

Split Tibialis Anterior Transfer for Correction of Residual Dynamic Metatarsus Adductus Following Ponseti Management of Idiopathic Clubfoot

Hosam Mohammed Khairy Tawfik Omar, Mohammed AbdElAziz Gaith,

Yamen Safwat AbdElDayem, Emhemmed Faraj Emmhemmed Aboubreeg

Department of Orthopedic Surgery, Faculty of Medicine, Zagazig University, Egypt

*Corresponding author: Emhemmed Faraj Emmhemmed, E-Mail: emhemmed.faraj@gmail.com

ABSTRACT

Background: Clubfoot represents one of the most common congenital orthopedic deformities. It affects 1-2/1000 live births all over the world. Cases of dynamic and severe deformity represent a challenging problem. This is because the conservative management is not effective as well as the surgical options are little.

Objective: Aim of the present study was to evaluate the better management of split tibialis anterior tendon transfer in the treatment of residual clubfoot.

Patients and methods: Eighteen cases (22 feet) with residual dynamic supination deformity following previous Ponseti management underwent split transfer of the anterior tibial tendon. This was a prospective study between March 2020 and February 2021, the cases were collected and the study was carried out at Zagazig University Hospitals.

Results: In our study, the mean age was 41.05 months (ranged from 30 to 59 months). Out of the 18 patients, there were 12 males and 6 females. Four cases (22.2%) were bilaterally affected. While 14 patients (77.8%) were one-side affected (5 left foot affected and 9 right foot affected). Our results showed marked improvement of patients according to Garceau and Palmer's criteria as the mean pre-operative assessment was 2.5 reaching 3.28 post-operatively. 14 patients (88.9%) were either poor or fair and no single patient was excellent pre-operatively, while postoperatively all patients became either excellent mostly or good.

Conclusion: Anterior tibial tendon transfer is a reasonable method of achieving the objective, either fully or split transfer because both operations have excellent results with low rate of major complications. It's very simple but yet very effective soft-tissue procedure to correct the muscle imbalance of the foot.

Keywords: Split tibialis anterior transfer, Residual dynamic metatarsus adductus, Ponseti management, Idiopathic clubfoot.

INTRODUCTION

Clubfoot is the most common congenital musculoskeletal disease with an average frequency of 1 to 4/1000 per birth. The deformity consists of the cavus, adductus, varus, and equinus of the foot. It is also one of the most common and challenging orthopedic deformities in children. Many studies, particularly in short-term studies, demonstrate good clubfoot treatment outcomes, reaching up to 97%⁽¹⁾.

Idiopathic clubfoot is characterized by an alteration of the morphology of the foot and its position with the leg, so the foot cannot physiologically move on the ground. For these reasons, the treatment should aim to correct the four components of the deformity in such a way as to restore as much as possible of the anatomic shape and function of the foot to allow plantigrade stance and proper gait⁽²⁾.

Timely Ponseti treatment starts with gentle manipulative and plaster cast treatment, gives excellent and very good results in 92-95% of cases and the only surgical intervention in this primary stage is percutaneous tendon Achilles tenotomy. This is applied in 85% of all treated feet. The essential element in treatment is followed by Denis Brown splint, which continues at least 24 months and after an individual estimation, probably one more year after that^(3,4,5).

Tibialis anterior tendon transfer was described as an effective method in the management of dynamic

supination as well as prevention of clubfoot relapse in children. The transferred tibialis anterior tendon is anchored in the center of the foot using different methods, each of which has its drawbacks. The traditional method of anchoring the tendon through the pullout sutures on the plantar surface of the foot has its known skin complication⁽⁶⁾.

Aim of the present study was to evaluate the better management of split tibialis anterior tendon transfer in the treatment of residual clubfoot.

PATIENTS AND METHODS

Eighteen cases (22 feet) with residual dynamic supination deformity following previous Ponseti management underwent split transfer of the anterior tibial tendon. This was a prospective study between March 2020 and February 2021, the cases were collected and the study was carried out at Zagazig University hospitals. Patients' age ranged from 2.5 years to 5 years old at the time of the operation with mean age was (3.42). 12 were male and 6 female. 9 with right foot affection, 5 with left foot deformity while 4 patients (8 feet) were bilateral.

Ethical consent:

An approval of the study was obtained from Zagazig University Academic and Ethical



This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY-SA) license (<http://creativecommons.org/licenses/by/4.0/>)

committee. A written consent was taken from each child's parents. 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.

Inclusion criteria: The patient's age ranged from 2.5 years to 5 years, and patient with idiopathic clubfoot deformity previously treated by Ponseti technique and showed residual dynamic supination.

Exclusion criteria: Patient with static bony defect and long lateral column, syndromic cases such as arthrogryposis multiplex congenital, neuromuscular disease as cerebral palsy, and patients with comorbidities, complex or atypical congenital talipes equinovarus, and prior foot surgery (other than Achilles tenotomy).

All the patients were subjected to the following:

1. History:

- **Obstetric history:** Any history of problems during pregnancy or labor and the type of labor (normal delivery or cesarean section). In this study, all patients were born normal delivery except two patients were delivered by cesarean section.
- **Family history:** History of the same disease running in family. In this study three patients had positive history of clubfoot two of them treated with Pponseti method and one had recurrent after Ponseti management. History of smoking and alcohol intake during pregnancy. In the current study there was no history of smoking or alcohol intake during the pregnancy.
- **History of previous line of treatment:** The age onset of casting, number of casting, previous Acilles tenotomy, compliance with the abduction brace and duration of its use, when did the parents noticed the recurrence? and history of recasting or other disorders.

2. Clinical examination: Started by general examination for exclusion of associated neurological disorders and other congenital anomalies.

Two scoring systems were used in this study: **Demiglio** scoring system and criteria of **Garceau and Palmer**.

- 3. Radiological examination:** Plain X-ray anteroposterior and lateral views were done for the affected feet.
- 4.** Routine preoperative laboratory investigations were done.
- 5.** A written consent was taken from each child's parents.
- 6.** Position the patient supine on a radiolucent table.
- 7.** Anesthesia team to induce general anesthesia.
- 8.** A third generation cephalosporin was administered before induction of anaesthesia.
- 9.** Place a tourniquet on the thigh.
- 10.** Clean the leg up to mid-thigh.

Statistical Analysis

Data collected throughout history, basic clinical examination, laboratory investigations and outcome measures were coded, entered and analyzed using Microsoft Excel software. Data were then imported into Statistical Package for the Social Sciences (SPSS version 20.0) software for analysis. According to the type of data, qualitative were represent as number and percentage, quantitative continues group was represent by mean ± SD. The following tests were used to test for significance. Differences between quantitative paired groups by paired t test and correlation by Pearson's correlation. P value was set at ≤0.05 for significant results & <0.001 for high significant result.

RESULTS

We studied 18 cases 12 males and 6 females with a mean age of 3.43 ± 0.71 years to assess outcome of split tibialis anterior tendon transfer in management of residual clubfoot.

Table (1): Age, sex and side distribution among studied group (18 cases)

		Age	
Mean ± SD (months)		41.05 ± 8.4	
Median (Range)		39.5 (30-59)	
		N	%
Sex	Male	12	66.7%
	Female	6	33.3%
	Total	18	100%
Side	Right	9	50.0%
	Left	5	27.8%
	Bilateral	4	22.2%

Age was distributed as 41.05 ± 8.4 months with minimum 30 months and maximum 59 months. Regarding sex, male was majority with 66.7% and female 33.3%. Right side affected was in 9 cases (50%), the left side was affected in five cases (27.8%) while four cases (22.2%) were bilateral.

Table (2): Preoperative and postoperative rating and score of feet according to Garceau and Palmer's criteria

		Pre		Post		P
		N	%	N	%	
Garceau and Palmers criteria	Poor	6	27.8%	0	0.0	0.0001 *
	Fair	8	61.1%	0	0.0	
	Good	4	11.1%	7	27.8%	
	Excellent	0	0.0	11	72.2%	
	Total	18	100%	18	100%	

The pre-operative score was fair 8 cases (61.1%), poor 6 cases (27.8%), good 4 cases (11.1%) and no case was excellent. While post-operatively became excellent 11 cases (72.2%), good 7 cases (27.8%) and no case was poor or fair.

Table (3): Describing of Dimeglio and Garceau score

	Pre	Post	Wilcoxon signed test	P
Dimeglio score	7.89 ± 1.13 (6-9) 8	2.05 ± 1.16 (0-4) 2	20.6	0.00**
Garceau score	2.5 ± 0.5 (2-3) 2.5	3.28 ± 0.46 (3-4) 3	4.5	0.00**

The mean pre-operative and post-operative improvement according to Demiglio scoring system, which is statistically significant (p value < 0.00). The mean pre-operative and post-operative improvement according to **Garceau** scoring system, which is statistically significant (p value < 0.00).

DISCUSSION

Regarding the age, our study showed a mean age of 41.05 ± 8.4 months, ranging from 30 to 59 months, half of them from 30 to 40 months. This was comparable with **Eid et al.** (7) who had mean patients age of 4 years (ranged from 2 to 5 years) more than half of them between 24 to 30 months, and his result showed excellent outcome as split tibialis anterior tendon transfer (TATT) was used in the treatment of dynamic supination. Also, **Abdel-AAI** (8) who studied the correction of residual metatarsus adductus deformity following Ponseti management of idiopathic clubfoot in toddlers by tibialis anterior tendon transfer. The mean age group of his study was 37.5 months (range 37-59 months) and all feet at the final follow up proved that tibialis anterior transfer effectively corrects residual metatarsus adductus deformity following Ponseti management for idiopathic congenital talipes equinovarus.

In our study where the unilateral cases of clubfeet were the most ones representing 77.8% of our investigated patients. On the other hand, the bilateral cases were 4 cases (22.2%) out of the 18 patients. This is compared with **Abdelkhalik et al.** (9) who had fourteen patients (63.6%) had unilateral affection while 8 patients (36.3%) had bilateral affection. **Kuo et al.** (10) had all his cases with unilateral with no bilateral cases.

In our study regarding the gender, there were 66.7% males and 33.3% females. This finding is not agreed with that of **Wallander** (11) who found no gender differences detected regarding the incidence of clubfoot. However, **Wijayasinghe et al.** (12) investigated a total number of 354 patients and found a ratio of 2.7:1 regarding males and females respectively. According to **Kruse et al.** (13) suggested that the female need more genetic load to be affected and this explain why male were more affected than female.

The current study showed significant improvement of heel varus by 12.4° as at that the preoperative mean AP talocalcaneal angle was 20.2°, while the mean postoperative changed to 32.6 ° at 6 months postoperatively.

Also, there was significant improvement in forefoot adduction as at the baseline, the AP talo-first metatarsal angle had a mean value of -10.2° and the mean angle changed to 1.3° at 6 months. It was known that when being negative value indicates forefoot adduction.

Preoperatively, the mean lateral talocalcaneal angle was 24.1°. This angle improved by 6.7° reaching 30.8° at end of follow-up. The highest increase in the lateral talocalcaneal angle was in the feet that received additional Achilles tenotomy.

Regarding the mean values of lateral talo-first metatarsal angle, it reached 11.5° post-operatively from 8.1° preoperatively, with a correct angle 3.4°. At baseline, the mean overlap ratio was 2.8 grades. In addition, it improved at 6 months post-operatively by 1.2 grades reaching 1.6 grades. In the study of **Kuo et al.** (10) who compared the outcome of full tendon (FT) transfer and the split tendon (ST) transfer, the AP talo-first metatarsal angle in both groups corrected an average of 20.9 degrees. The FT group corrected an average of 24.2 degrees, The ST group was corrected an average of 16.6 degrees, the lateral talo-first metatarsal angle was corrected an average of 4.7 degrees, the average improvement in the overlap ratio for 68 feet in both groups was 0.5 ± 1.3 grades. However, we should put in mind that the averages follow-up period of the **Kuo et al.** (10) study was 8.8 years, which may explain the difference between the results (14).

According to Garceau and Palmer's criteria, in our study, the pre-operative score was fair in 8 cases (61.1%), poor in 6 cases (27.8%), good in 4 cases (11.1%), and no case was excellent. While, post-operatively became excellent in 11 cases (72.2%), good in 7 cases (27.8%), and no case was poor or fair. The mean Garceau and Palmer's criteria was improved to 3.28 from 2.5, the improvement was highly significant (P< 0.0001).

This is compared with **Eid et al.** (7) who documented that all feet were improved according to the criteria of **Garceau and Palmer** from a preoperative mean of 2.5 to a mean of 3.2 at the final follow-up. **Kuo et al.** (10) reported that preoperative rating in the ST group (29 feet) showed one excellent, 24 good, four fair, and none poor. The average pre-operative score was 2.9 points. Postoperatively, there were 11 excellent, 18 good, none fair, and none poor. The average postoperative score was 3.4 points. Also, the clinical appearance of all feet was improved according to the criteria of Garceau and Palmer in **Abdel-AAI** (8) study from a preoperative mean of 2.7 to a mean of 3.4 at the final follow-up.

In our study, the mean Demiglio score preoperatively was 7.89 ± 1.13 and it improved

postoperatively reaching a mean of 2.05 ± 1.16 the p-value was < 0.001 . This is compared with **Eid et al.** ⁽⁷⁾ where the mean preoperative Dimeglio score was 7.8. This was improved to 1.9 at the final follow-up. This was found to be statistically significant ($p < 0.0001$). Also **Abdel-AAI** ⁽⁸⁾ had Demiglio score that was improved in the split group from 5.8 pre-operatively to 1.3 post-operatively at the final follow-up ⁽¹⁵⁾.

In general, according to many studies as **Kuo et al.** ⁽¹⁰⁾ and **Abdel-AAI** ⁽⁸⁾ who compared the results of two methods (split & full tibialis anterior transfer) and documented that there was no statistical significance between the two methods of tendon transfer. But **Kuo et al.** ⁽¹⁰⁾ preferred the split method, as they believed that it was less likely to result in over connection and that it preserved some inversion function.

CONCLUSION

The reason of residual dynamic deformity is overpowering of the anterior tibial tendon, with weak or no peroneal tendon function, so anterior tibial tendon transfer is a reasonable method of achieving the objective, either fully or split transfer because both operations have an excellent results with low rate of major complications. It is very simple but yet very effective soft-tissue procedure to correct the muscle imbalance of the foot. Most feet treated by this method achieved an excellent result (95%). In management of dynamic supination the split and full tibialis tendon transfer are still a point of debate as many studies prefer the full tendon transfer and others consider the split better because of low risk of over-correction, which preserve some inversion function.

REFERENCES

1. **Gintautienė J, Čekanauskas E, Barauskas V et al. (2016):** Comparison of the Ponseti method versus early tibialis anterior tendon transfer for idiopathic clubfoot: A prospective randomized study. *Medicina (B Aires)*, 52 (3): 163–70 .
2. **Faldini C, Traina F, Nanni M et al. (2016):** Congenital idiopathic talipes equinovarus before and after walking age: observations and strategy of treatment from a series of 88 cases. *J Orthop Traumatol.*, 17 (1): 81–7.
3. **Ponseti I, Smoley E (1963):** Congenital club foot: the results of treatment. *JBJS.*, 45 (2): 261–344.
4. **Ponseti I (1996):** Congenital clubfoot. *Fundam Treat.*, 5:37–48.
5. **Jochymek J, Turek J (2018):** The ultrasonography evaluation of talar dysplasia as a potential prognostic factor for predicting the course and outcomes of clubfoot deformity treatment using Ponseti technique. *Acta Orthop Traumatol Turc.*, 52 (2): 87–91.
6. **Yasin E, Amin H, Ghani H (2019):** A new anchoring technique for tibialis anterior tendon transfer. *J Pediatr Orthop B.*, 28: 564-571.
7. **Eid A, Nahla A, Alsoufi M (2014):** Split tibialis anterior transfer corrects residual dynamic metatarsus adductus following Ponseti management of idiopathic clubfoot. *SICOT.*, 15 (1): 88–91.
8. **Abdel-AAI M (2017):** Correction of Residual Metatarsus Adductus Deformity Following Ponseti Management of Idiopathic Clubfoot in Toddlers by Tibialis Anterior Tendon Transfer. *MOJ Orthop Rheumatol.*, 9 (1): 1–5.
9. **Abdelkhalik K, Mashhour M, Mohammady E et al. (2020):** Tibialis Anterior Tendon Transfer for Correction of Residual Dynamic Supination of Clubfoot Treated with Ponseti Technique. *Benha Med J.*, 73 (5): 86–91.
10. **Kuo K, Hennigan S, Hastings M (2001):** Anterior tibial tendon transfer in residual dynamic clubfoot deformity. *J Pediatr Orthop.*, 21 (1): 35–41.
11. **Wijayasinghe S, Abeysekera W, Dharmaratne T (2018):** Descriptive epidemiology of congenital clubfoot deformity in Sri Lanka. *J Coll Physicians Surg Pakistan*, 28 (2): 166–8 .
12. **Wallander H (2010):** Congenital clubfoot: Aspects on epidemiology, residual deformity and patient reported outcome. *Acta Orthop.*, 81 (339): 1–25.
13. **Kruse L, Dobbs M, Gurnett C (2008):** Polygenic threshold model with sex dimorphism in clubfoot inheritance: The Carter effect. *J Bone Jt Surg - Ser A.*, 90 (12): 2688–94.
14. **Chen C, Wang T, Wu K et al. (2019):** Comparison of two methods for idiopathic clubfoot treatment: A case-controlled study in Taiwan. *J Formos Med Assoc.*, 118 (2): 636–40.
15. **Holt J, Westerlind B, Morcuende J (2015):** Tibialis anterior tendon transfer for relapsing idiopathic clubfoot. *JBJS Essent Surg Tech.* 5 (3): 16-21.