VOLUME 69 | ISSUE 2 | APRIL - JUNE 2018 ISSN 2241-4347

ACTA ORTHOPAEDICA ET TRAUMATOLOGICA HELLENICA

- Osteochondral Lesions in Foot and Ankle (current treatment strategies and author's developed technique)
- Posterior Arthroscopic Tibio-Talo-Calcaneal Fusion: Early Experience with a new surgical technique
- Ten-year clinical experience of Ponseti method in the treatment of idiopathic clubfoot
- Adult Acquired Flatfoot Deformity
- Peroneal tendoscopy. A pictorial essay
- MIS Hallux Valgus Surgery – History and Third Generation Surgical Technique
- Combined Talar Body and Medial Malleolous Fracture
- Lateral Talar Process Fracture combined with Calcaneal Sustentaculum Tali Fracture. Case series and proposal of a possible mechanism of injury

HELLENIC ASSOCIATION OF ORTHOPAEDIC SURGERY AND TRAUMATOLOGY

ACTA
ORTHOPAEDICA ET TRAUMATOLOGICA HELLENICA

HAOST ADMINISTRATIVE BOARD

President:	Stamatios A. Papadakis
President 2017:	Pantelis K. Nikolaou
A' Vice-President:	Panayiotis I. Papaggelopoulos
B' Vice President:	Athanasios Th. Kostakos
General Secretary:	Odysseas A. Paxinos
Treasurer:	Konstantinos Th. Kateros
Special Secretary:	Alexandros A. Eleftheropoulos
Simple Member:	Zinon Th. Kokkalis
Member's Delegate:	Panayiotis D. Megaloikonomos

HAOST COLLEGE ADMINISTRATIVE BOARD

President:	Stefanos M. Proveleggios
Vice-President:	Aristides B. Zoubos
Ex Officio:	Panayiotis I. Papaggelopoulos
General Secretary:	Nikolaos Markeas
Member:	Anastasios Mourikis
Residents' Delegate:	Panayiotis Megaloikonomos

PRESIDENTS OF HAOST SECTIONS

Reconstructive Surgery:	Efstathios Chronopoulos
Oncology:	Theodoros Kormas
Foot & Ankle:	Iason Petroutsas
Spine:	Vasileios Lykomitros
Shoulder & Elbow:	Pericles Papadopoulos
Research:	Anastasios Christodoulou
Infections:	Konstantinos Malizos
Intramedullary nailing:	Christine Arnaoutoglou
Paediatric Orthopaedics:	Dimitrios Metaxiotis
Primary Health Care:	Athanasios Badekas

ZITA
MEDICAL MANAGEMENT

HELLENIC ASSOCIATION
OF ORTHOPAEDIC SURGERY
AND TRAUMATOLOGY

Published by: ZITA MEDICAL MANAGEMENT S.A.
1st klm Peanias - Markopoulou Avenue, Peania, Attica, Greece, P.O BOX 155, 190 02, tel.: +30 211 1001 777, fax: +30 210 6642116, E-mail: info@zita-management.gr

ACTA
ORTHOPAEDICA ET TRAUMATOLOGICA HELLENICA

EDITOR IN CHIEF
Nikolaos Papaioannou

ASSISTANT EDITORS
Theodoros Grivas
Nikolaos Markeas
Stamatios Papadakis
Ioannis Triantafyllopoulos

EDITORIAL BOARD
Dimitrios-Sergios Evaggelopoulos
Dimitrios Economopoulos
Efstathios Chronopoulos
Konstantinos Kateros
Kalliopi Lampropoulou-Adamidou
Andreas Mavrogenis

SCIENTIFIC COMMITTEE AND REVIEWERS

Georgios Babis
Athanasios Badekas
Alexia Balanika
Christos Baltas
Hippocrates Chatzokos
Anastasios Christodoulou
Konstantinos Demetzos
Ioannis Dionysiotis
Ismini-Niki Dontas
Eleni Douni
Panayiotis Efstathiou
Ioannis Feroussis
Antonis Galanos
Ioannis Gliatis
Michael Hantes
Anastasios Kanellopoulos
Theofilos Karachalios
Aikaterini Katsalira
Konstantinos Kazakos
Georgios Kontakis
Theodoros Kormas
Anastasios Korobilias
Dimitrios Korres
Irene Lambrinoudaki
Khaldi Lubna
Georgios Machairas
Evaggelos Magnisalis
Konstantinos Malizos
Panayiotis Megas
Dionysios Mouzakis
Pantelis Nikolaou
Elias Panayiotopoulos
Georgios Panayiotakopoulos
Andreas Panagopoulos
Panayiotis Papaggelopoulos
Apostolos Papalois
Georgios Papanikolaou
Athanasios Papavassiliou
Georgios Petsatodis
Spyridon Pnevmatikos
Georgios Sapkas
Symeon Tournis
Georgios Trovas
Eleftherios Tsiridis
Minos Tyllianakis
Eleni Vavouraki
Theodoros Xenakis

INSTRUCTIONS TO AUTHORS

1. Scope

"Acta Orthopaedica Et Traumatologica" is the official journal of the Hellenic Association of Orthopaedic Surgery and Traumatology, first published in 1948. This revived edition of Acta Orthopaedica Et Traumatologica, published in English, aspires to promote scientific knowledge in Orthopaedics and Traumatology worldwide. It is a peer-reviewed Journal, aiming at raising the profile of current evidence-based Orthopaedic practice and at improving the scientific multidisciplinary dialogue. Acta Orthopaedic Et Traumatologica Hellenica presents clinically pertinent, original research and timely review articles. It is open to International authors and readers and offers a compact forum of communication to Orthopaedic Surgeons and related science specialists.

2. Language

English is the official language of the journal. All submitted manuscripts should be written in English.

3. How to submit a paper

All submissions for peer-review should be performed online through the journal.

The Editorial office and the Editor-in-chief will perform the initial assessment of the manuscript and if the manuscript is suitable for the journal and the submission is complete, it will be sent to the relative reviewers. The reviewing process that is followed is double blinded. During on-line submission, authors can enter the name/s of non-preferred reviewers.

The time allocated for reviewers to assess the manuscript and submit their recommendation is three weeks. The Editor-in-chief makes the final decision for publication. The Editorial office will communicate the reviewer's comments and the decision to the authors.

4. Manuscript originality and copyright

The submitted manuscript should be original, should not contain previously published material and should not be under consideration for publication in another journal. The submission needs to be approved by all co-authors and in case of original research a 'guarantor' of the study is required. As 'guarantor' may be considered a senior author that is deemed to take overall responsibility for all aspects of the study (ethics, originality, consent, data handling, and all aspects of Good Medical Practice). The 'guarantor' of the study does not necessarily need to be the corresponding author. The journal will not hold legal responsibility should there be any claim for compensation.

All authors need to sign the copyright transfer form (link) and must have made substantial contributions as established by the ICMJE (http://www.icmje.org).

5. Conflict of interest disclosure

Each author needs to disclose any type of financial interest that is related to the study and might create a potential conflict. Funding of the study needs to be disclosed.

If there is no conflict of interest, this should be stated in the manuscript before the Reference section as follows: "The authors declared no conflicts of interest".

6. Research ethics and compliance

The journal follows the guidelines of the International Committee of Medical Journal Editors (www.icmje.org). For all original articles a statement in the text of approval from the local ethics committee, a statement that research was performed according to the ethical standards as described by the Declaration of Helsinki and a statement that informed consent for participation in the study was obtained from all subjects, are required. In case of study with animals the following statement needs to be added in the text: "All applicable international, national, and/ or institutional guidelines for the care and use of animals were followed".

7. Permissions and plagiarism

For the use of any figures already published elsewhere the authors are required to obtain written permission from the copyright owner(s) and to submit the evidence in the submission process. Plagiarism will not be accepted in any case. Dedicated software will be used on this purpose; manuscripts with plagiarism will be returned to the corresponding author without consideration for peer review.

8. Types of manuscript

The journal accepts the following types of articles:

- **Original articles:** The paper needs to offer new knowledge on Orthopaedics ant Traumatology. The conclusions need to be sound and supported by statistical analysis. When the accuracy of a diagnostic test is assessed, following the Standards for Reporting of Diagnostic Accuracy (STARD) flow diagram (http://www. stard-statement. org) is suggested. A structured abstract of 250 words, 3-5 keywords, text up to 4,500 words, figures (up to four figures or eight figure parts), a maximum of six tables, a maximum of fifty references and a maximum of seven authors are required for original articles.
- **Review Articles:** The journal may accept systematic reviews, meta-analyses, literature reviews and historical reviews of a subject. An unstructured abstract of 200 words, 3-5 keywords, text of no more than 6,000 words, figures (up to eight figures), a maximum of six tables, a maximum of a hundred references and a maximum of three authors are required for review articles.
- **Basic Science.** Basic science manuscripts could be either original or review articles on recent research achievements. Authors should follow the corresponding insturctions according to the type of manuscript (original or review).
- **Monographs.** Highly detailed and thoroughly documented studies or reviews written about a limited area of a subject or field of inquiry. Monographies will be published on special issues.
- **Pictorial Essays:** The purpose of pictorial essays is to provide a teaching message through high quality images. A brief text is required to accompany figures. An unstructured abstract of 200 words, 3-5 keywords, text of no more than 6,000 words, a maximum of 15 figures, a maxi-mum of 6 tables, a maximum of a 100 references and a maximum of 4 authors are required for pictorial essays.
- **Case Reports:** Reports on new or very rare clinical cases on Orthopaedics, Orthopaedic Pathologyand Trauma, new diagnostic criteria, new therapeutic methods with proven result. Maximum 1,500 words, 10 references and 6 figures. Abstract up to 100 words.
- **Letters to the editor:** Communication to the editor is welcomed and will be published if they offer pertinent and/ or constructive comment on articles published in the Acta Orthopaedica Et Traumatologica Hellenica. Letters are published at the discretion of the Editorial team and should be received within three months after on-line publication of an article. Following acceptance, letters will be sent to authors for response. Letter communications should include text of no more than 500 words, up to 2 figures and 10 references, without any abstract or keywords and a maximum of 3 authors.

9. Manuscript organization

A manuscript must contain the following parts for submission:

- *Cover letter:* Each manuscript needs to be accompanied by a cover letter signed by the corresponding author on behalf of the rest of the authors stating that the article is not under consideration in another journal. In case of article resubmission a point-by-point answer to the reviewer's comments needs to be submitted with the cover letter.
- *Title page:* It includes the title of the manuscript, the names, affiliations and e-mail addresses of all authors and the affiliation, address, e-mail address, telephone and fax number of the corresponding author. The name and affiliation of the 'guarantor' of the study needs to be included in the title page for original articles.
- *Blinded manuscript:* Blinded title page including only the title of the manuscript with no affiliation.
- *Abstract:* An abstract presenting the most important results and conclusions is required for all papers except for Letters to the Editor. For Original Articles the abstract needs to be structured as follows: Purpose, Material and Methods, Results, Conclusions. For Reviews and Pictorial Essays, a 1-paragraph unstructured abstract is required. The authors must prepare abstracts both in English and in Greek language as a courtesy to the Greek origin of the Journal.
- *Keywords:* Below the abstract, 3 to 5 keywords are required. Keywords need to be selected from the Medical Subject Headings (MeSH) database of the National Library of Medicine.
- *Text structure:* the text of the Original Articles needs to be organized as follows: Introduction, Materials and Methods, Results and Discussion. Review Articles, and Pictorial Essays require Introduction and Discussion sections only.
- *Fonts:* The suggested font is double spaced Times New Roman (12 pt).
- *Abbreviations:* Abbreviations should be used as minimum as possible. When used, they should be defined the first time they are used, followed by the acronym or abbreviation in parenthesis.
- *Acknowledgements, sponsorships and grants:* Acknowledgements need to be placed at the end of the manuscript before 'References' section. Any grant received or sponsorship from pharmaceutical companies, biomedical device manufacturers or other corporations whose products or services have been used needs to be included in the Conflicts of Interest Form and also mentioned in acknowledgements section.
- *Measurement Units:* All measurements should be mentioned in international units (SI). The full stop should be used as a decimal (i.e. 3.5 cm). Spaces should be added around the plus/minus symbol (i.e. 13.6 ± 1.2). There should not be any spaces around range indicators (i.e. 15-20) or equality/inequality symbols (i.e. r=0.37, p<0.005).

10. Figures and Tables

All figures and tables need to be cited in text consecutively in the order in which they appear in text into brackets and in Arabic numbers: i.e. (Fig. 1) and (Table 1). Figure parts need to be identified with lower case letters, i.e (Fig. 1a).

Figures need to be of high quality. Vector graphics, scanned line drawings and line drawings need to be in bitmap format and should have a minimum resolution of 1,200 dpi. Halftones (photographs, drawings or paintings) need to be in TIFF or JPEG format, up to 174 mm wide and up to 234 mm high and in minimum resolution of 300 dpi.

Patient anonymity should be ensured. All identifying data (name, identification numbers, initials) must be removed from text, images and tables. If it is mandatory for a patient's face to be included in the manuscript, the eyes should be sufficiently masked. If there is a possibility that a patient may be identified from a photograph or relevant legend and text, the patient's written consent should be submitted.

A figure caption and a table caption need to be added in the figure and table section respectively for each figure and table.

Tables should appear at the end of the main document, numbered in Arabic numerals, each on a different page. Each table should have a title describing its content. Abbreviations appearing in the table need to be explained in a footnote. All table columns must have a subhead that describes the type of data included in the column.

11. References

The accuracy of references is the responsibility of the authors.

References need to be cited in the text in the order in which they appear. The numbering needs to be in Arabic numbers and placed in the respective areas of text into square brackets i.e [1].

References that have not been published at the point of submission need to cited with the respective DOI (digital object identifier) number given for online first articles.

All authors (surnames and initials of first name) should be listed when they are three or fewer. If authors are more than three, the first three authors should be listed, then 'et al.' needs to follow the name of the third author.

When a book chapter is cited, the authors and title of the chapter, editors, book title, edition, city and country, publisher, year and specific chapter pages should be mentioned.

For Online Document, the following should be mentioned: authors (if any), title of page, name of institution or owner of Web site; URL; dates of publication, update, and access.

Reference examples:

■ Journal article:

Trianafyllopoulos IK, Lampropoulou-Adamidou K, Schizas NP, et al. Surgical treatment of acute type V acromioclavicular joint dislocations in professional athletes: An anatomic ligament reconstruction with synthetic implant augmentation. *J Shoulder Elbow Surg* 2017; doi: 10.1016/j.jse.2017.05.032 Epub 2017 Jul 21.

or

Papaioannou NA, Triantafyllopoulos IK, Khaldi L, et al. Effect of calcitonin in early and late stages of experimentally induced osteoarthritis. A histomorphometric study. *Osteoarthritis Cartilage* 2007; 15(4): 386-95.

■ Book chapters:

Triantafyllopoulos IK, Papaioannou NA. The Effect of Pharmacological Agents on the Bone-Implant Interface. In: Karachalios Th. (ed). Bone-Implant Interface in Orthopaedic Surgery. Springer – Verlag, London 2014, pp 221-237.

■ Online document:

National Institute for Health and Care Excellence. Fractures (Complex): Assessment and Management. Available via www.nice.org.uk/guidance/ng37. Published Feb 2016. Updated Sept 2017. Accessed January 2014.

12. Review of manuscripts

Acceptance of manuscripts for publication is decided by the Editor, based on the results of peer review. Authors need to make proof corrections within 72 hours upon pdf supplied, check the integrity of the text, accept any grammar or spelling changes and check if all the Tables and Figures are included and properly numbered. Once the publication is online, no further changes can be made. Further changes can only be published in form of Erratum.

EDITORIAL

Dear Colleagues

It is a great honor for me to serve as a guest editor in this special edition issue of the Acta Orthopedica et Traumatologica Hellenica about Foot and Ankle Disorders.

The past twenty years, the work and the progress that has been done in the field of Foot and Ankle Surgery in our country is remarkable and comparable to the other European Countries.

In 1995 the Section of Foot and Ankle of the HAOST was founded.

The founding committee of the Hellenic Foot and Ankle Society consisted from our senior colleagues Eleftherios Dounis as President, Spiros Karagiannis and Ploutarchos Siakantaris.

The Foot and Ankle Section of HAOST gradually became very active organizing Congresses and Instructional Courses, for residents and junior orthopedic surgeons.

Soon many orthopaedic surgeons with special interest and training in the Foot and Ankle Surgery joint the Department such us Stamatis E., Eleftheropoulos A., Chatziemmanouil D., Symeonidis P., Gougoulias N. and myself.

Our deceased colleague George Vlatis who helped tremendously in teaching and promoting Foot and Ankle Surgery in Greece along with Grivas T., Dagas S. and myself have published the first two volumes of “Foot and Ankle Disorders and Surgery” in Greek language.

In the meantime, the Greek Foot and Ankle Surgeons started to have a remarkable European and global presentation as guest lecturers, trainers, editorial members and chief editorial members of well renowned Journals, in the field of Foot and Ankle Surgery. Also they serve as members of committees and councils of prestigious Foot and Ankle Associations.

In this special issue of Acta Orthopaedica et Traumatologica Hellenica, I am happy to present some of the work that is being done by Greek Orthopedic Surgeons in the field of Foot and Ankle Surgery.

We have a combination of original articles, review articles and case reports that can be very educational and they could help the reader to see new trends in the field of Foot and Ankle Pathology and Surgery, new procedures and clarify conditions, symptoms and disorders.

Pediatric Foot and Ankle Surgery is also covered in this volume, and one can see the progress that is being done in this field as well.

I want to thank the Scientific Committee of Acta Orthopedica Traumatologica Hellenica and especially the Chief Editor Professor Nikos Papaioannou for giving me the opportunity to present the work of our colleagues in this special field.

I hope you will enjoy the reading and find some new insights that can be helpful in your practice.

Sincerely
Thanos Badekas MD
Director of the 3rd Orthopedic Clinic
Henry Dunant Hospital Center
Briganteer Gen of the Hellenic Police Medical Division
Council Member of the European Foot & Ankle Society
Past Chairman of the Scientific Committee of the European Foot & Ankle Society

ACTA ORTHOPAEDICA ET TRAUMATOLOGICA HELLENICA

CONTENTS

Osteochondral Lesions in Foot and Ankle
(current treatment strategies and author's developed technique)
T. Badekas, N.Souras **56-65**

Posterior Arthroscopic Tibio-Talo-Calcaneal Fusion: Early Experience with a new surgical technique
A. Papachristou, I. Giannaros, A. Eleftheropoulos **66-71**

Ten-year clinical experience of Ponseti method in the treatment of idiopathic clubfoot
Nikolaos G. Markeas, Dimitrios Begkas, Christos Apergis, Andreas Kondylis, Konstantinos Theodoridis **72-84**

Adult Acquired Flatfoot Deformity
Nikolaos Gougoulias **85-98**

Peroneal tendoscopy. A pictorial essay
Panagiotis Symeonidis **99-104**

MIS Hallux Valgus Surgery – History and Third Generation Surgical Technique
Dimitrios Hatziemmanuil **105-112**

Combined Talar Body and Medial Malleolous Fracture: A Case Report
S. Papadakis, N. Schizas, P. Lepetsos G. Macheras **113-116**

Lateral Talar Process Fracture combined with Calcaneal Sustentaculum Tali Fracture.
Case series and proposal of a possible mechanism of injury
A. Papachristou, K. Chitas, A. Fardellas, A. Konstantinidis, and A. Eleftheropoulos **117-125**

VOLUME 69 | ISSUE 2 | APRIL - JUNE 2018

Osteochondral Lesions in Foot and Ankle (current treatment strategies and author's developed technique)

T. Badekas[1], N.Souras[2]

[1]*Director of 3rd Orthopaedics Department, Henry Dunant Hospital Center, Athens, Greece*
[2]*Consultant of 3rd Orthopaedics Department, Henry Dunant Hospital Center, Athens, Greece*

ABSTRACT

Osteochondral lesion of the talus (OLT) is a broad term used to describe an injury or abnormality of the talar articular cartilage and adjacent bone. A variety of terms have been used to refer to this clinical entity, including osteochondritis dissecans (OCD), osteochondral fracture and osteochondral defect. Whether OLT is a precursor to more generalised arthrosis of the ankle remains unclear, but the condition is often symptomatic enough to warrant treatment. In more than one third of cases, conservative treatment is unsuccessful, and surgery is indicated. There is a wide variety of treatment strategies for osteochondral defects of the ankle, with new techniques that have substantially increased over the last decade. The common treatment strategies of symptomatic osteochondral lesions include nonsurgical treatment, with rest, cast immobilisation and use of nonsteroidal anti-inflammatory drugs (NSAIDs). Surgical options are lesion excision, excision and curettage, excision combined with curettage and microfracturing, filling the defect with autogenous cancellous bone graft, antegrade (transmalleolar) drilling, retrograde drilling, fixation and techniques such as osteochondral transplantation [osteochondral autograft transfer system (OATS)] and autologous chondrocyte implantation (ACI). Furthermore, smaller lesions are symptomatic and when left untreated, OCDs can progress; current treatment strategies have not solved this problem. The target of these treatment strategies is to relieve symptoms and improve function. Publications on the efficacy of these treatment strategies vary. In most cases, several treatment options are viable, and the choice of treatment is based on defect type and size and preferences of the treating clinician.

KEY WORDS: Osteochondral lesions; Osteochondritis dissecans; Talus; Foot and ankle; Cartilage damage; Subchondral bone

CORRESPONDING AUTHOR, GUARANTOR

Thanos Badekas MD,
Director of 3rd Orthopaedics Department, Henry Dunant Hospital Center, Athens, Greece, tel.: 6977075851
E-mail: thanosbadekas@gmail.com

VOLUME 69 | ISSUE 2 | APRIL - JUNE 2018

Introduction

Chondral and osteochondral injuries are relatively common in the weight bearing joints of the lower extremity (**Fig. 1**). The pathology can range from a simple contusion of the articular cartilage and subchondral bone to a fracture involving the cartilage alone or cartilage and underlying subchondral bone together. The mechanism of injury is one of three types of trauma: compaction, shearing, or avulsion. Because the injury is usually subtle and causes little to no dysfunction, the diagnosis of acute injuries is delayed. An osteochondral ankle defect is a lesion of the talar cartilage and subchondral bone mostly caused by a single or multiple traumatic events, leading to partial or complete detachment of the fragment. The defects cause deep ankle pain associated with weight bearing. Impaired function, limited range of motion, stiffness, catching, locking and swelling may be present.

Fig. 1 *MRI image of an osteochondral lesion of the talus*

The earliest report of osteochondritis dissecans (OCD) was published in 1888 by Konig, who characterized a loose-body formation associated with articular cartilage and subchondral bone fracture [1]. In 1922, Kappis described this process in the ankle joint [2]. On the basis of a review of all literature describing transchondral fractures of the talus, Berndt and Harty (**Fig. 2**) developed a classification system for radiographic staging of osteochondral lesions of the talus (OLTs) [3]. Their classification system has been the foundation for other systems, yet it remains the most widely used system today. Anatomic studies on cadaver limbs demonstrated the etiological mechanism of transchondral fractures of the lateral border of the talar dome. As the foot is inverted on the leg, the lateral border is compressed against the face of the fibula (stage I), while the collateral ligament remains intact. Further inversion ruptures the lateral ligament and begins avulsion of the chip (stage II), which may be completely detached but remain in place (stage III) or be displaced by inversion (stage IV). Berndt and Harty experimentally proved the traumatic etiology of the lesion; however, non-traumatic lesions also occur. Loomer et al. [4] added a stage V to this system, considering the presence of a subchondral cyst. Ferkel and Sgaglione [5] developed a classification system based on computerized tomography, while Hepple et al. developed an MRI classification system [6].

There is a wide variety of treatment strategies for osteochondral defects of the ankle, with new techniques that have substantially increased over the last decade. The widely considered treatment strategies of symptomatic osteochondral lesions include the non-surgical treatment with rest, cast immobilization and use of NSAIDs, and surgical excision of the lesion, excision and curettage, excision combined with curettage and microfracturing, filling of the defect with autogenous (cancellous) bone graft, antegrade (transmalleolar) drilling, retrograde drilling, fixation and techniques like osteochondral transplantation (osteochondral autograft transfer system, OATS) and autologous chondrocyte implantation (ACI).

Target of these treatment strategies is to relief symptoms and to improve function. Publications on the effectiveness of these treatment strategies vary. In most cases, several treatment options are viable, and the choice of treatment is based on the type and size of the defect and on preferences of the treating clinician.

VOLUME 69 | ISSUE 2 | APRIL - JUNE 2018

Conservative treatment of the osteochondral lesions of talus

Conservative treatment usually consists of immobilization and no weight-bearing, with or without treatment of non-steroidal anti-inflammatory drugs (NSAIDs) for approximately 6 weeks, followed by progressive weight-bearing and physical therapy. This protocol is instituted for Berndt and Harty type I and II lesions and small grade III lesions. Large grade III and any grade IV lesions are generally considered operative candidates. Additionally, grade I and II lesions that fail non-surgical management are also operative candidates [7]. Berndt and Harty [3] reported poor outcomes for nonoperative treatment of OLTs in their original article: good in 16%, fair in 9%, and poor in 75%. A systematic review of treatment strategies for OLT by Verhage et al. [8] in 2003 demonstrated only a 45% success rate for nonoperative treatment. The aim is to unload the damaged cartilage, so edema can resolve and necrosis is prevented. Tol et al. [9] on another review of the literature noted a success rate of only 45% with nonoperative treatment. The duration of symptoms prior to institution of non-operative treatment was either unreported or ranged from sub-acute to acute (<6 weeks) to chronic (>6 weeks). Patients were given the choice between operative and non-operative treatments, and the patient chose non-operative treatment. Conservative treatment consisted of weight bearing as tolerated and reported to be successful in a range 20%-54%.

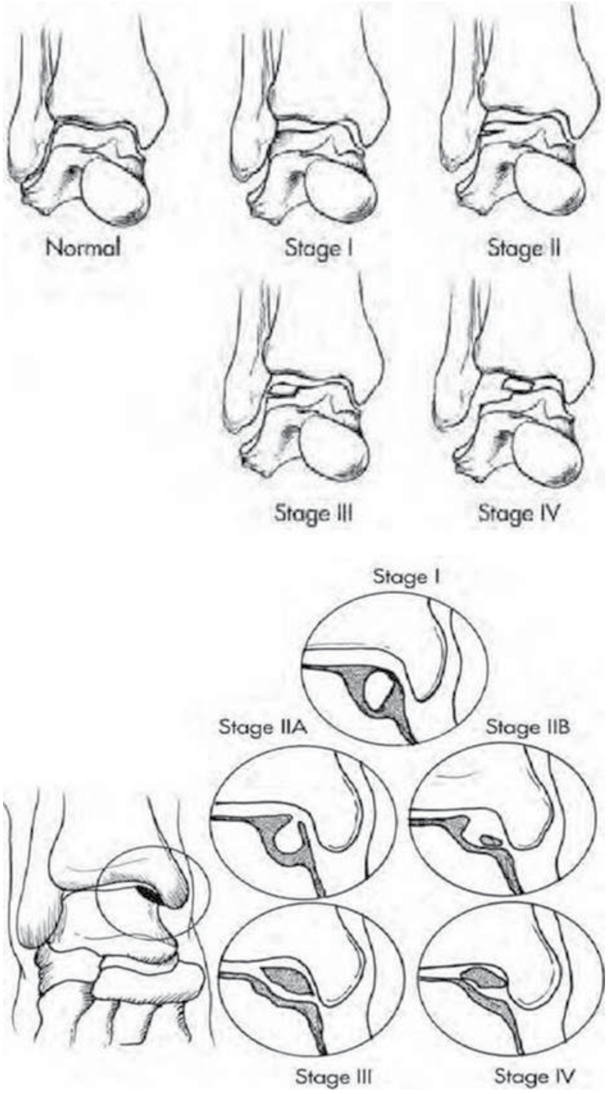


***Fig. 2** Berndt and Hardy classification*

Surgical management of the osteochondral lesions of talus

Retrograde drilling is usually reserved for large OCDs with intact overlying cartilage. This is a technique used for stable primary OCDs when there is more or less intact cartilage with a large subchondral cyst, or when the defect is hard to reach via the usual anterolateral and anteromedial portals, usually Berndt and Harty types I and II. Drilling attempts to bring blood supply to the lesion without disrupting the articular cartilage. It is the treatment of choice when there is a large subchondral cyst with overlying healthy cartilage. For medial lesions, arthroscopic drilling can take place through the sinus tarsi. For lateral lesions the cyst is approached from anteromedial. The aim is to induce subchondral bone revascularization and to stimulate the formation of new bone. Kono et al [10] and Taranow et al. [11] reported success of the treatment in a range of 81–100%.

Transmalleolar antegrade drilling is considered in cases of osteochondral lesions that present difficulty to be approached because of its location on the talar dome. In this technique, a K-wire is inserted about 3 cm proximal to the tip of the medial malleolus and directed across the medial malleolus into the lesion through the intact cartilage. Kono et al.

[10] and Robinson et al. [12] described the results of this technique that was reported to be successful in 63% of cases.

Surgical treatment includes excision, where the partially detached fragment is excised, and the defect itself is left untreated; excision and debridement, where after excision of the loose body, the surrounding necrotic subchondral tissue is curetted using either an open or arthroscopic technique; excision, debridement and bone marrow stimulation, where after excision and curettage multiple openings into the subchondral bone are created by drilling or by microfracturing. This way, intra-osseous blood vessels are disrupted and the release of growth factors leads to the formation of a fibrin clot. The formation of local new blood vessels is stimulated, bone marrow cells are introduced in the osteochondral defect, and fibro-cartilaginous tissue is formed. Van Dijk et al [13] in a review of the literature noted a success rate of 54% with the excision technique, where excision was performed for superficial cartilaginous lesions, with mainly intact underlying subchondral bone. Respectively, excision and curettage, reported a successful rate of 77%, where most patients had a Berndt and Harty stage III or IV lesion, although stage II lesions occurred. Finally, the treatment option of excision, debridement and bone marrow stimulation, reported the best rate of success (85%), where most patients often had a Berndt and Harty stage III or IV lesion, although stage I and II lesions occurred, whilst diameter of the lesions usually did not exceed 1.5 cm.

Kouvalchouk et al. [14] studied the filling of the defect with autogenous bone graft. In this technique, the remaining defect after excision and debridement of osteochondral lesions of the dome of the talus with partial necrosis, is filled with autogenous cancellous bone targeting to restore the mechanical properties of the talus. Indications for the treatment were large, often medial lesions exceeding 1.5 cm in diameter.

Larger lesions that fail to improve 6 months after arthroscopy should be considered for osteochondral grafting or autologous chondrocyte implantation. The concept of using restorative cartilage treatment with a osteochondral autograft and allograft has been reported in the literature [15,16]. The results of osteochondral autograft transplantation have been reported at intermediate follow-up with good results. Two related procedures have been developed: mosaicoplasty and OATS. Both are reconstructive bone grafting techniques that use one or more cylindrical osteochondral grafts from the less weight-bearing periphery of the ipsilateral knee and transplant them into the prepared defect site on the talus. This technique's target is to restore the mechanical, structural and biochemical properties of the original hyaline articular cartilage. It is carried out either by an open approach or by an arthroscopic procedure. Indications involve large, often medial lesions, sometimes with a cyst underneath. Osteochondral grafting of defects has yielded 90% to 94% good to excellent results, with Scranton et al. [17] noting 90% satisfaction in 50 patients at 36-month follow-up and Hangody et al. [18] reporting 94% good to excellent results in 36 patients at an average of 4.2 years.

Autologous chondrocyte implantation attempts to regenerate tissue with a high percentage of hyaline-like cartilage. The ACI technique involves placing cultured chondrocytes under a periosteal patch that covers the lesion. It is done for lesions larger than 1 squared cm, in the absence of generalized osteoarthritic changes. Harvesting is first accomplished from either the knee or ankle from the region on the perimeter of the talus lesion. A second procedure is performed after the cells have been cultured for 6 to 8 weeks. An osteotomy of the medial malleolus can be done for medial defects. The damaged articular surface is curetted to a stable border, and a periosteal patch is harvested from the tibia. The patch is sutured to the defect and sealed with fibrin glue. Finally, the cultured chondrocytes are injected under the patch. Whittaker et al [19] reported their results with ACI on 10 patients with a 4-year follow-up: 90% of patients were pleased with the results of the surgery at 24 months, with no change at 48 months.

In Europe and Australasia, matrix-based chondrocyte implantation (MACI) is available. It differs from traditional ACI in that the chondrocytes are not placed under the periosteal patch but are em-

VOLUME 69 | ISSUE 2 | APRIL - JUNE 2018

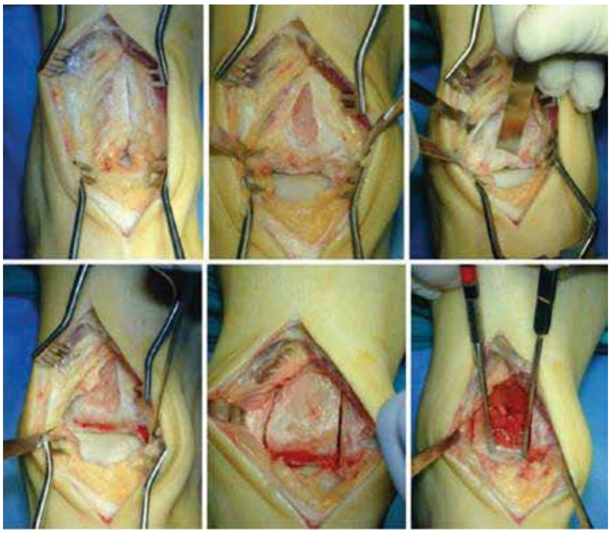


Fig. 3 *Trapezoid wedge shape for tibial osteotomy providing perpendicular access to the recipient site*

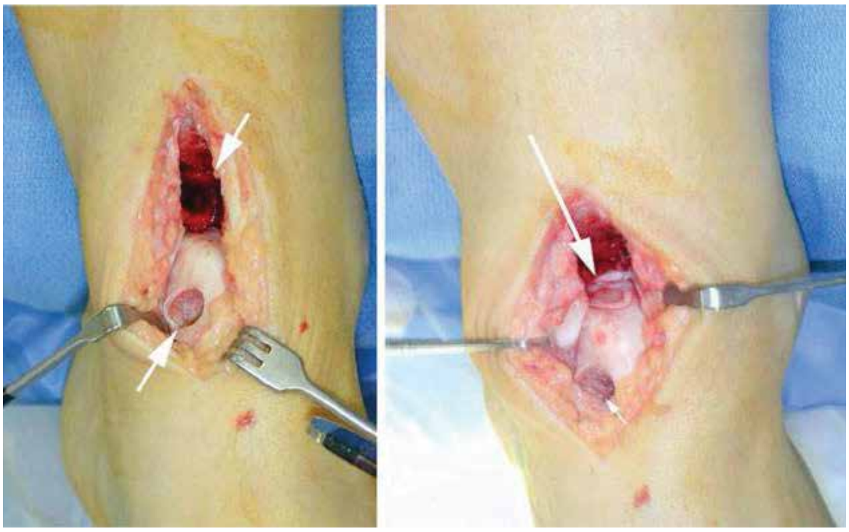


Fig. 4 *Donor medial talar facet recipient site with the local graft inserted*

bedded in a type I/III collagen membrane bilayer. As with ACI, the membrane is placed in the defect, but sutures are not required. The membrane bilayer is secured into place using fibrin sealant. Matrix-based chondrocyte implantation is technically easier than ACI and does not require an osteotomy.

Fixation technique is another treatment option in case of large, loose fragments that can be reattached to the underlying bone. Fixation to the talus may be obtained with headless screws, K-wires, absorbable pins or fibrin glue. Kumai et al [20] reported a success rate of 89% in 24 patients, where osteochondral lesions of stage II,III and IV were elevated, the defect was curetted and drilled, and following alignment of the bone fragment it was secured to the underlying bone with at least two bone pegs from the distal tibia. This type of injury is usually seen in acute injuries, and this technique typically fails in chronic lesions with sclerotic borders.

However, authors' preferred surgical treatment of talar osteochondral lesions is the use of local osteochondral talar autograft. In this surgical procedure, with the patient in supine position and under tourniquet control, an arthrotomy is performed through a 7cm antero-medial or antero-lateral incision, as required. The lesion is approached by removing a bone block from the tibia including the articular surface. To accomplish this, a wedge shaped bone block, 10mm wide, 20mm deep and 30mm in height is made at the distal anterior tibia

VOLUME 69 | ISSUE 2 | APRIL - JUNE 2018

Fig. 5 *Instrumention*

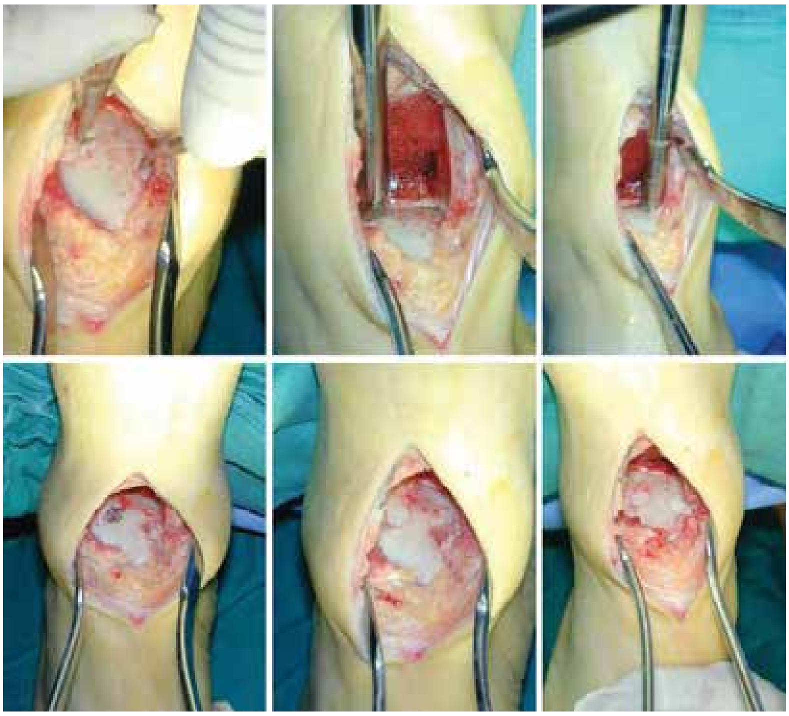


Fig. 6 *Perpendicular access to the recipient site: a case with two lesions*

articular surface on the side of the osteochondral lesion. Vertical parallel saw cuts are made with a high-speed micro oscillating saw by taking care to avoid injuring the uninvolved talar articular surface. Saw is then used to connect the two vertical parallel cuts proximally in the metaphysis. A 10mm wide thin osteotome is then driven from the tip of the transverse cut, inferiorly to the articular surface of the tibial plafond 10 to 20mm deep, depending on the location of the lesion on the talar dome (**Fig. 3**). The tibial fragment is removed and the defect created permits direct access to the lesion, especially by plantar-flexing the ankle. Initial debridement of loosen fragments is followed by drilling and ensuring that drill is perpendicular to the articular surface of the talus, directly over the lesion. Drill sizes are matched to the diameter of the defect 4, 6 or 8mm to the size of the defect, determined from the MRI pre-operative evaluation. The osteochondral graft is harvested from the anterior aspect of the ipsilateral talar articular facet by the same incision, as the tibial osteotomy. The graft is harvested using the core-harvesting device, by positioning the cutter over the talar facet, near to the anterior border and perpendicularly to the articular surface (**Fig. 4**). When the cutter reaches the desired depth, the harvester is removed with the graft and a positioning device is placed perpendicularly to the talar dome, orienting the outer flair of the graft toward the outer edge of the dome (**Figures 5 and 6**). For medial lesions (**Fig. 7**), a Chevron-type medial malleolar osteotomy is performed, that is fixed with two screws at the end of the procedure. The approach to lateral lesions is performed by an anterolateral incision splitting down the ATFL and CFL, followed by a modified Brostrom technique (**Fig. 8**).

The postoperative treatment includes immobilization for four weeks, walker boot for the next four weeks and weight bearing at six weeks. Range of motion exercises are allowed once the surgical incision is healed. In a retrospective study (T.Badekas, N.Souras, paper in process of publication, 2/18) of 121 patients from March 2005 to March 2015, 118 men and 3 women, with an age range of 19–53 (mean 38) years, symptom duration of 65 (range 6–98) months and standard follow-up of 36 months, the result was the significant improvement of an average

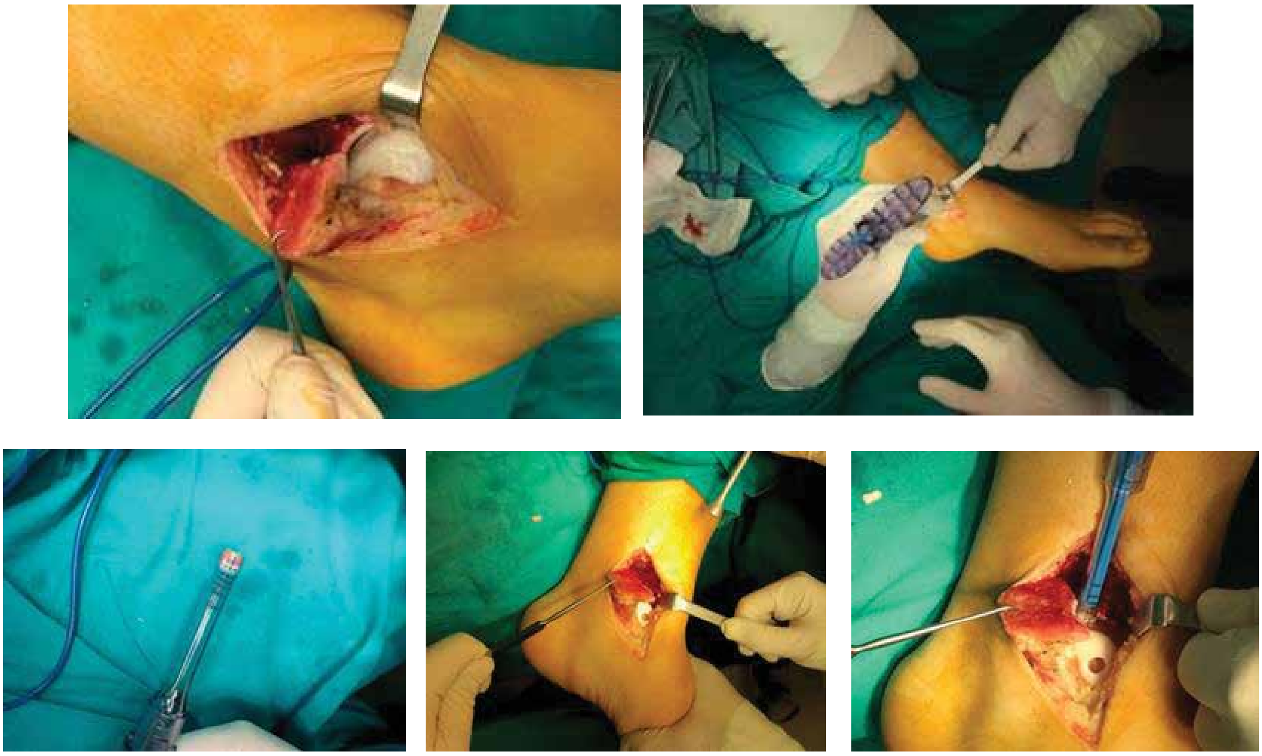


Fig. 7 *Medial malleolus osteotomy for true medial lesions*

preoperative AOFAS score, using the Ankle–Hindfoot Scale, that was 65 in an average postoperative AOFAS score that was 89. Patients younger than 40 years had higher average AOFAS scores postoperatively than patients older than 40. The presence of degenerative arthritis yielded a lower AOFAS score. However, the difference between these small subgroups was not significant. There were no perioperative complications and all patients stated they would undergo the procedure again.

Discussion

The talus is the third most common location of osteochondral lesions behind the knee and the elbow. Patients typically present after a traumatic injury to the ankle (85%) and complain of prolonged pain, swelling, catching, stiffness, and instability. Severe mechanical symptoms such as catching and grinding may indicate a severe OLT and possibly a loose body. A loose body can disrupt normal joint motion secondary to displacement of the fragment and can lead to arthrosis over time. Chronic ankle pain and stiffness without improvement from standard conservative measures should increase the suspicion for OLT.

OCLs of the talus more commonly affect men, in the right ankle, on the medial side. Lateral lesions are traumatic, whereas medial lesions may be atraumatic [3]. It has previously been recognized that medial and lateral lesions differ morphologically with lateral lesions presenting as flat, discoid fragments and medial lesions presenting as more rounded and deeper [21]. MRI studies have demonstrated that medial lesions tend to be deeper and more well defined, while lateral lesions are more superficial and less discrete in location. Lateral lesions are more liable to be displaced and so become symptomatic at an earlier stage. The morphological appearance of medial and lateral lesions can be explained by the different forces that are necessary to produce them. Lateral lesions are produced by a tangential shear force across the talar dome, whereas medial lesions are caused by a more perpendicular force resulting in a deeper lesion which is unlikely to displace from its bed [22].

Treatment strategies for osteochondral defects

VOLUME 69 | ISSUE 2 | APRIL - JUNE 2018

Fig. 8 *Lateral osteochondral lesion of the talus (OLT) approached through an anterolateral incision, with takedown of the anterior tibiofibular ligament (ATFL) and the calcaneofibular ligament (CFL). Reconstruction with modified Broström*

(OCDs) of the ankle have substantially increased over the last decade. The widely published treatment strategies of symptomatic osteochondral lesions include the non-surgical treatment and surgical excision of the lesion, excision and curettage, excision combined with curettage and microfracturing, placement of cancellous bone graft, antegrade (transmalleolar) drilling, retrograde drilling, fixation and techniques like osteochondral transplantation (osteochondral autograft transfer system, OATS) and autologous chondrocyte implantation (ACI).

Retrograde drilling is a technique used for stable lesions with an intact chondral surface (Berndt and Harty types I and II). Drilling attempts to bring blood supply to the lesion without disrupting the articular cartilage. Transmalleolar drilling is performed when a defect is hard to reach because of its location on the talar surface. A disadvantage is that healthy tibial cartilage is damaged.

Primary repair works best for large OCD lesions with healthy-appearing surface cartilage that is attached to a bone fragment. Fixation to the talus may be obtained with headless screws, K-wires, or absorbable pins. This type of injury is usually seen in acute injuries, and this technique typically fails in chronic lesions with sclerotic borders.

Microfracture stimulates subchondral bleeding and development of a fibrin clot. Debridement of diseased cartilage and subchondral cysts prior to microfracture is of paramount importance. Awls or drills are used after sufficient debridement to perforate the base of the lesion (3-4 mm apart) and bring mesenchymal stem cells, growth factors, and healing proteins to the defect. This fibrin clot heals in the defect and eventually becomes fibrocartilage (type I cartilage), which fills the void but lacks the organized structure of hyaline cartilage (type II cartilage). Fibrocartilage possesses inferior wear characteristics to hyaline cartilage, which has led investigators to develop articular cartilage transplantation.

Restoration of articular cartilage can be achieved by osteochondral autograft or allograft transplantation (OATS, mosaicoplasty), autologous chondrocyte implantation (ACI and MACI), and fresh osteochondral allografts (FOCAT).

The most important finding of a recent review of literature of van Djik et al. [13] was that bone marrow stimulation was identified as the best treatment option. In the same review, the results of non-operative treatment were low compared to operative treatment. In spite of this, non-operative treatment should always be the first treatment to be considered.

Nowadays literature on the treatment of osteochondral lesions of the talus involves arthroscopic excision, curettage and bone marrow stimulation, ACI and OATS. ACI is a relatively expensive technique, and OATS gives morbidity from knee complaints in a relevant number of patients. Therefore, is recommended [13] arthroscopic excision, curettage and BMS to be the first treatment of choice for primary osteochondral talar lesions. It is relatively inexpensive, there is low morbidity, a quick recovery and a high success rate.

Conflict of interest:
The authors declared no conflicts of interest.

VOLUME 69 | ISSUE 2 | APRIL - JUNE 2018

REFERENCES

1. Konig F. Uber freie Korper in den gelenken. *Dtsch Z Chir*.(1888);27:90-109.
2. Kappis M. Weitere beitrage zur traumatisch-mechanischen entstehung der "spontanen" knorpela biosungen. *Dtsch Z Chir*. (1922);171:13-29.
3. Berndt AL, Harty M. Transchondral fractures (osteochondritis diseccans) of the talus. *J Bone Joint Surg*. (1959);41A:988-1020.
4. Loomer R, Fisher C, Lloyd-Smith R, Sisler J, Cooney T: Osteochondral lesions of the talus. Am J Sports Med. Jan-Feb (1993);21(1):13-19.
5. Ferkel RD, Sgaglione NA, DelPizzo W, et al.: Arthroscopic treatment of osteochondral lesions of the talus: long-term results. Orthop Trans. (1990); 14:172-173
6. Hepple S, Winson IG, Glew D: Osteochondral lesions of the talus: A revised classification. Foot Ankle Int. (1999);20:789-793
7. Schachter AK, Chen AL, Reddy PD, Tejwani NC: Osteochondral Lesions of the Talus. JAAOS.May/June (2005);13:152-158.
8. Verhagen RA, Struijs PA, Bossuyt PM, van Dijk CN: Systematic review of treatment strategies for osteochondral defects of the talar dome. Foot Ankle Clin. (2003);8:233-242.
9. Tol JL, Struijs PA, Bossuyt PM, Verhagen RA, van Dijk CN. Treatment strategies in osteochondral defects of the talar dome: a systematic review. Foot Ankle Int. (2000);21:119-126.
10. Kono M, Takao M, Naito K (2006) Retrograde drilling for osteochondral lesions of the talar dome. Am J Sports Med34:1450–1456
11. Taranow WS, Bisignani GA, Towers JD et al. (1999) Retrograde drilling of osteochondral lesions of the medial talar dome. Foot Ankle Int 20:474–480
12. Robinson DE, Winson IG, Harries WJ (2003) Arthroscopic treatment of osteochondral lesions of the talus. J Bone Joint Surg Br 85:989–993
13. Zengerink M, Struijs PA, Tol JL, van Dijk CN: Treatment of osteochondral lesions of the talus: a systematic review. Knee Surg Sports Traumatol Arthrosc (2010) 18:238–246
14. Kouvalchouk JF, Schneider-Maunoury G, Rodineau J et al. (1990) Osteochondral lesions of the dome of the talus with partial necrosis. Surgical treatment by curettage and filling. Rev Chir Orthop Reparatrice Appar Mot 76:480–489
15. Assenmacher JA, Kelikian AS, Gottlob C, Kodros S. Arthroscopically assisted autologous osteochondral transplantation for osteochondral lesions of the talar dome: an MRI and clinical follow-up study. *Foot Ankle Int*. (2001);22:544-551.
16. Gautier E, Kolker D, Jakob RP. Treatment of cartilage defects of the talus by autologous osteochondral grafts. *J Bone Joint Surg Br*. (2002);84:237-244.
17. Scranton PE Jr, Frey CC, Feder KS. Outcome of osteochondral autograft transplantationfor type-V cystic osteochondral lesions of the talus. *J Bone Joint Surg Br*. (2006);88:614-619.
18. Hangody L, Fules P. Autologous osteochondral mosaicplasty for the treatment of full-thickness defects of weight-bearing joints: ten years of experimental and clinical experience. *J Bone Joint Surg Am*. (2003);2:25-32.
19. Whittaker JP, Smith G, Makwana N, et al. Early results of autologous chondrocyte implantation in the talus. *J Bone Joint Surg Br*. (2005);87:179-183.
20. Kumai T, Takakura Y, Kitada C et al. (2002) Fixation of osteochondrallesions of the talus using cortical bone pegs. J Bone Joint Surg Br 84:369–374
21. Canale ST, Belding RH. Osteochondral lesions of the talus. *J Bone Joint Surg [Am]* (1980);62-A:97-102.
22. Bruns J, Rosenbach B, Kahrs J. Etiopathogenetic aspects of medial osteochondrosis dissecans tali. *Sportverletz Sportschaden* (1992);6:43-9.

VOLUME 69 | ISSUE 2 | APRIL - JUNE 2018

READY - MADE CITATION

Badekas T, Souras N. Osteochondral Lesions in Foot and Ankle (current treatment strategies and author's developed technique). *Acta Orthop Trauma Hell* 2018; 69(2): 56-65.

ΠΕΡΙΛΗΨΗ

Η οστεοχόνδρινη βλάβη του αστραγάλου αποτελεί μια ευρεία έννοια που περιγράφει τον τραυματισμό ή την ανωμαλία στην αρθρική επιφάνεια του αστραγάλου. Διάφοροι όροι έχουν χρησιμοποιηθεί αναφορικά με τη συγκεκριμένη κλινική οντότητα, όπως η διαχωριστική οστεοχονδρίτιδα, το οστεοχόνδρινο κάταγμα ή το οστεοχόνδρινο έλλειμμα. Αν η οστεοχόνδρινη βλάβη του αστραγάλου αποτελεί πρόδρομο ανάπτυξης γενικευμένης αρθρίτιδας ή όχι αποτελεί θέμα μελέτης, παραμένει βέβαιο όμως πως συνιστά μια κλινική οντότητα που συνήθως είναι συμπτωματική και χρήζει θεραπείας. Σε περισσότερο από το ένα τρίτο των περιπτώσεων η συντηρητική θεραπεία αποτυγχάνει και χρειάζεται χειρουργική παρέμβαση. Υφίσταται ένα ευρύ φάσμα χειρουργικών επεμβάσεων που αφορούν στην οστεοχόνδρινη βλάβη της ποδοκνημικής άρθρωσης, με αρκετές νέες τεχνικές να βρίσκονται στο προσκήνιο την τελευταία δεκαετία.
Η συνήθης συντηρητική αντιμετώπιση περιλαμβάνει ανάπαυση, ακινητοποίηση και χρήση μη στεροειδών αντιφλεγμονωδών φαρμάκων, ενώ η χειρουργική αντιμετώπιση περιλαμβάνει από την απλή εξαίρεση της βλάβης μέχρι πιο σύνθετες τεχνικές όπως η χρήση αυτόλογου μοσχεύματος από μη φορτιζόμενη επιφάνεια του αστραγάλου. Στόχος της θεραπείας παραμένει η ανακούφιση των συμπτωμάτων και η βελτίωση της λειτουργικότητας της άρθρωσης. Τα συμπεράσματα των μελετών ως προς την αποτελεσματικότητα των διαφόρων τεχνικών διαφέρουν. Στις περισσότερες των περιπτώσεων η απόφαση για την χειρουργική τεχνική που θα χρησιμοποιηθεί για την αντιμετώπιση της βλάβης εξαρτάται από τον τύπο και το μέγεθος της βλάβης, καθώς και από την χειρουργική τεχνική που θα προτιμήσει ο εκάστοτε χειρουργός.

ΛΕΞΕΙΣ ΚΛΕΙΔΙΑ: Οοστεοχόνδρινες Βλάβες, Διαχωριστική Οστεοχονδρίτιδα, Αστράγαλος, Ποδοκνημική Άρθρωση, Χόνδρινη Βλάβη, Υποχόνδριο Οστό

VOLUME 69 | ISSUE 2 | APRIL - JUNE 2018

Posterior Arthroscopic Tibio-Talo-Calcaneal Fusion: Early Experience with a New Surgical Technique

A. Papachristou MD, I. Giannaros MD, and A. Eleftheropoulos MD

Department of Orthopaedic Surgery, Naousa's General Hospital, Lanara & Pechlivanou 3
Naousa - Imathia 59200 - Greece

ABSTRACT

Combined arthritis of the ankle and the subtalar joint is traditionally treated by tibio-talo-calcaneal fusion. We describe a new minimally invasive method for tibio-talo-calcaneal fusion with the use of a retrograde nail, under posterior hindfoot arthroscopy. The surgical technique, as well as the results of several cases, are presented. This novel surgical procedure seems to have a higher rate of patient satisfaction and lower morbidity than traditional methods, although it is not favourable when a significant deformity is present.

KEY WORDS: arthrodesis, tibio-talo-calcaneal, arthroscopy, intramedullary nail

Introduction

Hindfoot arthritis (combined arthritis of the tibiotalar and subtalar joints) is usually treated by tibio-talo-calcaneal fusion (TTC fusion) when conservative treatment has failed. Indications of TTC fusion are wide, including post-traumatic arthritis (avascular necrosis of the talus, pilon fracture, calcaneus fracture), rheumatoid arthritis, adult-acquired flatfoot (Myerson stage IV), as well as failed total ankle arthroplasty (**Fig. 1**). Several methods are already proposed in the literature comprising open, mini-invasive and arthroscopic techniques using screws, plates, external fixators or fibular grafts [1]. The use of an intramedullary nail under arthroscopic assistance offers a load-sharing rigid internal fixation, providing better fusion rates compared with open procedures while avoiding skin complications and presumably reducing the rate of infection (**Fig. 2**). Indeed, various studies demonstrated that intramedullary nails offer greater stiffness in bending and rotational directions than screws [2], and although their fixation might not be as rigid as blade or locking plates, they are load-sharing devices promoting healing [3]. Besides, by using a posterior arthroscopic approach, only two posterior portals are needed for preparation of the joint surfaces allowing one-step procedure. Moreover, by preserving vascularity, an optimal blood supply is provided locally, so high rates of fusion are expected within a shorter time frame.

CORRESPONDING AUTHOR, GUARANTOR

Alexandros Eleftheropoulos MD
Foot & Ankle Orthopaedic Consultant, Head of Orthopaedic Department, Naousa's General Hospital, Lanara & Pechlivanou 3, Naousa - Imathia, 59200 - Greece,
Phone: +30 23320 59250, Fax: +30 23320 59254, E-mail: el.alexandros@gmail.com

VOLUME 69 | ISSUE 2 | APRIL - JUNE 2018

***Fig. 1** Failed Total ankle arthroplasty.*

***Fig. 2** TTC Arthrodesis with arthroscopically assisted intramedullary nail.*

We present the surgical technique, refer to several cases treated by this method and discuss some distinguishing characteristics of the above-mentioned procedure compared to other methods of fusion.

Surgical technique

The procedure takes place under spinal or general anaesthesia. The patient is positioned in a prone position. Prophylactic antibiotic is given before the induction of anaesthesia. A tourniquet is applied at the thigh. Standard surgical preparations and draping are applied. No soft tissue distraction device is needed. Superficial anatomic landmarks are drawn on the skin. Using the standard posteromedial and posterolateral portals as they have been described by Nick van Dijk [4] (**Fig. 3**) , a standard 4-mm knee arthroscope with 30º of optics is inserted through the posterolateral portal. Posterior compartment is prepared using a 4.0 to 4.5 mm shaver through the posteromedial portal. The flexor hallucis longus tendon is identified and preserved as a medial landmark, as power instruments should not move beyond it to avoid damage to the posterior neurovascular bundle. Capsule, intermalleolar and posterior tibiofibular ligaments should be resected as they block access to the ankle joint (**Fig. 4**). The posterior talofibular ligament should only be partially resected as is mainly a posterolateral structure. Os trigonum is also resected, to allow easy access to the subtalar joint. The debridement and preparation of the articular surface of the ankle joint are made with a 4.5 mm shaver and a 4.5 mm barrel burr for cartilage removal. Sometimes, a fine osteotome or a fine flexible chisel can be used through the posteromedial or posterolateral portal (**Fig. 5**). All cartilage and approximately 2 mm of the subchondral bone are removed from the tibial plafond and the talar dome until fresh cancellous bone is visible (**Fig. 6**). After the preparation of the ankle joint is completed, the hindfoot is placed in neutral dorsiflexion, 0 to 5 degrees of heel valgus and 0 to 5 degrees of external rotation of the foot. Subsequently, a 2 cm incision is made in the plantar skin of the heel. Under fluoroscopic control, a guide wire is inserted through the calcaneus and the talus into the tibia. After reaming is performed (**Fig. 7**), a retrograde intramedullary nail is inserted (10 or 11 mm x 150 mm T2 Stryker®) and locked statically with one screw in the calcaneus (from posterior to anterior), one in the talus (from lateral to medial or the other way) and two screws proximally in the tibial shaft (from medial to lateral). Thereafter, preparation of the sub-

***Fig. 3** Standard posteromedial and posterolateral portals as described by Nick van Dijk [4].*

***Fig. 4** Typical instruments used in posterior hindfoot arthroscopy.*

talar articular surfaces takes place as described by van Dijk et al. [4]. The skin incisions are then closed, sterile dressings and a posterior splint are applied. Postoperatively, prophylactic anticoagulation is administrated for six weeks. At discharge, the back slab is exchanged with a non-weight bearing full cast. After 3 weeks, a walking boot is applied and patients are referred to physiotherapy with partial weight bearing of 15 to 20 kg. Progression to full weight bearing and muscle-strengthening exercises are commenced 6 weeks after surgery. Radiographic evaluation of the fusion is done 6, 8 and 12 weeks post-operatively (**Fig. 8**). Further follow-up is scheduled at 6 and 12 months following surgery, and annually thereafter.

Patients and Methods

Between 2014 and 2017, in our clinic, we operated on 12 patients (4 male and 8 female) with severe hindfoot arthritis. The mean age of the population was 68 years and their mean BMI 30.5. They all complained about pain and disability to perform their daily activities.

Patients' history and co-morbidities were investigated. Physical examination revealed severely restricted and painful arc of motion of the ankle and the subtalar joint. The posterior tibial and pedal pulses were present, and no neurologic deficit was recorded. Standard weight-bearing anteroposterior and lateral radiographs of the ankle and Broden's view of the hindfoot were taken. A CT scan was also requested in all patients to assess the degree of osteoarthritis.

Results

The mean hospitalization was 1.2 days. Deformity correction and hindfoot fusion were achieved in all twelve cases. There were no significant complications, such as infection, wound healing problems, nonunion, malunion or hardware failure. Fusion was achieved in approximately three months' time (2.5-3.5 months). All the patients returned to their daily activities in four to five months' time. The postoperative AOFAS score was significantly improved.

Discussion

Intramedullary fixation for hindfoot arthrodesis was first described in 1906, and its use has become steadily more popular over the last two decades [5]. Generally, it is reserved for salvage foot and ankle procedures with end-stage osteoarthritis, significant deformity, and gross instability. Also, as patients frequently present severe co-morbidities (for example diabetes mellitus, peripheral arterial disease, inflammatory arthritis and compromised soft tissue envelope from previous surgeries), com-

VOLUME 69 | ISSUE 2 | APRIL - JUNE 2018

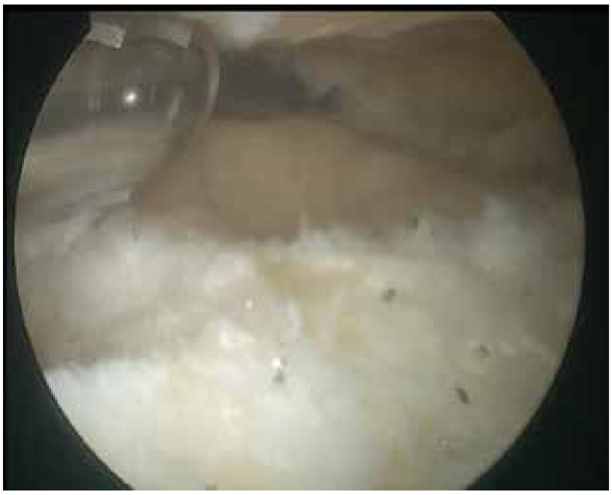


Fig. 5 *Arthroscopic preparation of the ankle joint.*

Fig. 6 *Subchondral bone removal until fresh cancellous bone is visible.*

plications such as infection, nonunion, malunion and nerve injuries are not uncommon. In some series, these complications rise to 50-60%, especially in complex cases [6]. Arthroscopically assisted IM nailing greatly reduces the rate of postoperative complications, although the small number of patients included in the reported series, do not allow achieving statistical significance [7]. Initially, anterior arthroscopic techniques were used for TTC fusion with retrograde intramedullary nail [8]. However, based on the description of posterior subtalar arthrodesis by van Dijk et al. [4], a posterior arthroscopic TTC fusion with retrograde intramedullary nail was later described by Bevernage et al. in 2010 [3]. They used this technique in 3 patients with a 100% reported fusion after 8 to 12 weeks. It is a minimally invasive procedure with several advantages compared to traditional or anterior arthroscopic methods.

To begin with, due to the reduced invasiveness of the procedure and the seemingly lower rate of skin complications and infection [9], the hospitalization length is reduced, there is no need for blood transfusion and patients return to their daily activities sooner. Furthermore, in this technique, a higher rate of fusion seems to be achieved, by retaining the vascularisation and the byproducts of reaming. Indeed, the blood supply to the distal tibia, the talus and the posterior facet of the calcaneus is theoretically preserved as the peroneal artery, the anterior and posterior tibial arteries and the vessels coming through the sinus tarsi and the deltoid ligament are not usually damaged. In addition, the anterior tibiotalar capsule remains intact, and as a result, the retaining reaming material rich in growth factors provides excellent consolidation without the need for auto- or allograft. Moreover, as the resection of the articular cartilage and subchondral bone is performed under arthroscopic vision, an optimal coaptation of the bony surfaces is obtained, which is essential for fusion [10]. In our technique, in order not to disturb the alignment of the ankle and hindfoot, the retrograde nail is inserted before the debridement of the subtalar joint. Finally, in comparison with the anterior approaches which prepare the posterior talocalcaneal facet through the sinus tarsi, by using an entirely posterior technique, the nutrient arteries through the interosseous ligament and the tarsal canal are not at risk, and the blood supply of the talus is not compromised [3].

Conclusion

Arthroscopically assisted IM nailing for TTC fusion is a promising technique with high patient satisfaction, earlier fusion rate, fewer wound complications and lower postoperative morbidity. However, it is technically demanding and is recommended for surgeons familiar with posterior ankle and sub-

VOLUME 69 | ISSUE 2 | APRIL - JUNE 2018

Fig. 7*. Guide wire insertion and reaming.*

Fig. 8*. Postoperative radiographic evaluation of fusion.*

talar arthroscopy. Indications are the same as for open TTC arthrodesis, with the prerequisite that deformity is not significant and can be reduced. To our knowledge, this is the larger case series of posterior arthroscopic TTC fusion with a retrograde intramedullary nail. We achieved fusion in all patients with excellent post-operative results.

Conflict of interest:

The authors declared no conflicts of interest.

REFERENCES

1. y Rico JV, Rodriguez-Martin J, Parra-Sanchez G, et al. Arthroscopic Tibiotalocalcaneal Arthrodesis with Locked Retrograde Compression Nail. *The Journal of Foot & Ankle Surgery 2013*; 52(4): 523–528.
2. Berend ME, Glisson RR, Nunley JA. A biomechanical comparison of intramedullary nail and crossed lag screw fixation for tibiotalocalcaneal arthrodesis. *Foot Ankle Int* 1997; 18(10): 639-643
3. Bevernage BD, Deleu PA, Maldague P, et al. Technique and early experience with posterior arthroscopic tibiotalocalcaneal arthrodesis. *Orthopaedics & Traumatology: Surgery & Research* 2010; 96(4): 469-475.
4. 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.
5. Woods JB, Burns PR. Advances in Intramedullary Nail Fixation in Foot and Ankle Surgery. *Clinics in podiatric medicine and surgery* 2011; 28(4): 633-648.
6. Cooper PS. Complications of ankle and tibiotalocalcaneal arthrodesis. *Clin Orthop Relat Res* 2001; (391): 33–44.
7. Franceschi F, Franceschetti E, Torre G, et al. Tibiotalocalcaneal arthrodesis using an intramedullary nail: a systematic review. *Knee Surgery, Sports Traumatology, Arthroscopy*, 2016; 24(4): 1316-1325.
8. Sekiya H, Horii T, Kariya Y, et al. Arthroscopic-assisted tibiotalocalcaneal arthrodesis using an intramedullary nail with fins: a case report. *J Foot Ankle Surg* 2006; 45(4): 266-270.
9. Roussignol X. Arthroscopic tibiotalar and subtalar joint arthrodesis. *Orthopaedics & Traumatology: Surgery & Research* 2016; (102) S195–S203
10. Bennett GL, Cameron B, Njus G, et al. Tibiotalocalcaneal arthrodesis: a biomechanical assessment of stability. *Foot Ankle Int* 2005; 26(7): 530-536.

VOLUME 69 | ISSUE 2 | APRIL - JUNE 2018

READY - MADE CITATION

Papachristou A, Giannaros I, Eleftheropoulos. A Posterior Arthroscopic Tibio-Talo-Calcaneal Fusion: Early Experience with a New Surgical Technique. *Acta Orthop Trauma Hell* 2018; 69(2): 66-71.

ΠΕΡΙΛΗΨΗ

Η συνδυασμένη οστεοαρθρίτιδα της ποδοκνημικής και της υπαστραγαλικής άρθρωσης αντιμετωπίζεται παραδοσιακά με διπλή πτέρνο-αστράγαλο-κνημιαία αρθρόδεση. Περιγράφουμε μια νέα ελάχιστα παρεμβατική μέθοδο ενδομυελικής ήλωσης με αρθροσκοπική υποβοήθηση για την διπλή αυτή αρθρόδεση. Η νέα αυτή μέθοδος έχει υψηλότερα ποσοστά ικανοποίησης και μικρότερα ποσοστά νοσηρότητας σε σχέση με τις παραδοσιακές τεχνικές. Παρόλα αυτά δεν ενδείκνυται σε περιπτώσεις προχωρημένης οστεοαρθριτικής παραμόρφωσης.

ΛΕΞΕΙΣ ΚΛΕΙΔΙΑ: Οστεοαρθρίτιδα, ποδοκνημική, υπαστραγαλική, αρθρόδεση, ενδομυελική ήλωση

Ten-year clinical experience of Ponseti method in the treatment of idiopathic clubfoot

Nikolaos G. Markeas, Dimitrios Begkas,
Christos Apergis, Andreas Kondylis, Konstantinos Theodoridis

Second Department of Orthopaedics, General Children's Hospital "P. & A. Kyriakou", Athens, Greece

ABSTRACT

Idiopathic clubfoot is the most common congenital deformity of the musculoskeletal system. Apart from the idiopathic form of the disease, this characteristic deformity has also been observed in the clinical picture of some syndromes, neuromuscular diseases or arthrogryposis multiplex congenita. Its etiology is not fully known, and there is disagreement among researchers about its treatment. The purpose of this study is to review the patients with idiopathic clubfoot treated with the Ponseti method between 2007-2016, with particular emphasis on the minimal cases that method failed and the literature data. In our department, 187 feet were treated in 123 infants (89 males and 34 females) aged 22 days (ranging from 5 days to 5 months). Ponseti's instructions have been precisely applied both during the manipulation exercises and the application of the plaster casts as well as during the implementation of Denis Browne brace. Achilles tenotomy was required in all unilateral cases (59 feet) and 49 cases of bilateral deformity (98 feet). In order to evaluate the severity of the disease and the improvement of the deformity during treatment, we used the Dimeglio scoring system. Radiological tests were required in very few cases after 6 months, in order to confirm the clinical outcome. In a follow-up of 12 months to 7 years, we had very good results. There was a great improvement of the deformity, with a full range of motion, without foot pain, calluses, hyperkeratoses or any difficulty in footwear. Patients were very satisfied with treatment results and able to participate in sports activities. In 7 cases a repeat of the procedure was required, while 4 cases of relapse were surgically treated with limited postero-lateral soft tissue release. Two girls presented a leg length discrepancy of 2-3 centimeters. One of them was treated with shoe modification, while the other was subjected to a temporary epiphysiodesis of the longer leg at the age of 10 years. We believe that the complete understanding of the pathogenesis of the disease, the excellent collaboration with parents and the correct application of the Ponseti's method, make it beneficial in any case of severe idiopathic clubfoot, when we want to avoid relapse of the deformity.

KEY WORDS: idiopathic clubfoot, Ponseti method, experience

CORRESPONDING AUTHOR, GUARANTOR

Nikolaos G. Markeas MD, PhD
Director of Second Department of Orthopaedics, General Children's Hospital "P. & A. Kyriakou", Athens, 42 Sikelianou street, Egaleo, 122 43 Athens, Greece
tel.: 6975856940, E-mail: markeasn@otenet.gr

VOLUME 69 | ISSUE 2 | APRIL - JUNE 2018

Introduction

Idiopathic clubfoot is the most common congenital deformity of the musculoskeletal system. In the literature, its incidence rates vary widely. There are 1-2 cases per 1,000 births of healthy infants [1]. Famous men of History and Art suffered from the disease, such as the Roman Emperor Claudius, Lord Byron, and Walter Scott [2]. The disease has been known since ancient times. Hephaestus, the deformed son of goddess Hera, was thrown into the sea by his own mother, but sea-goddess Thetis saved him from drowning [3]. "*Αμφιγυήεις*" (with both limbs crooked) and "*κυλλοποδίων*" (bowlegged) are the adjectives Homer uses for him (**Fig. 1**).

Fig. 1: *A black-figure vase of the geometric period, depicting god Hephaestus riding horseback, with a characteristic clubfoot deformity on the right lower limb.*

Several theories that have been proposed at times, unsuccessfully attempted to justify the true nature of the disease. The variety of different opinions proves the researchers' inability to agree. Theories consider as the main reason sometimes the developmental factor, in myogenic and/or neurogenic causes [4-7] and sometimes a blastic deficit in the endochondral growth of the talus [8]. In some cases there was a congenital disorder in the development of the dorsal artery of the foot and the posterior tibial artery [9-11], while in other cases it was clear that there was a responsible gene, despite the researchers' inability to detect a specific gene deficit [12,13]. There are published studies that report the coexistence of clubfoot and other congenital abnormalities [14], such as the spina bifida occulta in a monozygotic neonatal twin [15]. The research in order to find the cause of the disease continues until nowadays, as it is a real challenge for the clinical doctor. In a relatively recent study, there was no association of the deformity with the application of opioids during pregnancy [16]. It appears that the characteristic deformation probably represents the effect of the interaction of many factors on a genetically sensitive foot (**Fig. 2**).

In the idiopathic clubfeet, neck of the talus is shorter than normal and shifts inwards by drifting the navicular bone. The articular surfaces of the subtalar joint are malformed, forcing the calcaneus to take a wrong and dysfunctional position. The cuboid bone is displaced inwards with respect to the deformed calcaneus [17]. It is very impressive that current science opinion about the deformity does not deviate from Antonio Scarpa's initial formulation a few centuries ago: "The deformation is caused by the twisting of the navicular bone, the calcaneus and the cuboid bone around the talus" [18].

The treatment of the disease has taken various forms from time to time, following a variety of practices. The goals from ancient times to nowadays remain the same: 1) long-term correction of the deformity, 2) painless and functional foot, 3) avoiding surgery, 4) where surgery is needed, it is appropriate to limit the *à la carte* handling [19]. Hippocrates was perhaps the first one that tried to teach ways of correcting the deformation. During the Middle Ages, barber-surgeons, impostors and charlatans took over the baton [20]. After the Renaissance and during the 19th century, Achilles' tenotomy was popular, but did not solve the problem overall [21]. Nowadays, the techniques have

VOLUME 69 | ISSUE 2 | APRIL - JUNE 2018

Fig. 2: *The clinical picture of the congenital idiopathic clubfoot is consisted of several partial deformities: equinus, cavus, supination, varus, forefoot adduction, and foot rotation relative to the tibia.*

been significantly improved and are based on the belief that in order to avoid relapses, it is required by the physician to precisely understand the pathogenesis of the disease [22].

The basic conditions for the success of any treatment method are those supported by Tachdjian [1] and almost all writers agree [2,19,23]: "Treatment onset should be as early as possible and at the beginning should be conservative". Here, it is important to highlight the value of early diagnosis from the prenatal period with the help of fetal ultrasound tests, which are reliable from the 18th to the 24th week of pregnancy [24]. In case that conservative treatment is ineffective, surgical correction must be performed before the age of 12 months [25]. Turco suggested that surgery should be performed over the age of one year, on the basis that only in this period the tissues are recognizable, surgical times are easier, anesthesia risks are less, and the possibility of damaging articular cartilage and epiphyses from mismanagement is limited [26].

Previous policy, based on successive plaster casts every 7-10 days for 3 to 4 months, according to Kite's principles, belongs in the past [27]. Later, was found out that all the attempts of immobilization of the foot in pronation within the plaster, without previous correction the varus deformity of the calcaneus, caused the opposite effects of the desired [28,29]. Currently, the most effective methods of conservative treatment are French (functional) and Ponseti's method. French method requires enough time in each session, skill and good cooperation with parents. Practice, progress, and course evaluation are left to the physiotherapist's art, while the treating physician plays a secondary role [30].

Although the first publications by Ignacio Ponseti himself date back to the distant 1948, our department began to apply his method exclusively from 2007 and after. According to Ponseti's recommendations, successive plaster casts are applied weekly for the first 2 months. Each time that the plaster cast is changed, special exercises are performed, in order to contribute to a progressive improvement and correction of the varus deformity of calcaneus, the supination and adduction of the forefoot, while the equinus deformity is corrected after 2 months, when a closed transdermal tenotomy of Achilles tendon is performed under general (or local) anesthesia [25,31,32]. A plaster cast is placed additionally for one month and then is replaced with a Denis Browne corrective brace, which is placed for the first 3 months during the whole day and for the remaining 6 months only at night until start of walking. Ponseti's method fans support continued treatment until the age of 3 years. In Greece, as in other countries, French (functional) method did not find supporters [33].

Despite the fact that criticism has been made about the principles of application of the method, they were finally prevailed over time. Nowadays Ponseti's method is used in both the developed and the developing world [34-38]. The advantages of this method are more often studied, compared to other methods or surgical treatment, because it has been proven that

***Fig. 3:** After the Ponseti's method distention manipulations for the correction of the deformities (except for equinus deformity), a plaster of Paris or a synthetic resin cast is applied.*

***Fig. 4:** A Denis Browne brace in a toddler with a bilateral clubfoot.*

Ponseti's method results in a more functional, flexible and painless foot [39-41]. Even at older age, its application was successful [42,43], while it has also been tested in non-idiopathic forms of the disease, where previous methods were ineffective [44].

The reasons for Ponseti's method failure are related to delayed treatment initiation, mismanagement, various social and economic reasons, or the lack of knowledge [2,45,46]. Ponseti himself pointed out the mistakes of Kite's technique, paying great attention to avoiding them [29,31]. Many problems arise with the involvement of parents in the process. When a Denis Browne brace is applied, problems are multiplied [36]. Infants do not always tolerate it and sometimes they find out how to get rid of it, while the parents find it difficult to apply it correctly.

In this study we describe our 10-year experience of Ponseti's method application for the treatment of idiopathic clubfoot, with emphasis on a minimal number of cases that the method failed and the literature data.

Material-Methods

From January 2007 to December 2016, we hospitalized in our department 123 infants (187 feet) with idiopathic clubfoot, which was diagnosed prenatally by fetal ultrasound test, or immediately after birth by the clinical examination. These were 89 males (72.3%) and 34 females (27.7%). The mean age for starting the treatment was 22 days (range from 5 days to 5 months). In 59 cases the deformation was unilateral (35 right feet, 24 left) and in the remaining 64 cases bilateral. Patients who were suffering from non-idiopathic clubfoot were excluded from the study.

In order to perform the exercises correctly in every plaster cast change, we strictly followed Ponseti's instructions. We used plaster of Paris in 68 patients (55.28%) and synthetic resin for the rest (**Fig. 3**). We preferred general anesthesia in older infants, particularly in early cast changes, in our attempt to control hyperactivity and their expected reactions. It took about 5 to 7 cast changes (average 6.3 changes) before the Achilles tenotomy. Tenotomy was required in all unilateral cases (59 feet) and in 49 cases of bilateral deformation (98 feet). With the exception of very few patients during the first application of the method, where we preferred local anesthesia, the majority of cases were subjected to general anesthesia.

After tenotomy, casts were applied again for 1-2 more times (for 3-4 weeks). Then a Denis Browne type brace was applied, whose bar was adjusted so that its length was equal to the distance length between the shoulders. The deformed foot was immobilized at 65° of external rotation, while the normal foot at 45° of external rotation (**Fig. 4**). By giving instructions to the

VOLUME 69 | ISSUE 2 | APRIL - JUNE 2018

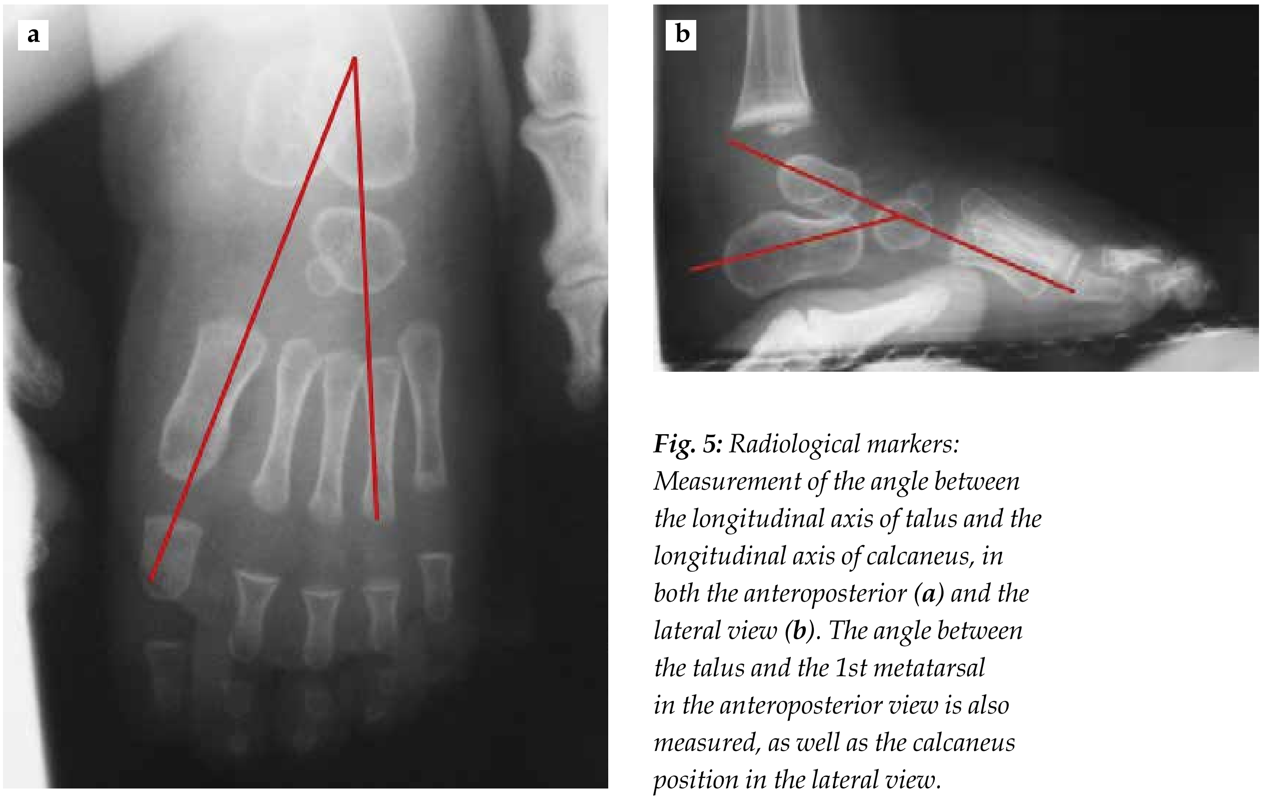


Fig. 5: *Radiological markers: Measurement of the angle between the longitudinal axis of talus and the longitudinal axis of calcaneus, in both the anteroposterior (**a**) and the lateral view (**b**). The angle between the talus and the 1st metatarsal in the anteroposterior view is also measured, as well as the calcaneus position in the lateral view.*

parents, we were trying to inform them about the way that the brace could be removed and re-applied, while trying to reassure them by providing them psychological support.

In order to assess the severity of the disease and the improvement of the deformity during or after treatment, we have used the Dimeglio scoring system, which is based on clinical criteria only and has been proven to be extremely reliable and easy to be applied. According to this, each component of the deformity (equinus deformity, varus deformity of the calcaneus, rotation of the foot in relation to the tibia, adduction of the forefoot) is estimated from 1 to 4, depending on the severity [47,48]. More points are added when skin creases, foot shortening and/or gastrocnemius atrophy, coexist. The final estimation of the severity of the disease is calculated by the sum of scoring points. Benign form scores <5 points, moderate severity form scores 5-9 points, severe form scores 10-14 points and very severe deformity scores15-20 points.

Roentgenograms were not used in the initial assessment of the disease, except in very few cases after the first 6 months. The angle between the longitudinal axis of the talus and the longitudinal axis of the calcaneus, was measured both in the anteroposterior and lateral views. The angle between talus and 1st metatarsal in the anteroposterior view was also measured. Finally, the calcaneus position in the lateral view was estimated (**Fig. 5**). Normal values of radiological measurements vary widely. In the anteroposterior view, the talocalcaneal angle ranges from 30 to 55 degrees. The angle of talus-1st metatarsal ranges from 5 to 15 degrees. In the lateral view, the talocalcaneal angle ranges from 25 to 50 degrees [49].

During the Denis Browne brace application, patients were regularly monitored on outpatient basis, every three months initially and every 6 months thereafter. Clinical examination included assessment of range of motion of individual foot joints (tibiotalar, subtalar, Chopart joint), shoe wear control, skin observation and the Chesnut test (block test) in order to determine the persistence of varus deformity of the calcaneus (**Fig. 6**). Roentgenograms were not necessary in most cases. The follow-up lasted 4.6 years

VOLUME 69 | ISSUE 2 | APRIL - JUNE 2018

Fig. 6: *In Chesnut (block) test, the foot is loaded on its outer margin, while standing over a book in an eccentric position. We can notice the degree of valgus deformation of the calcaneus.*

Fig. 7: *Limited posterolateral soft tissue release, in cases of relapse of the deformity, in the event of failure of the Ponseti's method.*

(ranging from 12 months to 7 years) and continues to date.

Results

According to the Dimeglio scoring system, during the initial assessment, 97 feet (51.8%) had severe deformity (score: 12-14 points), while in the remaining 90 feet (48.2%) the deformity was very severe (score: ≥15 points). After the end of the treatment there was a clear improvement. All bilateral cases were assessed with 5 points score, while the unilateral cases with 7 points score. The results were considered satisfactory when the infant had painless feet, without calluses and/or hyperkeratoses, while could easily wear shoes and participate in athletic activities, without any complaints or any other problems, with a range of motion of the individual foot joints within the normal limits.

The duration of Denis Browne brace application was 15 months (range 12-36 months). Ponseti's method had to be repeated in 7 cases. There were 4 relapses for which surgery was required. We preferred to perform a limited posterolateral soft tissue release, with posterior capsulotomies of the tibiotalar and talocalcaneal joints, along with division of the fibulocalcaneal ligament and open Achilles tendon lengthening (**Figure 7**). The final result in these cases, according to the Dimeglio scoring system and the Chesnut test, was considered satisfactory.

Two girls of the four patients in which soft tissue release was performed, presented leg length discrepancy. One of them presented a length discrepancy of 2 cm and a shoe modification has been done, by adding an outer sole to the shoe of the shorter leg. The other girl presented a leg length discrepancy of 3 centime-

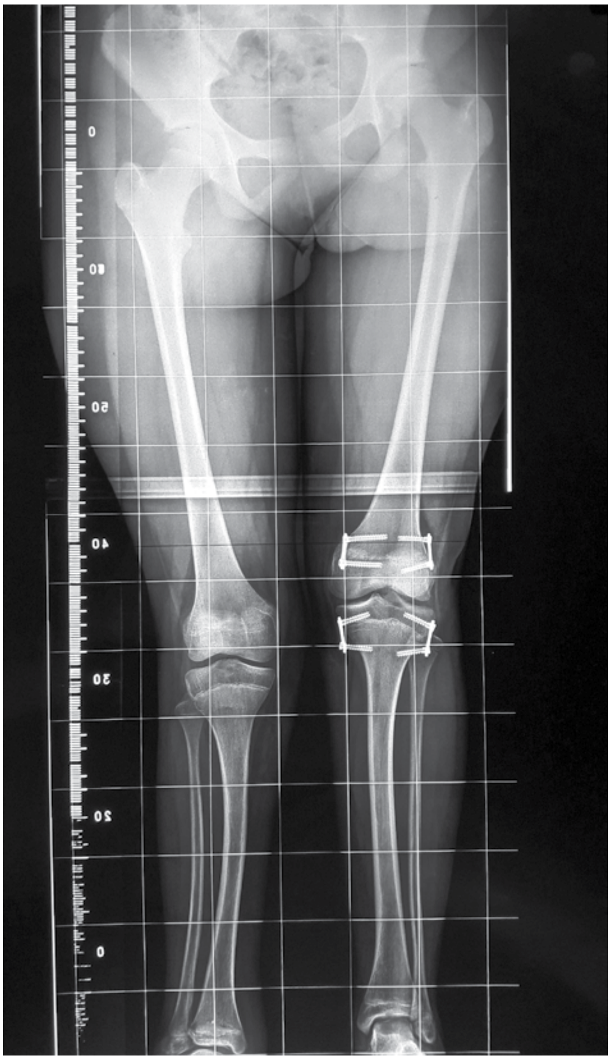


Fig. 8: *A 10-years-old girl, with a right clubfoot deformity and leg length discrepancy of 3cm. A temporary epiphysiodesis was attempted on the left longer leg.*

ters and a temporary epiphysiodesis was performed to her longer leg at the age of 10 (**Fig. 8**). In small number of cases, where we used x-rays to confirm the clinical outcome, the radiological markers were within the normal range, but the size of the talus was estimated to be shorter than normal (**Fig. 9**).

Fig. 9: *After the end of the treatment, X-rays can show the shorter than normal size of the talus.*

Discussion

The results of the application of Ponseti's method, which was for the first time applied in our department to 123 patients that are included in this study, responded to our concerns, as they were formulated in a previous published paper [2]. Surgical treatment, which was previously preferred as the most appropriate solution to rigid deformities that resist to the conservative treatment, resulted in correcting all the anatomical structures that are responsible for the deformity, without exception. According to the principles of Turco [26], in a single operation, with the posteromedial release of the responsible soft tissues, we attempted to achieve perfect anatomical reconstruction of the foot. The whole procedure involved extensive release of ligaments, complete release of the subtalar joint, release of the tendon sheaths, tendons lengthening (tibialis posterior and digitorum flexors), capsulotomies of talonavicular and naviculocuneiform joints and open lengthening of Achilles tendon (**Fig. 10**). The reduction of the navicular bone at the head of the deformed talus was achieved by the insertion of a Kirschner wire, which was removed after 6 weeks.

Many surgeons, after Turco, have attempted various modifications to his technique. Carrol [50] suggested, in addition to other manipulations, division of the plantar aponeurosis and capsulotomy of the calcaneocuboid joint. Goldner was not interested in the perfect release of the subtalar joint [51]. Simons [52] applied the Cincinnati posterior approach and the release of most of the anatomical structures surrounding the talus. Talonavicular and calcaneocuboid joints were opened, while in the opening of the subtalar joint the interosseous ligament was intersected.

In these interventions, there is no room for failure. During the first operation, surgeon has a unique op-

Fig. 10: During the posteromedial soft tissue release (according to Turco), we perform broad ligament releases, capsulotomies, tendon sheath divisions and lengthening of tendons.

portunity to correct all the deformity components. Surgical times do not apply a specific algorithm. Orthopedists are not helped by the understanding of standard techniques, nor the knowledge of bibliographical references. The surgeon, step-by-step, releases stiff periarticular tissue à la carte, according to the findings during surgery. The most common causes of relapse are incomplete first surgery and mismanagement. Multiple operations should be avoided, because they result to stiffness, scarring, soft tissue hardening, and muscle atrophy due to prolonged immobilization [2].

Following the Ponseti's method over the last decade, we have tried to avoid all these difficulties. The results justified our expectations. Besides, the existing literature supports the advantages of the method in a number of parameters [53-60]. This method has significantly reduced the cases that need to be operated on and has been established in the major clinical centers abroad as the most effective solution to idiopathic clubfoot. It is based on the full awareness of the pathogenesis of the initial deformity. Its excellent results are highlighted not only by clinical and radiological criteria but also by means of CT. It has been successfully applied to older than 2-year-old infants with neglected deformities. Late satisfactory results are considered to be equivalent to the early excellent results in the first months of application of the method. Recent meta-analyzes proved that this technique is superior to all the other treatment practices which have been used occasionally. Finally, Ponseti's method is more economical than other methods. It is obvious that nowadays, where there are tremendous financial problems and a large number of uninsured patients, a low-cost technique like this seems to be attractive.

During the manipulations between the successive plaster cast changes, before Achilles tenotomy, we faithfully followed the instructions given in the literature, although sometimes we could not resist the temptation to exert a slight thrust on the heel. However, we have resisted some challenges, such as the placement of a below knee splint (instead of above knee one) [61], the use of a 19-gauge needle (instead of a scalpel) for the tenotomy [62], or the botulinum A toxin infusion, because it has not been actually shown to speed up the correction of the deformity, or to reduce the need of tenotomy and the frequency of relapses [63].

We did not dare to use the Ponseti's method in non-idiopathic forms of the disease, especially in arthrogryposis, despite the encouraging studies of other researchers [44,64]. We also did not use physiotherapy [65], fully assuming the responsibilities and consequences of our practice, for the same reason that we do not support the application of the French (functional) method. The role of the Orthopedic Surgeon in the treatment of idiopathic congenital clubfoot should be prominent.

Assessing the severity of the deformity is required in any case to set the therapeutic plan. It is also useful for determining the prognosis of any therapeutic action. We cannot compare the early and final results of different treatment methods if we have not previously assessed the initial severity of the disease. Various scoring systems, all based on clinical criteria, have been applied for this purpose [47,48,66,67]. Among the two most popular systems of Pirani and Dimeglio, we preferred the latter because of the familiarity with it. Moreover, it does not seem to outweigh each other [68], although there has been a disagreement over the criteria in several publications [69].

VOLUME 69 | ISSUE 2 | APRIL - JUNE 2018

For the estimation of deformity we preferred clinical criteria instead of radiological. We looked at the X-rays only in very few cases, after 6 months, when we wanted to confirm the results of the method using objective criteria. At younger ages, most skeletal structures of the foot are cartilaginous, the bones appear very small, the osseous nuclei are in an eccentric position and their radiographic imaging is difficult. After the 6th month, we can estimate the various radiological markers, the calcaneus position and the size of the talus, but we cannot see any existing bone deformities [70]. At older ages, radiological testing can also confirm the treatment-related development of talus and calcaneus [71], as it has been shown that they have greatly restored their blood flow in most of the cases that were successfully treated with the Ponseti's method [10]. Lately, ultrasound test is getting more and more popular in the diagnostic approach and monitoring of the disease, as it is a non-invasive and non-ionizing technique, which is superior to the others in the presentation of cartilaginous anatomical structures [72]. On the contrary, CT scan is not indicated, because of the increased emission of ionizing radiation [54].

The reasons for Ponseti's method failure, as mentioned before, are related to a delay in treatment initiation, mismanagement, a variety of social and economic reasons, or the lack of knowledge. However, unpredictable factors may also lead to failure, such as tibial and/or fibular fractures during plaster cast application [73]. Gastrocnemius atrophy cannot be considered a reliable indicator of method failure, as it relates to the pathogenesis of the disease and remains until adulthood, despite any attempts to improve it [7]. Strengthening of the peroneal muscles in order to prevent relapses, perhaps may be useful if parents are properly informed and comply with the guidelines [74]. The efficacy of the tenotomy is questionable, given the Achilles tendon ability to be fully restored, not within 3-4 weeks when we remove the plaster casts, but at 12 weeks, as ultrasound tests showed in an experimental prospective study from Spain [75].

We believe that, in most cases of the method's failure, the main cause is the parents' inability to discipline at the stage of application of the Denis Browne brace. The truth is that when patients tolerate the brace, fewer relapses occur and the need of surgical treatment is rare [76]. Patients who have tolerated the brace for more than 2 years, were 2.7 times less likely to return to the operation hall than those who have not [77]. The use of new types of braces, in place of the traditional Denis Browne, promises comfortable application, tolerance and efficiency [78-80]. Relapses that occurred at ages under 2 years, were not related to the type of the brace [81]. The only reason that Denis Browne brace may be "accused", is the appearance of pes planovalgus deformity of the other foot, in unilateral forms of the disease [82].

In 7 cases where the method was repeated, it was about infants younger than one year old. In cases of relapse at older ages, we preferred limited soft tissue release (4 cases). Indications for surgical intervention in cases of relapses, as well as the type of manipulations for the correction of the deformity, have not yet been specified [83,84], but we know that in relapses following method's failure there are three internationally accepted solutions: 1) repetition of the method, 2) complete soft tissue release à la carte and 3) placement of an Ilizarov device [85]. We have no experience about Ilizarov's technique in the treatment of idiopathic clubfoot, but we know that when is combined with limited soft tissue release, it can give excellent results [86].

Recently, once again, have been formulated the clinical criteria on the basis of which we can clearly support that we have excellent results [87,88]: 1) feet without deformities, 2) possibility of using normal footwear without special modifications, 3) absence of pain or other disturbances, 4) satisfied parents. From this perspective, we think the results of our choices have justified our expectations.

Conclusions

All the attempts for the treatment of idiopathic clubfoot focus on either the distension of stiff soft tissue with manipulations, the correction of the deformity and the maintenance of the corrected foot position, or the surgical repair of deformities that do not respond to conservative treatment. The onset of treatment should be as early as possible. A complete understanding of the pathogenesis of the disease, close collaboration with parents, and correct application of the Ponseti's method, can make it useful in any case of severe idiopathic clubfoot, when we want to avoid relapses.

Conflict of interest:
The authors declared no conflicts of interest.

REFERENCES

1. Tachdjian MO. Disorders of the foot, In John Antony Herring's (ed): *Pediatric Orthopaedics*, 4th edition, Philadelphia, WB Saunders, 2008, p 1070.
2. Markeas N. Congenital club foot. Questions about its treatment. *Paediatriki* 2011; 74(2):87.
3. Bazopoulou-Kyrkanidou E. What causes the lameness of Hephaestus? *Paediatriki* 2008; 71: 283.
4. Kawashima T, Uhthoff HK. Development of the foot in prenatal life in relation to idiopathic club foot. *J Pediatr Orthop* 1990; 10:232.
5. Fukuhara K, Schollmeier G, Uhthoff HK. The pathogenesis of clubfoot. A histomorphometric and immunohistochemical study of fetuses. *J Bone Joint Surg Br* 1994; 76:450.
6. Loren GJ, Karpinski NC, Mubarak SJ. Clinical implications of clubfoot histopathology. *J Pediatr Orthop* 1998; 18:765.
7. Ippolito E, et al. Leg muscle atrophy in idiopathic congenital clubfoot: is it primitive or acquired? *J Child Orthop* 2009; 3(3): 171-178.
8. Irani RN, Sherman MS. The pathological anatomy of idiopathic club foot. *J Bone Joint Surg Am* 1963; 45:45.
9. Dobbs MB, Gordon JE, Schoenecker PL. Absent posterior tibial artery associated with idiopathic club foot. A report of two cases. *J Bone Joint Surg Am* 2004; 86:599.
10. Munajat I, et al. Deficient dorsalis pedis flow in severe idiopathic clubfeet: does Ponseti casting affect the outcome? *Foot* 2017; 32: 30-34.
11. Shaheen S, et al. Arterial tree anomalies in patients with clubfoot: an investigation carried out at Soba University Hospital. *J Pediatr Orthop B* 2018; 27(1): 67-72.
12. Dietz F. The genetics of idiopathic clubfoot. *Clin Orthop Relat Res* 2002; 401:39.
13. Basit S, et al. Genetics of clubfoot; recent progress and future perspectives. *Eur J Med Genet* 2017; (Epub ahead of print).
14. Stone P, et al. Idiopathic congenital talipes equinovarus; not always an isolated anomaly. A review of long-term outcomes. *J Matern Fetal Neonatal Med* 2017; 20: 1-6.
15. Kadia BM, et al. Spina bifida cystica and severe congenital bilateral talipes equinovarus in one twin of a monoamniotic pair: a case report. *BMC Res Notes* 2017; 10(1): 771.
16. Lind JN, et al. Maternal use of opioids during pregnancy and congenital malformations: A systematic review. *Pediatrics* 2017; 139(6).
17. Cahuzac JP, et al. Assessment of the position of the navicular by three dimensional magnetic resonance imaging in infant foot deformities. *J Pediatr Orthop B* 2002; 11:134.
18. Scarpa Antonio. *Commentarius de Penitiori Ossium Structura*, 1799.
19. Dobbs MB, Gurnett CA. Update on clubfoot: etiology and treatment. *Clin Orthop Relat Res* 2009; 467(5): 1146-1153.
20. Hernigou P, et al. History of clubfoot treatment, part I: From manipulation in antiquity to splint and plaster in Renaissance before tenotomy. *Int Orthop* 2017; 41(8): 1693-1704.
21. Hernigou P, et al. History of clubfoot treatment; part II: tenotomy in the nineteenth century. *Int Orthop* 2017; 41(10): 2205-2212.
22. Hernigou P. History of clubfoot treatment; part III (twentieth century): back to the future. *Int Orthop* 2017; 41(11): 2407-2414.
23. Pous JG, Dimeglio A. Neonatal surgery in clubfoot. *Orthop Clin North Am* 1978; 9:233.
24. Faldini C, et al. Prenatal diagnosis of clubfoot: a review of current available methodology. *Folia Med* 2017; 59(3): 247-253.
25. Ponseti IV. *Congenital Clubfoot: Fundamentals of Treatment*. Oxford, University Press, 1996.
26. Turco VJ. Surgical correction of the resistant clubfoot. One-stage posteromedial release with internal fixation: A preliminary report. *J Bone Joint Surg Am* 1971; 53:477.

27. Kite J. *The Clubfoot*. New York, Grune and Stratton, 1964.
28. Noonan KJ, Richards BS. Nonsurgical management of idiopathic clubfoot. *J Am Acad Orthop Surg* 2003; 11:392.
29. Sanghvi AV, Mittal VK. Conservative management of idiopathic clubfoot: Kite versus Ponseti method. *J Orthop Surg (Hong Kong)* 2009; 17(1): 67-71.
30. Bensahel H. The intimacy of clubfoot: The ways of functional treatment. *J Pediatr Orthop B* 1994; 3:155.
31. Ponseti IV. Common errors in the treatment of congenital clubfoot. *Int Orthop* 1997; 21:137.
32. Colburn M, Williams M. Evaluation of the treatment of idiopathic clubfoot by using the Ponseti method. *J Foot Ankle Surg* 2003; 42:259.
33. Steinman S, et al. A comparison of two nonoperative methods of idiopathic clubfoot correction: the Ponseti method and the French functional (physiotherapy) method. Surgical technique. *J Bone Joint Surg Am* 2009; 91 Suppl 2: 299-312.
34. Evans AM, Van Thanh D. A review of the Ponseti method and development of an infant clubfoot program in Vietnam. *J Am Podiatr Med Assoc* 2009; 99(4): 306-316.
35. Huntley JS. Optimizing the management of congenital talipes. *Practitioner* 2013; 257:15.
36. Pavone V, et al. Congenital idiopathic talipes equinovarus: an evaluation in infants treated by the Ponseti method. *Eur Rev Med Pharmacol Sci* 2013; 17(19):2675.
37. Duffy CM, et al. Surgical versus Ponseti approach for the management of CTEV: a comparative study. *J Pediatr Orthop* 2013; 33(3):326.
38. Salazar-Torres JJ, et al. Plantar pressures in children with congenital talipes equinovarus. A comparison between surgical management and the Ponseti technique. *Gait Posture* 2014; 39:321.
39. Zwick EB, et al. Comparison of Ponseti versus surgical treatment for idiopathic clubfoot: a short-term preliminary report. *Clin Orthop Relat Res* 2009; 467(10): 2668-2676.
40. Graf AN, et al. A long-term follow-up of young adults with idiopathic clubfoot: does foot morphology relate to pain? *J Pediatr Orthop* 2017; (Epub ahead of print).
41. Shah MQ, et al. Ponseti technique for management of congenital idiopathic clubfoot. *J Ayub Med Coll Abbottabad* 2017; 29(2): 246-249.
42. Hegazy M, et al. Results of treatment of idiopathic clubfoot in older infants using the Ponseti method: a preliminary report. *J Pediatr Orthop B* 2009; 18(2): 76-78.
43. Wang YZ, et al. Application of Ponseti method in patients older than 6 months with congenital talipes equinovarus. *Beijing Da Xue Xue Bao* 2009; 41(4): 452-455.
44. Janicki JA, et al. Treatment of neuromuscular and syndrome-associated (nonidiopathic) clubfeet using the Ponseti method. *J Pediatr Orthop* 2009; 29(4): 393-397.
45. Avilucea FR, et al. Effect of cultural factors on outcome of Ponseti treatment of clubfeet in rural America. *J Bone Joint Surg Am* 2009; 91(3): 530-540.
46. Ganesan B, et al. Ponseti method in the management of clubfoot under 2 years of age: A systematic review. *PLoS One* 2017; 12(6).
47. Dimeglio A, et al. Classification of clubfoot. *J Pediatr Orthop B* 1995; 4:129.
48. van Mulken, et al. Evaluation of the treatment of clubfeet with the Dimeglio score. J Pediatr Orthop 2001; 21:642.
49. Beaty JH. Congenital anomalies of lower extremity. In: Campbell's Operative Orthopaedics, S.T.Canale (editor), 10th edition, Mosby 2003.
50. Carroll NC. Preoperative clinical assessment of clubfoot. In Simons GW (ed): *The Clubfoot*. New York, Springer-Verlag, 1993, p. 77.
51. Goldner JL. Congenital talipes equinovarus-fifteen years of surgical treatment. *Curr Pract Orthop Surg* 1969; 4:61.
52. Simons GW: Complete subtalar release in clubfeet. Part II-comparison with less extensive procedures. *J Bone Joint Surg Am* 1985; 67:1056.
53. Abbas M, et al. Management of congenital talipes equinovarus by Ponseti technique: a clinical study. *J Foot Ankle Surg* 2008; 47(6): 541-545.
54. Farsetti P, et al. CT study on the effect of different treatment protocols for clubfoot pathology. *Clin Orthop Relat Res* 2009; 467(5): 1243-1249.
55. Halanski MA, et al. Resource utilization in clubfoot management. *Clin Orthop Relat Res* 2009; 467(5): 1171-1179.
56. Halanski MA, et al. Ponseti method compared with surgical treatment of clubfoot: a prospective comparison. *J Bone Joint Surg Am* 2010; 92(2): 270-278.
57. Zionts LE, et al. Has the rate of extensive surgery to treat idiopathic clubfoot declined in the United States? *J Bone Joint Surg Am* 2010; 92(4): 882-889.

58. He JP, Shao JF, Hao Y. Comparison of different conservative treatments for idiopathic clubfoot: Ponseti's versus non-Ponseti's methods. *J Int Med Res* 2017; 45(3): 1190-1199.
59. Svehlik M, et al. Ponseti method is superior to surgical treatment in clubfoot. Long-term, randomized, prospective trial. *Gait Posture* 2017; 58: 346-351.
60. Digge V, et al. Expanded age indication for Ponseti method for correction of congenital idiopathic talipes equinovarus: a systematic review. *J Foot Ankle Surg* 2018; 57(1): 155-158.
61. Mejabi JO, et al. A prospective cohort study on comparison of early outcome of classical Ponseti and modified Ponseti post tenotomy in clubfoot management. *Ann Med Surg* 2017; 24: 34-37.
62. Evans A, et al. "Fast cast" and "needle tenotomy" protocols with the Ponseti method to improve clubfoot management in Bangladesh. *J Foot Ankle Res* 2017; 10: 49.
63. Cummings RJ. The effectiveness of botulinum A toxin as an adjunct to the treatment of clubfeet by the Ponseti method: a randomized, double blind, placebo controlled study. *J Pediatr Orthop* 2009; 29(6): 564-569.
64. Kowalczyk B, Lejman T. Short-term experience with Ponseti casting and the Achilles tenotomy method for clubfeet treatment in arthrogryposis multiplex congenital. *J Child Orthop* 2008; 2(5): 365-371.
65. Janicki JA, et al. Comparison of surgeon and physiotherapist-directed Ponseti treatment of idiopathic clubfoot. *J Bone Joint Surg Am* 2009; 91(5): 1101-1108.
66. Flynn JM, et al. An independent assessment of two clubfoot-classification systems. *J Pediatr Orthop* 1998; 18: 323.
67. Laliotis N. Clinical evaluation of clubfoot. *Acta Orthop Trauma Hell* 2006; 57(3):162.
68. Anshuman R, et al. Correction of Pirani score and foot bimalleolar angle in the treatment of idiopathic congenital talipes equinovarus by Ponseti method in infants. *Acta Orthop Belg* 2016; 82(4): 861-865.
69. Fan H, et al. The correlation of Pirani and Dimeglio scoring systems for Ponseti management at different levels of deformity severity. *Sci Rep* 2017; 7(1).
70. Baghdadi T, et al. Ponseti casting method in idiopathic congenital clubfoot and its correlation with radiographic features abstract. *Arch Bone Jt Surg* 2017; 5(3): 168-173.
71. Beck JJ, et al. Alteration in hypoplasia of the hindfoot structures during early growth in clubfeet treated using Ponseti method. *J Child Orthop* 2017; 11(6): 434-439.
72. Chawla S, et al. Clinico-sonographical evaluation of idiopathic clubfoot and its correction by Ponseti method. A prospective study. *Foot* 2017; 33: 7-13.
73. Volz R, et al. Distal tibia/fibula fractures following clubfoot casting-report of four cases. *Iowa Orthop J* 2009; 29: 117-120.
74. Eamsobhana P, et al. Evertor muscle activity as a predictor for recurrence in idiopathic clubfoot. *Eur J Orthop Surg Traumatol* 2017; (Epub ahead of print).
75. Rios-Ruiz JG, et al. Sonographic evaluation of Achilles tendon healing in tenotomies for congenital clubfoot and Ponseti treatment. A 12-week follow-up. *Acta Orthop Mex* 2017; 31(3): 123-127.
76. Willis RB, et al. What proportion of patients need extensive surgery after failure of the Ponseti technique for clubfoot? *Clin Orthop Relat Res* 2009; 467(5): 1294-1297.
77. Goldstein R, et al. Age of recurrence in idiopathic clubfoot treated with the Ponseti method. *Bull Hosp Jt Dis* 2017; 75(3): 193-197.
78. Kessler JI. A new flexible brace used in the Ponseti treatment of talipes equinovarus. *J Pediatr Orthop B* 2008; 17(5): 247-250.
79. Khas KS, et al. Development of an orthosis for simultaneous three-dimensional correction of clubfoot deformity. *Clin Biomech (Bristol, Avon)* 2017; 51: 67-75.
80. Lara LCR, et al. Comparison between two types of abduction orthotics in treating congenital clubfoot. *Acta Ortop Bras* 2017; 25(4): 125-128.
81. Mahan ST, et al. Clubfoot relapse: does presentation differ based on age at initial relapse? *J Child Orthop* 2017; 11(5): 367-372.
82. Shirai Y, et al. Flatfoot in the contralateral foot in patients with unilateral idiopathic clubfoot treated using the foot abduction brace. *Medicine* 2017; 96:35.
83. Park SS, et al. Selective soft-tissue release for recurrent or residual deformity after conservative treatment of idiopathic clubfoot. *J Bone Joint Surg Br* 2009; 91(11): 1526-1530.

VOLUME 69 | ISSUE 2 | APRIL - JUNE 2018

84. Utrilla-Rodriguez E, et al. Treatment of clubfoot with the modified Copenhagen method: a 10-year follow-up. *Prosthet Orthot Int* 2017; (Epub ahead of print).
85. Liu YB, et al. Can repeated Ponseti management for relapsed clubfeet produce the outcome comparable with the case without relapse? A clinical study in term of gait analysis. *J Pediatr Orthop* 2017; (Epub ahead of print).
86. Wang XJ, et al. Ilizarov technique combined with limited adjunctive surgical procedures for correction of relapsed talipes equinovarus in children. *J Int Med Res* 2017; (Epub ahead of print).
87. Smythe T, et al. Assessment of success of the Ponseti method of clubfoot management in sub-Saharan Africa: a systematic review. *BMC Musculoskeletal Disord* 2017; 18(1): 453.
88. Smythe T, et al. What is a good result after clubfoot treatment? A Delphi-based consensus on success by regional clubfoot trainers from across Africa. Plos One 2017; 12(12).

READY - MADE CITATION

Markeas NG, Begkas D, Apergis C, Kondylis A, Theodoridis K. Ten-year clinical experience of Ponseti method in the treatment of idiopathic clubfoot. *Acta Orthop Trauma Hell* 2018; 69(2): 72-84.

ΠΕΡΙΛΗΨΗ

Η ραιβοϊπποποδία είναι η συχνότερη συγγενής παραμόρφωση του μυοσκελετικού συστήματος. Εκτός από την ιδιοπαθή μορφή της νόσου, η χαρακτηριστική παραμόρφωση έχει παρατηρηθεί επίσης στο πλαίσιο της κλινικής εκδήλωσης κάποιων συνδρόμων, νευρομυϊκής νόσου ή αρθρογρύπωσης. Η αιτιολογία της δεν έχει ακόμη πλήρως αποσαφηνιστεί ενώ η αντιμετώπισή της αποτελεί σημείο αντιλεγόμενο μεταξύ των ερευνητών. Σκοπός της μελέτης μας ήταν η ανασκόπηση των ασθενών με ιδιοπαθή ραιβοϊπποποδία που αντιμετωπίσαμε με τη μέθοδο Ponseti στη δεκαετία 2007-2016, δίνοντας ιδιαίτερη έμφαση στις ελάχιστες περιπτώσεις αστοχίας της μεθόδου, καθώς και στα δεδομένα της βιβλιογραφίας. Στην κλινική μας αντιμετωπίστηκαν 187 πόδια σε 123 βρέφη (89 άρρενα και 34 θήλεα), ηλικίας 22 ημερών (εύρος από 5 ημέρες έως 5 μήνες). Ακολουθήσαμε πιστά τις οδηγίες του Ponseti, τόσο κατά τη διενέργεια των ασκήσεων και τις εφαρμογές των ναρθήκων όσο και στη διάρκεια εφαρμογής του κηδεμόνα Denis Browne. Τενοντοτομή του Αχιλλείου απαιτήθηκε σε όλες τις ετερόπλευρες περιπτώσεις (59 πόδια) και σε 49 περιπτώσεις αμφοτερόπλευρης παραμόρφωσης (98 πόδια). Για την αξιολόγηση της βαρύτητας της νόσου και την εκτίμηση της βελτίωσης της παραμόρφωσης στη διάρκεια της θεραπείας, χρησιμοποιήσαμε το σύστημα αξιολόγησης του Dimeglio. Ο ακτινολογικός έλεγχος απαιτήθηκε σε ελάχιστες περιπτώσεις μετά τους 6 μήνες για την επιβεβαίωση του κλινικού αποτελέσματος. Σε ένα follow-up που κυμάνθηκε από 12 μήνες έως 7 έτη, είχαμε ικανοποιητικά αποτελέσματα. Η παραμόρφωση παρουσίαζε σαφή βελτίωση, τα πόδια εμφανίζονταν ανώδυνα με πλήρες εύρος κίνησης, δίχως κάλους, υπερκερατώσεις ή δυσκολίες στην υπόδηση. Οι ασθενείς δεν παραπονούνταν για ενοχλήσεις και συμμετείχαν απρόσκοπτα σε αθλητικές δραστηριότητες. Χρειάστηκε να επαναλάβουμε τη μέθοδο σε 7 περιπτώσεις, ενώ αντιμετωπίσαμε χειρουργικά 4 υποτροπές με περιορισμένη οπίσθια-εξωτερική απελευθέρωση μαλακών μορίων. Δύο κορίτσια εμφάνισαν ανισοσκελία της τάξεως των 2-3 εκατοστών. Το ένα αντιμετωπίστηκε με τροποποίηση των υποδημάτων ενώ το άλλο υποβλήθηκε σε προσωρινή επιφυσιόδεση του μακρύτερου σκέλους σε ηλικία 10 ετών. Πιστεύουμε ότι η πλήρης κατανόηση της παθογένειας της νόσου, η άψογη συνεργασία με τους γονείς και η πιστή εφαρμογή της μεθόδου Ponseti, την καθιστούν ωφέλιμη σε κάθε περίπτωση σοβαρής ιδιοπαθούς ραιβοϊπποποδίας, όταν επιθυμούμε να αποφύγουμε τις υποτροπές.

ΛΕΞΕΙΣ ΚΛΕΙΔΙΑ: ιδιοπαθής ραιβοϊπποποδία, μέθοδος Ponseti, εμπειρία

VOLUME 69 | ISSUE 1 | APRIL - JUNE 2018

Adult Acquired Flatfoot Deformity

Dr. Nikolaos Gougoulias, PhD, EFAS certif.

Consultant Orthopaedic Foot & Ankle Surgeon
Department of Orthopaedics & Trauma. Frimley Health NHS Foundation Trust,
Frimley Park Hospital, GU16 7UJ, Surrey, United Kingdom

ABSTRACT

Tibialis posterior tendon insufficiency can be the cause or the result of Adult Acquired Flatfoot Deformity. Other causes include midfoot arthritis, spring ligament rupture, accessory navicular detachment, acute rupture of tibialis posterior tendon or deep deltoid ligament, hallux valgus. In the early stages the hindfoot remains flexible, whilst later it can become rigid. Ankle valgus alignment and degeneration can also be present in some patients. Orthotics and physiotherapy constitute the first line treatment. Open or endoscopic tibialis posterior tendon debridement is indicated in the earlier stage, when no deformity is present. Calcaneal medialisation osteotomy and flexor digitorum tendon transfer are usually performed in flexible flatfeet, whilst additional medial (Cotton medial cuneiform osteotomy or midfoot arthrodesis) and/or lateral column (calcaneal lengthening osteotomy or calcaneocuboid arthrodesis) procedures, can be considered if the forefoot remains supinated after hindfoot neutralisation. Rigid feet can require corrective arthrodesis of the subtalar, talonavicular +/- calcaneocuboid joints. Gastrocnemius or Achilles tendon lengthening are often required to allow deformity correction. Ankle arthritis requiring usually tibiotalocalcaneal arthrodesis.

KEY WORDS: Flatfoot; planovalgus; pes planus; tibialis posterior

1. Introduction

The term "Adult Acquired Flatfoot Deformity" (AAFD) includes a variety of disorders that result in foot hyperpronation, valgus heel alignment and dropped medial arch of the foot. In the past the term "Tibialis Posterior Tendon Dysfunction" has been used, instead, to describe the same foot deformity [1-7]. However it has been realised that primary causes (**Table 1**), other than loss of strength and function of tibialis posterior (TP), may also be responsible for the development of pes planus deformity. Thus, TP tendinopathy and/or degeneration may be secondary to the development of planovalgus foot deformity, due to the increased stresses on the medial side of the foot during stance and gait. One has to also distinguish between deformities that first occur in adult life and those in childhood and adolescence, as the latter have different causes and a different management approach may be needed. Of course, children's flatfoot deformities will gradually result in worsening deformities in adults.

CORRESPONDING AUTHOR, GUARANTOR

Nikolaos Gougoulias MD, PhD, EFAS certif.
Consultant Orthopaedic Foot & Ankle Surgeon
Department of Orthopaedics & Trauma. Frimley Health NHS Foundation Trust,
Frimley Park Hospital, GU16 7UJ, Surrey, United Kingdom

VOLUME 69 | ISSUE 2 | APRIL - JUNE 2018

TABLE 1. *Causes of pes planus*

Tibialis posterior tendinopathy or rupture (80%)
Spring ligament degeneration or acute rupture
Midfoot joints arthritis
Tarsal coalition
Hallux Valgus
Rheumatoid arthritis
Neurological disorders

Fig. 1: *In this model a human hand stimulates the standing foot. When the arch is normal (a), the forces are distributed in a balanced fashion between heel, hallux and 5th toe. In the presence of a dropped medial arch (b), the medial aspect is overloaded (arrow) during stance.*

Fig. 2: *The action of the gastroc-soleus complex, through the Achilles tendon (black arrow), results in tightening of the plantar fascia (double ended white arrow), stabilisation of the midfoot and the medial arch, to allow the push-off phase of gait.*

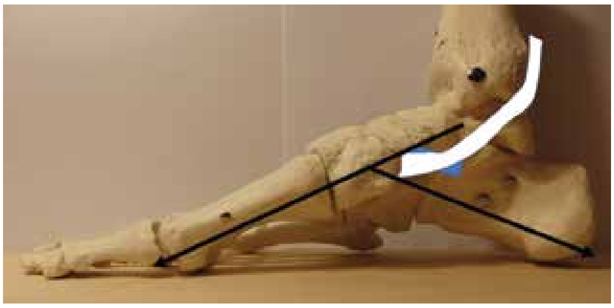


Fig. 3: *The foot medial arch is a result of the anatomic relation between the medial column and the calcaneus (black arrows), connected by the talus. The calcaneonavicular ("spring") ligament (blue), and tibialis posterior tendon (white) support the medial aspect of the talus.*

2. Clinical Anatomy, Pathomechanics and Aetiology

Some basic anatomic and biomechanical principles have to be taken into consideration, in order to understand the development of foot deformities. The foot functions as a tripod (**Fig. 1**), with the pressures being distributed between the heel, the first ray (1st metatarsal and hallux) and the 5th ray (5th metatarsal and 5th toe), during stance. The "windlass mechanism" is essential, to allow lifting the heel off the ground [1,2] (**Fig. 2**) .

The lateral foot column consisting of the calcaneus, cuboid and 4th, 5th metatarsals is relatively "flat", almost parallel to the ground, whilst the medial column (talus, naviculum, medial cuneiform, 1st metatarsal, hallucal phalanges), "descends" at an angle to the ground, in the standing foot. The middle rays (intermediate and lateral cuneiform bones and 2nd, 3rd metatarsals), are connected with strong ligaments, have little flexibility and connect the two columns distally. The normal medial arch of the foot is thus formed because of the inclination of the medial column, in relation to the calcaneum. The talus "sits" on the calcaneum (posterior and middle facets), whilst the talar head is not supported by osseous structures but is suspended on the so called "spring" (calcaneonavicular) ligament and is dynamically stabilised by the tibialis posterior tendon (**Fig. 3**). Thus, the medial foot arch consists of the 1st metatarsal, medial cuneiform, naviculum, talus and calcaneus. The foot arch resembles the "Roman arch" in terms of engineering

VOLUME 69 | ISSUE 2 | APRIL - JUNE 2018

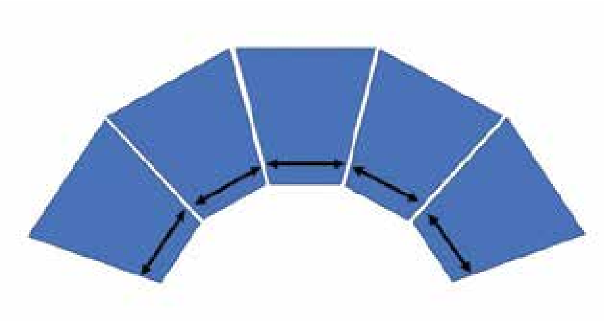


Fig. 4: *Roman arch: Its structural integrity and stability are based on the principle of balancing opposing forces.*

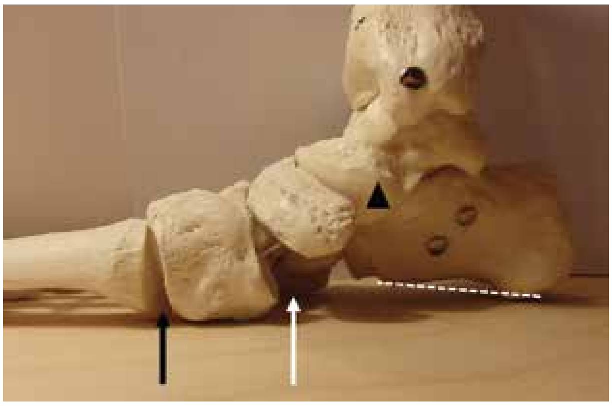


Fig. 5: *Arthritis at the first tarsometatarsal (black arrow), or medial naviculocuneiform (white arrow) joint, results in loss of integrity of the medial arch. The medial soft tissue structures (spring ligament, tibialis posterior tendon) cannot provide enough stability, the talar head shifts medially, and the talonavicular joint becomes uncovered (black triangle). The subtalar joint is also destabilised and calcaneal pitch angle drops (white dotted line). The foot appears flat.*

Fig. 6: *Degenerative changes at the first tarsometatarsal joint resulted in midfoot collapse and planovalgus deformity.*

Fig. 7: *The left heel (pes planus deformity) does not invert (remains valgus), during heel rise.*

(**Fig. 4**). In the foot, bones are connected with strong ligaments, and as mentioned earlier, the action of muscles, tendons and the tightening effect of the plantar fascia (windlass mechanism) [1,2].

Any reason that causes soft tissue laxity in the medial column and dysfunction of the windlass mechanism, can result in drop of the medial arch. Midfoot joints (tarsometatarsal, naviculocuneiform) arthritis results in loss of cartilage, and thus the ligamentous structures will loosen, as the reactive forces between the bones forming the medial column, cannot maintain stability (**Fig. 5**). This is seen on lateral foot weight bearing radiographs as "midfoot sag" (**Fig. 6**). Secondarily, due to biomechanical changes, the foot hyperpronates, cannot supinate, medial structures become overloaded during gait, TP tendon is "overused" and can become tendinopathic. In such case, midfoot arthritis (post-traumatic or idiopathic) is the primary condition and TP dysfunction the result [3-7].

The talus has no tendon attachments, thus the dynamic stabilisers of the hindfoot act beyond the Chopart's joint. This makes the talus prone to dis-

Fig. 8: Talonavicular joint becomes incongruent and the talar head uncovered medially (arrow), in advanced pes planus.

Fig. 9: Lateral pain can occur as a result of impingement between fibula and calcaneus in severe heel valgus alignment.

placement and loss of normal anatomic relationship, in cases of imbalance of the acting forces around the talus. This, for example, could be a result of TP weakness, because of acute rupture (rare), or tendinopathy (common). TP has a wide attachment of the naviculum and some fibers onto the medial cuneiform, and its action "locks" the talus and the talonavicular joint during the midstance phase of gait, produces initial plantar flexion and supination of the foot, allowing tightening of the plantar fascia (windlass mechanism), and the transverse tarsal joints, increases the strength of push-off, and finally the heel inverts at the subtalar joint and raise from the ground. Thus, TP dysfunction does not allow normal foot supination and heel inversion (**Fig. 7**). The heel remains in valgus, and peroneal tendons' action remains unopposed, thus resulting in increasing pronation, and a vicious cycle starts. After some time, the valgus heel alignment is worse, so the Achilles tendon attachment is transferred laterally. This results in abnormal mechanics of the gastroc-soleus complex, thus affecting the windlass mechanism [1,2].

Another reason for the foot to become flat is injury to the calcaneonavicular (spring) ligament. Loss of support of the talar head can result in overload of TP (dynamic stabiliser), and can subsequently lead to TP tendinopathy, pain, progressive planovalgus deformity, as mentioned earlier. Often, in long-standing AAFD, these two conditions (TP tendinopathy and spring ligament degeneration or rupture) co-exist, and it is difficult to say which is the primary initiator of the biomechanical events causing deformity [1-7].

A proportion of adult patients will present with worsening pes planus deformity that started in adolescent life, as a result of tarsal coalition. Some movement at the subtalar joint may be allowed, in fibrous coalitions, but generally the foot is chronically stiff. At some stage, due to the abnormal mechanics, the subtalar joint becomes arthritic and painful. TP tendinopathy may result as a secondary effect of the medial foot overload and the progressive deformity, that can be made worse by peroneal tendons overuse and secondary spasticity, that drives the foot into hyperpronation [8].

Hallux valgus (as the primary problem) may also result in progressive hindfoot valgus deformity as the function of the foot as a "tripod" is affected (**Fig. 1**). Medial shift of load during gait, will put TP and Achilles tendons in suboptimal position of action, and will initiate the sequence of pathomechanical events mentioned above.

In progressive planovalgus foot deformities, the heel remains in valgus, and a side effect is the functional shortening of the gastroc-soleus complex and the Achilles tendon.

Gradually, foot hyperpronation causes permanent changes in the alignment of bones (stiff deformity). The talus remains adducted and the talonavicular

VOLUME 69 | ISSUE 2 | APRIL - JUNE 2018

TABLE 2. *Johnson & Strom classification of Tibialis posterior tendon dysfunction*

	Stage I	Stage II	Stage III
Pain	Mild, medial	Moderate, medial	Severe, medial and lateral
Examination			
Swelling, tenderness	Mild, tenderness along TP	Moderate, tenderness along TP	Significant, tenderness along TP
Heel-rise test	Normal	Weakness	Weakness
“Too many toes” sign	Absent	Present	Present
Deformity	No	Yes, flexible	Yes, fixed
Pathologies	Normal TP, paratendinitis	Longitudinal tears of TP (tendinopathy)	Disrupted TP (severe tendinopathy)
Images	Normal	Deformity	Arthritis
Treatment	Conservative, tenosynovectomy	Flexor digitorum longus transfer	Triple arthrodesis

(TP: Tibialis posterior tendon)

joint becomes unstable and the talar head appears “uncovered” in the dorsoplantar weight bearing radiographic view (**Fig. 8**). The calcaneus cannot invert and remains in excessive valgus, and this can cause lateral (“subfibular”) impingement and pain (**Fig. 9**). Thus, talonavicular and subtalar joints become eccentrically loaded and degenerative changes can occur over the years. Lateral loading at the ankle joint may cause ankle arthritis, as well, in some patients. The forefoot is affected as well, and often hallux metatarsophalangeal joint arthritis and hallux rigidus may accompany pes planus deformities.

3. Clinical presentation and diagnosis

Patients usually present with pes planus deformity and medial +/- lateral hindfoot pain. Sometimes they complain of easy fatigue when walking. Often, they have symptoms associated with the forefoot (big toe pain at the hallux MTP joint, or metatarsalgia, related to forefoot overload). Others may also have heel pain at the plantar (plantar fascia origin) or posterior (Achilles tendon) aspect. Thorough clinical examination is essential. The patient should be examined standing, gait should be observed and also non-weight bearing to assess joints active and passive range of motion, and the tender spots or areas in the patient’s foot. Silfverskioldt test [9] is essential to assess calf muscle tightness (**Fig. 10**). The patient is asked to perform the “single heel rise” test (**Fig. 7**) to evaluate function of TP and flexibility of the subtalar joint.

Plain radiographs (ankle and foot weight bearing views) are needed (**Fig. 6, 8, 9**). More advanced imaging can be required. Ultrasound scans are helpful in examining TP tendon, whilst MR imaging to assess the condition of tendons, potential degeneration of joints, and to reveal/exclude the possibility of tarsal coalition in stiff subtalar joints. CT co-registered bone scan (SPECT-CT) can also be helpful in identifying the painful arthritic joints [10].

4. Classifications

Over the years several classification systems have been proposed. Johnson and Strom’s classification (1989), distinguished between three stages of TP tendon dysfunction, based on the location and intensity of pain, presence of deformity, and hindfoot flexibility [11,12], (**Table 2**).

Myerson was later credited with the modification of Johnson and Storm’s classification, describing a fourth stage, characterised by valgus alignment and lateral arthritis at the ankle joint [13]. Myerson proposed in 2007 [14] a comprehensive, detailed, but also quite

TABLE 3. *Myerson's AAFD classification*

Stage	Clinical findings	Imaging	Treatment
I			
A	TP tenderness, normal anatomy	Normal	Immobilisation, orthotics, NSAID's, tenosynovectomy
B	TP tenderness, normal anatomy	Normal	
C	Slight hindfoot valgus, normal anatomy	Slight hindfoot valgus	
II			
A1	Supple hindfoot valgus, flexible forefoot varus	Hindfoot valgus, Meary's line disrupted, Loss of calcaneal pitch	Orthosis, medial displacement calcaneal osteotomy, Achilles tendon or gastrocnemius lengthening and flexor digitorum longus transfer if deformity corrects only with ankle plantar flexion
A2	Supple hindfoot valgus, fixed forefoot varus		Orthosis, medial displacement calcaneal osteotomy, flexor digitorum longus transfer, Cotton osteotomy
B	A2 + forefoot abduction	Talonavicular joint uncovered, forefoot abduction	Orthosis, medial displacement calcaneal osteotomy, flexor digitorum longus transfer, lateral column lengthening
C	B + medial column instability, first ray dorsiflexion with hindfoot correction, sinus tarsi pain	First tarsometatarsal plantar gapping	Medial displacement calcaneal osteotomy, flexor digitorum longus transfer, Cotton osteotomy or medial column fusion
III			
A	Rigid hindfoot valgus, lateral hindfoot pain (sinus tarsi)	Subtalar joint space loss, angle of Gissane sclerosis, hindfoot valgus	Triple arthrodesis or custom bracing if not surgical candidate
B	A + forefoot abduction	A+ forefoot abduction	A+ lateral column lengthening
IV			
A	Supple ankle valgus	Ankle valgus	Surgery aiming at plantigrade foot+ deltoid reconstruction
B	Rigid ankle valgus		Tibiotalocalcaneal arthrodesis

complicated, classification system, that takes into consideration clinical appearance, radiographic findings, joints flexibility or rigidity and proposes treatment. Myerson's classification describes four stages and their subdivisions (**Table 3**).

Although this is a difficult classification to remember, studying the classification, one can become familiar with the different pathologies and deformities that are evident in AAFD. Furthermore, it takes into consideration the position of the forefoot and midfoot (tarsometatarsal joint 1) flexibility or rigidity.

Parsons et al. [15] suggested that stage II should be subdivided based on the severity and flexibility of forefoot supination when the hindfoot is brought

VOLUME 69 | ISSUE 2 | APRIL - JUNE 2018

TABLE 4. *Raikin's classification of AAFD*

Stage	Hindfoot	Midfoot	Ankle
Ia	Posterior tibial tendon tenosynovitis		
		Neutral	Neutral
Ib	Posterior tibial tendinitis without deformity	Mild flexible mid-foot supination	Mild valgus (<5°)
IIa	Flexible planovalgus (<40% talar uncoverage,<30° Meary's angle, incongruency angle 20°–45°)	Mid-foot supination without radiographic instability	Valgus with deltoid insufficiency
IIb	Flexible planovalgus (>40% talar uncoverage, >30° Meary angle, incongruency angle >45°)	Mid-foot supination with instability	Valgus with deltoid insufficiency and tibiotalar arthritis
IIIa	Flexible planovalgus (<40% talar uncoverage,<30° Meary's angle, incongruency angle 20°–45°)	Arthritic changes isolated to medial column	Valgus secondary to bone loss in lateral ankle compartment (deltoid normal)
IIIb	Flexible planovalgus (>40% talar uncoverage, >30° Meary angle, incongruency angle >45°)	Medial and middle-column mid-foot arthritic changes	Valgus secondary to bone loss in lateral ankle compartment and deltoid insufficiency

into neutral position. This is a clinically significant observation, as it can affect the choice of surgical procedures that are needed, to allow the foot to be plantigrade after hindfoot correction.

Raikin et al. [16] proposed another classification in 2012, taking into account the condition of the hindfoot, midfoot and ankle (**Table 4**).

Raikin's classification system is quite complex and maybe not so "user-friendly". One can note that stage I is characterised by neutral hindfoot, stages IIa and IIIa by moderate hindfoot deformity, whilst stages IIb and IIIb by severe hindfoot deformity. Arthritic changes in the midfoot are seen in stage III, whilst different degrees of ankle deformity and/or instability are seen in stages II and III.

Interestingly, none of the above classifications are validated. It seems that Johnson and Storm's classification system (from 1989) is the simplest and most widely used. Stage I is characterised by medial pain, TP tenosynovitis and no deformity. Nonoperative management is recommended. In stage II disease, we are dealing with flexible planovalgus deformities and significant weakness and degeneration/tears of TP. Calcaneal osteotomy for deformity correction and tendon transfer is indicated. Stage III includes stiff deformities with arthritic changes. One has to take into consideration stage IV (credited to Myerson) that describes ankle valgus (flexible or rigid), that usually required tibiotalocalcaneal arthrodesis. It is important to remember midfoot flexibility versus rigidity and Parson's remark about and forefoot alignment after hindfoot correction, as this may have implications on surgical treatment options [15].

5. Treatment

Irrespective of staging of AAFD, nonoperative management is indicated first for 6 months, before any decisions regarding corrective surgeries are met. An exclusion to this concept includes acute soft tissue injuries (e.g. tibialis posterior tendon or deep deltoid ligament ruptures) that result in rapid onset development of medial hindfoot instability and progressive deformity, especially in younger patients. In those patients early surgical management may be indicated.

5.1 Nonoperative treatment

Non-surgical management options include modifications of activities, weight loss, analgesics and anti-inflammatories, physiotherapy (to strengthen TP and functionally lengthen the calf muscles) and orthotics. Various types of orthotics have been described for AAFD management. These include insoles, ankle

VOLUME 69 | ISSUE 2 | APRIL - JUNE 2018

Fig. 10: *Gastrocnemius muscle origin is at the femoral condyles (proximal to the knee), so it bridges two joints (knee and ankle). In this case the ankle cannot be dorsiflexed beyond neutral* ***(a)****, thus calf muscles are tight. When the knee flexes* ***(b)****, the gastrocnemius muscle relaxes, and the ankle can be dorsiflexed more. This shows that gastrocnemius, only, is tight. If increased ankle dorsiflexion could not be achieved even with the knee flexed, then not only the gastrocnemius, but the gastroc-soleus / Achilles tendon, are tight. This has implications in management (which structure – gastrocnemius muscle, or Achilles tendon - to release).*

Fig. 11: *In flexible planovalgus foot deformity, the valgus heel* ***(a)*** *is neutralised in relation to the tibia (black lines), using a medial heel wedge insole* ***(b)****.*

Fig. 12: *MRI showing significant tendinopathy of tibialis posterior tendon (arrow).*

Fig. 13: *A lateral heel "L"-shaped incision* ***(a)*** *can be used to perform calcaneal osteotomy. The calcaneal tuberosity is shifted medially, as shown on intraoperative axial fluoroscopy view* ***(b)****.*

braces, and custom-made boots. In flexible deformities, corrective insoles (with medial heel corrective wedge and soft arch support) may be sufficient. As the foot is flexible, the corrective medial heel wedge may be able to restore neutral hindfoot alignment (**Fig. 11**). It is important that soft arch support is used, to avoid applying pressure to the painful medial arch of the foot if hard materials are used. It is important to emphasize that the heel wedge (and not the arch support), is the corrective part of the insole. In rigid deformities on the other hand, one should only use accommodative (not corrective) insoles, as the stiff joints will not allow neutralisation of hindfoot alignment. Ankle braces and rigid supportive shoes are more ap-

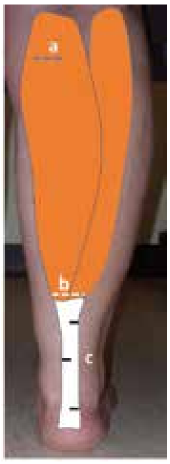


Fig. 14: *Gastrocnemius muscle contracture often requires release, at proximal medial gastrocnemius approx. 2.5 cm below the knee crease (a), or at the musculotendinous junction (b). If the gastroc-soleus complex is tight, Achilles tendon lengthening through a percutaneous "triple-cut" can be performed (c).*

Fig. 15: *Flexor digitorum longus (FDL) tendon is harvested in the midfoot region, after it is dissected carefully from Flexor hallucis longus (FHL).*

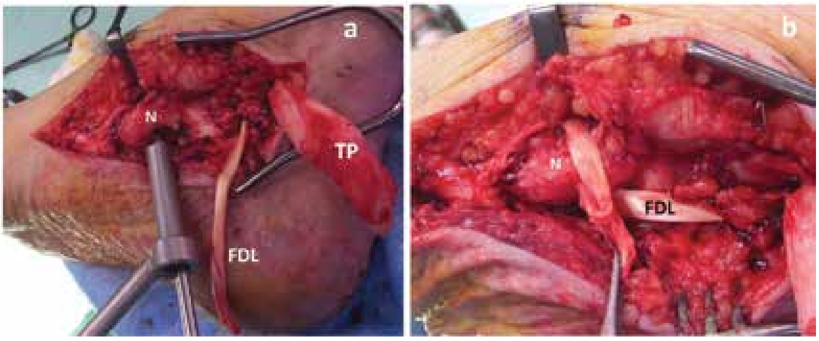


Fig. 16: (a)*: Tibialis posterior tendon (TP) is significantly thickened and tendinopathic. Flexor digitorum longus (FDL) has been retracted proximally, and a 5mm tunnel is drilled in the navicular bone (N).*
(b)*: FDL is passed through the osseous tunnel from plantar to dorsal, and once tightened with the foot in inversion, it is sutured to itself.*

Fig. 17: *A 22- year old patient has significant medial pain and worsening planovalgus deformity, as a result of a "foot sprain" that caused detachment of the accessory navicular bone (arrow; a,b). Calcaneal medial shift osteotomy was performed to correct hindfoot valgus, whilst the accessory naviculum was excised and tibialis posterior was re-attached using an anchor. Very good deformity correction was achieved (c,d).*

propriate for rigid AAFDs (e.g. in stages III and IV, according to Johnson and Storm) [1,3-7].

5.2 Surgical treatment

Surgery is required when nonoperative management has failed and the patients accepts the risk and the recovery time associated with surgery.

Acute TP or deltoid ligament ruptures, may require early surgical reconstruction, to avoid progressive deformity. Often the ruptured tissues may be degenerate and augmentation using autologous tendon grafts, allografts, or orthobiologics. If the injury is chronic (beyond six weeks) and a degree of hindfoot valgus is already present, calcaneal medialisation osteotomy is also needed.

In feet without significant deformity and confirmed

VOLUME 69 | ISSUE 2 | APRIL - JUNE 2018

Fig. 18: *A complex deformity (a,b) required corrective fusions of the first tarsometatarsal and the subtalar joints (c,d).*

Fig. 19: *Severe planovalgus deformity with arthritic changes (a,b,c), was corrected with a triple hindfoot arthrodesis (d,e,f) in a 67-year old patient.*

(e.g. on ultrasound or MRI) TP tenosynovitis, open or endoscopic tendon debridement is an option. When longitudinal tears or significant tendinopathy (**Fig. 12**) is found, open tendon repair is needed [1-7].

In the presence of planovalgus deformity, with flexible subtalar joint, and no arthritic changes, joint preserving procedures are indicated [3-7,17]. Calcaneal (medial shift) osteotomy is mandatory (**Fig. 13**). Not only does it neutralise the weight bearing axis, and reduces the load to the medial side of the foot, but it is also considered a tendon transfer, as it places the insertion of Achilles tendon and the origin of plantar fascia to a more favourable biomechanical position (from excessive valgus to more neutral), in order for the windlass mechanism to be more effective during stance and gait [3-7,17]. It can be performed through an "L-shaped" lateral incision, or an oblique incision at the level of the osteotomy (taking care to avoid damage to the sural nerve), or through stab incisions using special instruments and fluoroscopy (minimally invasive technique) [18].

One has to emphasize the necessity for calf muscle lengthening, in the majority of patients requiring hindfoot valgus correction. Given that the Achilles tendon insertion has "moved" laterally in those patients, the gastroc-soleus muscle complex (triceps surae) becomes functionally tight. The Silfverskioldt test [9], that should have been performed preoperatively, will show whether the surgeon has to only lengthen the gastrocnemius [performing a proximal medial gastrocnemius release [19], or lengthening at the musculotendinous junction/ Strayer's procedure [20], or the Achilles tendon (performing formal Z-leghtnening, or a triple cut "Hoke" procedure) [3] (**Fig. 14**).

TP tendon exploration reveals the degree of degeneration. In mild tendinopathy one can consider debridement and repair (tubularisation using absorbable suture). In more severe tendinopathy, tendon transfer is indicated. Flexor digitorum longus (FDL) is usually

VOLUME 69 | ISSUE 2 | APRIL - JUNE 2018

Fig. 20: In a patient with fixed deformity and arthritis (a,b), "double" hindfoot corrective arthrodesis (of talonavicular and subtalar joints) was performed, preserving the calcaneocuboid joint, which is distracted (c, arrow) whilst deformity was corrected (c,d).

Fig. 21: Lateral (sinus tarsi) (a) and medial (b) approaches for triple arthrodesis.

used (**Fig. 15 and 16**). It lies next to TP, and functions along the same direction as TP. The surgeon can also assess tendon elasticity by pulling the tendon from a proximal to distal direction, in order to decide whether TP will be sacrificed (when the tendon appears stiff, without significant elasticity), or augmented by FDL (performing proximal tenodesis of TP to FDL, whilst FDL is attached to the foot navicular bone). The author recommends that, in cases of significant TP tendinopathy and degeneration and pain in the region of the medial malleolus or more proximally, TP should be sacrificed to avoid continuous postoperative symptoms.

Some patients can develop AAFD as a result of an accessory navicular foot bone. Those patients develop medial pain and progressive planovalgus deformity usually as a result of an avulsion injury that de-stabilises the synchondrosis between the accessory navicular and the "main" navicular bone. Thus, tibialis posterior becomes weak, without inherent tendinopathy or rupture. In those patients, calcaneal osteotomy restores hindfoot alignment, whilst excision of accessory navicular and TP re-attachment (Kidner procedure) [21] restores strength and function of TP (**Fig. 17**).

Recently another method of surgical treatment of flexible pes planus has been proposed, using a sinus tarsi implant, the so called "arthroereisis screw ", to stop pronation at the subtalar joint [22-24]. At the same time a medial soft tissue procedure can be performed. The users of the technique advocate removal of the implant 6-12 months later, as in the meantime the foot should have become dynamically stable. The theoretical advantage of this technique – that was initially introduced to treat paediatric flatfoot deformities - is that a calcaneal osteotomy is not performed. However, there are no comparative studies to support superiority of one technique over the other.

Once the hindfoot has been reduced to more neutral, relative hindfoot – forefoot alignment has to be assessed. In feet of residual forefoot supination, one can consider a plantarflexion (dorsal closing wedge) medial cuneiform (so called "Cotton") osteotomy. Alternatively, arthrodesis of first tarsometatarsal and/or naviculocuneiform joints can be performed [1,3-7] (**Fig.18 and 19**).

Midfoot arthrodesis [25] (involving tarsometatarsal and /or naviculocuneiform joints), is generally indicated in patients with "midfoot sag" on the lateral weight bearing foot radiograph.

Some authors advocate lateral column lengthening in feet with severe planovalgus (e.g. >40% uncovered

VOLUME 69 | ISSUE 2 | APRIL - JUNE 2018

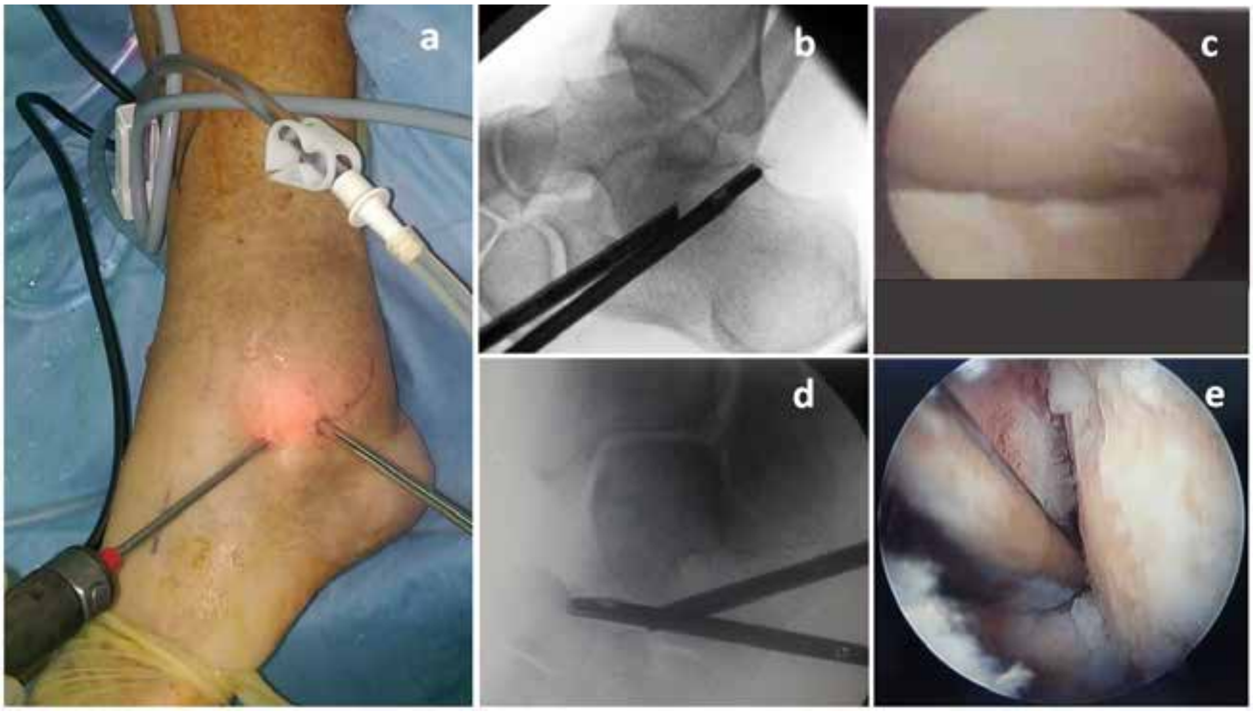


Fig. 22: *Two sinus tarsi endoscopic portals (a) allow preparation of subtalar (b,c), talonavicular (d,e), +/- calcaneocuboid arthrodesis.*

talar head at the talonavicular joint, on the weight-bearing view). This procedure requires a calcaneal or cuboid osteotomy, interposing a bone block taken from the medial cuneiform or allograft. Lateral column lengthening can be associated with stiffness and sometimes pain at the calcaneocuboid joint or the lateral midfoot joints (tarsometatarsal joints 4 and 5). Another option is to perform calcaneocuboid arthrodesis, interposing bone block. This carries a higher risk for non-union [1,3,4,7].

Rigid hindfoot valgus is usually accompanied by arthritic changes in some of the hindfoot joints (subtalar, talonavicular, calcaneocuboid) and then triple hindfoot arthrodesis is required (**Fig. 19**). It is debatable whether all three joints need to be fused, as studies have shown that "double arthrodesis" of subtalar and talonavicular joints, only, is sufficient [26] (**Fig. 20**). Given that corrective arthrodesis "opens" the lateral side (supinating the hindfoot), it could distract the calcaneocuboid joint, predisposing to non-union if arthrodesis is attempted. Triple arthrodesis requires usually two surgical approaches. A lateral "sinus tarsi" approach for subtalar and calcaneocuboid joints (along the line that connects the tip of the fibula and the 4th metatarsal base), and a medial approach along TP tendon (between the insertions of tibialis anterior and posterior tendons) (**Fig. 21**). The lateral approach is at risk of wound dehiscence (related to deformity correction that stretches the lateral approach skin edges), so many surgeons advocate one medial approach only to approach subtalar and talonavicular joints, avoiding fusion of the calcaneocuboid joint. If sufficiently trained, the surgeon can also prepare the joints arthroscopically using two sinus tarsi portals [27] (**Fig. 22**).

Ankle valgus alignment associated with AAFD, if flexible, may be treated effectively with deltoid ligament reconstruction and osteotomy (distal tibia/fibula or calcaneus). In the presence of significant degeneration and rigidity, tibiotalocalcaneal arthrodesis is the most reliable option. Depending on the patients' profile, and after discussion of the increased associated risk, one can also consider triple arthrodesis, soft tissue (deltoid ligament, TP) reconstruction and total ankle replacement (simultaneously or at a later stage) for some of these patients.

VOLUME 69 | ISSUE 2 | APRIL - JUNE 2018

6. Conclusion

It becomes apparent that preoperative planning is quite complicated. The aim of surgery is to produce a plantigrade foot, balancing forces between medial and lateral column, also taking into consideration and adjusting alignment between hindfoot and forefoot. The à la carte surgery is often required, depending on clinical and imaging findings. Thus, clinical assessment and preoperative evaluation and planning, as well as surgical management, requires the depth knowledge and experience in foot and pathology and surgery. A

Conflict of interest:

The authors declared no conflicts of interest.

REFERENCES

1. Miller M, Thompson S, Hart S. Foot and Ankle. In: Miller's Review of Orthopaedics. 6th Edition, Saunders 2014. pp 430-436; 478-480.
2. Dawe EJC, Davis J. Anatomy and Biomechanics of the foot and ankle. *Orthopaedics and Trauma* 2011;25:4:279-286.
3. Deland JT. Adult-acquired flatfoot deformity. *J Am Acad Orthop Surg* 2008;16:399-406.
4. Pinney SJ, Lin SS. Current concept review: acquired adult flatfoot deformity. *Foot Ankle Int* 2006;27:66-75.
5. Crevoisier X, Assal M, Stanekova K. Hallux valgus, ankle osteoarthrosis and adult acquired flatfoot deformity: a review of three common foot and ankle pathologies and their treatments. *EFORT Open Reviews* 2016; 1(3): 58-64.
6. Kohls-Gatzoulis G, Angel JC, Singh D, et al. Tibialis posterior tendon dysfunction. A common and treatable cause of adult acquired flatfoot. *BMJ* 2004;329:1328-1333.
7. Zaw H, Calder JDF. Operative management options for symptomatic adult acquired flatfoot deformity. *J Bone Joint Surg Br* online 2010. (accessed at http:// www.boneandjoint.org.uk/content/focus/operative-management-options-symptomatic-adult-aquired-flat-foot-deformity on 01/12/2017).
8. Gougoulias N, O'Flaherty M, Sakellariou A. Taking out the tarsal coalition was easy: but now the foot is even flatter. What now? *Foot Ankle Clin* 2014;19(3):555-68.
9. Silfverskiöld, N. Reduction of the uncrossed two-joints muscles of the leg to onejoint muscles in spastic conditions. *Acta Chir Scand* 1924;56:315–328
10. Pagenstert GI, Barg A, Leumann AG, et al. SPECT-CT imaging in degenerative joint disease of the foot and ankle. *J Bone Joint Surg Br* 2009;91(9):1191–6.
11. Johnson KA, Strom DE. Tibialis posterior tendon dysfunction. *Clin Orthop Relat Res* 1989; 239:196–206.
12. Abousayed MM, Tartaglione JP, Rosenbaum AJ, et al. Classifications in brief: Johnson and Storm classification of adult acquired flatfoot deformity. *Clin Orthop Relat Res* 2016;474:588-593.
13. Myerson MS. Adult acquired flatfoot deformity: treatment of dysfunction of the posterior tibial tendon. *Instr Course Lect* 1997;46:393–405.
14. Bluman EM, Title CI, Myerson MS. Posterior tibial tendon rupture: a refined classification system. *Foot Ankle Clin* 2007;12:233–249,
15. Parsons S, Naim S, Richards PJ, et al. Correction and prevention of deformity in type II tibialis posterior dysfunction. *Clin Orthop Relat Res* 2010;468:1025–1032.
16. Raikin SM, Winters BS, Daniel JN. The RAM classification: a novel, systematic approach to the adult-acquired flatfoot. *Foot Ankle Clin* 2012;17:169–181.
17. Arangio GA, Salathe EP. A biomechanical analysis of posterior tibial tendon dysfunction, medial displacement calcaneal osteotomy and flexor digitorum longus transfer in adult acquired flat foot. *Clin Biomech (Bristol, Avon)* 2009;24:385-390.
18. Sherman TI, Guyton GP. Minimal Incision/Minimally Invasive Medializing Displacement Calcaneal Osteotomy. *Foot Ankle Int* 2018;39(1):119-128.
19. Barouk P. Technique, indications, and results of proximal medial gastrocnemius lengthening. *Foot Ankle Clin* 2014;19(4):795-806.
20. Hoefnagels EM, Belkoff SM, Swierstra BA. Gastrocnemius recession: A cadaveric study of surgical safety and effectiveness. *Acta Orthop* 2017;88(4):411-415.
21. Lee KT, Kim KC, Park YU, et al. Midterm out-

come of modified Kidner procedure. *Foot Ankle Int* 2012;33(2):122-127.

22. Bernasconi A, Lintz F, Sadile F. The role of arthroereisis of the subtalar joint for flatfoot in children and adults. *EFORT Open Reviews* 2017;2(11):438-446.
23. Viladot Voegeli A, Fontecilla Cornejo N, Serrá Sandoval JA, et al. Results of subtalar arthroereisis for posterior tibial tendon dysfunction stage IIA1. Based on 35 patients. *Foot Ankle Surg* 2018;24(1):28-33.
24. Ceccarini P, Rinonapoli G, Gambaracci G, et al. The arthroereisis procedure in adult flexible flatfoot grade IIA due to insufficiency of posterior tibial tendon. *Foot Ankle Surg* 2017;pii: S1268-7731(17)30080-2. doi: 10.1016/j.fas.2017.04.003. [Epub ahead of print]
25. Gougoulias N, Lampridis V. Midfoot arthrodesis. *Foot Ankle Surg* 2016;22(1):17-25.
26. Stapleton JJ, Zgonis T. Hindfoot Arthrodesis for the Elective and Posttraumatic Foot Deformity. *Clin Podiatr Med Surg* 2017;34(3):339-346.
27. Jagodzinski NA, Parsons AM, Parsons SW. Arthroscopic triple and modified double hindfoot arthrodesis. *Foot Ankle Surg* 2015;21(2):97-102.

READY - MADE CITATION

Gougoulias N. Adult Acquired Flatfoot Deformity. *Acta Orthop Trauma Hell* 2018; 69(2): 85-98.

ΠΕΡΙΛΗΨΗ

Η ανεπάρκεια του οπισθίου κνημιάιου τένοντα μπορεί να είναι αιτία επίκτητης βλαισοπλατυποδίας των ενηλίκων. Άλλες αιτίες αποτελούν η αρθρίτιδα του μέσου ποδός, η ρήξη του πτερνοσκαφοειδούς συνδέσμου, η αποκόλληση του επικουρικού σκαφοειδούς οστού, η οξεία/τραυματική ρήξη του οπισθίου κνημιαίου τένοντα, ή του δελτοειδούς συνδέσμου, το βλαισό μεγάλο δάκτυλο. Στα αρχικά στάδια το πόδι παραμένει εύκαμπτο, ενώ αργότερα μπορεί να γίνει δύσκαμπτο. Κάποιοι ασθενείς μπορεί να παρουσιάσουν και βλαισότητα με εκφυσλιστικές αλλοιώσεις στην ποδοκνημική άρθρωση. Η αρχική αντιμετώπιση περιλαμβάνει την εφαρμογή ορθωτικών και φυσικοθεραπεία. Ανοικτός ή ενδοσκοπικός καθαρισμός του οπισθίου κνημιαίου έχει ένδειξη στο αρχικό στάδιο, αν δεν υπάρχει παραμόρφωση. Οστεοτομία ραιβοποίησης της πτέρνας και τενοντομεταφορά του καμπτήρα του μεγάλου δακτύλου ενδείκνυται σε εύκαμπτη βλαισοπλατυποδία. Αν το πρόσθιο πόδι παραμένει σε υπτιασμό μετά τη διόρθωση του οπισθίου ποδιού, μπορεί να απαιτηθεί συμπληρωματική επέμβαση, στην έσω κολώνα (οστεοτομία Cotton του έσω σφηνοειδούς ή αρθρόδεση μέσου ποδιού), ή την έξω κολώνα του ποδιού (οστεοτομία επιμήκυνσης πτέρνας ή αρθρόδεση πτερνοκυβοειδούς). Δύσκαμπτες παραμορφώσεις απαιτούν διορθωτικές αρθροδέσεις της υπαστραγαλικής, αστραγαλοσκαφοειδούς +/- πτερνοκυβοειδούς άρθρωσης. Επιμήκυνση Αχιλλείου τένοντα ή γαστροκνημίου μυός χρειάζεται συχνά συμπληρωματικά, ώστε να επιτραπεί η διόρθωση της παραμόρφωσης. Σε συνυπάρχουσα αρθρίτιδα της ποδοκνημικής, συνήθως απαιτείται κνημαστραγαλοπτερνική αρθρόδεση.

ΛΕΞΕΙΣ ΚΛΕΙΔΙΑ: πλατυποδία, βλαισοπλατυποδία, βλαισό πόδι, οπίσθιος κνημιαίος

VOLUME 69 | ISSUE 1 | APRIL - JUNE 2018

Peroneal tendoscopy. A pictorial essay

Panagiotis Symeonidis

St. Luke's Hospital, Thessaloniki, Greece

ABSTRACT

Tendoscopy of the peroneal tendons is gaining popularity in the diagnosis and treatment of retromalleolar pain as a result of tenosynovitis, impingement and tendon tear. Further indications for the technique include tendon subluxation or dislocation, a low riding muscle belly and symptomatic vinculae. The method combines the advantages of minimally invasive surgery such as minimal soft tissue trauma, quick recovery, small scars and better cosmesis with a short hospital stay and low cost. Similar to any advanced operative technique, a thorough knowledge of the local anatomy, adherence to detail, adequate training and familiarity with small joint arthroscopic skills are prerequisites for a safe and successful peroneal tendoscopy.

KEY WORDS: tendoscopy; peroneal tendon tear; tenosynovitis

Introduction

Peroneal tendoscopy is an evolving technique in the diagnosis and treatment of various pathologic and traumatic conditions which affect the peroneal tendons. Although the technique was first described in detail by Niek van Dijk in 1997, until recently the relevant publications have been sparse. [1, 2] A better understanding of the local anatomy based on high quality cadaveric and imaging studies, along with advances in the instrumentations have led a new generation of surgeons to increase their exposure with the technique and apply it in an ever growing spectrum of indications [3, 4, 5, 6]

Advantages of tendoscopy over open procedures include a relatively low intra- and postoperative morbidity (especially with regards to postoperative pain), minimal soft tissue trauma which results to a quicker recovery and the option to be performed as a day surgery with a low cost. Further advantages are a superior cosmetic result due to the small incisions and the option to convert the procedure to an open one without changing the operative setup and patient positioning. [7, 8]

The peroneals are amenable to tendoscopy as they run a subcutaneous course and share a common peroneal sheath to a considerable length. This common sheath usually extends from the retrofibular groove to the peroneal tubercle, although anatomical variations to this common course have been described. The sheath surrounds the two tendons as a tubular bursa in two layers, between which a working area is being created [9, 10, 11]. The length which can be scoped in a routine procedure is between a point 2.5 – 3 cm

CORRESPONDING AUTHOR, GUARANTOR

Panayiotis Symeonidis
Tel.: +30-231-0-258100
Email: p.symeonidis@gmail.com

proximal to the tip of the lateral malleolus up to the peroneal tubercle on the lateral aspect of the calcaneous. At this level the sheath splits creating separate chambers for each tendon. In specific cases, a short 2.7 mm scope may follow each tendon separately in its distal course.

The most common indication for performing a peroneal tendoscopy is a persisting posterolateral pain along the course of the tendons with inconclusive imaging studies. As it has been shown, the average positive predictive value of MRIs for peroneal pathology is below 0.8. [5] Relevant pathologic conditions diagnosed and treated with peroneal tendoscopy are a small tendon tear, tendinopathy, a low riding muscle belly (especially of the peroneus brevis), impingement of the tendons due to a hypertrophic or prominent tubercle, tendon subluxation or dislocation, an accessory peroneal muscle (peroneus quartus) and hypertrophic vinculae causing impingement or symptomatic snapping [1, 12, 10].

The surgeon needs to be aware of the fact that an isolated peroneal pathology is relatively infrequent [13]. Before proceeding to a peroneal tendoscopy, he needs to consider all aspects of foot alignment and function, which may coexist with, cause, or contribute to the pain over the peroneals. Typically these would include ankle instability, hindfoot varus or valgus malalignment, subtalar joint pathology and neuropathic pain. Therefore a tendoscopy may also be performed as part of a more complex procedure in order to address such coexisting issues [10].

A thorough knowledge of the local anatomy and advanced arthroscopic skills are prerequisites for performing a peroneal tendoscopy. Adequate exposure and training of the technique in cadaveric courses are essential in order to ensure a safe and successful procedure.

Operative technique

Preoperative planning

After careful clinical examination and review of the imaging studies, the surgeon is advised to ask the patient to actively evert the foot. In most cases the peroneals are palpable under the skin and can easily be marked at the bedside before induction of anaesthesia. This is also the best time to mark the point of maximum tenderness over the course of the tendons, which usually represent areas of localized pathology such as tears or / and synovitis. (**Fig. 1**)

Fig. 1: *Preoperative skin marking*

Instrumentation

A 2.7 mm 30 degrees arthroscope is recommended in order to combine adequate visualization with safe maneuvering in the limited working space. [14]Larger scopes may be used but the ability to slide between the tendons with a side to side motion is limited. A Wissinger rod helps in exchanging portals easily without causing more trauma to the tendon sheath. Small diameter 2.5 to 2.9 mm shavers are used for debridement [10]. A high pressure fluid irrigation is to be avoided. Rather, a gravity-feed or low-pressure, low-flow pump system is used in order to prevent insufflation of the subcutaneous tissue [15]. Finally, the procedure can be aided by a combination of small joint instruments such as mini probes and graspers.

Tendoscopy can be performed under either general or regional anaesthesia. Popliteal blocks in particular offer the advantage of a prolonged postoperative analgesia in an otherwise mobile patient. Local anaesthesia has also been proposed, as it enables a dynamic evaluation of the tendons with active excursion in real time. Although it is

VOLUME 69 | ISSUE 2 | APRIL - JUNE 2018

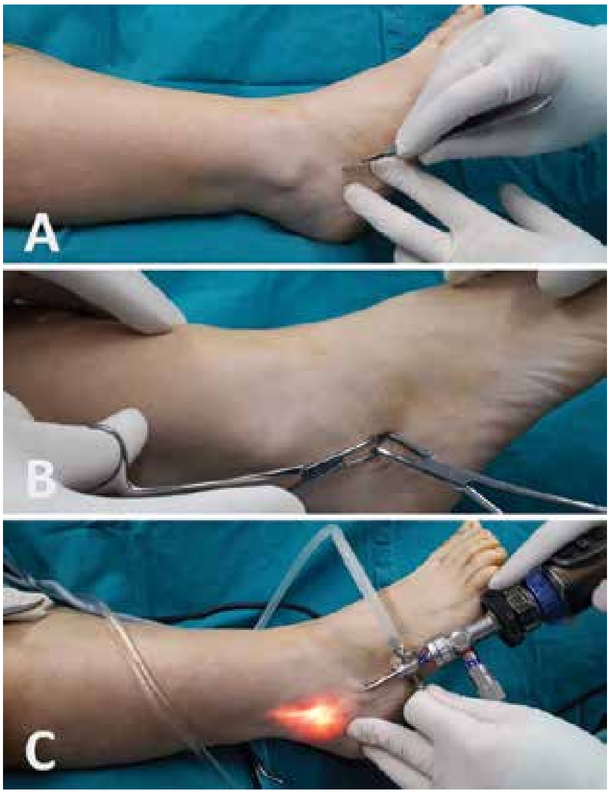


***Fig. 2:** A. Skin incision for the distal portal B. "Nick and spread" technique using two haemostats C. Introduction of the 2.7 mm arthroscope*

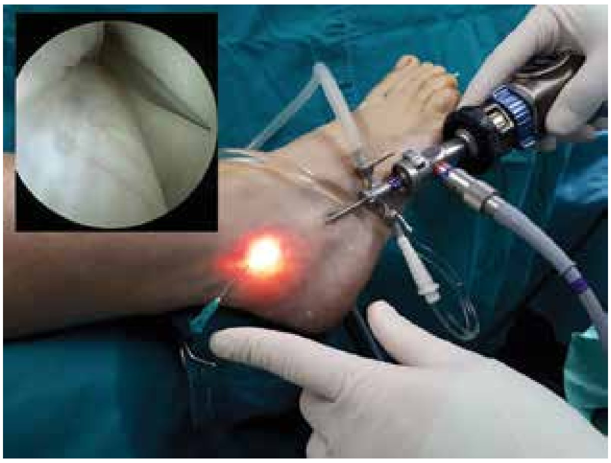


***Fig. 3:** Proximal portal placement through transillumination and introduction of needle, tendoscopic and open view.*

not essential, the use of a thigh or high ankle tourniquet is recommended [3].

Patient positioning

The patient can be placed in either a lateral or a semilateral decubitus position with the affected side facing up [14]. The latter gives the option to combine the procedure with an anterior ankle arthroscopy [10]. A third option is the supine position, especially if the tendoscopy is to be combined with a lateral ankle reconstruction procedure. [9]

Portal placement

Typically a two portal technique is used. The distal portal is made first. A number 11 blade is used for the skin incision which is located around 2 cm distal to the tip of the lateral malleolus and is 3 to 5 mm long and parallel to the tendons' direction. (**Fig. 2a**) By using a "nick and spread" technique, the surgeon develops the space between the subcutaneous tissue and the tendon sheath with one or two small haemostats [3]. (**Fig. 2b**) This allows for identification and protection of branches of the sural nerve crossing the surgical site and visualization of the external surface of the sheath. [14] The tendon sheath is raised with a curved Kelly clamp and a blunt trocar is introduced under direct vision. Another helpful step is to inject 20 cc of saline solution into the sheath before incising it. Arthroscopic view may be inhibited by either stenosing tenosynovitis, scar formation or by hypertrophied, frayed tendons. The saline enlarges the sheath throughout its length, facilitating the easier passage of the arthroscope. [10, 16]

A useful maneuver is to plantar flex the ankle while the arthroscope is being introduced. This causes the course of the peroneal tendons to straighten and with a gentle push the scope can be driven in a cephalad direction to the retromalleolar zone [10]. (**Fig. 2c**) An 18 gauge needle is introduced with transillumination approximately 2.5 cm proximal to the posterior edge of the lateral malleolus. (**Fig. 3**) The superior portal is then created with an 11 blade and a small probe is introduced. Care is being taken not to injure the tendons when creating portals with the knife [16].

The surgeon evaluates the integrity of the tendons, the presence and extent of tenosynovitis,

VOLUME 69 | ISSUE 2 | APRIL - JUNE 2018

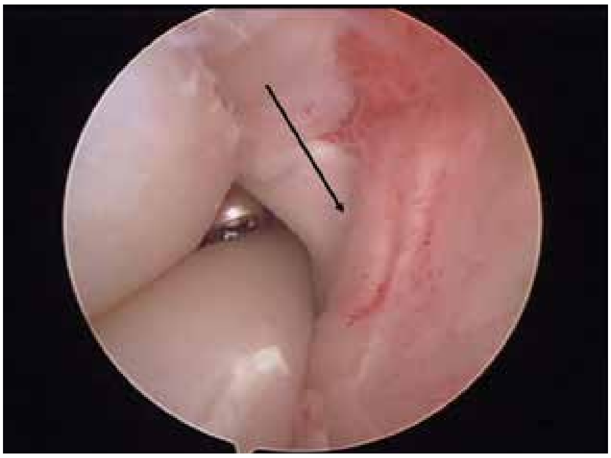


Fig. 4: *Introduction of shaver through the superior portal. Peroneal vinculum to the right (arrow).*

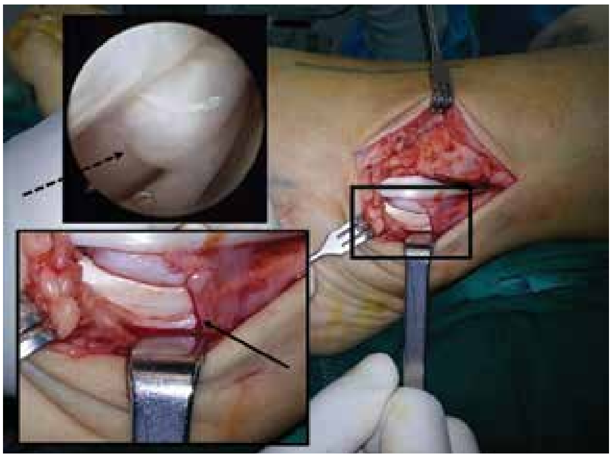


Fig. 5: *Dislocation of peroneous longus with partial tear of peroneous brevis (arrow). Arthroscopic and open view of the tendons on either side of the lateral malleolus (dotted arrow).*

Fig. 6: *Tendoscopic debridement of a partial peroneous brevis tendon tear.*

Fig. 7: *Small distal tear of peroneous longus, tendoscopic and open view.*

Fig. 8: *Extended tear of peroneous longus, tendoscopic view with the probe inside the tear (arrow) and operative approach.*

vinculae, and low lying muscle fibers, the anatomy of the retromalleolar groove and the presence of a peroneus quartus. (**Fig. 4, 5**) It is important for the surgeon to evaluate both surfaces of each tendon by switching portals and rotating the scope accordingly. Small longitudinal tears and tenosynovitis can be debrided arthroscopically with small 2.5 to 2.9 shavers. (**Fig. 6**) Larger tears are better treated with a mini open or extended approach, depending on the level and length of the rupture. (**Fig. 7, 8**)

Postoperative care

Portals are at best sutured with a single non

VOLUME 69 | ISSUE 2 | APRIL - JUNE 2018

absorbable suture. A drain is not required. The postoperative regimen is dictated by the specific pathology which was treated. In general, a tenosynovitis debridement requires a 2 weeks protected weight bearing status in a crepe bandage. In cases of tendon tear the ankle is immobilized in a type of ankle brace which offers control of inversion, such as a short boot or a cast. When the tendoscopy involves peroneal groove deepening or tendon repair procedures the immobilization non weight bearing status is prolonged to 4-6 weeks accordingly. In any case, ankle dorsi- and plantar flexion exercises are initiated as early as possible whereas inversion and eversion motions are usually restricted in the early postoperative period.

Complications

In general, peroneal tendoscopy is a safe procedure. [1, 6] Complications include injury to the sural nerve or the communicating branch of the sural nerve to the superficial peroneal nerve, extended perforation and trauma to the peroneal sheath which results increased swelling postoperatively, and an iatrogenic laceration of the peroneal tendons themselves.

Conflict of interest:
The authors declared no conflicts of interest.

REFERENCES

1. Bernasconi A, Sadile F, Smeraglia F, et al. Tendoscopy of Achilles, peroneal and tibialis posterior tendons: An evidence-based update. *Foot Ankle Surg*. 2017 Jun 21. pii: S1268-7731(17)30128-5. doi: 10.1016/j.fas.2017.06.004.
2. van Dijk CN, Scholten PE, Kort NP. Tendoscopy (tendon sheath endoscopy) for overuse tendon injuries. *Oper Tech Sports Med* 1997;5:170-178.
3. Christensen J, Lanier T, Tendoscopy of the Ankle. *Clin Podiatr* Med Surg 28 (2011) 561–570.
4. Hull M, Campbell JT, Jeng CL, et al. Measuring Visualized Tendon Length in Peroneal Tendoscopy. *Foot Ankle Int*. 2018 Apr 1:1071100718768506. doi: 10.1177/1071100718768506. [Epub ahead of print].
5. Kennedy JG, van Dijk PA, Murawski CD, et al. Functional outcomes after peroneal tendoscopy in the treatment of peroneal tendon disorders. *Knee Surg Sports Traumatol Arthrosc*. 2016 Apr;24(4):1148-54. doi: 10.1007/s00167-016-4012-6. Epub 2016 Feb 4.
6. Monteagudo M, Maceira E, Martinez de Albornoz P. Foot and ankle tendoscopies: current concepts review. *EFORT Open Rev*. 2017 Mar 13;1(12):440-447. doi: 10.1302/2058-5241.160028. eCollection 2016 Dec.
7. Cychosz C, Phisitkul P., Barg A., et al. Foot and Ankle Tendoscopy: Evidence-Based Recommendations. *Arthroscopy*. 2014 Jun;30(6):755-65.
8. Lui TH, Tse LF. Peroneal Tendoscopy. *Foot Ankle Clin N Am* 20 (2015) 15–25.
9. van Dijk CN, Kort N, Scholten PE. Tendoscopy of the Posterior Tibial Tendon. *Arthroscopy*. 1997 Dec;13(6):692-8.
10. Marmotti A, Cravino M, Germano M, et al. Peroneal tendoscopy. *Curr Rev Musculoskelet Med*. 2012 Jun;5(2):135-44.
11. Sobel M, Geppert MJ, Hannafin JA, et al. Microvascular anatomy of the peroneal tendons. *Foot Ankle*. 1992;13:469–72.
12. Guelfi M, Vega J, Malagelada F, et al. Tendoscopic Treatment of Peroneal Intrasheath Subluxation: A New Subgroup With Superior Peroneal Retinaculum Injury. *Foot Ankle Int*. 2018 May;39(5):542-550. doi: 10.1177/1071100718764674. Epub 2018 Mar 29.
13. Roster B, Michelier P, Giza E. Peroneal Tendon Disorders. *Clin Sports Med*. 2015 Oct;34(4):625-41.
14. Vega J, Golano P, Batista JP, et al. Tendoscopic Procedure Associated With Peroneal Tendons. *Techniques in Foot & Ankle Surgery* Vol 12, N 1, March 2013.
15. Sammarco VJ. Peroneal Tendoscopy Indications and Techniques. *Sports Med Arthrosc*. 2009 Jun;17(2):94-9.
16. Reilingh M, De Leeuw P, Van Sterkenburg M, et al. Tendoscopy of Posterior Tibial and Peroneal Tendons. *Tech Foot & Ankle* 2010;9: 43—47.

VOLUME 69 | ISSUE 2 | APRIL - JUNE 2018

READY - MADE CITATION

Symeonidis P. Peroneal tendoscopy. A pictorial essay. *Acta Orthop Trauma Hell* 2018; 69(2): 99-104.

ΠΕΡΙΛΗΨΗ

Η τενοντοσκόπηση των περονιαίων τενόντων εφαρμόζεται με αυξανόμενη συχνότητα σε ασθενείς με εμμένον άλγος που εντοπίζεται πίσω από το έξω σφυρό, ως αποτέλεσμα τενοντοελυτρίτιδας, συνδρόμου προστριβής και τενόντιας ρήξης. Περαιτέρω ενδείξεις της τεχνικής περιλαμβάνουν υπεξάρθρημα ή εξάρθρημα των τενόντων, χαμηλά προσφυόμενη μυική γαστέρα του βραχέως περονιαίου τένοντα και συμπτωματική υπερτροφία του αγγειακού χαλινού (vinculum) των περονιαίων. Η μέθοδος συνδυάζει τα πλεονεκτήματα των τεχνικών ελάχιστης παρεμβατικότητας, όπως περιορισμένη κάκωση μαλακών μορίων, ταχεία αποκατάσταση και καλύτερα αισθητικά αποτελέσματα με τον βραχύ χρόνο νοσηλείας και το χαμηλό κόστος. Όπως και σε κάθε απαιτητική χειρουργική τεχνική, προαπαιτούμενα για την ασφάλεια και την επιτυχία της τενοντοσκόπησης των περονιαίων αποτελούν η άριστη γνώση της ανατομίας της περιοχής, η προσήλωση του χειρουργού σε τεχνικές λεπτομέρειες της μεθόδου, και η εκπαίδευση και εξοικείωσή του με την αρθροσκόπηση των μικρών αρθρώσεων.

ΛΕΞΕΙΣ ΚΛΕΙΔΙΑ: Τενοντοσκόπηση, ρήξη περονιαίων τενόντων, τενοντοελυτρίτις περονιαίων

VOLUME 69 | ISSUE 1 | APRIL - JUNE 2018

MIS Hallux Valgus Surgery – History and Third Generation Surgical Technique

Dimitrios Hatziemmanuil
European Interbalkan Medical Center

ABSTRACT

Forefoot deformities, especially Hallux Valgus is the most common reason for visiting a Foot and Ankle surgeon, and one of the commonest orthopaedic conditions overall. More than 100 procedures have been described over the years for the surgical treatment of Hallux Valgus. The expansion of MIS procedures in medicine, and the patient demand for a functional and cosmetically appealing result has led to the development of percutaneous forefoot surgery techniques. The Third Generation Surgical Technique (Percutaneous Chevron and Akin) is presented in this paper.

KEY WORDS: Halux valgus; Minimally Invasive Surgery

Forefoot deformities, especially Hallux Valgus is the most common reason for visiting a Foot and Ankle surgeon, and one of the commonest orthopaedic conditions overall.

It has been reported that about 2-4% percent of the population has a Hallux Valgus deformity, and this might actually be underreported [1]. As a result, we have to estimate that about 400.000 Greeks will have this condition.

More than 100 procedures have been described over the years for the surgical treatment of Hallux Valgus, and 10-20 of them are still being used today. This shows the complexity of the deformity, and the inability of one technique to give high patient satisfaction results for all cases.

A 90% patient satisfaction rate is usually reported as a good result, but in practice we come across worse results, with commonest complications recurrence of deformity, malunion, stiffness, transfer metatarsalgia, inability to wear shoes, prolonged pain and swelling, and unacceptable cosmesis with multiple incisions.

We also have to take into account that for women, appearance (and incision length!) is much more important than we think and want to accept as Orthopaedic Surgeons (**Figs. 1,7**), and that feet is commonly projected as an important extension of their sex appeal. Long incisions are perceived by many of them as a significant cosmetic issue (**Fig. 18**).

CORRESPONDING AUTHOR, GUARANTOR

D. Hatziemmanuil
Mob. +30-6944467297
E-mail: dimifoot@otenet.gr

VOLUME 69 | ISSUE 2 | APRIL - JUNE 2018


Figs. 1, 7*: Preop and 1 month postop, mis incisions appearance*

Looking at women fashion shoes, commonly high healed and narrow, obviously uncomfortable for women (that many of them love to wear them daily), we have to consider that maybe pain perception might depend on the looks. And that is even more important if the pre op deformity was small. So where do evidence based medicine come in if this is the case? Should we continue to use functional scoring systems (i.e AOFAS) or should we focus on satisfaction based scoring?

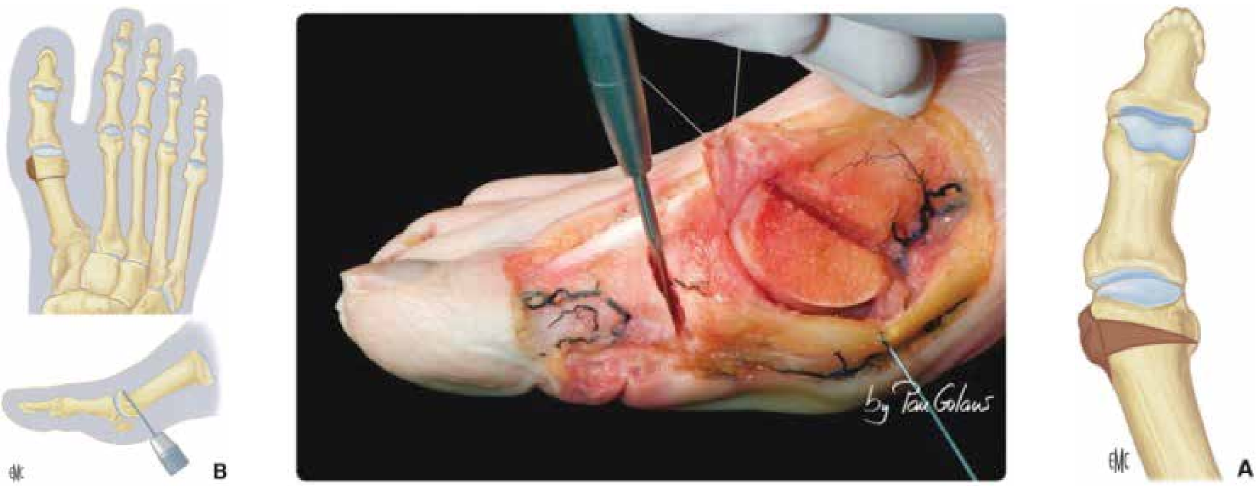
Following the trend of all surgical specialties and other fields of orthopaedics (arthroscopic surgery, mis joint replacement) minimally invasive surgery in the forefoot region gained popularity in the 90s in the United States where the first generation techniques (no fixation Reverdin-Isham) where being used by "podiatrists". An osteotomy that alters only the DMAA, without correction of the IM angle, no sesamoid reduction and no fixation, depending only on the "intact" soft-tissues. In Europe this trend was publicised by De Prado (**Figs. 19,20, 23**). It never gained popularity among Foot and Ankle surgeons because of the high rate of catastrophic complications (**Fig. 10**) and the ignorance of basic orthopaedic principles.

Fig. 18*: comparison standard incision/mis on the same patient, 1 month postop*

Giannini later published his Bosch-like SERI technique as a second generation technique, with the use of Kirschner wires as temporary fixation, as did Mafulli [2,3,4], but Myerson's team published dissapointing results [5]. (**Figs. 15, 21**)

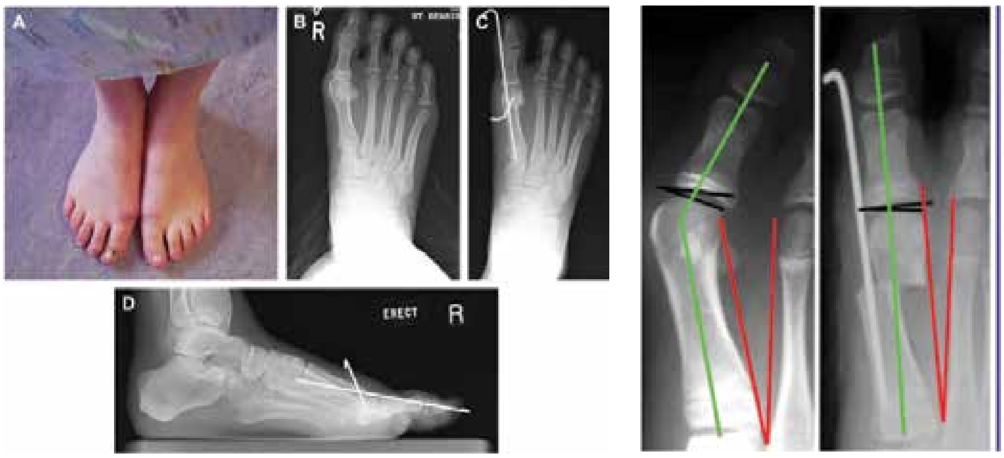
Redfern and Vernois in the 2010's developed the third generation technique, with the use of

VOLUME 69 | ISSUE 2 | APRIL - JUNE 2018



Figs. 19, 20, 23: *Reverdin Isham (first Generation-no fixation technique).*
From the book ¨Minimally Invasive Foot Surgery", De Prado, Elselvier

Fig. 10*: Catastrophic complication of no fixation technique*



Figs. 15, 21: *Second generation techniques, K-wire fixation*

Figs. 5-6: Beaver blade

Fig.16: High Torque Motor Unit for percutaneous forefoot surgery

Fig.8 Bone paste

cannulated screws as fixation devices of a Chevron-Akin osteotomy (MICA) [6].

This technique and its variations is becoming popular between many Foot and Ankle surgeons across Europe and Australia as it combines the minimally invasive approach and excellent cosmesis with the predictability of the basic principles of orthopaedic surgery. The percutaneous Chevron and Akin technique will be described in this paper.

It has shown similar radiological results with Scarf-Akin osteotomies, but with statistically significant less postoperative pain up to 6 weeks, less wound complications, and excellent range of motion [9, 14, 15, 16, 17].

Learning Curve

Formal foot and ankle training and specific cadaveric training is mandatory, preferably in more than one courses. We have to keep in mind that orthopaedic surgeons are not familiar with this type of instruments, making these procedures unexplored territory. [10,11]

A step by step approach is advised, starting with the simpler procedures first (Akin osteotomy, Distal Minimally-invasive Metatarsal Osteotomy-DMMO [6, 7, 14]) and only when the surgeon has become familiarised with the technique and equipment after a minimum of 20 cases can proceed to more complex procedures such as the percutaneous Chevron .

Patient Selection

Any patient with a mild to moderate deformity that could be treated by an open chevron+Akin or scarf osteotomy, can be a candidate for percutaneous correction. Severe deformities should be treated with basal osteotomies or fusions.

Typical indications/contraindications are similar to open procedures.

Equipment

Beaver blades (**Figs. 5-6**), are very useful in creating controlled small cuts, also giving excellent tactile feedback in periosteal elevation and in lateral release.

Small periosteal elevators are used to create a

VOLUME 69 | ISSUE 2 | APRIL - JUNE 2018

***Fig. 9, 13**: Comparison of level of osteotomy in open and percutaneous chevron*

***Fig.14:** avoidance of shortening be distal pointing of the pivot hole*

***Fig.11:** Dispacement of osteotomy*

working space under soft tissues, and bone levers to displace the osteotomy.

Motorised burrs are used to remove the "bunion" and create the osteotomy. The motors are high torque (**Fig. 16**) comparing with conventional motorised units (neurosurgery-arthroscopy) as a result lower motor speed are required. Less RPM results in less soft tissue and bone trauma, but also gives the burr the power not to get stuck in between osteotomies.

A C-arm is used throughout the procedure.

Surgical Technique

A 3-5 mm incision is created with the beaver blade, just proximal of the 1st metatarsal neck. A working space is created dorsally and plantarly, and also distally over the bunion, using the beaver and the periosteal elevator.

Using a 3-4 mm wedge burr a bunionectomy is performed, with a "peeling" wrist movement. The amount of bone removed is checked with the C-arm, and should not be more than it would be in an open procedure, always respecting the sesamoid groove. Bone paste is easily extracted through the portal. (**Fig. 8**)

Next, the apex of the osteotomy is created using a 3X20mm chevron burr. It should be extracapsular, located just proximal to the neck of the osteotomy (**Figs. 9, 13**). Plantar direction of the osteotomy is similar to the open procedure, ie. parallel to the plantar surface of the 1st metatarsal, or pointing at the head of the 5th metatarsal.

The burr will remove about 2-3 mm of metatarsal. In order to compensate for the resulting shortening the pivot hole can be made with an appropriate distal direction. [12,13] (**Fig. 14**)

The dorsal and the plantar part of the osteotomy is then completed, always respecting the vital structures that surround the metatarsal.

It is again noted that appropriate cadaveric training, foot and ankle experience and exposure to simpler percutaneous techniques (ie Akin osteotomy) is mandatory in order to avoid catastrophic complications.

Displacement is achieved by an intramedullary bone lever or a simple Kirchner wire (1.6-1.8mm) (**Fig. 11**). Dorsal/plantar angulation is checked with the C-arm.

The fixation is performed by two parallel cannulated compression screws, the most proximal

VOLUME 69 | ISSUE 2 | APRIL - JUNE 2018

Fig. 2: *proximal screw engages three cortices for extra stability, by exiting the proximal metatarsal through its lateral cortex.*

Fig. 22: *Taping*

Figs. 3, 4: *Percutaneous Akin Osteotomy*

Fig.12: *Percutaneous lateral release*

one entering the metatarsal just distal to the cuneiform-metatarsal joint. It is advised that this proximal screw engages three cortices for extra stability, by exiting the proximal metatarsal through its lateral cortex. (**Fig. 2**)

The second more distal screw enters the displaced head in a parallel fashion.

Stability of the displacement is checked.

The Akin osteotomy follows if indicated. Approximately at the 1/3 to mid shaft of the first phalanx a skin incision is performed, and the soft tissues dorsally and plantarly are elevated in order to create the required working space.

A 2-3 mm bone wedge is removed pointing parallel or slightly proximally, respecting the lateral cortex. The osteotomy is displaced and fixed with a cannulated screw. (**Figs. 3, 4**)

VOLUME 69 | ISSUE 2 | APRIL - JUNE 2018

A soft tissue lateral release might be frequently needed (**Fig. 12**). The adductor, suspensory ligament, lateral head of the flexor brevis can be released all or selectively through a lateral dorsal portal, appropriately placed. Again training and experience is needed in order to avoid damaging neuromuscular structures.

Taping (**Fig. 22**) is an important part of the procedure, and should not be neglected. Its not a surprise that every training course has a practical session on taping. Appropriate taping guarantees optimal soft tissue healing, avoidance of overcorrection, stiffness, and controls postoperative oedema.

A heel weightbearing shoe is used for 5-6 weeks postoperatively, and following that period comfortable sport shoes or well made sandals are used for 1-2 months. Sporting activities (running-jumping) are not allowed for a minimum of three months. Ⓐ

Conflict of interest:
The authors declared no conflicts of interest.

REFERENCES

1. Myerson MS: Hallux Valgus , *Foot and Ankle Disorders*, WB Saunders, 2000.
2. Minimally Invasive Surgery in Hallux Valgus and Digital Deformities Atilio Migues, MD; Gustavo Campaner, MD; Pablo Sotelano, MD; Marina Carrasco, MD; Gabriel Solari, MD, *Orthopedics* July 2007 - Volume 30, Issue 7.
3. Minimally Invasive Hallux Valgus Correction *Orthopaedic Clinics of North America*, Volume 40, Issue 4, October 2009, Pages 525–530. Francesco Oliva MD, PhD, Umile Giuseppe Longo MD, Nicola Maffuli MD, MS, PhD, FRCS (Orth).
4. The minimally invasive osteotomy “S.E.R.I.” (simple, effective, rapid, inexpensive) for correction of bunionette deformity. *Foot Ankle* Int. 2008 Mar;29(3):282-6. doi: 10.3113/FAI.2008.0282. Giannini S1, Faldini C, Vannini F, Digennaro V, Bevoni R, Luciani D.
5. Radiographic Results After Percutaneous Distal Metatarsal Osteotomy for Correction of Hallux Valgus Deformity Anish R. Kadakia, Jonathan P. Smerek and Mark S. Myerson *Foot Ankle Int* 2007 28: 355 DOI: 10.3113/FAI.2007.0355.
6. Percutaneous Surgery for Severe Hallux Valgus. *Foot Ankle Clin*. 2016 Sep;21(3):479-93. doi: 10.1016/j.fcl.2016.04.002. Vernois J1, Redfern DJ2.
7. Percutaneous Surgery for Metatarsalgia and the Lesser Toes. Foot Ankle Clin. 2016 Sep;21(3):527-50. doi: 10.1016/j.fcl.2016.04.003. Redfern DJ1, Vernois J2. *Foot Ankle Int.* 2016 Jan; 37(1):58-63. doi: 10.1177/1071100715598601. Epub 2015 Aug 27.
8. Outcome of Minimally Invasive Distal Metatarsal Metaphyseal Osteotomy (DMMO) for Lesser Toe Metatarsalgia. Haque S1, Kakwani R2, Chadwick C1, Davies MB1, Blundell CM1.
9. Two year outcomes of minimally invasive hallux valgus surgery. Foot Ankle Surg. 2017 Oct 13. pii: S1268-7731(17)31295-X. doi: 10.1016/j.fas.2017.09.007. Chan CX1, Gan JZ2, Chong HC2, Rikhraj Singh I2, Ng SYC2, Koo K2. Author information.
10. Minimally invasive forefoot surgery: a cadaveric study. Dhukaram V1, Chapman AP, Upadhyay PK. *Foot Ankle Int.* 2012 Dec;33(12):1139-44.DOI: 10.3113/FAI.2012.1139.
11. Minimally invasive Akin osteotomy and lateral release: Anatomical structures at risk-A cadaveric study. Yañez Arauz JM1, Del Vecchio JJ2, Codesido M1, Raimondi N1. Foot (Edinb). 2016 Jun;27:32-5. doi: 10.1016/j.foot.2016.03.003. Epub 2016 Mar 19.
12. A comparative study of bone shortening and bone loss with use of saw versus burr in hallux valgus surgery. *Foot Ankle Surg*. 2013 Mar;19(1):67. doi: 10.1016/j.fas.2012.11.006. Epub 2013 Jan 7. Redfern D. Comment on. A comparative study of bone shortening and bone loss with use of saw blades versus burr in hallux valgus surgery. [Foot Ankle Surg. 2012]
13. A comparative study of bone shortening and bone loss with use of saw blades versus burr in hallux valgus surgery. Shahid MS1, Lee P, Evans S, Thomas R. Foot Ankle Surg. 2012 Sep;18(3):195-7. doi: 10.1016/j.fas.2011.11.001. Epub 2011 Dec 15.

VOLUME 69 | ISSUE 2 | APRIL - JUNE 2018

14. Distal osteotomy of the lateral metatarsals: A series of 72 cases comparing the Weil osteotomy and the DMMO percutaneous osteotomy. J. Henry, J.-L. Besse, M.-H. Fessy, l'AFCP. *Orthopaedics & Traumatology: Surgery & Research*. Volume 97, Issue 6, Supplement, October 2011, Pages S57–S65.
15. Clinical and Radiological Outcomes Comparing Percutaneous Chevron-Akin Osteotomies vs Open Scarf-Akin Osteotomies for Hallux Valgus. Lai MC1, Rikhraj IS1, Woo YL1, Yeo W1, Ng YCS1, Koo K1. *Foot Ankle Int.* 2017 Dec 1:1071100717745282. doi: 10.1177/1071100717745282.
16. Hallux Valgus Correction Comparing Percutaneous Chevron/Akin (PECA) and Open Scarf/Akin Osteotomies. Lee M1, Walsh J2, Smith MM3, Ling J4, Wines A5, Lam P6. *Foot Ankle Int.* 2017 Aug;38(8):838-846. doi: 10.1177/1071100717704941. Epub 2017 May 5.
17. Treatment of moderate hallux valgus by percutaneous, extra-articular reverse-L Chevron (PERC) osteotomy. Lucas y Hernandez J1, Golanó P2, Roshan-Zamir S3, Darcel V4, Chauveaux D1, Laffenêtre O5. *Bone Joint J.* 2016 Mar;98-B(3):365-73. doi: 10.1302/0301-620X.98B3.35666.

READY - MADE CITATION

Hatziemmanuil D. MIS Hallux Valgus Surgery – History and Third Generation Surgical Technique. *Acta Orthop Trauma Hell* 2018; 69(2): 105-112.

ΠΕΡΙΛΗΨΗ

Οι παραμορφώσεις του προσθίου ποδός, και ειδικά ο Βλαισός Μέγας Δάκτυλος είναι η συχνότερη αιτία που οι ασθενείς επισκέπτονται εναν Ορθοπαιδικό Χειρουργό Ποδοκνημικής και Άκρου Ποδός. Περισσότερες απο 100 διαφορετικές τεχνικές έχουν περιγραφεί για την χειρουργική θεραπεία του Βλαισού. Η επέκταση των τεχνικών ελάχιστης παρεμβατικότητας (MIS) στην Ιατρική, αλλά και η απαίτηση των ασθενών για καλαίσθητο και λειτουργικό αποτέλεσμα οδήγησε στην ανάπτυξη των διαδερμικών τεχνικών στην χειρουργική του προσθίου ποδός. Σε αυτό το άρθρο παρουσιάζεται η τρίτη γενιά διαδερμικής διόρθωσης του Βλαισού: η Διαδερμική Chevron και Akin

ΛΕΞΕΙΣ ΚΛΕΙΔΙΑ: Βλαισός Μέγας Δάκτυλος, Τεχνικές Ελάχιστης Παρεμβατικότητας

VOLUME 69 | ISSUE 1 | APRIL - JUNE 2018

Combined Talar Body and Medial Malleolous Fracture: A Case Report

S. Papadakis, N. Schizas, P. Lepetsos G. Macheras
4th Orthopaedic Department, KAT Hospital, Athens,Greece

ABSTRACT

The combination of ipsilateral talar body and medial malleolus fracture is rare to occur. Such injuries are seen in multiply injured and polytraumatised patients. The high variability of talar fractures, their relatively low incidence together with the high percentage of concomitant injuries makes treatment of these injuries a challenge to the surgeon. Open reduction and adequate internal fixation followed by supervised aggressive physiotherapy gives good functional outcome as in this case.

KEY WORDS: Talar body fracture; Medial malleolus fracture

Introduction

Fractures of the talus account for the 0.3% of the total of fractures with an incidence of 3.2 per 100000 of population and are more common in males (82:18). Talar body fractures occur in only 7% to 38% of all talar fractures. [1] Sneppen et al. classified talar body fractures into five distinct groups: compression (talocrural joint), shearing (coronal or sagittal), posterior tubercle, lateral tubercle and crush fractures. [2] Sneppen et al. reported the early results for patients with fractures of the talar body, most of which had been treated non-operatively. High rates of malunion, osteonecrosis, and arthritis were noted. [2] There have been isolated reports of operative treatment. [3,4,5]

The clinical outcome after talar body fractures is determined by the severity of the injury and the quality of reduction and internal fixation. The timing of definite internal fixation does not appear to affect the final result. The incidence of avascular necrosis is almost certainly dictated by the fracture pattern and its disruption of the intrinsic blood supply to the talus. The revascularization process can be achieved by stable surgical reduction and internal fixation. On the other hand anatomic reduction provides low rates of arthritis. [6,7] Preoperative planning of definite internal fixation requires CT scanning. To obtain a complete intraoperative overview allowing for anatomical reconstruction of the articular surfaces and the axial deviation bilateral approaches are usually necessary. Internal fixation is achieved with screws or mini-plates.

Materials and Methods

A male 34 years old patient of free history and

CORRESPONDING AUTHOR, GUARANTOR
Nikitas Schizas
Tel.: +30-6932683598
E-mail: nikit.schizas@gmail.com

VOLUME 69 | ISSUE 2 | APRIL - JUNE 2018

Pre-Op Xray Post-Op Xray

1 Year Post –Op Xray

3 Months Post-Op Xray

2 Years Post-Op Xray

significantly increased body weight (140 kg) is brought to the E.R. due to a traffic accident. During the physical examination the patient complained of pain at his left ankle and right wrist while both sites appeared to be significantly swollen and bruised. Radiographic evaluation with plain x-rays set the diagnosis of perilunar dislocation of the right carpus and a combined shearing sagittal talar body and medial malleolous fracture of the left foot. Surgical treatment was decided in order to achieve anatomic reduction of the left ankle and the patient was operated the next day using open reduction and internal fixation of the talar body and medial malleolous.

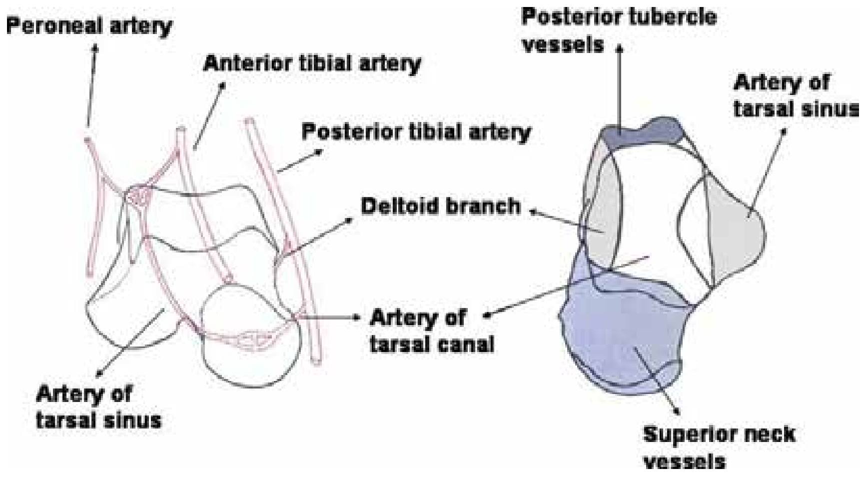
Results:

Physiotherapy was initiated three months post operation for a total duration of six months. Two years after surgery the patient presents with moderate symptoms like swelling of the ankle after extended periods of standing, or walking. The clinical and radiological findings are indicative of the presence of post traumatic arthritis concerning both the ankle and subtalar joints, although no signs of avascular necrosis of the talus were found.

Discussion

Complexity in the blood supply to the talus itself makes it one of the bones in the body vulnerable to avascular necrosis. Arthritis in the ankle and subtalar joints can occur in the absence of avascular necrosis of the talus and joint incongruity. The reported incidence of avascular necrosis for severely comminuted talar body fracture is around 50%-75%. Vallier et al. reporting on radi-

VOLUME 69 | ISSUE 2 | APRIL - JUNE 2018



ographic findings of 26 talar body fractures with a minimum follow-up of 1 year, noted a 38% incidence of AVN, 65% incidence of post-traumatic tibiotalar arthritis and 34% incidence of posttraumatic subtalar arthritis. [5] Lindvall et al., in 2004, reported on 26 isolated cases of talar neck and body fractures with a minimum follow-up of 48 months and found a 50% incidence of AVN and 100% incidence of post-traumatic arthritis. Timing of fixation did not seem to affect the outcome, union or prevalence of AVN in the later study. [8] The appearance of a radiolucent zone 4-8 weeks after the injury at the subcortical bone of the talar dome indicating bone remodelling "Hawkins' sign" is highly predictive of a revitalisation of the talar body after a fracture. Talar body fractures are produced by an axial compression of the talus between the tibial plafond and calcaneus. In cases with a combined medial malleolar fracture, an additional inversion torque seems to distribute this force to the medial structures, producing a vertical split of the talar body and the medial malleolar fracture. [9]

Conclusion

Fractures of the talar body are often severe injuries. Conservative treatment with closed reduction and casting leads to a very high rate of complications. Hence, open reduction and internal fixation in the appropriately selected patients can be performed safely with the prospect of reducing complications. An accurate reduction and stable fixation are also mandatory in order to provide the best biomechanical environment for revascularization of the lateral part of the talar body.

Conflict of interest:

The authors declared no conflicts of interest.

REFERENCES

1. Court-Brown CM, Caeser B: Epidemiology of acute fractures: A review. (2006) *Injury*, 37:691-697.
2. Sneppen O, Christensen SB, Krogsoe O, Lorentzen J: Fracture of the body Of the Talus.(1977) *Acta Orthop Scand*, 48:317-24.
3. Ebraheim NA, Patil V, Owens C, Kandimalla Y: Clinical outcome of fractures of the talar body. *International Orthopaedics* (SICOT). DOI 10.1007/s00264-007-0399-5.
4. Canale ST, Kelly FB Jr: Fractures of the neck of the talus. *J Bone Joint Surg Am* 1978, 60:143-156.
5. Vallier HA, Nork SE, Benirschke SK, Sangeorzan BJ: Surgical treatment of talar body fractures. *J Bone Joint Surg Am* 2003, 85:1716-1724.
6. Haliburton RA, Sullivan CR, Kelly PJ, Peterson LF: The extraosseous and intra-osseous blood supply of the talus. *J Bone Joint Surg Am* 1958, 40:1115-1120.

VOLUME 69 | ISSUE 2 | APRIL - JUNE 2018

7. Schulze W, Richter J, Russe O et al.: Surgical treatment of talus fractures: a retrospective study of 80 cases followed for 1-15 years. *Acta Orthop Scand* 2002, 73:344-351.
8. Lindvall E, Haidukewych G, Di Pasquale T, Herscovici D Jr, Sanders R: Open reduction and stable fixation of isolated, displaced talar neck and body fractures. *J Bone Joint Surg Am* 2004, 86:2229-2234.
9. Verettas DAJ, Ververidis A, Drosos GI, Chatzipapas CN, Kazakos KI: Talar body fracture combined with bimalleolar fracture. *Arch Orthop Trauma Surg* 2008, 128:731-734.

READY - MADE CITATION

Papadakis S, Schizas N, Lepetsos P, Macheras G. Combined Talar Body and Medial Malleolous Fracture: A Case Report. *Acta Orthop Trauma Hell* 2018; 69(2): 113-116.

ΠΕΡΙΛΗΨΗ

Η συνύπαρξη κατάγματος σώματος του αστραγάλου και του έσω σφυρού σύστοιχα δεν παρατηρείται συχνά. Τέτοιου τύπου κακώσεις απαντούν συχνότερα σε πολυτραυματίες. Η μεγάλη ποικιλία των τύπων κατάγματος του αστραγάλου, η σχετικά χαμηλή τους επίπτωση, μαζί με την υψηλή πιθανότητα συνύπαρξης συνοδών τραυματισμών, καθιστά τους παραπάνω τραυματισμούς πρόκληση για τους χειρουργούς. Η ανοικτή ανάταξη και εσωτερική οστεοσύνθεση σε συνδυασμό με επιθετική φυσιοθεραπευτική αγωγή μετεγχειρητικά οδηγεί σε καλά λειτουργικά αποτελέσματα, όπως στο παρακάτω περιστατικό.

ΛΕΞΕΙΣ ΚΛΕΙΔΙΑ: Κάταγμα, Σώμα του αστραγάλου, Έσω σφυρό, Εσωτερική οστεοσύνθεση

VOLUME 69 | ISSUE 1 | APRIL - JUNE 2018

Lateral Talar Process Fracture combined with Calcaneal Sustentaculum Tali Fracture. Case series and proposal of a possible mechanism of injury

A. Papachristou[2], K. Chitas[1], A. Fardellas[1], A. Konstantinidis[3], and A. Eleftheropoulos[1]*

[1]*Trauma and Orthopaedic Department, Naousa's General Hospital, Naousa, Greece*
[2]*Trauma and Orthopaedic Department, Kastoria's General Hospital, Kastoria, Greece*
[3]*Trauma and Orthopaedic Department, 424 Military Hospital, Thessaloniki, Greece*

ABSTRACT

Background: Lateral Talar Process fracture in association with a Sustentaculum Tali frac-ture is very uncommon and needs a high clinical suspicion, a thorough clinical examination, and a careful radiological evaluation. The mechanism of this combined injury is not clear yet, as only a few references in a small number of case series exist.

Methods: We present a series of four patients sustaining a Lateral Talar Process fracture, with a Sustentaculum Tali fracture in two of them. All patients were treated operatively, either with open reduction and internal fixation or with arthroscopic excision of the frag-ments in one case.

Results: All fractures treated with internal fixation were united, with very good to excellent results. The mean American Orthopaedic Foot and Ankle Society hindfoot score was 93.6 and the mean Foot and Ankle Disability Index score was 89.3. All patients returned to their previous activities with mild, occasional pain in two of them.

Conclusion: An association of a Lateral Talar Process and a Sustentaculum Tali fracture was observed in half of the patients. The mechanism of the combined injury may involve axial loading and subtalar subluxation. Once the articular surfaces commence shifting, if the force responsible for the instability continues to exert, the combined injury may occur. Therefore, if one fracture is encountered, CT scan images should be methodically scrutinised for the presence of the other fracture, especially, in patients with a mechanism of injury involving snowboarding or a fall from a height.

LEVEL OF CLINICAL EVIDENCE: IV

KEY WORDS: Talus; Os Calcis; Lateral Talar Process; Sustentaculum Tali; Fracture; Mechanism of injury

CORRESPONDING AUTHOR, GUARANTOR

Alexandros Eleftheropoulos MD
Foot & Ankle Orthopaedic Consultant, Head of Orthopaedic Department, Naousa's General Hospital Greece, Phone: +30 23320 59250, Fax: +30 23320 59254,
Email: el.alexandros@gmail.com

VOLUME 69 | ISSUE 2 | APRIL - JUNE 2018

Introduction

Isolated Lateral Talar Process (LTP) fractures are rare injuries, first reported by Marottoli in 1942, as quoted by Nicholas et al. [1]. Hawkins in 1965 [2], classified LTP fractures into three types. Type I consisted of a single large fragment. Type II was a comminuted fracture whereas; type III was a small or "chip" fracture of the tip of the LTP (**Fig. 1**). Another clas-sification widely used is the one proposed by McCrory and Bladin in 1996 [3], who subdi-vided LTP fractures in chip fractures (type I); large-fragment fractures (type II) and com-mi-nuted fractures (type III).

These injuries were generally associated with motor vehicle accidents, falls from a height or inversion injuries [2]. Starting from the 70s, as snowboarding became more popular, an in-creased incidence of LTP fracture was reported in athletes participating in this sport. Kirk-patrick et al. [4] prospectively documented that in 3213 snowboarding injuries 2.3% were LTP fractures. The unexpectedly high incidence of LTP fracture in snowboarders led to the term “snowboarder’s fracture” [1].

On physical examination, patients with an LTP fracture usually present with point tender-ness and marked swelling on the lateral aspect of the ankle, just distal to the lateral malleo-lus. On standard radiographic examination, the fracture is difficult to be appreciated and needs a certain amount of awareness to identify it [5]. As a conse-quence, this injury is fre-quently misdiagnosed as a lateral ankle sprain and overlooked at the initial presentation [3,6,7].

As far as the treatment is concerned, if the frac-ture is not displaced, it may be treated with im-mobilisation in a boot or cast for 6-8 weeks [2]. For comminuted or displaced fragments more than 2 mm, surgical reduction and fixation of the fracture should be attempted [8-10]. If this is not possible, early excision of the fragment(s) should be performed [7,10]. Late or missed treatment, nonunion, malunion, and overgrowth are associ-ated with poor outcome resulting in pain, func-tional impairment and subtalar osteoarthritis [7].

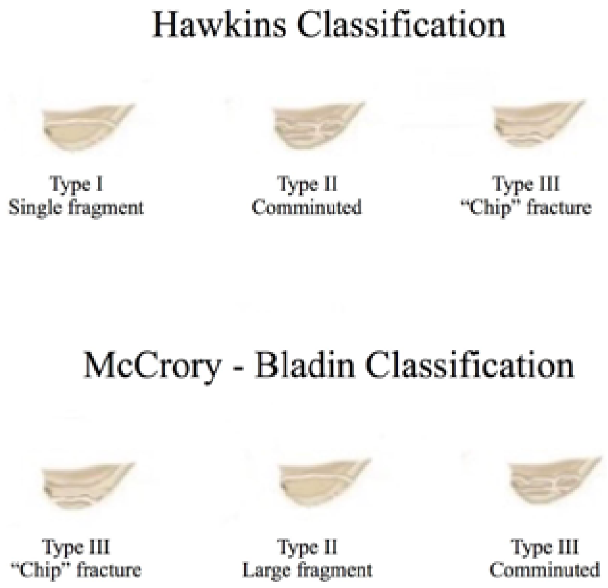


Fig. 1: *Hawkins and McCrory - Bladin Classification*

On the other hand, isolated Sustentaculum Tali (ST) fractures are also uncommon and often missed upon the first presentation [11-13]. Due to the strong trabecular structure and thick cortical bone, solitary fractures of the ST without addi-tional calcaneal injuries occur in less than 1% of all calcaneal fractures [14]. More frequently, they are associated with fractures of the medial fac-et of the subtalar joint, subtalar dislocations, or they are a part of more complex os calcis fractures [15,16].

Patients with ST fractures present with pain on the medial aspect of the hindfoot just distal and anterior to the medial malleolus. Pain might be elicited by passively moving the great toe. In standard radiographs, it is difficult to diagnose an ST fracture [17]. Therefore, a high index of suspicion is needed, especially, in patients with a history of subtalar dislocation, talar fracture, midfoot injuries or a fall from a height. The di-agnosis is finally made by per-forming a CT scan, which not only helps identify the Sustentaculum fracture but also identi-fies additional injuries. Surgery is indicated if the fragment is displaced more than 2 mm, if the medial facet is depressed, if there is a tendon entrapment or if the fracture also involves the posterior facet of the calcaneus [14].

***Fig. 2:** Pre-operative CT Scan images. A and B) Large displaced LTP fracture in two pa-tients. C) Associated ST fracture in the third patient. D) Severely comminuted LTP fracture in the fourth patient.*

Materials and methods

Between August 2010 and May 2017, at our institution, we assessed four patients (all male) who sustained an LTP fracture associated or not with an ST injury.

They all complained about pain and inability to bear weight on their injured leg. After doc-umentation of the patients' demographic data and side of the injured foot, the mechanism of injury was inquired. A patient reported a twisting injury to his foot while playing football and three patients reported an axial impact of their foot after a fall from a height. Physical examination revealed marked swelling as well as point tenderness around the region of the lateral malleolus. The posterior tibial and pedal pulses were present, and no neurologic defi-cit was recorded. Standard anteroposterior and lateral radiographs of the ankle were taken. Due to irregularities at the contour of the LTP in both views, a CT scan was requested (**Fig. 2**). On the CT scan, a large displaced McCrory-Bladin type II LTP fracture was noticed in two patients. In one of them, due to the presence of a talar beak sign, further MRI was per-formed to rule out a concomitant tarsal coalition. In the other two patients, CT scan helped diagnose a combined injury; a comminuted relatively undisplaced McCrory-Bladin type III LTP fracture in association with a large ST fracture in one patient and a severely commi-nuted McCrory-Bladin type III fracture with a concomitant small avulsion ST fracture in the other. Their foot was temporarily immobilised in a back slab and placed on a Brown's splint.

***Fig. 3:** LTP fragments after arthroscopic excision.*

All patients underwent surgery as soon as the swelling has subsided, no more than ten days. A tourniquet was placed at the thigh and was inflated at 300 mmHg. Prophylactic antibiotic was administered before the induction of anaesthesia.

Of the four patients, in three (75%), the LTP was accessed openly through a lateral hockey stick

VOLUME 69 | ISSUE 2 | APRIL - JUNE 2018

TABLE 1. *Patients' functional scores in relation to the fracture type at last follow up.*

	LTP Fracture Type[a]	ST Fracture	Treatment	AOFAS score	FADI score	Follow up (mo)
Patient I	Type II	No	ORIF	100	99	24
Patient II	Type II	No	ORIF	94	86.5	24
Patient III	Type III	Present	ORIF	87	82.4	60
Patient IV	Type III	Present	Arthroscopic Excision	N/A	N/A	5

[a]*McCrory-Bladin LTP fracture classification [3].*

incision, with the patients in a lateral decubitus position. The incision started two cm proximally and posteriorly to the tip of the lateral malleolus and ended two cm distally to the lateral malleolus. The calcaneofibular ligament was detached to visualise the fracture site.

In the patient with the associated tarsal coalition, the fragment was reduced and fixed with a staple, whereas, in the other patient with the McCrory-Bladin type II LTP fracture, the fragment was anatomically reduced and fixed with two cortical 1.5 mm mini-fragment screws. The calcaneofibular ligament was repaired, and the wound was irrigated and closed.

In the patient with the comminuted LTP and the combined ST fracture, the LTP fragments were minimally displaced and adequately big to consider internal fixation with three cortical 1.5 mm mini-fragment screws. The patient was then placed in a supine position, with the involved limb in a figure of four position. The concomitant ST fracture was accessed through a medial subtalar approach. After meticulous dissection and exposure of the frac-ture site, the fragment was stabilized with three cortical 1,5 mm mini-fragment screws. The deltoid ligament was reinforced, and the wound was closed in the standard fashion.

Finally, in the patient with the severely comminuted McCrory-Bladin type III fracture, the LTP fragments were excised arthroscopically. The patient was placed in a prone position. Superficial anatomic landmarks were drawn on the skin. Standard posterolateral and poster-omedial portals were created according to van Dijk [18] to access and remove an oversized os trigonum. An accessory lateral middle portal just distal and anterior to the tip of the fibu-la was created on the lateral foot as described by Frey et al. [19] to remove the fragments of the fractured LTP (**Fig. 3**). The concomitant ST avulsion fracture was considered too small to be removed or fixed.

Post-operatively, a back slab was applied, and prophylactic anticoagulation (Innohep 0.45 [Tinzaparin]; LEO Pharmaceutical Inc) was administrated for six weeks. At discharge, the back slab was exchanged with a full cast, and the patients were ordered not to bear weight. After three weeks, a walking boot was applied, and partial weight bearing of 15 to 20 kg was commenced. Patients began range-of-motion exercises avoiding inversion and eversion of the hindfoot. Progression to full weight bearing and muscle-strengthening exercises be-gun six weeks after surgery.

Results

At three months postoperatively, all patients were walking without crutches and reported no pain or disability and demonstrated full ankle and subtalar range of motion. The patient treated endoscopically, 5 months after surgery is very satisfied, full weight bearing without pain or instability and demonstrating full ankle and subtalar range of motion. For the re-maining patients, further follow-up was performed at 6 and 12 months after operation, and annually thereafter. The mean follow-up time was 28.25 months

VOLUME 69 | ISSUE 2 | APRIL - JUNE 2018

Fig. 4: *Postoperative X-Rays at last follow up. Mild osteoarthritic changes at the subtalar joint can be observed in all patients treated with ORIF.*

(range, 5-60 months). Pa-tients were assessed clinically (pain, ankle and subtalar ROM) and radiologically. Evaluation of functional result was done using the American Orthopaedic Foot and Ankle Society (AOFAS) hindfoot score and the Foot and Ankle Disability Index [20,21].

At the most recent follow-up, the mean AOFAS score was 93.6 (range, 87 to 100) and the mean FADI score was 89.3 (range, 82.4 to 99; **Table 1**). One patient (33.3%) was extremely satisfied with the functional result, as he returned to the same level of activities before inju-ry, without reporting pain, swelling, or subjective limitation of hindfoot motion. The other two patients (66.6%) were very satisfied with the outcome, as they returned to their usual activities with having mild, occasional pain only during their recreational activities.

At radiological evaluation, in all patients treated with ORIF, fractures appeared united with-in six months after the surgery. At their latest follow-up (2 and 5.5 years after the injury) mild osteoarthritic changes at the talofibular joint and the medial talocalcaneal facets were observed (**Fig. 4**).

Discussion

An LTP fracture associated with ST fracture is a very rare injury, and there are only isolated references in a small number of case series.

F. von Knoch et al. [22] in 2007 documented one combined injury in 23 snowboarders with an LTP fracture. Mark Gatha et al. [23] in a small case series of 4 patients that sustained an ST fracture recorded one combined LTP fracture. Dürr et al. [14] in 2013 reported that over the course of 15 years, they treated operatively 31 patients for ST fractures. Accompanying injury to the LTP was seen in 23% of these patients. In our series, half of the patients had a combined fracture, although, no safe conclusions can be drawn, as the number of our cases is limited. Larger scale studies or retrospective analysis of existing series might reveal an increased incidence of this combined entity.

As far as the mechanism of the combined injury is concerned, it seems to be multifactorial and not fully defined. In literature, there are few reports describing the mechanism of each fracture in isolation and only scarce references of their association.

Sustentaculum Tali is the most stable part of the calcaneus, and high energy is needed to be fractured. It is a general belief that isolated ST fractures occur from axial loading and inver-sion of the hindfoot. Wuelker and Zwipp [13] by stud-

VOLUME 69 | ISSUE 2 | APRIL - JUNE 2018

ying the fracture anatomy of the axial-ly loaded calcaneus observed that with the hindfoot in inversion (varus) an isolated fracture of the sustentaculum could be produced. Gatha et al. [23] also report that the mechanism of injury seems to involve high-energy axial and varus loading with some component of rota-tion.

More controversy exists regarding LTP fracture. Huson, as quoted by Hawkins [2], pointed out that with heel inversion the posterior articulation of the subtalar joint becomes incon-gruent as the head of the talus shifts laterally and the lateral process of the talus shifts up-wards. As a consequence, the subtalar joint opens and, if the inverted foot comes into dorsi-flexion, a compression force is exerted on the lateral process.

Based on this study, Hawkins [2] formulated the suggestion that lateral process fracture is caused by forced axial loading of the talus when the inverted foot is severely dorsiflexed. However, Boon et al. [24] in their anatomical study, demonstrated that also external rotation was a crucial factor in producing this type of fracture. The importance of dorsiflexion and external rotation of the foot was mentioned even by Dimon [25]. He suggested that the an-terolateral portion of the articular surface of the talus is sheared off by a compressive force exerted by the posterior facet of the calcaneus when the foot is dorsiflexed and slightly ex-ternally rotated.

On the other hand, Funk et al. [26] refuted the consolidated mechanism of the involved injury. By subjecting dynamic inversion or eversion to ten axially loaded and dorsiflexed cadaveric leg specimens, they suggested that eversion and not inversion was necessary to produce an LTP fracture. They also stated that Boon's results were non-contradictory to theirs. Eversion and external rotation of an axially loaded dorsiflexed ankle may be independent injury mechanisms for an LTP fracture. Indeed, they explain that during a fall, the ankle may be subjected to forces with continuously changing vectors, and thus, a torque about a combined eversion/dorsiflexion/external rotation axis is not improbable.

It can be concluded, therefore, that the mechanism of injury of the combined fractures re-sembles a subtalar joint subluxation. Heel inversion causes a lateral shift of the head of the talus and incongruity of the posterior subtalar joint articulation. If an inverted and axially loaded foot is forced into dorsiflexion, an LTP fracture may occur [2]. However, as Boon et al. [24] stated, dorsiflexion and inversion in an axially loaded foot is not enough to produce an LTP fracture, but when the talocalcaneal congruency is disrupted, an external rotation force is also needed.

On the other hand, Funk et al. [26] in their cadaveric study noted that by subjecting their specimens in axial loading, eversion and ankle dorsiflexion, all resulted LTP fractures were intra-articular (McCrory-Bladin type II, III). Since the aforementioned fractures involved the posterior talocalcaneal joint surface, they postulated that these fractures have been caused by localised compression of the subtalar joint surface beneath the lateral process. Interestingly, in their experiments, no extra-articular LTP avulsion fractures were produced (McCrory-Bladin type I), probably because another mechanism of injury is needed to cause this type of LTP injury.

Based on these observations, we suggest that the combined fracture of the LTP and ST may result from two possible mechanisms. In both mechanisms, the common key is the forced axial loading, as from a fall from a height, motor vehicle accident or sports injury. If then, the axially loaded foot is subjected to continuous inversion, an ST fracture happens first, resulting in spontaneous subtalar joint subluxation. By applying more inversion, dorsiflexion and external rotation, the LTP could also fail. Another possible mechanism may involve continuous eversion in an axially loaded dorsiflexed foot. This time, by exercising compres-sion on the subtalar articular surface, the LTP could fail first, leading again to subtalar joint instability. If the oblique axial force continues, then an ST fracture may occur.

Conclusion

Isolated ST and LTP fractures are not common entities in clinical practice and literature. Moreover, they are frequently missed and misdiagnosed as ankle sprains. Recently, the awareness of these two fractures has inclined due to the introduction of sports such as snowboarding and the increasing number of road traffic accidents. Nevertheless, their com-bination is still met only in isolated cases.

The mechanism of this combined injury is not clear yet. It seems that the common denomi-nator of these injuries is forced axial loading and subtalar subluxation. Indeed, in all cases, a loss of talocalcaneal congruity, leading to subtalar instability and subluxation, is needed to produce this entity. Once the articular surfaces start to move, if the force responsible for the instability continues to apply, the combined injury might occur. We propose that ST frac-tures in association with an LTP fracture may be caused by continuous inversion in an axi-ally loaded, inverted, dorsiflexed and externally rotated foot or from continuous eversion in an axially loaded and dorsiflexed foot. In reality, the combined injury might be more common than generally thought. In our series, half of the patients had a combined fracture, whereas, as mentioned before, Dürr et al. [14] in 2013, reported that almost a quarter of their patients had an association of an ST and an LTP fracture. Thus, when an LTP fracture is encountered, a meticulous study of the CT scan images is indispensable, in order not to miss a possible ST fracture and vice versa. A

ABBREVIATIONS

LTP: Lateral Talar Process
ST: Sustentaculum Tali

COMPLIANCE WITH ETHICAL STANDARDS

Conflict of Interest: *The authors declare that they have no conflict of interest.*
Funding: *There is no funding source.*
Ethical approval: *This article does not contain any studies with human participants or ani-mals performed by any of the authors.*
Informed consent: *Informed consent was obtained from all individual participants included in the study.*

ACKNOWLEDGEMENTS

Christos Kalitsis
Stavros Dimitriadis

REFERENCES

1. Nicholas R, Hadley J, Paul C, et al. "Snowboarder's fracture": fracture of the lateral process of the talus. *The Journal of the American Board of Family Practice* 1994; 7(2):130-133.
2. Hawkins LG. Fracture of the Lateral Process of the Talus: A Review Of Thirteen Cases. *The Journal of Bone & Joint Surgery* 1965; 47(6): 1170-1175.
3. McCrory P, Bladin C. Fractures of the Lateral Process of the Talus: A Clinical Review. "Snowboarder's Ankle". *Clinical Journal of Sport Medicine* 1996; 6(2): 124-128.
4. Kirkpatrick DP, Hunter RE, Janes PC, et al. The snowboarder's foot and ankle. *The American journal of sports medicine* 1998; 26(2): 271-277.
5. Melenevsky Y, Mackey RA, Abrahams RB, et al. Talar fractures and dislocations: a ra-diologist's guide to timely diagnosis and classification. *Radiographics* 2015; 35(3): 765-779.
6. Judd DB, Kim DH. Foot fractures frequently misdiagnosed as ankle sprains. *Am Fam Physician* 2002; 66(5): 785-794.
7. Parsons SJ. Relation between the occurrence of bony union and outcome for fractures of the lateral process of the talus: a case report and analysis of published reports. *Br J Sports Med* 2003; 37(3): 274-276.
8. [Mukherjee SK, Pringle RM, Baxter AD. Fracture of the lateral process of the talus. A report of thirteen cases. *The Journal of bone and joint surgery*. British volume 1974; 56(2): 263-273.
9. Valderrabano V, Perren T, Ryf C, et al. Snowboarder's Talus Fracture: Treatment Out-come of 20 Cases After 3.5 Years. *Am J Sports Med* 2005; 33(6): 871-880.
10. Perera A, Baker JF, Lui DF, et al. The management and outcome of lateral process fracture of the talus. *Foot and Ankle Surgery* 2010; 16(1): 15-20.

VOLUME 69 | ISSUE 2 | APRIL - JUNE 2018

11. Clare MP, Sanders RW. Open Reduction and Internal Fixation With Primary Subtalar Arthrodesis for Sanders Type IV Calcaneus Fractures. *Techniques in Foot & Ankle Surgery* 2004; 3(4): 250-257.
12. Rammelt S, Zwipp H. Calcaneus fractures: facts, controversies and recent develop-ments. *Injury* 2004; 35(5): 443-461.
13. Wuelker N, Zwipp H. Fracture anatomy of the calcaneus with axial loading. Cadaver experiments. *Foot and Ankle Surgery* 1996; 2(3): 155-162.
14. Dürr C, Zwipp H, Rammelt S. Fractures of the sustentaculum tali. *Oper Orthop Trau-matol* 2013; 25(6): 569-578.
15. Della Rocca GJ, Nork SE, Barei DP, et al. Fractures of the Sustentaculum Tali: Injury Characteristics and Surgical Technique for Reduction. *Foot & Ankle International* 2009; 30(11): 1037-1041.
16. Zwipp H, Rammelt S, Barthel S. Calcaneal fractures—open reduction and internal fixation (ORIF). *Injury* 2004; 35(2): 46-54.
17. Bonvin F, Montet X, Copercini M, et al. Imaging of fractures of the lateral process of the talus, a frequently missed diagnosis. *European Journal of Radiology* 2003; 47(1): 64-70.
18. van Dijk CN, Scholten PE, Krips R. A 2-portal endoscopic approach for diagnosis and treatment of posterior ankle pathology. *Arthroscopy: The Journal of Arthroscopic and Re-lated Surgery* 2000; 16(8): 871-876.
19. Frey C, Gasser S, Feder K. Arthroscopy of the Subtalar Joint. *Foot & Ankle International* 1994; 15(8): 424-428.
20. Kitaoka HB, Alexander IJ, Adelaar RS, et al. Clinical Rating Systems for the Ankle-Hindfoot, Midfoot, Hallux, and Lesser Toes. *Foot & Ankle International* 1994; 15(7):349-353.
21. Martin RL, Burdett RG, Irrgang JJ. Development of the foot and ankle disability index (FADI). *J Orthop Sports Phys Ther* 1999; 29(1): A33.
22. [von Knoch F, Reckord U, von Knoch M, et al. Fracture of the lateral process of the ta-lus in snowboarders. The Journal of bone and joint surgery. *British volume* 2007; 89(6):772-777.
23. Gatha M, Pedersen B, Buckley R. Fractures of the Sustentaculum Tali of the Calcane-us: A Case Report. *Foot & Ankle International* 2008; 29(2): 237-240.
24. Boon AJ, Smith J, Zobitz ME, et al. Snowboarder's talus fracture. Mechanism of injury. *The American journal of sports medicine* 2001; 29(3): 333-338.
25. J. H. Dimon III. Isolated Displaced Fracture of the Posterior Facet of the Talus. *The Journal of Bone & Joint Surgery* 1961;43(2): 275-281.
26. Funk JR, Srinivasan SCM, Crandall JR. Snowboarder's talus fractures experimentally produced by eversion and dorsiflexion. *The American journal of sports medicine* 2003; 31(6): 921-928.

VOLUME 69 | ISSUE 2 | APRIL - JUNE 2018

READY - MADE CITATION

Chitas K, Fardellas A, Konstantinidis A, Eleftheropoulos A. Lateral Talar Process Fracture combined with Calcaneal Sustentaculum Tali Fracture. Case series and proposal of a possible mechanism of injury. *Acta Orthop Trauma Hell* 2018; 69(2): 117-125.

ΠΕΡΙΛΗΨΗ

ΣΚΟΠΟΣ: Τα μεμονωμένα κατάγματα της έξω απόφυσης του αστραγάλου και του υπερείσματος του αστραγάλου όχι μόνο είναι σπάνιες κακώσεις αλλά συχνά παραβλέπονται λόγω παρόμοιου μηχανισμού κάκωσης και όμοιας κλινικής εικόνας με τα διαστρέμματα της ποδοκνημικής. Ο συνδυασμός των δύο καταγμάτων είναι ακόμη περισσότερο ασυνήθης και χρειάζεται μεγάλη υποψία για την διάγνωσή του.
Σκοπός της παρουσίασης είναι να επισημάνουμε την παρουσία της κάκωσης αυτής και παραθέτοντας την υπάρχουσα βιβλιογραφία να προτείνουμε έναν πιθανό μηχανισμό κάκωσης για τον συνδυασμό των δύο καταγμάτων.
ΥΛΙΚΟ ΚΑΙ ΜΕΘΟΔΟΣ: Παρουσιάζουμε μια σειρά τεσσάρων ασθενών με κάταγμα του έξω φύματος του αστραγάλου και συνοδό κάταγμα του υπερείσματος του αστραγάλου σε δύο από αυτούς. Όλοι οι ασθενείς υποβλήθηκαν σε χειρουργική αποκατάσταση είτε με ανοικτή ανάταξη και εσωτερική οστεοσύνθεση ή με αρθροσκοπική αφαίρεση των τεμαχίων του έξω φύματος του αστραγάλου σε μία περίπτωση.
ΑΠΟΤΕΛΕΣΜΑΤΑ: Όλα τα κατάγματα που υποβλήθηκαν σε ανοικτή ανάταξη και εσωτερική οστεοσύνθεση πορώθηκαν με πολύ καλά έως εξαιρετικά αποτελέσματα. Όλοι οι ασθενείς επέστρεψαν στις προηγούμενες δραστηριότητές τους με ήπιο, περιστασιακό πόνο
σε δύο από αυτούς. Η αρθροσκοπική αντιμετώπιση, που εφαρμόστηκε στον τέταρτο ασθενή, επέτρεψε την άριστη επισκόπηση του έξω φύματος του αστραγάλου και την αφαίρεση των οστικών τεμαχίων με την όσο δυνατόν λιγότερη παρέμβαση στα μαλακά μόρια.
ΣΥΜΠΕΡΑΣΜΑ: Μετά από ανασκόπηση της βιβλιογραφίας καταλήξαμε στο συμπέρασμα ότι η συνδυασμένη κάκωση απαιτεί ένα μηχανισμό υψηλής ενέργειας με αξονική φόρτιση του ποδιού. Η παρουσία συντριπτικού ή μεγάλου τεμαχίου στην έξω απόφυση του αστραγάλου προϋποθέτει την εξάσκηση δύναμης βλαισότητας με την ποδοκνημική σε ραχιαία κάμψη. Η παρουσία αντίθετα ενός μικρού τεμαχίου στην παρυφή της έξω απόφυσης του αστραγάλου συναντάται μετά από εξάσκηση ραιβότητας, έξω στροφής με ραχιαία κάμψη της ποδοκνημικής. Κοινός παρονομαστής στο μηχανισμό κάκωσης των δύο καταγμάτων είναι η αξονική φόρτιση με υπεξάρθρημα της υπασταγαλικής άρθρωσης. Αν η δύναμη που ευθύνεται για την αστάθεια συνεχίσει να ασκείται μπορεί να προκύψει ο συνδυασμένος τραυματισμός. Επομένως, αν στον απεικονιστικό έλεγχο παρατηρηθεί ένα από τα κατάγματα, θα πρέπει να αναζητείται η ύπαρξη και του άλλου κατάγματος, ειδικά σε ασθενείς που παρουσιάζονται μετά από πτώση από ύψος ή κατά την ενασχόληση με «χιονοσανίδα».

ΛΕΞΕΙΣ ΚΛΕΙΔΙΑ: Αστράγαλος, Πτέρνα, Έξω φύμα αστραγάλου, Υπέρεισμα αστραγάλου, Κάταγμα, Μηχανισμός κάκωσης