

Clinical and Functional Outcomes of Ilizarov-Based Gradual Correction of Equinus Foot Deformity: A Prospective Study

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ABSTRACT

Background: Equinus foot deformity is a common disabling condition that significantly impairs gait and quality of life. Ilizarov-based gradual correction offers a promising treatment approach, yet outcome data from Bangladeshi populations remain limited. **Objective:** To evaluate the clinical and functional outcomes of Ilizarov-based gradual correction of equinus foot deformity. **Methods & Materials:** This prospective observational study was conducted at Kushtia Medical College Hospital, Kushtia, Bangladesh, from January 2021 to December 2025. A total of 25 patients with equinus foot deformity underwent Ilizarov-based gradual correction. Clinical and functional outcomes were assessed using standardized scoring systems. Data were analyzed using SPSS version 23.0. **Results:** The mean preoperative equinus angle was $38.4^\circ \pm 9.6^\circ$, which was corrected to $4.2^\circ \pm 2.8^\circ$ postoperatively ($p < 0.001$). Excellent functional outcomes were achieved in 68.0% of patients ($n=17$), good in 20.0% ($n=5$), and fair/poor in 12.0% ($n=3$). Pin site infection occurred in 24.0% ($n=6$), and recurrence in 8.0% ($n=2$). Mean fixator time was 14.8 ± 3.6 weeks. **Conclusion:** Ilizarov-based gradual correction provides effective deformity correction and favorable functional outcomes in patients with equinus foot deformity, with acceptable complication rates. This technique is a reliable treatment option in resource-limited settings.

Keywords: Deformity correction, Equinus foot, Functional outcome, Ilizarov external fixator, Orthopedic surgery

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INTRODUCTION

Equinus foot deformity is a common and disabling condition characterized by limited ankle dorsiflexion, resulting in the inability to bring the foot to a neutral or plantigrade position [1]. This deformity may arise from a variety of etiologies, including congenital causes such as clubfoot, neurological conditions such as cerebral palsy and poliomyelitis, post-traumatic contractures, and complications following compartment syndrome or burns [2]. Regardless of the underlying cause, persistent equinus deformity leads to significant functional impairment, abnormal gait patterns, and compensatory changes in the knee, hip, and spine [3]. The condition profoundly affects quality of life, limiting mobility, participation in daily activities, and overall independence [4]. The management of equinus foot deformity depends on the severity of the deformity, its underlying etiology, and the presence of associated conditions [5]. Non-operative treatments, including serial casting and orthotic devices, are effective in mild and flexible deformities but often fail in severe or rigid cases [6]. Surgical options range

from soft tissue procedures such as Achilles tendon lengthening to bony procedures such as osteotomies and arthrodesis [7]. However, conventional surgical approaches may be associated with complications including wound breakdown, neurovascular injury, and recurrence, particularly in patients with compromised soft tissues or poor vascularity [8]. The Ilizarov external fixator, based on the principles of distraction osteogenesis and tension-stress, has emerged as a valuable tool for the gradual correction of complex foot and ankle deformities [9]. This technique allows for simultaneous correction of multiple components of the deformity through gradual, controlled distraction of soft tissues and bone, thereby minimizing the risk of neurovascular compromise and skin necrosis [10]. The circular frame provides multiplanar stability and permits early weight-bearing, which promotes bone healing and functional recovery [11]. The gradual nature of correction allows soft tissues to adapt to the new position, making the Ilizarov method particularly suitable for severe and rigid deformities that would be

difficult to correct acutely [12]. Clinical evidence supporting the use of Ilizarov external fixation for equinus foot deformity has accumulated over recent years. A study of 24 patients with equinus deformity treated with Ilizarov external fixation reported excellent correction of the deformity with significant improvement in functional outcomes [9]. Another study evaluating gradual correction of foot and ankle deformities using the Ilizarov technique reported satisfactory outcomes in the majority of patients, with good correction of deformity and functional recovery [10]. A systematic review of circular external fixation for foot and ankle deformities in patients with cerebral palsy reported good correction rates and functional improvements, with acceptable complication rates [11]. Additionally, research has demonstrated that the Ilizarov method provides good to excellent results in the correction of complex foot and ankle deformities, with high patient satisfaction [12]. Despite the growing body of evidence supporting Ilizarov-based gradual correction, comprehensive data on its outcomes for equinus foot deformity in the

Bangladeshi population remain limited. Most published studies originate from high-income countries or specialized centers, and there is a paucity of prospective data from resource-limited settings where the burden of neglected and complex foot deformities is substantial. Understanding the clinical and functional outcomes of this technique in the local context is essential for guiding clinical decision-making, optimizing treatment protocols, and improving patient care. This prospective observational study was therefore undertaken to evaluate the clinical and functional outcomes of Ilizarov-based gradual correction of equinus foot deformity in patients treated at Kushtia Medical College Hospital, Kushtia, Bangladesh.

METHODS & MATERIALS

This prospective observational study was conducted at Kushtia Medical College Hospital, Kushtia, Bangladesh, from January 2021 to December 2025. A total of 25 patients with equinus foot deformity underwent Ilizarov-based gradual correction.

Inclusion criteria: Patients aged 10 to 60 years, of either sex, with equinus foot deformity (ankle dorsiflexion less than neutral) of any etiology, and providing written informed consent were eligible for inclusion.

Exclusion criteria: Patients with active infection at the surgical site, severe peripheral vascular disease, Charcot arthropathy, or those unwilling to complete the follow-up protocol were excluded.

Study procedure: After obtaining written informed consent, demographic and baseline clinical data were recorded. All patients underwent Ilizarov-based gradual correction using a standard circular frame construct. Gradual distraction was performed at a rate of 1 mm per day until correction was achieved. Clinical outcomes were assessed using the American Orthopaedic Foot and Ankle Society (AOFAS) Ankle-Hindfoot Scale [13]. Pain intensity was evaluated using the Visual Analogue Scale (VAS) ranging from 0 (no pain) to 10 (worst pain) [14]. The equinus angle was measured radiographically.

Complications were documented throughout follow-up.

Data analysis: Data were entered into a predesigned proforma and analyzed using SPSS version 23.0. Continuous variables were expressed as mean ± standard deviation, and categorical variables as frequencies and percentages. A paired t-test was used to compare preoperative and postoperative parameters. A p-value <0.05 was considered statistically significant.

RESULT

The demographic and clinical characteristics of the study population are summarized in Table I. The mean age was 32.4 ± 12.6 years (range 12–58), with a male predominance (60.0%). Congenital clubfoot was the most common etiology (40.0%), followed by neurological conditions (28.0%) and post-traumatic contractures (20.0%). The right side was involved in 52.0% of patients, and the mean duration of deformity was 8.6 ± 5.2 years.

Table I
Demographic and clinical characteristics of the study population (n=25).

Variable	Category	n (%)
Age (years)	≤20	8 (32.0)
	21–40	11 (44.0)
	>40	6 (24.0)
Sex	Male	15 (60.0)
	Female	10 (40.0)
Etiology	Congenital clubfoot	10 (40.0)
	Neurological	7 (28.0)
	Post-traumatic	5 (20.0)
	Others	3 (12.0)
Side affected	Right	13 (52.0)
	Left	12 (48.0)

The preoperative and postoperative functional scores are presented in Table II. The mean AOFAS score improved significantly from 42.6 ± 10.8 preoperatively to 82.4 ± 8.6 postoperatively (p<0.001). The mean VAS pain score decreased from 6.8 ± 1.4 to 2.2 ± 1.1 (p<0.001).

Table II
The mean Preoperative and postoperative functional scores.

Score	Preoperative	Postoperative	p-value
AOFAS	42.6 ± 10.8	82.4 ± 8.6	<0.001
VAS	6.8 ± 1.4	2.2 ± 1.1	<0.001

*Paired t-test was used to compare preoperative and postoperative parameters. AOFAS = American Orthopaedic Foot and Ankle Society; VAS = Visual Analogue Scale; SD = standard deviation.

The mean improvement was highest among patients with congenital clubfoot (41.2 ± 8.4), followed by neurological (38.6 ± 9.2), post-traumatic (36.8 ± 10.6), and other etiologies (34.2 ± 11.8). However, the difference among the groups was not statistically significant (p = 0.312) (Table III).

Table III
The mean AOFAS improvement across etiologies.

Etiology	Improvement	p-value*
Congenital clubfoot	41.2 ± 8.4	0.312
Neurological	38.6 ± 9.2	
Post-traumatic	36.8 ± 10.6	
Others	34.2 ± 11.8	

*One-way ANOVA was used to compare mean AOFAS improvement across etiologies. AOFAS = American Orthopaedic Foot and Ankle Society.

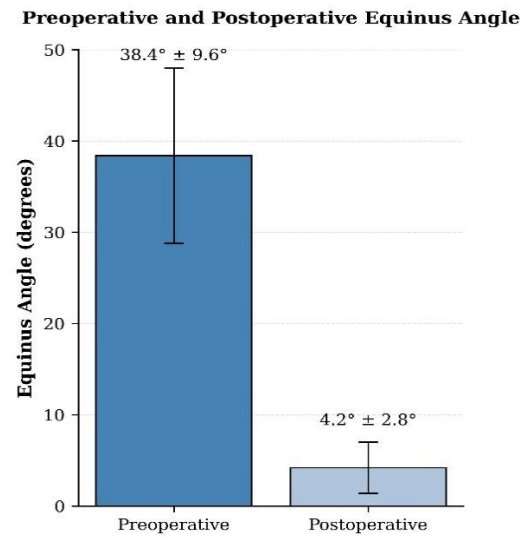


Figure 1 Preoperative and postoperative equinus angle.

The equinus angle improved significantly from a mean of $38.4^{\circ} \pm 9.6^{\circ}$ preoperatively to $4.2^{\circ} \pm 2.8^{\circ}$ postoperatively ($p < 0.001$), representing a mean correction of 34.2° . In *Figure 1*, the substantial reduction in

equinus angle achieved with Ilizarov-based gradual correction is demonstrated. The distribution of functional outcomes based on postoperative AOFAS scores is presented in *Table IV*. Excellent results

were achieved in 68.0% of patients ($n = 17$), good in 20.0% ($n = 5$), fair in 8.0% ($n = 2$), and poor in 4.0% ($n = 1$). In *Figure 2*, the distribution of functional outcomes is demonstrated.

Table IV
Complications encountered during treatment.

Complication	n (%)
Pin site infection	6 (24.0)
Recurrence of deformity	2 (8.0)
Wire loosening	2 (8.0)
Skin ulceration	1 (4.0)

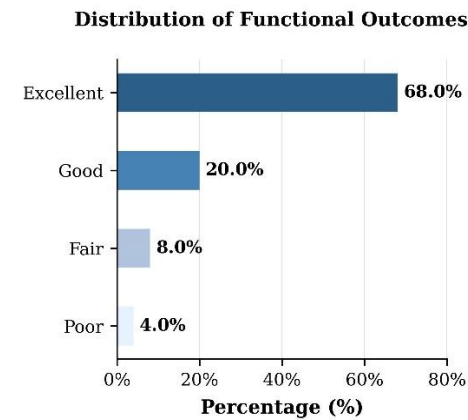


Figure 2 Distribution of functional outcomes.

Figure 2 demonstrates the distribution of functional outcomes, with the majority of patients achieving excellent or good results

following Ilizarov-based gradual correction.

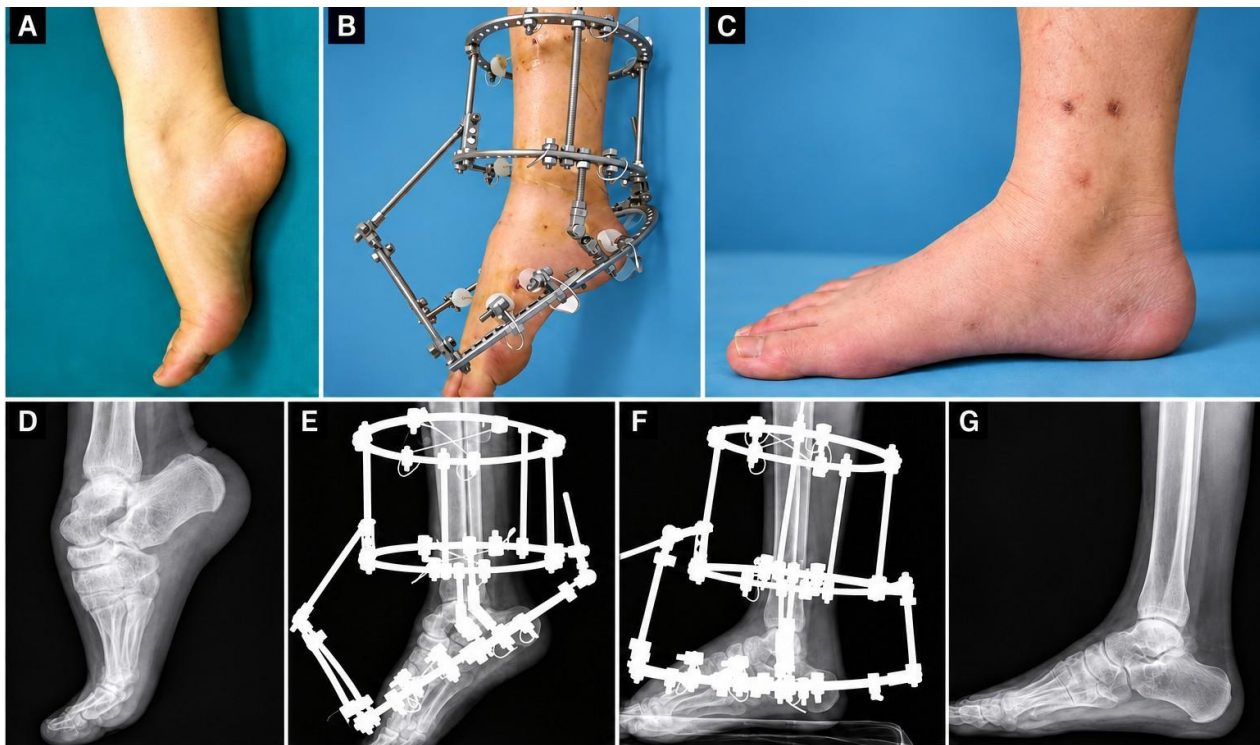


Figure 3 Clinical and radiographic follow-up of a patient with equinus foot deformity treated with Ilizarov external fixator.

Clinical and radiographic follow-up of a patient with equinus foot deformity treated with Ilizarov external fixator. (A) Preoperative clinical photograph showing equinus deformity of the foot and ankle. (B) Postoperative clinical photograph with Ilizarov external fixator in situ. (C) Clinical photograph after frame removal showing a plantigrade, corrected foot. (D) Preoperative lateral radiograph. (E, F) Postoperative radiographs with Ilizarov frame during correction. (G) Final lateral radiograph after frame removal showing maintained correction.

Figure 3 demonstrates the clinical and radiographic progression from the preoperative equinus deformity through gradual correction with the Ilizarov frame to maintained plantigrade alignment after frame removal.

DISCUSSION

This prospective study of 25 patients with equinus foot deformity demonstrates that Ilizarov-based gradual correction achieves significant improvement in both clinical and functional outcomes. The mean equinus angle corrected from 38.4° to 4.2° ($p < 0.001$), representing a mean correction of 34.2° . The mean AOFAS score improved from 42.6 to 82.4 ($p < 0.001$), and excellent or good functional outcomes were achieved in 88.0% of patients. These findings compare favorably with published series and support the role of circular external fixation as a reliable treatment option for this challenging deformity. The degree of deformity correction observed in

this study is consistent with the broader literature. A study of 24 patients with equinus deformity treated with Ilizarov external fixation reported excellent correction of the deformity with significant improvement in functional outcomes [15]. Another study evaluating gradual correction of foot and ankle deformities using the Ilizarov technique reported satisfactory outcomes in the majority of patients, with good correction of deformity and functional recovery [16]. A systematic review of circular external fixation for foot and ankle deformities reported good correction rates and functional improvements, with acceptable complication rates [17]. The mean correction of 34.2° in our cohort aligns closely with these findings, confirming the effectiveness of the gradual distraction technique for equinus deformity. The functional improvement observed in this study a mean AOFAS gain of 39.8 points is clinically meaningful and consistent with previous reports. A study evaluating the outcomes of Ilizarov correction for complex foot and ankle deformities reported significant improvements in functional scores, with high patient satisfaction [18]. The magnitude of improvement in our cohort is comparable, confirming that the Ilizarov technique not only achieves deformity correction but also restores meaningful function and reduces pain in patients with equinus deformity [19]. The significant reduction in VAS pain scores from 6.8 to 2.2 further supports the clinical benefit of gradual correction, which addresses both the mechanical and functional

consequences of the deformity. The analysis of outcomes by etiology revealed that patients with congenital clubfoot achieved the greatest functional improvement (mean AOFAS gain 41.2), followed by neurological conditions (38.6) and post-traumatic contractures (36.8). However, these differences did not reach statistical significance ($p = 0.312$), suggesting that the Ilizarov technique is effective across different etiologies of equinus deformity [16]. This finding is clinically important as it supports the broad applicability of the technique regardless of the underlying cause. The complications observed in this study pin site infection in 24.0%, recurrence in 8.0%, and wire loosening in 8.0% are consistent with the known risks of circular external fixation. Pin site infection remains the most common complication of Ilizarov-based procedures, with reported rates ranging from 10% to 30% depending on the definition and duration of follow-up [20]. In our cohort, all pin site infections resolved with local wound care and oral antibiotics, and no cases of deep infection, neurovascular injury, or amputation were observed. The recurrence rate of 8.0% is comparable to the 5% to 15% reported in other series of Ilizarov correction for foot deformities and reflects the challenging nature of maintaining correction in patients with severe or long-standing deformities [17]. The absence of major complications such as amputation or neurovascular injury in our series reflects careful patient selection, meticulous surgical technique, and adherence to the principles of gradual

correction and stable fixation. The strengths of this study include its prospective design, which allowed for systematic data collection and comprehensive follow-up, and the use of validated outcome measures including the AOFAS Ankle-Hindfoot Scale and VAS pain score^[13]. The inclusion of a relatively homogeneous patient population with well-defined inclusion criteria enhances the internal validity of the findings. Additionally, the study provides valuable data from a resource-limited setting where alternative reconstructive procedures may not be readily available or affordable^[21].

LIMITATIONS

The single-center design, relatively small sample size (n=25), and absence of a control group limit generalizability. Lack of long-term follow-up may not capture recurrence or adjacent joint arthritis. Unmeasured confounding variables, including etiology and severity, may have influenced outcomes.

CONCLUSION

Ilizarov-based gradual correction achieves significant improvement in equinus foot deformity, with the mean equinus angle correcting from 38.4° to 4.2° (p<0.001) and excellent or good functional outcomes in 88.0% of patients. This technique offers a reliable treatment option, particularly in resource-limited settings where alternative reconstructive procedures may be unavailable.

RECOMMENDATION

We recommend Ilizarov-based gradual correction for equinus foot deformity, particularly in severe or rigid cases. Larger multicenter studies with extended follow-up and comparative designs are warranted to validate these findings and assess long-term outcomes.

CONFLICT OF INTEREST

The authors declare no conflicts of interest. No funding was received for this study. The corresponding author had full access to all data and final responsibility for the decision to submit for publication.

AI DECLARATION

Artificial intelligence tools contributed marginally to manuscript preparation and development. All core scientific content was human-verified.

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ETHICAL APPROVAL

The study was approved by the Institutional Ethics Committee

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