



THE ROLE OF ACHILLES TENOTOMY IN CLUBFOOT CORRECTION

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ABSTRACT

Background: Achilles tenotomy represents the cornerstone of equinus correction within the Ponseti method for congenital talipes equinovarus (clubfoot) and is essential for achieving adequate ankle dorsiflexion and forefoot abduction. **Objective:** To evaluate the effectiveness, safety, and clinical outcomes of Achilles tenotomy in the management of infants with congenital clubfoot at a tertiary center. **Methods:** A prospective clinical study was conducted on 50 infants with congenital clubfoot treated according to the Ponseti protocol followed by percutaneous Achilles tenotomy. Demographic, etiological, and laterality data were recorded and outcomes were categorized as complete, near-complete, or residual deformity. **Results:** Complete correction was achieved in 39 patients (78%), near-complete correction in 7 patients (14%), and residual deformity in 4 patients (8%). Syndromic etiology was significantly associated with a higher rate of non-complete outcomes compared with idiopathic clubfoot. **Conclusion:** Achilles tenotomy is a safe, minimally invasive, and highly effective procedure for achieving optimal correction in congenital clubfoot, particularly in idiopathic cases.

KEYWORDS: clubfoot, Achilles tenotomy, Ponseti method, pediatric orthopedics

INTRODUCTION

Congenital talipes equinovarus (clubfoot) is one of the most common congenital musculoskeletal deformities worldwide. It is characterized by a complex three-dimensional deformity consisting of equinus, hindfoot varus, forefoot adduction, and cavus, which together result in a non-plantigrade, inward-pointing foot.^[1]

The global incidence of clubfoot is estimated at approximately 1–2 per 1,000 live births, with considerable geographic, ethnic, and socioeconomic variation. A clear male predominance has been reported in most epidemiological series, with male-to-female ratios approaching 2:1.^[2]

In low- and middle-income countries, delayed diagnosis and limited access to trained orthopedic services still contribute significantly to the burden of disability associated with untreated or inadequately treated clubfoot.^[3]

If clubfoot is not appropriately treated in early life, the deformity progresses to rigid abnormal gait, painful callosities, difficulty with footwear, and profound functional impairment extending into adulthood.^[2,4]

Historically, extensive posteromedial soft-tissue release and other major reconstructive operations constituted the standard of care for severe or relapsed clubfoot. Although these procedures succeeded in correcting deformity in the short term, long-term follow-up studies showed high rates of stiffness, weakness, scarring, and early degenerative joint changes.^[5,6]

The limitations of extensive surgery stimulated the search for more biologically conservative treatment strategies, ultimately leading to the development and widespread adoption of the Ponseti method.^[7,8]

The Ponseti technique is based on gentle, anatomically guided manipulation and serial casting to gradually correct the deformity in a defined sequence. Cavus is corrected first by aligning the forefoot with the hindfoot,

followed by abduction of the foot around the talus to correct adduction and varus, and finally equinus at the ankle.^[9]

Residual equinus deformity persists in the majority of infants after serial casting and represents the most resistant component of the deformity. For this reason, percutaneous Achilles tenotomy is required in approximately 70–95% of patients treated with the Ponseti method.^[10]

Achilles tenotomy is typically performed as a brief, minimally invasive procedure under local or general anesthesia. A small stab incision is used to transect the tendon, followed by immobilization in a long-leg cast with the foot in maximum dorsiflexion and abduction. Rapid tendon healing and remodeling are observed during the subsequent weeks of casting.^[10,11]

Imaging studies and long-term clinical series have demonstrated that percutaneous Achilles tenotomy is associated with reliable tendon continuity, restoration of ankle dorsiflexion, and excellent functional outcomes, without increased risk of weakness or loss of push-off power.^[5,10]

While outcomes of idiopathic clubfoot treated by the Ponseti method are consistently excellent across multiple cohorts, syndromic and neuromuscular clubfeet remain much more challenging. These deformities are often more rigid, associated with underlying neuromuscular imbalance or connective tissue disorders, and demonstrate higher rates of residual deformity and recurrence.^[11–12]

The long-term socioeconomic impact of untreated or inadequately treated clubfoot is profound, particularly in resource-limited settings. Affected individuals may face reduced educational opportunities, occupational limitations, social stigma, and long-term dependence on family or social support systems.^[13,14]

From a public health perspective, early diagnosis and timely initiation of appropriate treatment for clubfoot represent both a medical and a socioeconomic priority. Effective correction in infancy can prevent a lifetime of disability.^[2,8]

Although the Ponseti–tenotomy protocol has become the global standard of care for idiopathic clubfoot, the majority of the published outcome data originate from high-income countries with established referral systems and follow-up infrastructure.^[12,14]

There is a relative scarcity of published data from Middle Eastern and low-resource settings, where patterns of presentation, access to care, and treatment adherence may differ significantly from those reported elsewhere.^[12,14]

The present study was designed to evaluate the effectiveness and safety of Achilles tenotomy as part of the Ponseti method in infants with congenital clubfoot treated at Mosul General Hospital, Iraq. In addition, it explores the influence of etiology, sex, and side of involvement on early clinical outcomes.^[13,14]

METHODS

This prospective clinical study was conducted at the Orthopedic Surgery Unit of Mosul General Hospital, Mosul, Iraq, between May 2023 and May 2024.

Fifty consecutive infants aged 1 day to 6 months with a diagnosis of congenital talipes equinovarus were enrolled. There were 37 males (74%) and 13 females (26%). Thirty-three patients (66%) had unilateral deformity and 17 (34%) had bilateral involvement. Forty-two cases (84%) were classified as idiopathic and eight (16%) as syndromic based on associated congenital or neuromuscular abnormalities.

All patients were treated using the standard Ponseti protocol. Gentle manipulations and long-leg casts were applied in a stepwise fashion to correct cavus, forefoot adduction, and hindfoot varus. Casts were changed at weekly intervals during the initial phase of correction, with intervals increasing as deformity improved.

Once adequate correction of forefoot and hindfoot components was achieved, residual equinus was addressed by percutaneous Achilles tenotomy. The procedure was performed under general or local anesthesia according to patient age and anesthetic assessment. A small stab incision was made just proximal to the Achilles tendon insertion, and the tendon was carefully transected.

Immediately following tenotomy, a long-leg cast was applied with the foot in approximately 15° of dorsiflexion and 60–70° of abduction. The cast was maintained for 30 days to allow tendon healing and remodeling in the corrected position.

After cast removal, all patients were fitted with a Dennis Browne–type foot abduction brace. The brace was worn full-time (23 hours per day) until the age of one year, and then during sleep only until at least four years of age. Parents received detailed counseling regarding the importance of brace compliance to prevent relapse.

Follow-up visits were scheduled one month after removal of the post-tenotomy cast, every three months during the full-time bracing period, and every six months during night-time brace use. At each visit, clinical evaluation included assessment of ankle dorsiflexion, presence of a plantigrade foot, forefoot position, and any signs of dynamic or fixed forefoot adduction.

Outcomes were categorized as complete correction (plantigrade foot with adequate dorsiflexion and forefoot

abduction without dynamic deformity), near-complete correction (mild dynamic forefoot adduction without functional limitation), or residual deformity (persistent equinus and/or fixed forefoot adduction). For statistical analysis, complete correction was compared with non-complete outcomes (near-complete plus residual deformity).

Data were summarized using frequencies and percentages. Associations between outcome (complete vs non-complete) and categorical variables (sex, etiology,

and side of involvement) were evaluated using chi-square or Fisher's exact tests as appropriate. Odds ratios (OR) with 95% confidence intervals (CI) were calculated. A p value ≤ 0.05 was considered statistically significant.

RESULTS

Fifty infants with congenital clubfoot completed the study. Most patients (84%) presented within the first ten days of life, reflecting early referral and initiation of treatment.

Table 1: Age distribution at presentation (n = 50).

Age group (days)	Number	Percentage
1–10	42	84%
11–20	2	4%
21–30	1	2%
31–40	3	6%
41–50	1	2%
>50	1	2%

The majority of infants (84%) presented within the first ten days of life, whereas only a small minority presented after one month of age.

Table 2: Sex versus outcome (complete vs non-complete).

Sex	Complete	Non-complete (DFA + residual)	Total
Male	29	6	35
Female	10	5	15
Total	39	11	50

Male infants constituted 70% of the cohort (35/50). The proportion of non-complete outcomes was 17.1% in males and 33.3% in females. Fisher's exact test did not demonstrate a statistically significant association

between sex and outcome ($p = 0.27$). The odds of non-complete outcome in males compared with females were OR 2.42 (95% CI 0.60–9.68).

Table 3: Etiology versus outcome (complete vs non-complete).

Etiology	Complete	Non-complete (DFA + residual)	Total
Idiopathic	36	6	42
Syndromic	3	5	8
Total	39	11	50

Idiopathic clubfoot accounted for 84% of cases and showed a high rate of complete correction (85.7%), whereas syndromic clubfoot demonstrated complete correction in only 37.5% of cases. Fisher's exact test revealed a statistically significant association between

etiology and outcome ($p = 0.009$). Syndromic etiology was associated with a tenfold increase in the odds of non-complete outcome compared with idiopathic clubfoot (OR 10.0; 95% CI 1.9–53.2).

Table 4: Side of involvement versus outcome (complete vs non-complete).

Side	Complete	Non-complete (DFA + residual)	Total
Bilateral	17	6	23
Left	16	3	19
Right	17	2	19

Unilateral deformities (left or right) represented a majority of cases, while 23 infants (46%) had bilateral involvement. Chi-square analysis of the 3×2 table did not show a statistically significant association between side of involvement and outcome ($\chi^2 = 1.80$, $df = 2$, $p = 0.77$).

Overall, complete correction was obtained in 39 patients (78%), near-complete correction with mild dynamic forefoot adduction in 7 patients (14%), and residual deformity in 4 patients (8%). No major complications such as excessive bleeding, infection, neurovascular

injury, or overcorrection were observed during or after Achilles tenotomy.

DISCUSSION

This prospective clinical study confirms the high effectiveness of Achilles tenotomy as an integral component of the Ponseti method for correcting congenital clubfoot in infants.^[2-5] The satisfactory outcome rate of 92% in this cohort (complete plus near-complete correction) is comparable with the results of large series from other regions, which have reported success rates between 85% and 95% for idiopathic clubfoot treated by the Ponseti technique.^[9,10]

These findings support the concept that, when properly implemented, the Ponseti-tenotomy protocol is robust and reproducible across diverse clinical environments, including resource-limited settings.^[5-10]

The most important determinant of outcome in the present study was etiology. Syndromic clubfoot showed significantly worse outcomes than idiopathic clubfoot, with a markedly higher proportion of non-complete corrections.^[11-13]

The calculated odds ratio of 10.0 for non-complete outcome in syndromic versus idiopathic cases (95% CI 1.9–53.2; $p = 0.009$) reflects a strong association and underscores the inherent treatment challenges posed by syndromic deformities.^[12-13]

These results are consistent with prior reports indicating that syndromic and neuromuscular clubfeet are more rigid, less responsive to conservative manipulation and casting, and more likely to require additional interventions.^[13]

In contrast, sex and side of involvement were not significantly associated with outcome in this cohort. This is in agreement with several epidemiological studies suggesting that, once treatment is initiated, biological sex and laterality exert limited influence on early correction outcomes.^[6,12,14]

The predominance of early presentation within the first ten days of life likely contributed substantially to the favorable results observed. Neonatal tissues are highly malleable, facilitating more rapid and complete correction with fewer casts.^[6,12]

Numerous authors have emphasized that delayed presentation correlates with increased cast numbers, higher rates of residual deformity, and greater need for adjunctive procedures.^[12]

An equally important determinant of long-term success is adherence to the post-correction bracing protocol. Although brace compliance was not quantitatively analyzed in this study, strict parental education and close

clinical follow-up were emphasized as key components of care.^[9,10]

Previous studies have consistently identified poor brace compliance as the principal risk factor for relapse after initially successful correction using the Ponseti method.^[9,10]

The absence of major complications related to percutaneous Achilles tenotomy in this series reinforces the documented safety of the procedure when performed under appropriate conditions by trained surgeons.^[1,5,10]

Magnetic resonance imaging and clinical follow-up studies have demonstrated that tendon continuity is restored and normal function is achieved after tenotomy, without evidence of long-term weakness or functional compromise.^[5,10]

From a broader perspective, early and successful correction of clubfoot has substantial socioeconomic implications. By restoring the child's ability to walk with a plantigrade, pain-free foot, effective treatment prevents a lifetime of disability and dependency.^[2,14]

In many low- and middle-income countries, untreated clubfoot contributes to significant educational disadvantage, reduced economic productivity, and social marginalization.^[2,14]

The present study adds to the growing body of evidence that the Ponseti-tenotomy paradigm can be successfully implemented in such settings, provided that appropriate training and follow-up systems are in place.^[12,14]

However, several limitations must be acknowledged, including the relatively small sample size, especially in the syndromic subgroup, and the absence of long-term functional and radiographic outcomes into adolescence.^[15,16]

Future multicenter studies with larger cohorts and extended follow-up are warranted to further clarify the durability of correction, the true recurrence rates, and the functional outcomes associated with different etiological subgroups.^[8,14,15]

Despite these limitations, the current findings provide valuable regional data supporting the effectiveness and safety of Achilles tenotomy as part of the Ponseti method in the Iraqi healthcare context.^[12,14]

CONCLUSION

Achilles tenotomy is a simple, minimally invasive, and highly effective procedure that plays a pivotal role in achieving and maintaining full correction of congenital clubfoot when combined with the Ponseti method and appropriate bracing. Early diagnosis, meticulous application of the Ponseti casting sequence, strict adherence to foot abduction bracing, and careful follow-

up are essential to minimize relapse, particularly in infants with syndromic etiology.

Ethical considerations

The study was conducted in accordance with the ethical standards of Mosul General Hospital and the principles of the Declaration of Helsinki. Informed consent was obtained from the parents or legal guardians of all infants prior to inclusion in the study.^[16]

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