Original Article

Evaluation of Lateral Column Lengthening Using Autogenous Fibular Graft in the Treatment of Supple Flat Foot

Abstract

Background: Treatment options of flat foot vary from using orthosis to arthrodesis and the surgical procedure varies from soft-tissue operations till bony osteotomies. We hypothesized that the clinical, functional, and radiological outcomes of lateral calcaneal lengthening osteotomy using fibular graft in the treatment of symptomatic flat foot are satisfactory. Materials and Methods: A prospective study was conducted involving 25 feet of 25 patients who underwent lateral calcaneal lengthening due to symptomatic flexible flat foot. All patients underwent clinical and radiological evaluation preoperatively and postoperatively, American Orthopedic Foot and Ankle Society (AOFAS) hindfoot/ankle scoring preoperatively and postoperatively. All patients underwent osteotomy of the calcaneus using a saw, after a satisfactory correction of the deformity obtained, autogenous fibular graft was inserted in the osteotomy site, and tendon Achilles lengthening was performed. Results: In our study, we had 25 patients, the average age was 11.48 years. There were 15 girls and 10 boys. The average AOFAS preoperative score was 68.56 ± 5. A 3-month postoperative. The average score was 86.40 ± 3.65. A final AOFAS hindfoot/ankle score at the time of maximal follow-up (average 21 months; range, 6–36 months) had an average score of 95.19 ± 1. A final AOFAS hindfoot/ankle score at the time of maximal follow-up (average 21 months; range, 6–36 months). Conclusion: Isolated lateral column lengthening using autogenous fibular graft was found to provide significant correction of all components of the supple pes planovalgus and forefoot abduction deformity. Level of Evidence: Level IV.

Keywords: Fibular graft, lateral column lengthening, pesplannus

Introduction

Pesplannus is a term where the longitudinal arch of the foot does not exist or fallen down.\textsuperscript{[1,2]} Pathological types of flat foot may be; congenital (oblique talus, congenital vertical talus, accessory navicular, tarsal coalition or as a part of generalized dysplasia)\textsuperscript{[3]} or acquired most common due to tibialis posteriorly tendon dysfunction.\textsuperscript{[3,4]}

The surgical procedure varies from soft-tissue operations till bony osteotomies, as soft-tissue reconstruction, osteotomies, arthroereisis, and arthrodesis. Solely soft-tissue procedures, arthrodesis, and arthroereisis have shown unsatisfactory outcomes.\textsuperscript{[5‑9]} Many authors have suggested joint-sparing procedures.\textsuperscript{[7‑10]} We hypothesized that the clinical, functional, and radiological outcomes of lateral calcaneal lengthening osteotomy using fibular graft which is unique in the treatment of symptomatic flat foot are satisfactory.

Materials and Methods

Between January 2018 and February 2020, a prospective study was conducted involving 25 feet of 25 patients who underwent lateral calcaneal lengthening due to symptomatic flexible flat foot. There were 15 females (60%) and 10 males (40%).

Inclusion criteria

- Painful, passively correctable pes planovalgus (PPV)
- No asymptomatic arthritis in the subtalar, calcaneocuboid, and talonavicular joints.

Exclusion criteria in our study

Fixed pes planovalgous, osteoporosis of the calcaneus. Advanced degenerative arthritis of the subtalar, talonavicular, or calcaneocuboid joints, paralytic condition affecting foot and ankle, severe trophic skin disorders. Standard contraindications to any surgery such as poor circulation, unhealthy or compromised patient, and concurrent infection.

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All patients underwent clinical and radiological evaluation pre and postoperatively. Preoperative and postoperative radiographic data were recorded from standardized weight-bearing radiographs, including lateral calcaneal pitch, lateral talometatarsal angle, and anteroposterior (AP) talonavicular coverage angle.

Lateral view of the foot, lines are drawn along the longitudinal axes of the calcaneus, talus, and first metatarsal. Assess the lateral talometatarsal angle and the calcaneal pitch angle.

AP view of the foot, radiological analysis is performed with weight-bearing AP view and assess the talonavicular coverage angle.

American Orthopedic Foot and Ankle Society (AOFAS) hindfoot/ankle scoring preoperatively,[11] and 3 months after the second foot surgery, and at the time of maximal follow-up. According to the clinical evaluation criteria, the preoperative there are 15 feet were fair and 10 feet were clinically poor, one female patient was clinically good in both feet and had no neuromuscular problems; the pain was persistent postoperative and irritating for both the child and the parents.

**Surgical technique**

The patient was placed supine on the operating table with a bump placed beneath the ipsilateral buttock to medially rotate the foot. A pneumatic thigh tourniquet was typically used for hemostasis. An oblique or a curvilinear incision was placed distal to the sinus tarsi and 1–1.5 cm proximal to the calcaneocuboid joint, an image intensifier was sometimes used to confirm the osteotomy 1.5 cm posterior to the calcaneocuboid joint location before execution. Osteotomy of the calcaneus using a saw, a laminar spreader was used to distract the osteotomy, after a satisfactory correction of the deformity obtained, autogenous fibular graft was inserted in the osteotomy site, and [Figures 1 and 2] tendon Achilles lengthening was performed in all patients. The graft was fashioned into a triangle, with its cortical base measuring 7–10 mm in width. The cortical base was oriented lateral and apex medial, and fixed by K-wires [Figures 3 and 4]. After 2 weeks, postoperatively the cast was changed with the removal of stitches. One month later, the cast was removed for removal of the K-wires and another below-knee nonweight bearing cast was done with the ankle in the neutral position, and this was for another 4–6 weeks. The patient continued in a medical shoe was used, in which the medial part is elevated to maintain the correction produced and prevent recurrence [Figure 5].

**Follow-up**

The patients were followed up in the outpatient clinic and evaluated both radiological and clinically in every visit, the 1st visit was 1 week after discharge from the hospital, the 2nd visit was 3 weeks postoperative, then every month for the first 3 months, then every 3 months till the end of the follow-up.

In every visit, the patient was evaluated clinically for pain, the position of the cast and the neurovascular condition of the operated foot, and foot the position of the foot arches and the position of the heal after cast removal, also plain X-rays were performed for the foot and ankle...
Results

In our study, we had 25 patients, the average age was 11.48 years (range, 8–18 years). There were 15 girls and 10 boys. The average duration of conservative treatment was 4.5 months (range 3–6 months). All patients had Achilles tendon lengthening. The average follow-up was 18 months (range 6–36 months). All patients are evaluated clinically and radiologically pre and postoperative.

Clinical results are shown in Table 1 preoperatively, and during the last visit showed significant correction ($P < 0.001$) in all parameters postoperatively. The pain which was the main indication for the surgery was eliminated in all patients. In the follow-up period, we had not encountered difficulties in wearing shoes. Postoperative 14 patients showed excellent results (16–18 points), 9 patients show good results (13–15 points), and 2 patients show fair results (10–12 points), and no patients showed poor results (<10 points). One patient with a fair clinical score had severe preoperative pain, which is diminished postoperative, the medial arch is Grade 3 (severe), there is no arch and the medial border of the foot is convex preoperative but become Grade 2 (moderate), the arch is absent, but the medial border of the foot is straight, heel alignment preoperative which was assessed clinically by measuring the posterior tibiocalcaneal angle was severe 20° postoperative become 12°.

The average AOFAS preoperative score was 68.56 ± 5.05 (range, 58–76), The most common reasons for lower scores included pain, limitations of daily and recreational activities, limited walking distances, difficulty on uneven, and obvious functional gait abnormalities. A 3-month postoperative AOFAS score was determined for all 25 patients after foot surgery. The average score was 86.40 ± 3.65 (Range, 78–92) [Tables 2 and 3].

The most common complaints after surgery included activity limitations (limitation of some recreational activities, including running, basketball, and so on) and associated pain (mild-to-moderate pain when engaging
improved on the daily dressing. One patient (4%) show incision dehiscence which
some activities). A final AOFAS hindfoot/ankle score
The mean ± standard deviation of preoperative was
The mean difference between preoperative and 3- month postoperative was −17.84 and the percent
The mean difference between preoperative and maximum follow-up was −26.63 and the percent of change was 30.82%. There was a significant increase in AOFAS at maximum follow-up compared with preoperative (P = 0.001) [Table 3].
The mean difference between preoperative and 3-month postoperative was −17.84 and the percent of change was 26.02%. There was a significant increase in AOFAS at 3-month postoperative compared with preoperative [Table 3].
The mean difference between preoperative and maximum follow-up was −8.79 and the percent of change was 9.23%. There was a significant increase in AOFAS at maximum follow-up compared with preoperative (P = 0.001).

The preoperative and postoperative radiographic angular measurements of this study and statistical analysis of these data (paired t-test) and the mean percentage improvement between preoperative and postoperative measurements are summarized in Table 4.

Complications
One patient (4%) show incision dehiscence which improved on the daily dressing. One patient (4%) show mild sural neuritis improved dramatically by physiotherapy. One patient (4%) Sublaxed talonavicular joint on postoperative which corrected by K-wire pass across medial cuneiform, navicular and talus, on final follow-up the graft incorporated well with well-covered talonavicular.

Two patients, a graft minimally dislocated after surgery, but then healed uneventfully. In both cases, there are bony prominence. One of these two patients also exhibited some loss of forefoot adduction correction. At follow-up, moderate pain was present at the lateral ankle and subtalar joint, and the result was rated as fair.

Statistical analysis
Statistical analysis was performed in this study using IBM SPSS Statistics for Windows, version 22.0 (IBM Corp, Armonk, NY, USA). A significant correlation was considered when P < 0.05.

Discussion
Reconstructive surgery for (FFF) flexible flat foot in the pediatric population is reserved for patients with moderate to severe deformities who have generally failed nonsurgical care. This rule was followed also in this thesis. All cases had a history of at least 3 months of unsuccessful conservative treatment in the form of orthotic or shoe modification. On reviewing the literature, the goals of many techniques proposed for surgical treatment of FFF in children were raising the medial arch and correcting heel valgus and forefoot abduction. Surgical procedures can be categorized as a bony interference in the form of osteotomy or arthrodesis or a soft-tissue correction in the form of tendon transfer or lengthening. However, many authors prefer a combination procedure including bony and soft tissue interference to correct all the components of the deformity of FFF.[12]

There is general agreement that a surgical procedure for correction of symptomatic flat foot in a growing child should not rely on soft tissue tightening alone and should not fuse joints.[13]

Understanding the components of the deformity of FFF will lead to a successful approach to its surgical correction. These combined relationships create a sag in the middle of the foot with lowering of the medial longitudinal arch.[14,15]
In this study, a simple bony technique Lateral calcaneal lengthening osteotomy to restore the medial longitudinal arch and to correct forefoot abduction, allowing minimizing the strain and to reach a successful function of the medial ligament and correcting all the components of the deformity of FFF in one setting. Arthrodesis, although used by many authors as part of their procedures to correct the components of FFF deformity with a successful short-term results, all long-term follow up studies have shown that arthrodesis of any joint or joints in the foot of a child leads to early degenerative changes at adjacent joints, because of the shift of stress to the still mobile joints.\textsuperscript{[16,17]}

Seymour\textsuperscript{[12]} reported 50% poor results of naviculocuneiform fusions after 15 years. Butte\textsuperscript{[8]} also reported 50% poor results after naviculocuneiform fusion in 76 feet. Crego and Ford\textsuperscript{[9]} reported poor results in five of seven naviculocuneiform fusions. LeLièvre\textsuperscript{[20]} considered any surgical procedure which required loss of joint function to produce correction of the pronated foot to be physiologically unsound. In contrast, calcaneal osteotomy does not result in an iatrogenic coalition and retains joint motion.\textsuperscript{[19,21]}

Soft-tissue procedures are no longer advocated as the sole method of correcting a flexible flatfoot deformity.\textsuperscript{[22,23]} The results of tendon and ligament transposition deteriorate over time, with eventual recurrence of deformity and associated symptoms.\textsuperscript{[22,23]} Various medial column soft-tissue procedures have been described, including transfer of the tibialis anterior to the navicular and tenodesis of the anterior and posterior tibial tendons.\textsuperscript{[24]} Viegas\textsuperscript{[25]} also has experienced progressive degradation of various soft tissue procedures when performed in isolation for flexible flatfoot correction; progressive recurrence of deformity was observed. Diminution of the medial longitudinal arch and a progressively everted relaxed calcaneal stance position in patients who underwent Kidner and/or Young procedures. Loss of radiographic correction (decreased calcaneal pitch and increased talar declination and medial divergence) correlated directly with increased clinical symptomology and recurrent deformity.\textsuperscript{[14,25]}

Some authors used the technique of artificial prosthesis in the lateral sinus tarsi region (arthroereisis) as an alternative to extra articular subtalar arthrodesis, to correct heel valgus.\textsuperscript{[16,27]} Furthermore, subtalar arthroereisis is a relatively simple, minimally invasive procedure in treating flexible flatfoot at pediatric age. There are many complications by this technique due to insertion of spacers, metal or bioabsorbable screws transversely in the sinus tarsi as granuloma formation, displacement of the implant, biomaterial failure and staining of the tissues, implant irritation and sinus tarsi pain, and other problems related to proper sizing and configuration of the implants used.\textsuperscript{[28,29]}

For more composite evaluation, the AOFAS score was used. Significant improvement was achieved (mean difference 95.19 ± 1, \( P < 0.001 \)). 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. In addition, the use of a walking aid was diminished. This was reflected in the 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.

All radiographic criteria revealed improvement. On the lateral view, average improvements were 16.6° ± 5.9° for the calcaneal pitch angle, and 10.5° ± 5.66° for the talar-first metatarsal angle, on the dorsoplantar view, the talonavicular coverage angle improved by an average of 7.7° ± 2.61°.

It is concluded that lateral calcaneal lengthening osteotomy is effective in treating the symptomatic flexible flatfoot, which is refractory to conservative treatment. A potential disadvantage of the osteotomy is that it increases calcaneocuboid pressure that correlates with a higher risk of arthrosis or arthritis. In this current analysis, after follow-up, no patients had calcaneocuboid pain on palpation and attempted range of motion of this joint. There was also no radiographic evidence of degenerative arthritis at this joint in any of the 25 patients, based on the review of plain films obtained at the time of the latest follow-up.

According to these results, the objective of the technique was achieved. Good alignment and improvement in sagittal and hindfoot motion were observed. Such an

### Table 4: Statistical analysis of radiological assessment

<table>
<thead>
<tr>
<th>Measurement (°)</th>
<th>Range</th>
<th>Mean±SD</th>
<th>Mean (pre-post)</th>
<th>Percent of change</th>
<th>( P )</th>
</tr>
</thead>
<tbody>
<tr>
<td>LCP</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre</td>
<td>0-13</td>
<td>6.76±3.407</td>
<td>~16.640±5.9</td>
<td>246.15</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Post</td>
<td>10-38</td>
<td>23.40±6.377</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LTMA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre</td>
<td>3-23</td>
<td>11.616±5.63</td>
<td>10.524±5.66</td>
<td>90.6</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Post</td>
<td>0-2.3</td>
<td>1.091±0.6370</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AP TNCA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre</td>
<td>3-14</td>
<td>8.619±2.7021</td>
<td>7.773±2.619</td>
<td>90.18</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Post</td>
<td>0.2-1.5</td>
<td>0.845±0.336</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SD: Standard deviation, LCP: Lateral calcaneal pitch, LTMA: Lateral talo metatarsal angle, AP: anteroposterior, TNCA: Talo navicular cuboid angle
improvement in the AOFAS score has been previously reported,[30] Phillips[31] reported 90% good and excellent results in patients having Evan’s opening lateral wedge osteotomy. Anderson and Fowler[32] reported good results in nine feet treated with the Evan’s procedure after a follow-up of 6.5 years. Sangeorzan et al.[30] observed dramatic radiographic improvements in seven symptomatic flatfeet operated on by the Evans technique.

Using lateral column lengthening via 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.

Fortunately, no recurrence of the deformity was observed in the studied group except in one of the unsatisfactory feet in which the patient removed the plaster early (only after 1 month) and neglected the regular follow-up regimen. Associated symptoms of pain, fatigue, and activity reduction improved markedly postoperatively and along the whole period of follow-up with no deterioration Furthermore, no deterioration was observed in the postoperative radiological measurement till the latest period of follow-up examination.

Thus, the adopted technique proved effectiveness in correcting FFF deformity with no recurrence of either associated symptoms or any of the components of the deformity provided it is done meticulously in the proper indication of pure flexible type of flat foot However, a long term follow up of these cases is recommended to ensure maintenance of correction and absence of recurrence.

Satisfaction of all patients and their parents with the outcome of surgery was evidenced by the return of all cases with bilateral deformities to correct the contralateral foot.

The current study thus provides a detailed description of a simple procedure to correct all the components of the deformity of FFF in one sitting.

A satisfactory correction can be achieved by this technique and can be conducted successfully in young and old children. Good result is supposed to occur in a properly selected patient, the supposed degenerative joint changes can be avoided and the need for arthrodesis later in life can be eliminated.

**Conclusion**

Although the mechanism of lateral column lengthening and its relationship to the restoration of the medial longitudinal arch is still unproven, isolated lateral column lengthening was found to provide significant correction of all components of the supple PPV and forefoot abduction deformity. This series indicates a statistically significant improvement in all clinical and radiographic parameters.

**Ethical approval**

The study was approved by the ethical committee of the university. And were in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

**Informed consent**

All patients signed an informed consent after clear explanation of the surgical procedure.

**Financial support and sponsorship**

Nil.

**Conflicts of interest**

There are no conflicts of interest.

**References**


