Clinical Research on Foot & Ankle

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Abstract

Background: To The aim of this study is to assess the correction of adult Stage II/A fexible fatfoot deformity using a combination of gastrocnemius aponeurosis lengthening, arthroereisis and percutaneous medializing calcaneal osteotomy.

Methods: From 2014 to 2018, data were collected on 35 feet over 31 patients, with 4 bilateral cases, who underwent this combination technique. The average age of the patients was 37 years. Inclusion criteria were Stage II/A fexible fatfoot, whereas the exclusion criteria were other Stages of fatfoot, rigid fatfoot, synostoses and fatfoot with congenital and neurological malformation. We used the lateral and anteroposterior talocalcaneal angles as well as medial arch angle and talo-frst metatarsal angle measurements to assess e f cacy of our technique. All data were analyzed statistically with Student's t test.

Results: The mean values of the preoperative and postoperative weightbearing radiographic angles are 137° vs 123° for the Medial Arch Angle, 8° vs 3° for the Talo-frst metatarsal angle, 34° vs 27° for the anteroposterior Talocalcaneal divergence angle and 42° vs 39° for the lateral Talocalcaneal divergence angle ($p<0.001$). In 33 of 35 feet (94%) the results we observed show the improvement of radiographic measurements as well as normal foot function at 6 months. Mean follow up time was 37 months. American Orthopedic Foot and Ankle Society (AOFAS) scores were calculated for all patients, and based on fnal results; it showed improvement on the 3 scales of pain, function and alignment.

Conclusion: Based on the literature and on our statistical results we fnd that combining gastrocnemius aponeurosis lengthening with arthroereisis and percutaneous medializing calcaneal osteotomy is an optimal surgery for the correction of Stage II/A fexible fatfoot.

Keywords

Arthroereisis; Percutaneous; Calcaneal osteotomy; Gastrocnemius lengthening

Abbreviations

American Orthopedic Foot and Ankle Society (AOFAS); Anteroposterior (AP); Flexor Digitorum Longus (FDL); Posterior Tibial Tendon De -ciency (PTTD)

Introduction

Adult exible atfoot is de ned as a weight bearing attening of the medial arch of the foot in addition to plantar exion of the talus [1]. e posterior tibial tendon dysfunction is the most common factor leading to development of atfoot [2]. e pull of the Achilles tendon falls lateral to the axis of the subtalar joint creating excessive hindfoot valgus [2]. Over time, static stabilizers of the medial foot like spring ligament becomes attenuated [3].

Stage I PTTD consists of a painful synovitis but no deformity as the tendon has a normal function. Stage II/A describes progressive failure of the tendon with a exible atfoot deformity, which is correctable passively, with mild sinus tarsi pain whereas in Stage II/B talonavicular uncoverage is >40% in addition to the presence of forefoot abduction. In Stage III, the deformity is rigid with degenerative changes in the midfoot and hindfoot [4]. Finally, stage IV describes valgus tilting of the talus within the ankle mortise with associated deltoid insu ciency, with or without tibiotalar arthritis [5].

We performed physical exam to determine exibility and deformity of Stage II/A and assess any de cits of posterior tibial tendon or spring ligament [1]. In Flexible Flatfoot we will encounter inversion loss or eversion caused by subtalar or Chopart's joint dysfunction or PTTD [6]. e posterior tibial tendon is involved when the foot is everted; reduced active inversion may suggest spring ligament lesion [6]. e too many toes sign is a result of forefoot abduction and is included in Stage II/B deformity; Hallux Valgus is an associated nding in Flatfoot deformity [3]. Flatfoot is considered pathological when it is symptomatic; Pain is o en located me-

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rence of each including lateral column procedures which carry the risk of arthritis at the calcaneocuboid joint and exor digitorum longus tendon transfer which can fail and lead to recurrence [7]. e percutaneous medializing calcaneal osteotomy corrects the hindfoot valgus by translating the calcaneal tuberosity medially realigning the Achilles tendon and reduces skin complications [8]. Medializing calcaneal osteotomy a er 5 years of follow up, showed 91% of patient satisfaction [9].

Arthroereisis or sinus tarsi implant is used to reduce talonavicular divergence and correct hindfoot valgus by applying a conical implant in between the anterior apophysis of the calcaneus and the reduced lateral process of the talus [10]. Gastrocnemius muscle retraction is also an asso-

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ciated factor leading to hindfoot valgus; thus, gastrocnemius aponeurosis lengthening is an added technique to further realign the hindfoot [11]. We reviewed the literature and we opted to combine percutaneous medializing calcaneal osteotomy, arthroereisis and gastrocnemius aponeurosis lengthening to deal with stage II/A atfoot addressing its deformities with minimal complications and without medial so tissue repair.

Methods

Data collection

Between 2014 and 2018, data on 31 non-athlete patients were collected (4 patients treated bilaterally) 18 women and 13 men, with mean BMI of 27.2 kg/m2 who underwent percutaneous correction of exible adult atfoot at the Hôpitaux Civils de Colmar France using a combination of three procedures: Gastrocnemius aponeurosis lengthening, arthroereisis and percutaneous medializing calcaneal osteotomy. e inclusion criteria of this study were adult exible atfoot Stage II/A. In this study we used 4 angles to assess the atfoot deformity preoperatively and postoperatively, the lateral and AP angles of the Talocalcaneal divergence which refers to the angle between lines drawn down the long axis of the talus and calcaneus measured on a weight bearing AP and lateral foot radiography, Lateral (normal values between 30°-50°) and AP (normal values between 20°-30°), along with Talo- rst metatarsal Angle comprising the angle between the longitudinal axis of talus and that of rst metatarsal bone on weight bearing lateral foot radiography (Normal Values Between 0°-4°) and Medial Arch Angle that is formed by three speci c points in the standing patient: the lower point of the calcaneus, the lower point of the talus-navicular joint and the impact point of the medial sesamoid bone (normal values between 120°-130°) at a lateral foot radiography [1,2,7] . is is a retrospective single centre study that was conducted on a total of 35 feet in 31 patients between the ages of 29 years and 55 years with an average length of follow up to 37 months. All patients have the clinical diagnosis of adult exible atfoot Stage II/A; we excluded patients with rigid atfoot, tarsal coalitions, congenital or neurological malformation. At our medical institution, the clinical assessment of a patient with atfoot consists of a medical examination of the foot and radiography measurements and AOFAS ankle-Hindfoot score.

Surgical technique

Patient lied in prone position with the foot free. Tourniquet placed at the thigh in ated at 100 mmHg above the systolic blood pressure. C arm placed properly to obtain true AP and lateral views and wrapped with sterile plastic coverage (Figure 1).

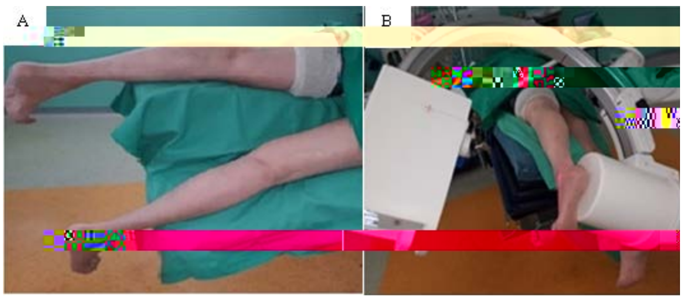

Figure 1: A) Surgical Prone Position. B) Surgical Prone Position with C-arm.

Sterile prepping and draping of the foot. Next, a 3 cm midline incision was performed over the posterior aspect at the middle third of the leg and a Z plasty of the gastrocnemius aponeurosis to induce lengthening (Figure 2).

Figure 2: Surgical Illustration Showing Z Lengthening of Gastrocnemius Aponeurosis.

en we performed medializing calcaneal osteotomy via a percutaneous chevron osteotomy (Figure 3A).

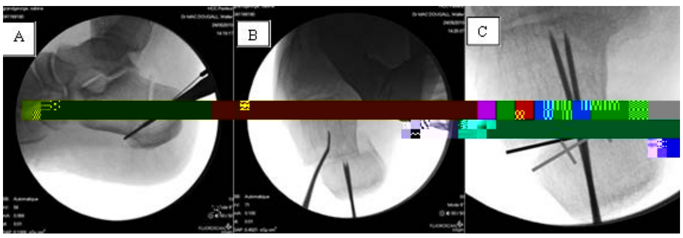

Figure 3: A) A Pro le Radiographic View of Calcaneal Chevron Osteotomy. B) Axial View Shows Medialisation Using Lever Arm. C) Axial Radiographic View Shows Medial Translation of Not More an One ird of Calcaneal Width with Slight Internal Rotation of the Posterior Calcaneal Fragment.

Additionally, we performed a slight medial rotation of the posterior calcaneal fragment and medial translation of not more than one third of calcaneal width for further correction ad [(A)26 (8s (icn)mm (Figur)13 (es 3B a)9

At last, we performed arthroereisis via a lateral percutaneous approach under radiographic guidance, the size of sinus tarsi implant is chosen ac-cording to the t of the implant inside the sinus tarsi joint, the implant being conical in shape and lock the talocalcaneal joint in a reduced state and furthermore aids in talonavicular coverage (Figure 4).

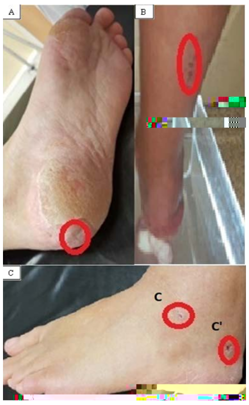

Figure 4: A) Axial A Postero-Inferior Incision for Calcaneal Osteosyntesis. B) Incision for Gastrocnemius Aponeurosis Lengthening at the Posterior Distal Third of the Leg. C) Laternal Incision at the Level of Sinus Tarsi for Arthroereisis. 2-C' Laternal Incision for the Percutaneous Calcaneal Osteotomy.

Postoperative management involved protected non-weight bearing in a cast in a neutral position for 2 weeks. Emphasis was placed on postoperative elevation of the limb to minimize the inevitable swelling that results after surgery. Touchdown weight bearing in a cast continues for an additional 4 weeks. Weight bearing radiographs were obtained at 8 weeks postoperatively to assess correction and alignment. The patient was encouraged to begin regular shoe wear after 12 postoperative weeks.

Statistical analysis

Experimental data were analyzed using "GraphPad Prism 6"(La Jolla, CA, USA). Data were presented as mean ± SEM. All groups of the data were firstly assessed for normal distribution (using the Kolmogorov–Smirnov test) with outliers excluded. Comparison between two groups was performed using a two tailed unpaired t-test for normal distributed data or a" Mann–Whitney U-test "for nonparametric data. All data sets were significant with p value < 0.0001 . All data were analyzed statistically with "Student's t test".

Results

In order to assess the correction of flexible adult flatfoot deformity, we measured the mean values of the preoperative and postoperative weight bearing radiography angles as well as the AOFAS scores.

The medial arch angle was reduced postoperatively with measured values seen in (Figure 5). A significant decrease was observed for the talo-first metatarsal angle (Figure 6). The AP talocalcaneal divergence angle was also reduced (Figure 7). Finally, a significant statistical difference between the preoperative and postoperative lateral Talocalcaneal divergence angle (p<0.001) (Figure 8). In all of the studied cases, the results were back within normal radiographic ranges (Table 1) as well as normal postoperative foot function; pain and alignment according to the AOFAS hind foot score (Table 2).

Angle	Preoperative	Postoperative	Mean difference ± SEM
Medial arch angle	135 ± 2	121 ± 1	14± 1
Talo-first metatarsal Angle	6 ± 1	2	4
AP Talocalcaneal angle	34 ±1	27 ± 1	8 ± 1
lateral Talocalcaneal angle	46 ± 1	37 ± 1	9 ± 1

Table 1: Mean radiographic preoperative and postoperative measured angles result with their mean difference and standard error of the mean SEM.

Result	Preoperative	Postoperative	Mean difference ± SEM
AOFAS score	48 ± 8	78 ± 6	29 ± 6

Table 2: Mean clinical preoperative and postoperative AOFAS score result with it is mean difference and standard error of the mean SEM.

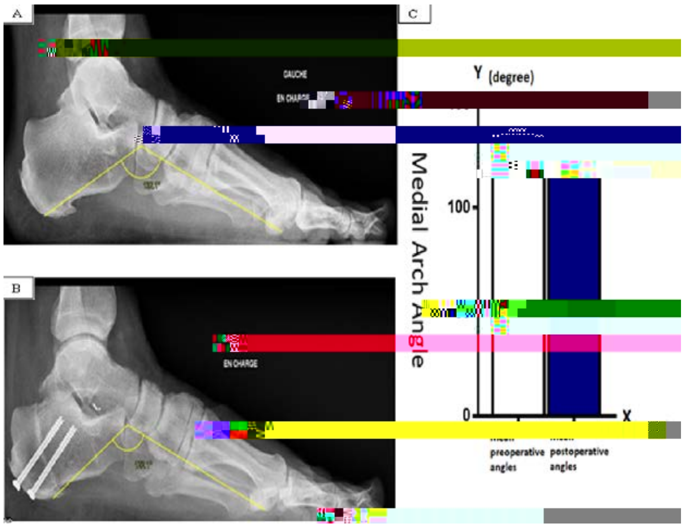

Figure 5: A) Axial Preoperative Medial Arche Angle Measurement on a Lateral Ankle Plain Radiograph. B) Postoperative Medial Arche Angle Measurement on a Lateral Ankle Plain Radiograph. C) Results of the Mean Distribution of the Medial Arche Preoperatively and Postoperatively.

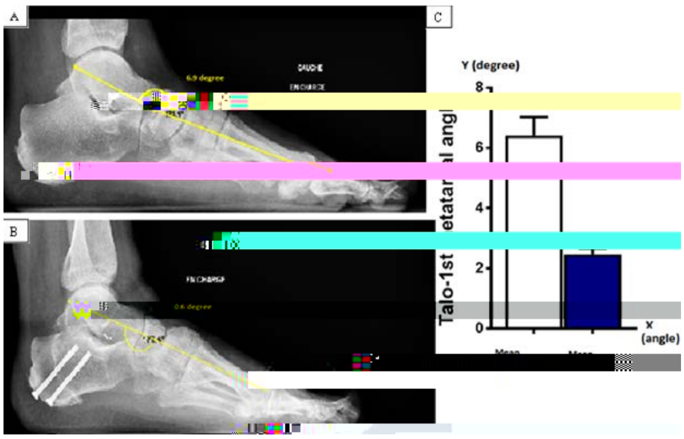

Figure 6: A) Preoperative Tarso-1st Metatarsal Angle Measurement on a Laternal Ankle Plain Radiograph. B) Postoperative Tarso-1st Metatarsal Angle Measurement on a Laternal Ankle Plain Radiograph. C) Results of the Mean Distribution of the Tarso-1st Metatarsal Angle Preoperatively and Postoperatively.

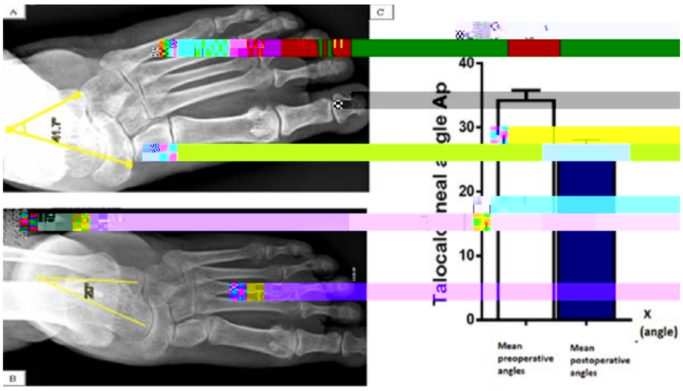

Figure 7: A) Preoperative Talocalcaneal Divergence Angle Measurement on an Anteroposterior Ankle Plain Radiograph. B) Postoperative Talocalcaneal Divergence Angle Measurement on an Anteroposterior Ankle Plain Radiograph. 325ce ier

provement in radiographic parameters measured at 6 months (97%) and at nal follow up (87%) which show nearly the same postoperative results as our combination technique. It has been hypothesized that medializing calcaneal osteotomy corrects atfoot deformity by re-tensioning the plantar fascia [25]. Spring ligament reconstruction corrects the atfoot deformity in cadaveric studies but has not been proven clinically [26].

e most common lateral column procedures are both Evans lateral column lengthening through the distal calcaneus [27-29] and calcaneocuboid distraction arthrodesis [28,30].

e aim of the lateral calcaneal lengthening is to adduct the forefoot at the talonavicular joint and correct the peritalar subluxation [29,31].

As the lateral column is lengthened, the navicular is translated medially on the talar head. is results in plantar exion of the forefoot at the talonavicular joint and elevation of the medial longitudinal arch. Nonunion rate is quoted as 1%–5% with increased risk in smokers [28,32,33].

A criticism of lateral column lengthening is that it does not correct the deforming force of the achilles tendon and leads to inadequate correction of hindfoot valgus and is better used for correction forefoot abduction rather than hindfoot valgus [32]. Medializing calcaneal osteotomy can correct hindfoot valgus and alter the direction of pu (c)-7(f t)-6 (h)er tationha,32,33].4.9 (m)2(l)-((les t)6 (en)45o)12 Tw -1.675 -1.2 6 0 (a)-5 (lo)12 (na)

Con ict of Interest

We have no con ict of interests to disclose and the manuscript has been read and approved by all named authors.

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