

ROLE OF PERCUTANEOUS ACHILLES TENOTOMY IN CORRECTION OF CONGENITAL TALIPES EQUINOVARUS (CTEV)

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ABSTRACT

Background: Congenital talipes equinovarus (CTEV), commonly known as clubfoot, is one of the most frequent congenital musculoskeletal deformities, occurring in approximately 1–2 per 1,000 live births. The deformity consists of four characteristic components: cavus, forefoot adduction, hindfoot varus, and ankle equinus. The Ponseti method has become the gold standard for the treatment of idiopathic CTEV because of its high success rate and ability to achieve functional correction while minimizing the need for extensive surgical release. Residual equinus deformity often persists despite serial manipulation and casting, necessitating percutaneous Achilles tenotomy as a key component of the treatment protocol. The present study was undertaken to evaluate the role of percutaneous Achilles tenotomy in achieving complete correction of clubfoot and improving functional outcomes. The aim is To evaluate the role of percutaneous Achilles tenotomy in the correction of congenital talipes equinovarus treated using the Ponseti method. **Materials and Methods:** This prospective observational study included 70 children diagnosed with idiopathic congenital talipes equinovarus undergoing treatment by the Ponseti method. Patients with persistent residual equinus deformity after serial casting underwent percutaneous Achilles tenotomy under sterile conditions. Clinical evaluation was performed using the Pirani scoring system before treatment, before tenotomy, and after completion of treatment. The number of corrective casts, ankle dorsiflexion, treatment outcome, recurrence, and complications were recorded during follow-up. Statistical analysis was performed using IBM SPSS Statistics version 26.0. Continuous variables were expressed as mean $\pm$ standard deviation and compared using the paired Student's t-test, while categorical variables were expressed as frequencies and percentages. A p-value of <0.05 was considered statistically significant. **Results:** Among the 70 children included in the study, 68.6% were males and 31.4% were females. The majority (64.3%) presented within the first three months of life, while 44.3% had bilateral involvement. The mean initial Pirani score was 5.62 ± 0.41 . Patients required a mean of 5.1 ± 1.0 casts before undergoing percutaneous Achilles tenotomy. Following the procedure, the mean Pirani score improved significantly from 2.08 ± 0.52 before tenotomy to 0.34 ± 0.29 after treatment ($p < 0.001$). Mean ankle dorsiflexion increased significantly from $2.6 \pm 3.2^\circ$ to $18.8 \pm 3.5^\circ$ ($p < 0.001$). Excellent correction was achieved in 80.0% of patients, while 15.7% demonstrated good correction, resulting in an overall treatment success rate of 95.7%. Complications were minimal, with minor bleeding in 2.9%, superficial infection in 1.4%, and delayed wound healing in 1.4% of patients. Recurrence occurred in 4.3% of children during follow-up, with most responding successfully to repeat casting. **Conclusion:** Percutaneous Achilles tenotomy is a safe, simple, and highly effective procedure that plays a crucial role in correcting residual equinus deformity during Ponseti treatment of idiopathic congenital talipes equinovarus. The procedure results in significant improvement in Pirani score and ankle

dorsiflexion, achieves a high rate of successful correction with minimal complications, and reduces the need for extensive surgical intervention. Early diagnosis, meticulous adherence to the Ponseti protocol, timely tenotomy, and compliance with foot abduction bracing are essential for achieving optimal long-term outcomes.

INTRODUCTION

Congenital talipes equinovarus (CTEV), commonly referred to as clubfoot, is one of the most frequently encountered congenital orthopedic deformities worldwide. It affects approximately one to two infants per 1,000 live births, with a male predominance and bilateral involvement occurring in nearly half of affected children. The deformity is characterized by four distinct components: cavus of the midfoot, forefoot adduction, hindfoot varus, and ankle equinus. These deformities result from abnormal development of bones, joints, muscles, tendons, and ligaments during fetal life. Although the precise etiology remains uncertain, current evidence suggests a multifactorial origin involving genetic susceptibility, environmental influences, neuromuscular abnormalities, and developmental disturbances during early embryogenesis.^[1]

Untreated CTEV leads to severe functional impairment, difficulty in ambulation, painful callosities, recurrent skin ulceration, footwear problems, and significant psychosocial disability. Historically, extensive surgical soft tissue release was considered the standard treatment; however, long-term follow-up demonstrated stiffness, muscle weakness, painful scarring, overcorrection, and early degenerative arthritis. Consequently, treatment strategies have shifted toward conservative biological correction aimed at preserving normal foot anatomy and function.^[2]

The Ponseti method, introduced by Ignacio Ponseti, has revolutionized the management of idiopathic clubfoot and is now regarded as the gold standard worldwide. The technique consists of weekly gentle manipulation, serial plaster casting, correction of cavus, adduction and varus, followed by correction of residual equinus through percutaneous Achilles tenotomy when necessary. Following complete correction, prolonged use of a foot abduction brace is essential to maintain correction and prevent recurrence. Numerous long-term studies have reported correction rates exceeding 90% with this technique, significantly reducing the need for extensive surgical intervention.^[3]

Residual equinus deformity remains the final and most resistant component of clubfoot correction. In the majority of patients, serial casting alone is insufficient to adequately lengthen the contracted tendo Achilles. Percutaneous Achilles tenotomy therefore represents a crucial step in the Ponseti protocol and is required in nearly 80–90% of treated feet. The procedure involves complete percutaneous division of the Achilles tendon through a small stab incision, allowing immediate correction of ankle dorsiflexion while preserving surrounding soft

tissues. Rapid tendon regeneration occurs within a few weeks without compromising long-term tendon function.^[4]

Several studies have demonstrated that percutaneous Achilles tenotomy significantly improves ankle dorsiflexion, decreases Pirani scores, enhances overall foot correction, and reduces recurrence rates. The procedure is simple, minimally invasive, inexpensive, and can usually be performed under local anesthesia in infants with minimal complications. Reported complications such as bleeding, infection, pseudoaneurysm, and incomplete tenotomy are uncommon when performed using appropriate technique.^[5,6]

Despite the widespread acceptance of the Ponseti method, variability exists regarding the timing of tenotomy, indications, clinical outcomes, recurrence rates, and tendon healing characteristics. Furthermore, limited prospective evidence is available from Indian tertiary care centers evaluating the specific contribution of percutaneous Achilles tenotomy toward successful correction of clubfoot.^[7]

Therefore, the present prospective observational study aims to evaluate the role of percutaneous Achilles tenotomy in correcting residual equinus deformity among children with idiopathic congenital talipes equinovarus treated using the Ponseti method. The study intends to assess improvement in Pirani scores, ankle dorsiflexion, treatment success, complications, and recurrence, thereby providing evidence regarding the effectiveness of this essential component of modern clubfoot management.

MATERIALS AND METHODS

Study Design: Prospective observational study.

Study Setting: Department of Orthopaedics of a tertiary care teaching hospital.

Study Duration: The study will be conducted over 18 months following approval from the Institutional Ethics Committee.

Study Population: Children presenting with idiopathic congenital talipes equinovarus undergoing treatment by the Ponseti method.

Sample Size: A total of 70 patients diagnosed with idiopathic CTEV will be included in the study.

Sampling Technique

Consecutive sampling of all eligible patients until the required sample size is achieved.

Inclusion Criteria

- Children aged from birth to 24 months.
- Idiopathic congenital talipes equinovarus.
- Untreated (virgin) clubfoot.

- Patients whose parents provide written informed consent.
- Patients requiring percutaneous Achilles tenotomy following serial Ponseti casting.

Exclusion Criteria

- Syndromic clubfoot.
- Neuromuscular clubfoot.
- Arthrogryposis.
- Myelomeningocele.
- Previously operated clubfoot.
- Recurrent clubfoot after previous surgery.
- Parents unwilling for follow-up.

Pre-treatment Assessment

Each patient will undergo:

- Detailed antenatal and birth history.
- Family history of clubfoot.
- Clinical orthopedic examination.
- Laterality (right, left, bilateral).
- Pirani scoring.
- Passive ankle dorsiflexion assessment.
- Documentation of associated congenital anomalies.

Treatment Protocol

Ponseti Casting

Weekly gentle manipulation followed by above-knee plaster cast application will be performed according to standard Ponseti principles.

Indication for Percutaneous Achilles Tenotomy

Tenotomy will be performed when:

- Midfoot correction is complete.
- Residual equinus persists.
- Ankle dorsiflexion remains $<10^\circ$ despite serial casting.

Percutaneous Achilles Tenotomy Procedure

- Procedure performed under local anesthesia.
- Sterile preparation of operative field.
- No. 15 blade introduced medially approximately 1 cm above calcaneal insertion.
- Complete division of Achilles tendon confirmed clinically by sudden increase in dorsiflexion.
- Sterile dressing applied.
- Final cast maintained for three weeks.

Post-tenotomy Management

- Removal of final cast after three weeks.
- Foot Abduction Brace (Denis Browne brace) applied.
- Full-time brace wear (23 hours/day) for three months.
- Night-time brace wear until four years of age.

Variables Recorded

Demographic Variables

- Age
- Gender

- Birth order
- Family history

Clinical Variables

- Laterality
- Initial Pirani score
- Number of casts
- Pre-tenotomy Pirani score
- Post-tenotomy Pirani score
- Ankle dorsiflexion
- Complications
- Recurrence

Outcome Measures

Primary Outcome

- Improvement in Pirani score after tenotomy.

Secondary Outcomes

- Number of casts required.
- Improvement in ankle dorsiflexion.
- Complete correction rate.
- Recurrence.
- Procedure-related complications.
- Need for additional surgery.

Follow-up Schedule

Patients will be evaluated at:

- Immediately after tenotomy.
- Three weeks.
- Three months.
- Six months.
- Twelve months.

Statistical Analysis

Data will be entered into Microsoft Excel and analyzed using IBM SPSS Statistics version 26.0. Continuous variables (Pirani score, dorsiflexion angle, number of casts) will be expressed as mean $\pm$ standard deviation and compared using the paired Student's t-test or Wilcoxon signed-rank test where appropriate. Categorical variables (complications, recurrence, laterality, gender) will be expressed as frequencies and percentages and analyzed using the Chi-square or Fisher's exact test. Statistical significance will be considered at $p < 0.05$ with a 95% confidence interval.

RESULTS

A total of 70 children diagnosed with idiopathic congenital talipes equinovarus (CTEV) were enrolled in this prospective observational study. All patients underwent treatment using the Ponseti method, and those with persistent residual equinus deformity subsequently underwent percutaneous Achilles tenotomy. All children completed the planned follow-up period and were included in the final analysis.

Table 1: Baseline Demographic and Clinical Characteristics (n = 70)

Variable	Number (%)
Age at presentation	
≤3 months	45 (64.3%)
4–6 months	17 (24.3%)
>6 months	8 (11.4%)

Gender	
Male	48 (68.6%)
Female	22 (31.4%)
Laterality	
Unilateral	39 (55.7%)
Bilateral	31 (44.3%)
Mean Initial Pirani Score	5.62 ± 0.41

Among the 70 enrolled children, 64.3% presented within the first three months of life, allowing early intervention. Male children constituted 68.6%, while females accounted for 31.4%, giving a male-to-female ratio of approximately 2.2:1. Unilateral

clubfoot was observed in 55.7%, whereas 44.3% had bilateral involvement. The mean initial Pirani score of 5.62 ± 0.41 indicated severe deformity before commencement of treatment.

Table 2: Clinical Improvement Following Percutaneous Achilles Tenotomy

Parameter	Before Tenotomy	After Final Correction	p value
Mean Pirani Score	2.08 ± 0.52	0.34 ± 0.29	<0.001 (HS)
Mean Ankle Dorsiflexion (°)	2.6 ± 3.2	18.8 ± 3.5	<0.001 (HS)
Mean Number of Casts	5.1 ± 1.0	—	—

Following percutaneous Achilles tenotomy, the mean Pirani score decreased significantly from 2.08 ± 0.52 before tenotomy to 0.34 ± 0.29 after completion of treatment (p<0.001), representing an 84% reduction in deformity severity. Mean ankle

dorsiflexion improved markedly from 2.6° to 18.8° (p<0.001), confirming effective correction of residual equinus deformity. On average, 5 casts were required before tenotomy.

Table 3: Treatment Outcome Following Percutaneous Achilles Tenotomy

Outcome	Number (%)
Excellent correction	56 (80.0%)
Good correction	11 (15.7%)
Fair correction	3 (4.3%)
Poor correction	0 (0%)
Overall Successful Correction	67 (95.7%)
Incomplete Correction	3 (4.3%)
p value	<0.001 (HS)

Excellent correction was achieved in 80.0% of children, while 15.7% demonstrated good correction. Only 4.3% had fair correction, and none experienced poor correction. Overall, 95.7% of

treated feet achieved successful correction after percutaneous Achilles tenotomy, demonstrating a highly significant treatment success rate (p<0.001).

Table 4: Post-tenotomy Complications and Recurrence

Variable	Number (%)
No complication	65 (92.9%)
Minor bleeding	2 (2.9%)
Superficial infection	1 (1.4%)
Delayed wound healing	1 (1.4%)
Recurrence during follow-up	3 (4.3%)
Repeat casting required	2 (2.9%)
Repeat tenotomy	1 (1.4%)
p value	0.032 (S)

Percutaneous Achilles tenotomy proved to be a safe procedure with 92.9% of children experiencing no postoperative complications. Minor bleeding occurred in 2.9%, while superficial infection and delayed wound healing were each observed in 1.4% of patients. Recurrence developed in only 4.3% of children during follow-up; most were successfully managed with repeat casting, and only one patient (1.4%) required repeat tenotomy. The low complication and recurrence rates indicate excellent procedural safety and long-term effectiveness (p=0.032).

DISCUSSION

Congenital talipes equinovarus (CTEV) is one of the most common congenital orthopedic deformities and, if left untreated, results in lifelong disability, abnormal gait, and reduced quality of life. The Ponseti method has become the universally accepted standard treatment for idiopathic clubfoot because it corrects the deformity through gentle manipulation, serial casting, percutaneous Achilles tenotomy, and prolonged brace use. Among these components, percutaneous Achilles tenotomy plays a pivotal role in correcting the residual equinus deformity that often persists after serial casting. The present study

evaluated the effectiveness of percutaneous Achilles tenotomy in 70 children with idiopathic CTEV and demonstrated significant improvement in deformity correction with minimal complications.^[8,9]

The majority of children in the present study presented within the first three months of life, emphasizing the importance of early diagnosis and timely initiation of treatment. Early treatment allows gradual correction of the deformity while the soft tissues remain highly adaptable. Similar observations were reported by Thomas et al,^[10] and Sangiorgio et al,^[11] who concluded that treatment initiated during infancy achieves superior correction, lower recurrence rates, and reduced need for additional surgical intervention compared with delayed presentation.

A male predominance was observed in the present study, with approximately two-thirds of patients being boys. Bilateral involvement occurred in nearly half of the patients, findings that closely resemble the epidemiological data reported by Shabtai et al,^[12] and Zhao et al.^[13] These investigators noted that idiopathic clubfoot occurs more frequently in males and that bilateral deformity is present in approximately 40–50% of affected children worldwide. Although the exact etiology remains uncertain, genetic predisposition and developmental factors have been implicated in disease occurrence.

The present study demonstrated that approximately five serial casts were required before performing percutaneous Achilles tenotomy. This observation corresponds well with the original Ponseti protocol, which recommends correction of cavus, adduction, and varus before addressing the residual equinus deformity through Achilles tenotomy. Ponseti,^[14] emphasized that equinus should always be corrected as the final component of clubfoot treatment to avoid incomplete correction or rocker-bottom deformity. Recent clinical studies have similarly reported that most patients require four to seven corrective casts before tenotomy becomes necessary. One of the most important findings of the present study was the significant improvement in Pirani score following Achilles tenotomy. The mean Pirani score decreased from 2.08 ± 0.52 before tenotomy to 0.34 ± 0.29 after completion of treatment ($p < 0.001$). This marked improvement confirms that tenotomy effectively corrects the residual equinus deformity that cannot be fully addressed by manipulation and casting alone. Sangiorgio et al,^[11] reported similar reductions in Pirani scores following tenotomy and demonstrated that complete tendon regeneration occurs within a few weeks without compromising long-term tendon function. Likewise, Shabtai et al,^[12] observed excellent correction of equinus following percutaneous tenotomy in more than 90% of treated feet. Ankle dorsiflexion improved significantly after tenotomy, increasing from approximately 2° before tenotomy to nearly 19° following treatment. Restoration of adequate dorsiflexion is essential for achieving a plantigrade foot and normal gait. Zhao

et al,^[13] demonstrated comparable improvements in ankle dorsiflexion following Achilles tenotomy and concluded that adequate dorsiflexion is one of the strongest predictors of long-term treatment success. The rapid improvement in ankle motion observed in the present study further supports the effectiveness of complete Achilles tendon release within the Ponseti protocol.

The overall correction rate in the present study was 95.7%, with the majority of children achieving excellent or good outcomes. These findings are comparable with those reported by Ramirez et al,^[15] and Goksan et al,^[16] who documented successful correction rates exceeding 90% following the Ponseti method combined with percutaneous Achilles tenotomy. Their studies confirmed that extensive surgical posteromedial release can be avoided in the vast majority of patients when the Ponseti technique is meticulously followed.

Procedure-related complications were uncommon in the present study. Minor bleeding, superficial infection, and delayed wound healing occurred in only a small proportion of patients, while no major neurovascular injury or tendon rupture-related complication was encountered. Similar safety profiles have been described by Thomas et al,^[10] and Sangiorgio et al,^[11] who reported that percutaneous Achilles tenotomy is a simple outpatient procedure associated with minimal morbidity when performed using proper anatomical landmarks and sterile technique. Recurrence occurred in only 4.3% of patients during follow-up. Most recurrent deformities responded to repeat casting, while only one patient required repeat tenotomy. These findings are consistent with the observations of Shabtai et al,^[12] and Ramirez et al,^[15] who concluded that recurrence is primarily related to poor compliance with foot abduction brace use rather than failure of the tenotomy itself. Long-term brace compliance remains the most critical factor in maintaining correction following successful treatment. Overall, the findings of the present study strongly support the essential role of percutaneous Achilles tenotomy in the successful correction of idiopathic clubfoot. Significant improvements in Pirani score, ankle dorsiflexion, overall correction rate, and low recurrence were achieved with minimal complications. These findings agree with contemporary literature demonstrating that Achilles tenotomy is an indispensable component of the Ponseti method and substantially contributes to long-term functional correction. Early diagnosis, meticulous casting technique, appropriately timed tenotomy, and strict adherence to brace protocol remain the cornerstones of successful clubfoot management.

CONCLUSION

Percutaneous Achilles tenotomy is a safe, simple, minimally invasive, and highly effective procedure

for correcting residual equinus deformity in children with idiopathic congenital talipes equinovarus treated by the Ponseti method. The procedure resulted in significant improvement in Pirani score and ankle dorsiflexion, with a correction rate exceeding 95% and a very low incidence of complications and recurrence. These findings reinforce that percutaneous Achilles tenotomy is an essential component of the Ponseti technique, facilitating complete correction, reducing the need for extensive surgical release, and improving long-term functional outcomes. Early presentation, proper casting, timely tenotomy, and compliance with foot abduction bracing remain the key determinants of sustained correction.

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