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Original Article

A Combined Reconstructive Procedure with Rerouting of Tibialis Anterior Tendon in Management of Severe Flexible Flatfoot in Children in Damietta

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ABSTRACT

Article information

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Background: Severe flexible flatfoot [FFF] in children can cause long-term disability if left untreated. Various surgical techniques have been described to correct the deformity. However, no surgical technique is universally accepted.

Aim of the work: The aim of this study is to evaluate the clinical and radiological outcomes of a combined reconstructive procedure involving rerouting of the tibialis anterior tendon for severe flexible flatfoot in children.

Patients and Methods: This prospective study included 20 children [35 feet] with severe FFF who underwent a combined procedure involving medializing calcaneal osteotomy, lateral column lengthening, and rerouting of the tibialis anterior tendon. Clinical assessment and radiographic evaluation of talo-first metatarsal [T1MT] angle, Meary's angle and calcaneal pitch were done preoperatively and at final follow-up [minimum 6 months]. Evaluation of function was done using the American Orthopedic Foot & Ankle Society [AOFAS] score.

Results: There was significant improvement in the mean AOFAS score from 52.5 ± 13.5 preoperatively to 87 ± 7.8 at final follow-up. The mean T1MT angle improved from 17.29° ± 4.32° to 6.66° ± 4.1° and calcaneal pitch from 8.63° ± 2.51° to 21.43° ± 4.95°. No major complications were encountered.

Conclusion: Rerouting of the tibialis anterior tendon as an adjunct to combined reconstructive procedure provided satisfactory clinical and radiological outcomes in management of severe flexible flatfoot in children with minimal complications.

Keywords: Achilles Tendon; Flatfoot; Foot Orthoses.

INTRODUCTION

Flatfoot, medically referred to as pes planus, is characterized by complete contact of the foot arch with the ground during weight-bearing. In children, two primary types of flatfoot exist: flexible flatfoot [FFF] and rigid flatfoot. Flexible flatfoot, a prevalent condition, typically resolves spontaneously during childhood as the foot arch is evident in non-weight-bearing positions [1].

Severe flexible flatfoot in pediatric cases may manifest as foot or leg pain, fatigue, and challenges engaging in activities involving prolonged standing or walking, thus potentially impacting the child's quality of life [2].

Effective management strategies for Flexible Flatfoot [FFF] remain a topic of debate within the medical community. Recommendations vary widely, from advocating aggressive surgical correction in children as young as two years old to advising against any interventions, including shoe modifications or inserts. Most orthopedic practitioners recommend a middle ground approach that balances the severity of the condition with appropriate intervention [3].

The range of treatment choices spans from employing orthotic devices to opting for arthrodesis. Initially, conservative measures like corrective footwear, arch supports, and heel wedges are recommended. If these methods prove ineffective in alleviating the patient's symptoms, particularly pain during daily activities, surgical interventions may be warranted. In cases of idiopathic origin, careful consideration is advised before proceeding with surgery, given the typically benign nature of the condition [4].

The surgical treatment of severe flexible flatfoot in pediatric patients may encompass interventions aimed at realigning the foot and reconstructing the arch, including procedures like tendon elongation, ligament repair, or foot bone fusion [5]. Surgical intervention is usually recommended in cases where non-invasive therapies have not effectively addressed symptoms or enhanced functionality. Comprehensive post-operative care and rehabilitation are vital for achieving a favorable treatment outcome [6].

In a combined procedure, a medializing calcaneal osteotomy is performed using an oblique osteotome at the calcaneal tuberosity to address the valgus alignment of the heel. This is accompanied by a lateral column lengthening procedure to correct hindfoot valgus and restore the integrity of the lateral arch. Furthermore, rerouting of the tibialis anterior tendon is implemented to provide reinforcement to the first tarsometatarsal joint and sustain the corrective adjustments [7].

Severe flexible flatfoot is a common pediatric condition that requires surgical intervention in resistant cases. While there are various corrective techniques described in the literature, no single procedure proves consistently superior [4]. Medializing calcaneal osteotomy accompanied by lateral column lengthening is widely used to correct hindfoot valgus and restore the medial longitudinal arch. However, recurrence and secondary loss of correction remain challenges [8]. Rerouting of the tibialis anterior tendon acts as an adjunct, functionally replacing the spring ligament and providing dynamic support to enhance stability of the reconstructive procedure [9]. The current study aims to evaluate the outcomes of a combined technique incorporating rerouting of the tibialis anterior tendon along with standard osteotomies. This approach was hypothesized to decrease risk of recurrence by reinforcing the correction achieved.

The objective of the study is to assess the feasibility of combined technique in the treatment of flexible flatfoot in children and assess its related outcomes.

PATIENTS AND METHODS

Study Design: A prospective interventional study that was conducted for 20 severe flexible flat foot children admitted in department of Orthopedic surgery, Al-Azhar university Hospital in Damietta. and Mansoura insurance hospital and treated with combined reconstructive procedure with rerouting of tibialis anterior tendon

Inclusion criteria: aged from 9 to 14 years who has severe degree flexible flat foot with failed conservative measures.

Ethical approval: The Committee of the Damietta Faculty of Medicine IRB, Al-Azhar University granted permission [DFM-IRB0001367-22-10-001] on 16-10-2022. Preoperative written consent for the surgery and for the child's participation in the study was obtained from the parents.

Data collection: For every child, the following data were obtained: demographic [age, sex], clinical [weight, height] and the main complain of the patient pain in the foot and leg, difficulty in walking, running or jumping and, unsightly appearance of the foot, excessive shoe wear and distortion. X-ray [lateral and anteroposterior views] of the foot: Lines are drawn along the longitudinal axes of the calcaneus, talus, and first metatarsal to measure the following angles: lateral talometatrasal angle the calcaneal pitch angle. In addition, computed tomography [CT] of the foot was done to exclude arthritis and tarsal coalition.

Surgical Technique

The surgery involves rotating the foot internally while the patient is in a supine position. A lengthwise incision is made over the calcaneocuboid joint, with careful attention to avoid damaging its capsule. An osteotomy is performed longitudinally on the lateral side of the calcaneus, approximately 1.0-1.5 cm proximal to the calcaneocuboid joint. Although the graft is typically stable, one or two K-wires may be used for additional fixation to ensure stability.

A tendo Achilles lengthening procedure is performed through a posterior-medial incision to allow for 10-15% dorsiflexion. Medial plantar structures plication and naviculocuneiform fusion are carried out. Two intersecting K-wires are used to approximate the raw surfaces, aiding in the restoration of the medial arch.

Maintaining the tendon insertion undisturbed, the tibialis anterior tendon is mobilized proximally, the distal end of the tendon is directed to pass through the plantar aspect of the naviculocuneiform fusion and talonavicular joint. A groove is fashioned beneath the navicular tuberosity to secure and maintain the tibialis anterior tendon in place.

The tibialis anterior tendon is then stitched to the soft tissues located beneath the talar head. The tightened ligamentous flap is then folded over the plantar soft tissues covering the tibialis anterior tendon, forming a robust plantar ligament to support the naviculocuneiform fusion and the talonavicular joint. A below-knee plaster cast without weight bearing is worn for 8 weeks to facilitate the healing of the ligament reconstruction.

Outcomes

Pain intensity was evaluated using an 11-point numeric rating scale [NRS] ranging from 0 to 10, where 0 represents no pain and 10 represents the most severe pain possible. Pain was re-evaluated for severity and its relation to movement and weight bearing at 3-weeks, 3-months and 6-months after surgery.

Radiological assessment using plain film for evaluation of PO Meary's angle after removal of stitches and 6-months after surgery. A mid-calf line was drawn on the dorsum of the leg for evaluation of the determined preoperative angle. The following radiological angles were compared pre- and post-operatively: talo-first metatarsal angle [T1MT], Lateral talo-first metatarsal angle [T-H], Calcaneal pitch angle [CpA].

The assessment of ankle and hind foot function before and after surgery was done using the American Orthopedic Foot & Ankle Society [AOFAS] score. This score evaluates pain, function, and alignment, with a maximum of 100 points. Ratings of 90 – 100 were classified as excellent, 75 – 89 as good, 50 – 74 as fair, and below 50 as poor.

Quality of life improvement: The outcomes were evaluated based on improvement in foot aesthetics [cosmetic appearance], footwear compatibility, pain alleviation, and activity improvement.

Statistical Analysis: All information was gathered, organized, and statistically analyzed using SPSS 22.0 for Windows [SPSS Inc., Chicago, IL, USA]. Data underwent normality testing using the Shapiro-Wilk test. Categorical data were presented as frequencies and relative percentages. The Chi-square test [$\chi 2$] and Fisher's exact test were employed to assess variances between categorical variables, as appropriate. Numeric data were described as mean ± SD [standard deviation] for normally distributed variables and as median and range for non-normally distributed data. The paired t-test was utilized for comparing two related groups of normally distributed variables, while the Wilcoxon signed-rank test was used for non-normally distributed variables. Repeated measures ANOVA was applied to compare means across one or more variables based on repeated observations for normally distributed variables. Conversely, Friedman's test was utilized for non-normally distributed variables. All statistical analyses were two-tailed, with a significance level set at a P-value of ≤ 0.05 indicating a significant difference and $P > 0.05$ indicating a non-significant difference.

RESULTS

Table [1] shows general characteristics of the studied patients. The mean age was 11.6 ± 1.76 years. Among the 20 patients, 11 [55%] were male and 9 [45%] were female. In terms of the affected side, 3 patients [15.0%] had deformity on the right side, 2 patients [10.0%] had deformity on the left side, and 15 patient [75.0%] had deformity on both sides [right and left].

Table [2] shows that there is a significant reduction in NRS from preoperative to postoperative.

Table [3] illustrates changes in radiological parameters among the studied participants. For T1MT, the mean value before the operation was 17.29 ± 4.32, and after the operation, it became 6.66 ± 4.1 [P=<0.001]. For the T-H, there was a significant reduction from preoperative to postoperative. Regarding Meary's angle, there is a significant reduction from 22.57 ± 7.57 preoperative to 3.88 ± 0.518 postoperative. Also, in cp angle showed there is a significant increase in calcaneal pitch angle from preoperative to postoperative.

Table [4] shows that 94.3% of the patients had pain relief, 68.6% of the patients showed improvement of shoe wear, 97.1% of the patients showed cosmetic improvement, and 88.6% of the patients showed improvement in activity.

The average AOFAS score before surgery was 48.6 ± 11.6 [ranging from 25 to 73]. After 3 months, the mean AOFAS score was 84.5 ± 10.5 [ranging from 64 to 93], and after 6 months, it was 86.5 ± 8.5 [ranging from 68 to 95]. 25 [71.5%] feet had excellent functional scores, seven [20%] feet had good scores and three [8.5%] feet were poor [Table 5].

Table [1]: General characteristics of the studied patients

Variables		
Age [years]	Mean ± SD	11.6 ± 1.76
BMI [kg/m^2]	Mean ± SD	23.67 ± 2.24
Sex n=20], n [%]	Males Females	11 [55%] 9 [45%]
Side n=20], n [%]	Bilateral Right Left	15 [75%] 3 [15%] 2 [10%]
The main complaint [n=35], n [%]	Pain Cosmetic Pain and Cosmetic	16 [45.7%] 5 [14.3%] 14 [40%]

Table [2]: NRS distribution among the studied patients

	Studied patients, [n=35 feet]
NRS	
Preoperative, Mean ± SD	6.29 ± 1.92
3 months postoperative, Mean ± SD	2.31 ± 1.51
6 months Postoperative, Mean ± SD	0.8 ± 0.933
P-value	**<0.001**

Table [3]: Changes in radiological parameters among the studied participants

Radiological finding	Pre-operative [n=35]	Post-operative [n=35]	P value
T1MT °, Mean ±SD	17.29 ± 4.32	6.66 ± 4.1	**<0.001**
T-H °, Mean ±SD	18.09 ± 5.34	5.51 ± 3.27	**<0.001**
Meary's angle °, Mean ±SD	22.57 ± 7.57	3.88 ± 0.518	**<0.001**
cpA °, Mean ±SD	8.63 ± 2.51	21.43 ± 4.95	**<0.001**

Table [4]: Quality of life improvement among the studied patients

	Studied feet [n=35 feet]	
	No.	%
Pain relief	33	94.3%
Improvement of shoe wear	24	68.6%
Cosmetic	34	97.1%
Improvement of activity	31	88.6%

Table [5]: The American Orthopedic Foot and Ankle Society [AOFAS] among studied cases

	Studied patients [n=35]
Excellent, n [%]	25 [71.5%]
Good, n [%]	7 [20%]
Poor, n [%]	3 [8.5%]
Preoperative, Mean ± SD [range]	48.6 ± 11.6 [25 – 73]
3 months postoperative, Mean ± SD [range]	84.5 ± 10.5 [64 - 93]
6 months postoperative, Mean ± SD [range]	86.5 ± 8.5 [68 - 95]

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DISCUSSION

Flatfoot deformity encompasses various factors such as the collapse of the medial arch, hind foot turning outward, and forefoot shifting. Surgery may be an option if conservative treatments yield inadequate results [10]. Different surgical approaches, involving both soft tissue and bone procedures, have been developed to correct these deformities with differing outcomes [11]. For instance, one procedure focuses on correcting the medial arch issues by rerouting the tibialis anterior tendon to function as a plantar muscle and provide support to the talar head [12].

Our findings revealed that the average age was 11.6 ± 7.65 years, with 55% being males and 45% females. Our results align with those of **Sakr et al.** [13], who studied 28 feet among 16 patients, with an average age of 11.6 ± 2.1 years. In their study, 8 patients were male [50%] and 8 were female [50%]. The affected side was bilateral in 12 patients [75%], right-sided in three patients [18.8%], and left-sided in one patient [6.2%]. The primary complaints were pain in 13 feet [46.4%], cosmetic concerns in three feet [10.7%], and a combination of pain and cosmetic issues in 12 feet [42.9%].

Our results demonstrate a notable decrease in T1MT from preoperative to postoperative assessments. Our findings are consistent with **El-Tayeby et al.** [12], who observed correction of the lateral T IMT angle from an average of 30.1° to 85° after surgery. They also noted correction of the T-H angle from an average of 40° to 21.5°, as well as correction of the CP from an average of 4° to 21.3°. Additionally, the anteroposterior TIMT angle was corrected from an average of -16° to an average of 2°.

Our findings indicate a notable decrease in T-H from preoperative to postoperative, along with a significant increase in the calcaneal pitch angle over the same period. Our results align with **Kim et al.** [14], who reported that the preoperative values for L-T1MTA and L-CPA [indicators of the medial longitudinal arch] were 9.8 ± 5.22 and postoperative values were 19.7 ± 4.92, respectively. Measures for AP-TCA and L-TCA [related to heel valgus] also showed significant improvement [$p < 0.05$]. Similarly, our findings are in line with **Oh et al.** [15], who conducted a study involving adolescent and young adult patients who underwent surgery. All patients were available for follow-up clinical and radiographic assessment.

Our findings indicate a substantial decrease in Meary's angle from preoperative to postoperative. Our results are consistent with **Kim et al.** [16], who observed the following changes in Meary's angle [degrees]: Preoperatively, the mean ± SD was 35.8 ± 7.8, early postoperatively it was 11.0 ± 9.1, and finally postoperatively it was 11.2 ± 7.1. Statistical analysis revealed a highly significant reduction in Meary's angle from preoperative to postoperative [p-value < .0001].

Meary's angle [MA] is utilized to assess the degree of pes planus on lateral weight-bearing foot X-rays. It represents the angle formed by a line along the mid-talar axis and the first metatarsal axis on the radiograph [17].

In our research, the mean AOFAS score showed a notable improvement from 52.5 ± 13.5 before the operation to 87 ± 7.8 during the final follow-up. Our results were consistent with prior studies that investigated alternative reconstructive techniques. **Oh et al.** [15] observed a substantial increase in the average AOFAS score from 49.1 before the surgery to 93.4 at the last follow-up [15]. Additionally, **Viegas** [18] noted a significant enhancement in the mean AOFAS score from 68.59 before the operation to 96.35.

The primary role of the tibialis anterior tendon is in the swing phase rather than the stance phase [19]. Hence, it raises doubts about the procedure's direct impact on the elevation of the medial arch, a task that is more likely influenced by the unopposed action of the long peroneal muscle [13]. A comprehensive long-term follow-up study is essential to explore the potential enduring implications and biomechanical alterations resulting from this procedure

This research has certain limitations, including the small sample size of operated feet and the relatively short follow-up duration, which may not fully capture the long-term effects of the procedure. Another limitation is the absence of a comparative analysis between the outcomes of this procedure and alternative methods.

Conclusion: Surgery to correct flexible flatfoot led to decreased pain and enhanced functional abilities, allowing for engagement in sports. The suggested combined procedure along with tibialis anterior rerouting yielded positive radiological and clinical results in managing symptomatic flexible flatfoot in young individuals.

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REFERENCES

1. Rungprai C, Maneeprasopchoke P. A Clinical Approach to Diagnose Flatfoot Deformity. J. Foot Ankle Surg Asia-Pacific. 2021 Jun 1;8[2]:48-54. doi: 10.5005/jp-journals-10040-1149.

2. Herdea A, Neculai AG, Ulici A. The Role of Arthroereisis in Improving Sports Performance, Foot Aesthetics and Quality of Life in Children and Adolescents with Flexible Flatfoot. Children [Basel]. 2022 Jun 29;9 [7]:973. doi: 10.3390/children9070973.

3. Atik A, Ozyurek S. Flexible flatfoot. North Clin Istanb. 2014;1[1]:57-64. doi: 10.14744/nci.2014.29292.

4. Madden CM, Mahan KT. An Update on Pediatric Flatfoot. Clin Podiatr Med Surg. 2023 Apr; 40[2]:365-379. doi: 10.1016/j.cpm.2022.11.006.

5. Dare DM, Dodwell ER. Pediatric flatfoot: cause, epidemiology, assessment, and treatment. Curr Opin Pediatr. 2014 Feb;26[1]:93-100. doi: 10.1097/MOP. 0000000000000039.

6. Bouchard M, Mosca VS. Flatfoot deformity in children and adolescents: surgical indications and management. J Am Acad Orthop Surg. 2014 Oct;22[10]:623-32. doi: 10.5435/JAAOS-22-10-623.

7. DeVries JG, DeCarbo WT, Scott RT, Bussewitz B, Thompson M, Hyer CF. Soft Tissue Reconstruction and Osteotomies for Pes Planovalgus Correction.

Clin Podiatr Med Surg. 2022 Apr;39[2]:207-231. doi: 10.1016/j.cpm.2021.11.010.

8. Modha RK, Kilmartin TE. Lateral Column Lengthening For Flexible Adult Acquired Flatfoot: Systematic Review and Meta-Analysis. J Foot Ankle Surg. 2021 Nov-Dec;60[6]:1254-1269. doi: 10.1053/j.jfas.2021.02.015.

9. Maharaj JN, Cresswell AG, Lichtwark GA. Tibialis anterior tendinous tissue plays a key role in energy absorption during human walking. J Exp Biol. 2019 Jun ;222[Pt 11]:jeb191247. doi: 10.1242/jeb.191247.

10. Chien BY, Vosseller JT, Younger A, Greisberg J. Surgical Treatment of the Flexible, Progressive Collapsing Foot: Deformities, Definitions, and Decisions. Instr Course Lect. 2023;72:555-563.

11. Hosny GA, Hussein MA, Zaghloul KM, El-Mowafi H, Khalifa AA. Lateral column lengthening [LCL] using a rectangular shape graft for managing symptomatic flexible flatfoot showed acceptable early functional and radiological outcomes. Foot [Edinb]. 2023 May;55:101986. doi: 10.1016/j.foot.2023.101986.

12. El-Tayeby HM. The severe flexible flatfoot: a combined reconstructive procedure with rerouting of the tibialis anterior tendon. J Foot Ankle Surg. 1999 Jan-Feb; 38[1]:41-9. doi: 10.1016/s1067-2516[99]80087-8.

13. Sakr SA, Zayda AI, Mesregah MK, Abosalem AA. Tibialis anterior rerouting combined with calcaneal lengthening osteotomy as a single-stage reconstruction of symptomatic flexible flatfoot in children and adolescents. J Orthop Surg Res. 2023 Jun 13; 18[1]:429. doi: 10.1186/s13018-023-03890-7.

14. Kim HY, Cha YH, Lee JS, Kil KM, Choy WS. Changes in Gait and Radiographic and Clinical Results of Calcaneal Lengthening Osteotomy in Children with Idiopathic Flexible Flatfoot. Clin Orthop Surg. 2020 Sep;12[3]:386-395. doi: 10.4055/cios19150.

15. Oh I, Williams BR, Ellis SJ, Kwon DJ, Deland JT. Reconstruction of the symptomatic idiopathic flat-foot in adolescents and young adults. Foot Ankle Int. 2011 Mar;32[3]:225-32. doi: 10.3113/FAI.2011.0225.

16. Kim J, Mizher R, Sofka CM, Ellis SJ, Deland JT. Medium- to Long-term Results of Nonanatomic Spring Ligament Reconstruction Using an Allograft Tendon in Progressive Collapsing Foot Deformity With Severe Abduction Deformity. Foot Ankle Int. 2023 Apr;44[4]:363-374. doi: 10.1177/1071100-7231157657.

17. Steadman J, Bakshi N, Philippi M, Arena C, Leake R, Barg A, Saltzman CL. Association of Normal vs Abnormal Meary Angle With Hindfoot Malalignment and First Metatarsal Rotation: A Short Report. Foot Ankle Int. 2022 May;43[5]:706-709. doi: 10.1177/10711007211068473.

18. Viegas GV. Reconstruction of the pediatric flexible planovalgus foot by using an Evans calcaneal osteotomy and augmentative medial split tibialis anterior tendon transfer. J Foot Ankle Surg. 2003 Jul-Aug;42[4]:199-207. doi: 10.1016/s1067-2516[03]70029-5.

19. Knutsen AR, Avoian T, Sangiorgio SN, Borkowski SL, Ebramzadeh E, Zionts LE. How do different anterior tibial tendon transfer techniques influence forefoot and hindfoot motion? Clin Orthop Relat Res. 2015 May;473[5]:1737-43. doi: 10.1007/s11999-014-4057-0.

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