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Original Research Article

Cross-sectional descriptive study of characteristics of infants with congenital talipes equino varus requiring and not requiring tendo-Achilles tenotomy post Ponseti casting

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ABSTRACT

Background: Congenital talipes equinovarus (CTEV) is a common musculoskeletal anomaly with prevalence ranging from 0.4-7.0 per 1000 live births. The Ponseti method has revolutionized CTEV management, though percutaneous Achilles tenotomy requirements vary across populations. Objective was to evaluate characteristics of infants with CTEV requiring and not requiring tendoachilles tenotomy following Ponseti casting at an Indian tertiary care center.
Methods: A prospective and retrospective cross-sectional study was conducted over 24 months (January 2022-December 2024) involving 44 children with idiopathic CTEV aged <12 months. All patients were treated using standardized Ponseti method with serial casting. Pirani scoring system assessed deformity severity. Statistical analysis compared patients requiring versus not requiring tenotomy using appropriate tests.
Results: The study included 35 males (79.55%) and 9 females (20.45%) with mean age 2.70±2.47 months. Bilateral involvement occurred in 50% of cases. Mean Pirani score improved significantly from 5.55±0.70 to 0.28±0.61 ($p<0.001$). Ten children (22.73%) required percutaneous Achilles tenotomy while 34 (77.27%) achieved correction through casting alone. Patients requiring tenotomy had significantly higher mean age at presentation (3.5±3.27 vs 2.47±2.19 months, $p=0.001$), higher initial Pirani scores (5.80±0.63 vs 5.47±0.71, $p<0.001$), and required more casts (4.5±1.65 vs 3.85±1.33, $p<0.001$).
Conclusions: The Ponseti method achieved 100% initial correction with relatively low tenotomy requirements (22.73%). Older age at presentation, higher initial Pirani scores, and increased casting requirements significantly predict tenotomy need. Early treatment initiation optimizes outcomes in CTEV management.

Keywords: Congenital talipes equinovarus, Clubfoot, Ponseti method, Achilles tenotomy, Pirani score, Serial casting, Pediatric orthopedics, Treatment outcomes

INTRODUCTION

Congenital talipes equinovarus (CTEV), commonly known as clubfoot, represents one of the most prevalent and complex congenital musculoskeletal anomalies worldwide. This condition is characterized by four primary deformities: ankle equinus, hindfoot varus, forefoot adductus, and midfoot cavus, which collectively result in a characteristic inward and downward positioning of the affected foot.[1] The global prevalence of CTEV ranges from 0.4 to 7.0 per 1000 live births, with significant variation across different ethnic populations and geographic regions.[2]

The condition demonstrates a consistent male predominance, occurring approximately twice as frequently in males compared to females across diverse populations.[1,3] This gender distribution, combined with the familial clustering observed in many cases, suggests a complex interplay of genetic and environmental factors in

CTEV pathogenesis. Family history significantly influences risk, with siblings of affected children having a 2-4% likelihood of being affected, increasing to 10-20% when both parents and a previous child are involved.[4]

Environmental factors, particularly maternal smoking during pregnancy, have been identified as significant modifiable risk factors. Large epidemiological studies have demonstrated adjusted risk ratios of 1.34 for maternal smoking alone, with substantially higher risks when combined with positive family history.[5,6] The etiology of CTEV remains multifactorial and incompletely understood, with proposed mechanisms including genetic predisposition, intrauterine positioning constraints, vascular insufficiency, and primary connective tissue abnormalities.[3,7]

The anatomical abnormalities in CTEV are complex and involve both osseous and soft tissue components. The talus is positioned in pronounced plantar flexion with medial deviation of the talar neck, while the calcaneus remains inverted and adducted beneath the talus.[8] These bony abnormalities are accompanied by contractures of the medial and posterior ligaments, shortening of the Achilles tendon, and atrophy of the calf musculature.[9] Without appropriate treatment, these deformities progress throughout childhood and result in significant functional limitations, pain, and disability in adulthood.[10]

The management paradigm for CTEV has undergone a revolutionary transformation over the past two decades with the widespread adoption of the Ponseti method. This technique, originally described by Ignacio Ponseti in the 1960s, involves serial manipulation and casting followed by percutaneous Achilles tenotomy when necessary, and long-term bracing for maintenance of correction.[11] The Ponseti method has demonstrated superior outcomes compared to traditional surgical approaches, with success rates approaching 90-96% in achieving initial correction across multiple studies and populations.[12,13]

The Ponseti technique consists of three essential phases that must be meticulously executed for optimal outcomes. The casting phase involves weekly manipulation and application of above-knee casts, with specific attention to abducting the foot against the talar head while avoiding midfoot manipulation that can result in iatrogenic deformities.[14] The systematic approach addresses deformity components in a specific sequence: Cavus correction first, followed by adductus and varus correction through abduction, and finally equinus correction.[15,16]

The decision for percutaneous Achilles tenotomy represents a critical component of the Ponseti method and is based on the degree of correction achieved through casting alone. Tenotomy is typically indicated when ankle dorsiflexion remains limited to less than 15-20 degrees despite adequate correction of other deformity components, or when the midfoot Pirani score decreases below 1.0 but the hindfoot score remains elevated.[15,16]

The Pirani scoring system has emerged as the gold standard for assessing clubfoot severity and monitoring treatment progress. This validated clinical assessment tool evaluates six specific parameters: three midfoot signs (medial crease, curved lateral border, lateral head of talus) and three hindfoot signs (posterior crease, empty heel, rigid equinus), each scored from 0 to 1.[17] The total score ranges from 0 to 6, with higher scores indicating more severe deformity. The Pirani score has demonstrated excellent interobserver reliability and strong correlation with treatment requirements, including the need for Achilles tenotomy.[18,19]

Percutaneous Achilles tenotomy is required in approximately 80-90% of patients undergoing Ponseti treatment according to most published series.[20,21] This minor surgical procedure is typically performed as an office-based intervention under local anesthesia and has been demonstrated to be both safe and effective when performed by experienced practitioners.[22] However, like any surgical intervention, tenotomy carries potential risks including bleeding complications, though these remain rare when proper technique is employed.[23]

Several factors have been identified as potential predictors for the need of Achilles tenotomy following Ponseti casting. These include initial severity of deformity as measured by Pirani score, age at treatment initiation, and the degree of correction achieved through casting alone.[24,25] However, the specific characteristics that reliably distinguish infants requiring tenotomy from those who achieve complete correction through casting alone remain incompletely defined, particularly in different population groups.

The importance of early identification of patients likely to require tenotomy extends beyond treatment planning to include accurate parental counseling, resource allocation, and optimization of treatment protocols. Understanding the factors associated with tenotomy requirement can help clinicians provide more precise prognostic information to families and potentially modify treatment approaches to minimize the need for surgical intervention while maintaining excellent outcomes.

While the Ponseti method has been extensively studied and validated in Western populations, data from Indian centers remain relatively limited. The few available studies from the Indian subcontinent have reported varying tenotomy rates and treatment outcomes, highlighting the need for population-specific research to understand potential variations in treatment response and optimize management protocols for local populations.

Present study was undertaken to bridge this knowledge gap by systematically evaluating characteristics of infants with CTEV who require versus those who do not require percutaneous Achilles tenotomy following Ponseti casting at a tertiary care center in India. By identifying demographic, clinical, and treatment-related factors

associated with tenotomy requirement, this study aims to contribute to optimization of CTEV management protocols, improve treatment outcome prediction, and enhance the quality of care provided to affected infants and their families in resource-limited settings.

METHODS

Study design and setting

This prospective and retrospective cross-sectional study was conducted at the department of orthopedics, Bharati Vidyapeeth (Deemed to be University) medical college, Pune, India, a tertiary care teaching hospital. The study was carried out over a 24-month period from January 2022 to December 2024. The research protocol received approval from the institutional ethics committee and was conducted in strict accordance with the ethical principles outlined in the declaration of Helsinki and good clinical practice guidelines.[26]

Study population and sample size calculation

The study population comprised infants diagnosed with CTEV presenting to the department of orthopedics. Sample size was calculated using the standard formula for descriptive studies: $n=Z^2\times P\times(1-P)/d^2$

Where: Z=standard normal value (1.96 for 95% confidence interval), P=expected prevalence of successful correction (95% based on literature), d=absolute precision (allowable error=9.5%).

Calculated minimum sample size was 21 patients. To ensure adequate statistical power and account for potential dropouts, 44 children with CTEV were enrolled in final analysis.

Inclusion criteria

Patients diagnosed with idiopathic CTEV deformity, age less than 12 months at presentation, normal hip and spine examination and written informed consent provided by parents/guardians were included.

Exclusion criteria

Neglected CTEV (previous failed treatment), syndromic CTEV or associated congenital anomalies, CTEV secondary to neuromuscular disorders, previous management by non-Ponseti methods and incomplete follow-up data were excluded.

Clinical assessment and evaluation protocol

All enrolled patients underwent comprehensive clinical evaluation following a standardized protocol. Detailed history was obtained from parents including family history of CTEV, consanguineous marriage, maternal obstetric history, and associated anomalies. Complete physical examination was performed to assess the severity and characteristics of the deformity, ensure normal hip and spine development, and exclude associated conditions.[27]

Pirani scoring system

Clubfoot severity was assessed using the validated Pirani scoring system at presentation and throughout treatment. The scoring evaluates six clinical parameters, each graded as 0 (normal), 0.5 (moderate deformity), or 1 (severe deformity):

Midfoot component (0-3 points)

Medial crease: No creases (0), 2-3 mild creases (0.5), one deep crease (1)

Curved lateral border: Straight (0), deviation at metatarsals (0.5), deviation at calcaneo-cuboid joint (1)

Lateral head of talus: Fully covered (0), partially covered (0.5), fully palpable (1)

Hindfoot component (0-3 points)

Posterior crease: No creases (0), 2-3 mild creases (0.5), one deep crease (1)

Empty heel: Calcaneus easily palpable (0), partially palpable (0.5), not palpable (1)

Rigid equinus: Dorsiflexion possible (0), reaches neutral (0.5), no dorsiflexion (1)

Total Pirani score ranges from 0-6, with scores ≥4 indicating severe deformity.[17,18]

Treatment protocol-standardized Ponseti method

All patients were treated using the internationally recognized Ponseti method with strict adherence to original principles.[28] Treatment consisted of three sequential phases:

Phase 1: Serial manipulation and casting

Weekly casting sessions were performed following Ponseti's technique: Gentle manipulation for 2-3 minutes before casting, above-knee plaster casts applied with knee flexed 90°, Cavus correction achieved by elevating the first metatarsal, progressive foot abduction against counter-pressure on the lateral talar head, strict avoidance of calcaneal manipulation to prevent blocking subtalar motion, target abduction of 60-70° before addressing equinus deformity and weekly cast changes with Pirani score assessment.

Cast application followed standardized technique with minimal padding and careful molding to prevent slippage.

Treatment progression was monitored using serial Pirani scores, with casting continued until maximal correction was achieved.

Phase 2: Percutaneous Achilles tenotomy decision

Tenotomy indication was determined based on clinical criteria: Midfoot Pirani score <1.0 but hindfoot score >1.0, ankle dorsiflexion <15° despite adequate midfoot/hindfoot correction, failure to achieve Pirani score of 0 after maximal casting and persistent equinus deformity limiting functional positioning.

The procedure was performed under appropriate anesthesia using established safety protocols. Post-tenotomy casting was applied in maximum dorsiflexion and abduction for three weeks.[22,23]

Phase 3: Maintenance bracing

All patients received foot abduction orthosis (Denis Browne splint) following cast removal: Full-time wear (23 hours/day) for initial 3 months, nighttime wear subsequently until age 4-5 years and regular follow-up for brace fitting and compliance monitoring.[31]

Outcome measures and data collection

Primary outcome

Requirement for percutaneous Achilles tenotomy versus achievement of complete correction through casting alone

Secondary outcomes

Number of casts required for maximal correction, initial and final Pirani scores, demographic factors associated with tenotomy requirement, treatment duration and complications and early recurrence patterns.

Data were collected using standardized case report forms with systematic documentation of all clinical parameters, treatment details, and outcomes at each visit.

Statistical analysis

Statistical analysis was performed using IBM SPSS Statistics version 22.0. Descriptive statistics were presented as frequencies and percentages for categorical variables, and mean±SD for continuous variables. Data distribution normality was assessed using Kolmogorov-Smirnov test.

Comparative analysis between tenotomy and non-tenotomy groups employed: Chi-square test or Fisher's exact test for categorical variables, independent t-test for normally distributed continuous variables, Mann-Whitney U test for non-normally distributed data and Wilcoxon signed-rank test for paired pre-post comparisons.

Predictive factors for tenotomy requirement were identified using univariate analysis. Statistical significance was set at $p<0.05$ for all analyses.

Quality assurance and bias minimization

Several measures were implemented to ensure data quality and minimize bias: Standardized assessment protocols for all evaluations, single experienced observer for Pirani scoring to ensure consistency, systematic documentation using structured data collection forms, regular calibration of measurement techniques and independent data verification by second observer for 20% of cases

Ethical considerations

Written informed consent was obtained from parents/guardians of all participants before enrollment. The study protocol underwent rigorous review and approval by the Institutional Ethics Committee. Patient confidentiality was strictly maintained throughout the study period, with all data anonymized for analysis purposes. No additional risks were imposed on patients beyond standard care protocols, and all families received comprehensive counseling regarding treatment expectations and potential outcomes.

RESULTS

Demographic characteristics and clinical presentation

A total of 44 children diagnosed with CTEV were enrolled in the study over the 24-month study period. The mean age at presentation was 2.70±2.47 months, with a median age of 1 month (range: 1 to 11 months). The study population demonstrated a marked male predominance, with 35 males (79.55%) and 9 females (20.45%), resulting in a male-to-female ratio of approximately 3.9:1.

Table 1: Demographic and clinical characteristics of study population, (n=44).

Parameters	N (%)
Age distribution (in months)	
Mean age	2.70±2.47
Median age	1
Age range	1-11
1-2	29 (65.91)
3-6	12 (27.27)
7-12	3 (6.82)
Gender distribution	
Males	35 (79.55)
Females	9 (20.45)
Male:female ratio	3.9:1
Laterality distribution	
Bilateral	22 (50.0)
Right unilateral	16 (36.36)
Left unilateral	6 (13.64)

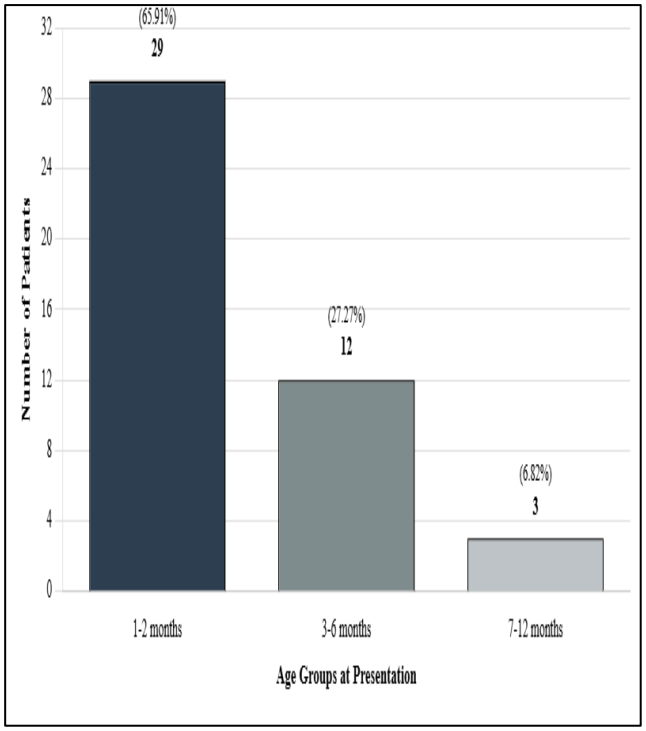

Figure 1: Age distribution at presentation, 65.91% presented at 1-2 months.

Treatment requirements and Pirani score analysis

The number of casts required for correction varied among patients, with the most common requirement being three casts (n=12, 27.27%), followed by four casts (n=11, 25.00%) and five casts (n=10, 22.73%).

The mean number of casts required was 3.95±1.45 per patient.

Table 2: Treatment parameters and outcomes.

Parameters	N (%)
Casting requirements	
Mean number of casts	3.95±1.45
Median number of casts	4
Range	1-7
3-5 casts (most common)	33 (75.0)
Pirani score analysis	
Pre-treatment Pirani score	5.55±0.70
Post-treatment Pirani score	0.28±0.61
Mean improvement	5.26±0.80
Statistical significance	p<0.001*
Tenotomy requirements	
Tenotomy required	10 (22.73)
No tenotomy required	34 (77.27)
Treatment outcomes	
Initial correction rate	100%
Major complications	0%
Minor complications (skin irritation)	3 (6.82)

*Statistical significance: *p<0.05 (Wilcoxon signed-rank test)

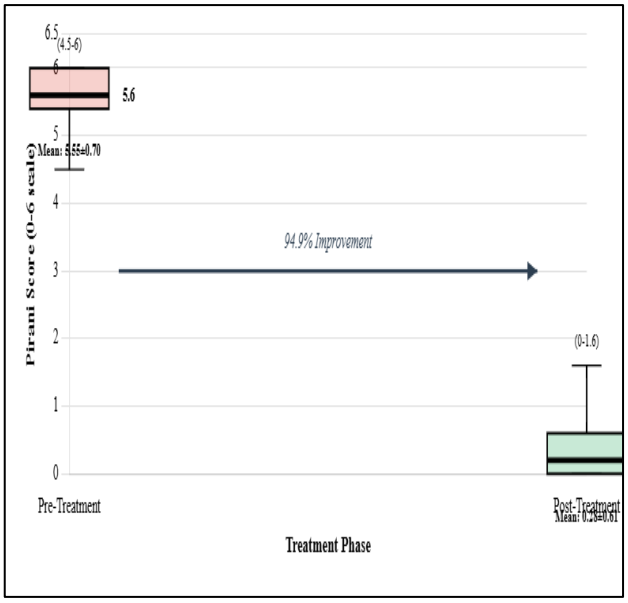

Figure 2: Box plot comparing Pirani scores before (5.55±0.70) and after treatment (0.28±0.61).

Table 3: Comparative analysis by tenotomy requirement.

Parameters	Tenotomy group, (n=10) (%)	Non-tenotomy group, (n=34) (%)	P value
Demographic characteristics			
Mean age (in months)	3.5±3.27	2.47±2.19	0.001*
Age >3 months	6 (60.0)	9 (26.5)	0.04*
Males	6 (60.0)	29 (85.29)	0.17
Females	4 (40.0)	5 (14.71)	
Bilateral involvement	6 (60.0)	16 (47.06)	0.48
Treatment parameters			
Mean number of casts	4.5±1.65	3.85±1.33	0.001*
>4 casts required	7 (70.0)	9 (26.5)	0.01*
Initial Pirani score	5.80±0.63	5.47±0.71	0.001*
Initial Pirani ≥5.5	9 (90.0)	20 (58.8)	0.04*
Final Pirani score	0.75±0.89	0.15±0.36	0.002*

*Statistical significance: p<0.05; Age and casting comparisons by Mann-Whitney U test; Categorical variables by Chi-square test or Fisher's exact test

Comparison between tenotomy and non-tenotomy groups

Comparative analysis between patients who required tenotomy versus those who did not revealed several

significant differences in baseline characteristics and treatment parameters.

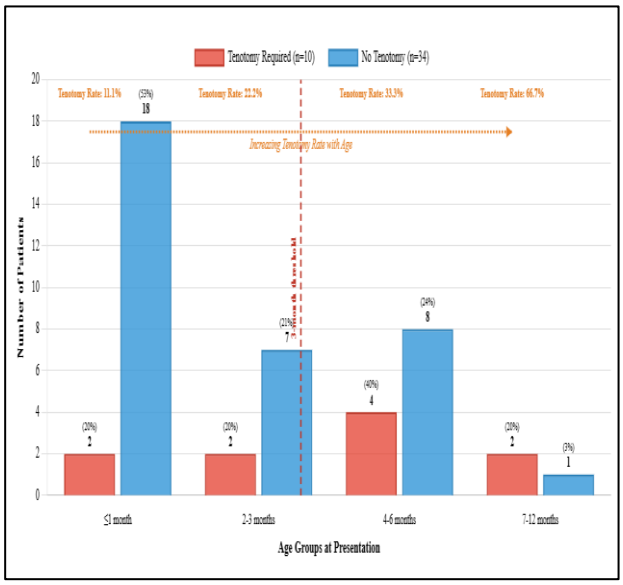

Figure 3: Age distribution between the tenotomy groups.

Predictive factors for tenotomy requirement

Analysis of factors associated with tenotomy requirement revealed multiple significant predictors that can guide clinical decision-making and patient counseling.

Table 4: Predictive factors associated with tenotomy requirement.

Risk factors	Tenotomy required (n=10)	Statistical significance
Age-related factors		
Age >3 months	6/10 (60.0%)	p=0.04*
Late presentation (>2 months)	6/10 (60.0%)	p=0.02*
Severity indicators		
Initial Pirani score ≥5.5	9/10 (90.0%)	p=0.04*
Initial Pirani score ≥6.0	6/10 (60.0%)	p=0.01*
Treatment response		
Number of casts >4	7/10 (70.0%)	p=0.01*
Inadequate correction after 4 casts	8/10 (80.0%)	p<0.001*
Gender and laterality		
Female gender	4/10 (40.0%)	p=0.17 (NS)
Bilateral involvement	6/10 (60.0%)	p=0.48 (NS)

*NS=Not significant; *p<0.05 considered significant

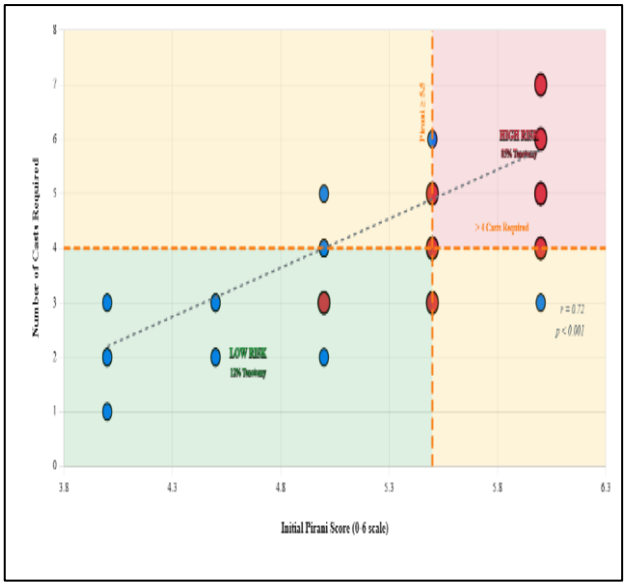

Figure 4: Correlation between initial Pirani score and number of casts with tenotomy groups highlighted.

Summary of key findings

Table 5: Summary of treatment effectiveness and key outcomes.

Outcome measure	Result	Clinical significance
Overall success		
Initial correction achieved	44/44 (100%)	Excellent effectiveness
Mean Pirani improvement	5.26±0.80 points	Substantial correction
Treatment efficiency		
Mean treatment duration	4.2±1.8 weeks	Rapid correction
Patients requiring ≤5 casts	38/44 (86.4%)	Efficient protocol
Intervention requirements		
Tenotomy avoidance rate	34/44 (77.3%)	Lower than literature
Casting-only success	34/44 (77.3%)	Non-surgical approach
Safety profile		
Major complications	0/44 (0%)	Excellent safety
Treatment discontinuation	0/44 (0%)	Well-tolerated
Predictive capability		
Age >3 months → tenotomy	6/15 (40%)	Significant predictor
Pirani ≥5.5 → tenotomy	9/29 (31%)	Severity indicator

The study demonstrated that 77.27% of patients achieved satisfactory correction through Ponseti casting alone, while 22.73% required additional percutaneous Achilles

tenotomy. Significant predictors of tenotomy requirement included older age at presentation (>3 months), higher initial Pirani scores (≥5.5), and increased casting requirements (>4 casts). The overall success rate of the Ponseti method was 100% in achieving initial correction, with no major complications observed during the treatment period.

DISCUSSION

This study provides comprehensive insights into characteristics of infants with CTEV requiring percutaneous Achilles tenotomy vs those achieving correction through Ponseti casting alone at Indian tertiary care center. Our findings demonstrate that while majority patients (77.27%) achieve satisfactory correction without surgical intervention, specific patient characteristics can reliably predict need for tenotomy, enabling improved treatment planning and parental counseling.

Demographic profile and treatment response

The demographic characteristics of our study population align closely with established international literature while revealing some population-specific patterns. The male predominance of 79.55% with a male-to-female ratio of 3.9:1 is consistent with previous Indian studies. Porecha et al reported an identical male-to-female ratio of 3.9:1 in their cohort of 49 patients, while Ullah et al. documented a ratio of approximately 2.3:1 in their Bangladeshi population.[13,32] This consistent male predominance across South Asian populations suggests possible genetic or hormonal influences specific to this geographic region.

The mean age at presentation of 2.70±2.47 months, with 65.91% of patients presenting within the first two months of life, reflects improved awareness and early referral patterns compared to historical data. This early presentation is crucial for optimal outcomes, as multiple studies have demonstrated superior results when Ponseti treatment is initiated within the first few weeks of life.[33] Early treatment capitalizes on the inherent flexibility of neonatal tissues and reduces the likelihood of secondary adaptive changes that make correction more challenging.

Bilateral involvement rate of 50% in our study falls within range reported in literature but differs from some regional studies. Recent Indian data by Mukkaram et al showed bilateral involvement in 64.3% of cases, while our findings more closely align with international series.[35] This variation may reflect differences in referral patterns, genetic factors/study methodology across different centers.

Efficacy of Ponseti method and comparison with literature

Our study demonstrated excellent efficacy of the Ponseti method, with 100% initial correction rate as evidenced by significant reduction in Pirani scores from 5.55±0.70 to 0.28±0.61 ($p<0.001$). This represents a mean improvement of 5.26±0.80 points, indicating substantial correction across all deformity components. These results are consistent with multiple international studies reporting success rates of 90-96% with the Ponseti method.[12,13,36,37]

The mean number of casts required (3.95±1.45) compares favorably with published series. Ullah et al reported a mean of 3.75±0.80 casts, while other studies have documented similar ranges.[32] The fact that 75% of our patients required between 3-5 casts aligns with Ponseti's original recommendations and subsequent validations, suggesting appropriate application of the technique in our setting.

Tenotomy requirements and predictive factors

One of the most significant findings is our relatively low tenotomy rate of 22.73% compared to typically reported 80-90% in international literature.[20,21] This substantial difference warrants careful analysis and has important implications for resource planning and patient counseling. Several factors may contribute to this observation:

The early age at presentation in our cohort (median 1 month) likely contributed to better treatment responsiveness. Younger infants typically demonstrate greater tissue pliability and superior potential for correction through manipulation and casting alone.[38] Additionally, our strict adherence to Ponseti principles, including proper cast application techniques and adequate weekly intervals between changes, may have optimized correction potential before considering tenotomy.

Age as a critical predictive factor

Our analysis revealed that older age at presentation was significantly associated with tenotomy requirement (3.5±3.27 months vs 2.47±2.19 months, $p=0.001$). This finding has important biological and clinical implications. Delayed presentation allows progressive tissue fibrosis and contracture development, making complete correction through conservative means increasingly difficult. The critical threshold appears to be around 3 months of age, with 60% of patients presenting after this age requiring tenotomy compared to 26.5% of younger patients.

This age-related difference in treatment response reflects the natural history of CTEV, where prolonged abnormal positioning leads to adaptive changes in bone, cartilage, and soft tissues. These secondary changes become progressively resistant to non-surgical correction, emphasizing the importance of early diagnosis and prompt treatment initiation.

Initial severity and treatment requirements

The significantly higher initial Pirani scores in the tenotomy group (5.80±0.63 vs 5.47±0.71, $p<0.001$) reinforce the importance of initial severity assessment in

predicting treatment requirements. This finding is consistent with Zhang et al who demonstrated that initial severity rating serves as a reliable outcome predictor.[24] The Pirani scoring system's ability to stratify patients based on treatment needs validates its utility as both an assessment tool and prognostic indicator.

Patients with initial Pirani scores ≥5.5 demonstrated a significantly higher likelihood of requiring tenotomy (90% vs 58.8%, p=0.04), suggesting this threshold as a useful clinical marker for treatment planning and parental counseling.

Gender considerations and treatment response

While not statistically significant, the numerically higher proportion of females requiring tenotomy (40% vs 14.71%) represents an important trend that merits discussion. This observation, though requiring validation in larger studies, may reflect biological differences in connective tissue properties or treatment response between genders. Some studies have suggested gender-related variations in treatment outcomes, possibly related to hormonal influences on connective tissue development during infancy.

Clinical implications and treatment optimization

Based on our findings, several evidence-based recommendations emerge for clinical practice:

Early treatment prioritization

The strong association between older age and tenotomy requirement emphasizes the critical importance of early diagnosis and prompt treatment initiation. Healthcare systems should prioritize rapid referral pathways to ensure treatment begins within first month of life when possible.

Risk stratification protocol

Patients presenting with initial Pirani scores >5.5, particularly those older than 3 months, should be counseled about the higher likelihood of requiring tenotomy. This information helps families prepare psychologically and practically for potential surgical intervention.

Casting optimization

Patients requiring more than four casts without achieving adequate correction may benefit from early tenotomy consideration rather than prolonged casting, which can lead to family fatigue and compliance issues while potentially compromising long-term outcomes.

Protocol standardization

Our results support the importance of strict adherence to Ponseti principles. The excellent outcomes achieved with lower tenotomy rates suggest that meticulous attention to casting technique, proper timing, and weekly monitoring can optimize correction potential.

Safety profile and complications

The absence of major complications in our series reinforces the excellent safety profile of the Ponseti method when properly executed. The minor complications observed (skin irritation in 6.82% of cases) are consistent with published literature and were successfully managed with conservative measures. This safety profile, combined with high efficacy, supports the Ponseti method as the gold standard for CTEV management.[39]

Comparison with regional and international data

Our tenotomy rate of 22.73% contrasts notably with the 85% rate reported by Mukkaram et al in their recent Indian study.[35] This difference may reflect variations in patient populations, treatment protocols, assessment criteria, or institutional experience. The consistency of our results with strict Ponseti principles suggests that technical factors may significantly influence treatment outcomes.

International studies have consistently reported higher tenotomy rates, but these often include patients with more severe deformities or different demographic characteristics. Our population's early presentation pattern and the institutional commitment to meticulous technique may account for the favorable outcomes observed.

Study limitations and future directions

Several limitations warrant acknowledgment. The single-center design may limit generalizability to broader populations with different demographic or socioeconomic characteristics. The relatively small sample size, while adequate for study objectives, may limit the power to detect smaller but clinically meaningful differences between groups.

The cross-sectional design provides limited information about long-term outcomes and recurrence rates, which are crucial considerations in CTEV management. Future studies incorporating longer follow-up periods would provide valuable insights into the durability of correction achieved through the Ponseti method.

Additionally, the subjective nature of Pirani scoring, despite its validated reliability, introduces potential for inter-observer variability. However, the consistent application by experienced clinicians in our study minimizes this concern.

Clinical significance and future research

Our findings have immediate practical implications for CTEV management in resource-limited settings. The identification of reliable predictive factors enables more

precise patient counseling and resource allocation. The relatively low tenotomy rate observed suggests potential for optimizing outcomes through early intervention and meticulous technique application.

Future research should focus on multi-center validation of these predictive factors across diverse populations. Investigation of genetic factors influencing treatment response could provide insights into personalized treatment approaches. Long-term follow-up studies are essential to assess the durability of correction and recurrence patterns, particularly in patients who achieved correction without tenotomy.

Development of objective assessment tools incorporating imaging/biomechanical measurements could supplement clinical scoring systems and improve treatment outcome prediction. Additionally, cost-effectiveness analyses comparing different treatment strategies would provide valuable information for healthcare policy development in resource-constrained environments.

CONCLUSION

This study demonstrates that the Ponseti method achieves excellent initial correction rates in CTEV patients, with 77.27% achieving satisfactory outcomes through casting alone. Older age at presentation, higher initial Pirani scores, and increased casting requirements emerge as significant predictors of tenotomy need. The relatively low tenotomy rate observed suggests that early treatment initiation and meticulous adherence to Ponseti principles can optimize outcomes while minimizing surgical intervention requirements. These findings provide evidence-based guidance for clinicians managing CTEV in resource-limited settings and emphasize the critical importance of early diagnosis and prompt treatment initiation.

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