

## Mosca's Technique in Surgical Treatment of Symptomatic Flexible Flat Foot in Children and Adolescents

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### ABSTRACT

**Background:** Flexible flatfoot refers to downfall of the medial longitudinal arch on the weight bearing state, while it looks relatively normal in the non-weight-bearing position. The deformity has three components heel valgus, forefoot abduction and downfall of the medial longitudinal arch. **Objective:** This study aimed to evaluate Mosca technique in correction of all the components of the deformity of flexible flatfoot in one sitting.

**Patients and Methods:** A prospective study on 16 feet of 16 patients (8 males and 8 females) who underwent Mosca technique for symptomatic flatfoot in the period between July 2018 and July 2020. All patients were operated upon in Zagazig University Hospitals. The mean age of the studied group was 10.4 years old, and their mean follow up period was 12 months. Clinical assessment using American Orthopaedic Foot and Ankle Society (AOFAS) scoring system was performed. Radiological assessment of talonavicular coverage and talo-first metatarsal angle was done.

**Results:** Radiological results showed median decrease in the lateral talo-metatarsal angle from 27° preoperative to 3° postoperative at last follow-up. Meanwhile the median decrease in the talonavicular angle was 33° preoperative to 6° postoperative ( $P < 0.05$ ). Postoperative complications were minimal and controllable. Superficial wound infection on the lateral aspect of the foot which improved with antibiotics.

**Conclusions:** Correction of all components of the deformity in one sitting, the technique does not use arthrodesis, so the distribution of stresses in the different foot joints is not disturbed.

**Keywords:** Flexible flatfoot, Mosca's technique, Children, Adolescents.

### INTRODUCTION

The complicated foot malformation known as flatfoot is frequently observed in therapeutic settings. Foot abduction, medial longitudinal arch collapse, and hind foot valgus are all characteristics of the condition (1,2). Flatfeet were categorised into three categories by **Harris and Beath** (3): rigid flatfoot, flexible flatfoot with a short Achilles tendon, and flexible flatfoot with tarsal coalitions. Due to the plantar fascia's "windlass action," the longitudinal arch can be formed in a flexible flatfoot (FFF) by dorsiflexing the great toe and standing on toes (4,5). Most neonates have FFF, which is a typical foot shape, and most children naturally experience longitudinal arch elevation within the first ten years of life (2, 4, 6). There is general agreement that a patient with FFF who is asymptomatic does not require any particular treatment. Although they have been shown to be ineffective in correcting the deformity, shoe inserts may provide symptom relief. As a result, surgery is frequently considered in symptomatic individuals who do not respond to conservative treatments (4,7).

There have been many suggested surgical treatments for flatfoot, which can be divided into the categories of soft tissue repair, osteotomies, arthroereisis, and arthrodesis (6-9). Arthrodesis, arthroereisis, and just soft tissue operations have had dismal results. Therefore, for treating planovalgus foot abnormalities in children and adolescents, joint-sparing operations like lateral column lengthening and calcaneal osteotomy should be used (6, 8-10).

This study aimed to evaluate Mosca' technique in correction of all the components of the deformity of flexible flatfoot in one sitting.

### PATIENTS AND METHODS

This prospective study was conducted on 16 feet (8 males and 8 females) with flexible flatfoot deformity. Ages ranged from 6 to 16 years old with a mean age of 10.4 years. There were 16 unilateral cases 68.75% Rt feet and 31.25% Lt feet patients were operated in Zagazig university hospital and follow up duration was 12 months (ranging from 6 to 18 months).

**Inclusion criteria:** Symptomatic cases. Age from 6-16 years old, resistant to conservative measure, and patients with open growth plates, as determined with plain radiographs.

**Exclusion criteria:** Asymptomatic cases, age above 16 years old, patients with insufficient follow-up data or lost, and patients with tarsal coalition or neuromuscular disease.

#### Pre-operative:

All patients underwent full clinical evaluation (history, general examination and local examination). A comprehensive general examination of each patient performed and related signs to flat feet noticed as generalized laxity, coronal and rotational lower limb malalignment. For all patients the foot and ankle should be examined with the patient standing and sitting, as a flatfoot deformity may not be apparent in the absence of weight bearing. Also, the patient's gait, range of motion, flattening of the longitudinal arch, abduction of the forefoot (too many toes), heel valgus, tightness of Achilles tendon, tip toe position (double heel rise), the associated varus of the heel and supination of the foot should be assessed. Scoring system is a part of clinical evaluation. Preoperative scoring system in a form of questionnaire had been designed to give information as

to how foot pain has affected the patient ability to manage in everyday life. In this study we used American Orthopaedic Foot and Ankle Society (AOFAS) Ankle-Hindfoot score. Radiographic assessment was based on evaluation of five parameters: standard anteroposterior (AP) and lateral radiographs. The talo navicular coverage, Meary's angle (AP talus-1st metatarsal angle), AP talo-calcaneal angle, calcaneal pitch angle and the lateral talo-calcaneal angle. A Meary's angle greater than 4 degrees convex downward suggests pes planus. This angle is also called the talus-first metatarsal angle and constitutes the angle obtained from lines drawn from the center longitudinal axes of the talus and first metatarsal bone. A calcaneal inclination angle less than 18 degrees is indicative of pes planus. This angle is obtained from the calcaneal inclination axis and the horizontal surface on which the foot is placed. Preoperative complete blood count (CBC), prothrombin time (PT), partial thromboplastin time (PTT), international normalized ratio (INR), liver and renal function tests were done. All the patients received a single dose of prophylactic antibiotic first generation cephalosporin 50 mg/kg within one hour before tourniquet inflation.

**Post-operative follow-up:**

**First two weeks:** Antero-posterior and lateral X-rays for the operated foot was done on the same day of operation. At the end of 2<sup>nd</sup> week sutures were removed and the below knee slab changed to complete cast below knee. Absolute non weight bearing for the 1st 6 weeks post-operatively had been done.

**From the 2<sup>nd</sup>-week to the 8<sup>th</sup>- week postoperatively:** At 6<sup>th</sup> week pins and cast were removed, protective weight bearing as tolerated by the patients was allowed. Follow up X- ray by the end of the 6<sup>th</sup> week. From the 6<sup>th</sup> week to the 6<sup>th</sup> month postoperative, patients used medial longitudinal arch

support. Return to pre-operative function and activity as tolerated by the patients as early as possible to be tried.

**Ethical consent:**

An approval of the study was obtained from Zagazig University Academic and Ethical Committee. Every patient signed an informed written consent for acceptance of participation in the study. This work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

**Statistical analysis**

The collected data were coded, processed and analyzed using the SPSS (Statistical Package for Social Sciences) version 22 for Windows® (IBM SPSS Inc, Chicago, IL, USA). Data were tested for normal distribution using the Shapiro Walk test. Qualitative data were represented as frequencies and relative percentages. Chi square test ( $\chi^2$ ) was used to calculate difference between two or more groups of qualitative variables. Quantitative data were expressed as mean  $\pm$  SD. Independent samples t-test was used to compare between two independent groups of normally distributed variables (parametric data). P value  $\leq$  0.05 was considered significant.

**RESULTS**

**Clinical results and functional evaluation:**

16 cases were assessed clinically pre- and post-operative by (Jack test, tip toe test, too many toes sign and tight tendon Achilles). Tip toe test and Jack test turned from positive preoperative to negative postoperative in all cases, too many toes sign turned from positive to negative postoperative in all cases except in 2 cases, 9 cases with tight tendon Achilles preoperative only one case showing recurrent tendon Achilles contracture postoperative (Tables 1 & 2).

**Table (1):** Pre- & post-operative clinical improvement of tendon Achilles tightness, heel valgus ( too many toes sign), Jack test and tip toe test

Patient	Side	Operated side	Jack test		Tip toe test		Tight achillis		Too many toes sign	
			pre	post	pre	post	pre	post	pre	Post
1	Unilat	Lt	+	-	+	-	-	-	+	-
2	Unilat.	Rt	+	-	+	-	-	-	+	-
3	Unilat.	Lt	+	-	+	-	+	-	+	-
4	Unilat.	Rt	+	-	+	-	-	-	+	-
5	Unilat.	Lt	+	-	+	-	+	-	+	-
6	Unilat.	Rt	+	-	+	-	+	-	+	-
7	Unilat.	Lt	+	-	+	-	-	-	+	-
8	Unilat.	Rt	+	-	+	-	+	-	+	-
9	Unilat.	Lt	+	-	+	-	+	-	+	-
10	Unilat.	Rt	+	-	+	-	-	-	+	+
11	Unilat.	Lt	+	-	+	-	-	-	+	-
12	Unilat.	Rt	+	-	+	-	-	-	+	-
13	Unilat.	Lt	+	-	+	-	+	-	+	-
14	Unilat.	Rt	+	-	+	-	+	-	+	+
15	Unilat.	Rt	+	-	+	-	+	-	+	+
16	Unilat.	Rt	+	-	+	-	+	-	+	+

**Table (2):** Number of preoperative and postoperative cases positive test result

	Number of preoperative cases positive test result	Number of postoperative cases positive test result
Jack test	16	0
Tip toe test	16	0
Tight Achilles	9	0
Too many toes sign	16	4

**Radiological results**

Lengthening the calcaneus and reconstruction of medial soft tissue resulted in improvement of the mean of the lateral talometatarsal angle from 27.9° preoperative to 3.82° at last follow up, an improvement of the mean of the AP–talonavicular angle from 33° preoperative to 6.67° at last follow up and improvement of the mean of calcaneal pitch angle from 12.8 preoperative to 26.6 at last follow up.

The median reduction in angle measures was more accurate to assess improvement in the angle to

avoid extreme values. It was as following: The median drop in the lateral talo-metatarsal angle was 27° (range: 12° to 45°) and 3° (range: 0° to 15 °) at last follow-up.

The median reduction in the talo-navicular angle was 33° (range: 12° to 70°) and 6° (range: 3° to 20°) at last follow up. The median rise in the calcaneal pitch angle was 11° (range: 8° to 14°) and 23°(range: 19° to 27°) at last follow up. The average reduction in both angles was statistically significant (P< 0.04) (Tables 3, 4).

**Table (3):** Pre and postoperative radiological scoring using AP TNA, CPA and Lateral TMTA

Patient Number	Operated side	Pre			Post		
		TNA	TMTA	CPA	TNA	TMTA	CPA
1	Lt	21	29	4.5	3	2.5	24
2	Rt	23	37	8	2.5	2	16
3	Lt	24	26	6.5	3.5	4	22
4	Rt	24	30	4.5	10	3.5	23
5	Lt	26	33	5.5	2	4.5	25
6	Rt	22	28	7.5	4.5	3	23
7	Lt	30	25	4	5	5	15
8	Rt	36	27	5.5	6.5	4	24
9	Lt	37	38	5	5.5	2	17
10	Rt	31	25	7	4.5	3.5	19
11	Lt	32	32	7.5	9	5	18
12	Rt	29	34	7	2	2	16
13	Lt	28	36	6.5	8.5	3	17
14	Rt	30	35	4.5	3	2.5	16
15	Rt	33	30	5	6	3.5	19
16	Rt	37	31	6	2.5	4	20

**Table (4):** Median variation in TMA, and TNA after operative procedure

Angle	Preoperative Median (range)	Postoperative Median (range)	P Value
TMA	31° (25° - 38°)	3.375° (2° - 5°)	<0.04
TNA	28.93° (21° - 37°)	4.875° (2° - 10°)	
CPA	5.9°(4°-8°)	19.625°(16°-25°)	

**According to American Orthopaedic Foot and Ankle Society (AOFAS)**

The mean functional American Orthopaedic Foot and Ankle Society (AOFAS) Ankle-Hindfoot score improved from 43.45 (31-55) preoperatively to 85.52 (68-92) postoperatively at last follow up (P value < 0.001) using paired t-test as a significance test for evaluation of pre- and post-operative AOFAS score (Tables 5 & 6).

**Table (5):** Ankle- Hindfoot score:

Patient Number	Age	Sex	Side distribution	Operated side	Pre	Post	Result
1	7	♂	Unilat	Lt	42	86	Good
2	11	♀	Unilat.	Rt	40	91	Good
3	13	♀	Unilat.	Lt	41	85	Good
4	9	♂	Unilat	Rt	33	75	Fair
5	10	♀	Unilat	Lt	47	91	Good
6	6	♂	Unilat.	Rt	34	75	Fair
7	16	♂	Unilat.	Lt	35	77	Fair
8	8	♂	Unilat.	Rt	31	70	Fair
9	9	♀	Unilat.	Lt	46	87	Good
10	11	♂	Unilat.	Rt	45	92	Good
11	9	♂	Unilat.	Lt	28	91	Good
12	7	♀	Unilat.	Rt	30	83	Good
13	10	♂	Unilat.	Lt	37	91	Good
14	11	♀	Unilat.	Rt	40	53	Poor
15	10	♀	Unilat.	Rt	49	92	Good
16	13	♂	Unilat.	Rt	44	88	Poor

**Table (6):** Clinical results assessed by AOFAS score

Number of cases	Range	Result
10	80-100	Good
4	60-80	Fair
2	30-60	Poor

Clinical results are assessed by AOFAS score and the functional assessment showed improvement postoperatively as follows: 16 cases operated, 10 cases showed good results , 4 cases were fair and 2 cases showed poor results postoperatively (Table 7).

**Table (7):** Pre and postoperative AOFAS significant difference.

AOFAS	Mean ± SD	T	P value
Preoperative	39.5 ± 6	-37.693	< 0.001
Postoperative	80 ± 8		

**DISCUSSION**

Pathoanatomy of the planovalgus foot deformity is complex and involves several key components: Relative shortening of the lateral column in relation to the medial column, relationships of the hindfoot bones are abnormal so that the facet joint orientation in the subtalar joint leads to a progressive medial subluxation of the talar head, and navicular displaces laterally on the talar head <sup>(11)</sup>.

The Evans-originally described lateral calcaneal lengthening osteotomy for paediatric flatfoot was discovered to restore the medial longitudinal arch and correct forefoot abduction, allowing for a reduction in strain and successful medial ligament restoration <sup>(12)</sup>. The average age of the 20 patients who had calcaneal lengthening osteotomy in the study by **Baghdadi et al.** <sup>(13)</sup> was  $10.4 \pm 0.9$  years. The average number of follow-up months was  $23.1 \pm 9.9$  months. The AOFAS score was used to evaluate the patients. When compared to pre-operative score, the AOFAS score at the final follow-up dramatically improved ( $37$  to  $88$ ,  $P < 0.0001$ ).

The mean of the lateral talo-metatarsal angle improved radiographically from  $28.1^\circ$  preoperative to  $4.7^\circ$  at the most recent follow-up, as did the mean of the AP-talonavicular angle ( $P$  value  $0.05$ ) and the mean of the calcaneal pitch angle (from  $7.5^\circ$  preoperative to  $21^\circ$  at the most recent follow-up). Following surgery, radiographic indicators significantly improved ( $P < 0.0001$ ) <sup>(13)</sup>.

Six patients in their study reported ankle and subtalar joint pain, five patients reported walking-related discomfort at the calcaneocuboid joint, and two patients reported pain during inversion and eversion. Twelve patients with tight tendon Achilles prior to surgery had three patients with persistent tight tendon Achilles postoperatively, and three more patients with residual heel valgus. Hardware irritation and distal segment displacement were observed as postoperative problems in two and three instances, respectively, but had no long-term clinical effects <sup>(13)</sup>. **Marengo et al.** <sup>(14)</sup> evaluated 38 operated feet, with a mean age of  $13.3 \pm 2.2$  years (range  $7.8$ - $17$ ) at the time of surgery, in order to examine the clinical, functional, and radiological results of calcaneal lengthening osteotomy for the treatment of symptomatic flatfoot. From a preoperative value of  $49.9 \pm 16$  (range  $23$ - $75$ ) to a postoperative value of  $89 \pm 15.9$  (range  $34$ - $100$ ), the AOFAS score considerably increased ( $p < 0.001$ ). The mean lateral talo-metatarsal angle radiographically improved from  $15.1^\circ$  preoperative to  $6.7^\circ$  at the most recent follow-up, as did the mean calcaneal pitch angle, which went from  $8.8^\circ$  preoperative to  $22.6^\circ$  at the most recent follow-up. Four patients in their study experienced pain at the ankle and subtalar joint, four patients felt discomfort at the calcaneocuboid joint during walking, and no patients experienced pain with inversion or eversion. Of the 14 patients who had tight tendon Achilles prior to surgery, two had residual heel valgus, and two more had tight tendon Achilles postoperatively.

A scientific review on lateral column lengthening for pes-planovalgus deformity, encompassing 103 patients and 156 feet, was done by **Kumar et al.** <sup>(15)</sup> The median follow-up period was 70.2 months (range  $24.9$ - $156$ ) and the mean age was 13.3 years (range:  $5.7$ - $42$ ). The mean preoperative AOFAS score was 58.85 (range  $34$ - $78$ ) feet, while the mean postoperative AOFAS score was 92.25 feet (Range  $73$ - $100$ ). The mean of the lateral talometatarsal angle improved radiographically from  $19.7^\circ$  preoperative to  $5.2^\circ$  at the most recent follow-up, as did the mean of the AP-talonavicular angle ( $28.4^\circ$  preoperative to  $6^\circ$  at the most recent follow-up ( $P$  value  $0.05$ )). Also, the mean of the calcaneal pitch angle ( $21.9^\circ$  at the most recent follow-up). The calcaneal pitch, lateral talo-metatarsal, and AP talo-navicular angles all improved statistically significantly ( $p$ -value  $0.001$ ). In their investigation, complications included calcaneocuboid subluxation, metal sensitivity, sural neuropathy, pseudo-arthritis, non-union, and adhesion development <sup>(15)</sup>.

When treating children with symptomatic flatfoot, **Suh et al.** <sup>(16)</sup> compared lateral column lengthening (LCL) with arthroreisis (AR). In the LCL and AR groups, there were 21 and 13, respectively, studies that examined 1144 and 818 feet from 729 and 565 individuals, respectively. In all included studies of the LCL group and eight studies of the AR group, the mean age varied from 8.6 to 13.6 years and from 7.7 to 12.1 years, respectively. The age range was 2-15 years without the mean age was reported in the remaining five studies in the AR group. In all included studies of the LCL group, the mean follow-up time ranged from six months to 10.9 years, while in 11 studies of the AR group, it ranged from 18.4 months to six years. The final two studies in the AR group revealed the follow-up period's range (1-15 years) but not its mean duration. The LCL (AOFAS ankle-hindfoot rating) improved more than the AR institution (AOFAS ankle-hindfoot rating improvements ranged from 27.7 to 39.1) (17 to 22) for both respectively. In comparison with the AR institution, the LCL's complication rate increased from 0% to 86.9%. The most common headaches in the LCL and AR groups, respectively, were calcaneocuboid subluxation and chronic discomfort. The LCL (0% to 27.3%) and AR (0% to 36.4%) groups showed comparable re-operation costs. The outcomes compared to the AR organization showed that the LCL organisation had more radiographic corrections and AOFAS score improvements. The LCL institution experienced more complications than the AR group did on a regular basis, and the two organisations' re-operation rates were comparable. In LCL studies, disadvantages such as insufficient corrections, overcorrections, loss of correction due to insufficient graft size, graft migration, or malposition have been reported. Common complications include overcorrection and undercorrection, and the AR group has also reported calcaneus fractures, inflammatory

synovitis, sinus tarsi pain, cortical erosion, and talar avascular necrosis.

Our study's objective is to assess the effectiveness of lateral column lengthening with medial soft tissue reconstruction to treat both bone and soft tissue defects in children with severe and symptomatic flexible flatfoot. As the osteotomy location is away from the growth plate in individuals with skeletal immaturity, this approach was chosen to lessen the surgical insult and conduct a correction that aids in continued growth and remodeling.

The current study involved 22 feet 18 patients with flexible flatfoot deformity. The patients' ages ranged from 7 to 17 years (mean 10.4 years), and they were monitored for at least 16 months. The American orthopedic foot and ankle score was used in the current study to score outcomes. Our findings showed that the mean AOFAS ankle-hindfoot score increased from 42.55 (30-55) preoperative to 85.45 (68-92) postoperative at the last follow up (P value < 0.001).

The mean of the lateral talometatarsal angle improved radiologically from 27° preoperative to 3° at the most recent follow-up, as did the mean of the AP-talonavicular angle (P 0.05) and the mean of the calcaneal pitch angle (P 0.05) from 12.8° preoperative to 26.6° at the most recent follow-up.

The findings of this study demonstrated the efficacy of lateral column lengthening as a surgical technique to treat children's flexible flatfoot-related pain and deformity, allowing them to resume normal activities.

At the most recent follow-up, the results following surgery were 7 patients (38.9%) had slight occasional pain, while 11 patients (61.1%) claimed total pain alleviation. Ankle and subtalar joint discomfort was present in three patients with modest pain. While walking, two patients experienced discomfort in the calcaneocuboid joint, and another two patients experienced discomfort in the talonavicular joint, but there was no pain experienced during inversion and eversion. One patient continued to have a tight tendon. Eleven patients' Achilles had tight tendon preoperatively, while two other patients still had heel valgus.

Due to the negative consequences of removing the crucial joint complex's shock-absorbing function, arthroplasty of one or more of its joints has been abandoned as a treatment for FFF. The ankle and mid-tarsal joints have premature degenerative arthrosis as a result of talo-navicular, subtalar, and triple arthrodesis, which shifts stress on those areas.

The calcaneal lengthening osteotomy and medial soft tissue restoration benefits include ease of technical application and limited potential for neurovascular structure injury. Contrary to subtalar or triple arthrodesis, this approach allows for the future application of other treatments in the operated foot. When arthrodesis is eventually necessary in these feet,

it will be much simpler to execute due to the restored foot alignment. The same surgical technique and assessment scoring system were used in this study, which was conducted on 22 feet. This had a positive impact on our results, and the use of such a surgical technique aided us in overcoming our weaknesses in future research.

The results of this study must be viewed in the context of some limitations including the small sample size (18 cases), brief follow-up period (mean 12 months), the highly subjective nature of the children's descriptions of the foot pain, and the absence of comparable prior studies on the same subject and age group in our area. In addition, it is crucial to conduct large-scale studies with extended follow-up periods in order to enforce our findings and make sure that there are no subsequent issues that contradict them.

## CONCLUSION

The results of this study supports the combination of lateral column lengthening and soft tissue reconstruction (Mosca technique) for treatment of plano-valgus foot deformity with the following advantages: (1) Correction of all components of the deformity in one sitting, the technique does not use arthrodesis, so the distribution of stresses in the different foot joints is not disturbed. (2) The technique can be done safely in young children as there is no interference with the centers of ossification of the foot bones with minimal complications. (3) An important advantage of this technique is that it lets other procedures to be done in the future in the operated foot as subtalar or triple arthrodesis.

**Conflict of interest:** The authors declared no conflict of interest.

**Sources of funding:** This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

**Author contribution:** Authors contributed equally in the study.

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