SATURDAY, JUNE 23, 2012

7:00 – 7:40 am

Symposium #4:
2nd MTP Instability

Moderator:

Michael J. Coughlin, MD
Boise, Idaho

7:00 am

Clinical Perspective: Anatomy and Treatment Options
Charles L. Saltzman, MD
Salt Lake City, Utah

Summary
A better understanding of the relative contributions of individual anatomic structures to the overall biomechanics of the metatarsophalangeal joint (MTPJ) may aid clinicians in matching the best repair technique to any given pathology. To that end a cadaveric and computer model investigation was undertaken to explore the biomechanical suitability of different treatment options for different pathologies.

Great toe hypermobility, hallux valgus and/or an elongated second metatarsal all have the potential to alter second ray MTPJ biomechanics. Resulting degenerative changes in the collateral ligaments, joint capsule and plantar plate often lead to chronic instability. Outcome data indicate the potential for improvements in current surgical repair options. The specific aim of this study was to evaluate the biomechanical performance of a novel MTPJ repair technique relative to the current standards of surgical care, namely flexor tendon transfer (FDL) and Weil osteotomy (WO) with direct plantar plate repair. The objective of the new surgery is to restore the native MTPJ biomechanics through direct soft tissue repair and anatomic reconstruction techniques that do not require an osteotomy.

CT and MRI data were used to construct a computer model of the second MTPJ. Mechanical properties for each tissue were assigned based upon literature values and cadaveric data was used to validate the model’s behavior. Simulations were performed to characterize multiple biomechanical metrics for the intact, injured and repaired conditions. The injured conditions consisted of an isolated plantar plate (PP) tear, a PP tear with lateral collateral ligament tears and a PP tear with bilateral collateral ligament tears.

The computer model demonstrated the ability of the new technique to restore the injured joint’s biomechanics back to the intact condition while elucidating some of the deficiencies present in current techniques. The FDL repair demonstrated stiffness in dorsiflexion and the iatrogenic sacrifice of the collateral ligaments may be the cause of dorsal laxity seen in the WO repair.
Plantar plate repair without osteotomy in conjunction with anatomic reconstruction of the collateral ligaments holds significant promise for improved MTPJ biomechanical performance. Additional clinical study work is needed to assess ultimate the impact of these findings on patient outcomes.
"Second metatarsophalangeal joint instability has been a frustrating diagnosis to make and treat for the last two decades. All methods, heretofore, have centered around indirect treatment of the deformity including: partial proximal phalangectomy, Flexor tendon transfers, soft tissue and bony arthroplasty, phalangeal osteotomies, and even metatarsal osteotomy. More recently, information about the type and magnitude of plantar plate pathology has led to a grading of the severity of the lesions; staging of clinical examination has led to more definitive diagnoses. This coupled with improved MRI imaging has enabled a preoperative plan to be developed. This coupled with small surgical instruments that allow access to the plantar plate from a dorsal approach (via a Weil osteotomy) has allowed direct repair of torn plantar plates. Early results are encouraging, and in this symposium the anatomy of plantar plate pathology will be discussed as well as methods of direct repair and preliminary surgical results of this new and exciting technique. "
Symposium #4: 2nd MTP Instability, Saturday, June 23, 2012
7:20 am

My Technique
Caio Nery, MD
Sao Paulo, Brazil

Surgical Technique
We always start with an arthroscopic evaluation of the involved lesser MTP joint using regional block anesthesia. We used the medial and lateral portals placed over the MTP articular space and a 2.7mm, 30 degrees arthroscope to this procedure. The central and distal portions of the plantar plate could be visualized, inspected, and palpated with a probe with the help of a light traction applied to the toe. The arthroscopy allows us to classify the plantar plate lesion.

An "S" shaped dorsal incision encompassing the arthroscopy portals was made over the involved digit and a longitudinal capsulotomy was performed to expose the MTP joint.

The extensor digitorum brevis and longus were elongated by Z-plasty or retracted medially, depending on the amount of the deformity. Using a sagittal saw, a Weil osteotomy, was performed. In those cases with metatarsalgia and plantar keratosis, a small slice of bone was removed to achieve a light elevation of the metatarsal head.

The distal fragment was pushed as proximally as possible and temporarily held in this position with a small Kirschner wire or may be fixed in its final position with one vertical screw. The type of lesion of the plantar plate was then inspected and confirmed.

Any piece of torn tissue was excised from the plantar margin of the proximal phalanx with a rasp or a small rongeur creating a roughened surface for the attachment of the plantar plate.

With a small needle and suture, the tear of the plantar plate was secured with non-absorbable sutures. Sometimes one can use a straight needle passed through the plantar plate to the sole of the foot, to help with the sutures. Horizontal sutures were used for longitudinal capsular tears, and transverse sutures were placed in the distal plate just proximal to where it was detached from the base of the proximal phalanx.

Two vertical drill holes (using a 1.5 mm K-wire) were made medially and laterally in the base of the proximal phalanx from the dorsal cortex to the plantar rim of the proximal phalanx (A). Using wire loops, the sutures attached to the plantar plate were then passed plantar to dorsal through the drill holes and then tied over the proximal phalanx fixing the plantar plate at the base of the phalanx (B).

As the sutures were tied over the dorsal phalangeal cortex, the digit was held in 20 degrees of plantar flexion. The Weil osteotomy was then fixed in the desired position with one vertical screw (C). After routine wound closure, a post-operative compression dressing was applied with the affected toe held in slight plantar flexion.
Anatomic Suture Anchor versus the Broström Technique for Anterior Talofibular Ligament Repair: A Biomechanical Comparison

Presenting Author: Norman E. Waldrop, III, MD
Vail, Colorado

Additional Authors: Coen Wijdicks PhD; Kyle Jansson; Robert F. Laprade, MD; Thomas O. Clanton, MD

Summary
Suture anchor repair of the lateral ankle ligamentous complex is a modification of the original Broström procedure that has gained popularity despite the paucity of biomechanical data reported on its use. The use of suture anchors to repair the ATFL produces a repair that can withstand similar loads to failure as the suture only Broström repair. However, all three repair groups were much weaker than the intact, uninjured ATFL.

Introduction
Suture anchor repair of the lateral ankle ligamentous complex is a technique modification of the original Broström procedure that has gained popularity over the past several years. The technique is simple in nature and well described, with excellent short to midterm patient outcomes now being reported. Despite its increasing popularity as a method for ankle ligament repair, there has been no biomechanical data reported on the use of suture anchors for ATFL repairs at the ankle. The purpose of our study was to perform a biomechanical comparison of the ultimate load to failure and stiffness of the traditional Broström technique using only a suture repair compared to both suture anchor repair of the ATFL. This data was then compared to the intact state to determine the mechanical properties of these repairs.

Methods
Twenty-four fresh-frozen cadaveric ankles were randomly divided into four groups of six specimens each. One group was an intact control group, with the other groups consisting of the traditional Broström and suture anchor modifications of the Broström procedure. The specimens were then loaded to failure to determine the strength and stiffness of each construct.
Results
In load-to-failure testing, the ultimate failure loads of the Broström (68.2 N ± 27.8 N; p = 0.013), suture anchor fibula (79.2 N ± 34.3 N; p = 0.037), and suture anchor talus (75.3 N ± 45.6; p = 0.027) repairs were significantly lower than that of the intact (160.9 N ± 72.2 N) ATFL group. Stiffness of the Broström (6.0 N/mm ± 2.5; p = 0.019), suture anchor fibula (6.8 N/mm ± 2.7 N; p = 0.047), and suture anchor talus (6.6 N/mm ± 4.0; p = 0.037) repairs, were significantly lower than that of the intact (12.4 N/mm ± 4.1 N/mm) ATFL group. The three repair groups were not significantly different from each other.

Conclusion
The use of suture anchors to repair the ATFL produces a repair that can withstand similar loads to failure as the suture only Broström repair. However, all three repair groups were much weaker than the intact, uninjured ATFL. Biomechanically, the results show that the suture anchor and the suture repair of the ATFL provide similar strength and stiffness. Unfortunately, these methods provide less than half the strength and stiffness of the native ATFL. As a result, regardless of the repair method, it is necessary to protect the repair sufficiently to avoid premature failure and early aggressive physical therapy may be detrimental.
Incidence and Risk Factors for High Ankle Sprains (Tibiofibular Syndesmosis Injuries) in Intercollegiate Football

Presenting Author: Kenneth J. Hunt, MD
Redwood City, California

Additional Authors: Elizabeth George, MD; Alex Sox-Harris; Jason Dragoo, MD

Summary
The purpose of this investigation was to determine the incidence and epidemiology of high ankle sprains in collegiate (NCAA) football players and to identify risk factors for these injuries. We found a significantly higher incidence of syndesmosis injuries during game competition, during running plays, and to running backs and interior defensive players. A wide range in time lost from participation supports the need for refining diagnostic, treatment, and surgical decision-making protocols.

Introduction
High ankle sprains, or injuries to the tibiofibular syndesmosis, are common in elite football players (1). These injuries differ from the more typical inversion ankle sprain in that they more often result in significant time lost from participation, are more likely to require immediate surgical decision-making, and are predictive of long-term ankle dysfunction (2). However, the present paucity of clinical data on high ankle sprains has resulted in a lack of clear guidelines available to the treating physician to aid in assessing injury severity and optimizing management decisions and prognosis (e.g., operative treatment, return to play timing, etc.). The purpose of this investigation was to determine the incidence and epidemiology of high ankle sprains (i.e., ligamentous injuries to the distal tibiofibular syndesmosis) in National Collegiate Athletic Association (NCAA) football players and to identify risk factors for these injuries.

Methods
We examined data from the NCAA’s Injury Surveillance System (ISS) for five football seasons (2004-2005 through 2008-2009), including all preseason, regular season and postseason practice and competition data. Injury rate (number of injuries divided by number of Athlete Exposures [A-Es]) was computed for practice and game competition exposures for partial and complete tibiofibular syndesmosis injuries. Pair-wise two-sample tests of equality of proportions were used to estimate risk factors.

Results
The overall incidence of high ankle sprains in NCAA football players was 0.24 per 1000 A-Es. Players were 13.9 times more likely to sustain the injury during games compared to practice (rate ratio of 13.94 [11.90, 16.34]). Complete syndesmosis injuries resulted in significantly greater time lost from participation (31.26 days, range 3-168 days) compared to partial syndesmosis injuries (15.76 days, range 1-172 days). Fewer than 3% of syndesmosis injuries resulted in surgical intervention. There was a significantly higher injury incidence on artificial “fill” surfaces (i.e. third generation artificial surfaces) compared to natural grass (p < 0.01). The vast majority of injuries occurred during contact with another player (75.2%), and just over half (51.7%) of injuries occurred during running plays (Figure 1). Running backs, defensive tackles, and linebackers were the most common positions suffering high ankle sprains.
Conclusion
Chronic Ankle Instability: Long Term Follow-up of Lateral Reconstruction using the Extensor Retinaculum flap. A Report of 150 Cases

Presenting Author: Paul J. Moroney, MD, FRCSI (Tr&Orth)
Dublin, Ireland

Additional Author: Yves Tourné, MD, PhD; Christian Mabit; Dominique Saragaglia

Summary
This study reviews 150 patients following reconstruction of the lateral ligament complex of the ankle for chronic instability at a mean follow-up of 11 years. We used an anatomic repair combined with an extensor retinaculum flap. At follow-up, residual instability was <5%; 93% of patients were satisfied and there was no progression of arthrosis. We believe that this technique provides excellent stability and protects against evolution of ankle arthrosis.

Introduction
Chronic instability is a common complication of lateral ankle sprains. Furthermore, patients often have unrecognised associated lesions affecting the ankle and subtalar joints. Many stabilising surgical techniques have been described, each with variable results reported at short or mid-term follow-up. The goals of this study were to report the long-term results of ligamentous retensioning combined with reinforcement using an extensor retinaculum flap, regarding stabilization and degenerative changes at the ankle joint.

Methods
This is a retrospective, multi-center study. One hundred and fifty cases were reviewed at a mean follow-up of 11 years. Functional results were assessed using the Karlsson and Good-Jones-Livingstone scores. Pre- and postoperative radiological assessment employed stress x-rays to measure varus tilt and anterior drawer, and the Van Dijk classification to grade osteoarthrosis. The Stata 10 program was used for statistical analysis.

Results
A thorough pre-operative work-up identified ligamentous lesions of the subtalar joint in 30% of cases. At review, 93% of patients were satisfied. Residual instability was only 4.8%. Radiographic analysis of both ankles revealed a differential in varus tilt of only 0.12 degrees and in anterior drawer of 0.17mm. There was no deterioration of the articular surfaces after 11 years follow-up.

Conclusion
To our knowledge, this is the largest series reported with such a follow-up. Our technique addresses both lateral ankle and subtalar instability without sacrificing the peroneal tendons. It protects against progression of posttraumatic arthrosis and provides superior results to other reported techniques in terms of patient satisfaction and residual instability. We believe that many poor individual results in other series are due to a failure to recognise and correct associated subtalar instability or other associated pathologies. In our series, a detailed set of pre-operative investigations helps us to avoid this common error.
Functional Outcome Assessment of Medial Ankle Ligament Repair – in Global and Isolated Medial Instability

Presenting Author:  J. Benjamin Jackson III, MD
Charlotte, North Carolina

Additional Authors:  Scot A. Youngblood, MD; Robert B. Anderson, MD; W. Hodges Davis, MD; J. Kent Ellington, MD; Bruce E. Cohen, MD; Carroll P. Jones, III, MD

Summary
Medial sided ankle instability is less common and not as well described as lateral instability in the literature. The outcomes of combined medial and lateral instability or global instability that underwent medial and lateral sided intervention have not been described. This retrospective review with a prospective history, physical, radiographs and functional examination looks to characterize patient outcomes in the intermediate term that had a medial sided repair either in isolation or combined with a lateral reconstruction.

Introduction
Ankle sprains are one of the most common musculoskeletal injuries and most often involve injury to the lateral ligament complex with an inversion mechanism. A subset of patients have a concomitant medial sided injury, leading to global ankle instability with even greater functional limitations. Another group of patients with an eversion mechanism have an isolated medial sided injury. This can lead to isolated medial ankle instability. We looked to evaluate the clinical and functional outcomes of these two groups of patients that underwent surgical repair of the medial ankle ligamentous complex without allograft.

Methods
A retrospective review was performed at our institution to identify patients undergoing a medial ankle repair. Medical record and radiographic reviews were performed. Patients younger than 18 years or those with peripheral neuropathy, rheumatoid arthritis or degenerative pes planovalgus were excluded. Patients were contacted and returned for a prospective history, physical examination, radiographs and functional testing by an independent surgeon. Patients also completed American Orthopaedic Foot and Ankle Society (AOFAS) Hindfoot and Foot Function Index (FFI) questionnaires.

Results
37 patients were available to for follow-up. The average follow-up was 23 months after surgery (range 8-62 months). 11 of the 37 patients had global ankle instability, medial and lateral, and a Brostrom-Gould procedure performed concomitantly with the medial sided repair. Of the 37 patients, 28 had resection of associated antero-medial osteophytes and 6 patients had a medializing calcaneus osteotomy during the index procedure. The average AOFAS Hindfoot Score was 87.4 (58-100) and the average FFI was 18.5% (0-70%). One of the 37 patients (3%) had clinically detectable laxity. Thirty-one of the 37 patients (84%) would have the surgery performed again, while 4 were ‘unsure’ and 2 would not have surgery. Three patients had additional procedures performed after the index procedure; none were for revision of the medial sided repair.
Conclusion
Medial-sided ankle injuries are less common than isolated lateral ankle disruptions and are often missed or overlooked. These injuries can lead to functional limitations and pain. Medial ligamentous repair in isolation or when combined with lateral ligament reconstruction can improve subjective symptoms and is associated with good functional scores at intermediate term follow-up.
Incidence and Risk Factors for Turf toe Injuries in Intercollegiate Football

Presenting Author: Elizabeth George, MD
Redwood City, California
Additional Authors: Kenneth J. Hunt, MD; Alex Sox-Harris; Jason Dragoo, MD

Summary
The purpose of this investigation was to evaluate recent National Collegiate Athletic Association (NCAA) data to determine the incidence, epidemiology and risk factors for turf toe injuries in collegiate football players. Our data suggest a decreased rate of turf toe injury compared to previously published data, although there remains a higher incidence on artificial surfaces versus natural grass. The overall decreased injury rate may suggest a benefit from recent changes to cleats and newer artificial playing surfaces.

Introduction
Turf toe injuries, or injuries to the first metatarsophalangeal (MTP) joint complex, typically occur during a hyperextension moment at the first MTP joint. Long-term morbidity secondary to turf toe injury has been reported, and includes persistent pain with athletic activities, restricted range of motion, hallux valgus and early hallux rigidus. Newer shoe designs and third generation artificial surfaces have purportedly reduced the incidence of turf toe injuries in elite competitive football. The purpose of this investigation was to evaluate recent National Collegiate Athletic Association (NCAA) data to determine the incidence, epidemiology and risk factors for turf toe injuries in collegiate football players.

Methods
Turf toe injuries, or injuries to the first metatarsophalangeal (MTP) joint complex, typically occur during a hyperextension moment at the first MTP joint. Long-term morbidity secondary to turf toe injury has been reported, and includes persistent pain with athletic activities, restricted range of motion, hallux valgus and early hallux rigidus. Newer shoe designs and third generation artificial surfaces have purportedly reduced the incidence of turf toe injuries in elite competitive football. The purpose of this investigation was to evaluate recent National Collegiate Athletic Association (NCAA) data to determine the incidence, epidemiology and risk factors for turf toe injuries in collegiate football players.

Results
The overall incidence of turf toe injuries in NCAA football players was 0.062 per 1000 athlete exposures (A-E). Athletes were nearly 14 times more likely to sustain the injury during games compared to practices (p < 0.01). The mean time lost from injury was 10.14+/−2.2 days. Fewer than 2% of turf toe injuries resulted in surgical intervention. There was a significantly higher injury rate on third generation artificial surfaces compared to natural grass (p < 0.01). The majority of injuries occurred as a result of contact with the playing surface (35.4%) or contact with another player (32.7%). Running backs and quarterbacks were the most common positions to suffer turf toe injury.

Conclusion
Our data suggest a decreased rate of turf toe injury during the recent seasons evaluated in this study compared to published data from previous decades. We also found a significantly higher rate of turf toe injuries during game competitions compared to practice in NCAA football, which is consistent with previously reported injury data. Turf toe most commonly occurs in offensive players, with running
backs and quarterbacks at greater risk than other positions. While we found a higher incidence of turf
toe injury on artificial surfaces compared to natural grass, the overall decrease in turf toe injuries may
suggest a benefit from recent changes to cleats and newer generations of artificial playing surfaces.
Turf toe injuries warrant thorough acute evaluation and appropriate management to prevent long-
term dysfunction.
A New Prognostic Classification of Fifth Metatarsal Stress Fracture using 'Plantar Gap'

Presenting Author:  Jun-Beom Kim, MD  
Seoul, Korea

Additional Authors:  Kyung-tai Lee, MD; Young Uk Park, MD; Hyuk Jegal, MD;  
Kiwon Young, MD; Jin-su Kim, MD, PhD; Jun-Bum Kim

Summary
There have been diverse results even in same Torg type classification in cases with fifth metatarsal stress fracture. The results of this study suggest that new classification might be used for prognosis in cases with a fifth metatarsal stress fracture.

Introduction
There have been diverse results even in same Torg type classification in cases with fifth metatarsal stress fracture.

Methods
Eighty six cases with a fifth metatarsal stress fracture that were treated with modified tension band wiring from January 2003 to May 2009 were evaluated retrospectively. This consecutive series of patients included 84 males and 2 females with a mean of 20.2 years of age at the time of surgery. All of the enrolled patients were elite athletes. Each case was classified according to Torg's classification and a new classification using a degree of plantar gap and morphology of fracture. They were divided into complete fracture and incomplete fracture. Incomplete fractures were divided with a degree of plantar gap-1mm. After the surgery, bone union was determined by CT findings. Statistical analysis of the Torg classification and time for bone union, as well as a new classification and time for bone union were performed.

Results
There was a significant difference in the time for bone union among the three Torg types. (p=0.004) There was a significant difference in time for bone union between complete fracture group and incomplete fracture group. (p<0.001) There was a significant difference in time for bone union between group A (plantar gap<1mm) and group B(plantar gap≥1mm) in incomplete fracture group. (p<0.001) In only cases with Tog I and II classification, there was a significant difference in time for bone union between complete fracture group and incomplete fracture group. (p<0.001) In addition, there was a significant difference in time for bone union between group C (plantar gap<1mm, incomplete fracture) and group D(plantar gap≥1mm, incomplete fracture) (p<0.001). There were eight cases of nonunion in Torg 2, and 1 case in Torg 3. With regard to new classification, there was 1 case of nonunion in complete fracture group and eight cases in incomplete fracture group, especially with plantar gap ≥1mm.

Conclusion
The results of this study suggest that new classification might be used for prognosis in cases with a fifth metatarsal stress fracture.
Prognosis of Multidirectional Chronic Ankle Instability

Presenting Author: Jin-su Kim, MD, PhD
Seoul, Korea

Additional Authors: Kiwon Young, MD; Young Uk Park, MD; Kyung-tai Lee, MD; Young koo Lee, MD; Gwak Heui-Chul, MD

Summary
The incidence of multidirectional chronic ankle instability is about 14.7% to need the operation at the ankle instability. And, the operative results of multidirectional chronic ankle instability are less satisfactory compared to the results of lateral chronic ankle instability.

Introduction
Lateral ligament reconstruction for chronic lateral ankle instability (CAI) do not fully address successful outcome. CAI has often several kinds of associated lesions or instability. We especially focus on the multidirectional chronic ankle instability (MCAI) as terms of association of chronic medial ankle instability or, and chronic syndesmotic instability. And, we evaluate the incidence of MCAI and compare the operative results between MCAI and CAI.

Methods
279 military patients with ankle instability which performed ligament reconstruction were evaluated retrospectively with prospectively collected data between May 2007 and March 2010. We diagnosed the medial ankle instability with medial drive through sign under 2.7mm diagnostic arthroscopy, the syndesmotic instability with proving more than 4mm anterior tibio-fibular diastasis. We evaluated the incidence of repairs of medial ankle ligament and syndesmotic fixation with suture button or syndesmotic screw. We divided two groups either combined reconstruction of ankle ligaments (group A, MCAI) or single lateral ligament reconstruction (group B, CAI). We used the American Orthopedic Foot and Ankle Society ankle-hindfoot score (AOFAS score), Visual Analog Scale (VAS) and ankle functional satisfactory scores were carried out.

Results
41 patients (14.7%) has MCAI. The AOFAS score and VAS was improved in both groups after operation. The mean AOFAS score for the group A increased from 65.4 to 82.4 (p<0.05) and for the group B from 68.2 to 89.9 (p<0.05). The mean VAS for the group A decreased from 6.0 to 3.6 (p<0.05) and for the group B from 5.7 to 2.6 (p<0.05). The poor satisfaction by functional ankle score for group A was 24.4% (10/41 patients) and for group B was 5.0% (12/238 patients). The clinical scores and satisfaction of group B was significantly better than group A (p<0.05).

Conclusion
The incidence of MCAI is about 14.7% to need the operation at the ankle instability. And, the operative results of MCAI are less satisfactory compared to the results of CAI.
8:20 am

Treatment of Large Cystic Defects of the Talar Shoulder by Autologous Free Vascularized Corticocancellous Bone Grafting from the Supracondylar Region of the Femur

Presenting Author: Stefan Demarmels, MD
Liestal, Switzerland

Additional Authors: Markus Knupp, MD; Lukas Zwicky, MSc; Marina Barandun, MD; Dirk Schaefer, MD; Beat Hintermann, MD

Summary
There are many treatment options available in therapy of cystic defects of the talar shoulder. Vascularized bone grafting by rotational pedicle bone grafts has its limitation in the dimension of the graft and the transplantation range due to the vessel length. We report on a novel technique using a free vascularized corticocancellous bone graft from the supracondylar region of the distal femur to address large cystic lesions of the talus.

Introduction
Reconstruction of the talar shoulder is a challenging procedure. Larger defects can be filled with non-vascularized auto- and allografts or vascularized bone grafts. For smaller lesions promising results have been reported on rotational vascular pedicle bone grafts from the first and third cuneiform or the cuboid. However, defect size is a limiting factor in this procedure. Additionally the transplantation range in these rotational grafts is limited by the length of the supplying vessels. We report on a novel technique using a free vascularized graft from the medial condyle of the femur to address large cystic lesions of the talus greater than 1 cm³.

Methods
We treated seven patients (females 4; males 3; age 35.8 [15.1-54.6] years) with large cystic lesions of the talar shoulder by a free vascularized corticocancellous bone graft from the supracondylar region of the distal femur. All patients were active and high demanding on the function of their ankle joint. Medial lesions were addressed by osteotomy of the medial malleolus. In lateral defects the anterior talofibular ligament was detached and the talus subsequently dislocated anteriorly to expose the lesion. After insertion of the bone graft the lateral ligaments were reconstructed in Brostrom fashion. All the defects were debrided and the graft inserted in a press fit manner. The postoperative treatment consisted of removable splinting with touchdown weight bearing and kinesitherapy for six weeks.
Pre- and postoperative CT-scans were used to evaluate the size of the lesion, to plan the procedure and to assess osteointegration. Clinical assessment included pre- and postoperative AOFAS hindfoot score and VAS score for pain.

Results
No intra- or perioperative complications were recorded. Bone graft incorporation was confirmed by CT-scan after 6 [4.5-7.4] months. The AOFAS hindfoot score increased from 63 [44-70] to 79 [50-85]. The VAS score for pain decreased from 5.9 [5-7] to 2.6 [1-4]. Two patients developed anterior ankle impingement due to the vascular pedicle. They were treated by arthroscopic debridement.

Conclusion
We observed promising results using a free vascularized corticocancellous bone graft from the supracondylar region of the distal femur to fill large cystic lesions of the talus. However, the vascular pedicle may lead to anterior ankle impingement and we only reported on a cohort with limited follow up time of 1.2 [0.5-2.3] years.
One Atage TTC Rod for Management of Combined Tibial Mal/nonunion and Ankle Arthritis

Presenting Author: Steven M. Raikin, MD
Philadelphia, Pennsylvania

Additional Author: Justin Kane

Summary
Fourteen patients with a combination of tibial shaft malunions or nonunions and ankle arthritis underwent one staged combined deformity / nonunion correction and ankle fusion with a retrograde fusion nail. All fourteen achieved successful fusion at an average of 18.5 weeks. There was one infection with a delayed union which required hardware removal and temporary external fixation. 4.7 year follow up demonstrated significant improvement in AOFAS-AH and VAS pain scores. Twelve patients were very satisfied with their results, while 1 patient was dissatisfied.

Introduction
Tibial shaft fractures can develop deformities resulting from malunion or nonunions of the fracture. Many of these will go on to develop post traumatic arthritic changes in the ipsilateral ankle joint resulting in further functional morbidity and pain. Failure of non-operative measure require addressing both the deformity / nonunion and the ankle joint, frequently as a staged procedure. We performed a one stage correction of both the malunion / nonunion and the ankle arthritis utilizing a retrograde intramedullary ankle / hindfoot fusion nail extending past the deformity. Nonunion / malunions were addressed via takedown, osteotomy and / or bone grafting as needed.

Methods
Retrospective analysis was performed on 14 patients with either combined tibial shaft malunions and / or nonunions together with ankle arthritis who underwent one staged deformity / nonunion correction with a retrograde fusion nail. There were 9 males and 5 females with an average age of 55.7 years old. Patients were seen for follow up evaluation at an average of 4.7 years post surgery (range 2-9.3 years). Fourteen patients had isolated post traumatic deformities, 2 had additional histories of rheumatoid arthritis, and two were neuroarthopathic. Patients had undergone an average 2.5 previous surgeries before there definitive fusion. Four cases had a history of prior infections, but none were infected at the time of their fusions. Seven cases utilized additional iliac crest bone graft, and two had implantable bone stimulators.

Results
All fourteen patients were available for final follow up. Average time to fusion was 18.5 weeks. This included one infected delayed union which required hardware removal and external fixation which took 11 months to heal. No other patients required any further surgeries. AOFAS-AH scores and visual analog scale pain scores were calculated pre operatively and at final follow up. These improved from 43 to 86 out of 100; and 8.3 to 2.8 out of 10 respectively - both of which were statistically significant. Twelve patients were very satisfied with their results, 1 was somewhat satisfied, while the patient who sustained the infection and delayed union stated that she was dissatisfied despite improvement in all objective scoring systems.

Conclusion
Severe multilevel combined tibial deformities with ankle arthritis can be corrected with a single staged surgical approach. This is done with a nonunion and / or malunion correction within the shaft fixed...
with a intramedullary devise which additionally crosses the surgically denuded and prepared arthritic ankle joint for concomitant ankle / hindfoot joint fusions. Follow-up analysis demonstrated reliable healing, deformity correction and improved functional and pain scores.
Outcomes Following Flexible Fixation of the Syndesmosis

Presenting Author: Joseph E. Bellamy, MD
Dallas, Texas

Additional Author: John S. Early, MD

Summary
Flexible fixation of the syndesmosis provides reliable and functional stabilization, which is durable even after return to weight bearing.

Introduction
While rigid fixation of the syndesmosis is standard, the advent of flexible fixation has generated interest in a less rigid form of stabilization, and fixation that potentially does not require secondary hardware removal. As previous reports in the literature have examined relatively small study populations, the purpose of this study was to further examine outcomes following flexible fixation of syndesmotic injuries with regard to re-operation rate, complications, as well as maintenance of reduction. We hypothesize that flexible syndesmotic fixation produces a reliable and functional outcome.

Methods
The database of a fellowship-trained orthopaedic foot and ankle surgeon was retrospectively reviewed to identify cases of syndesmotic fixation from 2005 to present. All cases utilizing a flexible device (TightRope, Arthrex; ZipTight, Biomet) were considered for inclusion. Disqualification criteria included previous surgery to the involved ankle, associated pilon type fractures, malunion/nonunion repairs, rigid syndesmotic fixation and charts with inadequate data. All patients followed a postoperative protocol of 6 weeks non-weight bearing unless the injury was an isolated syndesmotic injury in which case protected weight bearing was typically permitted after 2 weeks. Charts were reviewed for complications (heterotopic ossification, infection), reoperation rate, time to weight bearing and return to activity. Radiographs were reviewed for changes in tibio-fibular overlap as well as the medial and lateral clear spaces, comparing initial post-operative imaging to the most recent exam.

Results
A total of 66 cases were identified of which 44 met inclusion criteria for final review. Mean age at time of index procedure was 30 years (range 14-65) with 27 males and 17 females. Of the 44 cases, 8 cases were isolated syndesmosis injuries, 2 were Maisonneuve type injuries, and 34 had associated fractures requiring appropriate fixation. Thirty cases were repaired with a knotted device (TightRope), and 14 were repaired with a knotless device (ZipTight). Heterotopic ossification was identified in 4 cases (9%) with 2 cases in each of the fixation groups. Infection was found in 1 case (2%) utilizing a knotless device. Five cases required removal of the device due to pain, prominence or infection (11%) and of these, 4 were knotted devices. Average time to weight bearing was 5.6 weeks in a boot, and was 8.5 weeks out of the boot. Release to activity averaged 13.6 weeks. Radiographic review showed tibio-fibular overlap, lateral clear space and medial clear space changes to be 0.52 mm, 0.01 mm, and 0.14 mm respectively.

Conclusion
Flexible fixation of the syndesmosis appears to provide a reliable and functional method of stabilization with maintenance of reduction and return to activity. While device removal was
necessary in a small number of cases, use of a knotless device, as shown by a small subgroup of cases in this study, may decrease the need for removal due to pain and prominence.
Mid-term Results of Operative Treatment of Navicular Fractures and a New Navicular Fracture Classification

Presenting Author: Fabian Krause, MD
Basel, Switzerland

Additional Author: Timo Schmid; Martin Weber, MD

Summary
At mid-term follow-up, open reduction and internal fixation of navicular fractures lead to appropriate clinical outcome but is closely related to the severity of the initial fracture comminution. A new classification with close correlation to clinical and radiological outcome is proposed.

Introduction
Talar navicular body fractures are uncommon fractures. Formerly recommended treatment often was nonoperative, while nowadays open reduction and fixation is advocated. Some authors also propose primary arthrodesis in case of grossly destroyed articular surfaces. Two classification systems representing the mechanism of injury are described. A new classification system is introduced that allows better prediction of long-term outcome.

Methods
A review of records from 1997 through 2009 yielded 57 patients having sustained a navicular fracture. Twenty-four fulfilled the inclusion criteria and were followed until March 2011. There were 14 men and 10 women with an average age of 44 years (range 17-61). Average follow up was 67.5 month (range 11-157). Clinical outcome was measured by the AOFAS midfoot score, VAS Hannover Questionnaire. Radiologically osteoarthritic changes of the TN und naviculocuneiforme (NC) joints were graded according to Kellgren-Lawrence and Meary's angle was measured. According to the new classification navicular avulsion fractures of the proximal dorsal lip or the tuberosity were classified as type Ia and Ib and sagittal split fractures of the body as type II. Type III navicular fractures were separated in fractures with TN luxation and lateral plantar fragmentation (type IIIa) or multiple fragmentation of the proximal navicular joint surface (type IIIb).

Results
The mechanism of injury was a fall in 16 patients, a motor-vehicle accident in three, a motorcycle accident in three and a crush injury in two. Concomitant fractures of the foot comprised 8 cuboid fractures, 7 fractures of the talar head and 5 fractures of anterior calcaneal process. Associated lesions included injuries of the ipsilateral limb in four patients and multiple-system injuries in one. All patients were treated operatively by open reduction and internal fixation. In two cases primary arthrodesis (one TNC, one NC) was performed. 13 additional procedures were necessary (5 primary closed reduction and K-wire pinning of what metatarsals, 6 hardware removal, one TN arthrodesis, one corrective osteotomy) Overall results showed an AOFAS Score of 84.4 and a VAS Hannover Questionnaire Score of 75.5. Spearman's coefficients showed significant correlation of the clinical outcome with TN mobility (-0.44, p= 0.016), with TN arthrosis (-0.53, p=0.004), and with ST mobility (-0.53, p=0.004). Using the new classification 4 patients had type I fractures, 6 patients type II fractures, 5 type IIIa and 9 type IIIb fractures. In contrast to Sangeorzan's classification the proposed new classification showed significant correlation of the fracture type and AOFAS Score (-0.016, p=0.470 vs -0.39, p=0.030), of fracture type and Hannover Score (-0.14, p=0.253 vs -0.36, p=0.041), and of fracture type and osteoarthritis of TN joint (0.39, p=0.029 vs. 0.53, p=0.004)
**Conclusion**
At mid-term follow-up, open reduction and internal fixation of navicular fractures lead to appropriate clinical outcome but is closely related to the severity of the initial fracture comminution. A new classification with close correlation to clinical and radiological outcome.
Acute Complications Following Open Reduction and Internal Fixation of Calcaneus Fractures Using a Novel Intramedullary Fixation Technique

Presenting Author:   Kevin J. McCarthy, MD
Kansas City, Kansas

Additional Authors:   Erik T. McGoldrick, MD; M. Christian Moody, BS; Omar Almoghrabi, BS; Greg A. Horton, MD; Kelly Overman, MD; Sue Min Lai, PhD

Introduction
In the past two decades studies have demonstrated improved outcomes following open reduction and internal fixation of certain displaced intraarticular calcaneus fractures. Some surgeons are reluctant to manage these fractures operatively due to the risk of wound complications. Indeed, several authors have reported significant rates of soft tissue complications of varying severity. A biomechanical study validating a novel intramedullary fixation technique for displaced intraarticular calcaneus fractures has been previously published by Nelson et al. When subjected to cyclical loads in the lab, this intramedullary technique demonstrated less interfragmentary motion than traditional lateral plate fixation. Our hypothesis is that while providing robust fixation, this fixation technique would result in rates of acute wound complications similar to or lower than published rates for lateral plate fixation.

Methods
Our study is a retrospective review of all patients with displaced intraarticular calcaneus fractures that were treated operatively by a single surgeon at an academic medical center. This represents 159 calcaneus fractures in 146 consecutive patients treated between 2006 and 2011. Exclusion criteria included fractures treated with a primary subtalar fusion, exposures other than a lateral extensile approach, open fractures, and those not requiring fixation. Patients with less than 12 weeks of follow-up or incomplete medical records were also excluded. Although these headless compression screws can be applied in percutaneous manner, the goal of the study was to evaluate the complications associated with this technique in the fixation of displaced fractures which required extensile lateral approach for accurate reduction. We reviewed these charts and determined rates of wound complications. Major wound complications were classified as those requiring return to the operating room. Minor wound complications were defined as wounds requiring oral antibiotics or local wound care in clinic. We also examined patient factors such as age, time from injury to treatment, smoking status, presence of diabetes mellitus, and worker’s compensation status. A secondary measure was return to the operating room for reasons other than wound complications.

Results
After exclusion criteria were applied, there were a total of 81 calcaneus fractures in 78 patients for analysis. There were five (6.2%) major wound complications requiring return to the operating room. There were thirteen (16%) minor wound complications requiring oral antibiotics or clinic debridement. Fourteen feet (17.3%) required reoperation for late effects of a calcaneus fracture. Included in those 14 feet are eight feet (9.9%) which required implant removal due to pain or prominence.
Conclusion

These rates of major and minor wound complications are within the range of published rates of complications in previous series of patients undergoing open reduction and internal fixation of calcaneus fractures using a lateral extensile approach and plate fixation. Our study demonstrates that this novel technique is associated with an acceptable rate of wound complications when compared to traditional plate fixation. Prospective data continues to be collected which may allow us to make stronger recommendations in the future.
Prospective Randomized Trial Comparing ORIF with Minimally Invasive Reduction and Percutaneous Fixation in the Management of Displaced Intra-articular Calcaneal Fractures

Presenting Author: Venkatesan Sampath Kumar, MD  
*New Delhi, India*

Additional Authors: Kanniraj Marimuthu, MS; Suresh Subramani, MS; Vijay Sharma, MS; Prakash Kotwal, MS

Summary
A randomized controlled trial was undertaken to compare open reduction & internal fixation (ORIF) with minimally invasive reduction & percutaneous fixation (MIRPF) in the management of displaced intra-articular calcaneal fractures. The results showed that Minimally invasive reduction and percutaneous fixation is associated with fewer wound healing problems than open reduction and internal fixation. In addition MIRPF is associated with better functional outcomes and early return to occupation. The radiological outcomes in both the groups are similar.

Introduction
The management of displaced intra-articular calcaneal fractures remains controversial. A prospective, randomized trial was undertaken to compare wound healing problems, functional and radiological outcomes following management of displaced intra-articular calcaneal fractures treated surgically by either open reduction and internal fixation (ORIF) or minimally invasive reduction and percutaneous fixation (MIRPF).

Methods
45 displaced intra-articular calcaneal fractures were randomized on admission to undergo either ORIF (n = 23) or MIRPF (n = 22). Patients were followed up clinically and radiologically for a minimum of one year postoperatively. The primary outcome measure was wound healing complication. Functional outcome was assessed using Creighton Nebraska Health Foundation (CNF) scale, a previously validated system specific for calcaneal fractures. In each group time taken to return to occupation was documented for each patient. Radiological outcome was assessed by Bohler’s angle and Gissane’s angle in plain radiographs and CT scans both preoperative and postoperative were analysed for the quality of reduction and to document Score analysis of Verona (SAVE).

Results
7 (30%) of the 23 heels in ORIF group had wound healing problems as compared to none in MIRPF group (p = 0.005). There was no statistically significant difference in radiological outcomes between the two groups as measured by Böhler’s angle, Gissane’s angle and SAVE scoring. The median time to return to occupation was 2 weeks earlier (p = 0.004) and the functional outcome score (CNF score) at 1 year follow-up was better (p = 0.013) in minimally invasive group compared to open group.

Conclusion
Minimally invasive reduction and percutaneous fixation for displaced intra-articular fractures is associated with fewer wound healing problems than open reduction and internal fixation. In addition MIRPF is associated with better functional outcomes and early return to occupation. The radiological outcomes in both the groups are similar.
The Results of Ceramic Artificial Talus for Aseptic Talar Necrosis

Presenting Author: Yoshinori Takakura, MD, PhD
Nara, Japan

Additional Authors: Tsukasa Kumai, MD, PhD; Kazuya Sugimoto, MD, PhD; Akira Taniguchi; Yasuhito Tanaka, MD, PhD

Summary
It is the most difficult to treat for advanced aseptic talar necrosis with destroyed dome. Three types of ceramic artificial talus were replaced on 57 talar necrosis. Talar dome prosthesis was revised on whole body for 8. Results of whole body (third type) included revision are excellent until now. Artificial ceramic whole body should be indicated for aseptic talar necrosis even if talar neck and head of the talus are intact.

Introduction
The aseptic necrosis of the talar body is developed by neck fracture of the talus, alcoholism and induced steroid. Furthermore, it is often occurred by an unknown idiopathy. It is the most difficult to treat for advanced talar necrosis with destroyed dome. We have replaced a ceramic artificial talus for cases with necrosis of the talar body and report good results.

Methods
From 1999 to 2010, 57 feet with 55 patients with aseptic necrosis of the talus had been replaced by ceramic artificial prosthesis. There are 9 men and 46 women, with mean age of 62 years (19 to 89). The necrosis of the talar body was caused by neck and body fracture in 7 patients and idiopathy in 48. There was no alcoholism and case induced steroid. Ceramic artificial prosthesis was made from the image of CT scan of normal opposite talus. The bonding between ceramic talar prosthesis and talar neck was performed by bone cement (10 ankles; first type). However, the loosening between neck of the talus and prosthesis was recognized in some cases. Based on the results, we made the prosthesis (second type) without anchor combined with talar neck and replaced it for 17 ankles without bonding between the neck and prosthesis. But loosening and fracture of the talar neck was developed for same patients. 30 ankles were replaced by whole body (third type) of the talus. Furthermore, 8 patients (first and second type) with revision were rereplaced by whole body. They were assessed pre and postoperatively by AOFAS ankle/hindfoot score system.

Results
Follow-up was from 10 months to 137 months (mean 56 months). Results of first type were 2 revisions by whole body (3 deaths) and excellent 3, good 2, fair 2 and poor 3. Results of second type were 6 revisions and excellent 3, good 5, fair 6 and poor 3. Results of third type were no revision and excellent 22 and good 8. Results of revision by whole body were no re-revision and excellent 3, and good 5.

Conclusion
From 1999 to 2010, three types of ceramic artificial talus were replaced on 57 talar aseptic necrosis. Talar dome prosthesis was revised on whole body for 8. Results of whole body (third type) included revision are excellent until now. Artificial whole body should be indicated for aseptic talar necrosis even if talar neck and head of the talus are intact.
9:00 – 9:40 am

Symposium #5:
Techniques for the TAR in Trouble

Moderator:

Murray J. Penner, MD
Vancouver, BC, Canada

9:00 am
Intra-Operative Talar Tilt: Balancing the Bone and Soft Tissue
Dan Boack, MD
Berlin, Germany
Gutter Impingement – Causes and Treatment
Steven L. Haddad, MD
Glenview, Illinois

The Reality:

1) Unlike the knee, the ankle is a true tri-compartmental joint
   a. Articulation occurs between the tibia and talus, but also between the talus and medial/lateral malleoli
      i. Patients with significant arthritis in these “gutters” continue to have arthritic pain and stiffness

1. Gutter debridement is the solution
   a. Prosthesis must have inherent stability to accommodate aggressive gutter debridement, or coronal plane subluxation will occur
      i. Creates varus/valgus deformity or impingement against malleoli

Coronal plane instability may not allow aggressive gutter debridement
b. The posterior capsule is an often unrecognized component to ankle joint stiffness
   i. Particularly in post-traumatic arthritics
1. Capsule is thickened with scar following the index trauma
   ii. Capsule thickening can occur in post-operative phase from ankle replacement
   1. Joint space hematoma with even short-term immobilization can cause this contracture
   iii. Solution will involve separate incision posterior capsule release, with early mobilization

Significant stiffness despite no evidence of bone impingement

Generous posterior capsule release through coronal plane Achilles tendon lengthening approach

c. In cavovarus deformities, the posterior based fibula may not undergo sufficient resection to provide clear space for the articulating talus
   i. This also can provide posterior impingement and subsequent stiffness
   ii. Solution will involve resection of impinging fibula against talar prosthesis
   1. Often better done through posterior approach to insure too much fibula is not being removed
Posterior fibula impinging against posterior prosthesis, creating stiffness and pain
Cysts – Osteolysis, Stress Shielding and Management

Mr. Sunil Dhar, MBBS, MS, MCh Orth, FRCS, FRCS Orth
Consultant Orthopaedic Surgeon
Nottingham, UK

Total Ankle Arthroplasty (TAA) with third generation implants is becoming an increasingly predictable, robust procedure for end stage ankle arthritis. Whilst the medium term reports of most modern implants show increasingly satisfactory and similar clinical results, more is being learned about the phenomenon of cyst formation and stress shielding around these implants. In one instance (AES - Ankle Evolutive System: Transystem, France), peri-prosthetic cyst formation has led to the withdrawal of the implant.

Aseptic peri-prosthetic cyst formation in TAA is being increasingly recognized. Little clear evidence exists regarding the evolution of these cysts. Temporally, these can be classified into early onset (within 2 years) and late onset (after 5 years) types. The etiology is wide ranging from polyethylene wear by edge loading (instability or deformity) and edge wear (poor position of implants), stress shielding possibly by stemmed tibial components, inappropriate coating of the implants, increasing constraints on the implant and poor surgical technique. These will be discussed in some detail. The management of such cysts includes supervised neglect if stable or bone grafting or implant revision.
9:40 am

Catastrophic Polyethylene Failure in the Scandinavian Total Ankle Replacement (STAR): An Analysis of Patient and Implant-Related Factors

Presenting Author: Melissa Laflamme
Vancouver, BC, Canada

Additional Authors: Murray J. Penner, MD; D. Joshua Mayich, MD; Timothy R. Daniels, MD

Summary
Early catastrophic failure of the polyethylene has recently been reported with the STAR™ total ankle replacement. A consecutive series of 111 STAR™ in 97 patients has been followed prospectively. Sixteen patients underwent revision for catastrophic polyethylene failure. Our data showed that patients with better outcomes, especially men with higher BMI, tend to be more active and are therefore more at risk of early catastrophic failure.

Introduction
The STAR™ (Waldemar-Link, Hamburg) is an uncemented, three-component, mobile-bearing fully conforming and minimally constrained total ankle replacement design. Early catastrophic failure of the polyethylene has recently been reported by some authors with this implant. Since the STAR is a newcomer on the US market, one can certainly expect an increase in the use of this device in North America in the next decade. Therefore, a closer look for the etiologies behind this particular complication is needed.

Methods
A consecutive series of 111 STAR™ total ankle replacements in 97 patients performed in 2 different centres has been followed prospectively with respect to demographics and subjective patient-based outcomes. A subgroup of 16 patients who underwent revision for catastrophic polyethylene failure was compared to the group of patients that have had an intact primary STAR™ implant for at least 58,2 months to try to determine independent variables of early polyethylene failure based on total hip, knee and ankle replacement literature. A retrospective radiologic evaluation was also conducted.

Results
The mean time from implantation to failure was 58,2 months. No significant trauma was related to these failures. The mean age of patients with catastrophic failure was 62,3 years old compared to 61,9
for the control group. In the catastrophic failure group, 75% were men compared to 44.2% in the control group and the majority had a diagnosis of either post-traumatic or primary osteoarthritis of the ankle. Mean BMI were 27.5 and 31.5 for the control group and the polyethylene failure group respectively. Our data also revealed that the failure group had better outcome scores. There was no difference noted in the size or thickness of the implants used between the two groups, as was the rate of additional procedures performed. Surgeon’s experience in STAR™ implantation or total ankle replacement in general did not seem to play a role either.

**Conclusion**
This study demonstrates that patients with better outcomes, especially men with higher BMI, tend to be more active and therefore put more stress on their implants. This leads to an increased risk of early catastrophic polyethylene failure. In addition, the design of the STAR™ might also play a role in these early failures. Orthopaedic surgeons should be more cautious in the selection of their patients undergoing STAR™ total ankle replacement.
A Comparison of CT and Plain film Assessment of Osteolysis Following Total Ankle Joint Arthroplasty

Presenting Author: Gerard Bourke, MD
Melbourne, Victoria, Australia

Additional Author: Glenn Gomez, MD

Summary

Osteolysis remains a major problem following total ankle arthroplasty. Conventional radiography underestimates its extent and makes comparison difficult. CT scanning provides a method of accurately assessing and following progression of osteolysis as well as providing valuable information regarding loosening, subsidence and heterotrophic ossification. Routine follow up of ankle arthroplasty should include the use of CT scans to assess osteolysis and allow for timely intervention to prevent catastrophic implant failure.

Introduction

Introduction: Third generation Total Ankle Prosthesis have seen an improvement in short and intermediate term clinical results. However radiologic surveillance reveals high rates of early, progressive, asymptomatic osteolysis. This raises concerns regarding long term implant survivorship and future management of such lesions. Aim: To describe the incidence, and patterns, of peri prosthetic osteolysis in Total Ankle Joint Replacement (TAJR) using fine slice Cat Scan (CT). To develop a CT based classification system to standardise the routine assessment and monitoring of osteolysis in TAJR.

Methods

Method: Ct and plain films were reviewed from a total of 55 patients (57 ankles) following implantation of a third generation ankle arthroplasty performed by a single surgeon between 2001 and 2010. All 55 patients were assessed radiographically, with serial CT scans over an average of 5 years follow up (18 months -10 years). A 10 zone classification system (previously used by Besse et al for plain film assessment) was adapted to fine slice CT imaging producing a reproducible assessment protocol. The CT assessment was compared to the plain film assessment.

Results

Results: 98% of patients had some form of osteolysis, with 77% of patients having tibial and 80% talar lesions. Talar zone 5 was the most frequently affected area with 68% of patients having zone 5 lysis. Talar zone 9 lysis was present in 58% and tibial zone 7 in 54%. Talar lesions were also observed to be larger than their tibial counterparts. The vast majority of these lesions were progressive, however rates of progression varied highly. On two occasions lesions were seen to regress and fill in with bone. Heterotrophic ossification is a common finding especially posteriorly and may account for unexplained pain through impingement and reduced range of motion.

Conclusion

Discussion/Conclusion: Early and progressive periprosthetic osteolysis is a common problem which is generally asymptomatic. CT assessment has been shown to be more sensitive at detection and more accurate in quantification of such lesions. Long term consequences of such lesions are uncertain but remain concerning. CT scanning of TAJR should be part of the routine post operative surveillance for osteolysis, loosening and subsidence. Yearly clinical and /or radiologic assessment should be carried out until the natural history of TAJR has been established more clearly. Accurate assessment of
osteolytic lesions can be performed so that timely intervention can be carried out to prevent catastrophic failure of the prosthesis.
Bone Cysts in TAA

Presenting Author: Dan-Henrik Boack, MD
Berlin, Germany

Summary
In the literature it has been reported about bone cysts after TAR. A subtle analysis in a clinical prospective investigation was conducted. Prospective study: 2002-2011; Subjects: 601 TAA; Complete radiological analysis (X-rays, CT scans); 601 TAA were evaluated: In 66 TAA (11,0%) bone cysts have been developed. In our mid-term study 20,5% of TAR had radiological findings of cystic lesions. Proven frequency of 11% cysts in TAR (CT evidence) was recorded. Two third of them were progressive. Only 1,8% of TAA underwent a surgical procedure.

Introduction
TAR is a well-accepted procedure for end-stage ankle arthritis nowadays. Despite good short and midterm results, we do not have many long term studies. In the literature it has been reported about bone cysts after TAR. There are only small case series available. Hence why a subtle analysis in a clinical prospective investigation was conducted.

Methods
Prospective study: 2002-2011; Subjects: 601 TAA; Complete radiological analysis (X-rays, CT scans); Definition: newly developed cystic lesions in the bone post TAR; Follow-up: average 34 months;

Results
601 TAA were evaluated: 478 TAA (79,5%) have no cystic bone lesion; In 26 TAA (4,3%) the patient had cysts prior to operation and no changes were found during the follow up; In 31 TAA (5,2%) there were only one suspected small lesion (smaller than 5 mm) – without any symptoms (no CT scan was performed); In 66 TAA (11,0%) bone cysts have been developed. Localization of cystic lesions in the 66 cases: Only on tibial side: 50 (8,3%); On tibial and talar side: 8 (1,3%); Only on talar side: 8 (1,3%); This means that in total 58 tibial cystic lesions (9,7%) and 16 talar cystic lesions (2,7%) were found. Specific cyst location: Tibial cysts n=58: n=31 (5,2%) were on dorsal rim; n=4 (0,7%) were anterior, situated behind the component shield; n=6 (1,0%) surrounded the screw direction; n=17 (2,8%) central located / confluent cysts. Talar cysts: n=16: n=5 (0,8%) were isolated anterior located; n=2 (0,3%) were multiple located / confluent cysts; n=2 (0,3) were connected to the subtalar joint or sinus tarsi. Progression: During the investigation (average 34 months to 46 months) 24 cysts (4,0%) were constant and 42 cysts (7,0%) were enlarged. Choice of treatment: Conservative (observational) treatment were done in n=55 (9,2%) cases and Surgical procedures were performed in n=11 (1,8%) cases.

Conclusion
In our mid-term study 20,5% of TAR had radiological findings of cystic lesions. Proven frequency of 11% cysts in TAR (CT evidence) was recorded. Two third of them were progressive. Only 1,8% of TAA underwent a surgical procedure. To date there is only a small number of revised TAA due to cystic lesions. But it has been acknowledged that there are a higher total number of cysts. This could lead to serious long term problems. Therefore a periodical radiological check is recommended.
Radiographic Analysis of Subsidence in Total Ankle Replacement: 2-year Follow-up

Presenting Author: Samuel B. Adams, MD  
Durham, North Carolina

Additional Authors: Robin M. Queen, PhD; Jessica E. Carter, BS; Mark E. Easley MD; James K. DeOrio, MD; James A. Nunley, II, MD

Summary
This study examines subsidence following TAR, with particular interest in understanding talar subsidence. The results of this study indicate no evidence of post-operative TAR subsidence 2-years following surgery. It is unknown if subsidence might become a clinical concern, but our data suggests that these TAR implants (IB, ST) remain stable over the initial two years following surgery.

Introduction
Total ankle replacement (TAR) continues to grow as an alternative to arthrodesis for patients who suffer from end-stage arthritis. Previous reports in TAR have reported that implant subsidence particularly of the talar component is of major concern. Implant subsidence following TAR can alter implant stability and patient outcomes over time. Therefore, this study examined implant subsidence in patients who received a TAR.

Methods
Radiographs from 77 consecutive TAR patients between 2007 and 2008; 38 INBONE (IB) and 39 Salto-Talaris (ST) were assessed retrospectively. Implant failure occurred in 1 ST and 3 IB patients within two years of surgery leaving 73 patients with radiographs taken 6, 12, and 24 months following TAR that were used for this analysis. A single rater measured sagittal plane tibial and talar implant angles, vertical talar component distance, AP talar distance (lateral images), plus vertical and horizontal component sizes (control for radiographic magnification), medial tibial component angle, and prosthetic and native (contralateral) joint height (AP images). The inter-class correlation coefficient (ICC (3,1)) was used to determine measurement reliability. A 2X3 repeated measures ANOVA (Implant x time) was used to determine significant differences between the groups (P<0.05).

Results
ICC for all variables ranged from 0.46 to 0.993. There was no evidence of subsidence during the initial 2 years post TAR (P>0.05). The S-T implant had an increased medial tibial component angle (P=0.004). There were no differences for implant height between implants (P=0.14) or across time (P=0.89).

Conclusion
The implant failure rate of 5.19% within the first 2 years following TAR is higher than was expected. However, no evidence of post-operative TAR subsidence was found at 2-year follow-up after removing the patients who had an implant failure. In the first 2 years post-surgery, there was little evidence of change in radiographic alignment when using the INBONE and Salto-Talaris total ankle replacement implants. It is unknown if subsidence might become a clinical concern, but our data suggests that these TAR implants (IB, ST) remain stable over the initial two years after surgery. These findings could be the result of newer implant instrumentation which allow for more precise cuts causing less collapse on open unseen cavities underneath the prosthesis that could have been present with prostheses that were implanted in the past.
Medial Pain Syndrome in Patients with Total Ankle Replacement

Presenting Author: Alexej Barg, MD
Liestal, Switzerland

Additional Authors: Thomas Suter, MD; Lukas Zwicky, MSc; Markus Knupp, MD; Heath Henninger, PhD; Beat Hintermann, MD

Summary
Persistent pain in patients who undergo TAR is a common problem and has been described in up to 60% of all replaced ankles. In patients with medial pain syndrome a complex biomechanical problem is often observed, and a simple debridement of the medial gutter typically results in temporary pain relief.

Introduction
Total ankle replacement (TAR) is an increasingly recommended treatment for patients with end-stage ankle osteoarthritis (OA). TAR remains a technically demanding procedure and should be performed by experienced foot and ankle surgeons since the risk of persistent pain following TAR remains high. Pain is typically localized on the medial side. The aim of this study was to (1) establish a classification of medial pain syndrome in patients who underwent TAR and (2) describe treatment strategies as a function of the suggested classification.

Methods
We retrospectively reviewed data from 744 patients who had 778 TARs for painful, disabling ankle arthritis between May 2000 and December 2009. In 34 patients a bilateral TAR was performed. Only primary arthroplasties with a minimum of 2 years follow-up were included, resulting in 582 patients with 612 TARs. There were 319 female and 293 male patients with a mean age of 58.2 +/- 12.8 years. Underlying diagnoses were post-traumatic OA in 517 ankles, primary OA in 49 ankles, and inflammatory OA in 46 ankles. All patients were evaluated pre- and post-operatively (mean follow-up 5.9 years, range: 2 – 9). In 91 patients medial pain syndrome was diagnosed. Medial pain syndrome was defined as pain localized on the medial side with an intensity of at least “3” using a visual analogue scale (0-10) in at least 3 of 6 months before the last follow-up.

Results
The following classification of the medial pain syndrome has been established in our practice. Type I: medial impingement/contracture of medial ligaments; Type II: valgus deformity; Type III: varus deformity; and Type IV: varus-valgus deformity. The percentage distribution in the cohort was Type I (18%), Type II (32%), Type III (23%), and Type IV (18%). The following treatment strategies are suggested based on this classification scheme. Type I: in patients with well-aligned prosthesis components a medial release and/or exchange of insert (smaller size) should be performed, in patients with mal-alignment of prosthesis components a revision TAR should be performed. Type II: the valgus deformity is seen on the inframalleolar level, therefore medial displacement calcaneal osteotomy is recommended. Type III: the varus deformity is seen on the supramalleolar level, therefore supramalleolar osteotomy is recommended to restore the biomechanics of hindfoot. Type IV: a combination of supramalleolar varus deformity and calcaneal valgus deformity exists, therefore reconstructive surgery should be performed on both levels, first supramalleolar osteotomy of the tibia to correct the longitudinal axis of the tibia and then the medial displacement calcaneal osteotomy to address the valgus hindfoot deformity.
Conclusion
Persistent pain in patients who undergo TAR is a common problem and has been described in up to 60% of all replaced ankles. In patients with medial pain syndrome a complex biomechanical problem is often observed, and a simple debridement of the medial gutter typically results in temporary pain relief. Based on our experience, medial pain syndrome can be assigned to one of four Types to classify the typical causes of pain, and our clinical strategies to address each Type have been presented.
Total Ankle Arthroplasty with Calcaneo-Metatarsal Osteotomies for Ankle Osteoarthritis with Cavo-Varus Deformities: Early Results

Presenting Author: Hong-geun Jung, MD, PhD
Seoul, Korea

Additional Authors: Seung-hyub Jeon; Jong-tae Park; Tae-hoon Kim

Summary
To evaluate the clinical and radiographic results of the total ankle arthroplasty with bony reconstructions to address the ankle arthritis with cavo-varus deformity. Average age was 66.2 years. Eighteen additional bony reconstruction such as lateral sliding calcaneal osteotomy(9) and 1st metatarsal dorsiflexion osteotomy(4) were additionally performed. VAS pain score improved from preoperative average 8.8 to 2.4 and the AOFAS score improved from 36.9 to 89.3 at final follow-up (p<0.05).

Introduction
To evaluate the short term clinical and radiographic results of the total ankle arthroplasty (TAA) with combined bony reconstructions to address the end-stage ankle arthritis with cavo-varus deformity. The end-stage ankle OA with cavovarus or hindfoot varus deformity is found to be relatively not uncommon. In order to successfully address the disease entity with TAA, the combined deformity has to be corrected adequately in order to restore neutral coronal plane alignment and a congruent articulation of the ankle joint. Deformity correction in the coronal plane must be judiciously considered in TAA since residual angular deformity or malalignment after the operation can result in instability, progressive edge-loading or subluxation of the bearing, leading eventually to arthroplasty failure.

Methods
This study is based on the 10 ankles (8 patients) of end-stage ankle arthritis with cavo-varus deformity that were treated with TAA with combined calcaneo-metatarsal osteotomies from September 2004 to June 2010 with at least 12 months follow-up. The combined bony procedures as well as the VAS pain score, AOFAS score, radiographic measurements and patient satisfaction were evaluated.

Results
Average follow-up period was 17.9 months (12-43) and the age was 66.2 years (55-76). Eighteen additional bony reconstruction such as lateral sliding calcaneal osteotomy(9) and 1st metatarsal dorsiflexion osteotomy(4) were performed in addition to TAA. VAS pain score improved from preoperative average 8.8 (6-10) to 2.4 (0-7) and the AOFAS score improved from 36.9 (14-71) to 89.3 (68-100) at final follow-up (p<0.05). TAS angle increased from preoperative average 83.8o degrees (81-87) to 88.3o (85-89) and at final follow-up (p<0.05). Also tibio-calcaneal angle (TCA) decreased from 19.0o to 0.2o and Talar dome-ground surface angle (TD-GSA) decreased from 21.2o to 5.1o at final follow-up (p<0.05). Ninety percent of the patients were satisfied with the surgery.

Conclusion
We confirmed that adjunctive bony reconstructions are often necessary to successfully address the end-stage ankle arthritis with varus hindfoot deformity. TD-GSA and TCA were found important radiographic parameters related to the current disease entity.
Mid-term Revision Rates for a Semi Constrained Ankle Replacement Compared to a Mobile Bearing Ankle Replacement for Aseptic Loosening

Presenting Author: Alastair Younger, Vancouver, BC, Canada

Additional Authors: Timothy R. Daniels, MD; Murray J. Penner, MD; Tom Oxland, PhD; D. Joshua Mayich, MD; Kurt McInnes

Summary
7 of 113 mobile bearing ankles ankles with rigid bone fixation performed between 2000 and 2005 followed in 2011 were revised for aseptic loosening. Significantly more semi constrained ankles with less rigid bone fixation (24 of 135) performed between 1999 and 2005 were revised for aseptic loosening (p<0.005). The highest rate of loosening was seen for the most mobile component (p<0.005), the talar component in the semi constrained design. This conforms with our cadaver data.

Introduction
Treatment of end stage ankle arthritis includes the use of ankle joint replacement for specific indications. Ankle replacement has had a higher revision rate than hip and knee joint replacements, mainly due to aseptic loosening. In hip and knee replacement micromotion demonstrated by RSA analysis has been associated with aseptic loosening. We wished to determine if the difference in failure rate secondary to aseptic loosening of two different designs for which we have cadaver information on implant stability at the time of implantation.

Methods
At two institutions participating in a national database, one surgeon performing 135 semi constrained beaded ingrowth surface implants (implant A) from 1999 to 2005, and two surgeons performed 113 titanium plasma spray mobile bearing replacements (implant B) from 2000 to 2005. All operative reports of revision surgery were reviewed to identify loose metal components. The revision rate for aseptic loosening of metal components was compared at 6 to 11 years follow up. Revisions for sepsis or for fracture of the polyethylene component were excluded. Comparisons were made between ankles (implant A vs implant B) and between components (tibia vs talus). The revision rate for aseptic loosening was compared using Fisher’s exact test.

Results
There was a significantly higher rate of revision of implant A for aseptic loosening compared to implant B. Of the 113 Implant B’s 7 were revised on the talar side for aseptic loosening, and 2 on the tibial side. For the 135 implant A’s 24 talar components and 16 tibial components were revised for aseptic loosening (p<0.005). There was a higher rate of failed total number of components for implant A (p<0.0001) with 40 failed components at revision out of 270, vs 9 out of 226 for implant B. There was also a higher rate of aseptic loosening in Implant A between the talus and the tibia (p<0.005).

Conclusion
We have performed a cadaver study showing increased micro motion of implant A compared to implant B. We also showed increased motion in implant A’s talar component compared to the tibial component. The implants studied in the Cadaver study were implanted using the same techniques as used for this clinical series. This is the first time that we are aware of for any joint replacement (hip, knee, elbow, shoulder or ankle) that increased micro motion in a cadaver model has been positively associated with aseptic loosening rates. A weakness of the study is that another unstudied variable
may have caused the higher revision rate in implant A. However this would not explain the increased rate of revision of implant A’s talus compared to the tibial component. This provides evidence to indicate that replacements should be designed so that immediate bony stability is achieved at the time of implantation. New designs should adhere to this principle, and surgeons should select ankle joint replacements carefully with this information in mind.
10:15 – 10:40 am

Paper Session #14:
Complicated Ankle Arthroplasty Issues: Part II

Moderator:

Steven L. Haddad, MD
Glenview, Illinois

Johnny T.C. Lau, MD
Toronto, Ontario, Canada

10:15 am

Salvage Arthrodesis of the Hindfoot after Failed Total Ankle Replacement

Presenting Author: Norman Espinosa, MD
Zurich, Switzerland

Additional Authors:
Emanuel Benninger, MD; Fabienne Gerber; Georg Klummer, MD; Stefan Rahm, MD

Summary
This study investigates the clinical and radiographic outcomes after salvage hind foot arthrodesis due to failed total ankle replacement. Specific focus is put on complication rate and influence of technique.

Introduction
Total ankle replacement (TAR) has regained interest in the treatment of symptomatic end-stage ankle arthritis. However, longevity is limited and in case of failure ankle arthrodesis might be warranted. There is only few data available in literature regarding salvage arthrodesis after failed total ankle replacement. We present the short and midterm results in a series of patients that have been treated due to either septic or aseptic failure of total ankle replacement. The specific focus is put on technical influence regarding clinical outcome, union rate and complication.

Methods
From November 2002 until October 2010 nineteen patients underwent salvage ankle arthrodesis after failed total ankle replacement. All patients were retrospectively reviewed. Clinical outcome was assessed using the Foot Function Index, AOFAS hindfoot- and SF-36-scoring systems. In addition, all patients underwent radiographic assessment including conventional radiography and CT scans as well.

Results
Fourteen females and five males with a mean age of 60 years (range 26 – 79) participated in the study. The follow-up interval averaged 29 months (range 10 – 77). Fourteen patients showed aseptic loosening, while five revealed septic loosening of TAR. The following techniques were used to achieve hindfoot fusion: Screw fixation (N=5); intramedullary rod (N=7); blade plate (N=3); anterior double plating (N=4). All except one fusions were made using either an auto- or an allograft. Complete union
as confirmed by CT was achieved in 14 (74 %) patients after a mean time of 51 weeks (range 12 to 106). At final follow-up the SF-36 score reached an average value of 43 points (range 7 to 80 points). The foot function index (best score = 0%) reached 58% (range 22 to 74) for pain and 69% (range 42 to 98) for function. Six revision surgeries were necessary in a drug-addicted patient with low compliance. At final follow-up a fibrous union was achieved. Another two patients needed a second revision arthrodesis and one finally achieved complete union while the other was treated with a ring fixator because of an infection. The complication rate requiring further surgeries (hardware removal not included) was 26 % (i.e. five patients). All patients who had undergone anterior double plating arthrodesis had no complications and were clinically satisfied and showed complete union after a mean time of 15 weeks (12 to 20).

**Conclusion**
Salvage hindfoot arthrodesis after failed total ankle replacement has a high revision rate and surgeons should be aware of a possibly prolonged time until union when compared with primary ankle arthrodesis. Comparing the different salvage procedures best radiographic and clinical results were achieved in patients who underwent anterior double plating arthrodesis using either an allo- and/or an autograft.
The Place of Complete Division of the Deltoid Ligament in Total Ankle Replacement for Correction of Deformity

Presenting Author: Mr. Sunil Dhar, MBBS, MS, MCh Orth, FRCS, FRCS Orth
Nottingham, UK

Additional Authors: Mike Gale; Hatem Salem

Summary
Complete section of the deltoid ligament of the ankle is known to lead to medial instability with talar shift and valgus tilt. We have retrospectively analysed the effect of complete release of the deltoid ligament in severe ankle arthritis with significant varus deformities, both prior to and post total ankle replacement. No medial instability was encountered in any case postoperatively. The procedure can be safely carried out in specific instances.

Introduction
For a successful total ankle replacement, besides correctly sized and placed components, correct alignment and ligament balance are being increasingly recognised as essential. The medial deltoid ligament is vital for ankle stability and it’s sectioning leads to medial instability with talar shift and valgus tilt in most instances. However, the severely arthritic ankle with a significant varus deformity maybe an exception to the rule. We know that significant pre-operative deformity in the coronal plane is a risk factor for TAR failure if not adequately corrected because of altered mechanics and edge loading. We therefore proposed the hypothesis that a fixed varus deformity of the hindfoot has a major soft tissue component in the deltoid ligament and the tibialis posterior tendon. This shifts the centre of rotation of the ankle medially. Therefore, division of the soft tissue should correct the varus, restoring the centre of rotation to the centre of the joint where it should normally lie. This should also assist in correcting ankle frontal plane deformity and allow a TAR to be undertaken, where previously an ankle fusion may have been the only option.

Methods
Of over 400 TAR’s performed by the senior author (SD) between 1998 – 2010, 255 of these were the Scandinavian Total Ankle Replacement (STAR). Since October 2005 the senior author has performed TAR’s in 156 patients using the Mobility (DePuy) prosthesis. 96 patients had some pre-operative varus deformity (24%). Of these, 56 had documented pre-operative varus of >10 degrees. 16 joints (in 15 patients) required full deltoid ligament release to correct varus. All had a varus deformity of >15 degrees. The remainder were adequately corrected by joint debridement and bony cuts. We retrospectively analysed our cases of complete release of the deltoid ligament, specifically to assess any resultant joint instability.

Results
Average follow up was 37 months (3-84). 12 ankles required further surgery to achieve a stable balanced ankle (7 lateral ligament reconstruction, 5 tibialis posterior tendon lengthening and 3 calcaneal osteotomy and tib post lengthening in addition). The average preop varus deformity was 26 degrees. Full correction of deformity was obtained in all cases. However, there was a mean residual hind foot varus of 7.5 degrees (0-15). The average FFI score was 39.5 (0-59). No ankle had any evidence of medial instability either clinically or on weight bearing radiographs. The residual hind foot varus was attributed to the subtler joint. All patients stated they were “happy” with the eventual outcome of their ankle replacement.
Conclusion
In severely deformed (varus) arthritic ankles, the deltoid ligament can safely be sectioned without risk of the ankle developing medial instability or/and a valgus deformity. In such ankles, a lateral ligament reconstruction is likely to be needed to achieve lateral stability. This is best done in a staged fashion in our view and it is now the senior authors standard practice to counsel patients regarding this. The usual stages are an extensive medial release and TAR in stage 1 followed 6 weeks later by hind foot deformity correction (calcaneal osteotomy/STJ fusion) and/or a lateral ligament reconstruction.
Is Valgus Deformity Greater than Ten Degrees at the Ankle Really a Contraindication to Total Ankle Arthroplasty?

Presenting Author: Timothy R. Daniels, MD
Toronto, Ont, Canada

Additional Authors: D. Joshua Mayich, MD; Ellie Pinsker, BA & Sc, PhD Candidate

Summary
Although valgus deformity, in the presence of ankle arthritis, is commonly considered a contraindication to total ankle arthroplasty, the research substantiating this conclusion is sparse. 31 TAR in 29 patients with valgus deformity greater than 10 degrees were included in a longitudinal study. The two-year failure rate was 12.90%. ([CI] 3.63%–29.83%). Although clinical results from TAR in the setting of valgus can be good, the failure rate was relatively high. Caution should be exercised when performing TAR for this indication.

Introduction
Total ankle arthroplasty (or TAR) in the setting of coronal deformity is controversial. Historically, coronal deformity over 10 degrees was thought to be a contraindication; however, more recent literature has shown that acceptable outcomes can be achieved. Clinical information on the opposite deformity, valgus, is lacking. The purpose of this prospective cohort study was to evaluate survivorship of TAR components in the setting of preoperative valgus coronal deformity. A matched cohort of TAR performed in ankles with no coronal deformity was used for comparison.

Methods
Between 2001 and 2009 consecutive patients with valgus deformity greater than 10 degrees who were willing to undergo TAR were enrolled. A minimum of two-year follow-up was required. A primary outcome of revision of the metal components was selected. Secondary outcomes including reoperation and patient outcome scores, as well as radiographic and clinical data were also collected.

Results
31 TAR in 29 patients met the inclusion criteria. The two-year failure or metal component revision rate was 12.90%. (95% confidence interval [CI] 3.63%–29.83%). The two-year reoperation rate, which included any operation on the operated foot and ankle that was not a metal component revision, was 9.7% (95% confidence interval [CI] 2.56%–25.7%), with three patients requiring reoperation. This compared unfavorably to the control population. (Revision rate, reoperative rate) The AOS Pain Component decreased by an average of 27.7 ± 23.2 points in the valgus group and 34.7 ± 21.9 in the neutral group (p<0.01). There was no statistical difference in pain improvement between the two groups (p=0.793). The AOS Disability Component decreased by an average of 40.7 ± 18.6 points in the varus group and 38.0 ± 23.8 in the neutral group (p<0.01). There was no statistical difference in pain improvement between the two groups (p = 0.578).

Conclusion
Although clinical results from TAR in the setting of valgus can be quite good, the failure rate of TAR in this setting is relatively high. Caution should be used when attempting TAR in valgus deformity, and patients should be counseled appropriately before proceeding.
Revision Arthrodesis with the Use of Fresh Allograft and Rigid Plate Fixation

Presenting Author: Beat Hintermann, MD
Liestal, Switzerland

Additional Authors: Alexej Barg, MD; Markus Knupp, MD

Summary
Our surgical technique with the use of fresh allograft and anterior double plating was shown to be a reliable revision surgery method with low complication rate and high fusion rate. We recommend our treatment algorithm in this patient cohort with challenging bone conditions.

Introduction
End-stage ankle osteoarthritis is a debilitating condition that results in substantial functional limitation and a poor quality of life. Two treatment modalities have been discussed in the literature: arthrodesis as the traditional treatment and total ankle replacement (TAR) as an alternative method with increasing acceptance among orthopedic surgeons. Non-union in patients with ankle arthrodesis and failure of prosthesis components in patients with TAR belong to major postoperative complication requiring new treatment strategies. Revision arthrodesis in this patient cohort is technically demanding, especially due to decreased bone quality and/or deficient bone stock. The objectives of this study were therefore: 1) to describe our treatment algorithm and surgical technique in patients with failed ankle fusion / TAR, 2) to determine intra- and perioperative complications rate, and 3) to determine the fusion rate.

Methods
17 consecutive patients (8♂, 9♀, mean age 48 years, range 22 – 78) with failed TAR (n = 12) or failed ankle fusion (n = 5) were including into this prospective study. Patients with Charcot neuroarthropathy of midfoot and/or hindfoot were excluded. First, all hardware / prosthesis components were removed. Second, fibrous and necrotic tissue was removed until healthy, viable bone was exposed. In all patients isolated tibiotalar fusion was performed using anterior double plating with additional two oblique screws across the joint reaching the posterior aspect of talus under fluoroscopic control. In two patients additional posterior plate was used to achieve the appropriate primary stability. Postoperatively, all patients were allowed partial weight bearing during the first 8 weeks and full weight bearing thereafter. All patients were clinically and radiologically assessed after 3.5 (2 – 4.8) years. All radiographs were independently evaluated by two persons to assess the osseous healing. When not conclusive, computed tomography has been additionally performed.

Results
There were no intraoperative complications. Wound-healing occurred within two weeks after the surgery without adverse events in all but two cases. In two cases the infection resolved with intravenous antibiotics for 7 days, no operative debridement was necessary. A solid fusion at the site of arthrodesis was detected radiographically after 4, 6, and 8 months in 12, 4, and one patient, respectively. No ankles had to be revised. In three ankles progression of degenerative changes in subtalar joint was observed, however, up to date no subtalar fusion was necessary due to relatively low symptoms.
Conclusion
Our surgical technique with the use of fresh allograft and anterior double plating was shown to be a reliable revision surgery method with low complication rate and high fusion rate. We recommend our treatment algorithm in this patient cohort with challenging bone conditions.
WHERE IS THE EVIDENCE?

DEMOGRAPHICS

The incidence of Charcot Foot Arthropathy in a diabetic patient population appears to be approximately 0.3% per year. The typical patient is morbidly obese, has been diabetic for 10+ years, and has peripheral neuropathy as determined by insensitivity to the Semmes-Weinstein 5.07 monofilament.


HISTORICAL TREATMENT

The historical treatment of Charcot Foot Arthropathy involves immobilization of the involved foot in a short leg non-weight bearing total contact cast until the process resolves. This is followed by longitudinal management with accommodative bracing. This treatment is based primary on expert opinion and some small retrospective case series. Two recent prospective series have demonstrated that a weight bearing total contact cast can be successful in managing the acute destructive (Eichenholtz Stage II) phase of Charcot Foot.

SURGICAL INDICATIONS

A Longitudinal Observational Study using the AOFAS Diabetic Foot Questionnaire revealed that Charcot Foot imparts a severe negative impact on health related quality of life that is not lessened, even with successful treatment.


Patients who are clinically and radiographically non-plantigrade are likely to develop foot ulcers and skin breakdown in non-plantigrade regions of the foot.

<table>
<thead>
<tr>
<th>Clinically plantigrade</th>
<th>clinically non-plantigrade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiographic plantigrade</td>
<td>radiographic non-plantigrade</td>
</tr>
</tbody>
</table>

If the axis of the hindfoot (talus) is collinear with the axis of the forefoot (1st metatarsal), patients are unlikely to ulcerate. If this lateral talar-1st metatarsal angle is not collinear, patients are likely to ulcerate.

Is the definition of a favorable outcome simply limb salvage, or enhanced health related quality of life?
INTERNAL FIXATION FOR CORRECTION OF CHARCOT FOOT DEFORMITY

Introduction

a. Some Statistics
   i. Diabetes currently affects 246 million people worldwide and is expected to affect 380 million by 2025. (www.idf.org)
   ii. According to the CDC, 23.6 Million Americans (8%) have diabetes mellitus and it is on the rise (Increased 15.5% form 2003-2005). (www.diabetes.org)
   iii. 57 Million Americans are “Pre-Diabetic” (www.diabetes.org)
   iv. Amputations:
      1. 60% of amputations in the United States are due to diabetes
      2. About 70,000 Amputations/year occur due to diabetes
      3. The International Diabetes Foundation estimates that 85% of amputations are preventable. (www.idf.org)

b. Amputations are only part of the problem
   i. 73% of diabetics have hypertension
   ii. 60% of diabetics will die from a heart attack or stroke
   iii. Diabetes is the leading cause of Kidney Failure & Dialysis
   iv. $116 Billion per year on Diabetes

c. Foot and ankle Problems in diabetics come from chronic involvement of 3 systems
   i. Peripheral Neuropathy
      1. Sensory nerve loss results in pain and loss of sensation.
         a. Longer nerves are more involved...
         b. Causes “Stocking & Glove” loss of sensation
      2. Motor nerve loss results in weakness, contracture and deformity
      3. Autonomic nerve loss results in:
         a. Drying & cracking of skin (loss of integumentary protection from pathogens)
         b. Poor vasomotor control = Edema & Stasis
   ii. Vascular (Arterial)
      1. Diabetes represents an independent risk factor for large vessel disease
         a. Calcification of vessels is common & may make ABI measurements useless
         b. Small vessel disease is also extremely highly prevalent
         c. Combination can be devastating to wound healing potential
      2. Melton : Reviewed 1073 diabetic patients
         a. 8% with with one or more absent pulses
         b. 15% at ten years of diagnosis
         c. 45% at 20 years
         d. Duration of disease and degree of hyperglycemia correlate with the extent of disease present below the popliteal vessels.
   iii. Immune
      1. Hyperglycemia impairs macrophage function (phagocytosis)
2. Ketoacidosis delays migration of lymphocytes and impairs bactericidal function of these cells
3. Microangiopathy causes decreased tissue perfusion, oxygen levels and delivery of antibiotics

II. Traditional Treatment Models
   a. Casting
      i. Most patients with Neuroarthropathy present in the “Acute phase”.
      ii. Traditionally, treatment has been aimed at getting the patient form the “acute” phase into the “consolidation” phase before severe deformity develops.
      iii. Containment of the foot with a “total contact cast” is typically effective.
   b. Accommodative Bracing
      i. Patients with no little or no deformity whose foot is plantigrade typically function well with attention to daily foot care and an off the shelf or custom diabetic insole. These patients also need to be educated in daily foot care.
      ii. Patients with a “stable” rocker deformity may be able to be managed with a custom orthotic with relief posting for the offending prominence.
      iii. More severe deformities and minor instability can be managed with a Charcot Restraint Orthotic Walking boot (CROW Boot).
   c. Traditional Surgical Treatments
      i. Bone Resection of prominences causing ulceration
      ii. Tendo Achilles Lengthening and/or gastrocnemius recession.

III. Superconstructs
   a. “Superconstruct” — A superconstruct is defined by four factors:
      i. fusion is extended beyond the zone of injury to include joints that are not affected to improve fixation
      ii. bone resection is performed to shorten the extremity to allow for adequate reduction of deformity without undue tension on the soft tissue envelope
      iii. the strongest device is used that can be tolerated by the soft tissue envelope
      iv. devices are applied in a position that maximizes mechanical function.
   b. Reasoning for “Superconstruct” Methods in Neuroarthropathic Joints
      i. A subset of patients exists where gross instability of the neuroarthropathic joints makes management with a bracing and orthotics difficult or impossible.
      ii. These patients may benefit from deformity correction with arthrodesis of the foot.
      iii. Traditional fixation methods have been fraught with complications including loss of correction, reactivation of the Charcot process.
      iv. Reasons for these problems include:
          1. Poor Bone Quality
             a. “Dissolution” of the neuroarthropathic area occurs due to sympathetic denervation and resultant hyperemia
             b. Bone is often osteoporotic to begin with
             c. The bone becomes fragmented as part of the neuroarthropathic process.
          2. Poor Vascularity
             a. High rate of microvascular disease even when large vessel flow is good
             b. The bone itself may become dysvascular in the neuroarthropathic process
          3. Extended Healing Times
             a. Diabetics have poor immune function
b. Glycosylated tissues have poor healing potential
4. Poor Patient Compliance with restricted weight bearing protocols.¹
5. Progressive contracture of soft tissue envelope leads to irreducible dislocation.

v. Superconstruct methods attempt to improve initial mechanical stability and improve overall fatigue resistance.

IV. Plantar Plating
a. Schon recognized that application of plates in a plantar location offered multiple mechanical advantages, despite technical difficulties in applying the device in this location.
b. Schon developed the concept of plantar plating to improve the strength of the construct, noting that the plantar location would improve the intraoperative ability to achieve correction and place the device under tension during weight bearing.
c. In a simulated midfoot fusion model, Marks and colleagues showed that application of the plates plantarly was biomechanically more stable than crossed screws in stiffness and in load to failure.⁵
d. A similar study comparing plantar plate fixation with screw fixation for metatarsal osteotomies yielded similar results.⁶
e. Schon and colleagues reported successful results using this technique in 34 patients who had severe midfoot neuroarthropathic disease.⁷
V. Locked Plating
   a. Locked Plates create a fixed-angle device by rigidly attaching the screw to the plate.
   b. Locked Plates have the advantage of significantly improving fixation in osteoporotic bone.\(^8^9\)
   c. No clinical series to date, although anecdotal use reported.

VI. Axial Screw Fixation
   a. Refers to passing long screws through the foot so that the screw lies in the intramedullary canal of the metatarsals distally, and bridges the area of Charcot dissolution.
   b. Sammarco 1991 – Calcaneus to 4th MT shaft for lateral column fixation
   c. Sammarco and colleagues 2009\(^10\) - Twenty-two patients were followed for an average 52 months (minimum 2 years' follow-up). At final follow-up, there were no amputations, and all patients were considered to have successful limb salvage.

Reference List


Symposium #6: Diabetes, Saturday, June 23, 2012
11:15 am

Static Ring Fixation
Carroll P. Jones, III, MD
Charlotte, North Carolina

Who can be treated without surgery:
- Clinically and radiographically plantigrade.
- No open wounds / osteomyelitis.
- No evidence for painful "hypertrophic nonunion" appearance of Eichenholtz Stage III.

Who can be treated with internal fixation:
- No open wounds / osteomyelitis
- Good clinical host
- Good bone quality
- Not morbidly obese

Candidates for Static ring fixation of Charcot foot
- Open wounds with osteomyelitis
- Poor clinical host
- Poor bone quality
- Morbidly obese

Surgical steps

1. Percutaneous tendon Achilles lengthening or gastrocnemius lengthening to create motor balance. Remember that these patients have motor and vasomotor neuropathy in addition to sensory peripheral neuropathy.
2. Correction of the deformity through a small incision at the apex of the deformity. Remove a wedge of bone. Obtain tissue cultures from the infected bone. Patients will require culture-specific parenteral antibiotic therapy if infection is present at the time of surgery.
3. Apply a pre-assembled three-level static ring fixator.

References
Dynamic External Fixation in Charcot Arthropathy
Michael J. Pinzur, MD
Maywood, Illinois

Why is the ankle different from the foot?

Ankle Fractures in Neuropathic Patients
- High potential for mechanical failure
- High potential for infection
- Require “super constructs”

Ankle Fusion in neuropathic patients
- Most stability afforded by retrograde locked IM nail
- Circular Fixation best in the presence of infection
- New locked plates have been demonstrated to be successful in retrospective case series

References
5. Wukich, D, Belczyk, RJ, Burns, PR, Frykberg, RG: Complications Encountered with Circular Ring Fixation in Persons with Diabetes Mellitus. Foot Ank Int. 29: 994-1000, 2008.
Progressive Foot Deformity Evident in Neuropathic Charcot Arthropathy at One and Two Years

Presenting Author: Jeffrey E. Johnson, MD
St. Louis, Missouri

Additional Authors: Mary K. Hastings, PT, DPT, ATC; Michael J. Strube, PhD; Charles F. Hildebolt, DDS, PhD; Kay L. Bohnert, MS; Fred W. Prior, PhD; David R. Sinacore, PT, PhD, FAPTA

Summary
Foot deformity associated with neuropathic Charcot arthropathy (NCA) contributes to joint instability and amputation. Weightbearing radiographic measures of alignment were collected for up to 2 year on participants with NCA, participants with diabetes and peripheral neuropathy, and unimpaired participants. Radiographic alignment measures demonstrate baseline foot deformity in the NCA involved feet with progressive alignment worsening (“creep”) over the first and second year. Six-month interval data suggest worsening of alignment of the medial column prior to the lateral column.

Introduction
Foot deformity associated with neuropathic Charcot arthropathy (NCA) contributes to joint instability, ulceration, and amputation. The purpose of this study was to follow patients with and without acute NCA for up to 2 years to examine the magnitude and timing of foot alignment changes.

Methods
We followed 15 subject with NCA (8 men, 7 women) and 19 subjects with diabetes mellitus (DM) and peripheral neuropathy (PN) without NCA (DMPN group) (8 men, 11 women) for one year. Eight NCA and five DMPN participants were followed for two years. Sixteen subjects without DM, PN, or NCA (8 men, 8 women) served as a baseline unimpaired comparison group. Bilateral weightbearing foot radiographs were completed at baseline for all 3 groups, repeated at 6 months for the NCA group, and year one and two for the NCA and DMPN groups. The following measures were obtained from radiographs: Meary's angle, cuboid height, calcaneal pitch, and hindfoot-forefoot angle. Repeated measures analysis of variance (ANOVA) was used to assess the differences between NCA and DMPN groups, time points, and feet (involved and uninvolved). An ANOVA was used to assess the differences in baseline measures between groups.
Results
Meary's angle, cuboid height, and calcaneal pitch were worse in NCA involved feet at baseline (p<.05), one year (p<.05), and two years (p<.02) compared with the NCA uninvolved and DMPN feet. Baseline Meary's angle and cuboid height were worse in NCA involved feet compared to unimpaired comparison feet (p<.01) and Meary's angle was worse in NCA uninvolved feet compared to unimpaired comparison feet (p=.03). NCA involved feet alignment worsened over year one as measured by Meary's angle (p<.01), cuboid height (p<.01), and calcaneal pitch (p<.01) and cuboid alignment continued to worsen over year two (p=.01). The NCA involved feet, with six-month interval data during year one, had worsening of Meary's angle during the first 6 months (p=.03) and remained stable for the remaining follow up period. The change in hindfoot-forefoot angle over one year was worse in the NCA involved feet compared to the NCA uninvolved (p=.02) and DMPN feet (p=.01).

Conclusion
Radiographic alignment measures demonstrate baseline foot deformity with progressive changes (“creep”) over the first and second year. Six-month interval data suggest worsening of alignment of the medial column prior to the lateral column. Repeat alignment measures provide useful information about foot alignment stability and changes our traditional understanding of the natural history of NCA. Radiographic evidence of worsening foot alignment indicates the need for aggressive intervention (conservative bracing or surgical fixation) to prevent limb threatening complications from severe deformity and joint instability. Funded by R21 DK079457, K12 HD055931, K30 RR022251, UL1 RR 024992, R01 DK059224.
Medial Navicular Subluxation as a Radiographic Indicator of Charcot Neuroarthropathy: A Retrospective Radiographic Review

Presenting Author: Allyson Estess, MD
Los Angeles, California

Additional Authors: Timothy P. Charlton, MD; David B. Thordarson, MD; N. Marquand, BS

Background:
Various studies have attempted to classify clinical and radiographic Charcot changes based on anatomic location, stage and severity in an attempt to aid in the treatment of this complex clinical problem. None of the previous studies have had good predictive ability of the onset of midfoot Charcot arthropathy.

Purpose: This study was undertaken to assess if medial navicular subluxation (adduction of the navicular on the talus) is a radiographic precursor present in patients with Charcot arthropathy and if this finding could potentially play a direct role in guiding management options.

Study Design:
Retrospective radiograph and chart review.

Methods:
A retrospective review of 143 consecutive patients diagnosed with Charcot arthropathy of the foot from January 2004 to May 2011 was performed. Patients were identified based on a clinical diagnosis code 713.5 during an outpatient clinic visit from 2 surgeons at a single institution. After exclusion criteria, a series of radiographs of 50 feet in 40 patients was compared to an age matched control group. Radiographic data including talonavicular coverage angle and talonavicular uncoverage percentage were collected.

Results:
Statistical significance (p<0.05) was noted when comparing the mean talonavicular coverage angle of the Charcot arthropathy group (1.5 degrees) and the control group (12.1 degrees). Statistical significance was also noted when comparing the talonavicular uncoverage percent of the Charcot arthropathy group (12.2%) and the control group (22.0%). There was no statistical difference between the groups in regards to demographic data.

Conclusions:
Medial navicular subluxation is a radiographic finding that is more commonly present in patients with Charcot arthropathy than a matched control group. It is theorized that this is due to an unopposed pull of the posterior tibial tendon on the navicular. As a result, the senior author has performed a posterior tibial tendon tenotomy to facilitate midfoot reduction during Charcot reconstructions and this is the subject of future study.
The Effect of Lower Limb Cast Immobilisation on Calf Pump Function

Presenting Author:  Mr. Ben A. Hickey, BM, MRCS  
Cardiff, Wales

Additional Authors: Amy Claire Morgan, MBBch, MRCS, Orthopaedic Registrar;  
Dr. Neil Pugh, PhD FInstP C.Phys, consultant Medical Physicist;  
Anthony Perera, MBChB, MRCS, MFSEM, PGDip (Med Law), FRCS (Orth)

Summary
Lower limb cast immobilisation is associated with venous thromboembolism. Our aim was to determine the effects of below knee cast on calf pump function. Twenty participants were enrolled. Four movements (toe dorsi-flexion, toe plantar flexion, ankle dorsi-flexion, ankle plantar flexion) were performed pre and post application of below knee cast. Systolic velocity was measured at the popliteal vein using doppler. All movements significantly increased systolic velocity (p=0.0001). Cast application did not significantly impair calf pump function.

Introduction
Patients treated with lower limb cast immobilisation are at risk of venous thrombo-embolism (VTE). This may result from localised endothelial damage or altered calf pump function causing venous stasis. In an audit of patients treated with lower limb cast immobilisation at our institution between 1/1/2010 and 11/5/2011, 20 patients sustained symptomatic VTE within 6 months after cast immobilisation. All except 1 occurred in the casted limb. Therefore, VTE appears to be localised to the injured/casted limb. Our aim was to determine the effects of below knee cast on calf pump function to help direct treatment to prevent VTE.

Methods
Twenty healthy participants were enrolled in this research and ethics approved prospective study. Four foot and ankle movements (toe dorsi-flexion, toe plantar flexion, ankle dorsi-flexion, ankle plantar flexion) were performed by participants pre and post application of a below knee cast. Baseline and peak systolic velocity was measured at the popliteal vein during each movement. Participants with peripheral vascular disease, varicose veins, deep venous thrombosis or previous foot and ankle surgery were excluded.

Results
The mean patient age was 31 years (range 21-58), eleven were female. With cast in situ all movements resulted in a statistically significant increase in peak systolic velocity (p=0.0001). Toe dorsi-flexion increased velocity from baseline 8.8cm/s (4.2-21.7) to 53.6 cm/s peak (12.8-152.8) pre cast and 59.1 cm/s peak (10.5-184.1) post cast (pre-post mean difference p=0.572). Toe plantar-flexion increased velocity from baseline 9.2 cm/s (5.8-17.6) to 49.7 cm/s peak (15.5-127.7) pre cast and 57.3 cm/s peak (20.9-108.3) post cast (pre-post mean difference p=0.299). Ankle dorsi-flexion increased velocity from baseline 10.3 cm/s (5.4-26.4) to 115.4 cm/s peak (31.5-189) pre cast and 88.2 cm/s peak (23.2-234.2) post cast (pre-post mean difference p=0.299). Ankle dorsi-flexion increased velocity from baseline 10.3 cm/s (5.4-26.4) to 115.4 cm/s peak (31.5-189) pre cast and 88.2 cm/s peak (23.2-234.2) post cast (pre-post mean difference p=0.299). Although the post cast peak velocity was reduced compared to pre cast peak, the velocity still increased approximately 10 times from baseline. Ankle plantar-flexion increased velocity from baseline 11.4 cm/s (5.4-32.1) to 86.6 cm/s peak (39.9-158.9) pre cast and 112.9 cm/s peak (34.1-265.5) post cast (pre-post mean difference p=0.23).
Conclusion
This is the first study to examine the effect of lower limb cast immobilisation on calf pump function. Despite immobilisation, toe movements can increase popliteal vein velocity at least 5 times compared to measurement at rest. Ankle plantar flexion increased popliteal vein velocity at least 8 times compared to baseline, both pre and post cast immobilisation. Lower limb cast immobilisation did reduce the peak velocity achieved by ankle dorsiflexion compared to pre-cast peak, however the post cast peak was still significantly greater than baseline (8x baseline velocity). Toe and ankle movement significantly increases calf pump function in participants with below knee cast immobilisation. We recommend that all patients treated with below knee cast immobilisation are advised to perform regular toe and ankle exercises to reduce venous stasis and risk of VTE. One limitation of our study is that measurements were performed on healthy participants. We are therefore currently performing a further study in patients who have had lower limb cast immobilisation to verify our preliminary findings.
The Tripod Index Part 2: Diagnostic Accuracy in Symptomatic Flatfoot

Presenting Author: Marut Arunakul, MD
Iowa City, Iowa

Additional Authors: Phinit Phisitkul, MD; Jessica Goetz, PhD; John E. Femino, MD; Ned Amendola, MD

Summary
The Tripod Index showed high accuracy as a quantitative assessment in the diagnosis of a symptomatic flatfoot. The Tripod Index might be applied to clinical diagnosis of symptomatic flatfoot.

Introduction
The Tripod Index (TI) has been created to allow assessment of complex foot deformities involving multiple planes and levels such as flatfoot and cavovarus deformities. It utilizes the relationship between center of the heel, medial/lateral borders of the forefoot, and center of the talar head. This study aimed to verify diagnostic accuracy of the TI in symptomatic flatfoot.

Methods
Weight-bearing radiographs including foot AP with a hemispherical marker around the heel, lateral, and hindfoot alignment views were obtained on 91 patients (110 feet) presented with medial foot and ankle pain between June 2010 and May 2011 including 20 surgically indicated symptomatic flatfoot, 9 surgically indicated tarsal tunnel syndrome, 6 surgically indicated FHL tenosynovitis, 15 surgically indicated anteromedial ankle impingement, and 60 non-operatively treated plantar fasciitis. Radiographs were evaluated blindly for the TI, AP talonavicular coverage angle, lateral talo-first metatarsal angle, calcaneal pitch angle, medial cuneiform-fifth metatarsal height, and coronal plane hindfoot alignment. The sensitivity, specificity, likelihood ratios, and predictive values were calculated. Clinically diagnosed flatfoot deformity indicated for surgical reconstruction by one of the senior foot and ankle orthopaedic surgeon was used as the accepted standard for diagnosis.

Results
The sensitivity of the TI was 100%, comparable with coronal plane hindfoot alignment (95%), AP talonavicular coverage angle (95%), lateral talo-first metatarsal angle (100%), and medial cuneiform-fifth metatarsal height (100%). The specificity of the TI was 93%, comparable with coronal plane hindfoot alignment (98%) and lateral talo-first metatarsal angle (87%), but superior to AP talonavicular coverage angle (64%), calcaneal pitch angle (61%), and medial cuneiform-fifth metatarsal height (82%). The positive likelihood ratio of the TI was 14.29, which was less than coronal plane hindfoot alignment (47.5), but more than the AP talonavicular coverage angle (2.64), lateral talo-first metatarsal angle (7.69), calcaneal pitch angle (2.31), and medial cuneiform-fifth metatarsal height (5.56). The negative likelihood ratio of the TI was 0. The positive and negative predictive values were 77% and 100%, respectively.

Conclusion
The Tripod Index showed high accuracy as a quantitative assessment in the diagnosis of a symptomatic flatfoot.
<table>
<thead>
<tr>
<th>Diagnostic Accuracy Parameters</th>
<th>Tripod Index</th>
<th>Coronal Plane Hindfoot Alignment</th>
<th>AP Talonavicular Coverage Angle</th>
<th>Lateral Talonavicular First MTB Angle</th>
<th>Calcaneal Pitch Angle</th>
<th>Medial eminiform - Fifth MTB Height</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cutoff point*</td>
<td>≥ 26 %</td>
<td>≥ 8 mm</td>
<td>≥ 14 degree</td>
<td>≥ 8 degree</td>
<td>≤ 19 degree</td>
<td>≤ 6 mm</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>100%</td>
<td>95%</td>
<td>95%</td>
<td>100%</td>
<td>90%</td>
<td>100%</td>
</tr>
<tr>
<td>Specificity</td>
<td>93%</td>
<td>98%</td>
<td>64%</td>
<td>87%</td>
<td>61%</td>
<td>82%</td>
</tr>
<tr>
<td>Positive likelihood ratio</td>
<td>14.29</td>
<td>47.5</td>
<td>2.64</td>
<td>7.69</td>
<td>2.31</td>
<td>5.56</td>
</tr>
<tr>
<td>Negative likelihood ratio</td>
<td>0</td>
<td>0.05</td>
<td>0.08</td>
<td>0</td>
<td>0.1</td>
<td>0</td>
</tr>
<tr>
<td>Positive predictive value</td>
<td>77%</td>
<td>95%</td>
<td>59%</td>
<td>63%</td>
<td>34%</td>
<td>56%</td>
</tr>
<tr>
<td>Negative predictive value</td>
<td>100%</td>
<td>99%</td>
<td>98%</td>
<td>100%</td>
<td>95%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Table 1 Cut-off point, Sensitivity, Specificity, Likelihood ratios, and Predictive values of Tripods Index and other current accepted radiographic parameters for diagnosing symptomatic flatfoot.

*Data from Tripods Index Part 1: New radiographic parameter assessing foot alignment