

Lateral calcaneal lengthening osteotomy versus subtalar arthroereisis in symptomatic flexible flat foot in children

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Background

Pediatric Flexible flat foot is the prevalent type of flat foot. Conservative measures are the first line of treatment. However, surgery may be required in some cases.

Objective

To compare outcomes of lateral calcaneal lengthening osteotomy versus subtalar arthroereisis for the pediatric flexible flat foot.

Methods

Calcaneal lengthening osteotomy was operated on 25 feet and subtalar arthroereisis was operated on 19 feet. Patients were evaluated preoperative and postoperative according to the American orthopedic foot and ankle society (AOFAS) ankle-hindfoot score, Meary's angle and Talonavicular coverage angle. The follow-up duration was 18 months.

Results

Lateral calcaneal lengthening osteotomy showed better clinical and radiological outcome versus subtalar arthroereisis. In LCL group, American orthopedic foot and ankle society (AOFAS) ankle-hindfoot score (68.2 ± 1.45 preoperative to 98 ± 5 postoperative) and Talonavicular coverage angle (18.8 ± 5.6 preoperative to 3.96 ± 2.46 postoperative) improved versus SA group, the AFOAS (68.62 ± 2.93 preoperative to 96.55 ± 3.48 postoperative) and Talonavicular coverage angle (23.98 ± 5.88 preoperative to 5.94 ± 4.59 postoperative) respectively. Significant difference was found postoperative between the two groups regarding Meary's angle, in LCL group improved from 17 ± 5.04 preoperative to 4.44 ± 1.66 postoperative while in SA group the angle improved from 23.62 ± 7.74 preoperative to 2.98 ± 1.27 postoperative.

Conclusion

Calcaneal lengthening osteotomy achieved more improvement in AOFAS score than subtalar arthroereisis group with better clinical and radiological outcomes but subtalar arthroereisis is less invasive procedure with early weight bearing and mobilization.

Keywords:

calcaneal lengthening osteotomy, flat foot, pediatric, subtalar arthroereisis

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Introduction

Pes planus, flat foot, means loss of medial arch with hindfoot valgus deformity and forefoot abduction. Flexible flat foot may be symptomatic or asymptomatic, with preserved medial arch if no weight bearing and arch lost during standing [1].

Symptomatic forms can present with chronic foot or knee joint pain and walking difficulties, because this deformity changes the biomechanics of the lower limb joints and lower part of the vertebral column [2].

There is general consensus and evidence that within the first years of life a flat shape of the foot has to be considered physiological, often spontaneously corrected by the age of ten years [3].

The common non surgical management of painful pes planus include activity modifications, physiotherapy and orthotics [4]. Chronic symptomatic flexible flat foot in children and adolescents needs surgical intervention only if nonsurgical treatment had failed. Surgical treatment includes a variety of techniques including soft-tissue reconstruction, subtalar arthroereisis (SA) and Calcaneal Lengthening Osteotomy (LCL) [4].

Calcaneal Lengthening Osteotomy is a surgical option to correct flexible flat foot in patients who did not show any improvement after conservative treatment.

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Lateral column lengthening (LCL) surgery keeps the growth and development of the foot bones without joint fusion. Evans developed this technique to make the length of the lateral and medial columns equal, this can correct forefoot abduction [5,6].

Subtalar arthroeresis is another procedure for treating flexible flat foot by putting implant within sinus tarsi. This implant acts mechanically by preventing the abnormal rotations of the tarsus and biologically by stimulating the proprioceptors in the sinus tarsi [7].

Reaching an optimum and appropriate surgical treatment of pediatric pes planus is still a matter of debate. Therefore, the present study aimed to compare the clinical and radiological outcomes of LCL osteotomy versus SA as a treatment of symptomatic flexible flat foot.

Patients and methods

This retrospective interventional study was conducted at Beni-Suef University Hospital after approval by the Local committee and informed consent was obtained from patients. The population of the study was enrolled from June 2020 till June 2022. Two patient groups were formed out of the patients in whom lateral calcaneal lengthening osteotomy (Evan's osteotomy): group I (25 feet) and subtalar arthroeresis: group II (19 feet).

Inclusion criteria: Patients with flexible flat foot who had chronic foot pain and age between 9 and 16 years at time of surgery.

Exclusion criteria: Patients with asymptomatic flat foot, Patients unfit for surgery, Paralytic disorders and rigid flat foot.

Methods and tools

Clinical assessment: History taking as All Patients presented with foot pain. **Physical examination:** Forefoot abduction (too many toes sign), Loss of medial longitudinal arch, Prominence of the talar head, flexible or correctable to normal alignment by Jack's toe-raising and tiptoe standing tests. Assessment of gastrocnemius or the Achilles tendon shortening was achieved by the range of ankle dorsiflexion (Silfverskiöld test).

All patients were assessed clinically by American orthopedic foot and ankle society (AOFAS) ankle-hindfoot score preoperative and postoperatively at 3, 6, 12 and 18 months.

Radiological assessment

Preoperative and then 3, 6, 12, and 18 months postoperatively to assess changes in the foot angles: standing weight-bearing anteroposterior radiographs to

measure the talonavicular coverage angle and standing weight-bearing lateral radiographs to measure the Meary's angle. Talonavicular coverage angle: is the angle between two lines connecting the edges of articular surfaces of the talus and navicular bones in the standing weight-bearing anteroposterior radiographs. It is a measure of lateral subluxation of the navicular bone on the talus, Normally $<7^\circ$. Meary's angle: In the standing weight-bearing lateral radiographs, the midline axis of the talus is in line with the midline axis of the first metatarsal. Angle below 0 degree or convex downward means pes planus.

Preoperative preparation

Preoperative preparation was done for all patients in the form of full laboratory investigations. Prophylactic antibiotic (third generation cephalosporin). A standard consent of iliac crest graft was taken from LCL group.

Operative procedure

Under general anesthesia, patients were placed in supine position on a standard radiolucent table. A tourniquet was used.

Lateral calcaneal lengthening osteotomy (Evan's osteotomy) approach (group I)

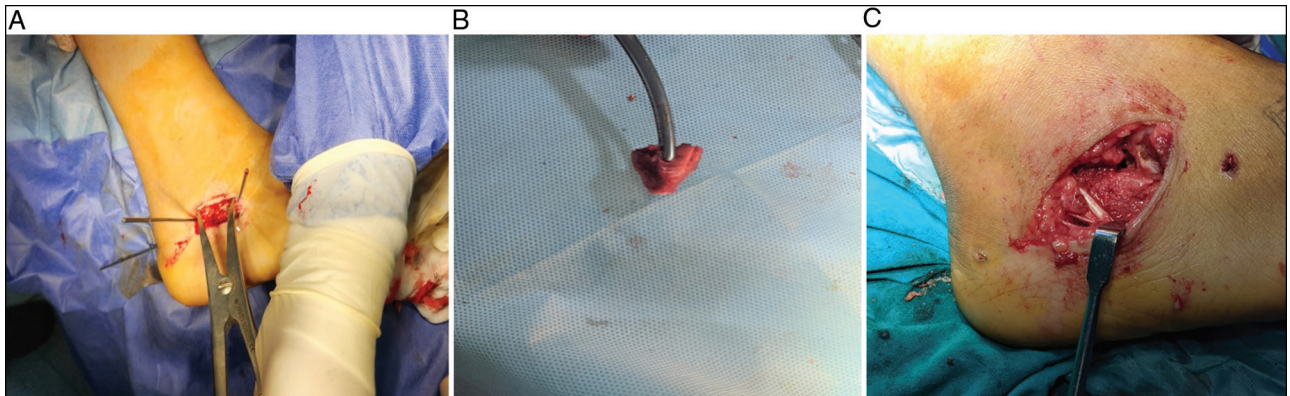
An oblique incision of 4–5 cm was performed on the lateral aspect of the calcaneus 1 cm below the lateral malleolus. The midline of the incision was about 1 or 1.5 cm proximal to the calcaneocuboid joint where the osteotomy site was done. Blunt superficial dissection of the subcutaneous tissues Then identification of the sural nerve, peroneus longus tendon, and peroneus brevis tendon just inferior to the muscle was done. Then a vertical incision was performed along the proximal edge of the muscle to expose the calcaneus bone.

The retractor was then placed along the superior and inferior borders of the calcaneus to expose the lateral surface of the calcaneus and protect the soft tissue. The osteotomy was performed 11 to 15 mm proximal to and parallel to the calcaneocuboid joint by osteotome and hummer from lateral to medial.

The tricortical iliac crest graft was typically trapezoidal in shape, ten to twelve millimeters long laterally and four to six millimeters medially. Figure 1

To decrease the incidence of calcaneocuboid subluxation which is the most common complication associated with LCL osteotomy, we insert the wire in the calcaneocuboid joint to stabilize it before distraction of the osteotomy then after impaction of the graft, the wire is advanced retrograde into the graft and the proximal calcaneus. The percentage of the subluxation of CC joint gradually decrease with time, at the last follow-up, the subluxation was improved, no

Figure 1



Clinical photos of iliac graft insertion: (a) size of the graft. (b): distraction of the osteotomy by lamina spreader.c) after insertion of iliac graft in the osteotomy site.

patients showed osteoarthritic changes in CC joint or nonunion at the osteotomy site. Figure 2

Subtalar arthroereisis (Group II)

A 2-cm incision was made on the lateral side of the hindfoot over the sinus tarsi, A guide pin was inserted through the sinus tarsi, perpendicular to the long axis of the calcaneus, checked by c-arm. The trial was placed onto the guide pin until the tip abutted the medial margin of the sinus tarsi. The correction was checked clinically and radiologically. The actual implant (BIOARCH subtalar system implant) advanced through the sinus tarsi and a screwdriver until the leading edge was one to two threads under the lateral bone cortex of the overlying talus neck. The range of motion and alignment of the subtalar joint and the position of the implant were assessed. Figure 3

Postoperative care

In LCL group, the patients were placed in a non-weight bearing short leg cast for 8 weeks. (Above knee cast when tendoachilles lengthening was done to relax the gastrocnemius muscle allowing full ankle dorsiflexion, in 10 feet). The K wire removed after 6 weeks and the patients started partial weight bearing after 8 weeks. In SA group, the patients were placed in a non-weight bearing short leg cast for 3 weeks to decrease the possible implant loosening and then started the partial weight bearing. Above knee cast for 6 weeks was applied when tendoachilles lengthening was done (in 9 feet). Then all patients of both groups were referred to rehabilitation center to continue muscle strengthening exercises and gait training.

Follow-up

was performed in the form of clinical and radiological evaluation, Plain Radiography foot at 1,3,6, 12, and 18 months.

Figure 2



Clinical photos of right foot preoperative A: side view and B: while performing tiptoeing test. C: Immediate postoperative clinical photo showing development of medial longitudinal arch Plain Radiography foot D: anteroposterior standing view preoperative showing Talonavicular coverage angle 28 degrees and E: lateral standing view showing Meary's angle 26 degrees. F: anteroposterior and G: lateral Radiography 6 weeks postoperative after calcaneal osteotomy showing union of iliac graft and subluxation in CC joint. H: anteroposterior and I: lateral standing Radiography 6 months postoperative, showing improvement in the Talonavicular coverage angle, Meary's angle and CC joint subluxation.

Figure 3



Clinical photos of right foot preoperative A: side view and B: while performing tiptoeing test. C: 18 months postoperative clinical photo showing development of medial longitudinal arch Plain Radiography foot D: anteroposterior standing view preoperative showing Talonavicular coverage angle and E: lateral standing view showing Meary's angle. F: anteroposterior and G: lateral Radiography 18 months postoperative after subtalar arthroereisis.

Statistical analysis

Data were collected, coded, revised, and entered into the Statistical Package for Social Science (IBM SPSS) version 20. The χ^2 test or independent t-test was used in the comparison between the two groups. $P < 0.05$ was considered Significant.

Results

This retrospective study was done on 44 patients (14 female and 30 male, the age ranged from 9–16 years old, Table 1.

The two groups were compared according to AOFAS, Talonavicular coverage angle and Meary's angle pre and postoperative. the LCL group show improvement in the AOFAS and talar head coverage with significant difference between the two groups regarding Meary's angle Table 2.

The complications in LCL group included, persistent pain was observed in one patient, pin tract infection in one patient treated by repeated dressing and antibiotics and residual deformity in another one that was accepted by the patient. in SA group persistent sinus tarsi pain was present in one patient and screw backed out in another one 2 months

Table 1 Demographic data, age and side

	LCL (N 25) Number (%)	SA (N. 19) Number (%)
Sex		
Female	4 (16.0%)	10 (52.6%)
Male	21 (84.0%)	9 (47.4%)
Side		
Left	10 (40.0%)	7 (36.8%)
Right	15 (60.0%)	12 (63.2%)
Age (yr)		
Range		9–16
Mean \pm SD	12.32 \pm 2.31	11.89 \pm 2.15

postoperative which was treated by reoperation with larger screw. Table 3

Discussion

Pes planus, flat foot, is a common foot deformity in which the medial longitudinal arch is lost. A treatment option for a flat foot that fulfills the target of a painless flat foot that well fits the shoe is still difficult as insufficient correction or overcorrection is commonly seen [8].

This study was conducted to compare the clinical and radiological outcomes of lateral calcaneal lengthening osteotomy versus subtalar arthroereisis as treatment options for symptomatic flexible flat foot.

The current work is a retrospective interventional study that included 44 patients with flexible flat foot who have chronic foot pain.

In our study the age of the patients ranged from 9–16 years old, in LCL group the mean age was 12.32 ± 2.31 while in SA group the mean age was 11.89 ± 2.15 . the study included 44 patients, 30 males (68%) and 14 females (32%). there, was no significant difference in lateral calcaneal lengthening osteotomy versus subtalar arthroereisis group regarding age and sex. as in previous studies, the two groups were homogenous in sex and age [9]. In agreement with study by Ghaznavi, A. *et al.* [8], in which the mean age was 9.2 ± 2.2 .

In *Tabirian et al.* [10] study, males were 64% while the gender percentage was not significantly different between the two groups. The mean age in LCL was 12.32 ± 2.31 and STA was 11.89 ± 2.15 , respectively and there was no significant difference between the age of the two groups.

In our study, a Final assessment was performed at the latest follow-up visit (18 months following surgery) comparing pre and postoperative. Similarly, *Tabirian*

Table 2 Preoperative and postoperative outcomes in the studied groups

Preoperative	LCL (N 25)		STA (N 19)		Paired t Test	
	Mean	SD	Mean	SD	t	P value
AOFAS ankle-hindfoot score	68.20	1.45	68.62	2.93	0.625	0.535
Talonavicular coverage angle	18.80	5.60	23.98	5.88	5.88	0.004
Meary's angle	17.00	5.04	23.62	7.74	3.431	0.001
Postoperative						
AOFAS ankle-hindfoot score	98.00	5.00	96.55	4.48	0.996	0.325
Talonavicular coverage angle	3.96	2.46	5.94	4.59	1.841	0.072
Meary's angle	4.44	1.66	2.98	1.27	3.187	0.002

Table 3 Complications in the studied groups

	LCL (N.25) Number (%)	STA (N.19) Number (%)
Complications		
None	22 (88%)	17 (89.5%)
Persistent pain	1 (4%)	1 (5.25%)
Screw backed out 2 months after operation	- (-)	1 (5.25%)
Residual deformity	1 (4%)	- (-)
Pin tract infection	1 (4%)	- (-)

et al. [10] reported that The postoperative follow-up ranged from 11 to 20 months, mean follow-up period could be affected by neurologic causes [9].

The present study revealed that postoperatively, the complete union was achieved in 100% of cases in LCL group. In LCL group, American orthopedic foot and ankle society (AOFAS) ankle-hindfoot score (68.2 ± 1.45 preoperative to 98 ± 5 postoperative) and Talonavicular coverage angle (18.8 ± 5.6 preoperative to 3.96 ± 2.46 postoperative) improved versus SA group, the AFOAS (68.62 ± 2.93 preoperative to 96.55 ± 3.48 postoperative) and Talonavicular coverage angle (23.98 ± 5.88 preoperative to 5.94 ± 4.59 postoperative) respectively. Significant difference was found postoperative between the two groups regarding Meary's angle, in LCL group from 17 ± 5.04 preoperative to 4.44 ± 1.66 postoperative while in SA group the angle improved from 23.62 ± 7.74 preoperative to 2.98 ± 1.27 postoperative.

As regard hindfoot motion (inversion plus eversion), all cases scored 6 and there was no restriction of the motion either pre or postoperative. As regard ankle-hindfoot stability (anteroposterior, varus-valgus), all cases were stable either pre or postoperative and scored 8.

Consistent with our results, *Sub et al.* [11] reported increase in the mean AOFAS score, in the LCL group was greater than in the SA group which indicated that the LCL group has more improvement in AOFAS scores [11]. However, another study reported that Both LCL and SA groups showed no significant difference between the groups during the last follow-up assessment

regarding total clinical scores [9]. In addition, in a met analysis by *Sub et al.* [11], The LCL group had more improvements Meary's angle measurement ranged from 21.7° to 9.5° in the LCL and from 12.8° to 10.6° in subtalar arthrodesis groups. The LCL group showed more improvement in the calcaneal pitch.

In contrast, *Chong et al.* [12] reported. The SA group showed more improvement in the calcaneal pitch versus LCL. They found significant improvement in the clinical and radiological outcome after either SA or LCL with no difference between the two groups. They explained that Subtalar arthrodesis is a less-invasive option versus LCL. SA aims to relocate the talus over the calcaneus correctly for subtalar joint remodeling [13].

Moreover, *Tabririan et al.* [10] found no significant difference between the two groups regarding Meary's angle. However, AOFAS significantly increased from 68.7 ± 5.7 to 87.8 ± 7.1 postoperative in LCL and from 67.3 ± 6.0 to 86.1 ± 7.5 in SA.

In our study, no pain was observed postoperatively except for one patient in the LCL group., Only one patient had a residual deformity and another patient had a pin tract infection treated by dressing and medical treatment in the calcaneal lengthening group. In SA group persistent sinus tarsi pain was present in one patient and screw backed out in another one 2 months postoperative which was treated by reoperation with larger screw The complications seen in the LCL were more than those in the SA group. *Sub et al.* reported the most common complication in the LCL was calcaneocuboid subluxation and persistent pain while implant loosening was the most common

complications in the SA group, [11]. *Dogan et al.* [9] reported similar results. In addition, associated forefoot abduction is better treated with LCL [14].

Study limitations

This study has several limitations. First, LCL techniques, methods and graft types are various. Second, implants for SA have different types. These could be conducted in further studies.

Conclusion

The calcaneal lengthening osteotomy had better clinical and radiological outcomes versus subtalar arthroereisis for the treatment of the flexible flat foot but subtalar arthroereisis is a less invasive procedure with early weight bearing and mobilization.

Acknowledgements

Nil.

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Nil.

Conflicts of interest

None declared.

Abbreviations

AOFAS, American orthopedic foot and ankle society; XXX, ankle-hindfoot score; LCL, Lateral column lengthening; SA, subtalar arthroereisis.

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