

Lengthening of Achilles Tendon from the Percutaneous Tenotomy Procedure in Ponseti's Method

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Research

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Abstract

Background Talipes equinovarus is one of the common congenital disease of foot deformity of newborn. Initial treatment is often with the Ponseti method. Studies have demonstrated that radiographic measurements can be made with clubfoot. The purposes of this study were to document the amount of Achilles tendon lengthening obtained from PAT in Ponseti's method and to analyze the factors that might impact on the amount of equinus correction.

Methods This is a retrospective study carried out from 2002 to 2006. Sixteen feet of twelve children that received percutaneous Achilles tendon tenotomy (PAT) for the treatment of congenital clubfoot were included. Assessments before and after treatment were performed using Dimeglio system. The foot length from toe to heel at the time of PAT, the pre- and post-PAT ankle dorsiflexion and post-casting lateral view of foot were obtained. The Pearson correlation coefficient was used to establish relationships between pre-, post-PATT and post-casting Tibio-calcaneal angle (TCA) and Achilles tendon length(ATL).

Results The TCA before, after PATT, and after casting were -9.3, 27.4 and 18.4degrees. The ATL before, after PATT, and after casting were 22.7, 31.3, and 28.3mm. The overall lengthening of Achilles tendon was 5.7% of the foot length. The pre-PATT TCA was correlated with post-PATT and post-casting TCA. The pre-PATT ATL was correlated with post-PATT ATL and post-casting ATL.

Conclusion Post-PAT correction effect is negatively correlated with the pre-PAT severity of equinus. The comparison between post-PAT and post-casting TCA could be used to check the quality of casting in the Ponseti method.

Level of Evidence: level IV

Introduction

Congenital talipes equinovarus (CTEV) is one of the most common congenital foot-deformity diseases in newborns. Over the centuries, it has been treated by various modalities ranging from extensive operative release to more conservative methods. With the use of the Ponseti technique, the number of patients who undergo radical soft tissue release has decreased, and the Ponseti method has become the gold standard of care for the treatment of congenital club foot. The Ponseti method includes clubfoot assessment, cast correction, percutaneous Achilles tenotomy (PAT), bracing, and tendon transfer if needed. The majority of clubfeet managed with the Ponseti method do not require further treatment. However, some series may require repeat casting, repeat tenotomy, or operative reconstruction for residual or recurrent deformity.^{4,11}

Clinicians have tried to find factors for predicting which feet may eventually require additional intervention.^{15,19} Two clubfoot scores have been widely used: the Pirani score and Dimeglio score.^{2,5} The scoring systems are appropriate for classifying the severity of club foot, it has not been mentioned whether the clinical findings can be utilized for predicting further operative intervention. Ponseti recommended the evaluation of infant clubfoot by physical examination, but many orthopedic surgeons

still rely on imaging methods such as ultrasound and radiographs for decision-making.^{13,14} Several studies have demonstrated that reliable radiographic measurements can be made on the feet of children with clubfoot.^{16,17} The purpose of this study was to document the amount of Achilles tendon lengthening obtained from PAT in Ponseti's method for the treatment of clubfoot, as well as to analyze the factors that might impact the amount of equinus correction.

Methods

This retrospective study was carried out after obtaining approval from the institutional ethical committee. The study included 16 feet of 12 children who received PAT as part of Ponseti's method for the treatment of CTEV from November 2002 to October 2006. All included patients had idiopathic clubfoot, and patients with any syndromic stigmata were excluded. Cases of atypical, complex clubfoot or those that received any previous treatment were excluded. All patients were treated by a single orthopedic surgeon and were regularly followed up for at least two years following the initial cast correction.

The patient data collected included sex, birthday, age at the start of treatment, side of involvement, and cast times. Assessments were performed before and after treatment using the Dimeglio system. The Dimeglio classification system includes four aspects of deformity: equinus, varus, rotation, and forefoot medial deviation. Each is scored on a scale of one to four with four additional categories: depth of posterior crease, medial crease, cavus, and muscle power. The individual scores can be 0 or 1, and the maximum total score is 20.³

In this study, we followed the protocol outlined in the Ponseti method, including the core principles and technical details of casting, PAT, brace type, and brace protocol. Residual equinus is defined as <5 degrees of ankle dorsiflexion when the foot is fully abducted and is treated with PAT. The foot length from toe to heel at the time of PAT was measured during surgery. The pre-PAT and post-PAT ankle dorsiflexion lateral view and post-casting lateral view of the foot were obtained in the operation room with an image intensifier.

The calcaneal axis was defined as the long axis of the ossified os calcis in a lateral view. The neutral tibio-calcaneal angle (TCA) was defined as a 90-degree angle of the tibia and the calcaneal axes. Positive values indicate dorsiflexion, and negative values indicate plantarflexion. The length of the Achilles tendon was calculated as follows. The proximal margin of the Achilles tendon was defined by a line perpendicular to the tibia axis and tangential to the distal margin of the primary ossification center of the tibia. The distal margin of the Achilles tendon was defined by the longitudinal axis of the calcaneus. The Achilles tendon length (ATL) between the upper and lower margins was measured from the midpoint of the retro-tibial and retrocalcaneal soft tissue space (Figure 1).

The Pearson correlation coefficient was used to establish relationships between the severity of deformity (Dimeglio classification) and the amount of correction (TCA change and ATL). Correlation analysis was also performed between the pre-PAT and post-PAT tibio-calcaneal angles to document whether the

Achilles tendon is the only contributor to the equinus deformity of the foot. A p-value less than 0.05 was considered statistically significant.

Results

A total of 16 feet of 12 patients were included in the study. Four were girls, and eight were boys. The average age of these patients who started the Ponseti method was 37.3 ± 39.9 days, and the average Dimeglio score was 11.8 ± 2.7 . Each deformed foot underwent manipulation and casting with an average of 5.2 ± 2.3 times. The age when they received PAT was 96.0 ± 67.7 days. The average TCA before PAT was -8.5 ± 10 degrees. After PAT, the improvement of TCA was 30.8 ± 10.4 degrees. After the application of a long leg cast, the TCA improvement became 22.8 ± 10.4 degrees. After PAT, the ATL was 8.5 ± 2.5 mm ($7.8 \pm 2.0\%$ of the foot length). After casting, this lengthening dropped to 5.1 ± 1.90 mm ($5.5 \pm 2.1\%$ of foot length) (Table 1).

TCA before PAT, after PAT, and after the cast were compared with each other, and a strong correlation was noted (Table 2). The lengthening of the Achilles tendon before PAT, after PAT, and after the cast also revealed strong correlations with each other (Table 3). As shown in Table 4, the severity of deformity (Dimeglio score and classification) was not correlated with the lengthening (lengthening % post cast – pre-op; Score: $R = 0.2118$, $p \leq 0.4311$, $t = 0.8109$, $DF = 14$; Classification: $R = 0.1253$, $p \leq 0.6438$, $t = 0.4727$, $DF = 14$).

Discussion

PAT is one of the important parts of the Ponseti method. The indication for PAT in third edition of Ponseti management is when ankle dorsiflexion remains less than 10 degrees above neutral after correction of cavus, adductus, and varus. Although Ponseti suggested evaluating infant clubfoot by physical examination, several studies have tried to use radiography and sonography as measurements for evaluating the effect of tenotomy.^{1,8,16} Zimmerman et al. indicated that the mean differences between pre- and post-tenotomy radiographs were a dorsiflexion increase of 17° , tibio-calcaneal angle increase of 19° , talo-calcaneal angle increase of 9° , and talo-first metatarsal angle increase of 10° .¹

The results from Radler et al. showed that only the lateral tibio-calcaneal angle and clinically measured dorsiflexion changed significantly after tenotomy, and the mean improvements were 16.9° and 15.1° , respectively.¹⁶ Hisateru et al. used ultrasound to observe the healing process in the gap after tenotomy at two-year follow-up.⁸ They concluded that only slight irregularity of the internal structure persisted in the affected foot compared to the normal foot.

In our study, we also recorded the amount of improvement of the lateral tibio-calcaneal angle (22.8°), which was similar to the results of Radler et al. and Zimmerman et al. In our opinion, the amount of Achilles lengthening or TCA change under radiography may be used in monitoring the completeness of PAT and the technique of post-PAT casting. If the long-term functional outcome is correlated with intra-

operative findings, then the intra-operative findings can be used as a parameter to determine operative decisions. For example, it can be used to predict the necessity of performing an open-ankle and subtalar joint capsular release in the future.

Noncompliance with an abduction orthosis is widely accepted as the primary risk factor for recurrence, but a significant relationship has not yet been established between the compliance and relapse of the deformity.^{4,6,7,18} Several studies have shown that residual equinus deformity (the extent of ankle dorsiflexion) before and after Achilles tenotomy are related to a higher need for future operative intervention.^{9,10,12} Kang et al. indicated that lateral TCA measured by radiographs is more objective than physical examination only and is also a predictor for the necessity of performing PAT.¹⁰ All our TCAs measured by radiographs after PAT were over 10 degrees and did not receive further intervention. However, a limitation of this study is that the post-casting ankle/foot lateral view was not taken at the same rotation angle as the pre-PAT and post-PAT lateral views due to the external rotation of the long leg cast near 70 degrees in the Ponseti method.

In conclusion, we revealed that the average lengthening of ATL after PAT was 8.5 mm, the average correction of TCA after PAT was 30.8°, and the average dorsiflexion of 8° was lost after casting. A lower pre-PAT TCA correlates with lower post-PAT and post-casting TCA. Furthermore, lower pre-PAT ATL correlates with a lower post-PAT and post-casting ATL. This means that the post-PAT correction effect is negatively correlated with the pre-PAT severity of equinus. The comparison between the post-PAT and post-casting TCA could be used to check the quality of casting in the Ponseti method. TCAs after PAT were all over 10 degrees, and no cases needed further operation in our study. Long-term follow up is necessary to document the final equinus correction.

Declarations

Availability of data and materials

Competing interests – not applicable

Funding – not applicable

Authors' contributions – Wei Ning, Chang analyzed and interpreted the patient data regarding the foot length, angle measurement and analysis under image intensifier. Yu Cheng, Lai performed the physical examination of the clubfoot, and Yen Chang, Lin was a major contributor in writing the manuscript. All authors read and approved the final manuscript.

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References

1. Catherine C. Zimmerman, et al. Reliability of radiographic measures in infants with clubfoot treated with the Ponseti method. *J Child Orthop*. 2015 Apr; 9(2): 99–104.
2. Dimeglio A, Bensahel H, Souchet P, Mazeau P, Bonnet F. Classification of clubfoot. *J Pediatr Orthop B* 1995; 4:129–36.
3. Dimeglio a, bensahel h, et al. Classification of clubfoot. *j pediatric orthopaedics*. 1995; 4: 129-1361
4. 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* 2004; 86-A:22–7.
5. Dyer PJ, Davis N. The role of the Pirani scoring system in the management of clubfoot by the Ponseti method. *J Bone Joint Surg Br* 2006; 88:1082–4.
6. 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* 2007; 89:487–93.
7. Halanski MA, Davison JE, Huang JC, Walker CG, Walsh SJ, Crawford HA. Ponseti method compared with surgical treatment of clubfoot: a prospective comparison. *J Bone Joint Surg Am* 2010; 92:270–8.
8. Hisateru Niki, et al. Ultrasonographic observation of the healing process in the gap after a Ponseti type Achilles tenotomy for idiopathic congenital clubfoot at two-year follow-up. *J Orthop Sci*. 2013 Jan; 18(1): 70–75.
9. Hosseinzadeh P, Steiner RB, Hayes CB, Muchow RD, Iwinski HJ, Walker JL, et al. Initial correction predicts the need for secondary Achilles tendon procedures in patients with idiopathic clubfoot treated with Ponseti casting. *J Pediatr Orthop* 2016; 36:80–3.
10. Kang S, Park SS. Lateral tibio-calcaneal angle as a determinant for percutaneous Achilles tenotomy for idiopathic clubfeet. *J Bone Joint Surg Am* 2015; 97:1246–54.
11. Laaveg SJ, Ponseti IV. Long-term results of treatment of congenital clubfoot. *J Bone Joint Surg Am* 1980;62:23–31.
12. O'Halloran CP, Halanski MA, Nemeth BA, Zimmermann CC, Noonan KJ. Can radiographs predict outcome in patients with idiopathic clubfeet treated with the Ponseti method. *J Pediatr Orthop* 2015; 35:734–8.
13. Ponseti IV. *Congenital clubfoot: fundamentals of treatment*. Oxford: Oxford University Press; 1996
14. Ponseti IV. The Ponseti technique for correction of congenital clubfoot. *J Bone Joint Surg Am* 2002;84-A:1889–90 author reply 90–1.
15. Scher DM, Feldman DS, van Bosse HJ, Sala DA, Lehman WB. Predicting the need for tenotomy in the Ponseti method for correction of clubfeet. *J Pediatr Orthop* 2004; 24:349–52.
16. Radler C, Manner HM, Suda R et al. Radiographic evaluation of idiopathic clubfeet undergoing Ponseti treatment. *J Bone Joint Surg Am* 2007; 89:1177–83.
17. Radler C, Egermann M, Riedl K, Ganger R, Grill F. Interobserver reliability of radiographic measurements of contralateral feet of pediatric patients with unilateral clubfoot. *J Bone Joint Surg*

Am 2010; 92:2427–35.

18. Thacker MM, Scher DM, Sala DA, van Bosse HJ, Feldman DS, Lehman WB. Use of the foot abduction orthosis following Ponseti casts: is it essential. *J Pediatr Orthop* 2005; 25:225–8.
19. Zhang W, Richards BS, Faulks ST, Karol LA, Rathjen KA, Browne RH. Initial severity rating of idiopathic clubfeet is an outcome predictor at age two years. *J Pediatr Orthop B* 2012; 21:16–9.

Tables

Table 1. Patient characteristics and radiograph findings.

	Average	SD
Age at starting Ponseti (days)	37.3	39.9
Number of casts before PAT	5.2	2.3
Age received PAT (days)	96	67.7
Dimeglio score		
Dimeglio score before Ponseti	11.8	2.72
Dimeglio score post Ponseti	4.56	0.72
Dimeglio classification (post-Ponseti)	2.8	0.6
TCA (degrees)		
TCA pre-PAT	-8.5	10
TCA post PAT	22.3	9.6
TCA pre-post PAT	30.82	10.41
TCA post cast	14.3	9.3
TCA pre-post cast	22.8	10.4
Tendon length (mm)		
Length pre-PAT	19.5	5.7
Length post PAT	27	6.9
Length post cast	24.6	5.8
Lengthening pre-post PAT	8.5	2.5
Lengthening pre-post cast	5.1	1.9
Foot length		
Foot length (mm)	95.1	11.1
Lengthening % foot length pre-post cast% ±	5.46	2.13
Lengthening % foot length pre-post PAT	7.8	2.01
The values are given as averages and standard deviations of the Dimeglio score, TCA, and tendon lengthening PAT: Percutaneous Achilles Tenotomy TCA: Tibio-calcaneo angle		

Table 2.

TCA	Correlation
Pre-PAT vs. post PAT	R= 0.437, p= 0.0032, t= 4.68, DF= 8
Post PAT vs. post cast	R= 0.643, p= 0.0477, t= 2.378, DF= 8
Post cast vs. pre-PAT	R= 0.717, p= 0.02276, t= 2.906, DF= 8
Correlation of tibiocalcaneal angle between three timing - before PAT, after PAT and after casting. TCA: Tibiocalcaneal angle, PAT: Percutaneous Achilles Tenotomy, R: correlation coefficient, DF: degree of freedom	

Table 3.

Achilles tendon length	Correlation
Pre-PAT vs. post PAT	R= 0.845, p= 0.003913, t= 4.46, DF= 8
Post PAT vs. post cast	R= 0.874, p= 0.002318, t= 5.087, DF= 8
Post cast vs. pre PAT	R= 0.877, p= 0.00218, t= 5.169, DF= 8
Correlation of achilles tendon length before PAT, after PAT and after casting, TCA: Tibiocalcaneal angle, PAT: Percutaneous Achilles Tenotomy, R: correlation coefficient, DF: degree of freedom	

Table 4.

	Dimeglio score before Ponseti	Dimeglio classification before Ponseti
Lengthening % foot length pre-post PAT	R = -0.08025, p <= 0.7677 t = -0.3012, DF = 14	R = -0.03821, p <= 0.8883 t = -0.1431, DF = 14
Lengthening % foot length pre-post cast	R = 0.2118, p<=0.4311 t = 0.8109, DF = 14	R = 0.1253, p<=0.6438 t = 0.4727, DF = 14
Regression analysis between achillies tendon lengthing percentage and Dimeglio score and Dimeglio classification before Ponseti method. PAT: Percutaneous Achilles Tenotomy, R: correlation coefficient, DF: degree of freedom		

Figures

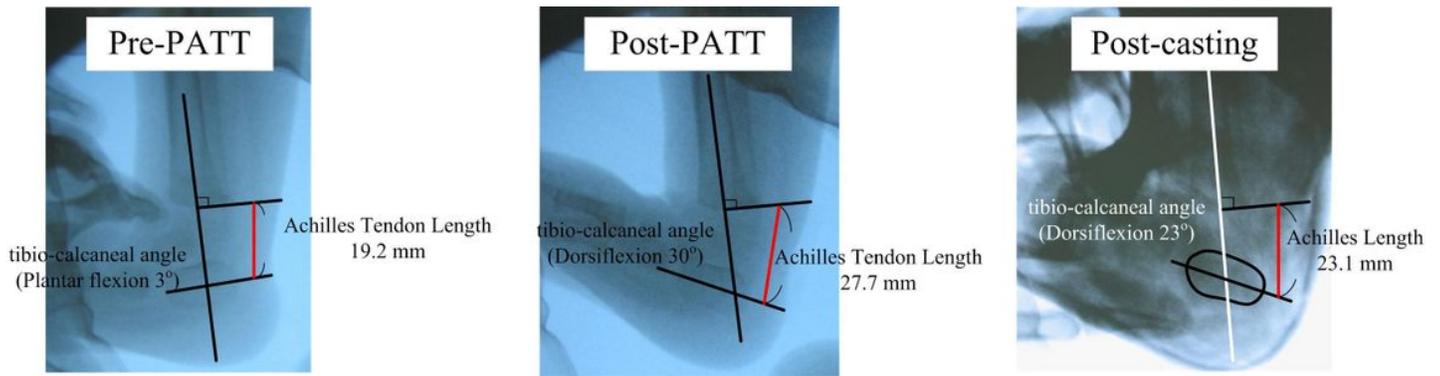


Figure 1

Pre-PAT, post-PAT, and post-casting ankle dorsiflexion (lateral view). Tibio-calcaneal angle (TCA) and Achilles tendon length (ATL) were measured.

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