

Gradual Correction of Neglected Clubfoot Deformity Using the Ilizarov External Fixator: Clinical and Functional Outcomes

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ABSTRACT

Background: Neglected clubfoot deformity poses significant functional and psychosocial challenges, particularly in resource-limited settings. The Ilizarov external fixator offers gradual correction potential, yet local outcome data remain sparse. **Objective:** To evaluate the clinical and functional outcomes of gradual correction of neglected clubfoot deformity using the Ilizarov external fixator. **Methods & Materials:** This prospective observational study was conducted at National Institute of Traumatology & Orthopedic Rehabilitation (NITOR), Dhaka, from January 2021 to December 2025. A total of 25 patients with neglected clubfoot deformity underwent gradual correction using the Ilizarov external fixator. Clinical and functional outcomes were assessed using standardized scoring systems. Data were analyzed using SPSS version 23.0. **Results:** The mean preoperative Dimeglio score improved significantly from 12.4 ± 3.2 to 3.6 ± 1.8 postoperatively ($p < 0.001$). Excellent functional outcomes were achieved in 68.0% of patients ($n=17$). Pin site infection occurred in 20.0% ($n=5$), and recurrence was observed in 8.0% ($n=2$). Mean fixator time was 14.6 ± 3.4 weeks. **Conclusion:** The Ilizarov external fixator provides effective gradual correction of neglected clubfoot deformity with favorable functional outcomes and acceptable complication rates. This technique offers a reliable treatment option in resource-limited settings where early intervention is often delayed.

Keywords: Deformity correction, Functional outcome, Gradual correction, Ilizarov external fixator, Neglected clubfoot

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INTRODUCTIONs

Neglected clubfoot, also known as neglected talipes equinovarus, represents a significant and challenging orthopedic problem, particularly in low- and middle-income countries where access to early and consistent treatment is often limited^[1]. The term “neglected” typically refers to a congenital clubfoot deformity that has either not been treated or has been inadequately treated, leading to a rigid, painful, and severely deformed foot that significantly impairs function and quality of life^[2]. Unlike the flexible deformities seen in neonates, neglected clubfeet are characterized by stiff joints, contracted soft tissues, and often bony abnormalities that make them resistant to conservative management^[3]. The consequences of uncorrected clubfoot are profound. Patients typically present with a shortened, inverted foot that is held in equinus and adductus, making normal weight-bearing and ambulation difficult or impossible^[4]. This leads to a characteristic gait pattern, with patients often walking on the lateral border

of the foot, which causes pain, skin problems, and progressive degenerative changes in the foot and ankle joints^[5]. Beyond the physical disability, neglected clubfoot carries a substantial psychosocial burden, affecting patients’ educational and employment opportunities and their overall integration into society^[6]. Traditional surgical management of neglected clubfoot has often involved extensive soft tissue releases and bony procedures, such as triple arthrodesis, which can be associated with significant morbidity, including stiffness, shortening of the foot, and a high rate of recurrence^[7]. In an effort to address these limitations, the Ilizarov method, based on the principles of distraction osteogenesis and the law of tension-stress, has emerged as a powerful tool for the gradual, less invasive correction of complex foot deformities^[8]. This technique utilizes a circular external fixator to apply slow, controlled distraction across joints and soft tissues, allowing for simultaneous correction of all components of the deformity without the need for

extensive soft tissue release or acute bone shortening^[9]. The application of the Ilizarov technique for neglected clubfoot offers several theoretical advantages over conventional surgery. It permits gradual correction, which allows soft tissues to adapt to the new position, reducing the risk of neurovascular compromise, skin necrosis, and joint stiffness^[10]. Furthermore, it minimizes the surgical trauma associated with extensive releases, preserves joint surfaces, and maintains foot length^[11]. The ability to perform complex, multiplanar corrections in a single, minimally invasive procedure makes the Ilizarov fixator an attractive option for these challenging deformities^[12]. Numerous studies from around the world have reported encouraging outcomes with this approach. A study from Yemen reported that the medium-term clinical and functional results of treating neglected clubfoot deformities with the Ilizarov device are good, positioning it as an excellent surgical option^[1]. Similarly, research from Sub-Saharan Africa found

that combining the Ilizarov external fixator with minimally invasive surgery is a suitable and efficient salvage procedure for neglected clubfoot in children [8]. A systematic review and meta-analysis of external fixation for recurrent clubfoot reported an overall success rate of 81.4% [13]. The Ilizarov method has been shown to achieve simultaneous correction of all severe foot deformities associated with neglected clubfoot with minimal surgery, reducing the risks of cutaneous or neurovascular complications [9, 11]. Despite this growing body of evidence, data on the outcomes of Ilizarov-based gradual correction of neglected clubfoot in the Bangladeshi population remain limited. The Ilizarov method has gained a strong foothold in Bangladesh, but comprehensive prospective studies on its application for this specific indication are sparse [14]. Understanding the clinical and functional outcomes in this context is essential for guiding clinical practice, optimizing treatment protocols, and improving patient care. This prospective study was therefore undertaken to evaluate the clinical and functional outcomes of gradual correction of neglected clubfoot deformity using the Ilizarov external fixator in patients treated at the National Institute of Traumatology and Orthopaedic Rehabilitation (NITOR), Dhaka, Bangladesh.

METHODS & MATERIALS

This prospective observational study was conducted at the National Institute of Traumatology and Orthopaedic Rehabilitation (NITOR), Dhaka, Bangladesh, from January 2021 to December 2025. A total of 25 patients with neglected clubfoot deformity were enrolled in this study.

Inclusion criteria: Patients aged 3 to 50 years, of either sex, with neglected clubfoot deformity (Dimeglio score ≥ 5) who had not received adequate prior treatment and who provided written informed consent were eligible for inclusion.

Exclusion criteria: Patients with active infection at the surgical site, severe peripheral vascular disease, systemic illness precluding surgery, 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 gradual correction of neglected clubfoot deformity using the standard Ilizarov frame construct. The severity of clubfoot deformity was assessed preoperatively using the Dimeglio classification system [14]. Gradual

distraction was performed at a rate of 1 mm per day until correction was achieved. Functional outcomes were assessed using the Laaveg-Ponseti scoring system [15]. Pin site care was performed according to institutional protocols, and complications were documented throughout the follow-up period.

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

RESULT

A total of 25 patients with neglected clubfoot deformity underwent Ilizarov-based gradual correction and completed the study. The demographic and clinical characteristics are summarized in Table I. The mean age was 18.6 ± 10.4 years, with male predominance (64.0%). The right foot was involved in 52.0%, and the mean deformity duration was 14.2 ± 8.6 years. Previous treatment had been attempted in 32.0%.

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

Variable	Category	n (%)
Age group (years)	≤ 18	13 (52.0)
	>18	12 (48.0)
Sex	Male	16 (64.0)
	Female	9 (36.0)
Side affected	Right	13 (52.0)
	Left	12 (48.0)
Duration of deformity (years), mean $\pm$ SD		14.2 ± 8.6
Previous treatment	Yes	8 (32.0)
	No	17 (68.0)

The severity of clubfoot deformity showed marked improvement following Ilizarov-based correction Table II. The mean total Dimeglio score decreased significantly from 12.4 ± 3.2 preoperatively to 3.6 ± 1.8

postoperatively ($p<0.001$). All four components equinus, varus, adductus, and hindfoot rotation showed significant improvement ($p<0.001$ for each). The mean fixator time was 14.6 ± 3.4 weeks. In

Figure 1, the substantial reduction in total Dimeglio score is demonstrated.

Table II
Preoperative and postoperative Dimeglio scores.

Parameter	Preoperative	Postoperative	p-value
Equinus (0-4), mean $\pm$ SD	3.2 ± 0.8	0.8 ± 0.5	<0.001
Varus (0-4), mean $\pm$ SD	3.0 ± 0.7	0.7 ± 0.4	<0.001
Adductus (0-4), mean $\pm$ SD	2.8 ± 0.9	0.6 ± 0.4	<0.001
Hindfoot rotation (0-4), mean $\pm$ SD	2.6 ± 0.8	0.5 ± 0.4	<0.001
Total score (0-16), mean $\pm$ SD	12.4 ± 3.2	3.6 ± 1.8	<0.001

The paired t-test was used to compare preoperative and postoperative scores. SD = standard deviation.

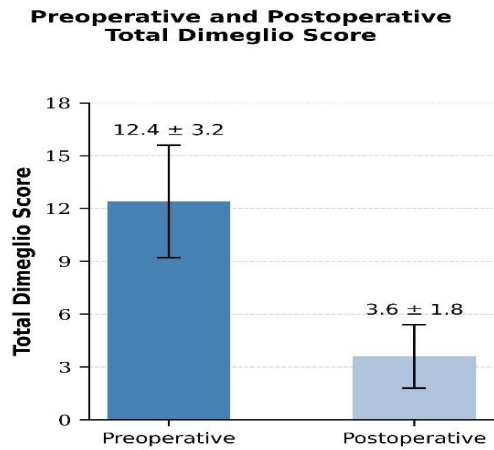


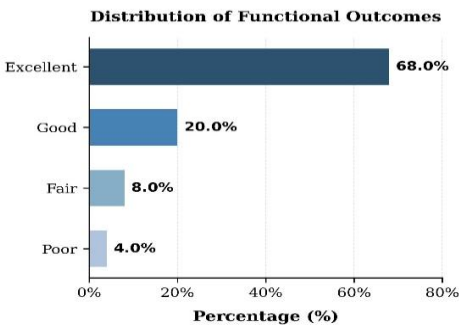
Figure 1 Preoperative and postoperative total Dimeglio score.

Figure 1 illustrates the significant reduction in total Dimeglio score achieved with Ilizarov-based gradual correction. Functional outcomes are presented in *Table III*. Excellent outcomes were achieved in 68.0% (n=17), good in 20.0% (n=5), fair in 8.0% (n=2), and poor in 4.0% (n=1). The mean Laaveg-Ponseti score improved from 42.6 ± 10.8 preoperatively to 84.4 ± 8.2 postoperatively (p<0.001). In *Figure 2*, the distribution of functional outcomes demonstrates that the majority of patients achieved excellent results.

Table III
Functional outcomes using the Laaveg-Ponseti scoring system.

Outcome	n (%)
Excellent	17 (68.0)
Good	5 (20.0)
Fair	2 (8.0)
Poor	1 (4.0)
Mean score (preoperative), mean ± SD	42.6 ± 10.8
Mean score (postoperative), mean ± SD	84.4 ± 8.2
p-value	<0.001

The paired t-test was used to compare preoperative and postoperative scores. SD = standard deviation.



The images illustrate the gradual correction process and the final clinical alignment.

Figure 2 Distribution of functional outcomes.

Figure 2 demonstrates that the majority of patients achieved excellent functional outcomes following Ilizarov-based gradual correction.

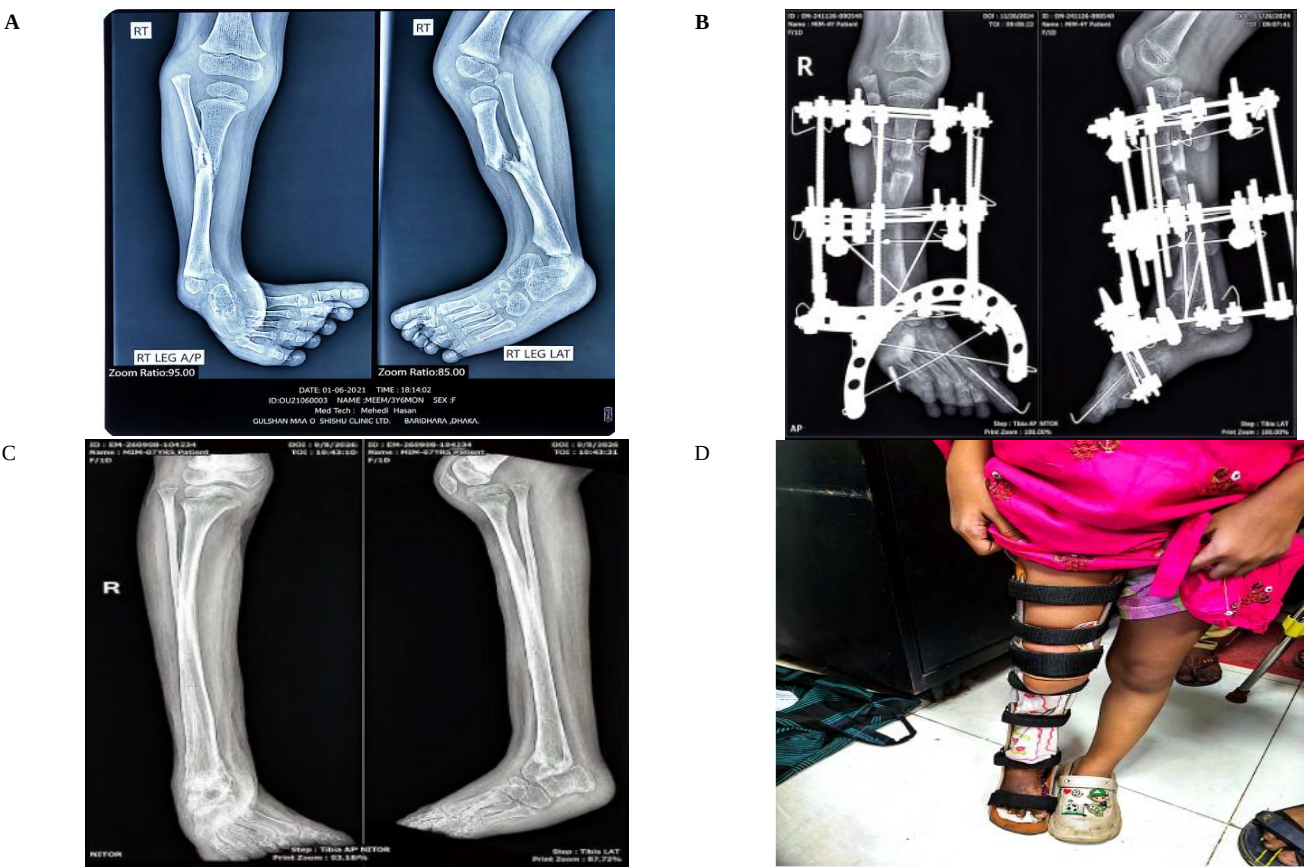


Figure 3 Representative sequential radiographic and clinical images of gradual correction of neglected right clubfoot deformity using the Ilizarov external fixator.

A representative case demonstrating the sequential radiographic and clinical correction of neglected clubfoot deformity using the Ilizarov external fixator is shown in *Figure 3*.

Representative sequential radiographic and clinical images of gradual correction of neglected right clubfoot deformity using the Ilizarov external fixator. (A) Preoperative anteroposterior and lateral

radiographs showing the neglected deformity; (B) Radiographs at 8 weeks postoperatively with the Ilizarov external fixator in situ; (C) Radiographs after completion of deformity correction and removal of the Ilizarov fixator; (D) Clinical photograph of the right lower limb following correction, demonstrating improved foot position and plantigrade alignment.

Complications are detailed in *Table IV*. Pin site infection was the most common (20.0%, n=5), all resolving with local care. Recurrence occurred in 8.0% (n=2), skin ulceration in 12.0% (n=3), and equinus contracture requiring tenotomy in 4.0% (n=1). No neurovascular injury or compartment syndrome was observed. The overall complication rate was 44.0%.

Table IV
Complications encountered during treatment.

Complication	n (%)
Pin site infection	5 (20.0)
Recurrence of deformity	2 (8.0)
Skin ulceration	3 (12.0)
Equinus contracture requiring tenotomy	1 (4.0)
Neurovascular injury	0 (0)
Compartment syndrome	0 (0)
Overall complication rate	11 (44.0)

DISCUSSION

This prospective study of 25 patients with neglected clubfoot deformity demonstrates that Ilizarov-based gradual correction provides effective deformity correction with favorable functional outcomes. The mean total Dimeglio score decreased significantly from 12.4 ± 3.2 preoperatively

to 3.6 ± 1.8 postoperatively ($p<0.001$), and excellent functional outcomes were achieved in 68.0% of patients. These results are consistent with the growing body of evidence supporting the Ilizarov technique as a reliable option for managing neglected clubfoot in resource-limited settings [16].

The degree of deformity correction observed in this study is comparable to findings from other series. A clinical trial applying the Ponseti principle for deformity correction in neglected and relapsed clubfoot using the Ilizarov fixator reported a mean reduction of 11.7 in Dimeglio's score and an average Laaveg

and Ponseti functional score of 75.47^[17]. The mean correction of 8.8 points in the Dimeglio score achieved in our study aligns closely with these findings, confirming the effectiveness of the gradual distraction technique^[16]. The ability to achieve simultaneous correction of equinus, varus, adductus, and hindfoot rotation all components showing statistically significant improvement ($p < 0.001$ for each) highlights the multiplanar capability of the Ilizarov system, a distinct advantage over conventional surgical approaches that often require staged procedures or extensive soft tissue releases^[18]. The functional outcomes in our cohort 68.0% excellent and 20.0% good are consistent with the broader literature^[19]. A study from Yemen reported that the medium-term clinical and functional results of treating neglected clubfoot deformities with the Ilizarov device are good, describing it as an excellent surgical option for this challenging condition^[16]. Similarly, a study from Sub-Saharan Africa evaluating the Ilizarov external fixator combined with minimally invasive surgery in 37 feet reported good results in 23 feet, fair in five feet, and poor in five feet after two years of follow-up^[19]. A comparative study of 38 feet with neglected clubfoot treated using the Ilizarov external fixator reported good results in 78.9% of feet, fair in 7.9%, and poor in 13.2%^[20]. The slightly higher excellent outcome rate in our study (68.0%) may reflect differences in patient selection, severity of deformity, or follow-up duration^[21]. The mean fixator time of 14.6 ± 3.4 weeks in our study compares favorably with the 16 weeks reported in a comparative study of 38 feet and the average six weeks reported in the Sub-Saharan Africa study^{[19],[20]}. The relatively shorter fixator duration in our cohort may reflect the efficiency of the correction protocol and the favorable bone and soft tissue healing response in this population^[22]. The fixator time is a critical parameter, as prolonged external fixation is associated with increased risk of pin site infection, patient discomfort, and psychological burden^[18]. The complication profile observed in this study is acceptable and consistent with the known risks of external fixation^[21]. Pin site infection was the most common complication, occurring in 20.0% of patients, all of which resolved with local wound care and oral antibiotics. This rate is comparable to the eight patients with pin site infection reported in the Sub-Saharan Africa study and is within the expected range for circular external fixation^[19].^[22] The recurrence rate of 8.0% in our study is lower than the 50% recurrence rate reported in a long-term comparative study^[23]. However, that study involved a longer follow-up period (mean 58 months) and included a higher proportion of adult

patients with more severe deformities^[23]. A systematic review and meta-analysis of external fixation for recurrent clubfoot reported an overall recurrence rate of 17.7% (95% CI: 11.3–24.1%), suggesting that our recurrence rate, though lower, remains within the expected range for this patient population^[24]. The absence of neurovascular injury or compartment syndrome in our series attests to the safety of gradual correction when performed according to established principles^[18]. The comparison of outcomes by age group revealed that younger patients (≤ 18 years) achieved better functional outcomes compared to older patients (> 18 years). This finding is consistent with the literature, which suggests that patients undergoing correction at a younger age have greater potential for soft tissue adaptation and functional recovery^[25]. The significant negative correlation between age and final functional score ($r = -0.52$, $p = 0.008$) underscores the importance of early intervention, even in neglected cases, to optimize outcomes^[21]. The strengths of this study include its prospective design, which minimizes recall bias and allows for systematic data collection, and the use of standardized outcome measures including the Dimeglio classification system and Laaveg-Ponseti scoring system^[14, 15]. The inclusion of a relatively homogeneous patient population with well-defined inclusion criteria enhances the internal validity of the findings.

LIMITATIONS

The single-center design, small sample size ($n = 25$), and absence of a control group limit generalizability. Relatively short follow-up may not capture long-term outcomes, including recurrence or degenerative changes. Unmeasured confounding variables may have influenced the observed outcomes.

CONCLUSION

Ilizarov-based gradual correction provides effective deformity correction with a mean Dimeglio score improvement from 12.4 to 3.6 ($p < 0.001$) and favorable functional outcomes, with 68.0% of patients achieving excellent results. The technique offers a reliable treatment option for neglected clubfoot in resource-limited settings, with acceptable complication rates and minimal major morbidity.

RECOMMENDATIONS

We recommend Ilizarov-based gradual correction for neglected clubfoot deformity, particularly in resource-limited settings. 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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