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Case Reports and Series

Mini-Invasive Treatment for Brachymetatarsia of the Fourth Ray in Females: Percutaneous Osteotomy With Mini-Burr and External Fixation—A Case Series

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ABSTRACT

Brachymetatarsia is a rare disease defined by metatarsal shortening and characterized by aesthetic dissatisfaction with or without pain. The aim of our study was to evaluate the outcomes of fourth ray brachymetatarsia treated with percutaneous osteotomy using a mini-burr and gradual lengthening with external fixation. A total of 7 females were recruited for the study; 6 (85.71%) of whom had a bilateral deformity, for a total of 13 feet affected by fourth ray brachymetatarsia. Percutaneous diaphysis osteotomy with a mini-burr followed by metatarsal elongation was performed. Metatarsal lengthening was measured as the difference between the preoperative and postoperative length at external fixator removal. The American Orthopaedic Foot and Ankle Society lesser toe metatarsophalangeal-interphalangeal score, patient satisfaction, restoration of Leliévre parabola, and treatment time were evaluated. Numerical data are reported as the mean ± standard deviation and 95% confidence intervals. The Mann-Whitney U test was used to compare the changes in the AOFAS score with a level of significance of $p < .05$. The mean metatarsal lengthening was 17.46 ± 4.89 (95% confidence interval [CI] 14.8 to 20.12) mm and the mean treatment time was 99.23 ± 8.53 (95% CI 94.59 to 103.87) days. The mean American Orthopaedic Foot and Ankle Society lesser toe metatarsophalangeal-interphalangeal score improved significantly from 76.38 ± 2.66 (95% CI 74.77 to 78.03) preoperatively to 86.46 ± 1.45 (95% CI 84.85 to 88.07) postoperatively ($p < .01$). In 12 of 13 feet (92.31%), the Leliévre parabola was restored, and the patients were satisfied with the clinical outcomes. The results of our study demonstrate that percutaneous osteotomy with the mini-burr and external fixation is an effective treatment for lengthening of fourth ray brachymetatarsia. Furthermore, we found good clinical and functional outcomes, high patient satisfaction, and a similar duration of treatment compared with other gradual lengthening procedures.

Brachymetatarsia is a rare foot deformity caused by the premature closure of the metatarsal epiphysis that leads to a shortened metatarsus (Figs. 1 and 2). Several factors seem to play a role in the etiology of this foot condition, including traumatic, iatrogenic, and congenital, with or without an association with systemic syndromes (1). This deformity is characterized by a wide range of clinical patterns from aesthetic dissatisfaction to severe pain. By definition, it is the presence of ≥1 metatarsals ending 5 mm before the parabolic metatarsal arc (2). It is more frequent in females (25:1), and the fourth ray is the most frequently affected (3), with an incidence of 0.02% to 0.05% (4). In 75% of cases, it presents as a bilateral condition (5).

Several procedures have been proposed for the surgical correction of this deformity to restore the Leliévre parabola. Gradual lengthening by distraction elongation (6) and one-stage elongation seem to be the most commonly used procedures. One-stage elongation is usually combined with hydroxyapatite (7) or bone grafting (8) and, when necessary, is completed with an adjacent metatarsal and phalange shortening osteotomy (9).

In our retrospective case series, we describe the results of gradual metatarsal lengthening performed with mini-burr percutaneous osteotomy followed by external fixation.

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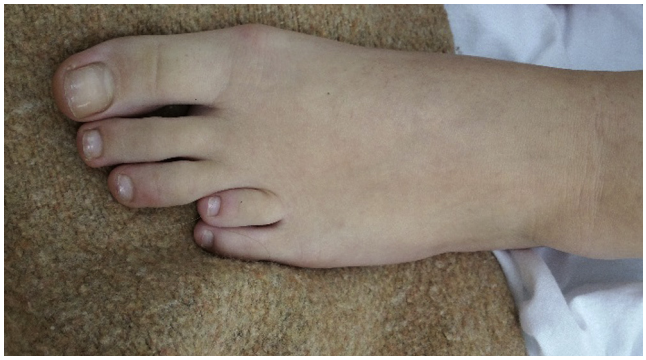

Fig. 1. Clinical photograph showing fourth ray brachymetatarsia.

Patients and Methods

From December 2012 to July 2015, we recruited 7 consecutive females with congenital metatarsal shortening of the fourth ray. Six of the patients (85.71%) were affected by bilateral brachymetatarsia, for a total of 13 rays (toe + metatarsal). The mean age was 25 (range 18 to 30) years. The amount of shortening was 11 to 24 mm. The inclusion and exclusion criteria are listed in Table 1. The demographic characteristics of the included patients are listed in Table 2. Before surgery, the patients were fully informed of the surgical procedure, treatment duration, and potential complications. All 7 patients provided written informed consent and agreed to undergo the procedure. The aim of surgery was to restore the normal anatomy and biomechanics of the metatarsal arc, thereby also improving the aesthetic aspect of the deformity. We measured the metatarsal lengthening after percutaneous surgery as the difference between the length before treatment and after external fixator removal. The Leliévre parabola was considered to be restored within <5 mm of tolerance (10). The American Orthopaedic Foot and Ankle Society (AOFAS) lesser toe metatarsophalangeal-interphalangeal score (11,12), patient satisfaction, and period required for external fixation were also recorded.

Operative Procedure

The procedures were performed by the same surgeon (F.Z.), with the patient in the supine position and under spinal anesthesia. A tourniquet was not used. A support was placed under the ipsilateral hip to internally rotate the leg and facilitate access to the lateral foot. Lengthening was achieved using a minifixator (Minirail™, Orthofix, Verona, Italy) and self-drilling, self-tapping screws with a 2-mm diameter. The screws were positioned at the level of the proximal and distal metaphyses under fluoroscopic guidance. After screw placement, the frame was removed. A 2-mm skin incision was performed at the level of the middle third of the metatarsal diaphysis to insert the mini-burr (Shannon 44™, Miltex Instrument, Co., Inc., Rietheim-Weilheim, Germany) for osteotomy. This procedure was completed under fluoroscopic guidance. Finally, the 2 metatarsal fragments were separated by about 3 mm, and a frame was applied. Sterile gauzes and bandages were used to cover the screw portals (Fig. 3). The first postoperative day, full weightbearing was allowed with an orthopedic shoe (Podalux™, DJO Global, Surrey, United Kingdom) without the use of a cane or other support.

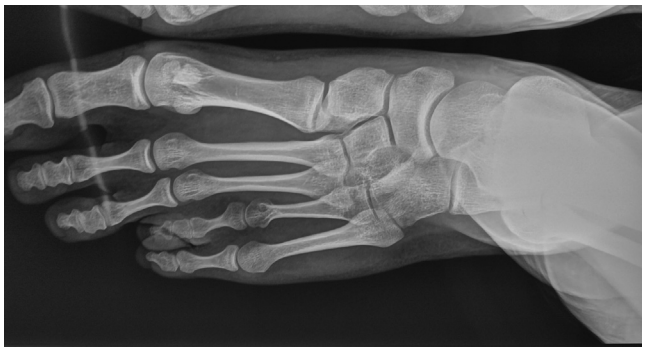

Fig. 2. Radiograph showing fourth ray brachymetatarsia.

Table 1
Overview of inclusion and exclusion criteria for patient selection

Inclusion criteria
Congenital brachymetatarsia of fourth ray
Age >18 yr
Pain or aesthetic dissatisfaction
Metatarsal ending ≥5 mm before parabolic arc
Exclusion criteria
Brachymetatarsia of a different ray
Brachymetatarsia secondary to trauma or foot surgery
Brachymetatarsia secondary to hereditary syndrome or associated with syndactyly and polydactyly

Postoperative Care

The patients were instructed in the care of the external fixator and how to medicate the pin tracts (Fig. 4) and to begin the lengthening at a rate of 0.25 to 1 mm/day starting 4 to 5 days postoperatively. Radiographic evaluations were performed 20, 45, and 90 days postoperatively before external fixator removal. The patients underwent clinical examinations every 10 days and used a personal elongation rate related to radiographic callus formation and stiffness developing at the metatarsophalangeal joint. Distraction was continued until the necessary metatarsal length was reached. The external fixator was removed as an outpatient procedure (Fig. 5). Patients continued to wear the orthopedic shoe for the next 3 weeks.

Statistical Analysis

The numerical data are reported as the mean ± standard deviation and 95% confidence intervals (CIs). The Mann-Whitney *U* test was used to evaluate the changes in the AOFAS lesser toe metatarsophalangeal-interphalangeal score. The level of significance was set at $p \leq .05$.

Assessors

Two of us (F.F., F.L.) performed the radiographic measurements, data collection, outcome assessments, statistical analysis, and language editing. Two others (O.C., F.S.) recruited the patients and performed the

Table 2
Main demographic characteristics

Demographic Characteristic	Value
Participants (N)	7 (100)
Female gender (N)	7 (100)
Age (yr)	
Mean	25
Range	18 to 30
Laterality (n)	
Bilateral (12 rays in 6 patients)	6 (85.71)
Left (1 ray in 1 patient)	1 (14.28)
Patients with aesthetic dissatisfaction (N)	7 (100)

Data in parentheses are percentages.