Original Article

Evertor Muscle Function as a Predictor of Recurrence of Deformity Following Treatment of Pediatric Idiopathic Clubfoot, A Cohort Study

Supphamard Lewsirirat, Phatchaya Klongkaew and Urawit Piyapromdee
Department of Orthopaedics Surgery, Maharat Nakhon Ratchasima Hospital, Thailand

ABSTRACT

Objectives: This study aimed to evaluate the relationship between evertor muscle function and the recurrence of deformity following treatment of pediatric idiopathic clubfoot.

Study design: A cohort study.

Setting: Maharat Nakhon Ratchasima hospital, Nakhon Ratchasima province, Thailand.

Subjects: Sixty-two children with idiopathic clubfoot.

Methods: Children with idiopathic clubfoot who were treated and followed up at Maharat Nakhon Ratchasima hospital, Thailand for a minimum of 2 years were enrolled. After the initial success of serial manipulation and plaster casting, parents were advised regarding the child's foot evertor muscle training and Achilles and tibialis posterior tendon stretching exercises without using the Denis Browne bar. Demographic data included age at onset, gender, Dimeglio score, number of casts required for initial correction, the need for Achilles tenotomy, and evertor muscle grading before and after training. All children were evaluated regularly for signs of recurrence. Univariate analysis was used to analyze the relative risk of recurrence with good and poor evertor muscle function.

Results: Sixty-two children with clubfoot, 42 males (67.7%) and 20 females (32.3%) were enrolled. Twenty-six (41.9%) children had bilateral deformities. Recurrence of deformities after treatment was documented in 22 children (35.5%). Severe deformity at presentation according to the Dimeglio score was a significant predictor of recurrence (p 0.012). After adjusting for relative risk base on the Dimeglio score, the recurrence was significantly higher in the poor evertor muscle function group with an adjusted RR of 9.59 (95%CI 3.43 - 26.80).

Conclusions: Evertor muscle function is associated with the recurrence rate of pediatric idiopathic clubfoot.

Keywords: recurrent clubfoot, evertor muscle function, evertor muscle grading

ASEAN J Rehabil Med. 2023; 33(2): 101-105.

Introduction

Clubfoot is a complex three-dimensional deformity. It is almost universally agreed that the initial treatment should be non-operative with serial manipulation and plaster casting according to the Ponseti method[1] with or without Achilles tenotomy, followed by the use of a brace to maintain the correction. Success rates for the initial treatment of idiopathic clubfoot were reported to be more than 90%.[2-4] Previous studies have identified clinical and demographic risks for recurrence, which has often been attributed to poor compliance with the recommendations for regular use of a foot abduction brace after the correction has been achieved.[5-8] Consistent use of the brace, however, cannot be the only factor determining recurrence. Muscle imbalance is recognized as a cause of joint deformity in pediatric orthopedics, and subtle imbalance around the ankle joint is an etiological factor in both idiopathic and non-idiopathic clubfoot deformity.

Only a few studies have addressed the specific issue of evertor muscle function as a contributing factor to recurrence in children with idiopathic and non-idiopathic clubfoot. Moreover, none of those studies specify whether the evertor muscle had been trained after the initial correction of clubfoot deformity. Rather, the studies mentioned only static immobilization using a foot abduction brace. In a study by Gelfer et al.,[9] all cases complied fully in using the foot abduction brace 23 hrs a day for three months and then 12-14 hrs a day during sleep and nap times after that. At the mean age of follow-up, 3.2 years (range 2.1-6.3 years), Gelfer reported that after the initial deformity had been corrected, there was no change in evertor muscle activity over time. Eamsobhana et al.,[10] who also prescribed wearing the foot abduction brace 23 hrs a day for the first 3 months and during sleep and nap time 8-10 hrs a day for another 4 years, reported no change in evertor muscle activity grading at six months after initial complete correction. However, muscle development during the infancy stage is crucial and can be encouraged through various activities, e.g., hand grip strengthening while the parent's finger touches the baby's palm. If the parent does this often, the finger will become difficult to pull out of the baby's grasp. It was also proposed that the evertor muscle could be strengthened by touching stimulation along the lateral dorsal surface of the toes

Correspondence to: Supphamard Lewsirirat, MD, Department of Orthopaedic Surgery, Maharat Nakhon Ratchasima Hospital, Chang Phuak Rd, Mueang District, Nakhon Ratchasima Province 30000 Thailand. Email: Supphamard@gmail.com

Received: October 4, 2022 Revised: December 20, 2022 Accepted: February 1, 2023

to the foot's lateral border. Because no quantitative method of measurement is currently available which could provide helpful information on the foot muscles involved in this infant age group, the principle author of this study proposed a qualitative method which involves categorizing responses into five grades (Figure 1). In Infants, the function is measured as the observed response after manual stimulation over the lateral border of the foot which is then compared to a standard set of pictures. In older children, the muscle function is tested by asking the children to evert the foot as much as possible and noting the degree of eversion.

This study aimed to assess the improvement of the evertor muscle after training without the foot abduction brace protocol as well as the relationship between evertor muscle function and recurrence rate in children with idiopathic clubfoot.

Methods

Children with idiopathic clubfoot, aged less than six months, who were treated at Maharat Nakhon Ratchasima hospital, Thailand, from January 2006 to December 2014 and who were followed up for at least two years were enrolled in this study. Children who had received previous treatment from other hospitals, previous surgery to the foot, or who were lost follow-up were excluded. In children with bilateral deformities, only one side was randomly selected. The Maharat Nakhon Ratchasima Hospital Institutional Review Board gave ethical approval for the study. The sample size was calculated using OpenEpi, Version 3, open-source calculator—SSCohort with a 95% confidence interval and 80% power. Using the Eamsobhana study as a reference, the ratio of good evertor to poor evertor was 1.8, the recurrence with a good evertor was 3.9%, the recurrence with a poor evertor was 57, so the necessary sample size was calculated to be 19 good evertor cases and 11 poor evertor cases, a total of 30 cases.

Sixty-two feet (42 males,20 females) were enrolled in this study. Baseline demographic data, including the age at onset, sex, severity (Dimeglio score), and evertor muscle function, were recorded.

The initial treatment consisted of serial manipulation and casting according to the Korat technique.[11] The Korat technique of manipulation and casting was developed at Maharat Nakhon Ratchasima hospital in the Nakhon Ratchasima (Korat) province of Thailand. The technique involves simultaneous pushing and pulling in supination, combining principles of both Kite's and Ponseti's manipulation methods. The cast was changed weekly to correct the clubfoot deformity until the normal foot form was achieved. The dorsal surface of all toes were exposed while casting. In addition, the parents were encouraged to repeat touching stimulation of the dorsal surface of the lateral toes to strengthen the toes extensor and to do the isometric evertor muscle exercise. The number of casts used was recorded. In cases of a very tight heel cord or inability to achieve passive dorsiflexion of the calcaneus through zero degrees even when holding the knee at 90 degrees of flexion, early percutaneous needle Achilles tenotomy was performed. After correction was achieved and with the patient's foot in a good position, evertor muscle function was evaluated using specific grading as described above.

After that, the parents were encouraged to follow an exercise program[11] aimed at continued stretching of the Achilles tendon and tibialis posterior muscles and strengthening the peroneus muscles. Parents were instructed to repeat the program as often as possible, for a daily minimum of 200 stretches (5 seconds for each stretching) and 200 strengthening stimulations (1-2 seconds for each strengthening stimulation), which

Grade 0: No muscle contraction seen.

Grade I: Prominence of the peroneus tendon under the skin seen only while stimulating

Grade II: Some foot eversion, but unable to reach perpendicular to the leg axis

Grade III: Eversion perpendicular to the leg axis

Grade IV: Eversion beyond perpendicular to the leg axis

Figure 1. Visual grading of evertor muscle function

could be divided into 2-4 sessions. No Denis Browne bars were used. All children were assessed regularly for signs of recurrence, defined as deterioration of the deformity component (cavus, forefoot adductus, heel varus, and equinus).

If a child had a recurrence of the deformity, the evertor muscle function was evaluated after the presentation. In non-recurrence cases, the evertor muscle function was evaluated at 2 years. Evertor muscle grades III and IV were classified as good evertor muscle function.

A single pediatric orthopedist documented all data.

Statistical analysis

STATA Statistics version 12 was used to analyze the data. Descriptive statistics are expressed as median, IQR (for skewed data), and percentage (for grouped data). Univariate analysis was used to assess the relative risk of recurrence between groups. Statistically significant difference for all between groups tests was defined as $p < 0.05$. The adjusted RR and the 95% confidence interval (CI) were used to analyze the association between evertor muscle functions and the recurrence.

Results

The demographic data and clinical characteristics after treatment of the good evertor muscle function group and the poor evertor muscle function group are shown in Table 1. There was no significant difference in the age of onset, sex, severity (Dimeglio score), number of casts, and percentage of early tenotomy between groups.

At baseline, all the clubfoot children had poor evertor muscle function. After serial manipulation and casting, 57 children had poor evertor muscle function, and only 5 children had good evertor muscle function. After training, 41 children developed good evertor muscle function, while 21 children still had poor evertor muscle function. The improvement of evertor muscle function during treatment is shown in Graph 1.

Recurrence was documented in 22 children (35.48%), and 19 had poor evertor muscle function. The incidence of recurrent idiopathic clubfoot in the good evertor muscle function group was 7.32%, and in the poor evertor muscle function group was 90.48% (Graph 2).

After adjusting for relative risk (Dimeglio score), children with poor evertor muscle function had a risk of recurrence of 9.59 times that of the good evertor muscle function group Table 2.

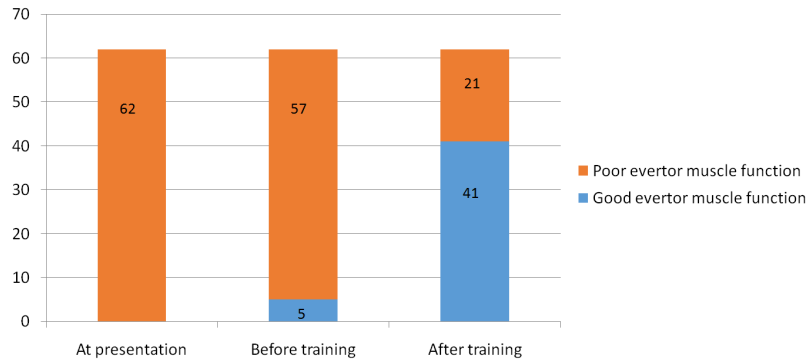
Discussion

The recurrence rate after treatment of idiopathic clubfoot ranges from 14% to 41%.[12] Some previous studies have identified clinical and demographic risks for recurrence in idiopathic clubfoot, with only lack of brace compliance being associated with poor outcomes.

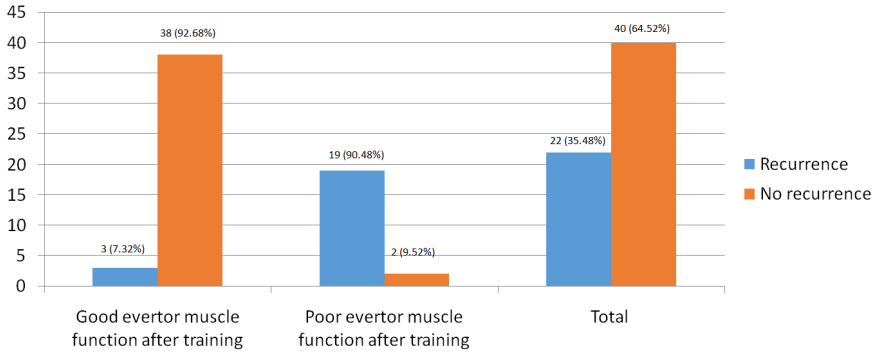
Table 1. Baseline demographic and clinical characteristics of clubfoot children comparing good and poor evertor muscle after training

	Good evertor muscle after training (N=41)	Poor evertor muscle after training (N=21)	*p*-value
Age of onset (days)[1]	17 [10-35]	16 [8-29]	0.33[a]
Sex female[2]	12 (29.27)	8 (38.09)	0.48[b]
Severity (Dimeglio score)[2]			
Mild	10 (24.39)	1 (4.76)	0.07[c]
Moderate	18 (43.90)	8 (38.10)	
Severe	13 (31.71)	12 (57.14)	
Numbers of casts[1]	3 [3-4]	3 [3-4]	0.90[a]
Early tenotomy[2]	24 (58.54)	12 (57.14)	0.64[b]

[1]Median [IQR], [2]number (%), [a]Mann-Whitney U test, [b]Chi-square test, [c]Fisher exact test



Graph 1. Proportion of patients with poor and good evertor muscle functions at initial presentation, before beginning training and after training



Graph 2. Proportion of patients with recurrence and no recurrence of deformity comparing good evertor muscle function after training and poor evertor muscle function after training plus both groups combined

Table 2. Relative risk of recurrence of deformity with good and with poor evertor muscle function

Factor	% Recurrence Crude	RR (95% CI)	Adjusted RR* (95% CI)
Good evertor muscle Function	7.32	1	1
Poor evertor muscle Function	90.48	12.37 (4.12-37.08)	9.59 (3.43-26.80)

*Adjusted for severity (Dimeglio score)

Edmonds and Frick[13] reviewed 187 clubfoot patients and found nine infants with clinical evidence of anterior and lateral compartment dysfunction. Of these nine infants, four (44%) had a recurrence despite a well-documented bracing regime.

Feldbrin et al.[14] performed electrophysiological studies on 52 children with 74 clubfeet and found isolated peroneal nerve damage in 27% of patients. An abnormal electrophysiological condition was a predictive factor for poor outcomes both in patients who were treated conservatively and those who were treated surgically, indicating that neurological abnormality might be one of the causes of recurrence.

Gelfer[9] studied 67 children (116 feet) with idiopathic and non-idiopathic clubfoot, and found that only poor evertor muscle function activity was associated with recurrence in both groups. That study also reported there was no change in evertor muscle activity over time once the initial deformity had been corrected. The cause of the recurrence may be neurological abnormality and may be due in all cases to prolonged immobilization with a foot abduction brace without evertor muscle strengthening exercise.

The present study showed an association between poor evertor muscle function and the recurrence of idiopathic clubfoot, similar to previous studies by Gelfer (2014),[9] Eamsobhana (2017),[10] and Little (2019)[15] which reported that only poor or absent evertor muscle function was found to be significantly associated with recurrence. However, the risk of recurrence in patients with poor evertor muscle activity was reported to be high (57% and 67.9%) in studies by Eamsobhana[10] and Little,[15] respectively.

The present study found the risk of recurrence of idiopathic clubfoot in children with poor evertor muscle function was 9.59 times higher than in those with good evertor muscle function after adjusting for relative risk as measured by the Dimeglio severity score. Nineteen of 21 cases (90.5%) with poor evertor muscle activity had recurrence after treatment, while only 3 of 41 cases (7.3%) with good evertor muscle had a recurrent deformity. The differences in the recurrence rate of poor evertor muscle in other studies may be due to differences in patients' idiopathic clubfoot severity level and the treatment protocol.

Because a foot abduction brace (FAB) was applied in all cases, this study supports that the evertor muscle function can be improved with appropriate muscle training. Little[15] reported that good evertor muscle activity was strongly predictive of no recurrence (negative predictive value=1) which invites further investigation as it is possible that in patients with good evertor muscle, a long period of FAB use may be unnecessary.

Evertor muscle training combined with the Achilles tendon and tibialis posterior tendon stretching exercises is an option for promoting the elimination of idiopathic clubfoot after correcting deformities by serial casting. The goal is to maintain normal foot form, prevent the recurrence of clubfoot deformities and optimize foot function. Another critical point is that the poor evertor muscle function in cases which are not getting better after training should be investigated further to identify the causes. Moreover, for the recurrent cases, early repeat serial casting either with or without Achilles tenotomy followed by prolonged use of a suitable orthotic device and a surgical plan for improving foot muscle balance such as tibialis anterior tendon transfer[16] are needed.

A limitation of this study is that adherence to the minimum of 200 stretching and 200 strengthening exercise repetitions a day of the exercise programs carried out by parents to optimize evertor muscle strength varied depending on the parents' diligence. Amazingly, some parents did the exercise program for their children up to 1,000 stretching and 1,000 strengthening repetitions a day. Further studies that closely monitor adherence

to exercise programs and that include design additional appropriate exercise programs are needed.

Another limitation is that ankle dorsiflexion and calf muscle function were not measured pre- and post-training. That information could have helped evaluate the success of Achilles tendon stretching and improvement of muscle balance.

Conclusion

Poor evertor muscle function is associated with higher rates of recurrence of deformity in pediatric idiopathic clubfoot. To minimize recurrence, the importance of exercises for the improvement of the evertor muscle should be emphasized to parents to help promote good outcomes following clubfoot treatment.

References

1. Ignacio V. Ponseti. Congenital clubfoot: fundamentals of treatment. Michigan: Oxford University Press; 1996. p. 140.
2. Herzenberg JE, Radler C, Bor N. Ponseti versus traditional methods of casting for idiopathic clubfoot. J Pediatr Orthop [Internet]. 2002 Jul-Aug [cited 2021 Feb 21];22(4):517-21. Available from: http://pubmed.ncbi.nih.gov/12131451/ doi: 10.1097/01241398-200207000-00019
3. Changulani M, Garg NK, Rajagopal TS, Bass A, Nayagam SN. Sampath J, et al. Treatment of idiopathic club foot using the Ponseti method, initial experience. J Bone Joint Surg [Br] [Internet]. 2006 Oct [cited 2021 Feb 21];88(10):1385-7. Available from: http://pubmed.ncbi.nih.gov/17012432/ doi: 10.1302/0301-620X.88B10.17578
4. Chotel F, Parot R, Seringe R, Berard J, Wicart P. Comparative study: Ponseti method versus French physiotherapy for initial treatment of idiopathic clubfoot deformity. J Pediatr Orthop [Internet]. 2011 Apr-May [cited 2021 Feb 21];31(3):320-5. Available from: http://pubmed.ncbi.nih.gov/21415694/ doi: 10.11097/BPO.0b013e31820f77ba
5. Chu A, Lehman WB. Persistent clubfoot deformity following treatment by the Ponseti method. J Pediatr Orthop B [Internet]. 2012 Jan [cited 2021 Feb 21];21(1):40-6. Available from: http://pubmed.ncbi.nih.gov/22134651/ doi: 10.1097/BPB.0b013e32834ed9d4
6. Dobbs MB, Rudzki JR, Purcell DB, Walton T, Porter KR, Gurnett CA. Factors predictive of outcome after use of the Ponseti method for the treatment of idiopathic clubfeet. J Bone Joint Surg [Am] [Internet]. 2004 Jan [cited 2021 Feb 21];86(1):22-7. Available from: http://pubmed.ncbi.nih.gov/14711941/ doi: 10.2106/00004623-200401000-00005
7. Haft GF, Walker CG, Crawford HA. Early clubfoot recurrence after use of the Ponseti method in a New Zealand population. J Bone Joint Surg [Am] [Internet]. 2007 Mar [cited 2021 Feb 21];89(3):487-93. Available from: http://pubmed.ncbi.nih.gov/17332096/ doi: 10.2106/JBJS.F.00169
8. Azarpira MR, Emami MJ, Vosoughi AR, Rahbari K. Factors associated with recurrence of clubfoot treated by the Ponseti method. World J Clin Cases [Internet]. 2016 Oct [cited 2021 Feb 21];4(10):318-22. Available from: http://pubmed.ncbi.nih.gov/pmc/articles/PMC5067494/ doi: 10.12998/wjcc.v4.i10.318
9. Gelfer Y, Dunkley M, Jackson D, Armstrong J, Rafter C, Parnell E, et al. Evertor muscle activity as a predictor of the mid-term outcome following treatment of the idiopathic and non-idiopathic clubfoot. Bone Joint J [Internet]. 2014 Sep [cited 2021 Jun 2];96-B(9):1264-8. Available from: http://pubmed.ncbi.nih.gov/25183601/ doi: 10.1302/0301-620X.96B9.33755
10. Eamsobhana P, Kongwachirapaitoon P, Kaewpornsawan K. Evertor muscle activity as a predictor for recurrence in idiopathic clubfoot. Eur J Orthop Surg Traumatol [Internet]. 2017 Oct [cited 2021 Jun 2];27(7):1005-9. Available from: http:/ /pubmed.ncbi.nhm.nih.gov/28528482/ doi: 10.1007/s00590-017-1975-z
11. Lewsirirat S, Piyapromdee U, Klongkaew P. An alternative treatment for clubfoot in infants: an evaluation of the Korat technique of serial casting with and without early percutaneous needle Achilles tenotomy. J Med Assoc Thai [Internet]. 2018 March [cited 2021 Jun 2];101(3):23-34. Available from: http://www.jmatonline.com/index.php/jmat/article/view/ 9533
12. Zionts LE, Dietz FR. Bracing following correction of idiopathic clubfoot using the Ponseti method. J Am Acad Orthop Surg [Internet]. 2010 August [cited 2022 Aug 8];18(8):486-93. Available from: http://pubmed.ncbi.nih.gov/20675641/ doi: 10.5435/00124635-201008000-00005
13. Edmonds EW, Frick SL. The drop toe sign: an indicator of neurologic impairment in congenital clubfoot. Clin Orthop Relat Res [Internet]. 2009 May [cited 2022 Aug 8]; 467(5):1238-42. Available from: http://pubmed.ncbi.nih.gov/19130157/ doi: 10.1007/s11999-008-0690-9
14. Feldbrin Z, Gilai AN, Ezra E, Khermosh O, Kramer U, Wientroub S. Muscle imbalance in the aetiology of idiopathic club foot. An electromyographic study. J Bone Joint Surg [Br] [Internet]. 1995 July [cited 2022 Aug 8];77(4):596-601. Available from: http://pubmed.ncbi.nih.gov/7615605/ doi: 10.1302/0301-620X.77B4.7615605
15. Little Z, Yeo A, Gelfer Y. Poor evertor muscle activity is a predictor of recurrence in idiopathic clubfoot treated by the Ponseti method: a prospective longitudinal study with a 5-year follow-up. J Pediatr Orthop [Internet]. 2019 July [cited 2022 Aug 8];39(6):e467-e471. Available from: http://pubmed.ncbi.nih.gov/30855553/ doi: 10.1097/BPO.0000000000001357
16. Gray K, Burns J, Little D, Bellemore M, Gibbons P. Is tibialis anterior tendon transfer effective for recurrent clubfoot? Clin Orthop Relat Res [Internet]. 2014 Feb [cited 2022 Aug 8];472(2):750-8. Available from: http://pubmed.ncbi.nih.gov/24061847/ doi: 10.1007/s11999-013-3287-x