Management of Symptomatic Flexible Flatfoot in Adolescents by Mosca's Lateral Calcaneal Lengthening

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Abstract:
Introduction: There is considerable debate as to the ideal procedure for the treatment of symptomatic flexible flatfoot (FFF) that is not followed by recurrence and minimizes complications. The purpose of the present study was to evaluate the results of calcaneal lengthening using Mosca's technique in adolescents with FFF in whom conservative treatment had been applied for more than one year but had failed.

Patients and Methods: Calcaneal lengthening osteotomy was performed using Mosca's technique in 19 feet of 14 patients with ten males, four females and five bilateral cases. The mean age at surgery was 13.53 (range 11.5-16) years. All FFF patients were evaluated as idiopathic. Bilateral cases were operated on at two sessions with an average interval of 15.6 months (range 12 to 21). The American Orthopaedic Foot and Ankle Society (AOFAS) ankle-hind foot scale was used for clinical assessment, and radiographic assessment was based on six parameters on standard anteroposterior and lateral radiographs.

Results: The mean follow-up period was 27.89 (range 18-44) months. The mean AOFAS score increased from 57.53 preoperatively to 96.32 postoperatively. All radiographic parameters significantly improved. Four patients had mild occasional pain. There was no nonunion or secondary subsidence of the arch. All Patients stated they were satisfied with the procedure.

Conclusion: Correction of flexible flatfoot deformity with Mosca's lateral calcaneal lengthening was an effective and reproducible method to restore normal foot alignment and good function.

Key words: Bone lengthening; calcaneus surgery; flat foot; foot deformities; planovalgus foot.

Introduction: Flatfoot is a complex foot deformity that is commonly seen in clinical practice. It is characterized by a combination of a collapse of the medial longitudinal arch, foot abduction, and hind foot valgus.\(^\text{[1,2]}\) Harris and Beath\(^\text{[3]}\) subdivided flatfeet into three types; flexible flatfoot, flexible flatfoot with a short Achilles tendon, and rigid flatfoot most commonly associated with tarsal coalitions. In a flexible flatfoot (FFF), the longitudinal arch can be created by dorsiflexing the great toe and on toe-standing due to the “windlass action” of the plantar fascia.\(^\text{[4,5]}\) FFF is a normal foot shape that is present in most infants and many adults and the longitudinal arch elevates in most children spontaneously within the first decade of life.\(^\text{[2,4,6]}\)

There is broad consensus that an asymptomatic patient with FFF needs no specific treatment. Shoe inserts have been proved to be ineffective in correction of the deformity but may relieve symptoms in some cases. Therefore, in symptomatic patients who
are unresponsive to conservative measures, surgery is often considered.[4-7]

Numerous surgical procedures to correct flatfoot have been proposed and can be categorized as soft tissue reconstruction, osteotomies, arthroereisis, and arthrodesis.[6-9] Solely soft tissue procedures, arthrodesis, and arthroereisis have shown unsatisfactory outcomes. Therefore, many investigators have suggested that joint-sparing procedures, such as lateral column lengthening and calcaneal osteotomy, should be the treatment of choice for correcting planovalgus foot deformities in children and adolescents.[6,8-10]

The purpose of the present study was to evaluate the radiological and clinical outcome of Mosca's technique for lateral calcaneal lengthening in adolescents with symptomatic FFF after failure of conservative treatment.

**Patients and methods:**

This was a retrospective study undertaken at Benha University Hospital, Egypt and approved by Research Ethics Committee of the University. From January 2006 till March 2014, lateral calcaneal lengthening using Mosca’s technique was performed for 14 patients with FFF with five bilateral cases with total of 19 feet. There were 12 right FFF and seven left FFF. Four patients were females and ten were males and none had undergone surgery for the deformity. The mean age at surgery was 13.53 years (SD 1.38; range 11.5-16). Inclusion criteria included adolescents with painful FFF in whom conservative measures like insoles and physical therapy had been applied for more than one year but failed. Cases of rigid flatfoot, post-traumatic flatfoot, and painful flatfoot for reasons other than loss of the arch were excluded from this study. All FFF cases were evaluated as idiopathic and had collapse of the medial longitudinal arch, forefoot abduction, and hind foot valgus. A general examination was done to assess the evidence of generalized ligamentous laxity that was present in six patients. The flexibility was confirmed, and the thigh-foot angle with the transmalleolar axis were assessed with the patient prone (Fig. 1). Ankle dorsiflexion was limited by a tight heel cord in 12 patients as identified by the Silfverskiöld test.

Clinical evaluation was carried out with the American Orthopaedic Foot and Ankle Society (AOFAS) ankle-hind foot scale. The AOFAS ankle-hind foot scale, an assessment tool widely accepted in the orthopaedic foot and ankle community, is a 100-point score comprising 40 points for pain, 50 points for function, and 10 points for alignment.[11] The preoperative AOFAS ankle-hind foot score ranged from 53 to 72 with a mean of 57.53 (SD 6.62). Radiographic assessment was based on six parameters on standard anteroposterior (AP) and lateral radiographs. The talo-navicular coverage, AP talus-1st metatarsal angle, AP talo-calcaneal angle, calcaneal pitch, Costa Bartini angle, and the lateral talo-calcaneal angle were evaluated (Table 1).
### Table 1 Preoperative and postoperative radiographic measures

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Preoperative</th>
<th>Postoperative</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>T-N coverage</td>
<td>Mean 28.42; SD 3.83; range 20-35</td>
<td>Mean 4.37; SD 1.98; range 2-10</td>
<td>.000</td>
</tr>
<tr>
<td>talus-1&lt;sup&gt;st&lt;/sup&gt; metatarsal angle</td>
<td>Mean 27.68; SD 4.36; range 20-37</td>
<td>Mean 3.16; SD .96; range 2-5</td>
<td>.000</td>
</tr>
<tr>
<td>talo-calcaneal angle</td>
<td>Mean 45.95; SD 4.56; range 39-53</td>
<td>Mean 23.63; SD 8.01; range 15-51</td>
<td>.000</td>
</tr>
<tr>
<td>calcaneal pitch</td>
<td>Mean 4.26; SD .93; range 3-7</td>
<td>Mean 19.47; SD 2.01; range 17-23</td>
<td>.000</td>
</tr>
<tr>
<td>Costa Bartini angle</td>
<td>Mean 152.32; SD 4.88; range 145-161</td>
<td>Mean 127.89; SD 3.65; range 123-135</td>
<td>.000</td>
</tr>
<tr>
<td>talo-calcaneal angle</td>
<td>Mean 51.89; SD 3.74; range 44-58</td>
<td>Mean 36.47; SD 5.66; range 28-45</td>
<td>.000</td>
</tr>
</tbody>
</table>

*The paired t-test was used to evaluate the statistical significance between the preoperative and postoperative measurements. †AP is anteroposterior and LAT is lateral. ‡SD is Standard Deviation.

Before surgery, we discussed the procedure in details with the patients and their families. Informed consent was obtained from the parents or guardians of all patients included in the study.

**Operative technique:**

The surgical technique used was basically the same as that reported by Mosca. The patient, under general anaesthesia with a thigh tourniquet, was placed in the supine position with a sandbag under the ipsilateral buttock to aid access to the lateral side of the foot. The patient was prepared from the iliac crest to the toes. A modified Ollier incision was made and the sinus tarsi was exposed. The peroneus longus and the peroneus brevis tendons were released with Z-cutting of the peroneus brevis tendon. A longitudinal incision along the medial border of the foot was made. The tibialis posterior tendon was released and cut in a Z-fashion. Percutaneous Achilles tendon lengthening was done if required.

An oblique calcaneal osteotomy was done from posterolateral to anteromedial between the anterior and middle facets about 2 cm posterior to the calcaneocuboid joint. With the foot in the original everted position, a Kirschner wire was inserted from the cuboid distally across the calcaneocuboid joint to avoid its subluxation with osteotomy distraction. An ipsilateral bicortical trapezoid-shaped iliac crest bone graft was harvested through a standard apophyseal-splitting approach. Using a spreader the osteotomy was then opened and bone graft was inserted. The degree of correction was checked clinically and with fluoroscopy. The peroneus brevis tendon was repaired after lengthening. The proximal slip of the tibialis posterior was advanced approximately 5 to 7 mm through a slit in the distal stump of the tendon and repaired as a Pulvertaft weave. Medial and plantar capsular imbrication of the talonavicular joint was performed. The incisions were closed and a well-padded short-leg non-weight-bearing cast was applied (Fig. 2).

Postoperatively, the cast was kept for eight weeks. Patients were assessed clinically and radiographically weekly for the first month, biweekly for the second month until fusion, and then every six months. The patients were monitored for the state of wounds, pin site, maintenance of correction, and progression of fusion. The pin was removed after six weeks and the cast was changed. Weight bearing was not permitted until union. A medial arch support was used for four months after which patients were allowed to stop using it. At the final follow
up, the outcome was assessed by the six radiographic parameters and clinically by the AOFAS ankle-hind foot scale.

Fig 2: The postoperative radiographs.

**Statistical analysis:**

The qualitative variables (sex and side) were expressed as an absolute value (n), frequencies, and percentages, while the quantitative variables (age, time to union, follow up duration, radiographic parameters, and AOFAS ankle-hind foot scores) were expressed as means, Standard Deviations (SD), and ranges. Statistical analysis was done to compare the mean preoperative and postoperative radiographic parameters and AOFAS scores using Student’s t-test. Level of significance was set at $P<0.05$. The descriptive analysis and statistical analysis were performed with IBM SPSS Statistics for Windows, Version 22.0 (IBM Corp., Armonk, NY, USA).

**Results:**

Patients were followed for a mean of 27.89 (SD 8.67; range 18-44) months. Bilateral cases were operated on at two sessions with an average interval of 15.6 months (SD 3.91; range 12-21). All osteotomies healed in a mean of 7.21 weeks (SD .713; range 6-8). The talo-navicular coverage was significantly decreased postoperatively ($P .000$) in all cases. The AP talus-1st metatarsal angle, AP talo-calcaneal angle, Costa Bartini angle, and the lateral talo-calcaneal angle were significantly decreased ($P .000$) after calcaneal lengthening. Calcaneal pitch angle was significantly increased after the operation ($P .000$) (Fig. 3,4) (Table 1). At the final follow-up, AOFAS ankle-hind foot score ranged from 82 to 100, with a mean of 96.32 (SD 5.83) with statistically significant improvement from the mean preoperative score of 57.53 ($P .000$).

Fig 3: Anteroposterior radiographs of a flexible flatfoot (a) preoperatively and (b) postoperatively at 18 months of follow up.

Fig 4: Lateral radiographs of the case in Fig 3 (a) preoperatively and (b) postoperatively at 18 months of follow up.

Four patients had mild occasional pain. One case of superficial wound infection was encountered and was treated with frequent antiseptic dressing changes and oral antibiotics. Delayed healing of the lateral incision occurred in five cases without signs
of infection and was managed by repeated dressing. There were no pin related complications. No cases of postoperative deep infections, non-union, or calcaneo-cuboid subluxation were encountered. There were no problems at the donor site or subluxation of the graft. Patients were asked about the satisfaction with their postoperative situation. All patients stated they were satisfied with the procedure (Fig. 5,6,7).

Fig 5: Clinical photos showing (a) the preoperative planovalgus deformity and (b) the postoperative deformity correction.

Fig 6: Postoperative clinical photos showing tip-toe standing and active range of motion without heel cord tightness.

Fig 7: Clinical photograph of the hind-feet in a patient with bilateral flexible flatfoot demonstrating the left foot after correction compared to the non-operated right side.

Discussion:

Flatfoot is a very commonly seen deformity in children and adolescents, most of which are flexible. Most authors currently agree that flexible flatfoot may be considered an anatomic variant and is not a disabling deformity. The usual indication for surgery in FFF is pain that does not respond to conservative management.\(^{[4-9]}\)

Numerous surgical procedures to correct flatfoot have been described. Surgeries that rely entirely on soft-tissue procedures are known to stretch out and fail in the short term. Arthrodesis of one or more of the joints in the subtalar complex has a detrimental effect of eliminating the shock-absorbing function and shifts stress to the ankle and mid-tarsal joints leading to premature degenerative arthrosis at those sites. Therefore, present surgical recommendations focus on preservation of subtalar motion.\(^{[6,8,12,13]}\)

Advocates of subtalar arthroereisis suggest that it is minimally invasive and preserves subtalar joint motion.\(^{[4]}\) Despite
reports of good outcomes, it has associated complications. The complications include those associated with biomaterials problems (breakage, degradation), inappropriate implantation (overcorrection, undercorrection, malpositioning, extrusion of implant, wrong size of implant), and biologic problems (implant-induced sinus tarsi impingement pain, foreign body reaction, synovitis, infection, intraosseous cystic formation in the talus, avascular necrosis of the talus, peroneal spasm, calcaneus fracture, and stress fractures of the fourth metatarsal).[4,13,14]

Osteotomy is the last category of procedures that has been used to treat flatfeet. The posterior calcaneus displacement osteotomy does not actually correct the malalignment of the subtalar joint, but merely creates a compensating deformity to improve the valgus angulation of the heel.[13] Vander Griend[13] described a Z-lengthening osteotomy of the calcaneus. This is more technically demanding, with probably more risk to damaging medially based structures. In 1975, Evans originally described treatment of planovalgus deformity with lateral column lengthening using autogenous tibial cortical bone graft.[16] In 1995, the technique was modified and further developed by Mosca[10] who described the specific location and direction of the osteotomy (exiting medially between the anterior and middle facets), and the trapezoidal shape of the bone graft. That was based on the observation that the center of rotation for the correction is near the center of the talar head and not simply the medial calcaneal cortex. Thus, the osteotomy is a distraction-wedge not simple opening wedge or plain distraction.

In addition, Mosca described the management of the medial and lateral soft tissues, the need to temporarily stabilize the calcaneocuboid joint, and the need to assess and concurrently manage contracture of the Achilles tendon.[5,6,10] In the present study, percutaneous Achilles tendon lengthening was done in 12 cases. In these cases, the Silfverskiöld test showed less than 10 degrees of dorsiflexion with the knee both flexed and extended indicating that the entire triceps surae was contracted and Achilles tendon lengthening was required. On the other hand, if at least 10 degrees of dorsiflexion is possible with the knee flexed, but not with the knee extended, the gastrocnemius muscle alone is contracted and an isolated gastrocnemius recession should be performed.[17] Rebalancing the forces that act on the arch can improve function and lessen the chance for further or subsequent development of deformity.[18]

In this series, the deformity was corrected in all cases with significant improvement in radiographic parameters and AOFAS ankle-hind foot score. There were very few minor surgical complications. Lateral incision wound healing was delayed in five cases. This might be explained by acute lateral soft tissue stretch. There was no calcaneo-cuboid subluxation, perhaps, due to stabilization by the K-wire.

It is difficult to compare our results with other authors because the reported series: presented several aetiologies; used inconsistent operative techniques; had variations in patient age; and lacked standardized outcome measures. For example, Adams et al.[19] found a significantly increased proportion of calcaneo-cuboid subluxation after lateral column lengthening in children with cerebral palsy. Ettl et al.[20] had no calcaneo-cuboid subluxation on using Mosca’s technique. Kim et al.[8] reported 3 cases of subluxation in 28 feet. Despite the excellent correction of deformity obtained by use of lateral column lengthening for FFF, some authors have reservations about its use because of reported secondary increases in the calcaneocuboid joint pressures.[21] However, the recent work of Xia et al.[22] found that lateral column lengthening using the Evans procedure can decrease the abnormally high pressure across the CC joint in the flatfoot. Ahn et al.[23] reported that the calcaneocuboid joint subluxation was gradually resolving over time, with no evidence of osteoarthritic change in the calcaneocuboid joint. Ragab et al.[24] reported that a calcaneal lengthening osteotomy might violate the subtalar joint and
have potentially deleterious long-term effects. However, this result has not been borne out by any published data.\textsuperscript{[13]}

In this study, the mean AOFAS score increased from 57.53 preoperatively to 96.32 postoperatively. This was better than the score of 71.9 reported by Haeseker et al.\textsuperscript{[25]} after distraction arthrodesis. However, it was comparable to other studies. Akimau and Flowers\textsuperscript{[12]} reported AOFAS score of 87±14 after lateral column lengthening. Klaue et al.\textsuperscript{[26]} reported increase in AOFAS score from 50 to 90 with a central calcaneal osteotomy. Oh et al.\textsuperscript{[27]} in their study of ten adolescents and young adults showed AOFAS scores increasing from 49.1 to 93.4 after combined medializing calcaneal osteotomy and lateral column lengthening in the symptomatic flat foot.

The advantages of calcaneal lengthening osteotomy are; being technically easy to be applied, low risk of neurovascular injury, and low loss of blood. In addition, it lets other procedures to be applied in the future contrary to arthrodesis. If arthrodesis is required later in these feet, it will be far easier to do because of the corrected alignment of the foot. However future long term studies may be needed to detect any deleterious effects on the subtalar joint caused by the osteotomy.

Limitations of the present study are that it is retrospective and has small numbers of patients.

Conclusions:
Calcaneal lengthening using the Mosca's technique was effective in deformity correction and pain relief of painful FFF in adolescents. The procedure corrected all components of flexible flatfoot while preserving subtalar joint motion. The technique is reproducible with minor complications.

References:
[10] Mosca VS. Calcaneal lengthening for valgus deformity of the hindfoot. Results in children who had severe, symptomatic flatfoot and skewfoot. J


