Double calcaneal osteotomy and percutaneous tenoplasty for adequate arch restoration in adult flexible flat foot

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Abstract Treatment of adult acquired flexible flat foot deformity can be problematic. Triple arthrodesis for structural correction has been the standard of care, thus sacrificing hind foot motion. The objective of this study was to assess the value of double calcaneal osteotomies in improving structural alignment while maintaining hind foot motion, which may further protect the function of adjacent motion segments. Double calcaneal osteotomies (Evans osteotomy and posterior calcaneal displacement osteotomy) were performed on 17 feet of 14 patients. Postoperative follow-up showed significant improvement in clinical foot and ankle scores.

Introduction

Flat foot is a complex deformity characterised by decrease in the medial arch height in which the talus is rotated medially and plantarward, the forefoot is pronated and abducted, and the talonavicular coverage angle is decreased. Also, the Achilles tendon may be shortened and exert a valgus moment on the calcaneus [1–3]. All of these lead to shifting of the load from the lateral column to the medial column, and consequently loss of the medial arch height [4, 5].

Previously, hind foot fusion procedures were the only way to manage this deformity. Unfortunately, extended hind foot fusions strongly affect hind foot motion [6].

More recently, other surgical techniques such as osteotomy, arthrodesis and adjunctive soft tissue procedures have been described with contradictory results and many limitations [7]. The small number of patients was considered a major limiting factor in many studies [8, 9]. Even in studies with an adequate number of patients, the lack of cohort homogeneity and absence of technique standardisation are obstacles to proper judgment [10]. In addition, the absence of long-term follow-up in the literature was noted. However, previous publications suggest that the median length of time to maximal improvement is ten months [11].

One of the most common causes of acquired flat foot deformity (AFFD) in adults is posterior tibial tendon dysfunction (PTTD). Early attempts to repair such tendons directly can give unsatisfactory results especially in the long term [12], whereas tendon reconstruction without structural support has failed to correct the lost arch [13, 14]. The risk of prolonged operative time, increased incidence of wound infection and longer hospital stay add to the cost when soft tissue reconstruction is considered.

Various osteotomies have been recommended for the correction of adult flat foot. The main advantage of periarticular osteotomies is preservation of joint function while improving structural alignment. Because the Achilles tendon can exert a deforming force, it is better to perform calcaneal osteotomy after a tendo-Achilles lengthening procedure. The lengthened Achilles tendon is looser and will exert less of a proximal deforming force [15].

Therefore, in this prospective study isolated double calcaneal osteotomy with only percutaneous tendo-Achilles lengthening was conducted on 14 patients with adult flexible flat foot over a mean follow-up period of 22 months.

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Materials and methods

In the period between 2007 and 2009, 14 patients with 17 symptomatic flexible flat feet were treated in our institution by double calcaneal osteotomies (Evans osteotomy and posterior calcaneal displacement osteotomy) (Fig. 1). All patients in this study were men. The mean age of the patients was 23 years (range: 18–39 years). The median follow-up period was 22 months (13–34 months). Fourteen procedures were performed on the right foot, and three procedures were completed on the left foot.

Preoperative assessment

Preoperative evaluation included adequate history taking, general and local examination to delineate the possible cause and the degree of the deformity with emphasis on onset of the symptoms, history of trauma, severity of the condition, presence of associated conditions (rheumatoid arthritis, etc.), occupation, activity level, obesity, footwear and history of the previous treatment.

Local examination was done to estimate the degree of motion around the subtalar joint, degree of dorsiflexion of the ankle joint, tightness of tendo-Achilles tendon, presence or absence of peroneal spasm, integrity of tibialis posterior tendon, degree of heel valgus and forefoot pronation.

Lateral and anteroposterior (AP) standing views were done pre- and postoperatively to compare the calcaneal pitch, talocalcaneal angle and talo-first metatarsal angles.

A footprint was taken pre- and postoperatively for all cases to assess the degree of correction by comparing the load distribution between the lateral and medial columns.

Indications for surgery in all patients were pain, instability and severe functional limitation after failure of

conservative treatment. Cases with radiological osteoarthritic changes and rigid cases were excluded.

Surgical technique

All patients underwent the classic technique of double calcaneal osteotomy described previously [8], with the following modifications:

A single lateral approach was used for exposure of the two osteotomy sites at the same time (Figs. 2 and 3), percutaneous tendo-Achilles tenoplasty was performed instead of open tendo-Achilles lengthening (Fig. 4) and the osteotomy was fixed using percutaneous K-wires rather than Steinmann pins.

Postoperative care

All patients were immobilised in a posterior splint for 1.5 months. K-wires were removed three weeks postoperatively. Partial weight-bearing was allowed after six weeks and full weight-bearing was allowed after three months.

Postoperative evaluation

Intraoperative complications were recorded. Patients were followed up at one week, then at one, three and six months postoperatively and then six monthly. At three months, the procedure was evaluated with regard to pain and motion using the American Orthopaedic Foot and Ankle Society (AOFAS) Ankle-Hindfoot Scale [16]. At the end of the study, the overall score was calculated. Undercorrection was defined as insufficient medial displacement of the posterior segment. This was determined on postoperative calcaneal axial radiographs when the displacement was less than one third of the width of the posterior segment and the hind foot remained in clinical valgus.

Fig. 1 Osteotomies performed

Fig. 2 Intraoperative view showing the proximal osteotomy

Fig. 3 Intraoperative view showing the second osteotomy

Statistical analysis

The paired *t* test was used for comparison between preoperative and postoperative parameters with regard to AOFAS score, talo-first metatarsal angle and talocalcaneal angle. A *p* value of <0.05 was considered to be significant. All statistical analysis was conducted using SPSS® version 11 (Chicago, IL, USA).

Results

The mean preoperative AOFAS score was significantly elevated from 48.4 ± 15.1 (17–69) to 78.6 ± 6.7 (60–90) at last follow-up ($p < 0.00128$). Similarly, significant reductions of the talo-first metatarsal angle and talocalcaneal angle on both AP and lateral views were obtained (Figs. 5

Fig. 4 Intraoperative view showing the percutaneous tendo-Achilles lengthening

Fig. 5 Patient before double calcaneal osteotomy

and 6). Table 1 demonstrates postoperative changes. All cases exhibited reduced hind foot dorsiflexion, excessive eversion and a fixed position of external rotation throughout the gait cycle. Following surgery, notable improvements were apparent. In all 17 procedures, the talonavicular joint became more congruous postoperatively with greater navicular “coverage” of the talar head. On comparing footprints, the pre- and postoperative load was found to be shifted from the medial to the lateral column, resulting in a more normal load distribution (Figs. 7 and 8). The bone graft used in the anterior calcaneal lengthening osteotomy was found to be incorporated in 16 (94%) of 17 feet. Failure of graft incorporation occurred in 1 (6%) of 17 ($p = 0.39$); in this foot, the graft was resorbed three months postoperatively and required exploration and grafting, which was accomplished successfully and the graft was incorporated at the final follow-up. Undercorrection was encountered in two patients; however, the AOFAS score was satisfactory in both. In another two patients, sural neuritis was reported. One of them responded to corticosteroid injection, while the residual numbness in the other case was not clinically significant. There were no recorded

Fig. 6 Lateral X-ray after double calcaneal osteotomy

Table 1 Clinical and radiological evaluation^a

	Preop.	Postop.	Mean difference
AOFAS score	48.4±15.1 (17–69)	78.6±6.7 (60–90)	30.2
Talo-first metatarsal angle lateral	21.14±3.61°	8.33±2.93°	12.81°
Talo-first metatarsal angle AP	22.53±3.57°	11.13±3.35°	11.40°
Talocalcaneal angle lateral	32.92° (25–42)	24.84° (17–39)	8.08
Talocalcaneal angle AP	37.23° (30–45)	26.92° (22–38)	10.31

^a Paired *t* test

cases of nonunion, delayed union of the osteotomy or wound complications.

Discussion

Pathological conditions and symptoms of flat foot are caused by structural loading changes along the medial foot and plantar arch, as well as by collapse through the midfoot and impingement along the lateral column and rear foot [1–5]. Muscles in the leg and foot tend to fatigue and cramp because of overuse [6–8]. Peritalar subluxation defines the pathological malalignment of the talus about the subtalar and midtarsal joints [9, 10].

Fig. 7 Footprint before double calcaneal osteotomy **Fig. 8** Footprint after double calcaneal osteotomy

At the latest follow-up, there was persistent and obvious reduction of the talo-first metatarsal angle in all patients in both planes (11.13 and 8.33, respectively). Such reduction enabled creation of sufficient arch restoration. This compares with previously reported results in which soft tissue reconstruction was used [14]. In other case series, lower postoperative angles were obtained [11, 17]; however, the preoperative angles were much less than mean preoperative angles in this study. This might give the impression of a lower degree of deformities in those series. The efficacy of the technique adopted in this series is further supported by evaluation of the talocalcaneal angle. At the latest follow-up, there was a considerable reduction indicated in both planes.

For more composite evaluation, the AOFAS score was used. Significant improvement was achieved (mean difference 30.2, $p < 0.05$). This improvement was noted in both objective and subjective parts of the AOFAS score. Low pain perception was reported by the vast majority of patients. Additionally, the use of a walking aid was diminished. This was reflected in marked increase of maximum walking distance by most patients. Thus, the primary goal of this technique was achieved, since the quality of life is the main goal of deformity correction procedures.

According to these results, the objective of the technique was achieved. Good alignment and improvement in sagittal and hind foot motion was observed. Such an improvement in AOFAS score has been previously reported [11, 17]. However, it is difficult to distinguish the split changes in each component (objective and subjective) because it was reported as an overall summation.

Using double calcaneal osteotomy alone offers many advantages. Structural arch restoration could be obtained without the need for soft tissue reconstruction. K-wire fixation instead of screws or Steinmann pins provides the advantage of being cheaper, easier to apply and avoids the need of a second step for removal. Finally, the versatility of the technique has been proven as it extended to involve all patients with flexible flat foot whatever its nature provided that there are no radiological arthritic changes.

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