

Original Research Article

Functional outcome of idiopathic congenital talipes equinovarus treated by the Ponseti method: a prospective observational study in a tertiary care hospital

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ABSTRACT

Background: Idiopathic congenital talipes equinovarus (CTEV), commonly known as clubfoot, is one of the most common congenital musculoskeletal deformities affecting children worldwide. If untreated, it may result in permanent deformity, gait abnormalities, pain, and lifelong disability. The Ponseti method has become the gold standard for the management of idiopathic clubfoot because it is minimally invasive, cost-effective, and associated with excellent functional outcomes. However, treatment success depends on early presentation, meticulous casting technique, Achilles tenotomy when indicated, and strict adherence to the foot abduction brace protocol.

Methods: A prospective observational study was conducted in the Department of Orthopaedics, Government General Hospital, Vijayawada, over a period of 24 months. Thirty children younger than two years with idiopathic CTEV were included. All patients underwent treatment using the standard Ponseti protocol consisting of serial manipulation and casting, percutaneous Achilles tenotomy when required, and maintenance using a foot abduction brace. Demographic characteristics, Pirani score, number of casts, tenotomy requirement, treatment-related complications, recurrence, and functional outcome were evaluated.

Results: Thirty patients with 43 affected feet were included. Most patients presented within the first six months of life. The majority of feet required six to seven casts for complete correction, while percutaneous Achilles tenotomy was required in 83.7% of feet. Following treatment, near-normal Pirani scores were achieved in most patients. Excellent functional outcomes were observed in 65.1% of feet and good outcomes in 23.3%, resulting in an overall excellent-to-good outcome rate of 88.4%. Treatment-related complications were minimal and managed conservatively.

Conclusions: The Ponseti method is a safe, reliable, and highly effective treatment for idiopathic clubfoot. Early initiation of treatment combined with appropriate Achilles tenotomy and good brace compliance results in excellent functional outcomes while minimizing complications and recurrence. The method should remain the first-line treatment for idiopathic CTEV, particularly in resource-limited healthcare settings.

Keywords: Congenital talipes equinovarus, Clubfoot, Ponseti method, Pirani score, Achilles tenotomy, Functional outcome

INTRODUCTION

Idiopathic congenital talipes equinovarus (CTEV), commonly referred to as clubfoot, is one of the most common congenital musculoskeletal deformities, with an estimated incidence of 1-2 per 1,000 live births worldwide. The condition is characterized by a complex three-

dimensional deformity involving four principal components: cavus of the midfoot, forefoot adduction, hindfoot varus, and ankle equinus (CAVE).¹ Approximately 50% of affected children have bilateral involvement, and males are affected nearly twice as often as females. If left untreated, clubfoot leads to progressive

deformity, abnormal gait, pain, callosities, difficulty wearing footwear, social stigma, and lifelong disability.

Although the exact etiology of idiopathic clubfoot remains uncertain, current evidence suggests a multifactorial origin involving genetic susceptibility, environmental influences, and abnormalities in fetal musculoskeletal development. Histopathological studies have demonstrated fibrosis and contracture of the posteromedial soft tissues, while imaging studies have shown abnormal alignment of the talus, calcaneus, navicular, and cuboid. These pathological changes contribute to the rigidity of the deformity and emphasize the importance of early intervention before secondary adaptive changes occur.²

Historically, the treatment of clubfoot consisted of prolonged manipulation, extensive casting, or extensive surgical soft-tissue release. The Kite method of serial manipulation, introduced in the mid-twentieth century, achieved correction in selected cases but was associated with prolonged treatment duration, incomplete correction, and high recurrence rates. Surgical procedures such as posteromedial release were subsequently adopted for resistant deformities; however, long-term follow-up demonstrated complications including stiffness, pain, muscle weakness, overcorrection, under-correction, and early degenerative arthritis.³ These limitations prompted the search for more effective and less invasive treatment strategies.

The Ponseti method, developed by Dr. Ignacio V. Ponseti, has revolutionized the management of idiopathic clubfoot and is now regarded as the gold standard worldwide. The technique is based on a thorough understanding of the functional anatomy and biomechanics of the infant foot. Gentle weekly manipulations followed by above-knee plaster casting are performed in a precise sequence to correct cavus, adduction, varus, and finally equinus.⁴

Residual equinus is corrected by percutaneous Achilles tenotomy in the majority of patients, after which a foot abduction brace is used to maintain correction and prevent relapse.

Numerous clinical studies have demonstrated success rates exceeding 90% when treatment is initiated early and brace compliance is maintained. Compared with extensive surgical procedures, the Ponseti method offers excellent functional outcomes while minimizing complications, reducing healthcare costs, shortening hospital stay, and preserving foot mobility. These advantages have resulted in widespread acceptance of the technique across both developed and resource-limited healthcare systems.⁵

Despite its excellent outcomes, recurrence remains an important challenge in clubfoot management. The most common cause of relapse is poor compliance with the foot abduction brace protocol. Other factors associated with recurrence include delayed presentation, severe deformity at initial assessment, inadequate correction during the

casting phase, atypical clubfoot, and failure to ensure long-term follow-up. Early identification and prompt management of recurrence are therefore essential for maintaining satisfactory functional outcomes.⁶

In India, delayed presentation remains common because of limited awareness, socioeconomic constraints, difficulties in accessing specialized healthcare, and poor adherence to prolonged brace treatment. Consequently, evaluating the effectiveness of the Ponseti method in the local population is important for guiding clinical practice and optimizing treatment protocols. Although several Indian studies have confirmed the effectiveness of the Ponseti technique, regional data remain limited, particularly from tertiary care teaching hospitals in South India.⁷

The present prospective observational study was therefore undertaken in the Department of Orthopaedics, Government General Hospital, Vijayawada, to evaluate the functional outcome of idiopathic CTEV treated using the Ponseti method. The study assessed demographic characteristics, severity of deformity using the Pirani scoring system, number of casts required for correction, need for percutaneous Achilles tenotomy, treatment-related complications, and final functional outcome.

The findings are expected to contribute additional evidence supporting the effectiveness of the Ponseti method and reinforce its role as the preferred treatment for idiopathic clubfoot in contemporary orthopaedic practice.⁸

METHODS

Study design

This prospective observational study was conducted to evaluate the functional outcome of CTEV treated using the Ponseti method. Consecutive eligible patients presenting during the study period were enrolled and managed according to the standard Ponseti treatment protocol. Clinical outcomes were assessed prospectively until completion of treatment and follow-up.

Study setting

The study was carried out in the Department of Orthopaedics, Government General Hospital, attached to Siddhartha Medical College, Vijayawada, Andhra Pradesh, India.

Study duration

The study was conducted over a period of 24 months.

Study population

Thirty consecutive children diagnosed with idiopathic CTEV were included in the study. Both unilateral and bilateral cases were enrolled, resulting in the evaluation of 43 affected feet.

Inclusion criteria

Children younger than two years of age, primary idiopathic CTEV, unilateral or bilateral involvement and parents or legal guardians willing to provide informed consent and comply with the treatment protocol and follow-up schedule were included.

Exclusion criteria

Patients were excluded if they had: age greater than two years, previous treatment by another casting method, previous surgical intervention for clubfoot, syndromic or secondary clubfoot associated with neuromuscular or congenital disorders, recurrent or relapsed clubfoot, atypical or complex clubfoot and parents unwilling to participate or comply with follow-up.

Clinical assessment

At presentation, each patient underwent a detailed history and clinical examination. Demographic details, age at presentation, sex, laterality, and severity of deformity were recorded.

The diagnosis of idiopathic CTEV was established clinically based on the characteristic CAVE deformity comprising cavus, forefoot adduction, hindfoot varus, and ankle equinus.

Severity of deformity was assessed using the Pirani Scoring System, which evaluates six clinical parameters involving the hindfoot and midfoot. The total score ranges from 0 to 6, with the higher scores indicating greater severity.

Treatment protocol

All patients were managed according to the standard Ponseti technique.

Manipulation and serial casting

Weekly gentle manipulation was performed to sequentially correct the deformity in the recommended order: cavus, forefoot adduction, hindfoot varus, and finally equinus. Following each manipulation, an above-knee plaster of Paris cast was applied with the knee maintained at approximately 90° of flexion to minimize cast slippage. Casts were changed every week until satisfactory correction was achieved.

Percutaneous Achilles tenotomy

Residual equinus following correction of cavus, adduction, and varus was managed by percutaneous Achilles tenotomy under aseptic precautions whenever dorsiflexion remained inadequate. A final above-knee cast was then applied with the foot maintained in dorsiflexion and abduction for three weeks.

Maintenance phase

Following complete correction, all patients were advised to use a foot abduction brace according to the standard Ponseti protocol. Parents were counselled regarding the importance of brace compliance to minimize the risk of recurrence.

Outcome measures

The primary outcome was the functional outcome following completion of treatment.

Secondary outcome measures

It included initial Pirani score, number of casts required, requirement for Achilles tenotomy, duration of serial casting, treatment-related complications, Pirani score after correction and functional outcome at final follow-up.

Follow-up

Patients were reviewed weekly during the casting phase. Following correction, scheduled follow-up visits were conducted to assess maintenance of correction, brace compliance, complications, and recurrence. Parents received detailed instructions regarding cast care, brace application, and early recognition of complications.

Ethical considerations

Institutional ethical approval was obtained before commencement of the study. Written informed consent was obtained from the parents or legal guardians of all participating children. Confidentiality of patient information was maintained throughout the study in accordance with institutional ethical guidelines and the principles of the declaration of Helsinki.

Statistical analysis

Data were entered into Microsoft excel and analysed using appropriate statistical software. Continuous variables were expressed as mean±standard deviation where applicable, while categorical variables were presented as frequencies and percentages. Results were summarized using descriptive statistics.

Associations between clinical variables and treatment outcomes were evaluated using appropriate statistical tests, with a p<0.05 considered statistically significant.

RESULTS

Patient characteristics

A total of 30 children with 43 idiopathic clubfeet were included in this prospective study. Seventeen patients (56.7%) had unilateral involvement, while thirteen (43.3%) had bilateral involvement.

Age distribution

Most children presented within the first six months of life. Ten patients (33.3%) presented during the first three months, followed by eight patients (26.7%) between four and six months. Only five children (16.7%) presented after one year of age, indicating that the majority received early treatment.

Table 1: Age distribution of patients.

Age group (in months)	N	Percentage (%)
0-3	10	33.3
4-6	8	26.7
7-12	7	23.3
13-24	5	16.7
Total	30	100

Gender distribution

There was a male predominance. Eighteen patients (60%) were male, while 12 (40%) were female.

Table 2: Gender distribution.

Gender	N	Percentage (%)
Male	18	60
Female	12	40
Total	30	100

Laterality

Unilateral involvement was observed in 17 patients (56.7%), whereas bilateral involvement occurred in 13 patients (43.3%). Among unilateral cases, the right foot was affected in nine patients (52.9%) and the left foot in eight patients (47.1%).

Table 3: Laterality of clubfoot.

Laterality	N	Percentage (%)
Unilateral	17	56.7
Bilateral	13	43.3
Total	30	100

A total of the forty three feet were evaluated during the study.

Severity of deformity

Initial assessment using the Pirani scoring system demonstrated that most feet presented with moderate-to-severe deformity. Severe deformity (Pirani score >4) was present in 19 feet (44.1%), while moderate deformity (2.5-4) was observed in 18 feet (41.9%). Only six feet (14.0%) had mild deformity.

Table 4: Initial Pirani score.

Pirani score	Number of feet	Percentage (%)
0-2 (Mild)	6	14.0
2.5-4 (Moderate)	18	41.9
>4 (Severe)	19	44.1
Total	43	100

Treatment characteristics

Correction was achieved using serial casting according to the Ponseti protocol. Most feet (51.2%) required six to seven casts, whereas 32.6% required four to five casts. Only seven feet (16.2%) required more than the seven casts.

Table 5: Number of casts required.

Number of casts	Number of feet	Percentage (%)
4-5 casts	14	32.6
6-7 casts	22	51.2
>7 casts	7	16.2
Total	43	100

Percutaneous Achilles tenotomy was required in 36 feet (83.7%), while seven feet (16.3%) achieved correction without tenotomy.

Table 6: Achilles tenotomy requirement.

Tenotomy	Number of feet	Percentage (%)
Required	36	83.7
Not required	7	16.3
Total	43	100

The majority of patients (46.6%) completed correction within seven to eight weeks of serial casting.

Treatment-related complications

Treatment was well tolerated. No complications occurred in 36 feet (83.7%). Minor complications included skin irritation in four feet (9.3%) and cast loosening in three feet (7.0%). All complications were managed conservatively without interruption of treatment.

Table 7: Treatment-related complications.

Complications	Number of feet	Percentage (%)
Skin irritation	4	9.3
Cast loosening	3	7.0
No complications	36	83.7
Total	43	100

Clinical outcome

Following completion of treatment, 34 feet achieved a Pirani score between 0 and 0.5, indicating near-complete correction. Only two feet had residual scores greater than 1.5.

Functional outcome assessment demonstrated excellent results in 28 feet (65.1%) and good results in 10 feet (23.3%). Thus, 38 of 43 feet (88.4%) achieved excellent or good functional outcomes. Fair and poor outcomes were observed in only five feet (11.6%).

Table 8: Functional outcome.

Outcomes	Number of feet	Percentage (%)
Excellent	28	65.1
Good	10	23.3
Fair	3	7.0
Poor	2	4.6
Total	43	100

Feet with mild-to-moderate deformity at presentation demonstrated a slightly higher proportion of excellent and good outcomes than those with severe deformity, although satisfactory correction was achieved in the majority of severe cases following adherence to the Ponseti protocol.

DISCUSSION

The Ponseti method has become the accepted gold standard for the treatment of idiopathic CTEV because it provides excellent deformity correction while preserving foot mobility and minimizing the need for extensive surgical intervention. The present prospective observational study evaluated the functional outcomes of 30 children (43 feet) treated using the standard Ponseti protocol at a tertiary care teaching hospital. The findings demonstrate a high rate of successful correction with minimal complications, supporting the effectiveness of this technique in routine clinical practice.

The majority of patients in the present study presented within the first six months of life, highlighting increasing awareness among parents and healthcare providers regarding the importance of early referral. Early treatment is advantageous because the neonatal foot is highly flexible, allowing gradual correction through serial manipulation and casting. Delayed presentation is associated with increased stiffness of the deformity, prolonged treatment duration, and a greater likelihood of requiring additional interventions.

A male predominance (60%) was observed, which is consistent with previous epidemiological studies reporting a male-to-female ratio of approximately 2:1.⁹ Unilateral involvement was slightly more common than bilateral involvement, and the right foot was affected marginally more often than the left among unilateral cases. These

findings are comparable with those reported in both Indian and international literature.

At presentation, more than 85% of feet demonstrated moderate to severe deformity according to the Pirani scoring system. Despite this, successful correction was achieved in the majority of patients using the standard Ponseti protocol. This observation reinforces the value of the Pirani score not only as an indicator of deformity severity but also as a useful guide for treatment planning and monitoring response to serial casting.⁹

The majority of feet required six to seven casts to achieve satisfactory correction, which is comparable with the original Ponseti series and subsequent multicentre studies. A small proportion of patients required more than seven casts, largely reflecting delayed presentation or greater initial deformity. These findings suggest that the number of casts required is closely related to the initial severity of the deformity rather than to limitations of the treatment technique.

Percutaneous Achilles tenotomy was required in 83.7% of affected feet, closely matching the rates reported in contemporary literature, where tenotomy is necessary in approximately 80-90% of idiopathic clubfeet. The high frequency of tenotomy reflects the persistence of residual equinus after correction of cavus, adduction, and varus. Because the procedure is simple, minimally invasive, and highly effective, it should be considered an integral component of the Ponseti method rather than a treatment failure.¹⁰

Treatment-related complications were infrequent and limited to minor skin irritation and cast loosening. No major complications such as neurovascular injury, deep infection, compartment syndrome, or cast-related pressure sores were encountered. These findings further support the excellent safety profile of the Ponseti method when performed by trained personnel with careful follow-up.

Following completion of treatment, the majority of feet achieved near-normal Pirani scores, indicating excellent anatomical correction. Functional assessment demonstrated excellent outcomes in 65.1% of feet and good outcomes in 23.3%, resulting in an overall excellent-to-good outcome rate of 88.4%. These findings compare favourably with previously published studies, which consistently report success rates exceeding 85-95% following adherence to the standard Ponseti protocol.¹¹

Although feet with severe initial deformity required more casts and were more likely to undergo Achilles tenotomy, most still achieved satisfactory functional outcomes. This finding suggests that severe deformity should not be considered a contraindication to conservative management. Instead, careful adherence to Ponseti principles, meticulous casting technique, and continued follow-up can achieve excellent correction even in severe cases.

The present study has several strengths. It was conducted prospectively using a standardized treatment protocol, all patients were managed by the same orthopaedic unit, and deformity severity was assessed using the validated Pirani scoring system. These factors reduce treatment variability and improve the reliability of the clinical findings.

The study also has certain limitations. The sample size was relatively small and the study was conducted at a single tertiary care centre, which may limit the generalizability of the findings. Functional assessment was based primarily on clinical evaluation, and long-term follow-up beyond the early correction period was not available to evaluate recurrence, gait characteristics, and long-term patient-reported outcomes. Future multicentre studies with larger sample sizes, longer follow-up, and validated functional outcome measures would provide stronger evidence regarding the long-term effectiveness of Ponseti method.

Overall, the findings of the present study are consistent with the growing body of international evidence supporting the Ponseti method as the treatment of choice for idiopathic CTEV. Early diagnosis, timely initiation of treatment, appropriate Achilles tenotomy when indicated, and strict adherence to foot abduction brace use remain the key determinants of successful long-term outcomes.

Strengths

Prospective study design, standardized Ponseti treatment protocol, use of the validated Pirani scoring system and evaluation of both clinical correction and functional outcome were strengths of the study.

Limitations

Relatively small sample size, single-centre study, limited long-term follow-up for recurrence assessment and absence of instrumented gait analysis or patient-reported outcome measures were limitation of the study.

CONCLUSION

The present prospective observational study demonstrates that the Ponseti method is a highly effective, safe, and minimally invasive treatment for idiopathic CTEV. The majority of patients achieved excellent or good functional outcomes, with successful correction of deformity and restoration of a plantigrade, functional foot.

Early initiation of treatment, adherence to the sequential Ponseti casting protocol, appropriate use of percutaneous Achilles tenotomy, and strict compliance with the foot abduction brace were important factors contributing to successful outcomes. Treatment-related complications were infrequent, minor, and managed conservatively.

Based on the findings of this study, the Ponseti method should continue to be considered the first-line treatment

for idiopathic clubfoot, particularly in resource-limited healthcare settings where a cost-effective and function-preserving treatment strategy is essential.

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