to the development of this article: RGH *(https://orcid.org/0000-0003-3951-8408) Conceived and planned the activities that led to the study, bibliographic review, participated in the review process and approved the final version; MSPC *(https://orcid.org/0000-0002-0758-2547) Conceived and planned the activities that led to the study, bibliographic review, participated in the review process and approved the final version; CDCCF *(https://orcid.org/0000-0003-3522-1076) Performed the surgeries, data collection and approved the final version; HDB *(https://orcid.org/0000-0002-1901-3309) Performed the surgeries, data collection and approved the final version; MMG *(https://orcid.org/0000-0001-7187-4774) Interpreted the results of the study, participated in the review process, data collection and formatting of the article; ABN *(https://orcid.org/0000-0002-2442-0427) Interpreted the results of the study, participated in the review process, data collection and formatting of the article. All authors read and approved the final manuscript. *ORCID (Open Researcher and Contributor ID).

References

1. Stormont DM, Peterson HA. The relative incidence of tarsal coalition. Clin Orthop Relat Res. 1983;(181):28-36.
2. Gantsoudes GD, Roocroft JH, Mubarak SJ. Treatment of talocalcaneal coalitions. J Pediatr Orthop 2012;32(3):301-7.
3. Mubarak SJ, Patel PN, Upasani VV, Moor MA, Wenger DR. Calcaneonavicular coalition: treatment by excision and fat graft. J Pediatr Orthop. 2009;29(5):418-26.
4. Snyder RB, Lipscomb AB, Johnston RK. The relationship of tarsal coalitions to ankle sprains in athletes. Am J Sports Med. 1981; 9(5):313-7.
5. Downey MS. Tarsal coalition. In: Banks AS, Downey MS, Martin DE and Miller SJ, editors. McGlamry's comprehensive textbook of foot and ankle surgery. 3rd ed. Philadelphia, PA: Lippincott Williams & Wilkins, 2001. p. 993–1031.
6. Blakemore LC, Cooperman DR, Thompson GH. The rigid flatfoot. Tarsal coalitions. Clin Podiatr Med Surg. 2000;17(3):531-55.
7. Mosca VS. Subtalar coalition in pediatrics. Foot Ankle Clin. 2015; 20(2):265-81.
8. Jayakumar S, Cowell HR. Rigid flatfoot. Clin Orthop Relat Res. 1977;(122):77-84.
9. Murphy JS, Mubarak SJ. Talocalcanealal Coalitions. Foot Ankle Clin. 2015;20(4):681-91.
10. Zaw H, Calder JD. Tarsal coalitions. Foot Ankle Clin. 2010;15(2):349-64.
11. Lemley F, Berlet G, Hill K, Philbin T, Isaac B, Lee T. Current concepts review: Tarsal coalition. Foot Ankle Int. 2006;27(12):1163-9.
12. Vincent KA. Tarsal coalition and painful flatfoot. J Am Acad Orthop Surg. 1998;6(5):274-81.
13. Swensen SJ, Otsuka NY. Tarsal Coalitions--Calcaneonavicular Coalitions. Foot Ankle Clin. 2015;20(4):669-79.
14. Kumar SJ, Guille JT, Lee MS, Couto JC. Osseous and non-osseous coalition of the middle facet of the talocalcaneal joint. J Bone Joint Surg Am. 1992;74(4):529-35.
15. Gonzalez P, Kumar SJ. Calcaneonavicular coalition treated by resection and interposition of the extensor digitorum brevis muscle. J Bone Joint Surg Am. 1990;72(1):71-7.
16. Cowell HR. Talocalcanealal coalition and new causes of peroneal spastic flatfoot. Clin Orthop Relat Res. 1972;85:16-22.
17. Rodrigues RC, Masiero D, Mizusaki JM, Imoto AM, Peccin MS, Cohen M, et al. Translation, cultural adaptation and validity of the "American Orthopaedic Foot and Ankle Society (AOFAS) Ankle-Hindfoot Scale. Acta Ortop Bras. 2008;16(2):107-11.
18. Shirley E, Gheorghe R, Neal KM. Results of Nonoperative Treatment for Symptomatic Tarsal Coalitions. Cureus. 2018;10(7):e2944.
19. Scranton PE Jr. Treatment of symptomatic talocalcaneal coalition. J Bone Joint Surg Am. 1987;69(4):533-9.
20. Takakura Y, Sugimoto K, Tanaka Y, Tamai S. Symptomatic talocalcaneal coalition. Its clinical significance and treatment. Clin Orthop Relat Res. 1991;(269):249-56.
21. Hamel J. [Resection of talocalcaneal coalition in children and adolescents without and with osteotomy of the calcaneus]. Oper Orthop Traumatol. 2009;21(2):180-92.
22. Hamel J, Nell M, Rist C. [Surgical treatment of talocalcaneal coalition: Experience with 80 cases of pediatric or adolescent patients]. Orthopade. 2016;45(12):1058-65.

DOI: https://doi.org/10.30795/jfootankle.2021.v15.1549

Original Article

Epidemiological study of ankle fractures

Jorge Mitsuo Mizusaki[1], Sérgio Damião Santos Prata[1], Marco Antonio Giglioni Rizzo[1], Luiz Augusto Sampaio Gonzaga Filho[1], Leandro Pessoa Carneiro[1]

1. Hospital Santa Marcelina, São Paulo, SP, Brazil.

Abstract

Objective: To evaluate the epidemiological characteristics of patients with fractures in the ankle region.

Methods: This prospective, observational, descriptive, and epidemiological study included ankle fractures treated at our service from March 1, 2017 to March 1, 2018. Data were obtained from 150 patients through a detailed questionnaire.

Results: The sample, which included 61.33% men, aged mainly between 20 to 30 years; 46.68% were of mixed race, and 41.33% had only completed elementary school. A total of 33.66% of the ankle fractures occurred in the afternoon. According to the Weber classification system, 46.66% were type B fractures.

Conclusion: Ankle fractures were more common in men of working age, and were mostly closed fractures in the right lower limb.

Level of Evidence IV; Prognostic Studies; Case Series.

Keywords: Ankle fractures/epidemiology; Ankle injuries/epidemiology; Fractures, bone/epidemiology; Surveys and questionnaires.

Introduction

Ten percent of all fractures in the human body occur in the ankle, which ranks second behind the hip in lower limb fractures. These values are similar in trauma referral hospitals in a number of states in Brazil: one study from Bahia found that 8.97% of all fractures from motorcycle accidents were in the ankle and/or foot, representing 27.05% of trauma-related orthopedic surgeries[1]. The peak incidence of ankle fractures is in younger men and older women. Characteristically, these are low-energy injuries, mostly caused by simple falls or sports accidents[2-4].

A classification system developed by Danis and modified by Weber describes the injury based on the location of the fracture in the lateral malleolus. Fractures can be classified as type A, B or C (a fracture below, at the same level as, or above the syndesmosis, respectively). This system remains popular and has shown substantial inter- and intraobserver reliability[5]. Lindsjö[6] commented that "even an exhausted doctor, on an emergency call at four o'clock in the morning, should be able to apply [this system], without making too many mistakes". An alternative classification system based on the mechanism of trauma was proposed by Ashurst and Bromer in 1922 and expanded by Lauge-Hansen in 1950 after cadaver studies[7,8].

Traditionally, these fractures have been treated with plaster casts. However, when to use surgical or conservative treatment has been widely discussed in recent decades[9,10]. Several studies[11-14] have found unsatisfactory results in 17 to 24% of cases, regardless of the follow-up time, even in Weber type B fractures, which have a good prognosis[15-17]. Other studies have found incomplete recovery up to 2 years after surgery[14-16]. Better quality materials and professional improvement has encouraged surgical treatment for these fractures, especially the more complex ones. However, provided that it is correctly indicated, non-surgical treatment for Weber type B fractures is still viable.

The lack of Brazilian studies on ankle fracture epidemiology encouraged the development of a study with a more detailed analysis.

Study performed at the Hospital Santa Marcelina, São Paulo, SP, Brazil.

Correspondence: Sérgio Damião Santos Prata. Rua Santa Marcelina, 177, Vila Carmosina - 08270-070, São Paulo, SP, Brazil. **E-mail:** sergioprata@yahoo.com.
Conflicts of Interest: none. **Source of funding:** none. **Date received:** June 28, 2021. **Date accepted:** July 11, 2021. **Online:** August 31, 2021.

How to cite this article: Mizusaki JM, Prata SDS, Rizzo MAG, Gonzaga Filho LAS, Carneiro LP. Epidemiological study of ankle fractures. J Foot Ankle. 2021;15(2):120-3.

Methods

This study was registered in Plataforma Brasil and was approved by the institutional ethics committee. This prospective, observational, descriptive, and epidemiological study included ankle fractures treated at our service from March 2017 to March 2018. A total of 150 patients were evaluated.

The data were obtained through a detailed questionnaire applied at the time of hospital discharge; each patient was interviewed in person. The analyzed variables included age, profession, sex, ethnicity, marital status, education, means of emergency transportation, time and day of the week of the trauma, the mechanism of trauma, fracture type and location, affected limb, Weber and Lauge-Hansen classification, treatment type, associated injuries, prescribed medications, and hospital length of stay.

Results

Of the 150 evaluated fractures, 50 (33.66%) occurred in the afternoon (Table 1). A total of 70 patients (46.68%) were of mixed race, 60 (40%) had completed high school, and 80 (53.33%) were married.

The sample was 61.34% men (92 patients), average age 20 to 30 years old.

The most common mechanism of injury (Table 2) was a fall from standing height (sports, walking, getting out of a car, dancing), which occurred in 51.42% of the patients, half of whom were women, whose mean age was 46.22 years old. The second most common mechanism was falling down stairs, which occurred in 20% of the patients, 85.71% of whom were women, whose mean age was 48.35 years. The third most common mechanism was being run over by a vehicle, which occurred in 10% of the patients, all of whom were men, whose mean age was 41.42 years. This was followed by car accidents, which occurred in 7.15% of the patients, all of whom were men, whose mean age of 30.8 years. The next most common mechanism was direct trauma to the fibula, which occurred in 4.28% of the patients, all of whom were men, whose mean age was 32.33 years. Falls from heights occurred in 7.15% of the patients, all of whom were men, whose mean age was 43.8 years. Most of the patients (102, 68%) arrived at the emergency department by their own means, and the highest incidence of trauma occurred on Sunday (32 patients, 21.34%).

The fracture occurred on right side in 83 patients (55.34%). Lateral malleolus fractures occurred in 67 patients (44.67%) (Table 3). The fractures were closed in 130 patients (86.66%) and open in 20 patients (13.34%). A concomitant skin lesion occurred in 42 patients (28%), and no medications were prescribed for 116 patients (77.33%).

The most frequent fracture type was Weber type B (Table 4), occurring in 70 patients (46.66%). Surgery was performed in 86 patients (57.33%), with the most common technique being internal fixation with plates and screws. A total of 43 patients (28.67%) were hospitalized, with a length of stay ranging from 4 to 7 days. All fractures healed without delayed consolidation or pseudarthrosis.

Table 1. Fractures according to the time of day they occurred

Time of the Trauma	Patients	%
Morning (6:00 am - 12:00 pm)	38	25.33%
Afternoon (12:00 pm - 6:00 pm)	50	33%
Evening (6:00 pm - 12:00 am)	48	32.00%
Night (12:00 am - 6:00 am)	14	9.34%

Table 2. Fractures according to treatment type

Treatment Type	Patients	%
Conservative	38	25.34%
External Fixation	10	6.67%
Surgical with Screws	16	10.66%
Surgical with Screws + Plates	86	57.33%

Table 3. Fracture location

Trauma Location	Patients	%
Lateral Malleolus	67	44.67%
Medial Malleolus	15	10%
Bimalleolar	58	38.66%
Trimalleolar	10	6.67%

Table 4. Fractures according to Weber classification

Weber Type	Patients	%
A	48	32%
B	70	46.66%
C	32	21.34%

Discussion

The incidence of ankle fractures, their social impact, and the lack of Brazilian epidemiological studies motivated this study. The study objectives were completed without data collection problems or errors in questionnaire application.

A total of 150 patients were treated between March 1, 2017 and March 1, 2018. All patients provided written informed consent.

The incidence of ankle fractures in men was 61.34% (92 patients) and 38.66% in women (58 patients), including a total of 86.66% closed fractures and 13.34% open fractures. The literature diverges somewhat from these results: White and Bugler[18] reported that open fractures are rare, accounting for only 2% of all ankle fractures. This disagreement can be explained by the fact that the hospital's region has a significant number of motorcycle accidents, which increases the number of serious fractures and, therefore, increases the rate of bone exposure.

In addition, a study by the Hospital do Servidor Público Municipal de São Paulo found a higher incidence of ankle fractures in older women, hypothesizing that postmenopausal osteoporosis was a an important associated factor[19].

The mean age in our sample was 45 years at the time of the injury, which is higher than that of the mean age of individuals who suffer isolated ankle sprains[20]. The distribution of ankle fractures was bimodal, with peak incidences in younger men and older women – an interval of 50 years between peaks[18]. The most affected general age group in our study was young adults between 20 and 30 years old, with a mean age of 28 years in men and 41 years in women, which differs from the literature. However, because the hospital's region is predominantly low income, motorcycles (and thus motorcycle accidents) are more common since it is a less expensive means of transportation.

Characteristically, ankle fractures are low-energy injuries, mostly caused by simple falls or sports accidents. Even exposed ankle fractures, which have a higher incidence in older women, are generally caused by simple falls rather than high-impact trauma[18]. In our sample, falls from standing height (sports, walking, getting out of the car, dancing) were the most common type (51.42%). Another finding was that more fractures occurred in the afternoon (33.3%) and on Sunday (21.34%), which follows, since it is a day of rest and leisure, with many people participating in sports.

A significant number of patients (22.67%) reported using alcohol and/or illicit drugs prior to the trauma, which was similar the number reported in other studies (20%)[20]. The fact that the highest incidence of fractures in our study was on Saturday and Sunday may also be related to the substance use. However, toxicological tests were not performed to determine the extent of this relationship.

There was a slight predominance of mixed-race patients (46.68%), which is directly related to the demographics of the hospital's region. Most patients were also married (53.33%) and their education level was consistent with their age group. The most common education level was high school. A total of 6.67% patients were illiterate, which was slightly higher than the São Paulo state average (4.3%)[19].

Since most fractures are due to low-energy trauma and do not have major clinical repercussions, the majority of our patients arrived at the emergency room by their own means (68%). However, all patients with open fractures arrived at the hospital by ambulance, demonstrating that emergency services were used for more serious victims, which confirms their importance and the need for efficiency.

The most frequent Weber classification was type B (46.66%), followed by type A (32%) and type C (21.34%), which agrees with the literature (38% type A, 52% type B, and 10% type C)[19] and demonstrates substantial interobserver reliability of this system.

One divergence with the literature was our Lauge-Hansen classification results. The proportions of supination-adduction, supination-external rotation, and pronation fractures in our sample were 32%, 28%, and 40% respectively. However, the most common injury pattern in the literature is supination-external rotation (60%), followed by supination-adduction (20%), and pronation (20%)[19].

Fractures are also classified as unimalleolar, bimalleolar, or trimalleolar based on the combined fractures of the lateral, medial, and posterior tibial malleolus. As the number of fractures increases, the prognosis worsens. The fractures in our sample were: lateral malleolus (44.67%), bimalleolar (38.66%), medial malleolus (10%), and trimalleolar (6.67%), which corroborates the literature in that most fractures occur in the lateral malleolus.

The vast literature on ankle fractures is replete with small heterogeneous case series reporting the outcomes of a confusing variety of treatment strategies and using disparate outcome assessments. Satisfactory results can be obtained from different types of treatment, and the indiscriminate use of surgery does not necessarily improve results, in addition to the fact that it exposes patients to additional complications. In our study, 74.66% of the patients underwent surgery, and 86 underwent osteosynthesis surgery with plates and screws. Only 25.34% were treated conservatively, which shows our service's clear preference for surgical treatment.

The patients in our sample remained hospitalized for up to 7 days, which was consistent with the literature. Our sample size is indicative of the large number of these fractures in tertiary hospitals. Orthopedists should be aware of the epidemiology of these injuries. The brief period of data collection prevented analysis of other outcomes. New studies with longer follow-up and/or including other institutions, could add new conclusions about other aspects of this type of trauma.

Conclusion

The ankle fractures in our sample occurred predominantly in patients aged between 20 and 30 years. Other relevant epidemiological factors included demographic variables, such as mixed race, being married, and having a high school education level, as well as injury characteristics, such as fractures on the right side and injury occurrence in the afternoon and on SundaysFalling from standing height was the most common trauma mechanism, with open fractures occurring in 28% of the cases, being the most common associated injury. Weber type B fractures were the most frequent type, and internal fixation with plates and screws was the most frequent treatment.

This prospective epidemiological study identified the characteristics of patients with ankle fractures, the characteristics of the fractures, and the type of treatment, demonstrating the importance of in-depth studies on this topic to facilitate faster patient recovery and return to daily activities, since most are young and economically active.

In addition, the results also demonstrate that a more detailed epidemiological understanding can facilitate the development of preventive and educational measures to reduce the incidence of vehicle accidents, which figured prominently in our study population.

Authors' contributions: Each author contributed individually and significantly to the development of this article: SDSP *(https://orcid.org/0000-0001-5957-527X) conceived and planned the activities that led to the study, participated in the review process; JMM *(https://orcid.org/0000-0001-6039-4599) data collection, interpreted the results of the study, statistical analysis, wrote the article; MAGR *(https://orcid.org/0000-0002-7424-9074) performed the surgeries, survey of medical records, participated in the review process; LASGF *(https://orcid.org/0000-0002-5765-2304) wrote the article, bibliographic review, clinical examination, statistical analysis; LPC *(https://orcid.org/0000-0001-6106-0101) data collection, formatting of the article, participated in the review process. All authors read and approved the final manuscript. *ORCID (Open Researcher and Contributor ID).

References

1. Jambeiro JES, Cordeiro Neto AT, Moreira FD, Alcantara Júnior WS, Siquieroli RV. Epidemiological profile of surgical ankle and foot injuries caused by motorcycle accidents attended at a state emergency hospital in Bahia. Rev ABTPé. 2017;11(1):32-7.
2. Court-Brown CM, McBirnie J, Wilson G. Adult ankle fractures--an increasing problem? Acta Orthop Scand. 1998;69(1):43-7.
3. Daly PJ, Fitzgerald RH Jr, Melton LJ, Ilstrup DM. Epidemiology of ankle fractures in Rochester, Minnesota. Acta Orthop Scand. 1987; 58(5):539-44.
4. Jensen SL, Andresen BK, Mencke S, Nielsen PT. Epidemiology of ankle fractures. A prospective population-based study of 212 cases in Aalborg, Denmark. Acta Orthop Scand. 1998;69(1):48-50.
5. Malek IA, Machani B, Mevcha AM, Hyder NH. Inter-observer reliability and intra-observer reproducibility of the Weber classification of ankle fractures. J Bone Joint Surg Br. 2006;88(9):1204-6.
6. Lindsjö U. Classification of ankle fractures: the Lauge-Hansen or AO system? Clin Orthop Relat Res. 1985;(199):12-6.
7. Ashurst AP, Bromer RS. Classification and mechanism of fractures oh the leg bones involving the ankle: Based on a study of three hundred cases from the Episcopal Hospital. Arch Surg. 1922;4(1):51.
8. Lauge-Hansen N. Fractures of the ankle. II. Combined experimental-surgical and experimental-roentgenologic investigations. Arch Surg. 1950;60(5):957-85.
9. Bauer M, Bergström B, Hemborg A, Sandegård J. Malleolar fractures: nonoperative versus operative treatment. A controlled study. Clin Orthop Relat Res. 1985;(199):17-27.
10. Rowley DI, Norris SH, Duckworth T. A prospective trial comparing operative and manipulative treatment of ankle fractures. J Bone Joint Surg Br. 1986;68(4):610-3.
11. Baptista MV, Costa AR, Jimenes Júnior N, Pegoraro M, Santos RD, Pimenta LSM. Surgical treatment of malleolar fractures in the ankle adults. Analysis of results in 70 patients. Rev Bras Ortop. 1996;31(9):745-58.
12. Santin RA, Araújo LH, Hungria Neto JS. Surgical treatment of Danis-Weber type b of maleolar fractures – analysis of results. Rev Bras Ortop. 2000;35(9):347-51.
13. Nilsson G, Nyberg P, Ekdahl C, Eneroth M. Performance after surgical treatment of patients with ankle fractures--14-month follow-up. Physiother Res Int. 2003;8(2):69-82.
14. Olerud C, Molander H. A scoring scale for symptom evaluation after ankle fracture. Arch Orthop Trauma Surg. 1984;103(3):190-4.
15. Bhandari M, Sprague S, Hanson B, Busse JW, Dawe DE, Moro JK, et al. Health-related quality of life following operative treatment of unstable ankle fractures: a prospective observational study. J Orthop Trauma. 2004;18(6):338-45.
16. Brown OL, Dirschl DR, Obremskey WT. Incidence of hardware-related pain and its effect on functional outcomes after open reduction and internal fixation of ankle fractures. J Orthop Trauma. 2001;15(4):271-4.
17. Mont MA, Sedlin ED, Weiner LS, Miller AR. Postoperative radiographs as predictors of clinical outcome in unstable ankle fractures. J Orthop Trauma. 1992;6(3):352-7.
18. White TO, Bugler KE. Ankle fractures. In: Court-Brown, Heckman JD, McQueen MM, Ricci WM, Tornetta III P, editors. Rockwood and Green's fractures. 8ª. ed. São Paulo: Manole; 2017. p. 2541-92.
19. Stéfani KC, Pereira Filho MV, Lago RR. Epidemiological study of foot and ankle fractures among Civil Servants in the State of São Paulo. Rev ABTPé. 2017;11(1):1-4.
20. Legay LF, Santos SA, Lovisi GM, Aguiar JS, Borges JC, Mesquita RM, et al. [Transport accidents involving motorcycles: epidemiological profile of victims in three Brazilian state capitals], 2007. Epidemiol Serv Saude. 2012;21(2):283-92.

DOI: https://doi.org/10.30795/jfootankle.2021.v15.1540

Original Article

Partial plantar fasciectomy for the treatment of plantar fibromatosis

Lucas Plens de Britto Costa[1], Lucas Furtado da Fonseca[1], André Vitor Kerber Cavalcanti Lemos[1], Vinicius Felipe Pereira[1], César de César Netto[2], Fernando Cepollina Raduan[2], Caio Augusto de Souza Nery[1], Nacime Salomão Barbachan Mansur[1,2]

1. Orthopedics and Traumatology Departament, Universidade Federal de São Paulo (UNIFESP), Paulista School of Medicine, São Paulo, SP, Brazil.
2. Department of Orthopaedics and Rehabilitation, University of Iowa, Iowa City, IA, USA.

Abstract

Objective: We describe a series of patients treated with resection of the affected band. We assessed functional outcome, recurrence rate, and surgical wound complications, comparing these data with the available literature.

Methods: This retrospective study (level of evidence IV) included 14 patients (17 feet) diagnosed with plantar fibromatosis in the medial portion of the fascia that was refractory to conservative treatment. All operations were performed between December 2016 and November 2018. All patients were assessed for symptom improvement and major and minor complications, in addition to recurrence during the study period.

Results: Our sample included 9 men and 5 women, whose mean age was 40.6 years (15-63). All of the patients underwent partial fasciectomy of the medial fascial band with margins of at least 2 cm. There was recurrence in 5 of the 17 feet (29%), but only two required further intervention. Wound dehiscence occurred in 3 patients (17%), and one of the cases was severe, requiring plastic surgery. Two feet showed signs of injury to the digital branch of the medial plantar nerve.

Conclusion: Partial plantar fasciectomy is an alternative treatment for plantar fibromatosis (Ledderhose's disease). Our results agree with the literature in terms of recurrence and postoperative complications. The moderate rate of complications must be taken into account when indicating this procedure.

Level of Evidence IV; Therapeutic Studies; Case Series.

Keywords: Fibromatosis, plantar; Treatment; Fasciectomy.

Introduction

Plantar fibromatosis, or Ledderhose's disease, is a locally aggressive, benign disorder characterized by fibroblast proliferation within the plantar aponeurosis and subsequent nodule formation[1]. Compared with Dupuytren's disease, an analog of plantar fibromatosis in the hands, little has been published since German physician Georg Ledderhose first reported clinical observations of 50 cases in 1897[2].

The disease is rare[3], mainly affecting middle aged men, although it has been reported in a nine-month-old infant. One-quarter of the cases are bilateral[4] and the disease is often associated with other forms of hyperproliferative fibromatosis, such as Dupuytren's disease (hands) and Peyronie's disease (penis)[5], as well as other pathologies, such as frozen shoulder, diabetes, and epilepsy[6]. Its cause is unknown and probably multifactorial, involving genetic predisposition[6-8]. The usual presentation is a slow-growing nodule 5 to 30mm in diameter in the medial plantar aponeurosis that does not affect the smooth muscle tissue or the skin and, thus, does not cause contractions[9]. Enlargement of the nodule can cause pain in the medial longitudinal arch, especially in the detachment phase[10,11]. Clinical management is the mainstay of treatment, including analgesia, corticoid infiltration, and physical therapy[11]. If conservative treatment fails, surgery, ie fasciectomy with or without margin and skin coverage (including a graft if necessary), can be considered[12]. Surgery with partial or complete resection of the fascia is recommended to reduce the risk of recurrence, as well as thorough wound closure to reduce the risk of dehiscence and painful scarring[11].

We report the surgical outcome of patients who underwent open partial fasciectomy after conservative treatment failed.

Study performed at the Orthopedics and Traumatology Departament, Universidade Federal de São Paulo (UNIFESP), Paulista School of Medicine, São Paulo, SP, Brazil.

Correspondence: Lucas Plens de Britto Costa. Rua Napoleão de Barros, 715, 1º andar, Vila Clementino, São Paulo, SP, Brazil. **CEP:** 04024-002. **E-mail:** plens.lucas@gmail.com. **Conflicts of Interest:** none. **Source of funding:** none. **Date received:** May 10, 2021. **Date accepted:** June 15, 2021. **Online:** August 31, 2021.

How to cite this article: Costa LPB, Fonseca LF, Lemos AVKC, Pereira VF, Cesar Netto C, Raduan FC, et al. Partial plantar fasciectomy for the treatment of plantar fibromatosis. J Foot Ankle. 2021;15(2):124-7.

Our hypothesis was that open partial fasciectomy would be associated with good functional outcome and low rates of recurrence and wound complications.

Methods

Study design

The study was approved by the institutional research ethics committee and is registered with Plataforma Brasil. This was a retrospective, single-center case series of patients who underwent surgery between December 2016 and November 2018.

Sample

The sample consisted of patients who underwent open partial fasciectomy after 6 months of conservative treatment (physical therapy, analgesia, and local corticosteroids) failed. Refusal to participate, treatment before or after the stipulated period, and insufficient data to assess the criteria were considered exclusion criteria.

Surgical technique

Open partial fasciectomy of the affected band was the selected surgical technique. The patient was positioned in horizontal dorsal decubitus, and a curvilinear incision was made under the medial plantar arch, which was carefully dissected to avoid devascularizing the skin. The fascial plane was delineated and the minimum resection margin was 2cm. The fascia was excised from the adjacent tissue and adequate hemostasis and closure were performed without tension. Sterile dressing was applied for 48 h after surgery (Figure 1). Load-bearing on the operated limb was prohibited until the wound had completely healed; the stitches were removed within 14 days, provided there were no wound complications.

Outcomes

Patients were reassessed postoperatively in the first, second, and fourth weeks, as well as in the second, fourth, eighth, and twelfth month. Functional assessment was performed preoperatively and on the final follow-up date. Complications and recurrences were determined at each time point. We evaluated the functional results with the AOFAS Ankle-Hindfoot Evaluation Scale[13].

Mild dehiscence was defined as non-healing 4 weeks after the procedure without the need to provide local coverage, while severe dehiscence was defined as non-healing that required plastic surgery for local coverage. Infection was defined as a discharge of purulent matter from the wound at any time. Any recurrence of the lesion during the study period was included in the analysis[14].

Statistical analysis

Descriptive statistical analysis (frequency table) was used for non-quantitative variables, while quantitative variables were described as mean and standard deviation. Proportion tests (chi square and adjustments) were performed in Epi Info.

Figure 1. A) The patient is placed in supine position without a cushion. The curvilinear incision lateral to the nodule is demarcated. B) The incision is deepened until a good medial skin flap is formed and the fascia margins can be clearly identified. C and D) The fascia is excised distally to proximally, protecting the adjacent tissue. E) The remaining tissue is inspected, including the free margin of the diseased area and the neurovascular structures. F and G) After thorough hemostasis, the subcutaneous tissue is closed and, finally, the skin is closed with simple stitches. H-J) The dimensions of the excised tissue are determined and documented.

Results

Fourteen patients diagnosed with plantar fibromatosis in the medial portion of the fascia were included in the study. The sample consisted of 9 men and 5 women, whose mean age was 38.5 years (14-63 years; median 39.85). Since 3 patients had bilateral involvement, a total of 17 feet were treated and evaluated. The right and left foot of one female patient with bilateral involvement were operated on at 14 and 15 years of age, respectively. Apart from this patient, the sample included a 29-year-old man, four women over 39 years of age, and 8 other men over 40 years of age (Table 1).

Wound dehiscence occurred in 3 feet (17%). Although 2 of the cases were mild and healed adequately after a series of local dressings, the other was severe, requiring plastic surgery for local coverage (Table 2).

There was recurrence in 5 of the 17 feet (29%) during the study period. However, only two (11.76%) required surgical re-intervention.

Table 1. Demographic data of patients with plantar fibromatosis

Factor	Male	Female	Mean Age (Min - Max)	Laterality (L - R - B)
Patients = 14	9	5	40.6 (15-63)	11 - 3 - 3

Mean age in years; L: left; R: right; B bilateral.

Table 2. Wound complication rate after surgery

Factor	Wound healed	Wound dehiscence	Signs of superficial infection	Purulent secretion	Signs of local abscess
Feet with PF (n=14)	14 (83%)	3 (17%)	0	0	0

PF: plantar fibromatosis.

Due to the wide margin of excision in one patient, a surgical procedure for local coverage was performed in association with the plastic surgery team. Two feet showed preoperative signs of involvement and damage to the medial plantar nerve. Intraoperatively, it was determined that plantar fibromatosis was involved a branch of this nerve and it was decided to resect it. The patients' mean AOFAS score improved from 48 (37-73) to 84 (68-92) over the study period (Table 3).

Discussion

This study evaluated the clinical and functional results of partial fasciectomy in patients with Ledderhose's disease and found good postoperative results. AOFAS Ankle-Hindfoot Evaluation Scale scores increased, and the recurrence rate was consistent with the literature. There was a moderate rate of postoperative complications. There were three cases of postoperative wound dehiscence that did not require antibiotic therapy and/or new surgical procedures, in addition to five cases of recurrence, two of which required a new procedure.

After surgical treatment and thorough wound closure, the recurrence rate was 29%, which is consistent with the scant literature (0-50%)[15] and superior to local excision of the nodule, which has a recurrence rate of 57-100%[16].

In our sample there were 3 cases (17%) of wound dehiscence, including 1 severe case (ie, requiring a new procedure). However, data on surgical wound complications and healing in plantar fibromatosis are scarce. Sammarco and Mangone[15] reported 11 cases of dehiscence in 23 operated feet, while Kadir et al.[17] reported 2 cases of pain and 1 case of scar hypersensitivity in 19 operated feet. Moreno et al.[18] reported 18 cases without pain or recurrence in 19 operated feet, with only one case of mild dehiscence.

Table 3. Recurrence rate, pre- and postoperative functional assessment and rate of medial plantar nerve injury

Factor	Recurrence	Preoperative AOFAS score mean (min. - max.)	Postoperative AOFAS score mean (min. - max.)	Medial plantar nerve injury
Feet with PF (17)	5 (29%)	48 (37-73)	84 (68-92)	2 (11%)

PF: plantar fibromatosis.

As the mean functional outcome, the mean AOFAS score for the midfoot increased from 48 (37-73) to 84 (68-92) points. However, only one other study has included this functional outcome[15], in which the AOFAS midfoot score increased from 70 (61-77) to 77 (64-88) points.

One positive point of this study was the varied sample, which included patients of different ages. The researcher who performed the retrospective data collection and analysis did not participate in the consultations, surgeries, satisfaction assessments, or the pre- or postoperative physical examinations. The follow-up period was substantial and there was a considerable sample, considering the disease's rarity and the paucity of articles on surgical results.

Because the surgeries were not performed by the same surgeon, individual skill can be a confounding factor in the results, especially in terms of complications. Despite being a retrospective study with a sample of 17 surgeries, this study has added to the available literature on the treatment of this disease. Moreover, there was no control group or prior sample size/strength calculation. Finally, our method for analyzing surgical wound dehiscence has not been validated.

Conclusion

Partial plantar fasciectomy is a reasonable alternative treatment for Ledderhose's disease. The results of our study agree with the literature in terms of epidemiology, recurrence, and postoperative complications. The considerable recurrence and reoperation rates must be taken into account when indicating this procedure.

Authors' contributions: Each author contributed individually and significantly to the development of this article: LPBC *(https://orcid.org/0000-0002-4955-6822) Data collection, statistical analysis, bibliographic review, formatting of the article, survey of the medical records, statistical analysis, participated in the review process; LFF *(https://orcid.org/0000-0001-6497-833X) Performed the surgeries, data collection, bibliographic review; AVKCL *(https://orcid.org/0000-0001-8974-5815) Performed the surgeries, data collection, bibliographic review; VFP *(https://orcid.org/0000-0002-1005-6089) Performed the surgeries, data collection, bibliographic review; CCN *(https://orcid.org/0000-0001-6037-0685) Data collection, bibliographic review approved the final version; FCR *(https://orcid.org/0000-0002-2922-1929) Performed the surgeries, data collection, bibliographic review clinical examination, approved the final version; CASN *(https://orcid.org/0000-0002-9286-1750) Data collection, bibliographic review approved the final version, interpreted the results of the study; NSBM *(https://orcid.org/0000-0003-1067-727X) Data collection, bibliographic review approved the final version, interpreted the results of the study, conceived and planned the activities that led to the study. All authors read and approved the final manuscript. *ORCID (Open Researcher and Contributor ID).

References

1. Carroll P, Henshaw RM, Garwood C, Raspovic K, Kumar D. Plantar Fibromatosis: Pathophysiology, Surgical and Nonsurgical Therapies: An Evidence Based Review. Foot Ankle Spec. 2018;11(2):168-76.
2. Ledderhose, G. Sur pathologic der aponeurote des fusses und der hand. Arch Klin. Chir. 1897;55:694–12.
3. Ledderhose Disease [Internet]. Gaithersburg: National Institutes of Health Genetic and Rare Diseases Information; 2017 [cited 2021 May 8]. Available from: https://rarediseases.info.nih.gov/diseases/6873/ledderhose-disease
4. Neagu TP, Sinescu RD, Enache V, Achim SC, Țigliș M, Mirea LE. Metastatic high-grade myxofibrosarcoma: review of a clinical case. Rom J Morphol Embryol. 2017;58(2):603-9.
5. Mohede DCJ, Riesmeijer SA, de Jong IJ, Werker PMN, van Driel MF. Prevalence of Peyronie and Ledderhose Diseases in a Series of 730 Patients with Dupuytren Disease. Plast Reconstr Surg. 2020;145(4):978-84.
6. Akdag O, Yildiran G, Karamese M, Tosun Z. Dupuytren-Like Contracture of the Foot: Ledderhose Disease. Surg J (N Y). 2016; 2(3):e102-e4.
7. Kim SK, Ioannidis JPA, Ahmed MA, Avins AL, Kleimeyer JP, Fredericson M, et al. Two Genetic Variants Associated with Plantar Fascial Disorders. Int J Sports Med. 2018;39(4):314-21.
8. Grenfell S, Borg M. Radiotherapy in fascial fibromatosis: a case series, literature review and considerations for treatment of early-stage disease. J Med Imaging Radiat Oncol. 2014;58(5):641-7.
9. Young JR, Sternbach S, Willinger M, Hutchinson ID, Rosenbaum AJ. The etiology, evaluation, and management of plantar fibromatosis. Orthop Res Rev. 2019;11:1-7.
10. Yasui Y, Takao M, Miyamoto W, Matsushita T. Plantar fibromatosis with flexion contracture and valgus deformity of the great toe. J Orthop Sci. 2016;21(3):395-8.
11. Veith NT, Tschernig T, Histing T, Madry H. Plantar fibromatosis-topical review. Foot Ankle Int. 2013;34(12):1742-6.
12. Yin MC, Ye J, Yao M, Cui XJ, Xia Y, Shen QX, et al. Is extracorporeal shock wave therapy clinical efficacy for relief of chronic, recalcitrant plantar fasciitis? A systematic review and meta-analysis of randomized placebo or active-treatment controlled trials. Arch Phys Med Rehabil. 2014;95(8):1585-93.
13. Rodrigues RC, Masiero D, Mizusaki JM, Imoto AM, Peccin MS, Cohen M, et al. Translation, cultural adaptation and validity of the "American Orthopaedic Foot and Ankle Society (AOFAS) Ankle-Hindfoot Scale. Acta Ortop Bras. 2008;16(2):107-111.
14. Mansur NSB, Lemos AVKC, Baumfeld DS, Baumfeld TS, Prado MP, Raduan FC, et al. Medial and lateral combined ligament arthroscopic repair for multidirectional ankle instability. Foot Ankle Orthop. 2021;6(1):1-8.
15. Sammarco GJ, Mangone PG. Classification and treatment of plantar fibromatosis. Foot Ankle Int. 2000;21(7):563-9.
16. Knobloch K, Vogt PM. High-energy focussed extracorporeal shockwave therapy reduces pain in plantar fibromatosis (Ledderhose's disease). BMC Res Notes. 2012;5:542.
17. Kadir HKA, Chandrasekar CR. Partial fasciectomy is a useful treatment option for symptomatic plantar fibromatosis. Foot (Edinb). 2017;31:31-4.
18. Moreno MVMG, Henkes GC, Costa FA, Gouvêa RS, Schiper L. Surgery treatment of Ledderhose disease with the wide ressection technique of the plantar fascia. Rev ABTPé. 2007;1(1):39-43.

DOI: https://doi.org/10.30795/jfootankle.2021.v15.1531

Original Article

Functional assessment of foot and ankle tendinopathies treated with tendoscopy

Rodrigo Guimarães Huyer[1], Mário Sérgio Paulillo Cillo[1], Carlos Daniel Cândido Castro Filho[1], Hallan Douglas Bertelli[1], Renato Morelli Berg[1]

1. Orthopedics and Traumatology Departament PUC-Campinas, Campinas, SP, Brazil.

Abstract

Objective: To assess postoperative clinical functional outcomes, based on the American Orthopaedic Foot & Ankle Society (AOFAS) score, of tendoscopies performed in the treatment of foot and ankle pathologies.

Methods: Our comparative assessment used AOFAS scores obtained preoperatively and at early and late postoperative stages - 1 month and 6 to 12 months after surgery - of 14 patients with foot and ankle tendinopathies. These included peroneal tendon dislocation, peroneal tendonitis, and tearing of the peroneus longus or brevis, all treated with tendoscopy for peroneal reconstruction and tenorrhaphy. The AOFAS score was obtained by functional assessment during outpatient physical examination. We presented a descriptive analysis of cases, comparing scores over time through the Friedman test followed by Dunn's test. The relationship between score variations and sex was assessed using the Mann-Whitney test; their comparison with age used Spearman's linear correlation coefficient. Significance levels were 5%.

Results: The AOFAS score showed important improvements such as preoperative scores of 56 and 67 followed by postoperative scores of 100 both in the early and late stages, supporting the efficacy and persistence of this treatment strategy. The p-value obtained after statistical analysis was <0.0001.

Conclusion: We concluded that the treatment of foot and ankle comorbidities with tendoscopy, in addition to being less invasive, shows consistency and efficacy as demonstrated by the AOFAS score and functional assessment via postoperative physical examinations. AOFAS scores were increased and maintained at high levels in the postoperative period, demonstrating the efficacy of this procedure and the duration of treatment results.

Level of Evidence IV; Case Series; Therapeutic Studies - Investigation of Treatment Results.

Keywords: Tendinopathy; Ankle injuries; Foot injuries; Tendon injuries; Surgical procedures, operative.

Introduction

In the orthopaedic environment, the evolution of treatment of foot and ankle comorbidities has become increasingly evident. Professionals in this specialty frequently observe important improvements in prognosis when the proposed treatment consists in a less invasive and more efficient alternative[1-5]. In this study, tendoscopy was used as a treatment strategy for foot and ankle comorbidities such as peroneal tendon dislocation, tearing, or tendonitis to prove its efficacy. The idea of the study consists in strengthening, within the orthopaedic scenario of the foot and ankle specialty, less invasive approaches that provide good and long-lasting results. The objective of this research was to report, by assessing 14 patients, improvements in symptoms after tendoscopic treatment by using the American Orthopaedic Foot & Ankle Society (AOFAS) score - evaluating pain, functionality, stability, mobility, and alignment of the hindfoot - in the preoperative (PRE), early postoperative (ePO, 1 month), and late postoperative (lPO, 6–12 months) periods. The intention is to prove the efficacy of less invasive treatments aiming at substituting - when possible - more invasive treatments that

Study performed at the Orthopedics and Traumatology Departament PUC-Campinas, Campinas, SP, Brazil.

Correspondence: Renato Morelli Berg. Rua Presidente João Goulart, 532, Jardim Chapadão - 13070-060, Campinas, SP, Brazil. **E-mail:** rmorelliberg@gmail.com.
Conflicts of Interest: none. **Source of funding:** none. **Date received:** April 14, 2021. **Date accepted:** July 11, 2021. **Online:** August 31, 2021.

How to cite this article: Huyer RG, Cillo MSP, Castro Filho CDC, Bertelli HD, Berg RM. Functional assessment of foot and ankle tendinopathies treated with tendoscopy. J Foot Ankle. 2021;15(2):128-32.

show unfavorable progressions regarding wound healing, higher chances of infection, and longer recovery periods after surgery, which could provide the specialty with better prognoses and be of utmost importance for the evolution of treatment strategies and patient wellbeing.

Methods

This study was approved by the ethics committee of Hospital Pontifícia Universidade Católica (PUC) – Campinas and was performed via a case series analysis with a retrospective clinical design. The study aimed to assess 14 patients. Inclusion criteria considered male and female patients of all ages who were diagnosed with tendon pathologies surrounding the foot and ankle, with the possibility of being treated by tendoscopy. Exclusion criteria consisted of patients who denied participation in the study, who presented signs of active infection in a previous surgical site, who had lower limb deformities that could limit rehabilitation, after-effects of comorbidities unrelated to the tendon injuries observed in this study, or neurological alterations. After triage and inclusion of the participant, assessment was performed by applying the AOFAS score[6] in the outpatient clinic of the Department of Orthopaedics and Traumatology of Hospital PUC – Campinas, at preoperative and postoperative (early, 1 month; late, 6–12 months) periods. The assessment, made through the application of questionnaires and a clinical functional examination, took around 30 minutes and were divided into 3 stages: anamnesis, questionnaire application, and recording of the obtained result. The free and informed consent form presented, as the objective explained to the patients, the functional assessment of postoperative results based on the AOFAS scores of tendoscopies performed in the treatment of foot and ankle pathologies.

Our methodology consisted in the descriptive analysis, through position and dispersion measures such as median, minimum, and maximum values for continuous variables, and frequency tables (absolute and relative) for categorical variables. For comparing scores over time, we applied the Friedman test followed by Dunn's test for identifying differences. For assessing the relationship between score variations and sex, we used the Mann-Whitney test. For comparing them with age, we used Spearman's linear correlation coefficient. The significance level adopted for the statistical tests was 5%.

Statistical tests applied in this study were non-parametric due to the reduced sample size. The level of significance adopted for the tests was 5% and analyses were performed using the SAS System software for Windows[7].

Results

According to our statistical analyses, by correlating comorbidities and treatments (Table 1), we noted an important evolution in AOFAS scores obtained in the PRE, ePO, and lPO periods. AOFAS scores obtained in the ePO and lPO periods were significantly different from those in the PRE period, demonstrating an interesting efficacy of the tendoscopy treat-

Table 1. General descriptive analysis

Sex	Frequency	Percentage	Cumulative frequency
f	7	46.67	7
m	8	53.33	15
Comorbididy	**Frequency**	**Percentage**	**Cumulative frequency**
Gout	1	6.67	1
Peroneal dislocation	6	40.00	7
Pes cavus + peroneus brevis tear	1	6.67	8
Peroneus longus tear	1	6.67	9
Peroneal tendonitis	5	33.33	14
Peroneal tendonitis + retromalleolar peroneus brevis split tear	1	6.67	15
Procedure	**Frequency**	**Percentage**	**Cumulative frequency**
Tendoscopy + Peroneal reconstruction	6	40.00	6
Tendoscopy + Partial resection + Tenorrhaphy	1	6.67	7
Tendoscopy + Open tenodesis + Percutaneous calcaneal osteotomy	1	6.67	8
Posterior tibial tendoscopy and arthroscopy	1	6.67	9
Peroneal tendoscopy	5	33.33	14
Tendoscopy + Open tenodesis	1	6.67	15

Variable	n	Mean	SD	Minimum	Median	Maximum
AOFAS_PRE	15	60.6	6.7	47.0	62.0	69.0
AOFAS_PO1	15	93.7	4.8	86.0	92.0	100.0
AOFAS_6_12	13	96.7	5.7	85.0	100.0	100.0

ment proposed by this study. Moreover, no significant difference was observed between postoperative scores (p-value <0.0001 between ePO and lPO - Friedman test) (Table 2), which highlights the duration of treatment effectivity.

The AOFAS scores obtained during the preoperative and postoperative periods showed important increases, indicating important improvements in prognosis considering the patient's pain and functionality. This was done using a physical examination for assessing stability of the operated limb, its function, mobility, and hindfoot alignment. Preoperative scores varied from 47 to 69, while postoperative scores varied from 89 to 100 in the ePO period and from 85 to 100 in the lPO period (Figure 1). These results were positively significant.

Another interesting and positive aspect was in regard to the age and sex of patients, since no significant differences were observed between different groups; this emphasized the universality of treatment by tendoscopy.

This way, we could contribute positively to the purpose of this study, which was to foster the idea of good prognoses and the efficacy of the tendoscopic treatment of foot and ankle comorbidities, aiming to render it increasingly accepted and used in the orthopaedic environment.

Discussion

Arthroscopy of the foot and ankle is a common technique. With the emergence of new, more refined surgical techniques and arthroscopic instrumentation, there was a natural transition to tendoscopic techniques, and this surgical modality has been incorporated to the arsenal of the foot and ankle surgeon. Tendoscopy is an endoscopy of the tendon sheath that has been described in many tendons of the foot and ankle, including the posterior tibial, peroneal tendons, the flexor digitorum longus, anterior tibial, and Achilles tendons[1-5]. In this study, we mainly analyzed the treatment of peroneal tendon comorbidities, due to a higher incidence among the selected patients.

The conservative treatment of extra-articular ankle pathologies is successful in most cases, but non-surgical treatment has a failure rate of 10% to 25%[2]. When clinical treatment fails, conventional open surgery can be indicated. As opposed to the elbow or the knee, for example, posterior tendon structures of the ankle are deep and can be difficult to feel at palpation; in addition, these structures are very close together, which could hamper diagnostic imaging[8]. When treating posterior extra-articular ankle pathologies, posterolateral or posteromedial incisions are made, which could imply in a risk of damage to adjacent structures[2-5,8]. Complication rates of open surgery procedures of the Achilles tendon vary between 4.7% and 11.6%; wound infection, dehiscence, and pain are the most frequently described problems[2]. With larger incisions, postoperative care may include immobilization in order to promote better wound healing[8]. The aim of this study relies in the proposition of shorter rehabilitation periods to patients, thus proving the efficacy of the tendoscopic treatment and its long-lasting effect, questioning the need for choosing invasive treatments that require larger incisions and have higher chances of complications and longer recovery periods.

Tendoscopies performed around the ankle joint, especially posterior procedures, may be technically demanding but offer a unique perspective of the pathological processes involving these structures. Certain anatomical particularities may render tendoscopy challenging. Factors that hinder the identification of structures or the access to them, such as decreases in tendon volume due to severe chronic injury or stenosing tenosynovitis or restricted access due to the curvature of the tendon's course, could prevent access to the site of the pathology. Therefore, when performing a tendoscopy, the sur-

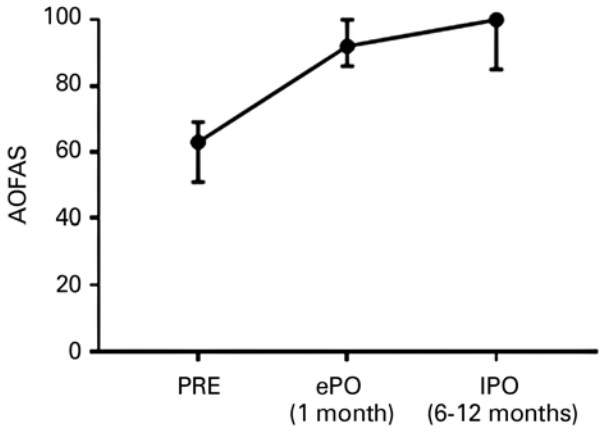


Figure 1. Median American Orthopaedic Foot & Ankle Society (AOFAS) scores for each period. Vertical bars indicate variations and minimum and maximum values.

Table 2. Descriptive analysis and comparison of the American Orthopaedic Foot & Ankle Society (AOFAS) scores between periods

Variable	n	Mean	SD	Minimum	Median	Maximum
AOFAS_PRE	13	62.0	5.7	51.0	63.0	69.0
AOFAS_PO1	13	93.5	5.1	86.0	92.0	100.0
AOFAS_6_12	13	96.7	5.7	85.0	100.0	100.0

p-value (Friedman test) <**0.0001,** differences between (Dunn's test): preoperative and postoperative (1 month) periods; preoperative and postoperative (6–12 months) periods.
No difference between 1 month and 6–12 months after surgery.

geon should be familiarized with the anatomy of the foot and ankle.

Some studies aimed to widen the possibility of knowing the tendoscopic view by the foot and ankle orthopedist. Van Dijk and Kort[5] performed a study with cadavers where, in 3 out of 7 tendoscopic investigations, they found that the peroneal tubercle on the calcaneus was between peroneal tendons, 4 to 5cm distal from the tip of the fibula. The posterior tibial tendon has myotendinous connections throughout its course. Van Dijk and Kort[5] have published a review on the anatomy of the posterior tibial tendon, and Steenstra and Van Dijk[9] have shown a general view of the Achilles tendon. Lui et al.[10] studied the flexor hallucis tendon and its various segments (zones). In this study, the authors verified that the medial plantar nerve was on the medial side of the plantar region, proximal to the tendon sheath in all samples; its relationship with the more distal sheath was variable. Synovectomy at this site should be performed with caution due to the anatomic proximity of the tarsal tunnel structures. The tendoscopy of posterior tibial, peroneus longus and brevis, and flexor hallucis longus tendons was described by van Dijk et al.[5,8]. Maquirriain[11] presented a study with 9 cadavers in which he showed that adequate access to the Achilles tendon could be achieved via an endoscope. Samarco and Henning[12] described the arthroscopic treatment of the peroneus tertius.

Sammarco[13] began recommending, as routine, the tendoscopy of peroneal tendons during the reconstruction of the ankle ligament complex in case of suspicion of peroneal pathologies.

Lui[14] stated that, with solid knowledge of indications, merits, and potential risks of new techniques, endoscopic procedures will be powerful tools in foot and ankle surgery and this study intended to provide further information and contribute so that tendoscopy is increasingly present in the daily practice of the foot and ankle orthopedist, effectively showing its good prognostic and the duration of its results. Furthermore, we have observed the universality of this treatment, which can be recommended for men or women of different ages.

Monteagudo et al.[15] state that tendoscopy is an apparently safe and reliable procedure for treating some foot and ankle disorders, and it can be used as an adjuvant procedure to other techniques. Level IV and V studies are predominantly found in the literature, and level I studies are not yet available. However, owing to the existence of many promising studies and constantly evolving endoscopic techniques for treating tendinopathies of the foot and ankle, the procedure may be recommended and more studies with higher levels of evidence should be promoted in order to strengthen this procedure in the treatment of foot and ankle injuries. This study has a level of evidence IV, which is a case series study that aims to broaden the idea of reliability and safety of the tendoscopic treatment even further, in addition to its efficacy.

Conclusion

The endoscopic treatment of the foot and ankle, by principle, aims to provide, in a less invasive manner, relief to symptoms of some foot and ankle comorbidities, such as peroneal tendon dislocation, peroneal tendonitis, or tearing of the peroneus longus or brevis, which are some of the pathologies treated in this study.

The objective of showing and underlining the efficacy of tendoscopy and the maintenance of its good prognosis by using the AOFAS score during the clinical functional assessment performed in postoperative periods was successfully achieved. AOFAS scores were significantly positive, remaining above 86 in the recent and late postoperative periods and reaching 8 values of 100 (best possible result for the score) in the late postoperative period. Moreover, the idea or choosing a less invasive procedure, even if requiring superior technique and instrumentation, was reinforced with great results through a reduction in the postoperative recovery period, the maintenance of symptom relief, and functionality recovery by patients subjected to functional assessment, whether they were women or men, of various ages, which confers an interesting universality to this treatment.

Authors' contributions: Each author contributed individually and significantly to the development of this article: RGH *(https://orcid.org/0000-0003-3951-8408) Conceived and planned the activities that led to the study, bibliographic review, participated in the review process and approved the final version; MSPC *(https://orcid.org/0000-0002-0758-2547) Conceived and planned the activities that led to the study, bibliographic review, participated in the review process and approved the final version; CDCCF *(https://orcid.org/0000-0003-3522-1076) Performed the surgeries, data collection and approved the final version; HDB *(https://orcid.org/0000-0002-1901-3309) Performed the surgeries, data collection and approved the final version; RMB *(https://orcid.org/0000-0002-4218-3023) Interpreted the results of the study, participated in the review process, data collection and formatting of the article. All authors read and approved the final manuscript. *ORCID (Open Researcher and Contributor ID).

References

1. Bulstra GH, Olsthoorn PG, Niek van Dijk C. Tendoscopy of the posterior tibial tendon. Foot Ankle Clin. 2006;11(2):421-7.
2. Morag G, Maman E, Arbel R. Endoscopic treatment of hindfoot pathology. Arthroscopy. 2003;19(2):E13.
3. van Dijk CN. Hindfoot endoscopy for posterior ankle pain. Instr Course Lect. 2006;55:545-54.
4. van Dijk CN. Hindfoot endoscopy. Foot Ankle Clin. 2006;11(2):391-414.
5. van Dijk CN, Kort N. Tendoscopy of the peroneal tendons. Arthroscopy. 1998;14(5):471-8.
6. Rodrigues RC, Masiero D, Mizusaki JM, Imoto AM, Peccin MS, Cohen M, et al. Translation, cultural adaptation and validity of the "American Orthopaedic Foot and Ankle Society (AOFAS) Ankle-Hindfoot Scale". Acta Ortop Bras. 2008;16(2):107-11.
7. SAS System for Windows (Statistical Analysis System), versão 9.4. SAS Institute Inc, 2002-2012, Cary, NC, USA.
8. van Dijk CN, Scholten PE, Krips R. A 2-portal endoscopic approach for diagnosis and treatment of posterior ankle pathology. Arthroscopy. 2000;16(8):871-6.
9. Steenstra F, van Dijk CN. Achilles tendoscopy. Foot Ankle Clin. 2006;11(2):429-38.
10. Lui TH, Chan KB, Chan LK. Cadaveric study of zone 2 flexor hallucis longus tendon sheath. Arthroscopy. 2010;26(6):808–12.
11. Maquirriain J. Endoscopic release of Achilles peritenon. Arthroscopy. 1998;14(2):182–5.
12. Sammarco GJ, Henning C. Peroneus tertius muscle as a cause of snapping and ankle pain: a case report. Am J Sports Med. 2007;35(8):1377-9.
13. Sammarco VJ. Peroneal tendoscopy: indications and techniques. Sports Med Arthrosc Rev. 2009;17(2):94-9.
14. Lui TH. Arthroscopy and endoscopy of the foot and ankle: indications for new techniques. Arthroscopy. 2007;23(8): 889-902.
15. Monteagudo M, Maceira E, Martinez de Albornoz P. Foot and ankle tendoscopies: current concepts review. EFORT Open Rev. 2017;1(12):440-7.

DOI: https://doi.org/10.30795/jfootankle.2021.v15.1535

Original Article

Inter-rater reliability of Böhler and Gissane angles in different calcaneal fracture according to the Essex-Lopresti and Sanders classifications

Rui dos Santos Barroco[1], Bruno Rodrigues de Miranda[1,2], Herbert Amantéa Fernandes[1], Gregory Bittar Pessoa[1], Danilo Ryuko Cândido Nishikawa[2], Leticia Zaccaria Prates de Oliveira[1], Álvaro Diego Pupa de Freitas[1], Caio Ivo de Almeida[1]

1. ABC School of Medicine, Santo André, SP, Brazil.
2. Hospital do Servidor Público Municipal de São Paulo, São Paulo, SP, Brazil.

Abstract

Objective: To evaluate the inter-rater reliability and intra-class correlation coefficients (ICC) of Böhler's angle and the critical angle of Gissane in calcaneal fractures, stratified by severity and by the Essex-Lopresti and Sanders classifications.

Methods: Retrospective study of radiographs obtained from 97 patients: 67 with calcaneal fractures and 30 with normal lateral radiographs (used as a control group). Böhler's angle and the angle of Gissane were measured by six raters: two orthopedic surgery residents, two musculoskeletal radiologists, a foot and ankle surgery fellow, and a senior consultant in foot surgery. Statistical analysis of inter-rater reliability was performed for the two angles, in the sample overall and stratified by the different radiographic and CT subtypes of calcaneal fractures.

Results: For the angle of Gissane, the ICC was at best 0.400 (95% CI: 0.250 to 0.581) for normal radiographs, with poor agreement across all classifications and severity stratifications. For Böhler's angle, the ICC values indicated weak to moderate agreement, with the best reproducibility obtained for the overall sample (0.740; 95% CI: 0.673 to 0.801). In Sanders type 1 fractures, the ICC was 0.704 (95% CI: 0.397 to 0.940), and in Sanders type 2 fractures, 0.762 (95% CI: 0.634 to 0.870).

Conclusion: Böhler's angle is more reproducible than the critical angle of Gissane, with greater inter-rater reliability among fractures deemed less severe on the Sanders classification, although the overall ICC ranged from weak to moderate at best.

Level of Evidence III; Case Control Study; Diagnostic Studies.

Keywords: Calcaneus; Intra-articular fractures; Radiology; Reproducibility of results.

Introduction

The diagnosis and prognosis of calcaneal fractures are related to their location and to the extent of joint involvement[1]. Some classification systems for these fractures use radiographs to determine their patterns, but this approach is limited by the difficulty in clearly defining the fragments[2].

For the radiographic evaluation of calcaneal fractures, Böhler's angle (BA) is frequently used to guide treatment, and is mentioned in several studies as a determinant of prognosis[3]. The crucial (or critical) angle of Gissane (AG) is also classically cited as a useful measure in the diagnosis of calcaneal fractures, but its reproducibility is lower compared to BA[4].

With the advent of computed tomography (CT), the determination of fracture patterns has evolved, and new classification systems have emerged. Among these, the Sanders classification is most popular; it uses an oblique coronal CT view to classify the fracture according to the degree of joint involvement of the posterior subtalar facet. Prognosis can also be

Study performed at the Hospital Estadual Mário Covas, ABC School of Medicine, Santo André, SP, Brazil.

Correspondence: Rui dos Santos Barroco. Avenida Indianópolis, 725, Indianópolis - 04062-001, São Paulo, SP, Brazil. **E-mail:** ruibarroco@uol.com.br.
Conflicts of interest: none. **Source of funding:** none. **Date received:** April 28, 2021. **Date accepted:** June 12, 2021. **Online:** August 31, 2021.

How to cite this article: Barroco RS, Miranda BR, Fernandes HA, Pessoa GB, Nishikawa DRC, Oliveira LZP, et al. Inter-rater reliability of Böhler and Gissane angles in different calcaneal fracture according to the Essex-Lopresti and Sanders classifications. J Foot Ankle. 2021;15(2):133-9.

estimated from the amount of fragments and the location of the fracture lines[5]. However, CT has higher cost and limited availability compared to plain radiographs. It may not be available at all emergency departments, which makes radiography still essential in establishing diagnosis and identifying factors implicated in fracture severity[6]. However, questions remain regarding the inter-rater reliability of these measurements[4].

Within this context, the present study aimed to evaluate inter-rater reliability in measurement of BA and AG in calcaneal fractures with different severity levels and typologies on the Essex-Lopresti and Sanders classifications. Our hypothesis is that more severe fractures would hinder measurement of angular radiographic parameters, thus limiting their reliability.

Methods

This study was approved by the relevant institutional Research Ethics Committee and registered on Plataforma Brasil (CAAE: 97546918.5.0000.0082). A retrospective investigation was conducted on radiographic images obtained from 97 patients seen at a tertiary orthopedic surgery service. Of these, 67 radiographs represented calcaneal fractures and 30 were normal; the latter were used as a control group (or comparators) for measurement of inter-rater reliability. The inclusion criteria were research patients with calcaneal fractures who were treated at our service between the years 2004 and 2018 and for whom plain radiographs and CT scans were available on the medical record. The exclusion criteria were patients who refused to participate in the study, who did not have the necessary imaging tests on file, or whose images were of insufficient quality for evaluation.

At the study service, lateral radiographs of the ankle are obtained using a standardized technique, with the patient in lateral recumbent position on the imaged side with the lower limb fully extended and in contact with the table. The beam was directed perpendicular to the film, centered on the calcaneus (approximately 2.5cm distal to the medial malleolus), with a source-to-image distance of 100cm.

All fractures were analyzed by an independent senior consultant in foot and ankle surgery and divided into groups, who classified them according to the Essex-Lopresti method; 24 fractures were of the tongue type and 43 of the joint depression type. The Sanders CT classification was also applied by the same senior consultant, who identified six type 1 fractures, 14 type 2 fractures, 23 type 3 fractures, and 14 type 4 fractures.

Six examiners took part in measurements of inter-rater reliability: two orthopedics residents, one first-year and one third-year; two radiologists with a special interest in musculoskeletal imaging; a foot and ankle surgery fellow; and a second senior consultant in foot and ankle surgery. All received printouts of the radiographs, previously organized by the independent consultant (who did not participate in the measurements) and sequentially numbered at random, without nominal identification of the patients, so that evaluation was blinded in relation to patient identity and among assessors. AG and BA measurements were performed using a goniometer. None of the examiners involved in performing the angular measurements had prior access to the radiographs or to the results of the other examiners.

AG is measured at the intersection of two straight lines, one drawn along the posterior facet and the other tangent to the anterior beak. Its normal range is from 105° to 135°[7]. BA is formed by a line drawn from the highest point of the anterior tuberosity to the highest point of the posterior facet and another line drawn from the highest point of the posterior facet tangent to the superior extremity of the calcaneal tuberosity. Its normal range is from 20° to 40°[8].

Data were collected using a standardized form and entered into an Excel spreadsheet. This was then exported into SPSS Version 10.1 (SPSS Inc., Chicago, IL) for statistical analysis.

A significance level of 0.05 was adopted. Intraclass correlation coefficients (ICC) were calculated for the assessment of agreement of the AG and BA measurements obtained by between the six observers, both in the sample overall and within separate subgroups defined by the Essex-Lopresti and Sanders tomographic classifications. Means were calculated with 95% confidence intervals. Levels of agreement were interpreted as follows: 0 to 0.2, weak; 0.21 to 0.4, fair; 0.41 to 0.6, moderate; 0.61 to 0.8, strong; and 0.81 to 1, almost perfect agreement.

Results

The sample consisted of 40 (41.2%) women and 57 (58.8%) men. The mean age was 44.9 years (range, 17 to 73 years) (Table 1). Of the radiographic images obtained, 52 (53.6%) were of the right foot and 45 (46.4%), of the left foot. Regarding the Sanders CT classification, there were six (9.0%) type 1 fractures, 24 (35.8%) type 2 fractures, 23 (34.3%) type 3 fractures, and 14 (20.9%) type 4 fractures.

According to the Essex-Lopresti radiographic classification, 43 (44.3%) fractures were of the joint depression type and 24 (24.7%) of the tongue type; 30 radiographs (30.9%) were normal (Table 1).

Observed ICC values for the AG were, at best, 0.400 (95% CI: 0.250 to 0.581) for normal radiographs, indicating poor inter-rater agreement in this stratum of radiographs. ICC values were even lower in the fracture group, across all fracture classifications and severity stratifications (Table 2). For BA, the ICC values indicated of weak to moderate agreement between raters, with the best reproducibility obtained for the overall sample (0.740; 95% CI: 0.673 to 0.801), as well as in Sanders type 1 fractures (0.704; 95% CI: 0.397 to 0.940), and in Sanders type 2 fractures, 0.762 (95% CI: 0.634 to 0.870) (Table 2).

Separate assessment of only those scans classified as Sanders type 1 showed no evidence of difference between raters in measurement of the angle of Gissane (p=0.101), but there was a significant difference in measurements of Böhler's angle (p=0.014). Among those fractures classified as Sanders type 2, there was evidence of significant differences between

observers in measurement of both AG (p<0.001) and BA (p=0.003).

In the most severe fracture patterns according to the Sanders classification, the measurements again show major differences between raters. Assessment of only those scans classified as Sanders type 3 showed evidence of significant differences between raters in measurements of AG (p<0.001), but no significant difference in measurements of BA (p=0.464). Finally, analysis of only those fractures classified as Sanders type 4 again showed evidence of significant differences between raters for both measures, AG and BA (p<0.001), demonstrating low reproducibility.

When analyzing the sample stratified by Essex-Lopresti classification, there were differences in reliability and reproducibility for both angles (BA and AG) across different scenarios.

In the sample with joint depression-type calcaneal fracture according to the Essex-Lopresti classification (Table 3, Figures 1 and 2), there was evidence of significant differences between observers in measurements of AG (p<0.001) and BA (p<0.001).

Assessment of only those radiographs classified as showing a tongue-type calcaneal fracture on the Essex-Lopresti scheme (Table 4, Figures 3 and 4) showed evidence of significant differences between raters in measurements of AG (p<0.001), but no significant difference in measurements of BA (p=0.081).

Even when analyzing the sample of normal radiographs (i.e., those showing no evidence of fractures), there were significant differences between raters in measurements of both angles (AG, p<0.001; BA, p=0.004; Figures 5 and 6), demonstrating, once again, the limitation of angular measurements for the reproducible assessment of the shape of the calcaneus.

Table 1. Characteristics of patients treated at the FMABC Department of Orthopedics and Trauma, 2004–2018 (n=97)

Age (years)	
Mean	44.9
Range (min; max)	17; 73
Gender	
Female	40 (41.2%)
Male	57 (58.8%)
Laterality	
Right	52 (53.6%)
Left	45 (46.4%)
Sanders classification (CT images)	
1	6 (9.0%)
2	24 (35.8%)
3	23 (34.3%)
4	14 (20.9%)
Essex-Lopresti classification (lateral radiographs)	
Joint depression-type calcaneal fracture	43 (44.3%)
Tongue-type calcaneal fracture	24 (24.7%)
Normal	30 (30.9%)

SD: standard deviation.

Discussion

The crucial angle of Gissane and Böhler's angle are classically used in the diagnosis of calcaneal fractures. Böhler[8] described his eponymous angle in 1931 as a diagnostic tool, establishing normal values between 30° and 35°. More recent studies have demonstrated a wider range of variation, with between 20 and 45° being considered normal[9]. Despite its widespread use in the literature, the original description of the technique for measuring the angle is confusing. In fact, the original article does not specifically describe obtaining

Table 2. Intraclass correlation coefficients (ICC) for assessment of the reproducibility of measurements of the critical angle of Gissane and Böhler's angle as obtained by different raters in the sample overall and stratified by the Essex-Lopresti and Sanders classifications

Stratification	Angle	
	Gissane (95%CI)	Böhler (95%CI)
Overall sample (n=97)	0.205 (0.129; 0.298)	0.740 (0.673; 0.801)
Sanders classification (CT images)		
1 (n=6)	0.285 (0.036; 0.762)	0.704 (0.397; 0.940)
2 (n=24)	0.146 (0.036; 0.328)	0.762 (0.634; 0.870)
3 (n=23)	0.173 (0.054; 0.366)	0.536 (0.364; 0.721)
4 (n=14)	0.210 (0.050; 0.498)	0.244 (0.077; 0.523)
Essex-Lopresti classification (lateral radiographs)		
Joint depression-type calcaneal fracture (n=43)	0.134 (0.047; 0.261)	0.621 (0.500; 0.740)
Tongue-type calcaneal fracture (n=24)	0.305 (0.151; 0.513)	0.444 (0.275; 0.642)
Normal (n=30)	0.400 (0.250; 0.581)	0.633 (0.488; 0.771)

Data expressed as intraclass correlation coefficient and 95% confidence interval.

Table 3. Estimated means (and 95%CI) for measurements of the critical angle of Gissane and Böhler's angle obtained by different raters in a sample of joint depression-type calcaneal fractures (Essex-Lopresti classification) (n=43)

Observer	Angle	
	Gissane	Böhler
Resident 1	111.4 (106.5; 116.3)	11.9 (6.3; 17.5)
Resident 2	126.0 (122.4; 129.7)	12.1 (7.1; 17.2)
Foot and ankle fellow	110.0 (104.2; 115.8)	9.3 (4.9; 13.6)
Radiologist 1	97.5 (91.4; 103.5)	11.4 (5.7; 17.0)
Radiologist 2	107.7 (101.1; 114.3)	6.6 (1.7; 11.6)
Senior consultant	95.1 (87.3; 102.9)	14.5 (9.7; 19.3)
p-value	**<0.001**	**<0.001**
Multiple comparisons	p-value	p-value
Resident 1 vs. Resident 2	**<0.001**	>0.999
Resident 1 vs. Foot and ankle fellow	>0.999	>0.999
Resident 1 vs. Radiologist 1	**0.002**	>0.999
Resident 1 vs. Radiologist 2	>0.999	0.298
Resident 1 x Senior consultant	**0.002**	>0.999
Resident 2 vs. Foot and ankle fellow	**<0.001**	0.597
Resident 2 vs. Radiologist 1	**<0.001**	>0.999
Resident 2 vs. Radiologist 2	**<0.001**	0.066
Resident 2 vs. Senior consultant	**<0.001**	>0.999
Foot and ankle fellow vs. Radiologist 1	**0.013**	>0.999
Foot and ankle fellow vs. Radiologist 2	>0.999	0.666
Foot and ankle fellow vs. Senior consultant	**0.013**	**0.001**
Radiologist 1 vs. Radiologist 2	0.093	0.500
Radiologist 1 x Senior consultant	>0.999	>0.999
Radiologist 2 x Senior consultant	0.071	**<0.001**

Data expressed as estimated means with 95% confidence intervals; p-values corrected by the sequential Bonferroni procedure.

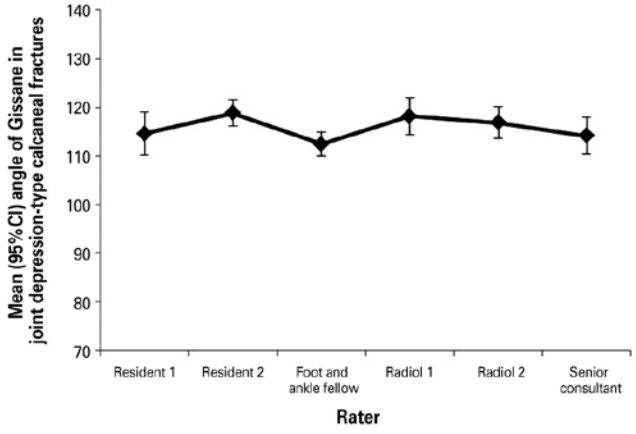


Figure 1. Estimated means (and 95%CI) for measurements of the critical angle of Gissane obtained by different raters in a sample of joint depression-type calcaneal fractures (Essex-Lopresti classification) (n=43).

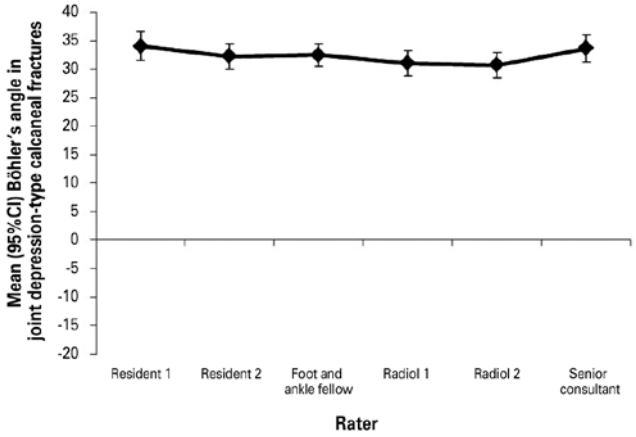


Figure 2. Estimated means (and 95%CI) for measurements of Böhler's angle obtained by different raters in a sample of joint depression-type calcaneal fractures (Essex-Lopresti classification) (n=43).

Table 4. Estimated means (and 95%CI) for measurements of the critical angle of Gissane and Böhler's angle obtained by different raters in a sample of tongue-type calcaneal fractures (Essex-Lopresti classification) (n=24)

Observer	Angle	
	Gissane	Böhler
Resident 1	116.8 (112.1; 121.4)	14.9 (11.1; 18.8)
Resident 2	123.4 (117.6; 129.2)	13.5 (10.1; 16.9)
Foot and ankle fellow	112.0 (107.3; 116.7)	9.3 (4.6; 14.0)
Radiologist 1	110.8 (105.9; 115.7)	11.1 (6.4; 15.8)
Radiologist 2	109.7 (105.8; 113.5)	8.0 (2.8; 13.2)
Senior consultant	108.2 (102.7; 113.8)	13.2 (9.6; 16.8)
p-value	**<0.001**	0.081
Multiple comparisons	p-value	p-value
Resident 1 vs. Resident 2	0.254	>0.999
Resident 1 vs. Foot and ankle fellow	0.456	0.431
Resident 1 vs. Radiologist 1	0.230	>0.999
Resident 1 vs. Radiologist 2	**0.013**	0.214
Resident 1 x Senior consultant	**0.043**	>0.999
Resident 2 vs. Foot and ankle fellow	**0.004**	0.895
Resident 2 vs. Radiologist 1	**0.002**	>0.999
Resident 2 vs. Radiologist 2	**<0.001**	0.485
Resident 2 vs. Senior consultant	**<0.001**	>0.999
Foot and ankle fellow vs. Radiologist 1	>0.999	>0.999
Foot and ankle fellow vs. Radiologist 2	>0.999	>0.999
Foot and ankle fellow vs. Senior consultant	>0.999	>0.999
Radiologist 1 vs. Radiologist 2	>0.999	>0.999
Radiologist 1 x Senior consultant	>0.999	>0.999
Radiologist 2 x Senior consultant	>0.999	0.673

Data expressed as estimated means with 95% confidence intervals; p-values corrected by the sequential Bonferroni procedure.

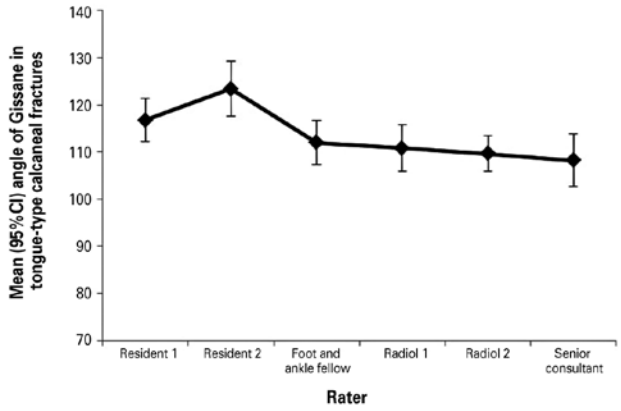


Figure 3. Estimated means (and 95%CI) for measurements of the critical angle of Gissane obtained by different raters in a sample of tongue-type calcaneal fractures (Essex-Lopresti classification) (n=24).

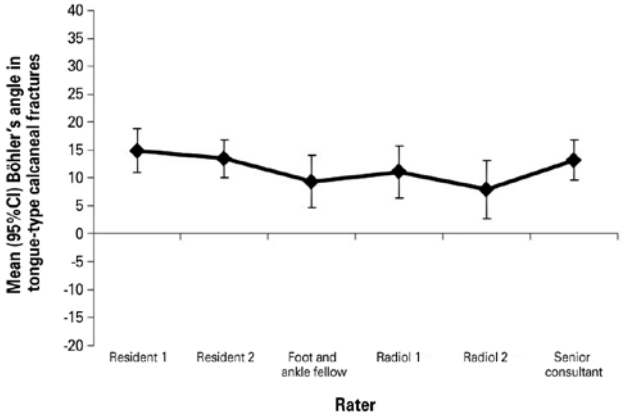


Figure 4. Estimated means (and 95%CI) for measurements of Böhler's angle obtained by different raters in a sample of tongue-type calcaneal fractures (Essex-Lopresti classification) (n=24).

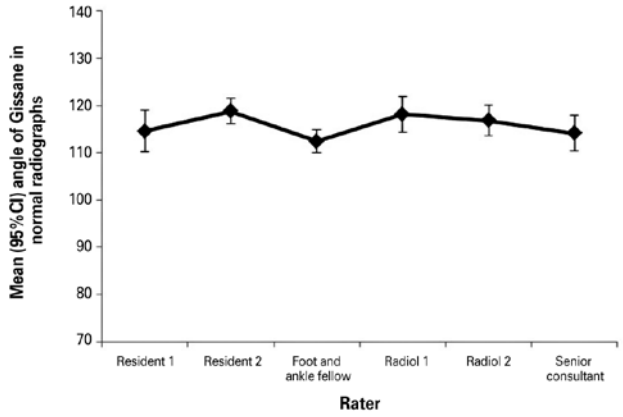


Figure 5. Estimated means (and 95%CI) for measurements of the critical angle of Gissane obtained by different raters in a sample of normal radiographs (Essex-Lopresti classification) (n=30).

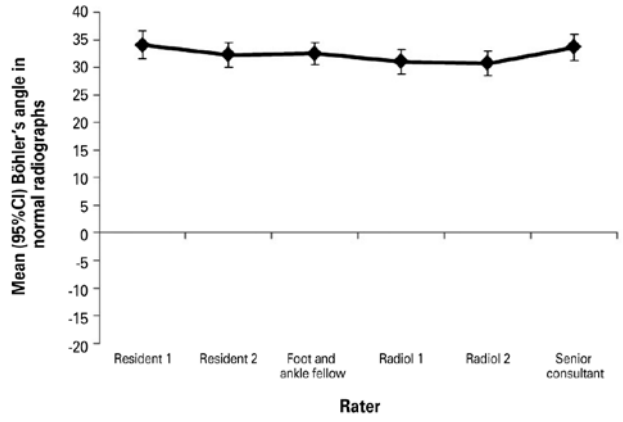


Figure 6. Estimated means (and 95%CI) for measurements of Böhler's angle obtained by different raters in a sample of normal radiographs (Essex-Lopresti classification) (n=30).

the angle in calcaneal fractures, nor does it exemplify its measurement in these situations. There is also no standardization of radiographic technique to guide the position of the foot during examination, e.g., regarding the source-to-image distance, angle, or center point of the source or cassette[8-10].

Knight et al.[4] reported good reproducibility in obtaining Böhler's angle for the diagnosis of articular fractures. In the same study, however, they described 97% accuracy for the diagnosis of fractures without use of either the angle of Gissane or Böhler's angle, calling into question their diagnostic utility[4]. The practical application of the angle of Gissane has also been questioned in the literature. Despite being an angle that determines the degree of collapse between the calcaneal facets, it is difficult to reproduce when the bone is fractured[1]. Several studies have questioned the use of both angles due to low inter-rater agreement and poor reproducibility[10].

In current clinical practice, the angle of Gissane is rarely used in the diagnosis and management of patients with calcaneal joint fractures, but Böhler's angle is still considered a useful tool in determining fracture severity, and has been cited by some authors as a parameter of restoration of normal anatomy after osteosynthesis[10]. Su et al.[11] reported preoperative use of Böhler's angle as a determining tool in surgical decision-making, demonstrating a relationship between a decreased angle and the need for surgical treatment, and establishing a relationship between BA values in the postoperative period and functional prognosis. Paley and Hall[12] also reported a prognostic correlation between lower BA values and worse postoperative functional outcomes. Barroco et al.[13] found a trend toward correlation between more severe calcaneal fractures according to the Sanders CT classification and lower BA values.

In the present study, we observed an ICC of 0.4 at most for the angle of Gissane, indicative of weak agreement between observers, across all types of joint fractures as well as in healthy, non-fractured calcaneus films—a fact also observed in the aforementioned study by Knight, in which this angle presented low reproducibility, sensitivity, and specificity even for fracture diagnosis. We observed a mean ICC of 0.305 for AG in tongue-type fractures, and 0.134 in joint depression-type fractures.

Measurement of Böhler's angle showed poor to moderate agreement, with mean ICCs of 0.621 for joint depression-type fractures and 0.444 for tongue-type fractures. The highest reliability was obtained in joint fractures of Sanders types 1 and 2. The ICCs found in this study are in agreement with the current literature. When analyzing tongue-type fractures, differences in AG values between observers were significant. In joint depression-type fractures, there were significant differences in agreement in the values of both angles.

We used the Sanders CT classification to categorize patients with joint fractures into subgroups, with the aim of evaluating inter-rater agreement in determining radiographic angles and establishing parameters with fracture patterns and degrees of joint involvement. One potential limitation of our study is that even CT classification systems are associated with inconsistent agreement between raters. Furey showed moderate agreement with use of the Sanders classification. Bhattacharya also demonstrated high degrees of variability and inconsistency in interpretation, resulting in weak to moderate reliability[14,15]. In our study, we chose to have an independent senior orthopedist classify the fractures in an attempt to reduce this possible assessment bias.

The literature also describes some factors that may be determinants of this low reproducibility of radiographic angles of the calcaneus. Obliquity when taking lateral radiographs is one of these factors. In most cases, patients who present to the radiology service with suspected calcaneal fractures are immobilized and in pain, factors that impair proper

positioning of the foot during radiographic examination[16]. Gonzalez et al.[16] concluded that oblique beam incidence makes it difficult to measure Böhler's angle, with anterior and caudad inclination leading to a reduction in the angle, while posterior and cephalad inclination increase its value. The level of training of the rater performing the measurement is also important. In the same study, Gonzalez concluded that more experienced orthopedic surgeons showed greater accuracy in determining Böhler's angle[16].

Conclusion

In our sample, Böhler's angle was generally more reliable than the angle of Gissane for the radiographic evaluation of calcaneal fractures. Even so, inter-rater agreement in measurement of Böhler's angle was generally weak to moderate, with better reliability only among those fractures deemed less severe according to the Sanders CT classification (types 1 and 2). In more severe fractures as classified by the Sanders method, both angles proved to be unreliable.

Authors' contributions: Each author contributed individually and significantly to the development of this article: RSB *(https://orcid.org/0000-0002-2870-2261) Conceived and planned the activities that led to the study, wrote the article, participated in the review process, approved the final version; BRM *(https://orcid.org/0000-0002-5306-2972) Conceived and planned the activities that led to the study, wrote the article, participated in the review process, approved the final version; HAF *(https://orcid.org/0000-0001-9920-5636) Wrote the article, participated in the review process, approved the final version; GBP *(https://orcid.org/0000-0003-4632-9672) Participated in the review process, approved the final version; DRCN *(https://orcid.org/0000-0003-0227-2440) Participated in the review process, approved the final version; LZPO *(https://orcid.org/0000-0001-5849-5841); ADPF *(http://orcid.org/0000-0001-5808-1788) Participated in the review process, approved the final version; CIA *(http://orcid.org/0000-0002-8951-1450). All authors read and approved the final manuscript. *ORCID (Open Researcher and Contributor ID).

References

1. Arslan G, Yirgin IK, Tasguzen A. A measuremental approach to calcaneal fractures. Eur J Trauma Emerg Surg. 2014;40(5):593-9.
2. Lauder AJ, Inda DJ, Bott AM, Clare MP, Fitzgibbons TC, Mormino MA. Interobserver and intraobserver reliability of two classification systems for intra-articular calcaneal fractures. Foot Ankle Int. 2006;27(4):251-5.
3. Bakker B, Halm JA, Van Lieshout EM, Schepers T. The fate of Böhler's angle in conservatively-treated displaced intra-articular calcaneal fractures. Int Orthop. 2012;36(12):2495-9.
4. Knight JR, Gross EA, Bradley GH, Bay C, LoVecchio F. Boehler's angle and the critical angle of Gissane are of limited use in diagnosing calcaneus fractures in the ED. Am J Emerg Med. 2006;24(4):423-7.
5. Swords MP, Alton TB, Holt S, Sangeorzan BJ, Shank JR, Benirschke SK. Prognostic value of computed tomography classification systems for intra-articular calcaneus fractures. Foot Ankle Int. 2014;35(10):975–80.
6. Roukis TS, Wünschel M, Lutz HP, Kirschner P, Zgonis T. Treatment of displaced intra-articular calcaneal fractures with triangular tube-to-bar external fixation: long-term clinical follow-up and radiographic analysis. Clin Podiatr Med Surg. 2008;25(2):285-99.
7. Essex-Lopresti P. The mechanism, reduction technique, and results in fractures of the os calcis. Br J Surg. 1952;39(157):395-419.
8. Böhler L. Diagnosis, pathology, and treatment of fractures of the os calcis. J Bone Joint Surg Am. 1931;13(1):75-89.
9. Isaacs JD, Baba M, Huang P, Symes M, Guzman M, Nandapalan H, et al. The diagnostic accuracy of Böhler's angle in fractures of the calcaneus. J Emerg Med. 2013;45(6):879-84.
10. Otero JE, Westerlind BO, Tantavisut S, Karam MD, Phisitkul P, Akoh CC, et al. There is poor reliability of Böhler's angle and the crucial angle of Gissane in assessing displaced intra-articular calcaneal fractures. Foot Ankle Surg. 2015;21(4):277-81.
11. Su Y, Chen W, Zhang T, Wu X, Wu Z, Zhang Y. Bohler's angle's role in assessing the injury severity and functional outcome of internal fixation for displaced intra-articular calcaneal fractures: a retrospective study. BMC Surg. 2013;13:40.
12. Paley D, Hall H. Intra-articular fractures of the calcaneus. A critical analysis of results and prognostic factors. J Bone Joint Surg Am. 1993;75(3):342-54.
13. Barroco RS, Miranda BR, Ghani MB, Ferreira AR, Oliveira LZ, Diedrichs L, et al. Intra-articular calcaneal fracture: correlation between Böhler's and Gissane's angles using the Sander's CT classification. Rev ABTPé. 2017;11(2):96-101.
14. Furey A, Stone C, Squire D, Harnett J. Os calcis fractures: analysis of interobserver variability in using Sanders classification. J Foot Ankle Surg. 2003;42(1):21-3.
15. Bhattacharya R, Vassan UT, Finn P, Port A. Sanders classification of fractures of the os calcis. An analysis of inter- and intra-observer variability. J Bone Joint Surg Br. 2005;87(2):205-8.
16. Gonzalez TA, Ehrlichman LK, Macaulay AA, Gitajn IL, Toussaint RJ, Zurakowski D, et al. Determining measurement error for Bohler's angle and the effect of X-ray obliquity on accuracy. Foot Ankle Spec 2016;9(5):409-16.

DOI: https://doi.org/10.30795/jfootankle.2021.v15.1536

Original Article

Radiographic assessment of the percutaneous Bianchi system technique for treatment of hallux valgus

Tércio Manoel de Vasconcelos Silva[1], Marcus Vinicius Mota Garcia Moreno[1], Janice de Souza Guimarães[1,2], Túlio Eduardo Vieira Marçal[1], Thiago Batista Faleiro[2,3], Marilton Jorge Torres Gomes[1], Michele Risi[4]

1. Hospital COT - Hospital Ortopédico e Traumatológico, Salvador, BA, Brazil.
2. Universidade Federal da Bahia, Salvador, BA, Brazil.
3. Hospital Santo Antônio, Obras Sociais Irmã Dulce, Salvador, BA, Brazil.
4. Associazione professionale PBS. Casa Di Cura Villa Donatello, Firenze, Italy.

Abstract

Objective: To present initial radiographic results of surgical correction of the hallux valgus angle (HVA) and the intermetatarsal angle (IMA) using the percutaneous Bianchi system (PBS) technique.

Methods: Seventeen patients with moderate to severe hallux valgus (HV) were exclusively treated with the PBS technique and assessed radiographically preoperatively and during the postoperative period, from January 2019 to January 2020. The degree of deformity correction was recorded, based on the HVA and the IMA. Stata (v. 14.0) software was used for statistical analyses. Pre-surgical and post-surgical mean HVA and IMA were compared using Student's *t* test for paired samples and the McNemar test was used to compare HVA and IMA categories. Statistical significance was set at 5% and 95% confidence intervals were estimated.

Results: Both HVA and IMA were reduced significantly during the assessment period. Mean radiographic correction of the HVA was 15.1° and mean radiographic correction of the IMA was 7.3.

Conclusions: According to the results presented, use of the PBS technique achieved adequate correction of the radiographic parameters of the patients who underwent the treatment as proposed, although it is necessary to conduct additional studies with longer follow-up to achieve a higher recommendation level.

Level of Evidence IV; Therapeutic Studies; Case Series.

Keywords: Hallux valgus; Osteotomy; Metatarsal bones; Metatarsophalangeal joint.

Introduction

Hallux valgus (HV) is a common disorder of the forefoot[1] that was first described in a scientific report published by Volkmann in 1856. However, it was left to Carl Hueter apud Nery[2] to define the deformity in 1871, which he characterized as a lateral deviation (in valgus) of the hallux, combined with a medial deviation (in varus) of the head of the first metatarsal bone[3]. Epidemiologically, it presents more frequently among females, aged from 40 to 60 years, with ratios reported in studies varying up to 15 women for each man affected, and it is generally bilateral[2]. There is a direct association with the type of footwear worn and with a variety of intrinsic anatomic and genetic factors and even with other systemic conditions, with regard to determinants of its functional severity and progression[1].

During the 2010s, there was growing interest in use of minimally invasive surgery to correct HV. Reverdin-Isham pioneered the study of percutaneous surgery for treatment of HV, proposing procedures based on an incomplete oblique intraarticular osteotomy of the head of the first metatarsal. With improvements to the percutaneous techniques proposed by Bösch et al.[1] and, later, by Giannini et al.[4] and Magnan et al.[5], a distal and transverse percutaneous osteotomy of the first metatarsal was developed for correction of mild and moderate HV.

Study performed at the Hospital COT - Hospital Ortopédico e Traumatológico, Salvador, BA, Brazil.

Correspondence: Tércio Manoel de Vasconcelos Silva. Rua João das Botas, 28, Canela – 40110-160, Salvador, BA, Brazil. **E-mail:** terciomvs@gmail.com.
Conflicts of interest: none. **Source of funding:** none. **Date received:** April 28, 2021. **Date accepted:** July 16, 2021. **Online:** August 31, 2021.

How to cite this article: Silva TMV, Moreno MVMG, Guimarães JS, Marçal TEV, Faleiro TB, Gomes MJT, et al. Radiographic assessment of the percutaneous Bianchi system technique for treatment of hallux valgus. J Foot Ankle. 2021;15(2):140-5.

Countless procedures, with different surgical approaches and fixation hardware[6] are described in the global literature for surgical treatment of this condition. The share the common objectives of correcting the inherent deformities that cause HV, improving pain and foot function, achieving low rates of relapse[1-3,6-9], reducing operating time, and enabling the procedure to be performed bilaterally in a single operating session[8,10]. In this context, the objective of the present study is to present the radiographic results of surgical correction of moderate and severe hallux valgus, using the percutaneous Bianchi system (PBS), which is a technique that employs a complete, extra-articular, nonlinear, distal osteotomy of the first metatarsal[6].

Methods

This study was approved by the Human Research Ethics Committee. This was a retrospective observational study with a case series design, conducted at a private orthopedics and traumatology clinic.

After each patient had read and signed the free and informed consent form (TCLE) agreeing to participate in the study, data collection was begun. Patients included in this study were all managed by the same surgical team, comprising a lead surgeon and an assistant surgeon, both of whom were orthopedists and specialists in foot and ankle surgery, and all patients exclusively underwent surgical treatment with the percutaneous PBS technique. Preoperative and postoperative radiographic examinations were analyzed for a 12-month period spanning January 2019 to January 2020, in addition to data collection via electronic medical records.

Inclusion criteria were as follows: patients over the age of 18 years, with moderate to severe HV, subjected to the PBS technique only, with persistent pain and deformities, which had not improved in response to conservative measures (changing footwear, physiotherapy, and others) for a minimum of 6 months. The exclusion criteria were: patients who had rigidity of the first metatarsophalangeal joint, rheumatoid arthritis or other inflammatory conditions, patients with diabetes, neurological disorders, hypermobility of the first tarsometatarsal joint, patients who needed an Akin osteotomy for correction of interphalangeal hallux valgus, and patients who had previously undergone some type of surgical procedure on the hallux.

X-ray images were acquired using the technique described by Tanaka et al.[11], in which the patients are positioned standing on the film, obtaining a weightbearing anteroposterior view. These images were used to measure the hallux valgus angle (HVA) and the intermetatarsal angle (IMA), measured between the 1st and 2nd metatarsals, as recommended by the American Orthopedic Foot and Ankle Society (AOFAS)[4]. The HVA is the angle formed by the axis of the proximal phalanx and the axis of the first metatarsal. The IMA is the angle formed by the axes of the first and second metatarsals.

All of the procedures and measurements were performed by the lead surgeon, using the standard PBS operating technique. It should be noted that all patients underwent the same postoperative protocol.

With the aid of Stata (v. 14.0) software, statistical analyses were conducted with descriptive tests, such as calculation of means and standard deviations, to describe the study population. Mean HVA and IMA before and after execution of the PBS technique were compared using Student's *t* test for paired samples, while Student's *t* test for independent samples was used to analyze the effects of age and left vs. right foot on reduction of measurements, with the objective of comparing the reduction in mean angles in different age ranges and different side feet (mean differences). The hypothesis of normality was confirmed using the Komogorov-Smirnov test. The McNemar test was used to compare HVA and IMA categories, before and after surgery. The level of statistical significance adopted for analysis was 5% and 95% confidence intervals were estimated.

Operating technique

With the patient supine, under spinal anesthesia or peripheral block, without a pneumatic tourniquet, the foot was positioned around 20 cm beyond the edge of the operating table.

A Beaver scalpel blade was used to make an approximately 2mm incision in the dorsal skin, lateral of the first metatarsophalangeal joint. This incision was used to perform a partial capsulotomy and tenotomy of the hallux adductor tendon, to enable displacement of the head of the first metatarsal and, as a result, varus reduction of the hallux.

A second incision, of 4-5mm, was then made in the skin slightly proximal and plantar of the head of the metatarsal, on the medial side. Capsulotomy of the first metatarsophalangeal joint of the subjacent bone was then conducted, using a "windshield wiper" action[8] and, via the same approach, a medial exostectomy was conducted using a Wedge burr (4.1 x 13mm). The exostectomy produces a toothpaste-like mixture consisting of bone residues and blood, which was eliminated via the incision by manual expression[8]. It should be emphasized that all of these stages are performed with radioscopic control. The same medial approach was then used to conduct the extra-articular osteotomy of the first metatarsal, using a straight Shannon burr (2 x 12 mm), with dorsal subcapital and slightly oblique alignment in relation to the longitudinal/coronal axis of the first metatarsal[6], taking care not to complete the first cut, to maintain lateral cortical bone.

Later, the dorsal cortical was osteotomized with a distal--to-proximal action in the sagittal plane, enabling the head of the first metatarsal to be slightly shortened and displaced into a slightly more plantar position. In a final action, the lateral cortical bone was severed with a slightly more oblique cut in the coronal plane, leaving a small step in the lateral border, which helps to stabilize the head of the first metatarsal, maintaining the correction. It is important to point out that the osteotomy can be displaced by up to 90% of the diameter of the diaphysis of the metatarsal, recentralizing the sesamoids and realigning the first ray[8]. No osteosynthesis materials were used. During exostectomy and osteotomy, the bone was irrigated with saline solution to reduce the risk of thermal necrosis[6].

After the desired correction had been achieved, an appropriate dressing was applied, consisting of protective bandaging around the hallux which, when correctly positioned, avoids over-correction. The dressing was changed 3 weeks after the surgical procedure and kept in place for a total of 6 weeks, or until formation of signs of consolidation were visible on X-rays[8]. Patients were permitted to walk immediately, from the first postoperative day onwards, depending on tolerance, wearing appropriate footwear with a flat and rigid sole[5].

Results

Profile of participants and assessment of the PBS technique

A total of 19 patients with moderate to severe HV were selected for the study, two of whom were excluded because they underwent osteotomy of the proximal phalanx of the hallux (Akin osteotomy). All of the 17 patients included were women, with a mean age of 51.1 ± 13.5 years, ranging from 22 to 66 years. Seven of them were over the age of 60 (41.2%). In terms of laterality, nine underwent surgery on the right foot and eight on the left. There were no cases of bilateral surgery (Table 1).

The radiographic analysis was conducted using preoperative images and images from 12 months after surgery. Standard weightbearing anteroposterior and lateral X-rays were used. The HVA and IMA were analyzed. The HVA was categorized as mild (15 – 20°), moderate (21 – 39°), or severe (≥ 40°) and the IMA was categorized as mild (9 – 11°), moderate (12 – 17°), or severe (≥18°)[4] (Figure 1).

On the basis of their HVA, 76.4% of cases were classified as severe preoperatively. At 12 postoperative months, all patients had HVA measurements less than 15°, which was a statistically significant difference. The same was observed in relation to the IMA, for which 76.4% of the patients were classified as moderate. After 12 months, sixteen patients had IMA measurements less than 9° and just one patient had an IMA of 9°, classified as mild (Table 2). A reduction in the degree of hallux valgus was observed after the surgical procedures.

Comparing the HVA measurements before the intervention and 12 months afterwards, a statistically significant reduction was observed after use of the PBS technique (p<0.001) (Figure 2). The patients exhibited mean scores of 22.9 ± 4.1 preoperatively, which reduced to 7.8 ± 2.7 during the postoperative period, i.e., there was a mean reduction of 15.1° (95%CI: 13.2 to 17.0). A similar result was observed in the analysis of IMA measurements, in which the mean reduction was 7.3° (95%CI: 5.9 to 8.7), which is a statistically significant difference (p<0.001). The mean preoperative angle was 13 ± 2.2, reducing to 5.7 ± 1.5 after surgery (Table 3). Figure 3 illustrates HV before and 12 months after the surgical procedure.

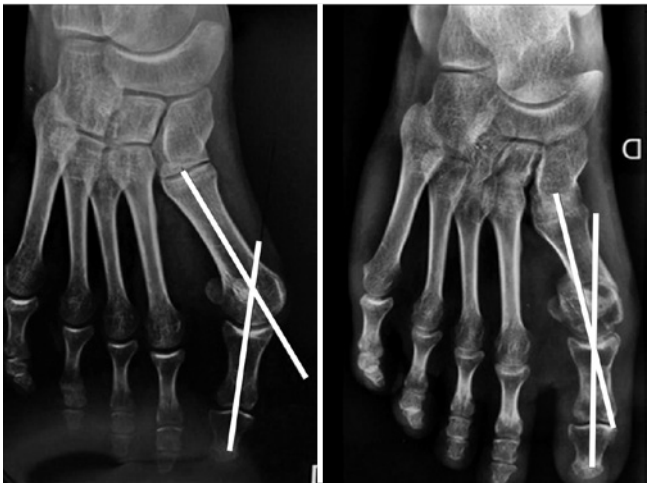


Figure 1. Anteroposterior X-ray showing correction of the hallux valgus angle – Preoperative (left); and 12 months after surgery (right).

Table 1. Characteristics at the initial assessment of patients with hallux valgus treated with the PBS technique

Characteristics	Statistic
Number of subjects	17 patients
Sex	
Female	17 (100%)
Age	
Mean ± SD	51.1 ± 13.5 years
Minimum – Maximum	22 – 66 years
Age group	
<60 years	10 (58.8%)
60 years or over	7 (41.2%)
Foot operated (laterality)	
Right	9 (52.9%)
Left	8 (47.1%)
Bilateral	0 (0%)

Table 2. Comparison of valgus categories based on the hallux valgus angle and the angle between the first and second metatarsals, before and after intervention, in patients with hallux valgus treated with the PBS technique

Measurements	Preoperative	Postoperative	p-value[a]
Hallux valgus angle			
Mild (<20°)	0 (0%)	17 (100%)	<0.001
Moderate (20 to 40°)	4 (23.6%)	0 (0%)	
Severe (>40°)	13 (76.4%)	0 (0%)	
Angle between the first and second metatarsals			
Mild (<11°)	2 (11.8%)	17 (100%)	<0.001
Moderate (11 to 16°)	13 (76.4%)	0 (0%)	
Severe (>16°)	2 (11.8%)	0 (0%)	

[a] McNemar test

Figure 2. Anteroposterior X-ray showing correction of the intermetatarsal angle – Preoperative (left); and 12 months after surgery (right).

Table 3. Comparison of measurements of the hallux valgus angle and the angle between the first and second metatarsals, before and after intervention, in patients with hallux valgus treated with the PBS technique

Measurements	Preoperative	Postoperative	Mean reduction during the postoperative period (95%CI)	p-value
Hallux valgus angle (in degrees)	22.9 ± 4.1	7.8 ± 2.7	15.1 (13.2 to 17.0)	<0.001
Angle between the first and second metatarsals (in degrees)	13.0 ± 2.2	5.7 ± 1.5	7.3 (5.9 to 8.7)	<0.001

Figure 3. Images illustrating presence of hallux valgus (left); and the result 12 months after the surgical procedure (right).

Table 4 shows the effects of age on reduction of the HVA and IMA angles in this patient sample. The results demonstrated that age group had no statistically significant effect on angle reduction after execution of the PBS technique. It was observed that the mean HVA reduction among patients less than 60 years old was 16° and the reduction among patients over the age of 60 was 13.9°, but this was not a significant difference (p=0.246). With regard to the IMA, the reduction among patients less than 60 years old was 6.8° and the reduction among patients over the age of 60 was 8°, which was also a non-significant difference (p=0.365).

Complications

One patient had an IMA measuring 9° 12 months after surgery (classified as a mild deformity). Complications such as relapses to moderate or severe grades, postoperative infections, hallux varus, avascular necrosis, pseudoarthritis, or malunion of the first metatarsal were not observed in the radiographic assessments during the follow-up period.

Discussion

Over recent years, there has been an exponential increase in studies investigating percutaneous HV surgery. There is a growing body of evidence in the literature suggesting that percutaneous HV surgery is safe and reliable[6].

Table 4. Comparison of measurements of the hallux valgus angle and the angle between the first and second metatarsals, before and after intervention, in patients with hallux valgus treated with the PBS technique, stratified by age and side operated (laterality)

Measurements	Preoperative	Postoperative	Mean reduction during the postoperative period	p-value[a]
Hallux valgus angle (in degrees)				
Age group				0.246
<60 years	23.0±4.3	7.0±2.3	16.0 (13.7 to 18.3)	
60 years or over	22.9±4.1	9.0±3.0	13.9 (10.1 to 17.6)	
Laterality				0.365
Right	22.1±4.1	7.8±3.2	14.3 (11.8 to 16.9)	
Left	23.9±4.1	7.9±2.2	16.0 (12.6 to 19.4)	
Angle between the first and second metatarsals (in degrees)				
Age group				0.390
<60 years	12.7±2.2	5.9±1.7	6.8 (4.6 to 9.0)	
60 years or over	13.4±2.2	5.4±1.3	8.0 (5.9 to 10.1)	
Laterality				0.653
Right	13.0 ± 2.2	6.0 ± 1.5	7.0 (4.8 to 9.2)	
Left	13.0 ± 2.3	5.4 ± 1.6	7.6 (5.4 to 9.9)	

[a] Comparison of postoperative mean differences between groups.

The PBS technique differs from other percutaneous techniques in terms of the characteristics of the first metatarsal osteotomy, which is complete and extra-articular, offering better protection of the blood supply to the head of the metatarsal[3]. Although it does not involve use of the hardware generally used in other minimally invasive techniques, the PBS technique does demand use of radiation, with fluoroscopic images, to view correction of the deformity. Appropriate planning, an experienced surgeon, and correct technical execution are therefore essential to reduce exposure[12].

In the PBS, the intrinsic stability of the osteotomy and the postoperative dressing are the two most important elements that maintain correction of the deformity.

This study demonstrates that the PBS technique was capable of correcting moderate and severe HV deformities, enabling correction of the two most important radiographic parameters: the hallux valgus angle and the intermetatarsal angle (HVA and IMA).

In 2016, Biz et al.[9] assessed radiographic and functional results in patients with mild to severe HV who were treated with the Reverdin-Isham technique and Akin osteotomy, with a 48-month follow-up period. In that study, the HVA was reduced from 26.4° to 12.3° at the assessment 3 months after surgery, and to a mean of 13.9° at the last follow-up assessment, while the IMA was reduced from 12.9° to 9.0°.

In 2018, Liuni et al.[6] evaluated the PBS technique and observed better HVA and IMA correction, even in more severe deformities. Mean HVA reduced from 34° to 9.3° at 2 months and to 10.6° at the 38-month assessment, with an increase of just 1.3° from the 2-month follow-up assessment to the last follow-up assessment. In turn, mean IMA reduced from 13.5° to 8° at the 2-month postoperative assessment and then to 8.5° at the last follow-up assessment, with a 0.5° correction loss from the 2-month follow-up assessment to the last follow-up assessment at 38 months.

The results observed in this study corroborate the literature and demonstrate adequate correction of the HVA and the IMA using the PBS technique. It was observed that radiographic angle correction was maintained up to 12 months after surgery, with no relapse to moderate or severe deformity.

The most important limitation of this study is the lack of a control group, which is an indispensable factor for comparison of results with those of traditional surgical techniques. The small number of patients is considered another limitation, since a larger cohort could have enabled stratification into groups to better analyze the efficacy of this technique. Additionally, the following radiographic parameters were not analyzed: measurements taken with a lateral view and weightbearing, the position of sesamoids in the AP view with weightbearing, and shortening of the first metatarsal in the AP view with weightbearing. There was also no analysis of clinical assessments of amplitude of metatarsophalangeal joint movement. The follow-up period of our series is relatively short (12 months), in particular for assessment of HV relapse.

Conclusions

The characteristics that should encourage use of the PBS technique are its minimally invasive character, the low incidence of complications, elimination of use of hardware for fixation, early mobilization with weightbearing, and minimal surgical scarring. According to the results presented, use of this technique achieved adequate radiographic correction of symptomatic HV classified as moderate to severe. The results were maintained up to the assessment performed 12 months after surgery. Notwithstanding, controlled and randomized studies with longer follow-up are needed to improve the recommendation level for the technique.

Authors' contributions: TMVS *(https://orcid.org/0000-0001-8764-8560) Conceived and planned the activities that gave rise to the study, wrote the article, participated in the review process, approved the final version; MVMGM *(https://orcid.org/0000-0002-7320-9628) Participated in the review process, approved the final version; JSG *(https://orcid.org/0000-0001-5996-6641) Participated in the review process, approved the final version; TEVM *(https://orcid.org/0000-0002-9162-5908) Participated in the review process, approved the final version; TBF *(https://orcid.org/0000-0002-6122-3609) Participated in the review process, approved the final version; MJTG *(https://orcid.org/0000-0003-4068-2598) Participated in the review process, approved the final version; MR *(https://orcid.org/0000-0001-7683-7470) Participated in the review process, approved the final version. All authors read and approved the final manuscript. *ORCID (Open Researcher and Contributor ID).

References

1. Bösch P, Wanke S, Legenstein R. Hallux valgus correction by the method of Bösch: a new technique with a seven-to-ten-year follow-up. Foot Ankle Clin. 2000;5(3):485-98.
2. Nery CAS. Hallux valgus. Rev Bras Ortop. 2001;36(6):183-200.
3. Chan CX, Gan JZ, Chong HC, Rikhraj Singh I, Ng SYC, Koo K. Two year outcomes of minimally invasive hallux valgus surgery. Foot Ankle Surg. 2019;25(2):119-26.
4. Giannini S, Ceccarelli F, Bevoni R, Vannini F. Hallux valgus surgery: the minimally invasive bunion correction (SERI). Tech Foot Ankle Surg. 2003;2(1):11–20.
5. Magnan B, Pezzè L, Rossi N, Bartolozzi P. Percutaneous distal metatarsal osteotomy for correction of hallux valgus. J Bone Joint Surg Am. 2005;87(6):1191-9.
6. Liuni FM, Berni L, Fontanarosa A, Cepparulo R, Guardoli A, Pellegrini A, et al. Hallux valgus correction with a new percutaneous distal osteotomy: Surgical technique and medium term outcomes. Foot Ankle Surg. 2020;26(1):39-46.
7. Lucattelli G, Catani O, Sergio F, Cipollaro L, Maffulli N. Preliminary Experience With a Minimally Invasive Technique for Hallux Valgus Correction With No Fixation. Foot Ankle Int. 2020;41(1):37-43.

8. Maffulli N, Longo UG, Marinozzi A, Denaro V. Hallux valgus: effectiveness and safety of minimally invasive surgery. A systematic review. Br Med Bull. 2011;97:149-67.
9. Biz C, Fosser M, Dalmau-Pastor M, Corradin M, Rodà MG, Aldegheri R, et al. Functional and radiographic outcomes of hallux valgus correction by mini-invasive surgery with Reverdin-Isham and Akin percutaneous osteotomies: a longitudinal prospective study with a 48-month follow-up. J Orthop Surg Res. 2016;11(1):157.
10. Huang PJ, Lin YC, Fu YC, Yang YH, Cheng YM. Radiographic evaluation of minimally invasive distal metatarsal osteotomy for hallux valgus. Foot Ankle Int. 2011;32(5):S503-7.
11. Tanaka Y, Takakura Y, Takaoka T, Akiyama K, Fujii T, Tamai S. Radiographic analysis of hallux valgus in women on weightbearing and nonweightbearing. Clin Orthop Relat Res. 1997;(336):186-94.
12. Kay DB. Fixation Principles in Minimal Incision Hallux Valgus Surgery. Foot Ankle Clin. 2020;25(3):385-98.

DOI: https://doi.org/10.30795/jfootankle.2021.v15.1465

Original Article

Post-traumatic digital flexion contracture (checkrein deformity)

Alberto Macklin Vadell[1], **Enzo Sperone**[1], **Martín Rofrano**[1], **Andrés Bigatti**[1], **Matías Iglesias**[1], **Iván Torterola**[1]

1. Sanatorio Finochietto, Ciudad Autónoma de Buenos Aires, Buenos Aires, Argentina.

Abstract

Objective: The aim of this study is to present a series of 8 patients, describing their clinical picture and assessing their treatment using plantar approach.

Methods: We retrospectively assessed 8 patients, all of which had a history of trauma. The clinical characteristics of these cases and postoperative results were investigated.

Results: Seven men and 1 woman with a mean age of 29 years were included. The follow-up period ranged from 6 to 28 months (mean 22 months). The deformity manifested from 5 to 24 months after the triggering injuries (mean 9.8 months). The hallux was the only digit affected in 1 patient, while the others presented with involvement of 1 or more small toes. There were no postoperative complications, and patients showed to be satisfied with functional outcomes.

Conclusion: Post-traumatic digital flexion contracture is an infrequent disease of unknown etiology. Lengthening of the flexor hallucis longus using a plantar approach, whether at the level of the midfoot or the toe, represents an alternative with satisfactory outcomes.

Level of Evidence IV; Therapeutic Study; Case Series.

Keywords: Contracture; Hallux; Foot deformities, acquired.

Introduction

Flexion contracture at the hallux interphalangeal joint that presents after trauma is known as checkrein deformity and can manifest, to a lesser extent, with extension contracture of the metatarsophalangeal joint and also include small toes. This contracture is flexible and is produced during ankle dorsiflexion and is totally or partially corrected during plantar flexion (Figure 1). Furthermore, it occurs due to traction by the flexor hallucis longus (FHL) and, although its cause is not clear, it is commonly described as tendon entrapment at the level of the ankle or the hindfoot[1]. In the literature, checkrein deformity has been associated with ankle fractures, whether surgically treated or not, as well as with leg, pilon, talar, and calcaneal fractures[2-6]. The FHL may be entrapped in the fibrous scar tissue or in the bony callus[2-7]. Some authors consider that FHL shortening is caused by the development of subclinical deep compartment syndrome[6]. Checkrein deformity usually appears spontaneously from 2 to 12 months after the triggering injury[4,8].

Clawson[9], in 1974, was the first to describe checkrein deformity as a dynamic process associated with lower limb fractures.

Since then, several approaches have been described for its treatment, which consists of lengthening of the FHL tendon[1-4,6-8]. If necessary, release of flexor digitorum communis (FDC) tendon or distal tenotomy is performed[6]. Endoscopic release of the fibrous tissue that entraps the FHL tendon with no need for its lengthening has also been described[10].

The aim of this study is to present a series of 8 patients with checkrein deformity, describing their clinical picture and assessing their treatment using a plantar approach.

Methods

This study was approved by the Ethics Committee of our institution.

We retrospectively evaluated 8 patients that had been operated by the same surgical team from 2011 to 2019. Four of

Study performed at the Sanatorio Finochietto, Ciudad Autónoma de Buenos Aires, Buenos Aires, Argentina.

Correspondence: Andrés Bigatti. Arcos 2728 1°14, Ciudad Autónoma de Buenos Aires – 1428, Buenos Aires, Argentina. E-mail: andres_bigatti9@hotmail.com
Conflicts of interest: none. **Source of funding:** none. **Date received:** April 11, 2021. **Date accepted:** July 02, 2021. **Online:** August 31, 2021.

How to cite this article: Macklin Vadell A, Sperone E, Rofrano M, Bigatti A, Iglesias M, Torterola I. Post-traumatic digital flexion contracture (checkrein deformity). J Foot Ankle. 2021;15(2):146-9.

these patients initially presented with closed leg fracture and were treated with intramedullary nailing; the remaining cases were the following: a closed leg fracture treated with casting, a closed fracture of the distal tibia treated with an external tutor, a closed fracture-dislocation of the ankle, and a closed ankle fracture, the last 2 treated with open reduction and internal fixation (Table 1).

The main patients' reasons for consultation were pain on the tip of the hallux, difficulty in wearing closed shoes, and gait changes. On physical examination, all patients presented with dynamic deformity of the hallux. Flexion of the interphalangeal joint and extension of the metatarsophalangeal joint were observed at ankle dorsiflexion, but this deformity was reduced at ankle plantar flexion. Weight bearing frontal and profile X-rays of leg, ankle and foot were requested for all patients, as well as echography and nuclear magnetic resonance (NMR), for diagnostic purposes.

Furthermore, the present study assessed the time elapsed from the initial injury to the onset of the deformity and whether there was involvement of small toes.

Patients were surgically treated with Z-lengthening of the FHL tendon and release of FDC when necessary. Seven of these patients were operated using a plantar approach, and only 1 case was approached distally at the level of the hallux. Below we describe the surgical technique employed in each approach.

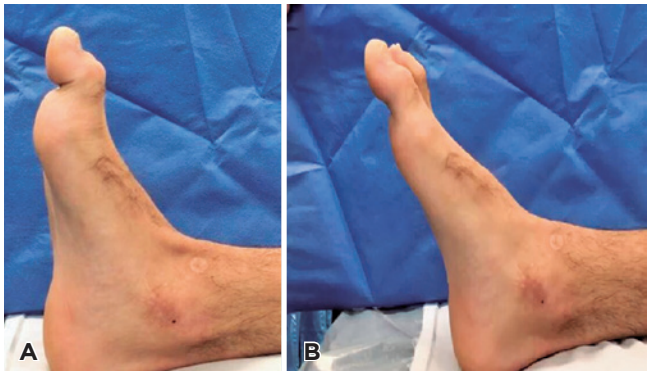


Figure 1. A) Flexion of the interphalangeal joint of the hallux at ankle dorsiflexion. B) Correction of the deformity at ankle plantar flexion.

The 8 operated patients were clinically assessed for pain according to the visual analog scale (VAS), type of shoe (possibility of using any type of shoes without making any change to them, limitation in the use of certain types of shoes, need for custom-made shoes), and degree of satisfaction (whether the patient would undergo surgery again).

Surgical technique and postoperative care: Plantar midfoot approach

The patient was placed in a supine position on the operating table, surgical fields were positioned according to the technique; moreover, a hemostatic cuff was used on the homolateral thigh, with enhancement at the level of the contralateral buttock. A longitudinal incision of approximately 3cm was made, lateral to the abductor muscle of the hallux and 2 cm proximal to the medial sesamoid bone. Tissue dissection was performed in layers, and FHL and FDC tendons were identified. Z-plasty lengthening was performed in order to achieve complete extension of the interphalangeal and metatarsophalangeal joints of the hallux with the ankle in the neutral position and suture with a non-resorbable monofilament thread (Figure 2). If there was involvement of small toes, tendinous connections were divided between the FHL and the FDC. If deformity persisted, percutaneous tenotomy was performed at the proximal level of the distal interphalangeal joint of each toe. Layered closure was performed. In the postoperative period, immobilization is maintained with a short cast boot including the hallux and the ankle at 90° for 6 weeks. Subsequently, the cast was removed, and weight bearing was initiated with a Walker boot and progressive mobilization of ankle and hallux.

Digital approach

The patient was placed in a supine position on the operating table, surgical fields were positioned according to the technique, a hemostatic cuff was placed on the homolateral thigh, with enhancement at the level of the contralateral

Table 1. Analysis of patients' characteristics.

	Age	Sex	Initial trauma	Initial treatment	Time of onset	Small toes	Approach
1	37	M	Leg Fx	IMN	14 months	All	Midfoot
2	26	M	Distal tibial Fx	External tutor	6 months	None	Midfoot
3	21	M	Ankle FD	ORIF	24 months	2nd	Midfoot
4	43	F	Leg Fx	IMN	8 months	2nd and 3rd	Midfoot
5	13	M	Leg Fx	Casting	5 months	2nd	Midfoot
6	29	M	Leg Fx	IMN	7 months	2nd	Midfoot
7	27	M	Ankle Fx	ORIF	9 months	2nd	Midfoot
8	39	M	Leg Fx	IMN	6 months	2nd	Digital

*M (Male); F: (Female); Fx: (Fracture); FD: (Fracture-Dislocation); IMN: (Intramedullary Nailing); ORIF: (Open Reduction and Internal Fixation).

buttock. A 3-cm incision is made on the plantar surface of the hallux. Tissue dissection was performed in layers, and FHL was identified. Z-plasty lengthening was performed in order to achieve complete extension of the interphalangeal and metatarsophalangeal joints of the hallux with the ankle in the neutral position and suture with a non-resorbable monofilament thread (Figure 3). In case of involvement of small toes, percutaneous tenotomy was performed at the proximal level of the distal interphalangeal joint of each toe. Layered closure was performed. In the postoperative period, immobilization was maintained with a short cast boot including the hallux and the ankle at 90° for 6 weeks. Subsequently, the cast was removed, and weight bearing was initiated with a Walker boot and progressive mobilization of ankle and hallux.

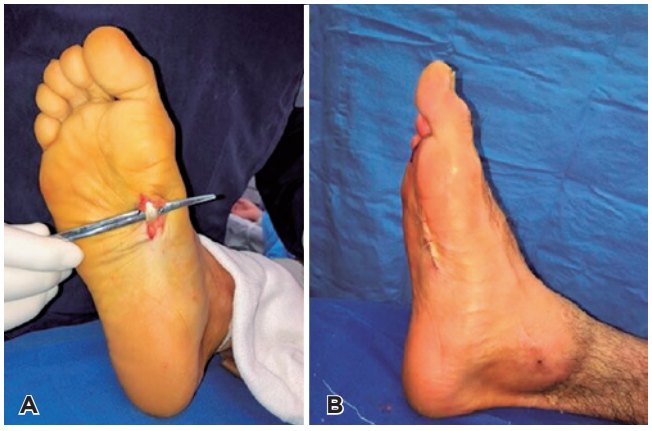


Figure 2. A) Identification of the FHL tendon using a plantar midfoot approach. B) Correction of the deformity.

Figure 3. Digital approach.

Results

Eight patients were retrospectively assessed, 7 men and 1 woman, with a mean age of 29 years (from 13 to 43 years). The postoperative follow-up of the 8 treated patients lasted for a minimum of 6 and a maximum of 28 months (mean 22 months).

Checkrein deformity manifested from 5 to 24 months after the initial injury (mean 9.8 months) (Table 1). This deformity affected only the hallux in 1 patient (12.5%); conversely, it also affected the second toe in 5 patients (62.5%), the second and the third toes in 1 patient (12.5%), and all small toes in 1 patient (12.5%).

The patients did not have neither wound complications nor postoperative neurovascular injuries. There were no recurrences nor need for reintervention. Seven patients reported absence of pain, and 1 reported mild pain. The 8 patients answered that they could wear any type of shoes without making any change to them and that they would undergo surgery again.

There were no evident functional differences between the cases in which lengthening of the FHL tendon was performed at the level of midfoot and the case that was approached at the level of the hallux.

Discussion

Post-traumatic digital flexion contracture, known as checkrein deformity, consists of the dynamic flexion of the interphalangeal joint and, to a lesser extent, extension of the metatarsophalangeal joint of the hallux. It manifests at ankle dorsiflexion and is totally or partially corrected at ankle plantar flexion. Small toes may also be affected, due to the connections between FHL and FDC tendons.

Checkrein deformity has been mainly related to leg and ankle fractures in the literature, which is consistent with our series. However, the cause of this deformity has not been elucidated yet. There have reports of adherence of the FHL tendon to the scar tissue surrounding the fracture[7] or entrapment of this tendon in the callus formed after fracture union[2]. However, none of these 2 situations could explain the development of this deformity in patients who do not have a fracture[8]. Feeney et al.[6] consider subclinical compartment syndrome of the leg as a possible explanation in those cases. The distal portion of the FHL muscle is found in a smaller and deeper compartment; thus, a localized increase in pressure could generate ischemia and muscle retraction[11].

NMR and echography allow us to visualize the muscle injury and the relationship of nervous and vascular structures with possible areas of fibrosis, edema, and hematoma, but they did not define the specific cause of the problem.

Clinically, the patients may present pain on the tip of the hallux due to hyperpressure, difficulty in crouching, gain limitation, and impossibility to wear certain type of shoes, especially women.

Kinesic treatment is not beneficial for these patients. We consider that treatment is surgical and consists of lengthening of the FHL tendon.

Feeney et al.[6] reported goods outcomes with Z-plasty through an internal retromalleolar approach in 10 patients. Lee et al.[8] found 2 partial recurrences and 1 complete recurrence in 5 patients using the same approach.

Lee et al.[1] reported good outcomes and no case of recurrence with an approach at the level of the tarsal tunnel in 8 patients. They did not have neurovascular complications; however, the authors describe the possibility of developing tarsal tunnel syndrome, thus highlighting the importance of taking care not to damage the neurovascular bundle.

Tenotomy and interphalangeal arthrodesis of the hallux may be good options, especially in the case of recurrence[12].

In our series, we observed very good outcomes with Z-lengthening of the FHL through plantar midfoot approach in 7 patients and with digital approach in 1 patient. There were no recurrences, and no differences were observed in final outcomes between the 2 approaches. Other authors have published good outcomes with the plantar midfoot approach[8,13]. Conversely, there is no clear evidence on the outcomes with distal approach. The need of performing distal tenotomies in case of involvement of small toes may be a disadvantage of the digital approach. Finally, the possibility of neurovascular injuries and postoperative adherences are lower with these 2 approaches compared to those using the tarsal tunnel and the internal retromalleolar area[1,8].

Conclusion

Post-traumatic digital flexion contracture is an infrequent injury of unclear etiology. It may be associated with different conditions, the most common of which being leg and ankle fractures. Plantar approaches, at the level of the midfoot and the toe, allow to lengthen the FHL tendon enough to correct the deformity with low risk of neuromuscular injuries and postoperative adhesions.

Authors' contributions: Each author contributed individually and significantly to the development of this article: AMV *(https://orcid.org/0000-0002-0384-4044) Conceived and planned the activities to execute the work, participated in the interpretation of the results, performed the surgeries and approved the final versión; ES *(https://orcid.org/0000-0001-5028-9584) Conceived and planned the activities to execute the work, participated in the interpretation of the results, performed the surgeries; MR *(https://orcid.org/0000-0003-1947-8218) Participated in the interpretation of the results and performed the surgeries; AB *(https://orcid.org/0000-0003-1690-025X) participated in the bibliographic search and executing the work; MI *(https://orcid.org/0000-0002-6336-6080) Participated in data collection and clinical evaluation of patients; IT *(https://orcid.org/0000-0001-9210-9051) Participated in the bibliographic search and the clinical evaluation of the patients. All authors read and approved the final manuscript. *ORCID (Open Researcher and Contributor ID).

References

1. Lee JH, Kim YJ, Baek JH, Kim DH. Z-plasty of the flexor hallucis longus tendon at tarsal tunnel for checkrein deformity. J Orthop Surg (Hong Kong). 2016;24(3):354-7.
2. Kim SH, Lee KT, Smith RW, Park YU. Checkrein deformity secondary to entrapment of FHL after talus fracture: a case report. Foot Ankle Int. 2010;31(4):336-8.
3. Rosenberg GA, Sferra JJ. Checkrein deformity--an unusual complication associated with a closed Salter-Harris Type II ankle fracture: a case report. Foot Ankle Int. 1999;20(9):591-4.
4. Sanhudo JA, Lompa PA. Checkrein deformity--flexor hallucis tethering: two case reports. Foot Ankle Int. 2002;23(9):799-800.
5. Carr JB. Complications of calcaneus fractures entrapment of the flexor hallucis longus: report of two cases. J Orthop Trauma. 1990;4(2):166-8.
6. Feeney MS, Williams RL, Stephens MM. Selective lengthening of the proximal flexor tendon in the management of acquired claw toes. J Bone Joint Surg Br. 2001;83(3):335-8.
7. Leitschuh PH, Zimmerman JP, Uhorchak JM, Arciero RA, Bowser L. Hallux flexion deformity secondary to entrapment of the flexor hallucis longus tendon after fibular fracture. Foot Ankle Int. 1995; 16(4):232-5.
8. Lee HS, Kim JS, Park SS, Lee DH, Park JM, Wapner KL. Treatment of checkrein deformity of the hallux. J Bone Joint Surg Br. 2008; 90(8):1055-8.
9. Clawson DK. Claw toes following tibial fracture. Clin Orthop Relat Res. 1974;(103):47-8.
10. Lui TH. Endoscopic adhesiolysis of the flexor hallucis longus muscle. Foot Ankle Spec. 2014;7(6):492-4.
11. Sassu P, Acland RD, Salgado CJ, Mardini S, Ozyurekoglu T. Anatomy and vascularization of the flexor hallucis longus muscle and its implication in free fibula flap transfer: an anatomical study. Ann Plast Surg. 2010;64(2):233-7.
12. Holcomb TM, Temple EW, Barp EA, Smith HL. Surgical correction of checkrein deformity after malunited distal tibia fracture: a case report. J Foot Ankle Surg. 2014;53(5):631-4.
13. Miranda BR, Barroco RS, Nishikawa DRC, Oliveira LZP, Ghani MBA. Checkrein deformity treated through a forefoot approach: a case report. Sci J Foot Ankle. 2019;13(4):259-63.

DOI: https://doi.org/10.30795/jfootankle.2021.v15.1545

Original Article

Epidemiological study of open fractures of the ankle and foot

Leandro Pessoa Carneiro[1], Luiz Augusto Sampaio Gonzaga Filho[1], Jorge Mitsuo Mizusaki[1], Sergio Damião Santos Prata[1], Marco Antonio Giglioli Rizzo[1]

1. Hospital Santa Marcelina, São Paulo, SP, Brazil.

Abstract

Objective: To characterize the epidemiological profile of patients treated at a hospital service with diagnosis of open fracture of the ankle and foot.

Methods: Retrospective, descriptive, epidemiological, observational study of open fractures of the ankle and foot selected by convenience sampling in a hospital service in São Paulo, state of São Paulo, Brazil, from March 1, 2017, to March 1, 2019, totaling 109 patients. Data collection was conducted for the analysis of variables included in patients' medical records.

Results: The medical records of 700 patients with open fractures were assessed. Of these patients, 13.2% (109 patients) had open fractures of the ankle and foot. There was a predominance of male young adults (70.8%) and of left lower limb fractures (51.85%). Most cases were classified as Gustilo and Anderson type II fractures (42.6%). Motorcycle accidents (44.45%) predominated, and students and professional motorcyclists were the most frequent occupations (37.04%). The most adopted stabilization method was osteosynthesis (internal fixation) (44.45%), and primary amputation was required in 3.7% of the cases.

Conclusion: Male young adults were the most affected by fractures of the ankle and foot, and traffic accidents were the leading cause. Most patients had an educational attainment of complete elementary education. Most fractures were classified as Gustilo and Anderson type II. Greater severity was observed in patients with associated injuries in other body segments and who developed early complications during hospitalization.

Level of Evidence IV; Prognostic Studies; Case Series.

Keywords: Open fractures/epidemiology; Foot bones; Ankle; Feet.

Introduction

Traffic accidents have a major negative socioeconomic impact and lead to high public health costs, especially those resulting in open fractures[1,2]. After the development of automotive vehicles and motorcycles, there has been a change in the pattern of fractures, characterized by more severe impairment of bones and soft tissues, which cause prolonged hospitalization and recovery periods[3,4].

The incidence of open fractures is estimated at 11.5 per 100,000 people, with lower limb fractures accounting for 40% of the cases. There have been variations in the epidemiology of fractures of the foot and ankle in different studies and in different regions of Brazil. An epidemiological study conducted in the state of Minas Gerais found that 13.2% and 5% of open fractures involved the foot and the ankle, respectively[5]. Similar results were observed in the southeast and north region, with involvement of the foot in 11.2% and 11.5% of the cases, and of the ankle in 4.8% and 4.26% of them, in this order[6,7]. Differences were observed in the state of São Paulo, where involvement of the ankle was more frequent than that of the foot, accounting for 11.27% and 4.91%, respectively[8].

The treatment of open fractures aims at caring for soft tissue injuries, as well as achieving early stabilization of fracture and preventing infection[9-12].

The aim of this study was to characterize the epidemiologic profile of open fractures of the ankle and foot.

Study performed at the Hospital Santa Marcelina, São Paulo, SP, Brazil.

Correspondence: Leandro Pessoa Carneiro. Rua Santa Marcelina, 177, Vila Carmosina - 08270-070, São Paulo, SP, Brazil. **E-mail**: leandro.carneiro7@gmail.com. **Conflicts of Interest:** none. **Source of funding:** none. **Date received:** June 23, 2021. **Date accepted:** July 07, 2021. **Online:** August 31, 2021.

How to cite this article: Carneiro LP, Gonzaga Filho LAS, Mizusaki JM, Prata SDS, Rizzo MAG. Epidemiological study of open fractures of the ankle and foot. J Foot Ankle. 2021;15(2):150-4.

Methods

This study was approved by the Institutional Review Board and registered on the Plataforma Brasil database under CAAE number: 39571320.5.0000.0066.

After study approval by the institutional REC, data were collected using a retrospective, descriptive, observational design. Patients were selected by convenience sampling in the institution.

The study assessed 700 medical records of patients admitted to a high-complexity hospital in the city of São Paulo, state of São Paulo, Brazil, with the diagnosis of open fracture, from March 1, 2017, to March 1, 2019.

All admitted patients diagnosed with open fracture of the foot and ankle were included. Exclusion criteria were patients previously treated at another services or hospitals; those who were admitted more than 6 hours after the accident; cases of hospital evasion and death before the orthopedic procedure; and those who refused to sign the informed consent form (ICF). The final sample consisted of 109 patients.

A data collection instrument was developed to analyze the medical records of patients with open fracture of the ankle and foot, which included questions on gender, affected side, occupation, educational attainment, etiology of trauma, type of pre-hospital care, mean of transportation to the emergency room (ER), day of the week, time of the accident, associated injuries, type of treatment received, length of hospital stay, and infections.

We also sought to investigate the consumption of alcohol or illegal drugs (marijuana, cocaine, crack, heroine, ecstasy, solvents) in the 6 hours preceding trauma. This information was verified from patients' report registered in their medical records, and no additional toxicological tests were performed to confirm these reports. The 6-hour interval may be explained by the average time when alcohol can be identified in blood toxicological tests. Data were collected by orthopedic and trauma residents, orthopedists, and experts in foot and ankle surgery.

Open fractures were classified according to the classification proposed by Gustilo and Anderson[11], which describes associated soft tissue injuries and may partly determine the treatment and prognosis of these injuries. Fractures classified as Gustilo and Anderson type II and III initially underwent debridement, surgical mechanical cleaning, and primary or secondary wound coverage, together with provisional external fixation for stabilization. Similarly, type I fractures received initial care for soft tissues and, depending on type and angle of deviation of the fractures, received conservative treatment with immobilization or subjected to permanent internal fixation.

The collected data were processed through Microsoft Excel spreadsheets, version 2017. Homogeneity between categories of qualitative variables (seasonal distribution, day of the week, time, age, educational level and occupation, type of accident, method of pre-hospital care and transport to hospital, classification of fractures) and the presence of association between these variables were assessed by the Pearson's chi-square test using the SPSS 20.0 software. All tests considered a level of significance of 5% (α=0.05), with statistical significance set at $p<0.05$.

Results

Open fractures of the foot and ankle accounted for 15.6% (109 fractures) of overall fractures. The most prevalent age group was that from 21 and 30 years, with statistical significance ($p<0.001$), and mean age was 28.21 years (Figure 1). There was a predominance of men (70.8%) and involvement of the left side (51.85%). Motorcycle accidents predominated (44.45%), followed by running overs (14.82%) (Table 1). The most frequent occupations were students (26.92%) and professional motorcyclists (15.4%) (Table 2), and most patients had an educational attainment of complete elementary education (59%) (Figure 2). It was found that 14.82% of the cases were repeated cases.

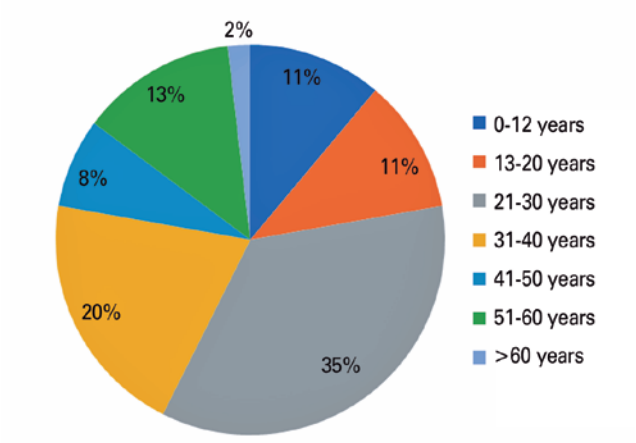


Figure 1. Patients' distribution by age group.

Table 1. Distribution by occupation

Occupation	Percentage (%)
Student	26.92
Motorcyclist	15.40
Construction industry	10.52
Trade industry	7.60
Retired	6.43
Manufacturing	6.14
Self-employed	5.55
Security industry	3.50
Unemployed	2.63
Housekeeper	1.75
Transportation industry	1.75
Agriculture	1.16
Other	10.59

Table 2. Distribution by trauma etiology

Etiology	Percentage
Motorcycle accident	44.45
Running over	14.82
Smashing	11.10
Fall from height	11.12
Automobile accident	5.56
Fall from one's height	3.7
Bicycle accident	3.7
Firearm wound	1.85
Physical aggression	1.85
Sports activity	1.85

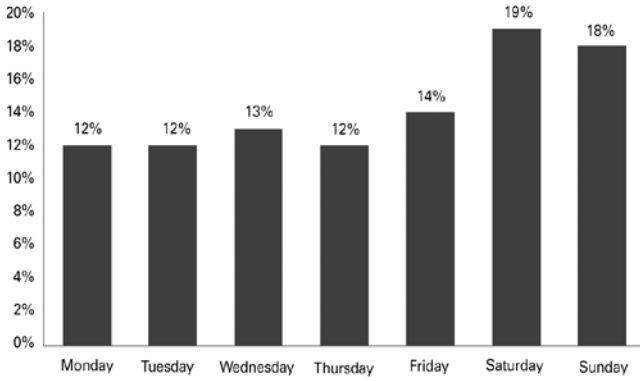


Figure 3. Distribution by day of the week.

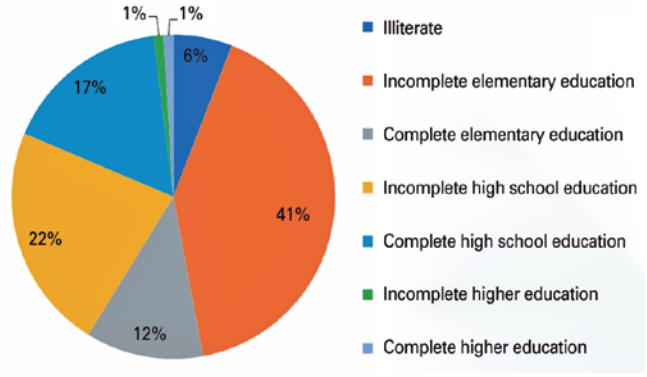


Figure 2. Distribution by educational attainment.

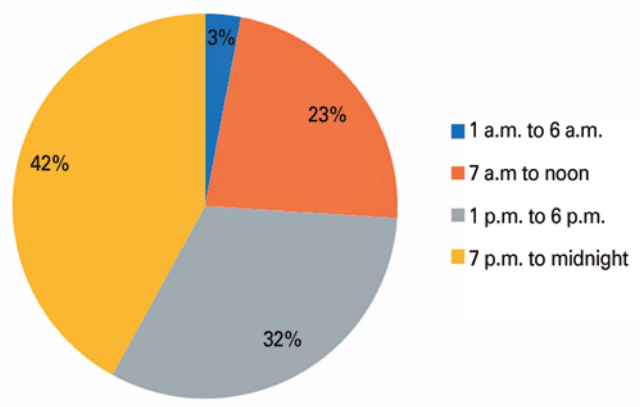


Figure 4. Distribution by time of day.

The occurrence of open fractures was greater in weekend days than weekdays (48.44%) (Figure 3), but with no statistical significance. Most accidents occurred from 7 p.m. to midnight (42%) (Figure 4), with statistical significance ($p<0.001$) compared to the other periods of the day.

The frequency of consumption of alcohol, illegal drugs (marijuana, cocaine, crack, heroin, ecstasy, solvents), and both in the 6 hours before the accident was 12.84%, 1.83%, and 3.66%, respectively. With regard to illegal drugs, two patients (1.83%) reported marijuana consumption, and four (3.66%) reported use of alcohol and cocaine in the 6 hours before the trauma.

In relation to fracture severity, there was a predominance of Gustilo and Anderson[4] type II fracture (moderate degree of contamination and skin injury >1cm and <10cm) (42.6%), followed by IIIA type fractures (high degree of contamination with skin injury >10cm, with possibility of primary coverage) (Figure 5). Furthermore, 22.06% of fractures had other trauma-associated injuries, such as close fractures (11%), skin injuries in other topographies (7.4%), abdominal trauma (1.83%), and traumatic brain injury (1.83%).

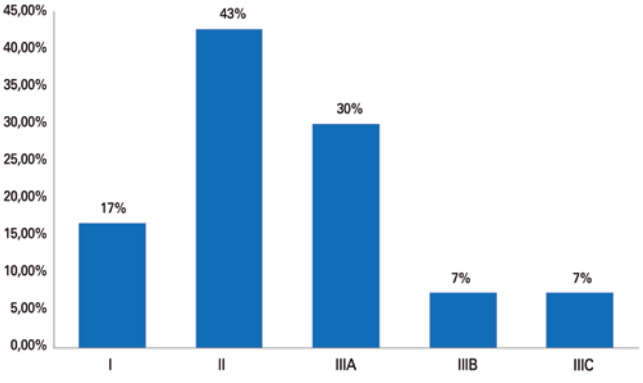


Figure 5. Distribution according to Gustilo and Anderson classification (Type I, II, IIIA, IIIB, IIIC).

The Mobile Urgent Care Service (*Serviço de Atendimento Móvel de Urgência*, SAMU) was the responsible for pre-hospital care and transportation to the ER in 56.72% of the cases, followed by the fire brigade (35 cases; 32.16%). Furthermore, 7.89% of patients arrived at the PS using their own mean of transportation, and 3.21% of them were rescued by the air services of the military police.

The type of treatment implemented in all cases (100%) involved antibiotic therapy, care of damaged soft tissues, appropriate cleaning, debridement, and fracture stabilization. The most frequent method of permanent bone stabilization was osteosynthesis (internal fixation) (56.45%), followed by external fixation (33.34%). Primary amputation was required in 3.7% of the cases. Permanent conservative treatment of fractures through immobilization (plaster cast sprints, plastering) was conducted in 6.51% of the cases.

Mean length of hospital stay was 8.57 days, and the rate of early infection was 7.4% in the first 7 days of fracture.

Discussion

It is assumed that, currently, the incidence of lower limb open fractures account for 40% of overall fractures[1,9]. Previously published studies found percentage variations in the occurrence of open fractures of foot and ankle with regard to the other body segments. Fractures of the distal tibia accounted for less than 1% of lower limb open fractures[5,13,14]. The percentage of open ankle fractures ranged from 4.8% to 11.27% of open fractures, whereas foot fractures ranged from 4.91% to 13.2%[5-8].

Other studies found that tibial pilon fractures associated with ankle fractures were present in 17% of the cases, and in 10.5% when associated with fractures of foot and ankle[13,15].

In the current study, the percentage of open fractures of foot and ankle was 15.6%, a result similar to that of previously published papers[1,5-9,11].

The implemented treatments were based on the current guidelines for open fractures, which establish that care should be initiated as early as possible at the site where the trauma occurred, with prompt wound isolation, limb immobilization, and hemorrhage control. Broad spectrum antibiotic therapy is recommended according to the degree of contamination and extent of skin injury, as proposed by the Gustilo and Anderson Classification[11]. In most cases, first-generation cephalosporins were administered aiming at both gram-positive and gram-negative germs. In selected cases with intense contamination and extensive skin injuries (>10cm), i.e., Gustilo and Anderson type III fractures[11], the addition of aminoglycosides aimed at gram-negative germs is recommended, and was implemented in the analyzed cases[6-8,11,12,16,17].

In the current study, the percentage of early infections (first 7 days) was 7.4%, results that differ from those of other studies from the national literature, which found percentages of 13.24%, 18.80%, and 23.7% for open fractures in general[18-20], and most infections were observed in open fractures classified as Gustilo and Anderson type III[18-22]. It is inferred that our results were lower than those observed in the literature due to the higher percentage of less severe fractures in the current study (42% of Gustilo and Anderson type II open fractures); additionally, most study were prospective, with follow-up duration longer than 6 weeks[18-22]. In the study with the highest percentage of infections (23.7%), it was found that this high percentage was associated with severity of soft tissue injuries and delayed orthopedic treatment[22]. Similarly, the study by Fernandes et al. found a statistically significant increase in infections rates for more severe fractures and that had their treatment delayed by 6 hours after trauma[18].

In order to minimize the risk for infection, timely treatment is performed with complete debridement, in which all foreign bodies and contaminated tissues, or those with suspected avascularization, are systematically removed, and death spaces and hematomas are minimized[13,17-22].

Patients underwent safe skeletal stabilization, with the recovery of limb length, a measure that enable to reestablish the appropriate soft tissue tension, in addition to improving circulation and facilitate venous and lymphatic return, thus favoring edema reduction[13,17-22].

According to the literature, plaster and traction devices are used less frequently in patients with open fractures[13,18,20], a finding consistent with the results obtained in the present study. Plaster devices hinder wound inspection and dressings, which may compromise early detection of ongoing compartment syndrome, as well as presence of skin necrosis, bullae, and infections[13,18,20].

External fixators are used mainly as temporary stabilizers, with conversion to internal fixation being performed at the appropriate time, provided there are no contraindications. Permanent treatment with an external fixator may be suggested if the patient has a stable fracture configuration, good quality reduction and circumferential contact[13,18,21-24].

Conclusion

This epidemiological study allowed us to characterize the pattern of open fractures of the ankle and foot, as well as patients' socioeconomic characteristics, and presence of associated injuries.

Male young adults were the most affected by these fractures, and traffic accidents were the leading cause. Most patients had an educational attainment of complete elementary education. Most fractures were classified as Gustilo and Anderson type II.

Authors' contributions: Each author contributed individually and significantly to the development of this article: LPC *(https://orcid.org/0000-0001-6106-0101) Reviewed bibliography, data collection, wrote the paper, interpreted the results of the study, participated in the review process; LASGF *(https://orcid.org/0000-0002-5765-2304) Reviewed bibliography, collected the data, interpreted the results of the study, participated in the review process; JMM *(https://orcid.org/0000-0001-6039-4599) conceived and planned the activities that led to the study, interpreted the results of the study, participated in the review process; SDSP *(https://orcid.org/0000-0001-5957-527X) conceived and planned the activities that led to the study, reviewed bibliography, wrote the paper, interpreted the results of the study, participated in the reviewing process, participated in the review process; MAGR *(https://orcid.org/0000-0002-7424-9074) conceived and planned the activities that led to the study, interpreted the results of the study, participated in the review process. All authors read and approved the final manuscript. *ORCID (Open Researcher and Contributor ID).

References

1. Lange RH, Bach AW, Hansen ST, Johansen KH. Open tibial fractures with associated vascular injuries: prognosis for limb salvage. J Trauma. 1985;25(3):203-8.
2. Sousa RLB, Sousa GS, Monroe KMCM, Pereira MGS. Injury accident reporting at a public hospital in the Brazilian Amazon. Rev Bras Promoç Saúde. 2017;30(1): 64-71.
3. Andrade LM, Lima MA, Silva CHC, Caetano JA. Motorcycle accidents: characteristics of the victims and accidents at a hospital in Fortaleza - CE, Brazil. Rev Rene, Fortaleza. 2009; 10(4):52-9.
4. Trevisol DJ, Bohm RL, Vinholes DB. Epidemiological profile of patients victims of traffic accidents treated in theemergency room of Hospital Nossa Senhora da Conceição in Tubarão,Santa Catarina state, Brazil. Rev Scientia Médica. 2012;22(3):148-52.
5. Cunha FM, Braga GF, Drumond Júnior SN, Figueiredo CTO. [Epidemiology of 1,212 open fractures]. Rev Bras Ortop. 1998; 33(6):451-6.
6. Prata Filho C, Mibielli MAN, Silos SS. Epidemiology of exposed fractures in the Clinic Hospital of Teresópolis – RJ. Rev Fac Med Teresópolis. 2018;2(2):113-23.
7. Guimarães RNO, Gurgel BEM, Valente NC, Maia FSC, Conceição TF. [Open fractures: epidemiological characterization of patients treated at a hospital in the Amazon]. Rev Cient Multidisc Nucl Conhec. 2009;6(4):117-31.
8. Arruda LRP, Silva MAC, Malerba FG, Fernandes MC, Turíbio FM, Matsumoto MH. Open fractures: prospective and epidemiological study. Acta Ortop Bras. 2009;17(6):326-30.
9. Court-Brown CM, Brewster N. Epidemiology of open fractures. In: Court-Brown CM, McQueen MM, Quaba AA, editors. Management of open fractures. London: Martin Dunitz; 1996. p. 25-35.
10. Brumback RJ. Open tibial fractures: current orthopedic management. Instr Course Lect. 1992;41:101-17.
11. Gustilo RB, Anderson JT. Prevention of infection in the treatment of one thousand and twenty-five open fractures of long bones: retrospective and prospective analyses. J Bone Joint Surg Am. 1976;58(4):453-8.
12. Worlock P, Slack R, Harvey L, Mawhinney R. The prevention of infection in open fractures: an experimental study of the effect of fracture stability. Injury. 1994;25(1):31-8.
13. Jaña Neto FC, Canal MP, Alves BAF, Ferreira PM, Ayres JC, Alves R. Analysis of the characteristics of patients with open tibial fractures of Gustilo and Anderson type III. Rev Bras Ortop. 2016; 51(2):143-9.
14. Court-Brown CM, Christie J, McQueen MM. Closed intramedullary nailing. Its use in closed and type | open fractures. J Bone Joint Surg Br. 1990;72(4):605-11.
15. Santos LFS, Fonseca JMA, Cavalcante BLS, Lima CM. Epidemiologic of orthopedic trauma study in a public emergency. Cad Saúde Coletiva. 2016;24(4):397-403.
16. Melcher GA, Hauke C, Metzdorf A, Perren SM, Printzen G, Schelegel U, et al. Infection after intramedullary nailing: an experimental investigation on rabbits. Injury. 1996;27 Suppl 3:SC23-6.
17. Moehring HD, Gravel C, Chapman MW, Olson SA. Comparison of antibiotic beads and intravenous antibiotics in open fractures. Clin Orthop Relat Res. 2000;(372):254-61.
18. Fernandes MC, Peres LR, Queiroz Neto AC, Lima Neto JQ, Turíbio FM, Matsumoto MH. Open fractures and the incidence of infection in the surgical debridement 6 hours after trauma. Acta Ortop Bras. 2015;23(1):38-42.
19. Oliveira R, Cruz L, Matos M. Comparative accuracy assessment of the Gustilo and Tscherne classification systems as predictors of infection in open fractures. Rev Bras Ortop. 2018;53(3):314-8.
20. Guerra MTE, Gregio FM, Bernardi A, Castro CC. Infection rate in adult patients with open fractures treated at the emergency hospital and at the ULBRA university hospital in Canoas, Rio Grande do Sul, Brazil. Rev Bras Ortop. 2017;52(5):544-8.
21. Müller SS, Sadenberg T, Pereira GJC, Sadatsune T, Kimura EE, Novelli Filho JLV. Epidemiological, clinical and micorbiological prospective study of patients with open fractures assisted at a university hospital. Acta Ortop Bras. 2003;5:158-69.
22. Matos MA, Nascimento JM, Silva BVP. Clinical and demographic study on open fractures caused by motorcycle traffic accidents. Acta Ortop Bras. 2014;22(4):214-8.
23. Norris BL, Kellam JF. Soft tissues injuries associated with high-energy extremity trauma: principles of management. J Am Acad Orthop Surg. 1997;5(1):37-46.
24. Pacolla CAJ. Open fractures. Rev Bras Ortop. 2001;36(8):283-91.

DOI: https://doi.org/10.30795/jfootankle.2021.v15.1564

Original Article

Functional evaluation of patients undergoing endoscopic calcaneoplasty for Haglund deformity

Hallan Douglas Bertelli[1], Bruno Arvatti Michelin[1], Isabela Ferreira Perucci[1], Mario Sérgio Paulillo de Cillo[1], Carlos Daniel Candido Castro Filho[1], Rodrigo Guimarães Huyer[1]

1. PUC - Pontifícia Universidade Católica de Campinas, Campinas, SP, Brazil.

Abstract

Objective: To analyze the functional outcomes of patients undergoing endoscopic calcaneoplasty for the treatment of Haglund deformity.

Methods: This study consists of a case series of patients undergoing endoscopic calcaneoplasty. The American Orthopaedic Foot and Ankle Society ankle-hindfoot scale, was used to evaluate patients before and 12 months after the procedure, providing preoperative and postoperative scores.

Results: Nineteen patients were evaluated for a total of 24 endoscopic calcaneoplasties. The American Orthopaedic Foot and Ankle Society scale provided a mean preoperative score of 31.4 and a mean postoperative score of 93.3, which shows a significantly increased score after surgery. The mean patient age was 52 years, and the youngest patient was 25 years old and the oldest patient was 73 years old. However, no significant relationship was found between age and change in the American Orthopaedic Foot and Ankle Society score. No complications were observed in the immediate or late postoperative periods.

Conclusion: Arthroscopic resection is efficient in the treatment of Haglund deformity given the significant improvement in the American Orthopaedic Foot and Ankle Society score observed after the procedure. Also, no postoperative complications were seen in patients who underwent endoscopic calcaneoplasty.

Level of Evidence: IV; Therapeutic Studies; Case series.

Keywords: Calcaneus/surgery; Exostoses; Endoscopy; Bursitis; Arthroscopy.

Introduction

Haglund syndrome refers to a triad formed by an increased posterosuperior calcaneal prominence (Haglund deformity), retrocalcaneal bursitis, and insertional Achilles tendinopathy. The typical clinical presentation consists of pain, edema, and hyperemia in the posterior region of the calcaneus, close to the calcaneal tendon insertion[1].

The retrocalcaneal bursa provides a gliding surface for the Achilles tendon during dorsiflexion and plantar flexion movements[2]. Retrocalcaneal bursitis is caused by impingement of the retrocalcaneal bursa between the posterosuperior process of the calcaneus and the anterior aspect of the Achilles tendon[3].

Achilles tendinopathy is caused by friction of the anterior Achilles tendon insertion against the bony prominence, especially when combined with a shortened triceps surae muscle. This results in local damage to the tendon and can lead to the appearance of partial longitudinal intratendinous tears[4].

The condition usually affects middle-aged individuals, preferably women, and is often bilateral. Differential diagnoses include traumas, such as calcaneal stress fracture or pseudarthrosis from tongue-type calcaneal fractures; infections, such as calcaneal tuberculosis; neoplasms, such as calcaneal osteochondroma; and inflammations, such as seronegative spondyloarthropathies[5-7].

Study performed at the Hospital Vera Cruz, Campinas, SP, Brazil.

Correspondence: Hallan Douglas Bertelli. Rua Dr. Mario Natividade, 936, Taquaral - 13076-112, Campinas, SP, Brazil. **E-mail:** hallanbertelli@gmail.com
Conflicts of interest: none. **Source of funding:** none. **Date received:** July 17, 2021. **Date accepted:** August 06, 2021. **Online:** August 31, 2021.

How to cite this article: Bertelli HD, Michelin BA, Perucci IF, Cillo MSP, Castro Filho CDC, Huyer RG. Functional evaluation of patients undergoing endoscopic calcaneoplasty for Haglund deformity. J Foot Ankle. 2021;15(2):155-60.

The etiology in most patients is idiopathic. However, several contributing factors have been associated with the onset of the condition, such as excessive exercise performed by runners, tight shoe wear, or altered subtalar joint biomechanics[8].

Diagnosis is based on clinical and imaging findings. Physical examination demonstrates increased volume and sensitivity to palpation over the bursa, which intensifies with passive dorsiflexion and plantar flexion of the ankle against resistance, in addition to pain, edema, and redness[9]. Lateral radiographs show a bony prominence (Haglund deformity) on the posterosuperior part of the calcaneal tuberosity, calcaneal edema, and increased density in bursae situated anteriorly to the calcaneal tendon[10]. Magnetic resonance imaging (MRI) is reserved for doubtful cases and allows an accurate assessment of soft tissues, calcaneal edema, local synovitis, and changes in the calcaneal tendon, if present[11].

Treatment is based on conservative and surgical approaches. Conservative approaches include adjustments to high heels, reassessment of the patient's shoe wear, and use of heel lifts to elevate the hindfoot[12]. Nonsteroidal anti-inflammatory drugs (oral or topical), bag of ice, stretching exercises and physiotherapy, rest, and immobilization can reduce the tension in the calcaneal tendon[12,13]. However, 50% to 65% of patients do not respond to conservative treatment after 6 months, and surgical treatment is then indicated[13].

Open surgical treatment consists of an extensive posterior longitudinal incision for release of the calcaneal tendon, combined with a wedge osteotomy of the posterosuperior region of the calcaneus[14,15]. Complications of open surgical treatment include skin breakdown, Achilles tendon avulsion, possible weakening of the bone structure when the entire posterosuperior aspect of the calcaneus is removed, recurrent pain caused by inadequate amounts of bone being resected, hypersensitivity around the operative wound, and stiffness of the Achilles tendon resulting in decreased dorsiflexion[12,14].

Arthroscopic techniques have become an important tool for diagnosing and treating intra-articular ankle abnormalities, such as anterior and posterior impingement syndromes, synovitis, and osteochondral lesions, for evaluating and removing free bodies, and for treating arthrosis. These techniques are effective and have lower complication rates than open techniques, as they are less aggressive to the skin, avoid complications arising from the surgical route, cause less postoperative pain, accelerate functional rehabilitation, and allow early discharge[12].

Van Dijk et al.[14] first described in 2001 a technique that is indicated for cases of pain, hypersensitivity, and hyperemia related to a posterosuperior calcaneal prominence with retrocalcaneal bursitis and imaging findings showing retrocalcaneal bursitis and mechanical impingement of Haglund deformity close to the tendon – thus consistent with Haglund syndrome –, after failed conservative treatment[9,16]. The procedure was named "endoscopic calcaneoplasty" and, since then, several studies have explored different arthroscopic portals, most of which presented good results and few complications[12]. Endoscopic calcaneoplasty is contraindicated for cases of insertional calcific tendinosis, vascular insufficiency, and local infection[16].

This study aimed to evaluate the functional outcome of patients undergoing endoscopic calcaneoplasty for the treatment of Haglund deformity.

Methods

The study was conducted at our institution between February and July 2021, after Research Ethics Committee approval (opinion no. 4.450.41, CAAE no. 39077820.5.0000.5412).

This is an evaluation of a case series with retrospective data collected from patients undergoing endoscopic calcaneoplasty to correct Haglund deformity. The following variables were evaluated: patient's age at the time of surgery, gender, and laterality of the condition. Clinical examination, radiography, and nuclear MRI were used for diagnostic purposes. Patients aged 18 years or over, clinically and radiologically diagnosed with Haglund syndrome, and surgically treated with endoscopic calcaneoplasty were included in the study. Patients with previous calcaneal fractures, with previous surgeries to treat Haglund syndrome, or patients already treated for Achilles tendon rupture were excluded.

The American Orthopaedic Foot and Ankle Society (AOFAS) has developed a standardized system for clinical and functional assessment of different parts of the foot, providing a better tool for analysis of foot conditions and proposal of therapeutic plans. The specific rating scale for the ankle and hindfoot consists of nine items, divided into three categories: pain (40 points), function (50 points), and alignment (10 points), with 100 possible points (Appendix). During preoperative outpatient follow-up, the AOFAS questionnaire was administered to the selected patients by a trained team member (BAM). Twelve months after the surgical procedure (endoscopic calcaneoplasty to treat Haglund deformity), the AOFAS questionnaire was administered for a second time by the same team member, and then the results were compared by statistical methods[17].

A descriptive analysis included measures of location and dispersion (mean, standard deviation, median, minimum and maximum values) for continuous variables and frequency tables (absolute and relative values) for categorical variables. For the study of the AOFAS scores obtained by the same participant over time, generalized estimating equations (GEEs) were used. Estimates were calculated by maximum likelihood to control for not assuming independence between the participants and the difference in measurements for each participant. Data were transformed into ranks because they were not normally distributed. Significance level for statistical tests was set at 5%.

Results

Nineteen patients were evaluated and 5 of them underwent the bilateral procedure, which resulted in 24 endoscopic calcaneoplasties to correct Haglund deformity. Eleven procedures were performed on the right side (45.83%) and 13 on the left side (54.17%), as shown in table 1.

Table 1. General descriptive analysis

Preoperative AOFAS score					
Age					
N	Mean	SD	Minimum	Median	Maximum
19	52.0	13.9	25.0	53.0	73.0
Operated side					
SIDE		Frequency	Percentage	Cumulative frequency	
Right		11	45.83	11	
Left		13	54.17	24	
Pain		Frequency		Percentage	
0		21		87.50	
20		3		12.50	
Function		Frequency		Percentage	
0		2		8.33	
4		4		16.67	
7		18		75.00	
Distance		Frequency		Percentage	
0		5		20.83	
2		7		29.17	
4		4		16.67	
5		8		33.33	
Surface		Frequency		Percentage	
0		10		41.67	
3		7		29.17	
5		7		29.17	
Gait		Frequency		Percentage	
0		8		33.33	
4		10		41.67	
8		6		25.00	
SAGITTAL					
MOTION		Frequency		Percentage	
0		8		33.33	
4		9		37.50	
8		7		29.17	
HINDFOOT					
MOTION		Frequency		Percentage	
0		7		29.17	
3		9		37.50	
6		8		33.33	
ANKLE					
STABILITY		Frequency		Percentage	
0		18		75.00	
8		6		25.00	

continue...

...Continuation

Table 1. General descriptive analysis

ALIGNMENT	Frequency	Percentage
0	5	20.83
5	13	54.17
10	6	25.00
Postoperative AOFAS score		
PAIN	Frequency	Percentage
20	1	4.17
30	7	29.17
40	16	66.67
FUNCTION	Frequency	Percentage
7	1	4.17
10	23	95.83
DISTANCE	Frequency	Percentage
2	1	4.17
5	23	95.83
SURFACE	Frequency	Percentage
3	5	20.83
5	19	79.17
GAIT	Frequency	Percentage
4	1	4.17
8	23	95.83
SAGITTAL		
MOTION	Frequency	Percentage
4	8	33.33
8	16	66.67
HINDFOOT		
MOTION	Frequency	Percentage
3	1	4.17
6	23	95.83
ANKLE		
STABILITY	Frequency	Percentage
6	1	4.17
8	23	95.83
ALIGNMENT	Frequency	Percentage
10	24	100.00

Note: AOFAS: American Orthopaedic Foot and Ankle Society; SD: standard deviation; N: number.

Preoperative questionnaire data showed a mean AOFAS score of 31.4, with a standard deviation of 21, a median of 25, and minimum and maximum values of 0 and 77, respectively. Postoperative questionnaire data showed a mean AOFAS score of 93.3, with a standard deviation of 8, a median of 96, and minimum and maximum values of 68 and 100, respectively (Table 2).

Thus, the descriptive analysis and the AOFAS score comparison between pre- and postoperative time points had a p-value (GEE) <0.0001. In figure 1, pre- and postoperative AOFAS scores were compared; (a) shows the dispersion of the AOFAS score at each time point for each patient, and (b) features bars representing median and interquartile range. There was a significant difference between the evaluations, which indicates a significant overall increase in the score after surgery and, therefore, a significant improvement after the surgical procedure.

The relationship between patient's age and AOFAS score was also studied. The mean age of patients was 52 (25-73) years, and the median age was 53 years. The GEE for this relationship found a p-value = 0.3373, which indicates that there was no interaction between age and improvement in the total AOFAS score or in any of its components. That is, functional improvement is independent of patient's age.

Discussion

Once the diagnosis of Haglund syndrome is confirmed by the sum of history taking, clinical evaluation, and imaging tests (radiography and MRI), conservative outpatient treatment is initiated. If the clinical symptoms remain at six-month follow-up, surgery is indicated.

The patients evaluated in this study underwent endoscopic calcaneoplasty, which consists of a bone resection performed arthroscopically, with use of two distal calcaneal paratendinous approaches (medial and lateral). The procedure aims to decompress the Achilles tendon, the bursa, and other retrocalcaneal soft tissues[18].

According to statistical data from this study, subjective aspects pointing to an improved AOFAS score were observed: the mean preoperative score was 31.4, while the mean postoperative score rose to 93.3. The results of this study are consistent with those of a systematic review published in November 2020 by the European Society for Sports Traumatology, Knee Surgery and Arthroscopy (ESSKA), which found that the correction of Haglund deformity provides a good clinical status and a low complication rate. The endoscopic approach ensures significantly better postoperative AOFAS scores and a faster return to daily activities when compared to open surgery[19].

Table 2. Descriptive analysis and comparison of American Orthopaedic Foot and Ankle Society scores between time points

Variable	N	Mean	SD	Minimum	Median	Maximum
Preop. total	24	31.4	21.0	0.0	25.0	77.0
Postop. total	24	93.3	8.0	68.0	96.0	100.0
P-value (GEE) <**0.0001**[1]						

Note: [1]Significantly increased score after surgery.
SD: standard deviation; GEE: generalized estimated equation; N: number; preop.: preoperative; postop.: postoperative.

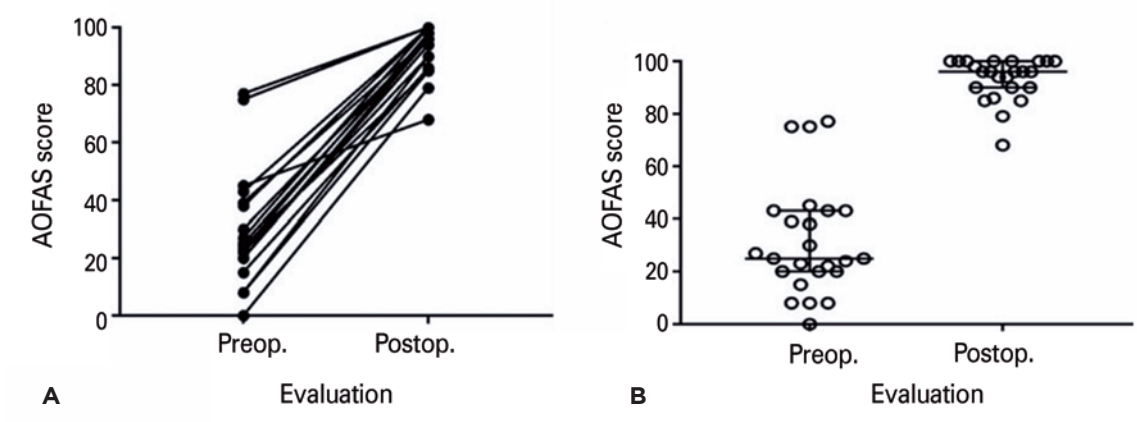


Figure 1. Comparison of AOFAS scores between time points.
Note: AOFAS: American Orthopaedic Foot and Ankle Society; preop.: preoperative; postop.: postoperative.

Finally, there were no postoperative complications in any of the 24 endoscopic surgeries performed: no Achilles tendon rupture, dehiscence, or sign of Achilles tendon infection were identified, either in the immediate postoperative period or in a period of 18 to 36 months after the procedure. These data are in line with findings described in the literature, as other studies have shown good outcomes in terms of improvement of both pain and function[14,16,19].

Conclusion

Arthroscopic resection is efficient in the treatment of Haglund deformity, which is a conclusion based on the significant improvement observed in the AOFAS score after the procedure. Also, the patients who underwent endoscopic calcaneoplasty in this study had no complications after surgery.

Authors' contributions: Each author contributed individually and significantly to the development of this article: HDB *(https://orcid.org/0000-0002-1901-3309) Conceived and planned the activities that led to the study, wrote the paper, participated in the reviewing process, approved the final version; BAM *(https://orcid.org/0000-0001-9610-6122) Conceived and planned the activities that led to the study, wrote the paper, participated in the reviewing process, approved the final version; IFP *(https://orcid.org/0000-0002-6476-2878) Conceived and planned the activities that led to the study, wrote the paper, participated in the reviewing process, approved the final version; MSPC *(https://orcid.org/0000-0002-0758-2547) Participated in the reviewing process, approved the final version; CDCCF *(https://orcid.org/0000-0003-3522-1076) Participated in the reviewing process, approved the final version; RGH *(https://orcid.org/0000-0003-3951-8408) Participated in the reviewing process, approved the final version. All authors read and approved the final manuscript. *ORCID (Open Researcher and Contributor ID).

References

1. Clancy WG. Runners' injuries. Part two. Evaluation and treatment of specific injuries. Am J Sports Med. 1980;8(4):287-9.
2. Canoso JJ, Liu N, Traill MR, Runge VM. Physiology of the retrocalcaneal bursa. Ann Rheum Dis. 1988;47(11):910-2.
3. Haglund P. Beitragzur Klinik der Achillessehne. Zeitschr Orthop Chir. 1928;49:49-58.
4. Schweitzer ME, Karasick D. MR imaging of disorders of the Achilles tendon. AJR Am J Roentgenol. 2000;175(3):613-25.
5. Shibuya N, Thorud JC, Agarwal MR, Jupiter DC. Is calcaneal inclination higher in patients with insertional Achilles tendinosis? A case-controlled, cross- sectional study. J Foot Ankle Surg. 2012;51(6):757-61.
6. Jung HG, Yoo MJ, Kim MH. Late sequelae of secondary Haglund's deformity after malunion of tongue type calcaneal fracture: report of two cases. Foot Ankle Int. 2002;23(11):1014-7.
7. Gillott E, Ray P. Tuberculosis of the calcaneum masquerading as Haglund's deformity: a rare case and brief literature review. BMJ Case Rep. 2013;2013:bcr2013009252.
8. Jung HG, Carag JA, Park JY, Bae EJ, Lim SD, Kim HS. Osteochondroma of the calcaneus presenting as Haglund's deformity. Foot Ankle Surg. 2011;17(2):e20-2.
9. Carreira D, Ballard A. Achilles tendoscopy. Foot Ankle Clin. 2015;20(1):27-40.
10. Reule CA, Alt WW, Lohrer H, Hochwald H. Spatial orientation of the subtalar joint axis is different in subjects with and without Achilles tendon disorders. Br J Sports Med. 2011;45(13):1029-34.
11. Pavlov H, Heneghan MA, Hersh A, Goldman AB, Vigorita V. The Haglund syndrome: initial and differential diagnosis. Radiology. 1982;144(1):83-8.
12. Singh R, Rohilla R, Siwach RC, Magu NK, Sangwan SS, Sharma A. Diagnostic significance of radiologic measurements in posterior heel pain. Foot (Edinb). 2008;18(2):91-8.
13. Green AH, Hass MI, Tubridy SP, Goldberg MM, Perry JB. Calcaneal osteotomy for retrocalcaneal exostosis. Clin Podiatr Med Surg. 1991;8(3):659-65.
14. van Dijk CN, van Dyk GE, Scholten PE, Kort NP. Endoscopic calcaneoplasty. Am J Sports Med. 2001;29(2):185-9.
15. Nesse E, Finsen V. Poor results after resection for Haglund's heel. Analysis of 35 heels in 23 patients after 3 years. Acta Orthop Scand. 1994;65(1):107-9.
16. Dinato MCME, Soares CAC, Ninomiya AF, Milano C, Pagnano RG. Endoscopic treatment of retrocalcaneal bursitis and haglund deformity. Rev Ortop Traumatol Ilustrada. 2015;6(2):40-5.
17. Rodrigues RC, Masiero D, Mizusaki JM, Imoto AM, Peccin MS, Cohen M, et al. Translation, cultural adaptation and validity of the "American Orthopaedic Foot and Ankle Society (AOFAS) Ankle-Hindfoot Scale. Acta Ortop Bras. 2008;16(2):107-11.
18. Sella EJ, Caminear DS, McLarney EA. Haglund's syndrome. J Foot Ankle Surg. 1998;37(2):110-4.
19. Alessio-Mazzola M, Russo A, Capello AG, Lovisolo S, Repetto I, Formica M, et al. Endoscopic calcaneoplasty for the treatment of Haglund's deformity provides better clinical functional outcomes, lower complication rate, and shorter recovery time compared to open procedures: a systematic review. Knee Surg Sports Traumatol Arthrosc. 2021;29(8):2462-84.

Appendix 1. AOFAS ankle-hindfoot scale

AOFAS ANKLE-HINDFOOT SCALE (100 POINTS TOTAL)	
Pain (40 points)	
• No pain	40
• Mild, occasional	30
• Moderate, daily	20
• Severe, almost always present	0
Functional (50 points)	
• Restraints in activities, support required	10
• No restraints, no support	7
• No restraints in daily activities, restrained recreational activities, no support	4
• Restraints in daily and recreational activities, cane required	0
Strong restraints in daily and recreational activities; walker, crutches, wheelchair, orthosis (ankle restraint, ankle immobilizer)	
Maximum walking distance, in blocks	
• More than 6	5
• 4 - 6	4
• 1 - 3	2
• Less than 1	0
Walking surfaces	
• No difficulties in any surface	5
• Some difficulty on irregular floors, stairs, steeps and hills	3
• Strong difficulties on irregular floors, stairs, steeps and hills	0
Gait abnormality	
• No abnormality, mild	8
• Evident	4
• Strong	0
Sagittal mobility (flexion + extension)	
• Normal or slightly limited (30° or more)	8
• Moderate limitation (15° – 29°)	4
• Strong limitation (less than 15°)	0
Hindfoot mobility (inversion + eversion)	
• Normal or slightly limited (75- 100% of the normal mobility)	6
• Moderate limitation (25 – 74% of the normal)	3
• Strong limitation (less than 25% of the normal)	0
Ankle-Hindfoot stability (anteroposterior, varus-valgus)	
• Stable	8
• Unstable	0
Alignment (10 points)	
• Good, plantigrade foot, well-aligned forefoot and hindfoot	10
• Fair, plantigrade foot, some degree of misalignment of the ankle and hindfoot, asymptomatic	5
• Poor, non-plantigrade foot, strong and symptomatic misalignment	0
TOTAL SCORE: _____	

DOI: https://doi.org/10.30795/jfootankle.2021.v15.1541

Case Report

Talus reconstruction using fresh structural allograft after nontraumatic avascular necrosis: case report

Andres Fuentealba Pooley[1], Hugo Henriquez Sazo[2,3], Leonardo Lagos Sepulveda[2], Christian Bastias Soto[2], Fernando Vargas Gallardo[2], Sergio Fernandez Comber[2]

1. Orthopedics and Traumatology Service, Hospital de Urgencia y Asistencia Publica, Santiago, Chile.
2. Orthopedics and Traumatology Service, Clínica Santa María, Santiago, Chile.
3. Traumatology Institute Santiago – Universidad de Chile, Santiago, Chile.

Abstract

Avascular necrosis of the talus is a rare condition that can lead to important functional sequelae. There are few therapeutic alternatives for more advanced stages of this disease, the majority of which sacrifice the ankle joint. We report the case of a 50-year-old patient with nontraumatic avascular necrosis that compromised a large part of the talar surface. After non-structural autograft failed, it was reconstructed using fresh structural talar allograft. At one year of follow-up, the patient reported a considerable decrease in pain. To our knowledge, this is the first reported case in which fresh structural allograft was used in the treatment of nontraumatic avascular necrosis of the talus.

Level of Evidence V; Therapeutic Studies; Expert Opinion.

Keywords: Osteonecrosis; Talus; Allografts; Reconstructive surgical procedures.

Introduction

Avascular necrosis (AVN) of the talus is an interruption of irrigation that leads to necrotic areas of variable extent. It is a rare entity and its prevalence is unknown, since many patients only seek treatment in its late stages[1].

Most often, vascular damage is secondary to a traumatic cause. However, there are cases of AVN without a history of trauma, for which multiple causes have been reported, including drugs or systemic pathologies. These nontraumatic causes represent 25% of all reported AVN cases[2].

There are multiple management alternatives in the treatment of AVN. Treatment will depend on the disease stage, as well as the severity and extent of the injury.

Fresh structural talar allograft has been traditionally used to manage osteochondral lesions (OCL) of the talus[3]. To our knowledge, this alternative has not been used in cases of massive nontraumatic AVN, probably due to the difficulty of the procedure and the lack of evidence on the subject. However, by preserving the joint, we believe that it would allow a greater level of functionality, which could be very important, especially in younger patients.

Case Description

This study was approved by the local institutional ethics committee. The patient granted consent to publish the data concerning her case.

We report the case of a 50-year-old female who presented with severe left ankle pain in August 2015. She had an iatrogenic lesion of the common right iliac artery during a spine surgery in 2010 that required emergency repair and a prolonged stay in an intensive care unit. The required vasoactive drugs led to multiple complications, including digital necrosis.

Five years after these events, she came to us complaining of anterior ankle pain, which increased during gait and ankle dorsiflexion. Subsequent imaging showed an important area of AVN in the left talus (Figure 1).

Study performed at Clinica Santa Maria, Santiago, Chile.

Correspondence: Sergio Fernandez Comber. Avenida Sta. María, 500, Providencia - 7520378, Santiago, Chile. **Email:** fernandez.sc@gmail.com. **Conflicts of interest**: None. **Source of funding:** None. **Date received:** May 19, 2021. **Date accepted:** June 20, 2021. **Online:** August 31, 2021.

How to cite this article: Fuentealba Pooley A, Henriquez Sazo H, Lagos Sepulveda L, Bastias Soto C, Vargas Gallardo F, Fernandez Comber S. Talus reconstruction using fresh structural allograft after nontraumatic avascular necrosis: case report. J Foot Ankle. 2021;15(2):161-6.

The talus was reconstructed using non-structural autograft harvested from the ipsilateral iliac crest, with good results for pain and the patient's return to normal activities. However, 3 years after this surgery the patient returned, reporting anterior ankle pain that increased with gait. The physical examination showed important swelling on the left ankle, associated with pain during maximum ankle dorsiflexion or plantar flexion.

Computed tomography revealed a massive AVN of the left talus associated with graft resorption and a significant depression in the lateral two-thirds of the talus (Figure 2). It was then decided to resect the left hemitalus and transplant fresh structural talar allograft according to the surgical technique described below.

Surgical technique

The anterior ankle approach was used. A large osteophyte on the anterior tibia was resected, allowing visualization of a large area of damaged cartilage on the articular surface of the talus, including an important depression in the lateral weight-bearing surface.

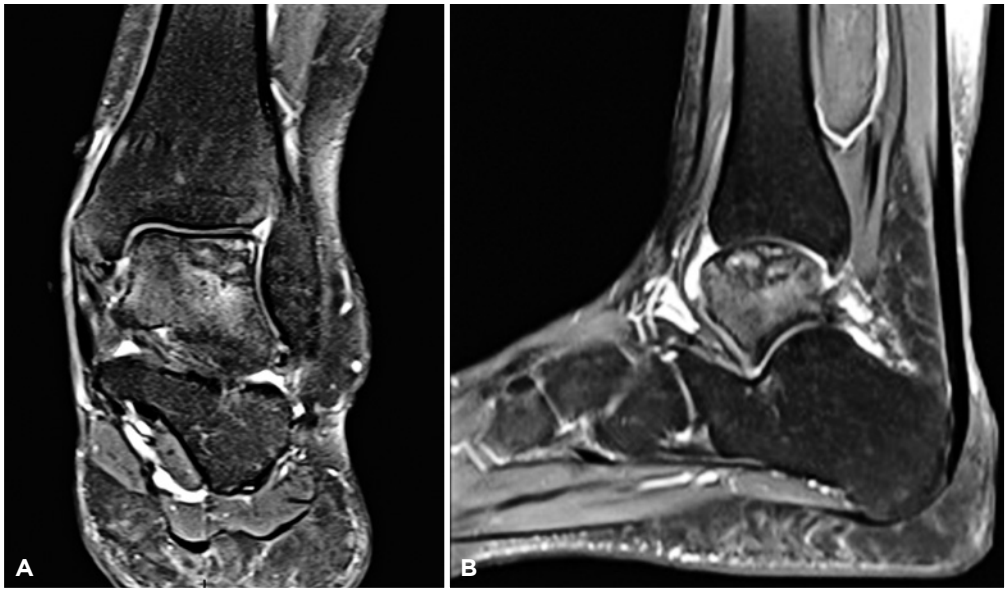


Figure 1. MRI of the ankle at initial patient presentation. Coronal (A) and sagittal (B) sections show the avascular necrosis of the talus, which affects approximately half of its articular surface.

Figure 2. Computed tomography of the ankle three years after reconstruction with iliac crest autograft, showing massive avascular necrosis of the lateral two-thirds of the talus, associated with graft resorption.

An AO distractor was applied to improve the exposure of the compromised area and an osteotomy of two-thirds of the lateral articular surface of the talus was performed, with radioscopy-guided incisions.

The recipient area was precisely measured and the talar allograft was adjusted with a bone saw to match the defect. The allograft's fit in the recipient site was then confirmed, achieving good joint reduction (Figure 3).

The allograft was fixed with 3 Zimmer Biomet® bioabsorbable screws (2.5mm); the screw heads were removed to avoid prominences in the joint area.

The wound was closed with absorbable sutures for subcutaneous tissue and monofilament for the skin. The ankle was covered with sterile gauze and a bandage and immobilized with a controlled ankle motion boot.

One year after surgery, the patient reported a 50% reduction in pain compared to her preoperative state, although she had not completely returned to work activities due to an inability to remain standing or walking for long periods. At this point, her Foot and Ankle Ability Measure was 54% and her American Orthopedic Foot & Ankle Society Ankle (AOFAS) - Hindfoot Scale score was 65. Computed tomography showed partial consolidation of the allograft (Figure 4).

Discussion

Managing AVN of the talus is complex[1,2]. The pathogenesis and etiologies of this disease have been better understood in recent years, increasing the therapeutic options. However, the results are still quite poor in terms of clinical outcomes[2], with arthrodesis performed as a definitive solution in many cases[4,5].

When faced with this pathology, a fuller understanding of the natural evolution of the disease is required. The most commonly used staging system is that of Ficat and Arlet[6], which has been modified over the years and currently includes: a preclinical stage (stage 0), a preradiographic stage

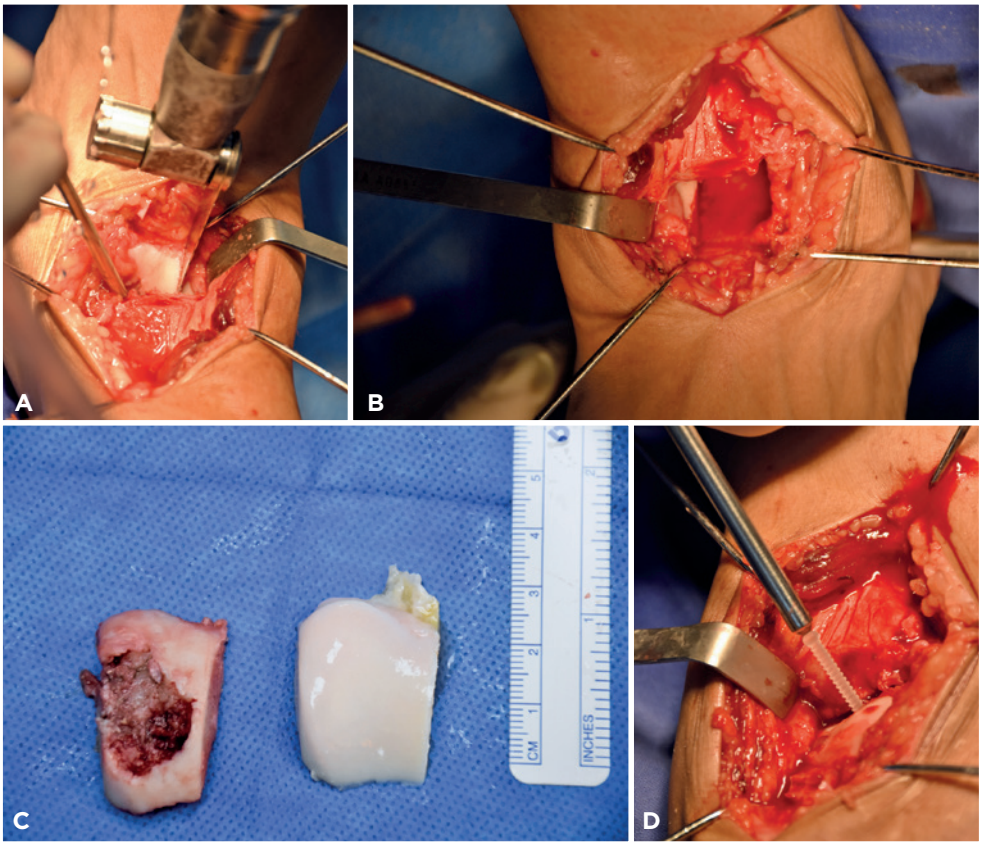


Figure 3. Intraoperative photographs of the procedure. A) Previously measured cuts of the native talus were performed with a bone saw; B) The recipient site after resecting the necrotic talus, corresponding to the lateral two-thirds of the articular surface; C) Comparison of the resected native talus with the fresh talar allograft . D) Allograft fixation with Zimmer - Biomet® 2.5mm bioabsorbable screws.

Figure 4. A and B: Computed tomography scans at first postoperative control: the allograft is in a good position, congruent with the articular surface. C and D: Computed tomography scans 1 year postoperatively: the allograft is partially integrated, with some graft resorption. The joint surface is regular, with no collapse of the allograft.

(stage I), pre-collapse with radiological changes (stage II), a transition phase with flattening of the articular surface and collapse with intact surrounding joints (stage III), and finally osteoarthritis (stage IV)[1]. The therapeutic options are determined by the stage of the disease[1,5]. In advanced stages, specifically when the talus has collapsed, more radical options that usually sacrifice the joint are recommended, such as ankle arthrodesis. Joint-sparing procedures, such as ankle arthroplasty, do not show predictable results in advanced AVN of the talus[1,4,5].

Gross et al.[5] conducted a systematic review to compare therapeutic options for AVN of the talus, concluding that conservative management should be attempted initially with restricted weight-bearing either with or without extracorporeal shock wave therapy. However, when nonoperative management fails, they recommend surgical management. For patients in Ficat and Arlet stages I-III, they recommend core decompression or non-structural autograft, reserving arthrodesis for the final stages of the disease or when previous treatments have failed[5].

Tibiotalar arthrodesis is a good option for advanced stages and has good results in terms of functional scales[4]. However, its disadvantage is lost joint mobility, limiting the patient's gait to different degrees. It is also not exempt from complications: depending on the case series, non-union rates can from 18%-40%[5].

Studies describing the use of fresh structural talar allograft are mainly conducted in patients diagnosed with OCL of the talus. It is normally indicated for large lesions, ie, more than 1.5cm in diameter or an area greater than 150mm[3].

Adams et al.[7] conducted a prospective study of 14 patients with OCL of the talus who were managed with fresh structural allograft, following them for 2 years. They reported an overall success rate of 86%, with significant improvement in terms of pain reduction (visual analog scale) and functional scales, obtaining a mean postoperative AOFAS score of 84 points. However, 5 patients (36%) in this series required some additional surgery to manage pain or stiffness[7].

Raikin[8] conducted another prospective study on 15 patients with cystic OCL of the talus who were managed with fresh structural allograft. The mean volume of these lesions was 6059mm^3, and the mean AOFAS ankle-hindfoot score was 83 points. Only two patients required ankle arthrodesis due to allograft failure.

Comparing our case with the literature, the results after 1 year of follow-up are acceptable, although the graft had not completely consolidated and the results of functional scales were moderate.

The delay in graft integration may be due to the pathophysiology of AVN, in which, unlike traumatic OCL, the complex vascular network that irrigates the talus may be affected. Thus, there would be a decrease in vascular supply to the grafted area, which could affect its osseointegration.

Using vascularized bone grafts may prevent this problem. Yu et al.[9] reported good results with vascularized cuneiform bone flap plus iliac cancellous bone grafting in Ficat and Arlet stage II, III, and IV patients with non-traumatic AVN of the talus. Specifically, the results were excellent in 90% of cases. However, these are technically very complex procedures, and their usefulness is mainly in small lesions up to Ficat and Arlet stage III[10].

Over a mean follow up of 6 years, Nunley et al.[11] reported that rotational vascularized pedicle bone graft from the cuboid had good results in terms of pain relief and physical function in 84% of their Ficat and Arlet stages II and III patients.

The delay in osseointegration in the present case could also be explained by the size of the graft, since the necrosis affected two-thirds of the lateral talus, with a volume of 8932mm^3 according to computed tomography. This is considerably higher than other reports[7,8].

However, although radiological consolidation of the graft had not occurred by 1 year of follow-up, our patient reported significant improvement compared to her preoperative state.

This study is limited by its retrospective design and by including a single case. The follow-up time should also be considered a limitation.

Conclusion

Although there is scant literature on this condition, we obtained favorable results with this technique in a patient with AVN of the talus. Further research with a higher level of evidence could confirm this technique as a management alternative, especially for young patients with massive lesions, for whom arthrodesis can be prevented or delayed.

Authors' contributions: Each author contributed individually and significantly to the development of this article: AFP *(https://orcid.org/0000-0003-0894-042X) Interpreted the results achieved, wrote the paper and participated in the reviewing process, bibliographic review, clinical examination; HHS *(https://orcid.org/0000-0002-2570-363X) performed the surgeries, planned the activities that led to the paper, participated in the reviewing process, approved the final version; LLS *(https://orcid.org/0000-0002-7010-7490) performed the surgeries, participated in the reviewing process, approved the final version; CBS *(https://orcid.org/0000-0001-8049-5098) participated in the review process, approved the final version; FVG *(https://orcid.org/0000-0002-4283-2900) participated in the review process and formatting of the article; SFC *(https://orcid.org/0000-0001-8369-1190) performed the surgeries, conceived and planned the activities that led to the paper, participated in the reviewing process, approved the final version. All authors read and approved the final manuscript. *ORCID (Open Researcher and Contributor ID).

References

1. Haskell A. Natural History of Avascular Necrosis in the Talus: When to Operate. Foot Ankle Clin. 2019;24(1):35–45.
2. Adelaar RS, Madrian JR. Avascular necrosis of the talus. Orthop Clin North Am. 2004;35(3):383–95.
3. Gross CE, Adams SB, Easley ME, Nunley JA. Role of Fresh Osteochondral Allografts for Large Talar Osteochondral Lesions. Instr Course Lect. 2016;65:301-9.
4. Lachman JR, Adams SB. Tibiotalocalcaneal Arthrodesis for Severe Talar Avascular Necrosis. Foot Ankle Clin. 2019;24(1):143-61.
5. Gross CE, Haughom B, Chahal J, Holmes GB. Treatments for Avascular Necrosis of the Talus: A Systematic Review. Foot Ankle Spec. 2014;7(5):387-97.
6. Ficat RP, Arlet J. Forage-biopsie de la tete femorale dans l'osteonecrose primative. Observations histo-pathologiques portant sur huit forages. Rev Rhum. 1964;31:257-64.
7. Adams SB, Dekker TJ, Schiff AP, Gross CP, Nunley JA, Easley ME. Prospective Evaluation of Structural Allograft Transplantation for Osteochondral Lesions of the Talar Shoulder. Foot Ankle Int. 2018;39(1):28–34.
8. Raikin SM. Fresh osteochondral allografts for large-volume cystic osteochondral defects of the talus. J Bone Joint Surg Am. 2009;91(12):2818-26.
9. Yu X, Zhao D, Sun Q, Wang T, Yu H, Su Y, et al. [Treatment of non-traumatic avascular talar necrosis by transposition of vascularized cuneiform bone flap plus iliac cancellous bone grafting]. Zhonghua Yi Xue Za Zhi. 2010;90(15):1035–8.
10. Dhillon MS, Rana B, Panda I, Patel S, Kumar P. Management Options in Avascular Necrosis of Talus. Indian J Orthop. 2018;52(3): 284-96.
11. Nunley JA, Hamid KS. Vascularized Pedicle Bone-Grafting from the Cuboid for Talar Osteonecrosis: Results of a Novel Salvage Procedure. J Bone Joint Surg Am. 2017;99(10):848-54.

DOI: https://doi.org/10.30795/jfootankle.2021.v15.1534

Case Report

Intraosseous uric acid tumor without joint involvement: case report

Elcio Valloto Junior[1], Valter Penna[1], Vinícius Medina Guimarães[1], Vinícius Dino Pozzebon[2], Mariana Oliveira de Araújo[2]

1. The Good Samaritan Charity Association, Maringá, PR, Brazil.
2. UniCesumar - Universidade CESUMAR, Maringá, Paraná, Brazil.

Abstract

We report an unusual case of extra-articular gouty tophus in the left medial malleolus. A 33-year-old man with a previous diagnosis of chronic gout presented with mild, non-disabling ankle pain associated with gout attacks. Imaging and histopathologic findings were inconclusive. The tumor was surgically resected, and the cavity was filled with methyl methacrylate. Histopathology confirmed the diagnosis in a sample collected intraoperatively. Giant cell tumor and bone cyst were ruled out. The patient had a good postoperative outcome.

Level of Evidence V; Therapeutic Study; Expert Opinion.

Keywords: Uric acid; Giant cell tumors; Bone cysts; Case reports; Diagnosis.

Introduction

The incidence of hyperuricemia leading to the formation of gouty tophi has increased in the last decades, given that risk factors associated with its etiology have become increasingly common in everyday life. The formation of gouty tophi results from chronic gout, which not always presents characteristic signs and symptoms and may vary according to the anatomical site. The classic manifestation of gout is an acute attack with inflammatory reaction, resulting in redness, burning sensation, increased sensitivity, swelling, and loss of function of the affected joints, among other systemic symptoms such as fever[1]. Therefore, patients with chronic gout are predisposed to the deposition of monosodium urate (MSU) crystals in tissues, especially inside and around joints, forming tophi. In addition to tophus formation, chronic gout can manifest by chronic synovitis, bone erosions, and cartilage damage. This disease often affects joints, and immune mechanisms lead to the formation of MSU crystals. The accumulation of crystals results from decreased vascularity and susceptibility of the synovial membrane to pass the crystals. For this reason, gout tends to affect mainly peripheral joints[2].

If gout is not controlled, attacks may occur leading to the development of tophaceous deposits, which, as mentioned above, mainly affect joints. However, they may also affect the subcutaneous tissue, renal tissue, tendons adjacent to the joint, and other less common sites, thus resulting in deformities characteristic of this disease. Rarely, tophaceous deposits can occur in intraosseous regions, with only a few cases reported in the literature[3]. In this context, we report a case of an unusual presentation of an extra-articular, intraosseous gouty tophus located on the medial malleolus of the left ankle.

Case Description

This rare case was reported after obtaining approval from the Research Ethics Committee and written consent from the patient.

A 33-year-old man, an agronomist, social drinker and non-smoker, presented with pain. He denied fever, use of medications, and underlying diseases, but reported a previous diagnosis of chronic gout. He reported a mild pain in the region of the medial malleolus of the left ankle for the

Study performed at the The Good Samaritan Charity Association, Maringá, PR, Brazil.

Correspondence: Elcio Valloto Junior Avenida Nóbrega, 590, Zona 4 - 87014-180, Maringá, PR, Brazil. **E-mail:** vallotojr@yahoo.com.br. **Conflicts of interest:** none. **Source of funding:** none. **Date received:** April 28, 2021. **Date accepted:** June 17, 2021 **Online:** August 31, 2021.

How to cite this article: Valloto Junior E, Penna V, Guimarães VM, Pozzebon VD, Araújo MO. Intraosseous uric acid tumor without joint involvement: case report. J Foot Ankle. 2021;15(2):167-70.

past 6 months, which worsened during gout attacks. Physical examination showed mild hyperemia on the medial malleolus, with moderate edema, pain on palpation of the region, mild local bulging, and full range of motion of the ankle, with no joint locking and no signs of ankle ligament instability. The patient had no history of trauma in the affected area. He reported that the area began to bulge, growing slowly over the last 6 months, leading to non-disabling pain.

A radiograph of the ankle showed the presence of a nonspecific mass – a pseudotumor on the medial malleolus (Figure 1). Computed tomography (CT) and magnetic resonance imaging (MRI) showed a heterogeneous, expansile, infiltrative mass in the distal tibia with disruption of the medial cortex (Figures 2 and 3). The results of intraosseous needle aspiration and histological analysis were inconclusive. Therefore, we surgically resected the tumor and sent the resected specimen for pathological analysis.

During the procedure, we found a bone bulge in the metaphyseal region of the distal tibia, covered only by a thin capsule without medial cortical support. After resection and curettage of the cavity, we observed no communication with the talocrural joint (Figure 4). After debridement of the canal, we filled the cavity with methyl methacrylate. Histopathology revealed fibroconnective tissue with MSU deposits, clearly showing amorphous eosinophilic material, which confirmed the diagnosis of intraosseous gouty tophus.

The patient had no complications. No weight-bearing was advised immediately after surgery. Postoperative radiographs are shown in Figures 5 and 6. We removed the stitches on day 15, and the patient started physical therapy. After 3 weeks, the load was progressively increased. Over the course of the month, he no longer had limitations or residual pain. After all procedures, the patient was also followed up at the rheumatology clinic.

Figure 1. Preoperative anteroposterior radiograph of the ankle showing an eccentric lytic lesion, with thinning and disruption of the medial cortex of the medial malleolus, without invading the articular cortex.

Figure 2. Coronal T1-weighted magnetic resonance imaging of the ankle showing expansion of the lesion to the medial cortex.

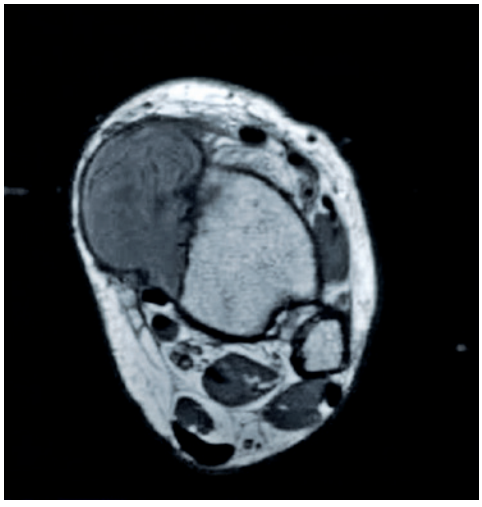


Figure 3. Axial T1-weighted magnetic resonance imaging of the ankle showing expansion of the lesion beyond the medial cortex.

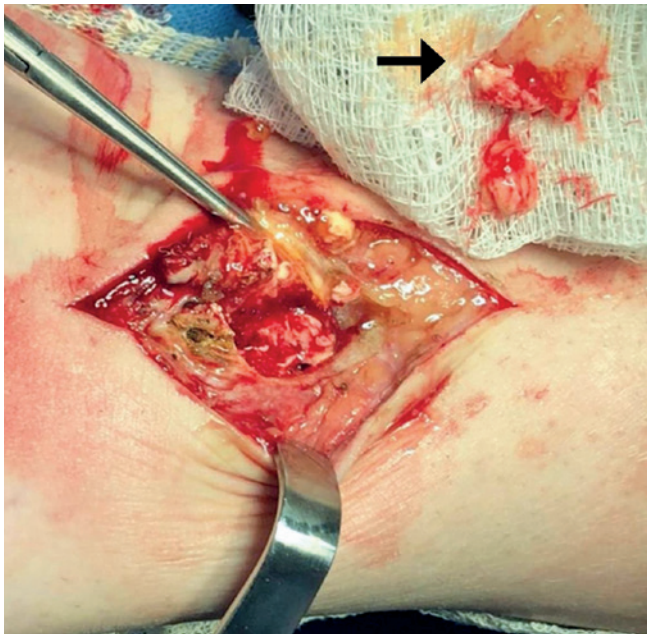


Figure 4. Intraoperative image – aspects of the tumor mass. Direct medial access to the ankle, dissection by planes, and identification of friable bone tissue, which was excised (arrow). There was no invasion of the articular surface.

Discussion

Tophi are formed by chronic MSU crystal deposition. Rarely, these depositions can occur in the bone itself, thus forming intraosseous gouty tophus, which is a rare condition with few reports in the literature[4].

Pathophysiologically, MSU crystals deposit first into the Haversian system, slowly enlarging the cavity, which will be filled with a large amount of MSU crystals. The tophus enlarges in a way that adjacent structures may be invaded, such as the metaphysis of the bone, thus destroying the interior of the bone as the bone expands due to tophus growth[4]. Radiographic findings of bone erosion, resulting from tophus growth, are punched-out, round, or oval lesions with sclerotic rims. Regarding MRI, studies have shown limited specificity for the diagnosis of local disease[5]. Plain radiographs are often used for preliminary diagnosis, with CT and/or MRI being used to establish the differential diagnosis[6].

It is necessary to differentiate intraosseous cystic gout lesions from other pathologies, such as giant cell tumor (GCT) and bone cysts. GCT is a neoplasm characterized by the proliferation of osteoclast-like cells, known as multinucleated giant cells[7]. Although usually benign, this proliferation can cause substantial changes in the local bone architecture, causing problems if located periarticularly. Typically, GCT is not visible in the mineralized matrix and lacks well-defined

Figure 5. Postoperative anteroposterior radiograph of the ankle showing lesion site filled with methyl methacrylate, supported by intact subchondral bone in the lower tibia, without extravasation of bone cement into the joint due to the integrity of the articular rhyme.

Figure 6. Postoperative lateral radiograph of the ankle showing lesion site filled with methyl methacrylate, without extravasation of bone cement into the joint due to the integrity of the articular rhyme.

sclerotic borders. The lesions are usually located in the epiphyseal region and tend to extend to the subchondral bone. CT and MRI are used to confirm lesion characteristics and differentiate them from other types of tumors, which may be confused with GCT[1].

Simple bone cysts are benign intraosseous lesions that appear as cavities filled with fluid and scattered giant cells[8]. Characteristically, cysts will contain yellowish viscous fluid if there is no associated fracture causing bleeding. Because these lesions are usually asymptomatic, diagnosis is made by routine imaging, such as ultrasound and radiographs. On imaging, cysts appear as radiolucent, well-defined, unilocular lesions. In addition, the cyst wall, composed of fibrovascular stroma, is thin and has an irregular or jagged appearance, with or without sclerotic rims[9]. In most cases, histopathology defines the diagnosis. However, the differential diagnosis with osteosarcoma, GCT, and other types of tumors requires a correlation between clinical, radiographic, and histopathologic features to be determined, given the similarities they share[8].

Based on the case reported here and on the analysis of the literature, we highlight the rarity of the case and the importance of distinguishing between differential diagnoses, such as GCT and simple bone cysts. In view of the features presented, the procedures were performed with the purpose of excluding differential diagnoses, improving quality of life, and reducing the patient's limitations.

Conclusion

Intraosseous gouty tophus is a rare, benign, poorly diagnosed condition in an uncommon site. In this case report, we showed approaches and challenges for diagnosis and treatment, since this type of tumor is rare and the postoperative recurrence rate is still unknown.

Authors' contributions: Each author contributed individually and significantly to the development of this article: EVJ *(https://orcid.org/0000-0002-1385-2224) Conceived and planned the activity that led to the study, wrote the article, participated in the review process; VP *(https://orcid.org/0000-0002-9024-8071) Conceived and planned the activities that led to the study, interpreted the results of the study; VMG *(https://orcid.org/0000-0002-3574-833X) Wrote the article, participated in the review process; VDP *(https://orcid.org/0000-0003-2056-8253) Wrote the article, participated in the review process.; MOA *(https://orcid.org/0000-0002-3811-5810) Wrote the article, participated in the review process. All authors read and approved the final manuscript. *ORCID (Open Researcher and Contributor ID).

References

1. Sakti M, Usman MA, Lee J, Benjamin M, Maulidiah Q. Atypical musculoskeletal manifestations of gout in hyperuricemia patients. Open Access Rheumatol Res Rev. 2019;11:47–52.
2. Ragab G, Elshahaly M, Bardin T. Gout: An old disease in new perspective – A review. J Adv Res. 2017;8(5):495–511.
3. Raikin S, Cohn BT. Intraosseous gouty invasion of the talus. Foot Ankle Int. 1997;18(7):439–41.
4. Surprenant MS, Levy AI, Hanft JR. Intraosseous gout of the foot: An unusual case report. J Foot Ankle Surg. 1996;35(3):237–43.
5. Morino T, Fujita M, Kariyama K, Yamakawa H, Ogata T, Yamamoto H. Intraosseous gouty tophus of the talus, treated by total curettage and calcium phosphate cement filling: A case report. Foot Ankle Int. 2007;28(1):126–8.
6. Su CH, Hung JK. Intraosseous Gouty Tophus in the Talus: A Case Report. J Foot Ankle Surg. 2016;55(2):288-90.
7. Baptista PPR, Próspero JD, Yonamine ES. Giant cell tumor. Rev Bras Ortop. 2001;36(7):239-44.
8. Doğanavşargil B, Ayhan E, Argin M, Pehlivanoğlu B, Keçeci B, Sezak M, et al. Cystic bone lesions: histopathological spectrum and diagnostic challenges. Turk Patoloji Derg. 2015;31(2): 95-103.
9. da Costa ED, Roque-Torres GD, Peyneau PD, Godolfim LR, Haiter Neto F, Almeida SM. Simple bone cyst: rare incidental finding in the mandibular condyle by cone beam computed tomography. Gen Dent. 2018;66(1):54-6.

DOI: https://doi.org/10.30795/jfootankle.2021.v15.1548

Case Report

Schwannoma of the medial plantar nerve: a case report

Adriano Machado Filho[1], **Jefferson Soares Martins**[2], **Paulo Victor de Souza Pereira**[3], **Ademir Freire de Moura Júnior**[2]

1. Hospital das Clínicas – EBSERH/UFG, Goiânia, GO, Brazil.
2. Hospital de Urgências de Goiânia (HUGO), Goiânia, GO, Brazil
3. Hospital Estadual de Urgências de Aparecida de Goiânia Cairo Louzada (HUAPA), Aparecida de Goiânia, GO, Brazil.

Abstract

We report the case of a 60-year-old woman with a schwannoma of the medial plantar nerve. She presented with the complaint of pain for about 2 years and a painful lesion in the medial plantar region of the left forefoot and on the second toe. Physical examination showed well-defined, firm tumor masses painful to palpation on the medial and plantar surface of the left forefoot and second toe. We surgically explored the area and excised 3 lesions, resulting in complete pain relief and no aesthetic complaints. Schwannomas of the medial plantar nerve are rare tumors, with only a few reports of cases extending to the forefoot. The finding of multiple schwannomas may be a red flag for the possible existence of local, painful, nerve lesions despite a negative Tinel sign. Appropriate surgical planning contributed to our successful intervention, without aesthetic, painful, or functional sequelae for the patient.

Level of Evidence V; Therapeutic Studies; Expert Opinion.

Keywords: Neurilemmoma; Foot; Neoplasms.

Introduction

Schwannoma or neurilemmoma are terms currently used to designate a benign myelin sheath tumor that arises from Schwann cells of the peripheral nerves. When located at the extremities, these tumors may be confused with a lipoma or a synovial cyst, being treated surgically when they become painful[1].

Most schwannomas are sensitive nodules associated with neurogenic pain or paresthesia. Surgical removal is indicated for the relief of symptoms and adequate diagnosis of the tumor, which is rarely malignant (1% of cases)[2]. Tumor removal does not compromise nerve integrity and may result in symptom relief and maintenance of nerve function. Schwannomas account for 5% of all benign soft tissue neoplasms, with a low local recurrence rate. They are usually isolated, solitary, slow-growing, well-encapsulated lesions[3].

These tumors are uncommon in the foot. In a review of 32 years' experience, only 12 of 104 cases were located in the foot[4]. Schwannoma of the medial plantar nerve is a rare tumor, with only a few cases in the literature and even fewer cases of schwannomas extending medially to the plantar surface of the foot. Case reports are mostly of adults between 30 and 49 years of age, with no predilection for race or sex[5].

We report the case of an older woman with 3 neurilemmomas of the medial plantar nerve that were surgically resected.

Case Description

This rare case was reported after obtaining approval from the local ethics committee and written consent from the patient.

An otherwise healthy 60-year-old woman presented with the complaint of pain for about 2 years and a painful lump on the second toe of her left foot. Physical examination showed tumors on the medial and plantar surface of the left forefoot and on the medial surface of the second toe of the same foot (Figure 1). The patient had no history of trauma and no family history of neurofibromatosis. Foot examination revealed a negative Tinel sign, but with decreased sensitivity (hypoesthesia) and pain while walking.

Study performed at the Hospital das Clínicas de Goiânia, Goiânia, GO, Brazil.

Correspondence: Adriano Machado Filho. Rua T-37, 3000, Setor Bueno, Ônix Bueno, Apt. 1411 - 74230-025, Goiânia, GO, Brazil. **E-mail:** adrianomf_5@hotmail.com
Conflicts of interest: none. **Source of funding:** none. **Date received:** June 27, 2021. **Date accepted:** July 03, 2021.**Online:** August 31, 2021.

How to cite this article: Machado Filho A, Martins JS, Pereira PVS, Moura Júnior AF. Schwannoma of the medial plantar nerve: a case report. J Foot Ankle. 2021;15(2):171-4.

Plain radiographs of the foot and ankle showed no bone or joint abnormalities, only soft tissue enlargement. Magnetic resonance imaging revealed an oval mass adjacent to the medial plantar nerve and 2 similar but smaller lesions on the second toe of the left foot (Figure 2). Under spinal anesthesia, we surgically explored the area (Figure 3) and excised 3 lesions (Figure 4).

Figure 1. Non-weight-bearing photograph of the left foot in A) front view and B) medial view showing a firm mass on the second toe.

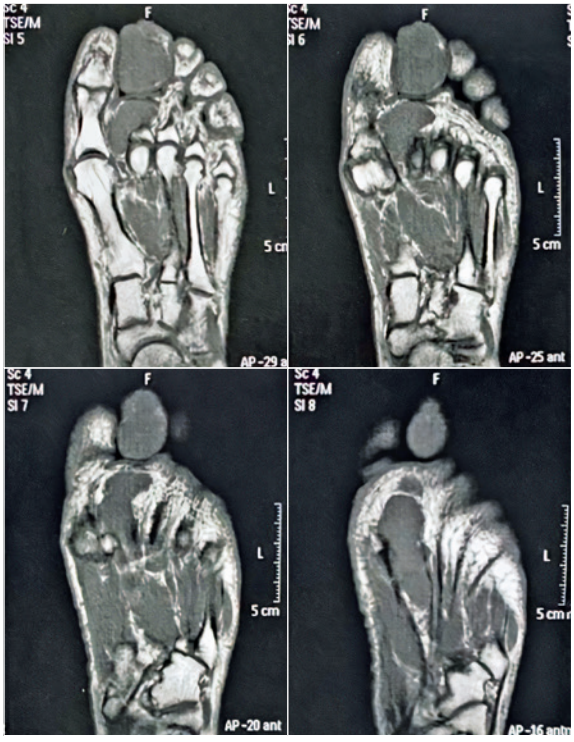


Figure 2. Magnetic resonance imaging of the left foot showing a cystic lesion hypointense on T1-weighted sequences on the medial and plantar surface of the second toe along the course of the medial plantar nerve.

Gross pathological examination of the 3 lesions showed irregularly shaped tissue specimens with a yellowish-brown color and fibroelastic consistency, measuring 7.4 x 2.8 x 1.8cm and weighing 30g. Microscopic evaluation revealed a fusiform mass characterized by alternating hypercellular and hypocellular areas. Given the absence of necrosis, mitosis, and nuclear atypia, the diagnosis of schwannoma was made.

Surgical technique

With the patient in the supine position under spinal anesthesia with a pneumatic tourniquet applied proximally on the left thigh, we made a wide incision of approximately 10cm on the medial surface of the forefoot using a No. 15 scalpel blade, opened it in layers, identified a well-defined fibroelastic tumor of nervous origin, and resected it with free margins. We then made an incision of approximately 4cm on the medial surface of the second toe, identified a well-defined fibroelastic tumor, and resected it with free margins. We removed the tourniquet and, once hemostasis was achieved, we closed the wound in layers and covered it with a sterile

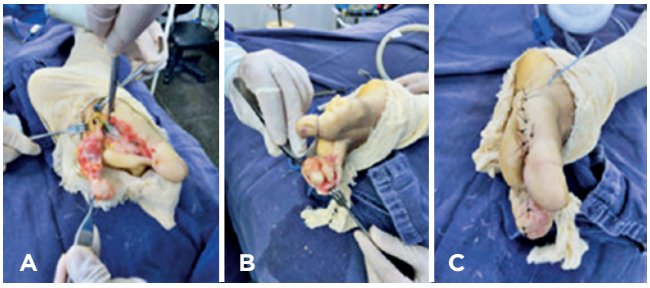


Figure 3. Intraoperative photograph of the left foot in medial view showing the removal of schwannomas from A) the first metatarsal and B) the second toe. C) Postoperative photograph after removal of schwannomas.

Figure 4. Resected tumors showing a yellowish-brown color and fibroelastic consistency.

dressing. The patient was discharged home 24 hours after the procedure. Postoperatively, there were no neural, sensory, or motor deficits. At 15 days after surgery, the patient was able to walk without pain and had no aesthetic complaints, and the stitches were removed (Figure 5). At 45-day review (Figure 6), the wound had healed completely, and the patient had no complaints. During the 1-year follow-up, she reported numbness in the plantar region of the foot, which was treated with pregabalin 75mg at night and use of hard-soled sandals for 90 days. After 90 days, she was allowed to wear normal shoes without walking aids, with no later complaints.

Discussion

Schwannomas or neurilemmomas are rare and almost always solitary tumors, although there are reports of multiple tumors in a single nerve, as described by Patel et al.[6]. They surgically removed 5 schwannomas of the ulnar nerve in a 37-year-old male patient complaining of painful masses in the right distal forearm, palm, and ring finger.

Schwannomas preferentially affect the flexor surface of the extremities, being more common in adults between 40 and 60 years of age, with no predilection for race or sex. Although schwannomas are rarely found in the foot, Angelini et al.[7] described 4 consecutive cases: a 57-year-old woman with a mass arising from the medial plantar nerve, a 45-year-old man with a schwannoma in the plantar region, a 58-year-old woman with a schwannoma arising from the sural nerve, and a 35-year-old woman with a tumor arising from the medial plantar nerve. All patients underwent surgical excision of the tumors and histological evaluation. Postoperatively, no signs of neurological deficit or tumor recurrence were observed at the final follow-up.

In most cases of schwannoma, the primary complaints include pain and/or numbness, and the precise localization of these symptoms is important to identify the compromised peripheral nerve. Because most schwannomas located in the foot present as slow-growing masses, patients might not seek medical care early, thus delaying clinical diagnosis for years[8].

Figure 5. Surgical wound at 15 days postoperatively.

Figure 6. Surgical wound at 45 days postoperatively.

Surgical excision is not always required, being recommended only in cases of large tumors arising from major peripheral nerves and in the presence of compressive symptoms[2], since a small, localized schwannoma can affect the plantar surface of the foot during activities such as walking and jumping, thus resulting in pain symptoms[9]. Postoperative morbidity resulting from surgical excision of schwannomas of the foot is minimal when the excision is properly performed, and local tumor recurrence is rare[8].

Factors such as the absence of a specific clinical diagnostic test, the variety of signs and symptoms, the rarity of the lesion, and a slow and painless growth for several years are associated with a delay in seeking care and in making the diagnosis[10].

Conclusion

We reported a rare case of schwannoma of the medial plantar nerve. The finding of multiple schwannomas may be a red flag for the possible existence of local, painful, nerve lesions despite a negative Tinel sign. Magnetic resonance imaging is a useful tool for the assessment and detection of schwannomas. Surgical excision with careful nerve dissection appears to be the most feasible treatment for this peculiar condition that may affect the foot. Appropriate surgical planning contributed to our successful intervention, without aesthetic, painful, or functional sequelae for the patient.

Authors' contributions: Each author contributed individually and significantly to the development of this article: AMF *(https://orcid.org/0000-0001-9620-7222) Conceived and planned the activities that led to the study, participated in the review process, participated in the writing of the article, data collection, approved the final version; JSM *(https://orcid.org/0000-0003-4742-1905) Interpreted the results of the study, participated in the review process, participated in the writing of the article, approved the final version; PVSP *(https://orcid.org/0000-0002-9538-8479) Participated in the review process, bibliographic review, survey of the medical records, participated in the writing of the article, approved the final version; AFMJ *(https://orcid.org/0000-0002-6430-8974) Participated in the review process, formatting of the article, participated in the writing of the article, approved the final version. All authors read and approved the final manuscript. *ORCID (Open Researcher and Contributor ID).

References

1. Renaud M, Paolo M, Ali C. Neurilemoma in the ankle as a cause of plantar foot pain: A report of one case. J Foot Ankle Surg. 2006;12(4):215-18.
2. Carter J, Ben-Ghashir N, Chandrasekar CR. Giant schwannoma of the medial plantar nerve. Foot (Edinb). 2016;26:4-6.
3. Albert P, Patel J, Badawy K, Weissinger W, Brenner M, Bourhill I, et al. Peripheral Nerve Schwannoma: A Review of Varying Clinical Presentations and Imaging Findings. J Foot Ankle Surg. 2017;56(3):632-37.
4. Kehoe NJ, Reid RP, Semple JC. Solitary benign peripheral-nerve tumours. Review of 32 years' experience. J Bone Joint Surg Br. 1995;77(3):497-500.
5. Merritt G 4th, Ramil M, Oxios A, Rushing C. Schwannoma of the plantarmedial aspect of the foot: A case report. Foot (Edinb). 2019;39:85-7.
6. Patel MR, Mody K, Moradia VJ. Multiple schwannomas of the ulnar nerve: a case report. J Hand Surg Am. 1996;21(5):875-6.
7. Angelini A, Bevoni R, Biz C, Cerchiaro MC, Girolami M, Ruggieri P. Schwannoma of the foot: report of four cases and literature review. Acta Biomed. 2019;90(1-S):214-20.
8. Carvajal JA, Cuartas E, Qadir R, Levi AD, Temple HT. Peripheral nerve sheath tumors of the foot and ankle. Foot Ankle Int. 2011;32(2):163-7.
9. Nishio J, Mori S, Nabeshima K, Naito M. Successful enucleation of large multinodular/plexiform schwannoma of the foot and ankle. Springerplus. 2015;4:260.
10. Jonathan CK, Fu-Keung IP, Tak-Chuen W, Prisilla LO, Sze-Yan C. Neurilemmomas of the hand: a review of the clinical presentation, surgical outcome, and potential risk factors. J Orthop Trauma Rehabil. 2017;22(01):48–51.

DOI: https://doi.org/10.30795/jfootankle.2021.v15.1533

Case Report

Synovial chondromatosis as an etiology of ankle impingement: a case report

Eli Ávila Souza Júnior[1]

1. Universidade Federal de Alfenas, Alfenas, MG, Brazil.

Abstract

Anterior ankle impingement is a common cause of chronic pain in this site and has synovial chondromatosis, albeit rare, as one of its possible etiologies. Both arthroscopic approach and open arthrotomy are reported as therapeutic option, but the few published data showed that the first is believed to bring more advantages. In a recent study, one of the limitations found by the authors was the rareness of this condition in the ankle, and thus the small number of publications on the topic. We present the rare case of synovial chondromatosis of the ankle in a middle-aged man, which was clinically manifested as anterior impingement syndrome and treated arthroscopically, showing an atypical arboriform vascularization pattern.

Level of Evidence V; Diagnostic Studies; Expert Opinion.

Keywords: Ankle joint; Chondromatosis, synovial; Arthroscopy.

Introduction

Anterior ankle impingement is a common cause of chronic pain in this joint. It is described as a syndrome that causes anterior ankle pain and restricted dorsiflexion, resulting from impingement of talotibial osteophytes or soft tissues[1].

Synovial chondromatosis of the ankle, one of the etiologies of anterior impingement, is a rare proliferative metaplastic synovial disease, of intra or extra-articular manifestation, which induces the formation of cartilaginous loose bodies within the joint space and may affect the anterior compartment, the posterior compartment, or both. This type of chondromatosis more often affects the knee, the elbow, and the hip, being less reported in the ankle[2]. It may also affect soft tissues, such as tendon sheaths and bursae[2,3].

Clinically, when chondromatosis is concentrated on the anterior compartment of the ankle, it manifests with signs and symptoms typically observed in anterior impingement syndromes: pain, edema, and limited range of motion, especially dorsiflexion[1]. Therefore, synovial chondromatosis, albeit rare, should always be considered as a possible etiology of impingement syndromes.

In a systematic review conducted in 2020 by Al Farii et al.[4] on the arthroscopic management of ankle synovial chondromatosis, one of the limitations presented by the authors was the rarity of this condition in the ankle, and thus the low number of publications addressing this topic.

The present report describes a rate case of ankle synovial chondromatosis clinically manifested as anterior impingement syndrome and treated arthroscopically, exhibiting an atypical arboriform vascularization pattern.

Case Description

This study was submitted to the institutional Research Ethics Committee linked to Brazil Platform.

A 48-year-old male hypertensive patient, a truck driver, who had been presenting with pain and discomfort on the anterior region of the right ankle since January 2018. There was no history of trauma or previous incidents. According to the patient, the pain increased when walking, standing, and applying manual pressure to the anterior region of the ankle. He also noticed the appearance of a small mass on the anterolateral region and, occasionally, inflammation at the site.

On clinical examination, the patient presented no foot deformities upon weight-bearing and had a usual gait pattern, without claudication. On inspection, edema was found in the anterolateral region of distal tibia. On palpation, no expansive

Study performed at the School of Medicine, Universidade Federal de Alfenas, Alfenas, MG, Brazil.

Correspondence: Eli Ávila Souza Júnior. Alameda Libânio, 72, Jardim da Colina - 37133-624, Alfenas, MG, Brazil. **E-mail:** Elijr42@yahoo.com.br. **Conflicts of interest:** none. **Source of funding:** none. **Date received:** April 25, 2021. **Date accepted:** June 20, 2021. **Online:** August 30, 2021.

How to cite this article: Souza Júnior EA. Synovial chondromatosis as an etiology of the ankle impingement: a case report. J Foot Ankle. 2021;15(2):175-8.

lesions were found in the ankle, but intensification of pain on palpation was observed in the anterior distal border of the tibia. With regard to mobility, a restriction of 15 degrees in ankle dorsiflexion was observed, with intensification of pain when this movement was performed in a forced manner. Neurovascular examination was normal.

The patient underwent radiographic tests, which showed anterior tibial articular osteophytosis, in addition to radiopaque loose bodies in the joint space (Figure 1).

Magnetic resonance imaging confirmed osteophytosis in the anterior tibial articular border, joint chondral loose bodies, in addition to extensive synovitis, characterized by hypersignal in T2 (Figure 2).

In view of clinical-imaging suspicion of syndrome of anterior ankle impingement due to synovial chondromatosis and the presence of an evident mass, the vantages and disadvantages of conservative vs surgical treatment were discussed with the patient and a joint decision was made for anterior videoarthroscopic surgical treatment, with diagnostic and therapeutic proposals being discussed simultaneously.

In January 2021, the patient underwent anterior videoarthroscopy of the right ankle, with the classical anteromedial and anterolateral portals. On articular inventory, extensive synovitis was observed in the ankle joint, as well as chondral loose bodies, abundant osteophytosis in the entire anterior border of the tibia, with direct impact on the talus, and an atypical neovascularization pattern covering the chondral surface of the talus and having an arboriform aspect (Figure 3).

Figure 1. Profile radiological scan of right ankle showing anterior tibial articular osteophytosis and radiopaque joint loose bodies.

The following procedures were performed, exclusively by an anterior arthroscopic approach: extensive ankle joint synovectomy, removal of articular free bodies, and of osteotomy of anterior tibial osteophytosis guided by intraoperative fluoroscopy (Figure 4).

Furthermore, cauterization of talar arboriform neovascularization was performed. The resected material was sent to the laboratory for histopathological examination (Figure 5).

The ankle was immobilized with an orthopedic boot and unrestricted protected support.

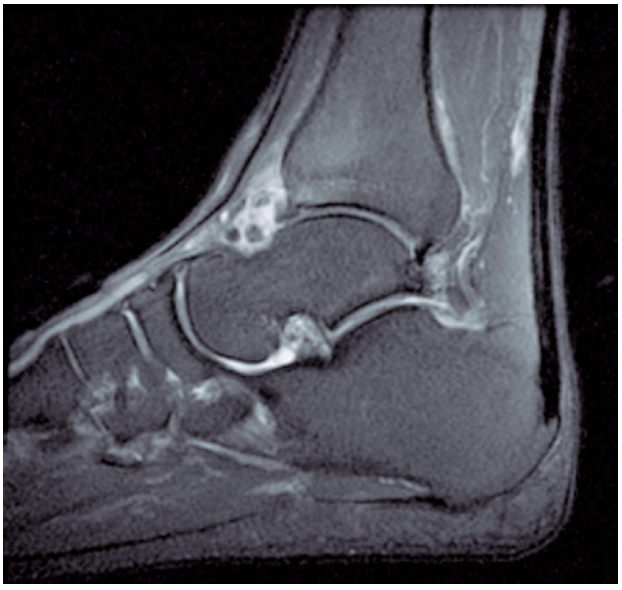


Figure 2. T2-weighted sagittal magnetic resonance image revealing osteophytosis in the anterior tibial articular border, joint chondral loose bodies, and synovitis.

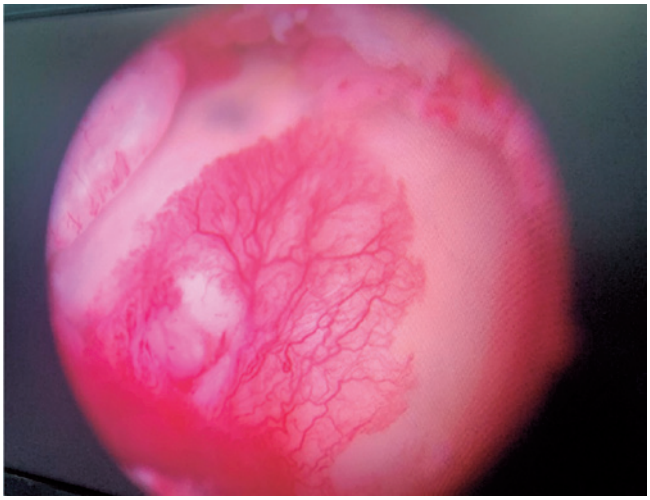


Figure 3. Intraoperative arthroscopic image demonstrating neovascularization covering the chondral surface of the talus and having an arboriform aspect.

On the first postoperative assessment, 1 week after surgery, the patient had already reported improvement in pain symptoms and was satisfied with reduction in anterior ankle edema. At 2 weeks postoperatively, the patient brought the results from histopathological examination, which described multiple firm whitish irregular fragments measuring 2.5 x 2.0 x 1.5 cm in total, consistent with synovial chondromatosis, with no signs of malignancy. At 3 months postoperatively, after physical therapy, the patient showed full improvement of impingement symptoms, improvement of 10 degrees in ankle extension, with no pain or functional complaints. Year patient follow-up was proposed, or earlier in case of appearance of symptoms, due to the risk, albeit low, of potential malignancy.

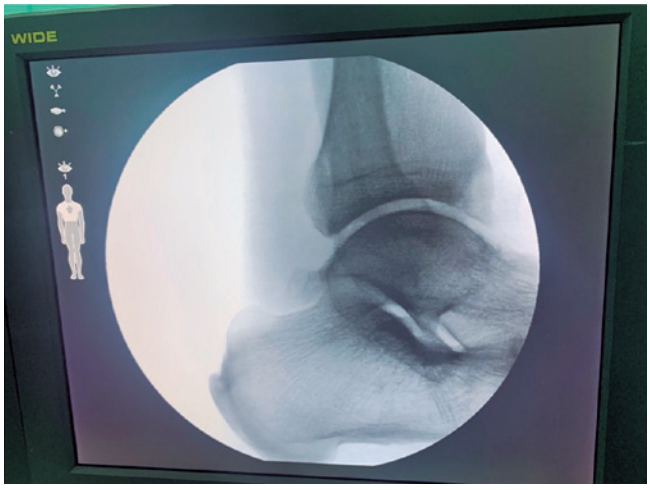


Figure 4. Profile view of fluoroscopic image of ankle after anterior tibial articular osteotomy.

Figure 5. Joint specimen collected on videoarthroscopy and sent to histopathological examination.

Discussion

Synovial chondromatosis is a rare joint disease that is even rarer in the foot and the ankle. It affects more men than women, is more frequent between 30 and the 50 years of age, and the role of trauma or genetic predisposition in its etiology has not been elucidated yet[5]. The present report is consistent with these findings, since it described the case of a 48-year-old man with no history of trauma or relevant genetic-hereditary issues. The case series reported by Saxena and St Louis[6] in 2017 supports these epidemiological data by presenting 2 cases of ankle synovial chondromatosis in male individuals aged from 37 to 43 years old. The most recent systematic review on the topic found a male/female ratio of 3:1, evidencing again the predominance of men[4].

From the clinical point of view, pain is the most common symptom, and more than a half of patients complain of edema and reduced ankle mobility[4]. These manifestations are typically described in syndromes of anterior ankle impingement, which have several variations described in the literature, such as impingement of bones or soft tissues affecting the anteromedial or anterolateral region[1]. In the case reported here, pain was indeed the most disturbing symptom for the patient, who also complained of persistent edema and difficult mobility, especially for extension. Since it is a diffuse hypertrophic synovial disease, with multiples loose bodies in the joint[4], impingement of bones and soft tissues affected the anterior compartment of the ankle as a whole, not respecting the anteromedial vs anterolateral separation. In the cases reported by Saxena and St Louis[6], pain and stiffness were also the predominant manifestations; moreover, the observed impingement and degeneration also affected the anterior compartment diffusely.

The present case, as well as those reported by Saxena and St Louis[6], and 95% of those investigated in the systematic review by Al Farii et al.[4], were classified into phase 3 chondromatosis, according to the classification described by Milgram[7], with free loose bodies within the joint. There are no data correlating disease phases, according to this classification, and risk of malignancy.

The treatment of synovial chondromatosis of the ankle is based on patient's age, symptoms, and clinical disease stage[4]. Both arthroscopic approach and open arthrotomy are reported, but the few published data showed that the first is believed to bring more advantages, allowing for a wider visualization, ease of access to more restricted, lower morbidity, earlier recovery, and greater patient's satisfaction. Isbell et al.[8] describe a case of recurrent disease that, on the second presentation, was managed using arthroscopy [intra-articular approach] and open resection [extra-articular approach], a fact that is confirmed by Mihovil's study employing complete synovial resection. Varied arthroscopy techniques are

reported, but all of them included total synovectomy and excision of joint loose bodies as the core of treatment[4]. When indicated, addition procedures, such as bursectomy, tendon sheath debridement, microfractures, osteochondral lesion debridement, and osteophyte resection are also performed using an open approach[4]. In the case reported here, ancillary procedures involved resection of anterior tibial osteophytes to control the syndrome of anterior bone impingement and complete cauterization of an atypical neovascularization that covered the chondral surface of the talus, as shown in Figure 3, a procedure not often described in the literature. There are no data proving the superiority of the arthroscopic approach over the open approach with regard to recurrence and risks of malignancy.

Although chondromatosis is often a benign condition, differential diagnosis with chondrosarcoma, as well as its potential for malignant transformation, is evidenced in up to 5% of the cases[9]. Perry et al.[10] reported the case of a woman with calcified joint loose bodies in the knee 13 years after initial trauma. Surgical treatment was total synovectomy, and histopathological analysis revealed grade 2 chondrosarcoma requiring transfemoral amputation. Therefore, histopathological analysis is always necessary, in addition to prolonged patient follow-up[6].

Conclusion

A joint condition little described in the literature, synovial chondromatosis should always be considered as an etiological hypothesis of syndromes of anterior ankle impingement. More publications on this unusual condition are needed to endorse studies that propose to explore the best therapeutic options for this disease. The bias of this study was its short follow-up, which did not allow us to describe the relationship with recurrence and malignancy.

Authors' contributions: Each author contributed individually and significantly to the development of this article: EASJ *(https://orcid.org/0000-0002-5054-874X) conceived and planned the activities that led to the study, wrote the article, interpreted the results of the study, data collection, bibliographic review. *ORCID (Open Researcher and Contributor ID).

References

1. Van Dijk CN, Verhagen RA, Tol JL. Arthroscopy for problems after ankle fracture. J Bone Joint Surg Br. 1997;79(2):280-4.
2. Ozmeric A, Aydogan NH, Kocadal O, Kara T, Pepe M, Gozel S. Arthroscopic treatment of synovial chondromatosis in the ankle joint. Int J Surg Case Rep. 2014;5(12):1010-3.
3. Bojanić I, Plečko M, Mataić A, Dimnjaković D. Anterior and Posterior Arthroscopic Treatment of Primary Synovial Chondromatosis of the Ankle. Foot Ankle Int. 2021;42(4):440-7.
4. Al Farii H, Doyle-Kelly C, Marwan Y, Volesky M, Turcotte R. Arthroscopic Management of Synovial Chondromatosis of the Ankle Joint: A Systematic Review of the Literature. JBJS Rev. 2020; 8(9):e2000045.
5. Galat DD, Ackerman DB, Spoon D, Turner NS, Shives TC. Synovial chondromatosis of the foot and ankle. Foot Ankle Int. 2008; 29(3):312-7.
6. Saxena A, St Louis M. Synovial Chondromatosis of the Ankle: Report of Two Cases With 23 and 126 Loose Bodies. J Foot Ankle Surg. 2017;56(1):182-6.
7. Milgram JW. Synovial osteochondromatosis: a histopathological study of thirty cases. J Bone Joint Surg Am. 1977;59(6):792-801.
8. Isbell JA, Morris AC, Araoye I, Naranje S, Shah AB. Recurrent Extra- and Intra-articular Synovial Chondromatosis of the Ankle with Tarsal Tunnel Syndrome: A Rare Case Report. J Orthop Case Rep. 2017;7(2):62-5.
9. Peixoto D, Gomes M, Torres A, Miranda A. Arthroscopic treatment of synovial chondromatosis of the ankle. Rev Bras Ortop. 2018; 53(5):622-5.
10. Perry BE, McQueen DA, Lin JJ. Synovial chondromatosis with malignant degeneration to chondrosarcoma. Report of a case. J Bone Joint Surg Am. 1988;70(8):1259-61.

DOI: https://doi.org/10.30795/jfootankle.2021.v15.1557

Technical Tips

Reconstruction of chronic extensor hallucis longus tendon rupture using plantaris tendon graft

Ricardo Ummen de Almeida Tenório Villar[1], Pedro Costa Benevides[1], Caio Augusto de Souza Nery[1,2], Marcelo Pires Prado[1], José Felipe Marion Alloza[1], Renato do Amaral Masagão[1], Alexandre Leme Godoy-Santos[1,3]

1. Hospital Israelita Albert Einstein, São Paulo, SP, Brazil.
2. Paulista School of Medicine, Universidade Federal de São Paulo, São Paulo, SP, Brazil.
3. Professor Manlio Mario Marco Napoli Laboratory, Hospital das Clínicas, Faculdade de Medicina, Universidade de São Paulo, SP, Brazil.

Abstract

Chronic tendon ruptures can be difficult to manage as end-to-end repair can be challenging. In this scenario, reconstruction techniques with tendon grafts may be useful. The ideal tendon graft would be one that has similar biomechanical properties, low donor-site morbidity and length compatible with the tendon gap. We describe a safe technique for the reconstruction of a chronic extensor hallucis longus tendon rupture using a plantaris tendon graft.

Level of Evidence V, Therapeutic Studies; Expert Opinion.

Keywords: Hallux; Muscle, skeletal; Tendon injuries; Rupture.

Introduction

The treatment of neglected or chronic extensor hallucis longus (EHL) tendon ruptures can be challenging. Retraction or degeneration of the tendon stumps are not uncommon, and the presence of some degree of tendon retraction and/or degeneration often makes primary repair impossible, requiring the surgeon to master reconstruction techniques using grafts or tendon transfers. Reconstruction techniques using extensor digitorum longus (EDL)[1], semitendinosus, gracilis, peroneal longus, and plantaris tendons have been described in the literature, but there is no consensus on which technique is optimal.

Here we present a technical tip using a reconstruction technique with free plantaris tendon graft to treat a chronic EHL rupture in a 33-year-old patient. This is a safe procedure associated with less morbidity than other techniques.

Clinical symptoms & radiological findings

A 33-year-old woman presented with the complaint of limited right hallux range of motion (ROM) for 5 months. She had dropped a sharp object on her right foot 4 years earlier. Physical examination showed a hallux flexus deformity with loss of active and passive dorsiflexion (Figure 1A-H). Muscle strength was decreased in dorsiflexion to the right hallux. Foot and ankle radiographic findings were normal. Magnetic resonance imaging (MRI) revealed an EHL rupture with the proximal stump at the level of the head of the talus (Figure 2A-G). The proximal and distal tendon ends were irregular and tortuous with a heterogenous sign. MRI also showed a dorsal talar osteophyte. Dynamic ultrasound confirmed the EHL rupture, showing the proximal stump at the level of the talonavicular joint and the distal stump at the mid-diaphysis of the first metatarsal. During the dynamic maneuver, we

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

Correspondence: Ricardo Ummen de Almeida Tenório Villar. Av. Albert Einstein, 627, Jardim Leonor - 05652-900, São Paulo SP, Brazil. **E-mail:** ricardovillar_@hotmail.com.
Conflicts of Interest: none. **Source of funding:** none. **Date received:** July 09, 2021. **Date accepted:** July 12, 2021. **Online:** August 31, 2021.

How to cite this article: Villar RUAT, Benevides PC, Nery CAS, Prado MP, Alloza JFM, Masagão RA, et al. Reconstruction of chronic extensor hallucis longus tendon rupture using plantaris tendon graft. J Foot Ankle. 2021;15(2):179-82.

Figure 1. Preoperative clinical photographs.

Figure 2. Intraoperative and postoperative photographs.

observed a synchronic motion of the two stumps-they were apparently still partially connected by a thin (1mm) fibrous scar tissue. Electromyography of the right lower limb revealed abnormalities in the deep peroneal nerve at the extensor retinaculum suggestive of compression. We performed operative treatment.

Technical tips

With the patient in the supine position under spinal anesthesia with a pneumatic tourniquet applied to the thigh, we made a dorsal incision along the course of the EHL tendon and identified the distal stump at the level of the neck of the first metatarsal. We extended the incision proximal to the level of the extensor retinaculum, where we identified the proximal stump. We debrided each end of both stumps and noted a large tendon defect (Figure 3A). We identified some osteophytes at the talonavicular joint and debrided them as well. In the middle third of the lower leg, we made a 3-cm longitudinal incision just medial to the tibia (Figure 3B). We then made an incision in the fascia, identified the plantaris tendon at its descending course and performed a proximal tenotomy. We harvested the plantaris tendon by advancing a stripper down to its calcaneal insertion, thus obtaining a 14-cm graft (Figure 3C). We anastomosed the graft to the proximal and distal stumps using 3-0 Vicryl® with a latero-lateral technique (Figure 3D). We closed the wounds in layers (Figure 3E) and applied a negative-pressure dressing (PICO®). We confirmed that the neutral position of the hallux was maintained after the repair (Figure 3F) and applied a short-leg cast. We removed the stitches after 2 weeks, when the patient began physical therapy with ROM exercises (except for plantar flexion). We then placed a moldable thermoplastic splint to hold the hallux in extension postoperatively (Figure 3G). We kept the patient non-weight-bearing for 6 weeks after surgery. At 3 months, the patient resumed her daily activities with no restrictions.

The correct position of the hallux was maintained after rehabilitation until the last visit (Figure 2H).

Discussion

Extensor tendon injuries account for 1% of all foot injuries[1,2]. The surgical treatment of neglected extensor tendon ruptures (>6 weeks) often requires the use of grafts due to tendon stump fibrosis and retraction. Al-Qattan proposed an anatomic classification based on the zone of injury[1,3]:

Zone 1: at the insertion site on the distal phalanx.

Zone 2: the area between zones 1 and 3.

Zone 3: over the first metatarsophalangeal joint.

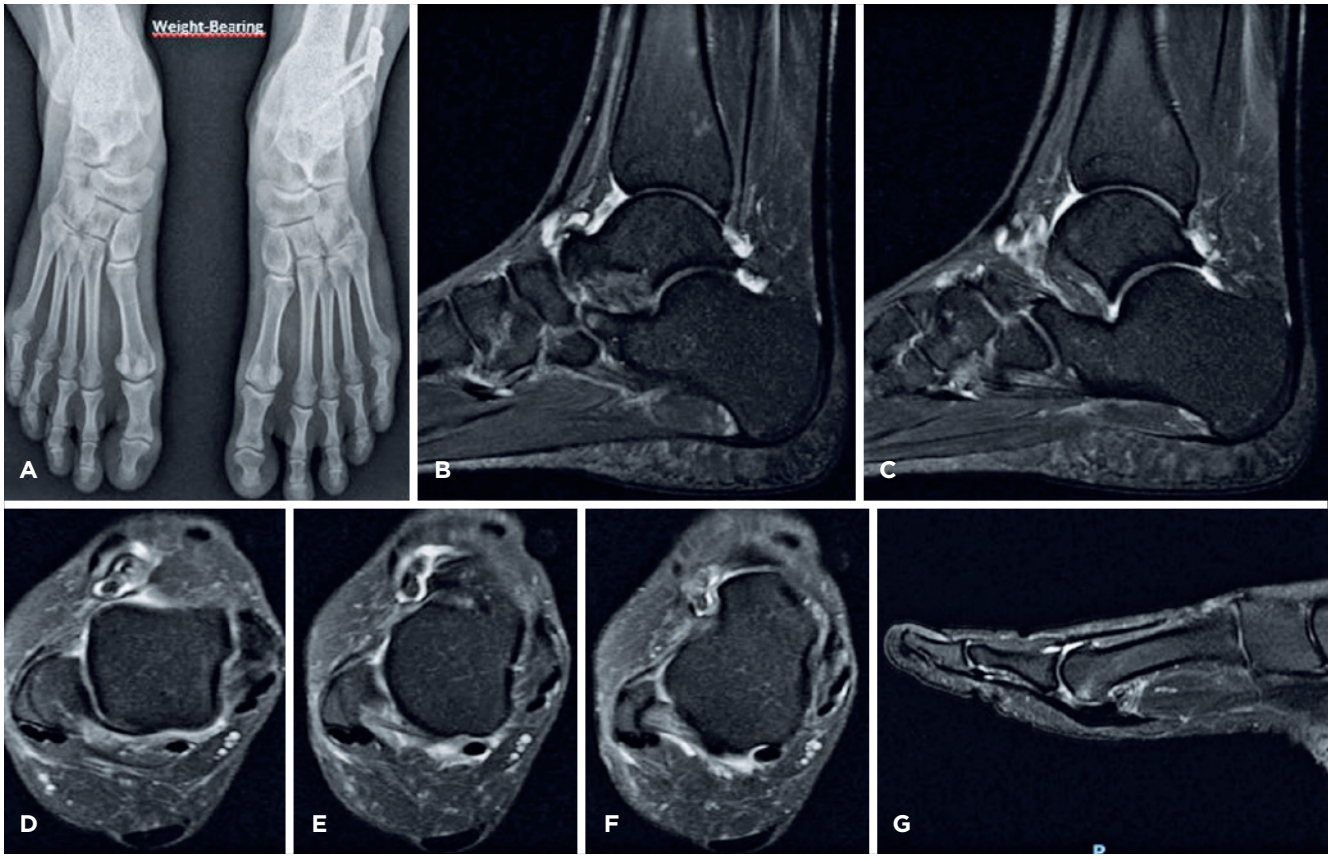


Figure 3. Radiographs and magnetic resonance images.

Zone 4: on the dorsum of the foot between zones 3 and 5.

Zone 5: laceration of the tendon beneath the extensor retinaculum.

Zone 6: in the lower leg proximal to the extensor retinaculum.

For late reconstruction of the EHL tendon requiring lengthening, techniques have been described using EDL[1], semitendinosus, gracilis, peroneal longus, plantaris tendon, and accessory extensor of the EHL tendon[4], in addition to the possibility of using an allograft from a tissue bank.

The use of grafts has been associated with donor-site morbidity, such as pain and loss of function. Using an allograft is an option to avoid donor-site morbidity; however, allografts are not widely available and require special infrastructure for collection, sterilization, and transportation.

Surgical results can be classified according to the grading system proposed by Lipscomb and Kelly *apud* Al-Qattan[3], as follows: good, the patient has normal ROM of the hallux (compared to contralateral) and no pain; fair, the patient has painless, active hallux extension and no tripping over the hallux when walking barefoot; and poor, the patient has no active hallux extension, tripping over the hallux when walking barefoot, or persistent pain.

We described here a technique with low patient morbidity, since the plantaris muscle is of secondary importance in biomechanics and is present in more than 90% of individuals[5]. The plantaris is one of the muscles of the superficial posterior compartment of the leg, originating from the lateral femoral condyle and inserting into the medial side of the calcaneus in most patients. It acts as an ankle plantar flexor and is a weak knee flexor. Savita et al.[6], in a study of 48 legs (24 patients), reported that the plantaris tendon length ranged from 34 to 38 cm in 66.5% of cases, being absent in 12.5%.

Yammine et al.[5], in a meta-analysis conducted in 2019 that compiled the results of 41 studies with a total of 10 062 legs, also showed that plantaris tendon grafts had satisfactory length (30.63±5.87cm) and thickness (3.68±1.37mm). These morphologic features are important because this graft allows us to perform several surgical techniques, including double grafts for greater resistance.

In the case reported here, the plantaris muscle, as it is a vestigial structure with a long tendon, provided a safe tendon graft option with low associated morbidity for the reconstruction of chronic EHL ruptures with large gaps between tendon stumps.

Authors' contributions: Each author contributed individually and significantly to the development of this article: RUATV *(https://orcid.org/0000-0002-4563-5726) Conceived and planned the activities that led to the study, participated in the review process, data collection; PCB *(https://orcid.org/0000-0002-4209-0564) Conceived and planned the activities that led to the study, participated in the review process, clinical examination; CASN *(https://orcid.org/0000-0002-9286-1750) Approved the final version, participated in the review process; MPP *(https://orcid.org/0000-0003-3812-9320) Approved the final version, participated in the review process; JFMA *(https://orcid.org/0000-0002-7664-2064) Data collection, formatting of the article; RAM *(https://orcid.org/0000-0002-7830-8318) Data collection, formatting of the article; ALGS *(https://orcid.org/0000-0002-6672-1869) Performed the surgeries, conceived and planned the activities that led to the study, clinical examination. All authors read and approved the final manuscript. *ORCID (Open Researcher and Contributor ID).

References

1. Wong JC, Daniel JN, Raikin SM. Repair of acute extensor hallucis longus tendon injuries: a retrospective review. Foot Ankle Spec. 2014;7(1):45-51.
2. Jaffe D. Restoration of Extension of the Great Toe After an Untreated, Retracted Extensor Hallucis Longus Rupture: A Case Report. JBJS Case Connect. 2019;9(4):e0348.
3. Al-Qattan MM. Surgical treatment and results in 17 cases of open lacerations of the extensor hallucis longus tendon. J Plast Reconstr Aesthet Surg. 2007;60(4):360-7.
4. Kurashige T. Chronic extensor hallucis longus tendon rupture treated with double-bundle autograft of extensor hallucis capsularis: A case report. SAGE Open Med Case Rep. 2019;7:2050313X19841962.
5. Yammine K, Saghie S, Assi C. A Meta-Analysis of the Surgical Availability and Morphology of the Plantaris Tendon. J Hand Surg Asian Pac. 2019;24(2):208-18.
6. Savita K, Tuli A, Agarwal S. Morphology of plantaris longus with special reference to its clinical importance. Int J Anat Res 2019;7(4.2):7101-4.

DOI: https://doi.org/10.30795/jfootankle.2021.v15.1558

Technical Tips

Distal fibular periosteal flap for superior peroneal retinaculum reconstruction

Samuel J Ahrenholz[1], Matthieu Lalevée[1,2], Hee Young Lee[1], Tutku E Tazegul[1], Christian A VandeLune[1], Nacime Salomão Barbachan Mansur[1,3], César de César Netto[1]

1. University of Iowa, Carver College of Medicine, Department of Orthopedics and Rehabilitation, Lowa City, IA, USA.
2. Department of Orthopedic Surgery, Rouen University Hospital, Rouen, France.
3. Universidade Federal de São Paulo, Paulista School of Medicine, Department of Orthopedics and Traumatology, São Paulo, SP, Brazil.

Abstract

Peroneal tendon instability is a common injury that occurs in physically active individuals, often as a result of trauma and in the context of an anatomically shallow distal fibular groove. Subluxation of these tendons over the lateral malleolus is accompanied by superior peroneal retinaculum injury. Several techniques have been described in the literature, including fibular groove deepening and retinaculum repair, but few reconstruction techniques are available for cases with insufficient residual retinaculum. We report the case of a 53-year-old man, without a history of trauma, who presented with chronic peroneal instability with a completely obliterated, unsalvageable retinaculum which we treated with a combination of fibular groove deepening and fibular periosteal flap to reconstruct the superior peroneal retinaculum.

Level of Evidence V; Case Report; Expert Opinion.

Keywords: Joint instability; Periosteum; Tendons; Tendon injuries; Ligaments.

Introduction

Dislocation or subluxation of the peroneal tendons is a common injury that occurs in athletes or physically active individuals often after trauma and can lead to chronic peroneal tendon instability. A shallow fibular groove is frequently associated with this pathology, and the superior peroneal retinaculum injuries are systematic[1,2]. In cases of chronic peroneal tendon instability, there is little evidence that conservative management can lead to significant healing; therefore, many researchers support surgical treatment[1,3-6].

Several procedures can be used to restore peroneal tendon stability[1,3]. In cases of a shallow fibular groove, surgical groove deepening is frequently performed in combination with repair or reinforcement of the superior peroneal retinaculum[5,6]. Usually, the damaged retinaculum is still present and allows direct suture, or it can be used as an anchor point for reinforcement. In the context of ancient chronic instability, the superior peroneal retinaculum may be obliterated and unusable.

The purpose of this study was to report a case of chronic peroneal instability with an obliterated peroneal retinaculum and to describe the surgical procedure we used to reconstruct the superior peroneal retinaculum with a fibular periosteal flap.

Case Description

This study was approved by an Institutional Review Board and the patient provided informed consent.

A 53-year-old active male patient suffered from chronic instability of the peroneal tendons in the right ankle for many years and did not report any history of trauma. The peroneal instability was initially asymptomatic, and the pain developed progressively within a few months. He was treated with an ankle brace which did not provide significant benefit.

Study performed at Department of Orthopaedic and Rehabilitation. University of Iowa, Carver College of Medicine, Lowa City, IA, USA.

Correspondence: César de César Netto. Department of Orthopaedic and Rehabilitation. University of Iowa, Carver College of Medicine. 200 Hawkins Dr, John Pappajohn Pavillion (JPP). Room 01066, Lower Level. Iowa City, IA, 52242. United States. **E-mail:** cesar-netto@uiowa.edu. **Conflicts of Interest:** none. **Source of funding:** none. **Date received:** July 10, 2021. **Date accepted:** July 12, 2021. **Online:** August 31, 2021.

How to cite this article: Ahrenholz SJ, Lalevée M, Lee HY, Tazegul T, VandeLune CA, Mansur NSB, et al. Distal fibular periosteal flap for superior peroneal retinaculum reconstruction. J Foot Ankle. 2021;15(2):183-7.

Subluxation of the peroneal tendons was confirmed clinically and triggered pain (Figure 1). Hindfoot alignment was neutral. Magnetic resonance imaging showed slight signs of peroneal tendinopathy, a deficient superior retinaculum, and an accessory peroneus quartus (Figure 2). Weight-bearing computed tomography assessment confirmed good alignment of the foot (foot and ankle offset, 4.41%) and insufficient peroneal groove depth.

Figure 1. Subluxation of the peroneal tendons in inversion.

After careful explanation of the disease and treatment options, the patient decided to proceed with surgical treatment.

Surgical procedure

With the patient in the supine position under general anesthesia with a tourniquet placed onto the operative thigh and inflated to 300 mm Hg after limb exsanguination, we made a 7-8-cm longitudinal incision along the course of the peroneal tendons at the level of the distal fibula. We carefully dissected the subcutaneous tissue down to the level of the peroneal retinaculum and noted a completely insufficient, obliterated superior peroneal retinaculum, with subluxation of the peroneal tendons anterior and lateral to the distal fibula after inversion of the subtalar joint. We also noted a low-lying peroneus brevis muscle belly and a peroneus quartus and resected them by sharp dissection. No peroneus brevis or peroneus longus tendon tears or splits were noted.

We then proceeded with groove deepening of the distal fibula. We inserted a 3.5-mm cannulated drill with a guidewire distal to proximal into the distal fibula and then made a drill hole in the posterior aspect of the distal fibula. We used a bone tamp to collapse the posterior surface of the distal fibula and deepened the peroneal groove without creating a rough raw bone surface (Figure 3).

We used a distal fibular periosteal flap to reconstruct the superior peroneal retinaculum due to insufficient retinaculum. We performed dissection anteriorly at the level of the distal fibular periosteum with a knife and elevated a 4-cm-long distal fibular periosteal flap from proximal to distal while keeping

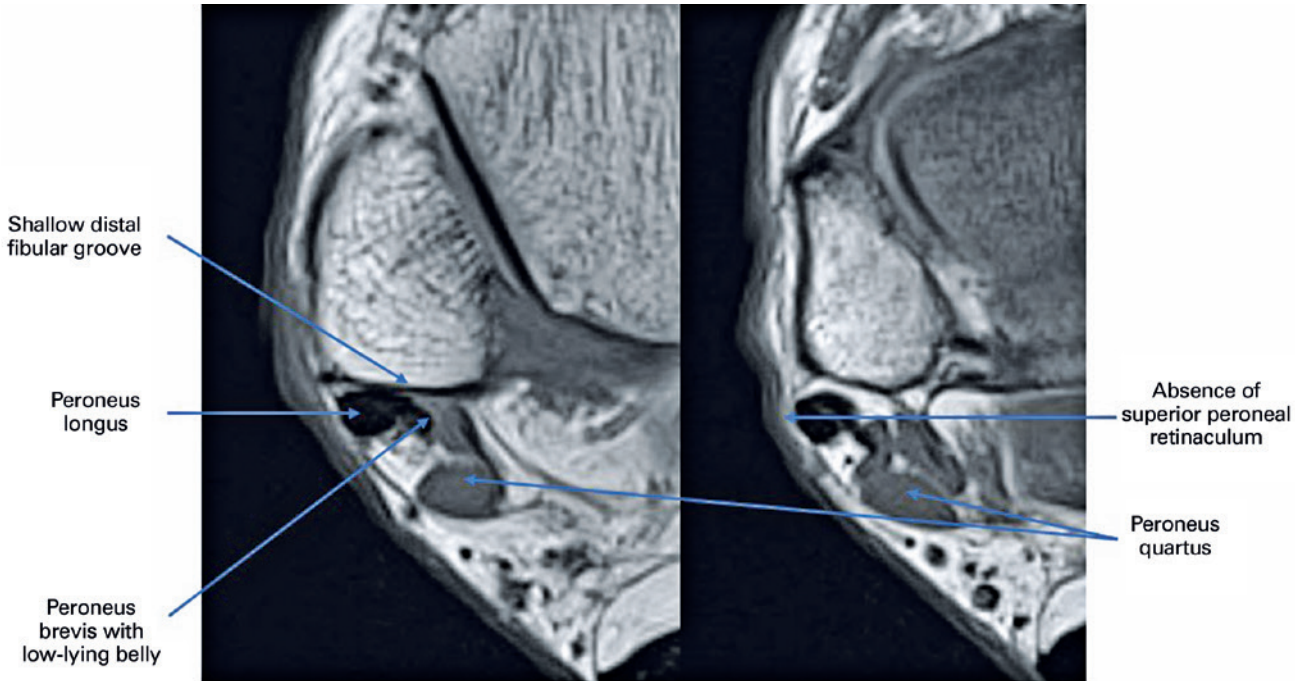


Figure 2. Axial T1-weighted magnetic resonance image showing the peroneal compartment in the retrofibular groove.

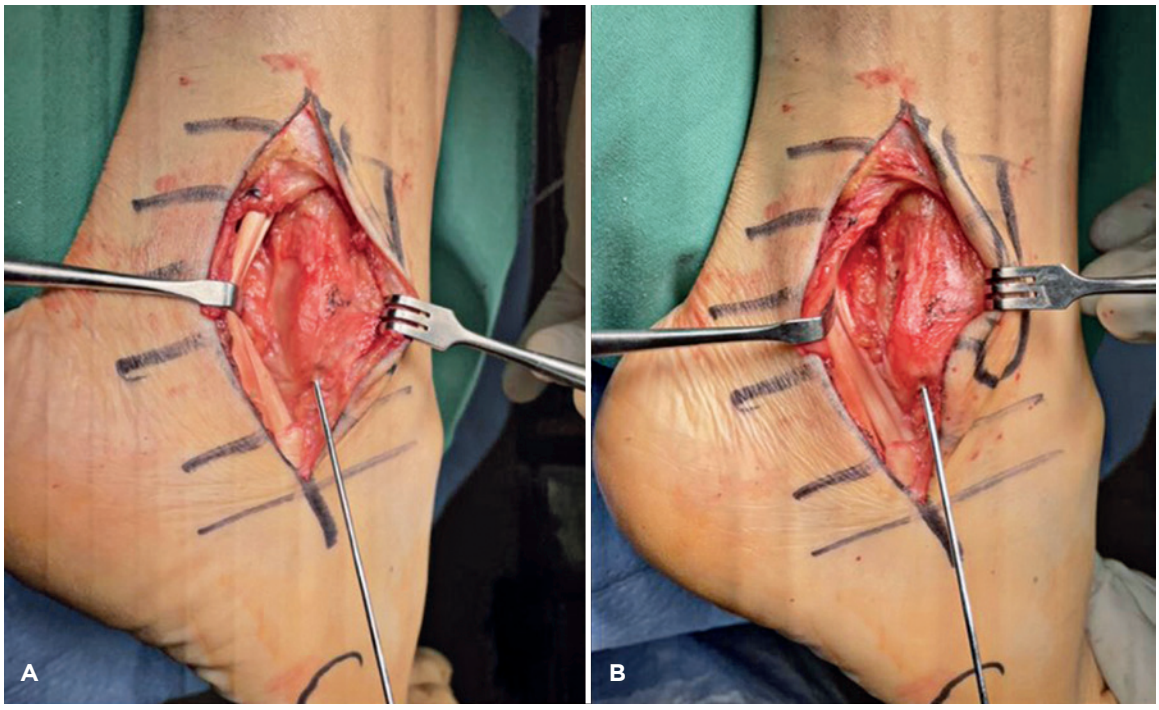


Figure 3. Deepening of the peroneal groove. A) Before deepening. B) After deepening.

a rotating point distally, still connected to the distal fibula (Figure 4). We used a K-wire to create two tunnels in the distal fibula from anterior to posterior at the posterior border of the distal fibula. We sutured the distal fibular periosteum using 2-0 Vicryl, serving as an external rotation point of the periosteal flap. We rotated the distal fibular periosteal flap medially and laterally to insert it into the posterolateral aspect of the calcaneal tuberosity. We then inserted a suture anchor into the posterolateral surface of the calcaneal tuberosity and used it to advance the periosteal flap, thus reconstructing the most important part of the superior peroneal retinaculum (Figure 5). We performed this process while keeping the peroneal tendons reduced into proper position. We carefully tensioned the suture, avoiding any compression of the peroneal tendons into the peroneal groove. We then placed the residual superior peroneal retinaculum medial tissue back into the distal fibula through transosseous sutures with 2-0 Vicryl and attached it to the newly reconstructed retinaculum (Figure 6).

We cleaned the wounds, released the tourniquet, and confirmed hemostasis. We then sutured the subcutaneous tissue and skin.

The patient was initially non-weight-bearing in a splint and progressively resumed weight-bearing in a walking boot 4 weeks after surgery for 4 supplementary weeks.

Figure 4. Fibular periosteal flap.

Discussion

More than 20 procedures have been described to repair or reinforce the superior peroneal retinaculum[7], but there are few descriptions of entire reconstruction of the peroneal retinaculum. Nevertheless, this procedure is essential in rare chronic cases with insufficient residual retinaculum.

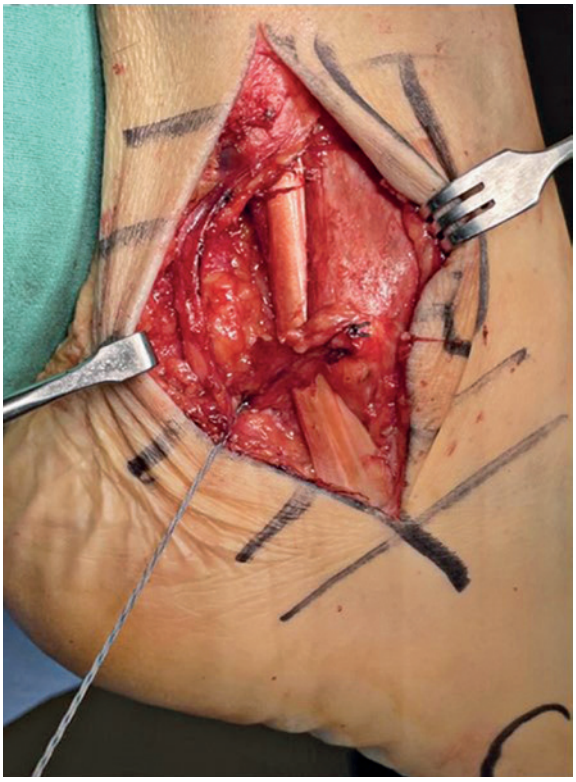


Figure 5. Anchorage of the fibular flap to the calcaneus.

Figure 6. Suture of the proximal part of the residual retinaculum.

Peroneal tendon rerouting behind the calcaneofibular ligament has been proposed[7] to palliate the insufficient peroneal retinaculum. However, this technique is non-anatomic and requires sectioning the calcaneofibular ligament to reroute the tendons and then repairing the calcaneofibular ligament over the latter. Peroneal tendon pathologies are frequently associated with lateral ankle instability and hindfoot varus[7]; therefore, this intervention appeared risky to us.

Tissue transfers, using the plantaris or a strip of the Achilles tendon, have also been proposed to reconstruct the peroneal retinaculum. However, harvesting these structures requires additional incisions[8].

The fibular periosteum is located close to the peroneal groove and is a suitable structure to replace the superior peroneal retinaculum. Several authors have described procedures using a periosteal flap to reinforce the residual retinaculum[7,9], but these techniques require anchoring the periosteal flap to the residual retinaculum. In the present case, the residual retinaculum was insufficient to apply these techniques. In 1930, Hanson described an entire reconstruction of the retinaculum using one periosteal flap from the distal fibula and one from the calcaneus, suturing them over the tendon[6]. We have improved this concept by using an entire fibular periosteal flap to avoid creating a point of fragility caused by suturing the two flaps. For the same reason, we reinforced the flap anchorage on the fibular side by using transosseous sutures and on the calcaneal side by using an anchor. Moreover, this technique respects the original anatomic insertions of the superior peroneal retinaculum on the fibula and on the calcaneus.

Conclusion

In this article, we described the anatomic reconstruction of the superior peroneal retinaculum using a fibular periosteal flap combined with fibular groove deepening. This procedure can be useful in rare cases of chronic peroneal instability associated with insufficient residual retinaculum.

Authors' contributions: Each author contributed individually and significantly to the development of this article: SJA *(https://orcid.org/0000-0002-5486-9858) Wrote the paper, participated in the reviewing process, approved the final version; ML *(https://orcid.org/0000-0001-5058-8867) Participated in the reviewing process, approved the final version; HYL *(https://orcid.org/0000-0003-4179-9501) Participated in the reviewing process, approved the final version; TT *(https://orcid.org/0000-0002-3802-3422) Participated in the reviewing process, approved the final version; CAV *(https://orcid.org/0000-0002-7797-6111) Participated in the reviewing process, approved the final version; NSBM *(https://orcid.org/0000-0003-1067-727X) Participated in the reviewing process, approved the final version; CCN *(https://orcid.org/0000-0001-6037-0685) Conceived and planned the activities that led to the study, approved the final version. All authors read and approved the final manuscript. *ORCID (Open Researcher and Contributor ID).

References

1. Alm A, Lamke LO, Liljedahl SO. Surgical treatment of dislocation of the peroneal tendons. Injury. 1975;7(1):14-9.
2. Mann RA. Surgery of the Foot: In Memory of Henri L. Duvries and Verne T. 5th ed. St. Louis: Mosby; 1986.
3. Beck E. Operative treatment of recurrent dislocation of the peroneal tendons. Arch Orthop Trauma Surg. 1981;98(4):247-50.
4. Kvist M. Achilles tendon injuries in athletes. Sports Med. 1994; 18(3):173-201.
5. Jones E. Operative treatment of chronic dislocation of the peroneal tendons. J Bone Joint Surg. 1932;14:574-6.
6. Hanson R. Operative treatment of a case of luxation habitualis tendon peroneal bilatal. Acta Orthop Scand. 1930;1(1/4):276–80.
7. Tan V, Lin SS, Okereke E. Superior Peroneal Retinaculoplasty: A Surgical Technique for Peroneal Subluxation. Clin Orthop Relat Res. 2003;(410):320-5.
8. Heckman DS, Reddy S, Pedowitz D, Wapner KL, Parekh SG. Operative treatment for peroneal tendon disorders. J Bone Joint Surg Am. 2008;90(2):404-18.
9. Gould N. Technique tips: footings. Repair of dislocating peroneal tendons. Foot Ankle. 1986;6(4):208-13.

DOI: https://doi.org/10.30795/jfootankle.2021.v15.1552

Technical Tips

Wrinkle sign for the Silfverskiöld test

José Antonio Veiga Sanhudo[1], **Giorgio Marin Canuto**[2]

1. Hospital Moinhos de Vento, Porto Alegre, Rio Grande do Sul, Brazil.
2. Hospital de Clínicas de Porto Alegre, Rio Grande do Sul, Brazil.

Abstract

Shortening of the triceps surae is evaluated using the Silfverskiöld test. The increase in dorsiflexion with the knee in flexion compared to the knee in extension makes the test positive. To perform the test, the examiner uses both hands and is not able to hold any device for objective measurement while assessing the magnitude of dorsiflexion. In view of this obstacle, this paper aims to describe a tip of a physical examination technique for evaluating the shortening of the triceps surae through the evaluation of the anterior wrinkle of the ankle. We performed the technique in a patient with shortening of the gastrocnemius and recorded the test, showing an increase in the anterior skinfold of the ankle. The test is simple, reproducible, requires no additional apparatus and shows variety in the severity of shortening.

Level of Evidence V; Therapeutic Studies; Expert Opinion.

Keywords: Gastrocnemius muscle; Ankle joint; Contracture; Orthopedic procedures.

Introduction

Gastrocnemius tightness is associated with many orthopedic disorders. The clinical test used to detect this problem was described by Nils Silfverskiöld in 1924 and is still very useful nowadays[1]. Ankle dorsiflexion is tested with the knee extended and flexed. The test is positive when dorsiflexion increases with knee flexion. Because the gastrocnemius proximal insertion is located at the distal femur, knee flexion will relax the gastrocnemius if it is tight, thus increasing ankle dorsiflexion. It is very important to hold the subtalar joint in a neutral position or in slight inversion to avoid midfoot dorsiflexion and false-negative results. Because the maneuver is passive, the patient should be relaxed throughout the test. The examiner flexes the knee with one hand, while the other hand keeps the subtalar joint in a neutral position or in slight inversion and pushes the ankle joint in dorsiflexion. The examiner uses both hands to perform the test and is not able to hold any device to objectively measure ankle dorsiflexion during its accomplishment. The authors describe a simple sign to check the Silfverskiöld positivity during the test without the use of any device.

Technique

This study was approved by the Institutional Review Board. With the patient lying supine and relaxed, the examiner stands facing the lateral aspect of the leg to be examined. One hand bends the knee by holding the proximal posterior aspect of the leg. The other hand positions the hindfoot in slight inversion, thus blocking the subtalar joint, and forces the ankle in dorsiflexion while passively extending and flexing the knee with the other hand (Figure 1). In this position, once ankle dorsiflexion is achieved, wrinkles can be seen on the anterior aspect of the joint (Figure 2A). While gazing at the wrinkles, the examiner gradually extends the leg and observes whether the wrinkles will disappear or not, which will depend on the degree of flexion resulting from the shortening of the gastrocnemius: the more the wrinkles disappear, the greater the severity of shortening of the gastrocnemius and the positivity of the test (Figure 2B).

Study performed at the Hospital Moinhos de Vento, Porto Alegre, Rio Grande do Sul, Brazil.

Correspondence: José Antônio Veiga Sanhudo. Rua Ramiro Barcellos, 910, Moinhos de Vento - 90035-000, Porto Alegre, RS, Brazil. **E-mail:** josesanhudo@yahoo.com.br.
Conflicts of Interest: none. **Source of funding:** none. **Date received:** July 06, 2021. **Date accepted:** July 15, 2021. **Online:** August 31, 2021.

How to cite this article: Sanhudo JAV, Canuto GM. Wrinkle sign for the Silfverskiöld test. J Foot Ankle. 2021;15(2):188-9.

Figure 1. Position of the examiner and the leg during the Silfverskiöld wrinkle sign test.

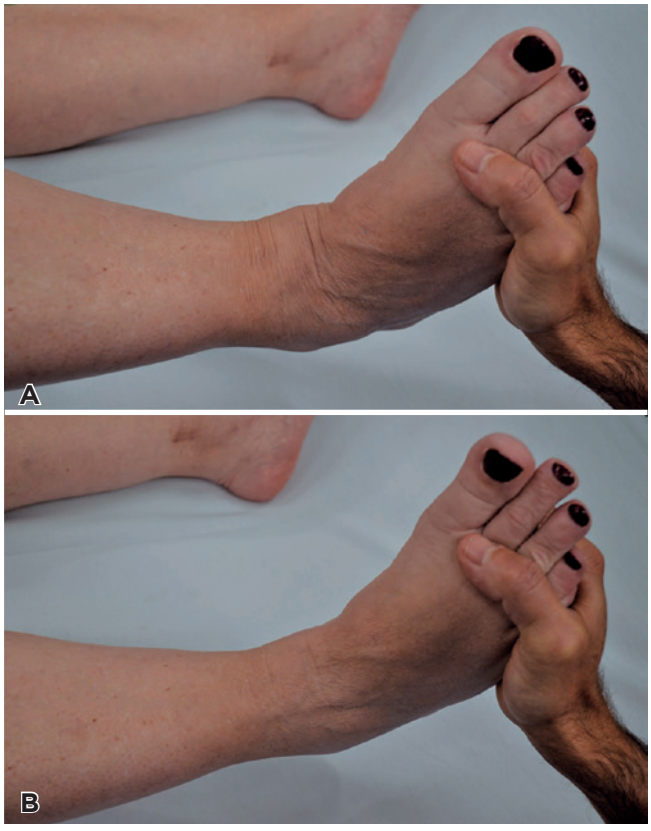


Figure 2. A. Wrinkles at the anterior part of the ankle with knee flexion during the test. B. Disappearance of the wrinkles with knee extension due to ankle plantar flexion (positive test).

Discussion

Gastrocnemius tightness is associated with a variety of orthopedic conditions, especially in the foot and ankle. To date, numerous studies have demonstrated the benefits of gastrocnemius recession in the treatment of these disorders[2,3].

The Silfverskiöld test was described almost 100 years ago, but few studies have been dedicated to assessing its reproducibility. Molund et al.[4] described a new device for measuring isolated gastrocnemius contracture. Twenty-four feet were examined by 4 examiners on 3 different occasions, and a low intraobserver and interobserver correlation coefficient was found when the classic Silfverskiöld test was performed; however, both intraobserver and interobserver correlations were much higher with the use of the device[4].

The wrinkle sign proposed here to assess the positivity of the Silfverskiöld test is simple, reproducible and does not require the use of any device. Although the Silfverskiöld test has been described as a qualitative measure, positive or negative, it is expected to show variable severity, which is demonstrated when performing the Silfverskiöld wrinkle sign test. The wrinkles will disappear more or less depending on the severity of gastrocnemius tightness.

Authors' contributions: Each author contributed individually and significantly to the development of this article: JAVS *(https://orcid.org/000-0002-4259-0358) Conceived and planned the activities that led to the study, clinical examination, survey of the medical records and approved the final version; GMC *(https://orcid.org/0000-0002-2712-9491) Participated in the review process, bibliographic review and formatting of the article. All authors read and approved the final manuscript. *ORCID (Open Researcher and Contributor ID).

References

1. Singh D. Nils silfverskiöld (1888-1957) and gastrocnemius contracture. Foot Ankle Surg. 2013;19(2):135–8.
2. Barske HL, DiGiovanni BF, Douglass M, Nawoczenski DA. Current concepts review: Isolated gastrocnemius contracture and gastrocnemius recession. Foot Ankle Int. 2012;33(10):915–21.
3. DiGiovanni CW, Kuo R, Tejwani N, Price R, Hansen ST Jr, Czierneckі J, et al. Isolated gastrocnemius tightness. J Bone Joint Surg Am. 2002;84(6):962-70
4. Molund M, Husebye EE, Nilsen F, Hellesnes J, Berdal G, Hvaal KH. Validation of a New Device for Measuring Isolated Gastrocnemius Contracture and Evaluation of the Reliability of the Silfverskiöld Test. Foot Ankle Int. 2018;39(8):960–5.

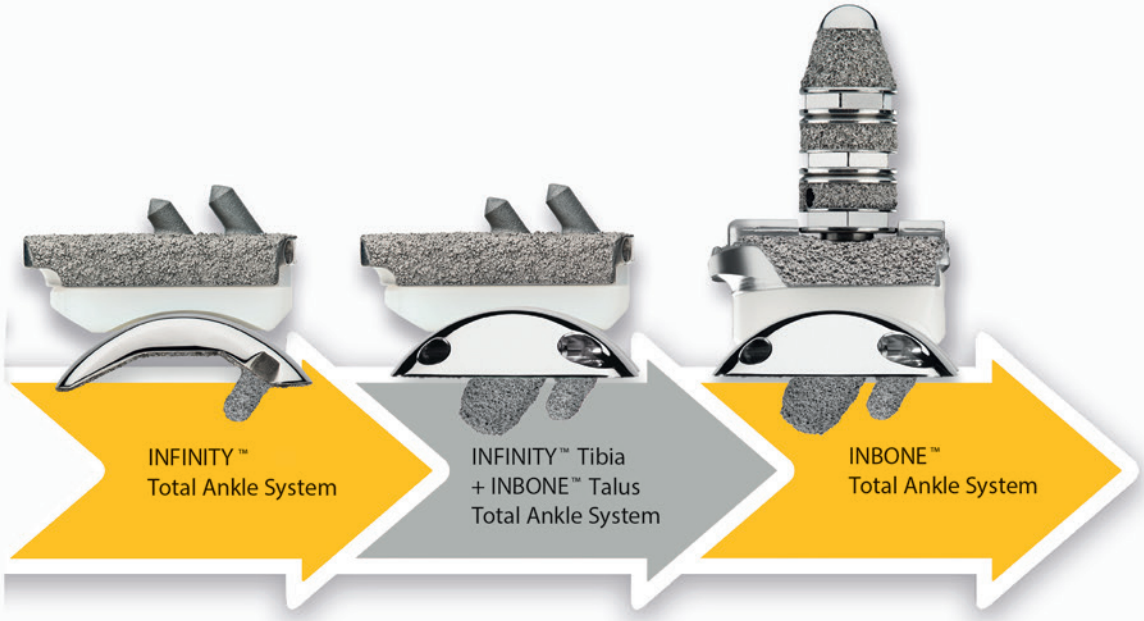
JOURNAL OF THE
Foot & Ankle

stryker

Coming together is what sets us apart

Wright Medical is now part of Stryker.

A comprehensive continuum of total ankle systems driven by innovation, history and experience.



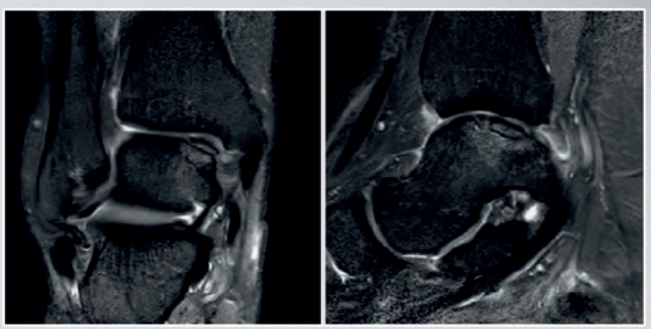
Together, we're energized and determined to remain your choice for total ankle replacements, today and going forward.

TR-BR- Infinity&Inbone -EN-07 /2021-rev_00
Infinity and Inbone Registrations Brazil - 80491360043; 80491360071; 80491360042; 80491360033
Infinity and Inbone Registrations Colombia - 2016DM-0014229; 2015DM-0013715
AP-015141, 04-2021

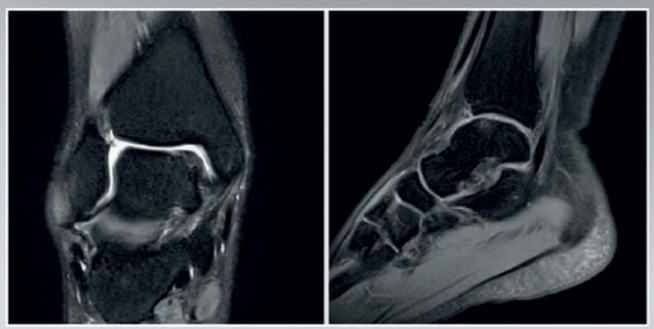
Geistlich
Surgery

AMIC® Chondro-Gide®

More than 10 Years Clinical Experience in the Ankle Joint



› The preoperative MRT-diagnostic image shows an osteochondral lesion >1.5 cm^2 on the medial edge of the talus. Images courtesy of Prof. Dr. Markus Walther



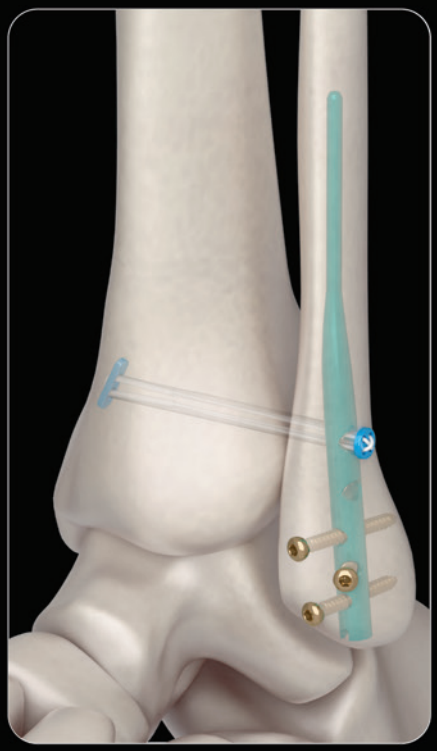
› After 3 years, the cancellous bone graft has been partially resorbed and the defect area is filled completely with regenerated cartilage. In comparison to the lateral talus, the edge on the radial side is slightly rounded. Images courtesy of Prof. Dr. Markus Walther

To start using **AMIC® Chondro-Gide®** to alleviate or prevent patient pain and slow the progression of cartilage damage, contact your local Geistlich representative.

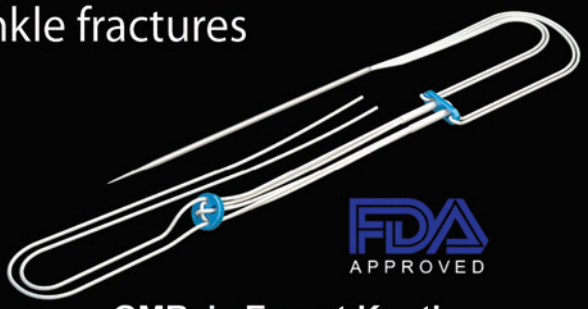
swiss made

FIBULA INTRAMEDULLARY NAIL

GMReis
Qualidade para Vida
Calidad para Vida Quality for Life الجودة للحياة



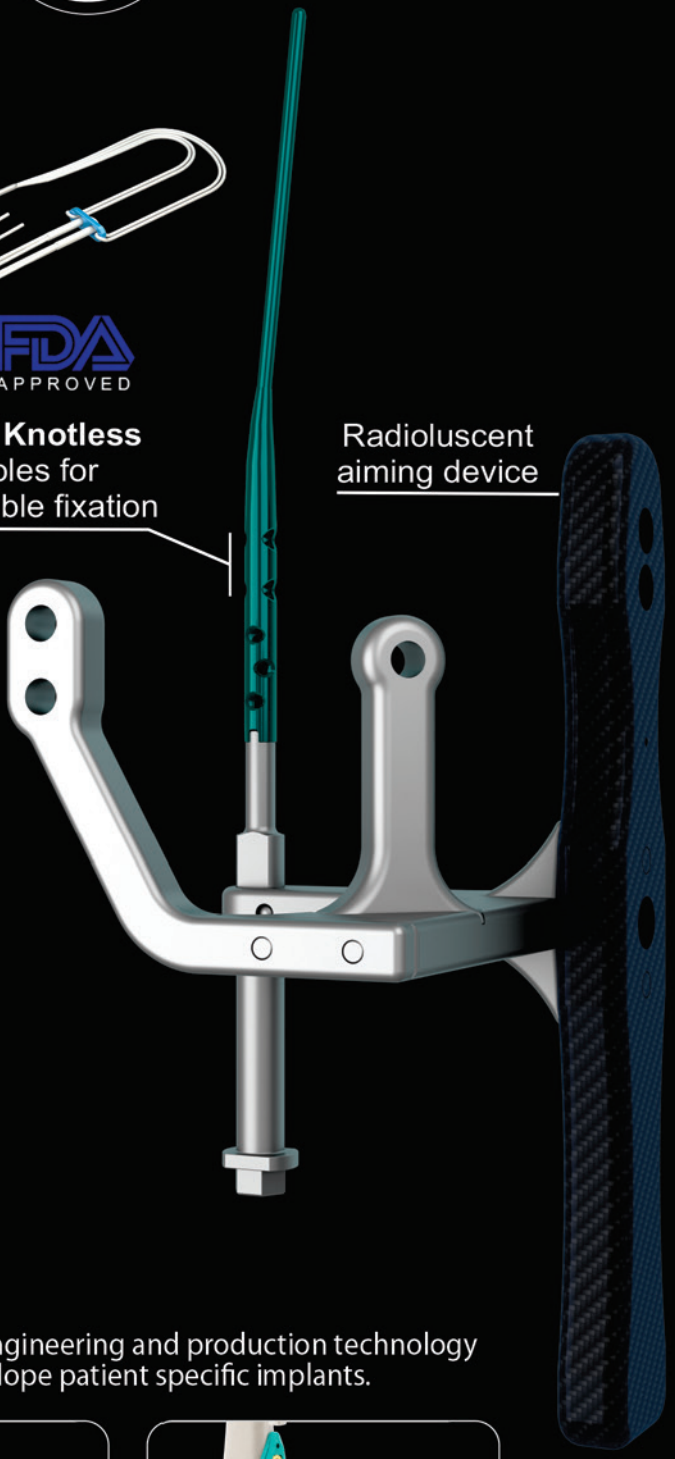
minimally invasive
treatment for
ankle fractures



FDA APPROVED

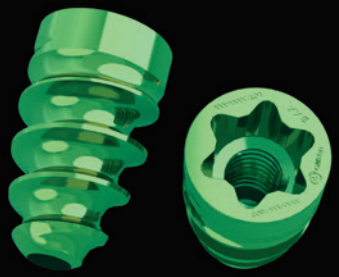
GMReis Expert Knotless
compatible holes for
syndesmosis flexible fixation

Radioluscent
aiming device

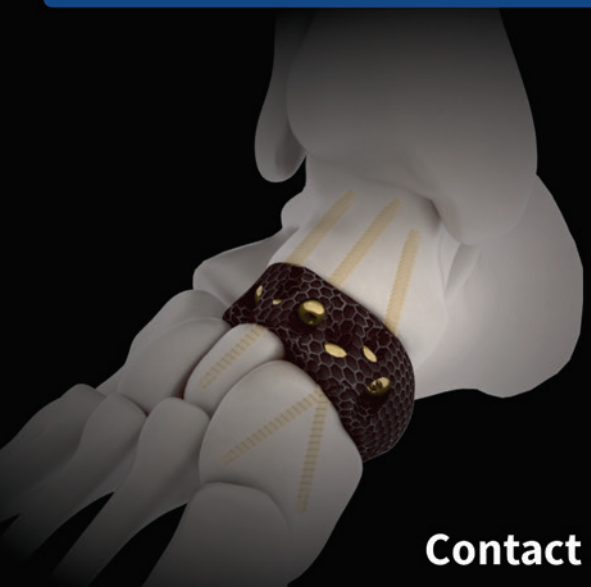


ARTROM

Subtalar cannulated arthroereisis
screws for flat foot treatment



PATIENTS SPECIFIC IMPLANTS



All the GMReis engineering and production technology
available to develope patient specific implants.

Contact Us: gmreis.com | marketingdigital@gmreis.com.br

CurveBeam

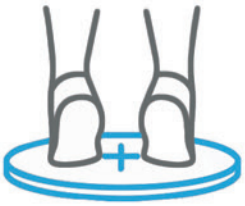
HiRise™

Weight Bearing CT Will Elevate Your Practice To The Next Level

Small device foot print; 58" x 73"; Self-shielded; Runs off standard 115V/230V outlet; 33-42 second scans.

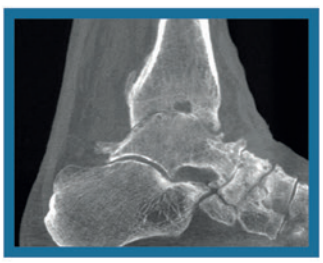
Image acquisition is 70% faster than X-Ray series - allows you to see more patients per day[1].

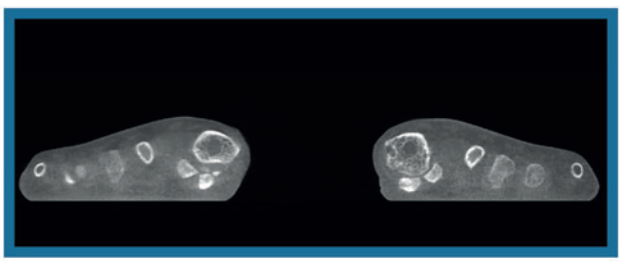
35% improved fracture detection and 2-fold improved identification of complex fracture over X-Ray[2].

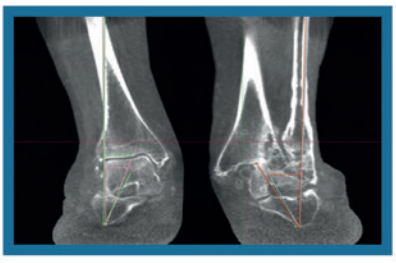


Largest field-of-view in its class - 20cm x 40cm - FOV can be narrowed to reduce exposure.

Assess total leg alignment in 3-Dimensions







(1) Richter M, Seidl B, Zech S, Hahn S. PedCAT for 3D-imaging in standing position allows for more accurate bone position (angle) measurement than radiographs or CT. Foot Ankle Surg. 2014 Sep;20(3):201-7. doi: 10.1016/j.fas.2014.04.004. Epub 2014 May 9. PMID: 25103709.

(2) Borel C et al. Diagnostic value of cone beam computed tomography (CBCT) in occult scaphoid and wrist fractures. Eur J Radiol. 2017 Dec;97:59-64. doi: 10.1016/j.ejrad.2017.10.010. Epub 2017 Oct 18. PMID: 29153368.

2800 Bronze Dr. Suite 110, Hatfield, PA 19440 | www.curvebeam.com | info@curvebeam.com | 267.483.8081