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Clinical and Ultrasonographic Outcomes of Percutaneous Achilles Tenotomy Using an 18-Gauge Needle in Idiopathic Clubfoot: A Prospective Study

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Learning Point of the Article:

Percutaneous Achilles tenotomy using an 18-gauge needle is a safe, cost-effective, and minimally invasive technique that achieves excellent clinical correction and complete ultrasonographic tendon healing in children with idiopathic clubfoot.

Abstract

Introduction: Percutaneous Achilles tenotomy is a critical step in the Ponseti method for correcting residual equinus deformity in idiopathic clubfoot. Needle tenotomy has emerged as a minimally invasive alternative to conventional scalpel-based tenotomy, offering potential advantages in safety, procedural cost, and ease of performance. Prospective combined clinical and ultrasonographic evidence evaluating this technique from Indian centers remains limited.

Objective: The aim of the study was to evaluate the clinical and ultrasonographic outcomes of percutaneous Achilles tenotomy using an 18-gauge needle in children with idiopathic clubfoot managed by the Ponseti method.

Materials and Methods: This prospective study included 45 children (76 ft) with idiopathic congenital talipes equinovarus. Serial Ponseti casting was performed until residual equinus was the only deformity remaining, after which percutaneous Achilles tenotomy was performed using an 18-gauge needle under general anesthesia. Patients were evaluated preoperatively and at 3 weeks, 2 months, 6 months, and 1 year using the Pirani score, passive dorsiflexion angle at the ankle, and foot bimalleolar angle on podogram. Ultrasonography was performed at the 3-week follow-up to assess tendoachilles healing.

Results: The mean age at tenotomy was 7.3 ± 2.76 months, with male predominance (71.11%) and bilateral involvement in 68.89% of cases. On ultrasonography at 3 weeks, 14 of 76 ft (18.42%) showed a tendon defect, and 9 of 76 ft (11.84%) showed peri-tendinous collections; both abnormalities resolved by the 2-month follow-up. The mean Pirani score improved significantly from 2.11 ± 0.40 preoperatively to 0 at 1 year ($t = 42.93$, $df = 66$, $P < 0.05$). The mean passive dorsiflexion angle improved from 128.74° ± 12.04° to 76.21° ± 2.15° (mean difference 52.53° ± 11.57°; $t = 36.90$, $df = 65$, $P < 0.05$), and the mean foot bimalleolar angle improved from 70.09° ± 2.70° to 81.74° ± 1.58° ($t = -48.96$, $df = 65$, $P < 0.05$). Forty patients (88.90%) maintained correction without additional surgery; four patients (8.88%) required posteromedial soft-tissue release, and one patient (2.22%) required unilateral tendoachilles lengthening.

Conclusion: Percutaneous Achilles tenotomy using an 18-gauge needle is a safe, effective, and minimally invasive technique for correcting residual equinus in idiopathic clubfoot. The procedure yields favorable clinical correction, satisfactory ultrasonographic tendon healing, and a low rate of secondary surgical intervention.

Keywords: Clubfoot, congenital talipes equinovarus, ponseti method, needle tenotomy, achilles tenotomy, ultrasonography, pirani score.

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Introduction

Idiopathic congenital talipes equinovarus (CTEV), commonly known as clubfoot, is one of the most prevalent congenital musculoskeletal deformities, occurring in approximately 1 in 1,000 live births worldwide [1]. The deformity is characterized by four cardinal components – cavus (high-arched foot), adduction (medial deviation of the forefoot), varus (hindfoot inversion), and equinus (plantarflexion) – and when left untreated, results in significant functional disability and gait impairment [1,2].

The Ponseti method of serial manipulation and casting has become the globally accepted standard of care for idiopathic clubfoot, achieving correction through gentle, biomechanically sound manipulation that exploits the plasticity of neonatal connective tissue and cartilaginous tarsal bones while minimizing the need for extensive soft-tissue surgery [2]. Despite successful correction of cavus, adduction, and varus by serial casting, residual equinus persists in approximately 80–90% of cases and requires Achilles tenotomy to achieve a plantigrade foot [2,3].

Ponseti originally performed tenotomy using an ophthalmic scalpel; subsequent surgeons adopted the No. 15 blade with satisfactory results [2]. However, percutaneous scalpel tenotomy carries a risk of hemorrhagic and neurovascular complications arising from posterior tibial vessel variations [4, 5]. In response, several alternative techniques have been described: Mini-open tenotomy under direct visualization [6], botulinum toxin injection to the triceps surae [7], keratome-based tenotomy [8], and percutaneous needle tenotomy [3].

The concept of large-gauge needle tenotomy was introduced by Minkowitz et al. in 2004, who used a precision-glide needle as a safe, cost-effective, office-based alternative to blade tenotomy [3]. The needle technique employs the beveled tip in a controlled sawing motion to divide tendon fibers with minimal collateral soft-tissue trauma. A subsequent systematic review by Dhingra et al. demonstrated a pooled success rate of 95% across 1,026 ft with a complication rate of 0.04% [9]. Despite this evidence, prospective studies combining serial clinical assessment with ultrasonographic documentation of tendon healing remain relatively scarce, particularly from resource-limited settings [10,11].

Although percutaneous Achilles tenotomy using a surgical blade is conventionally performed as an outpatient procedure with satisfactory outcomes, concerns regarding bleeding, inadvertent neurovascular injury, and soft-tissue trauma still persist, particularly in infants with small anatomical dimensions and vascular variations. The use of an 18-gauge needle has been proposed as a minimally invasive and potentially safer alternative because the beveled needle tip permits controlled division of tendon fibers with minimal collateral tissue injury, reduced bleeding risk, and lower procedural cost without requiring specialized surgical instruments or operating-room setup. Furthermore, prospective data correlating clinical outcomes with serial ultrasonographic assessment of tendon healing remain limited. The present study was therefore undertaken to prospectively evaluate the clinical effectiveness, procedural safety, and ultrasonographic healing outcomes of percutaneous Achilles tenotomy using an 18-gauge needle in idiopathic clubfoot managed by the Ponseti method.

Materials and Methods

Study design and setting

This prospective single-arm interventional study was conducted at the Department of Orthopaedics, N.S.C.B. Medical College and Hospital, Jabalpur, Madhya Pradesh, India, from July 15, 2021, to June 30, 2024. Institutional ethics committee approval was obtained before initiation, and written informed consent was taken from the parent or guardian of each participant.

Sample size

The sample size was calculated using the formula $n = z^2s^2 / d^2$, where z = 1.96 (95% confidence level [CI], $\alpha = 0.05$), s = standard deviation (SD) of total Pirani score (0.85) [12], and d = 5% relative error (mean = 5.12), yielding a minimum required sample of 45 children.

Eligibility criteria

Inclusion criteria

Children aged up to 5 years with unilateral or bilateral idiopathic clubfoot who had undergone serial Ponseti casting until residual equinus remained as the only deformity.

Exclusion criteria

Children with neurogenic clubfoot, myelomeningocele, distal arthrogryposis, or

acquired clubfoot.

Pre-operative assessment

All children presenting to the CTEV clinic underwent clinical assessment and Pirani scoring [13]. Serial Ponseti casting was performed at weekly intervals [2]. When residual equinus was the only remaining deformity, pre-anesthetic fitness was obtained, and the child was admitted for tenotomy. Preoperatively, the angle of passive dorsiflexion at the ankle was measured and video-recorded, and the foot bimalleolar angle was measured from a podogram.

Surgical technique

Table 1: Baseline characteristics and post-operative outcomes of study participants (n=45 children, 76 ft)

Variable	Category	Number	Percentage
Age group	≤5 months	15	33.33
	6–11 months	28	62.22
	≥12 months	2	4.44
Sex	Male	32	71.11
	Female	13	28.89
Side involvement	Bilateral	31	68.89
	Right	8	17.78
	Left	6	13.33
Mode of delivery	Normal vaginal	33	73.34
	Cesarean section	12	26.66
Post-operative management/outcome	Additional 1-week overcorrection cast	13	28.88
	Direct Steenbeck's brace application	32	71.11
	No further surgery required	40	88.9
	Posteromedial soft-tissue release	4	8.88
	Unilateral tendoachilles lengthening	1	2.22

All procedures were performed under general anesthesia with the child supine, knee flexed to 90°, and the foot held in forced plantarflexion. The tendoachilles was palpated and marked. An 18-gauge needle (Dispo-van) was inserted from the medial to the lateral aspect of the tendon [3, 14]. Using the beveled tip in a controlled swinging (sawing) motion, the tendon was divided until a characteristic snap was felt, and passive dorsiflexion improved to the desired angle. A Plaster of Paris cast in overcorrection was applied for 3 weeks following tenotomy [2].

Post-operative management and follow-up

At the 3-week follow-up, the cast was removed, and Pirani score, passive dorsiflexion angle, and foot bimalleolar angle were reassessed. Ultrasonography of the tendoachilles was performed using an ALPINION E-CUBE-7 machine with a high-frequency linear probe (7.5–10 MHz) to evaluate tendon healing, tendon defect, and peri-tendinous collections [10, 11]. Patients with inadequate correction at 3 weeks received an additional 1-week overcorrection cast before brace application. All other patients were fitted with Steenbeck's foot abduction brace. Parents were instructed in brace wear (23 h/day until the child began walking, followed by night-time wear until

4–5 years of age) and home physiotherapy exercises, including dorsiflexion stretching and external rotation [2]. Subsequent follow-up visits were scheduled at 2 months, 6 months, and 1 year.

Outcome measures

Primary clinical outcome measures were the Pirani score (range 0–6; 0 = complete correction) [13], passive dorsiflexion angle at the ankle (in degrees; smaller angle indicates greater dorsiflexion), and foot bimalleolar angle on podogram (normal ≥75°). The primary ultrasonographic outcome was assessment of tendoachilles continuity, tendon defect, and peri-tendinous collections at 3 weeks. Secondary outcomes were the need for additional casting at first follow-up, relapse rate, and requirement for further surgery (posteromedial soft-tissue release [PMSTR] or tendoachilles lengthening).

Statistical analysis

Data were entered into Microsoft Excel and analyzed using IBM Statistical Package for the Social Sciences version 23.0. Continuous variables were reported as mean ± SD and categorical variables as frequencies and percentages. The paired t-test was used to compare pre-operative and final follow-up values of continuous outcomes. A $P < 0.05$ was considered statistically significant.

Results

A total of 45 children with idiopathic clubfoot involving 76 ft were enrolled and followed for a minimum of 1 year. All patients completed the full follow-up schedule.

Demographic and baseline characteristics

The mean age at tenotomy was 7.3 ± 2.76 months. The majority underwent tenotomy in the 6–11 month age group (28 children, 62.22%), followed by the ≤5 months group (15 children, 33.33%), and ≥12 months group (2 children, 4.44%). Male predominance was noted (32 males, 71.11%; 13 females,

Table 2: Clinical and ultrasonographic outcomes following percutaneous achilles tenotomy

Follow-up point	Mean pirani score (±SD)	Mean passive dorsiflexion angle (°)±SD	Mean foot bimalleolar angle (°)±SD
Pre-operative	2.11±0.40	128.74±12.04	70.09±2.70
3 weeks	0.17±0.24	85.23±6.57	73.74±2.00
2 months	0.068±0.173	82.42±2.21	78.62±1.63
6 months	0.023±0.104	77.22±3.21	79.92±1.13
1 year	0	76.21±2.15	81.74±1.58
Ultrasonographic findings at 3-week follow-up (n=76 ft)			
Ultrasonographic finding	**Number of feet**	**Percentage**	**Ultrasonographic finding**
Normal study	53	69.74	Normal study
Defect in tendoachilles	14	18.42	Defect in tendoachilles
Peri-tendinous collections	9	11.84	Peri-tendinous collections
SD: Standard deviation			

28.89%). Bilateral involvement was present in 31 children (68.89%), right-sided in 8 (17.78%), and left-sided in 6 (13.33%). Thirty-three children (73.34%) were born by normal vaginal delivery and 12 (26.66%) by cesarean section (Table 1).

Ultrasonographic findings at 3 weeks

All 76 ft were evaluated by ultrasonography at 3 weeks [10, 11]. Fifty-three feet (69.74%) showed a normal study. Fourteen feet (18.42%) demonstrated a defect in the tendoachilles, and 9 ft (11.84%) showed peri-tendinous collections. All abnormalities had fully resolved by the 2-month follow-up, consistent with expected early tendon healing and remodeling after tenotomy [15, 16]. These findings are presented in Table 2.

Pirani score

The mean Pirani score was 2.11 ± 0.40 preoperatively and decreased progressively: 0.17 ± 0.24 at 3 weeks, 0.068 ± 0.173 at 2 months, 0.023 ± 0.104 at 6 months, and 0.00 at 1 year. The paired t-test demonstrated a statistically significant difference between pre-operative and 1-year values ($t = 42.93$, $df = 66$, $P < 0.05$, 95% CI). These results are presented in Table 1.

Passive dorsiflexion angle at the ankle

The mean passive dorsiflexion angle was 128.74° ± 12.04° preoperatively, reflecting significant equinus deformity. Progressive improvement was observed post-tenotomy: 85.23° ± 6.57° at 3 weeks, 82.42° ± 2.21° at 2 months, 77.22° ± 3.21° at 6 months, and 76.21° ± 2.15° at 1 year. The mean improvement from pre-operative to 1 year was 52.53° ± 11.57° ($t = 36.90$, $df = 65$, $P < 0.05$). A smaller angle in this convention indicates greater ankle dorsiflexion (better correction). Results are presented in Table 1.

Foot bimalleolar angle

The mean foot bimalleolar angle was 70.09° ± 2.70° preoperatively, below the normal threshold of 75°. Progressive improvement was documented: 73.74° ± 2.00° at 3 weeks, 78.62° ± 1.63° at 2 months, 79.92° ± 1.13° at 6 months, and 81.74° ± 1.58° at 1 year. The mean difference between pre-operative and 1-year values was −11.65° ± 1.93° ($t = -48.96$, $df = 65$, $P < 0.05$). Results are presented in Table 1.

Post-operative casting, bracing, and surgical outcomes

At the 3-week follow-up, 13 patients (28.88%) required an additional 1-week overcorrection cast before brace application, while 32 patients (71.11%) were directly fitted with Steenbeck's brace. During follow-up, five patients developed relapse: Four (8.88%) required PMSTR, and one (2.22%) required unilateral tendoachilles lengthening. Forty patients (88.90%) maintained correction without any further surgical

Clinical Message

Percutaneous Achilles tenotomy using an 18-gauge needle is a safe, effective, and cost-efficient alternative to traditional scalpel-based methods for correcting residual equinus in idiopathic clubfoot. Clinical outcomes demonstrate significant improvements in Pirani scores and ankle dorsiflexion, with ultrasonographic evidence confirming that initial tendon defects and peri-tendinous collections typically resolve completely within 2 months. The technique's low reintervention rate and minimal risk of neurovascular complications make it an ideal choice for high-volume or resource-limited orthopedic settings. Furthermore, because secondary surgical interventions were primarily required in older infants, the study reinforces the importance of early intervention and strict adherence to post-procedure bracing protocols.

Declaration of patient consent: The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given the consent for his/ her images and other clinical information to be reported in the journal. The patient understands that his/ her names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Conflict of interest: Nil **Source of support:** None

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