

ORIGINAL ARTICLE

Ilizarov-Assisted Ankle Arthrodesis for Advanced Post-Traumatic Ankle Osteoarthritis: Clinical and Functional Outcomes

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ABSTRACT

Background: Ilizarov external fixation enables gradual correction and arthrodesis in severe ankle arthritis with bone loss or deformity. However, outcome data from resource-limited settings remain limited, particularly regarding union rates and functional recovery in Bangladesh. This study addresses this gap. **Objective:** To evaluate clinical and functional outcomes of Ilizarov-assisted ankle arthrodesis in advanced post-traumatic ankle osteoarthritis. **Methods & Materials:** This prospective observational study was conducted at NITOR, Dhaka, from January 2021 to December 2025. A total of 30 patients with advanced post-traumatic ankle osteoarthritis underwent Ilizarov-assisted ankle arthrodesis. Union rate, time to union, functional scores, and complications were recorded. Clinical and functional outcomes were assessed using standardized criteria. Data were analyzed using SPSS version 23.0. **Results:** Bony union was achieved in 28 patients (93.3%), with a mean time to union of 16.8 ± 3.4 weeks. The mean AOFAS score improved from 42.6 ± 10.8 preoperatively to 78.4 ± 8.6 postoperatively ($p < 0.001$). Pin site infection occurred in 23.3%, nonunion in 6.7%, and malunion in 3.3%. No cases of neurovascular injury or amputation were observed. **Conclusion:** Ilizarov-assisted ankle arthrodesis achieves high union rates and significant functional improvement in advanced post-traumatic ankle osteoarthritis, with acceptable complication rates. This technique offers a reliable limb salvage option in resource-limited settings where alternative reconstructive procedures may be unavailable.

Keywords: Ankle arthrodesis, Functional outcome, Ilizarov external fixation, Limb salvage, Traumatic ankle osteoarthritis

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INTRODUCTION

Post-traumatic ankle osteoarthritis represents a significant and increasingly prevalent cause of chronic disability, particularly among young and middle-aged adults who have sustained prior ankle trauma [1]. Unlike primary osteoarthritis, which typically affects older populations, post-traumatic ankle arthritis often develops within 10 to 20 years following intra-articular fractures, recurrent sprains, or other traumatic insults to the ankle joint [2]. The condition is characterized by progressive cartilage degeneration, subchondral bone sclerosis, and osteophyte formation, leading to debilitating pain, stiffness, and functional limitation that profoundly impacts quality of life [3]. Epidemiological studies indicate that the overall risk of developing post-traumatic ankle osteoarthritis approaches 40% within 20 years after significant ankle injury, with rates approaching 100% in cases

of talar fractures [4]. The management of advanced post-traumatic ankle osteoarthritis poses a considerable therapeutic challenge. While total ankle arthroplasty has emerged as a viable option for selected patients, ankle arthrodesis remains the gold standard for end-stage disease, particularly in younger, active individuals with high functional demands [5]. Arthrodesis provides reliable pain relief and functional improvement by eliminating motion at the diseased joint. However, conventional internal fixation techniques using screws or plates may be inadequate in cases complicated by severe deformity, bone loss, infection, or poor soft tissue envelopes [6]. In such complex scenarios, alternative fixation strategies are required to achieve stable fusion and limb salvage [7]. The Ilizarov external fixator, based on the principles of distraction osteogenesis and tensioned wire fixation, offers distinct advantages for complex ankle

arthrodesis [8]. The circular frame provides multiplanar stability, allows for gradual correction of deformity, and permits early weight-bearing, all while minimizing soft tissue dissection and preserving vascularity [9]. These features make the Ilizarov technique particularly suitable for cases with active infection, segmental bone loss, or severe deformity where internal fixation is contraindicated [10]. Clinical evidence supporting the use of Ilizarov external fixation for ankle arthrodesis has accumulated over the past two decades. A study of 54 patients with septic ankle arthritis treated with Ilizarov arthrodesis reported primary bony fusion in 94% of cases, with significant improvements in AOFAS scores, VAS pain scores, and SF-12 health status measures [6]. Another series of 63 patients with end-stage varus ankle osteoarthritis demonstrated bony fusion in all ankles, with the mean AOFAS score improving from 42.14 to 80.90 at final follow-up [3]. A prospective study of 44 patients with infected ankle fractures and segmental bone loss achieved successful fusion in 43 of 44 patients using Ilizarov concepts, with good results in 32 cases [7]. More recently, a retrospective review of 81 patients with end-stage post-traumatic ankle arthritis, infection, or bone loss reported successful arthrodesis in 90.1% of patients, with excellent or good results in 71 patients [11]. Comparative studies have also evaluated the Ilizarov technique against internal fixation methods. A systematic review and meta-analysis comparing external and internal fixation techniques found comparable union rates between the two approaches, though external fixation was associated with higher odds of deep hardware infections and amputations, likely reflecting its use in more complex cases [10]. Another comparative study reported that although duration of surgery and blood loss were higher in the Ilizarov group, mid-term clinical outcomes were comparable to screw internal fixation [9]. These findings suggest that the Ilizarov technique remains a valuable option for complex cases where internal fixation is contraindicated or likely to fail. Despite the growing body of evidence supporting Ilizarov-assisted ankle arthrodesis, comprehensive data on its outcomes 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 complex ankle pathology is substantial. Understanding the clinical and functional outcomes of this technique in the local context is essential for guiding clinical decision-making, optimizing resource allocation, and improving patient care. This prospective observational study was therefore undertaken to evaluate the clinical and functional outcomes of Ilizarov-assisted ankle arthrodesis in patients with advanced post-traumatic ankle osteoarthritis 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 30 patients with advanced post-traumatic ankle osteoarthritis underwent Ilizarov-assisted ankle arthrodesis.

Inclusion criteria: Patients aged 18 to 65 years, of either sex, with advanced post-traumatic ankle osteoarthritis (Kellgren-Lawrence grade III-IV) and providing written informed consent were eligible for inclusion.

Exclusion criteria: Patients with active infection at the surgical site, Charcot arthropathy, severe peripheral vascular disease, 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-assisted ankle arthrodesis using a standard circular frame construct. Gradual compression was applied across the ankle joint to achieve fusion. Clinical outcomes were assessed using the American Orthopaedic Foot and Ankle Society (AOFAS) Ankle-Hindfoot Scale [12]. Pain intensity was evaluated using the Visual Analogue Scale (VAS) ranging from 0 (no pain) to 10 (worst pain) [13]. Union was confirmed 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 $\pm$ 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

A total of 30 patients with advanced post-traumatic ankle osteoarthritis underwent Ilizarov-assisted ankle arthrodesis and completed the study. The demographic and clinical characteristics are summarized in *Table I*. The mean age was 42.6 ± 12.8 years (range 19–65), with a male predominance (66.7%). The right side was involved in 56.7% of patients. The mean duration of symptoms was 3.8 ± 1.6 years, and all patients had a history of prior ankle trauma.

Table I: Demographic and clinical characteristics of the study population (n=30)

Variable	Category	n (%)
Age group (years)	≤ 40	13 (43.3)
	41–55	11 (36.7)
	> 55	6 (20.0)
Sex	Male	20 (66.7)
	Female	10 (33.3)
Side affected	Right	17 (56.7)
	Left	13 (43.3)

Union outcomes are presented in *Table II*. Bony union was achieved in 28 patients (93.3%), with a mean time to union of

16.8 ± 3.4 weeks. Nonunion occurred in 2 patients (6.7%). Among the 28 patients who achieved union, 12 (42.9%)

united within 16 weeks, 13 (46.4%) between 17 and 20 weeks, and 3 (10.7%) after 20 weeks. In Figure 2, the

distribution of time to union categories is demonstrated.

Table II: Union outcomes (n=30)

Parameter	Category	n (%)
Union achieved	Yes	28 (93.3)
	No	2 (6.7)

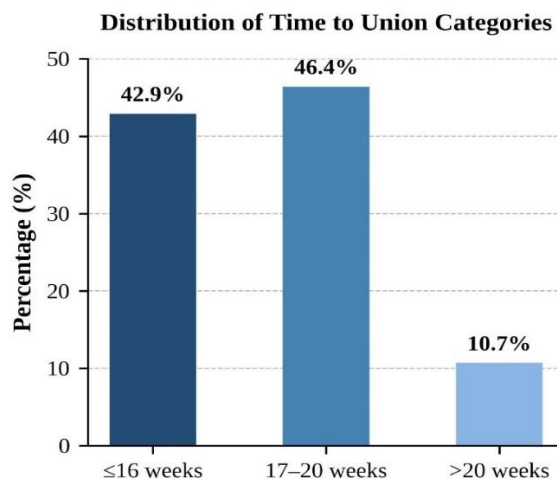


Figure 1: Distribution of time to union categories

Figure 1 illustrates the distribution of time to union among patients who achieved bony fusion, with the majority uniting between 17 and 20 weeks.

Functional outcomes are presented in Table III. The mean AOFAS score improved significantly from 42.6 ± 10.8 preoperatively to 78.4 ± 8.6 postoperatively ($p < 0.001$). The

mean VAS pain score decreased from 7.2 ± 1.4 to 2.4 ± 1.2 ($p < 0.001$). Based on postoperative AOFAS scores, excellent results (80–100) were achieved in 13 patients (43.3%), good (70–79) in 10 (33.3%), fair (60–69) in 5 (16.7%), and poor (<60) in 2 (6.7%). In Figure 1, the distribution of AOFAS functional outcomes is demonstrated.

Table III: Functional outcomes (n=30)

Parameter	Preoperative	Postoperative	p-value*
AOFAS score, mean $\pm$ SD	42.6 ± 10.8	78.4 ± 8.6	<0.001
VAS pain score, mean $\pm$ SD	7.2 ± 1.4	2.4 ± 1.2	<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.

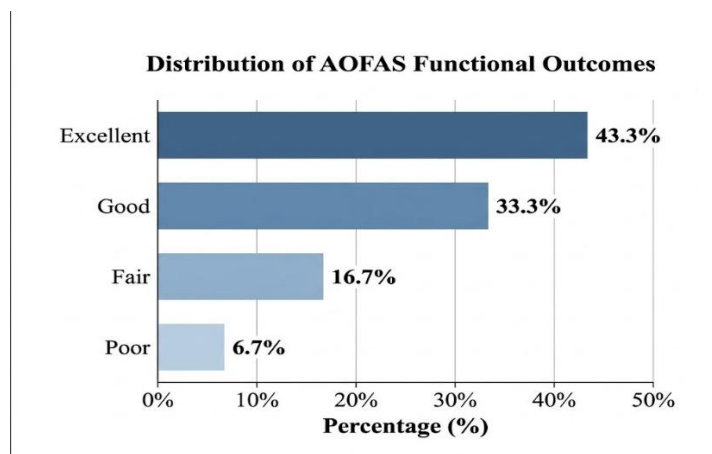


Figure 2: Distribution of AOFAS functional outcomes

Figure 2 demonstrates the distribution of functional outcomes based on postoperative AOFAS scores, with excellent and good results achieved in the majority of patients.

Complications are presented in Table IV. Pin site infection was the most common complication, occurring in 7 patients

(23.3%), all of which resolved with local wound care and oral antibiotics. Nonunion occurred in 2 patients (6.7%), and malunion in 1 (3.3%). One patient (3.3%) developed wound breakdown requiring debridement. No cases of neurovascular injury, deep vein thrombosis, or amputation were observed.

Table IV: Complications (n=30)

Complication	n (%)
Pin site infection	7 (23.3)
Nonunion	2 (6.7)
Malunion	1 (3.3)
Wound breakdown	1 (3.3)

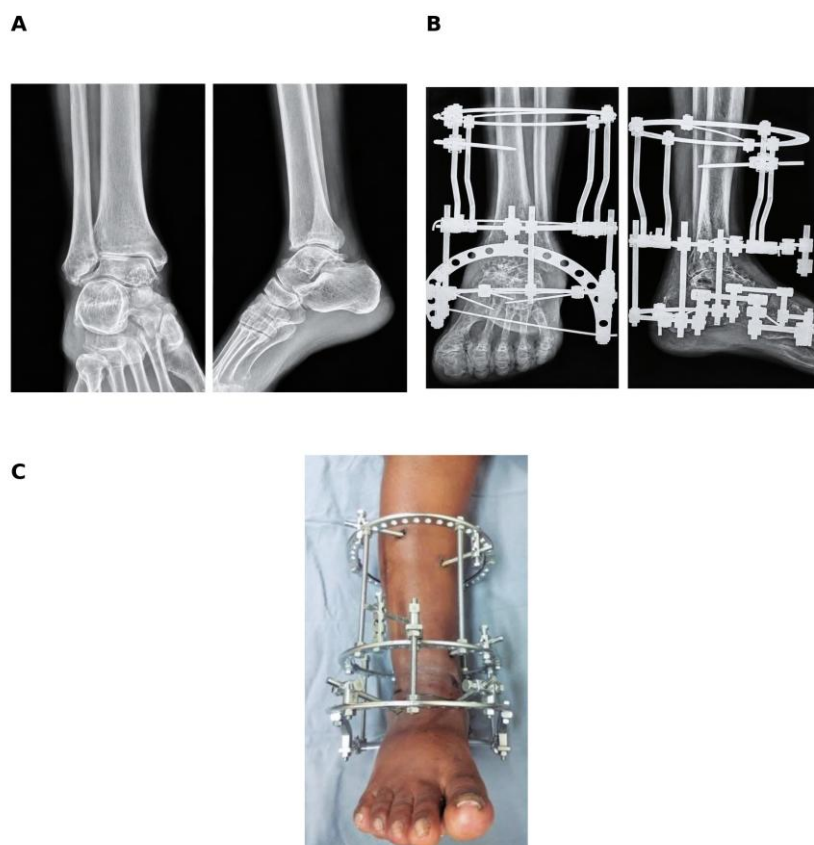


Figure 3: (A) Preoperative X-ray of advanced post-traumatic ankle osteoarthritis; (B) postoperative X-ray showing ankle arthrodesis with Ilizarov external fixation; (C) clinical photograph of the leg with the Ilizarov frame in situ

DISCUSSION

This prospective study of 30 patients with advanced post-traumatic ankle osteoarthritis demonstrates that Ilizarov-assisted ankle arthrodesis achieves a high union rate of 93.3%, with a mean time to union of 16.8 weeks and significant improvement in functional outcomes. The mean AOFAS score improved from 42.6 preoperatively to 78.4 postoperatively ($p < 0.001$), and the mean VAS pain score decreased from 7.2 to 2.4 ($p < 0.001$). These findings compare favorably with published series and support the role of circular external fixation as a reliable limb salvage strategy in complex ankle pathology [14]. The union rate of 93.3% observed in this study is consistent with the broader literature. A series of 81 patients with end-stage post-traumatic ankle arthritis, infection, or bone loss reported successful arthrodesis in 90.1% of patients, with excellent or good results in 71 patients [11]. Another study of 54 patients with septic ankle arthritis treated with Ilizarov arthrodesis reported primary bony fusion in 94% of cases, with significant improvements in AOFAS scores and SF-12 health status measures [6]. A prospective study of 44 patients with infected ankle fractures and segmental bone loss achieved successful fusion in 43 of 44 patients using Ilizarov concepts, with good results in 32 cases [7]. The consistency of these findings across different patient populations and settings underscores the reliability of the circular frame in achieving fusion even in compromised biological environments. The functional improvement observed in this study a mean AOFAS gain of

35.8 points is clinically meaningful and consistent with previous reports. A study of 63 patients with end-stage varus ankle osteoarthritis demonstrated bony fusion in all ankles, with the mean AOFAS score improving from 42.14 to 80.90 at final follow-up [3]. The magnitude of improvement in our cohort is comparable, confirming that the Ilizarov technique not only achieves union but also restores meaningful function and reduces pain in patients with advanced ankle arthritis [5]. The significant reduction in VAS pain scores from 7.2 to 2.4 further supports the analgesic benefit of arthrodesis, which eliminates motion at the diseased joint and thereby reduces mechanical pain. The complications observed in this study pin site infection in 23.3%, nonunion in 6.7%, and malunion in 3.3% 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 [15]. 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 nonunion rate of 6.7% is comparable to the 9.9% reported in a large series of salvage ankle arthrodesis and reflects the challenging nature of achieving fusion in patients with severe deformity, bone loss, or prior infection [16]. 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 [12]. 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 such as total ankle arthroplasty may not be readily available or affordable.

LIMITATIONS

The single-center design, relatively small sample size (n=30), and absence of a control group limit generalizability. Lack of long-term follow-up beyond the study period may not capture adjacent joint arthritis or late hardware complications. Unmeasured confounding variables may have influenced outcomes.

CONCLUSION

Ilizarov-assisted ankle arthrodesis achieves a high union rate of 93.3% with a mean time to union of 16.8 weeks and significant functional improvement, with the mean AOFAS score increasing from 42.6 to 78.4 (p<0.001). The technique offers a reliable limb salvage option for advanced post-traumatic ankle osteoarthritis, with acceptable complication rates, particularly in resource-limited settings where alternative reconstructive procedures may be unavailable.

RECOMMENDATIONS

We recommend Ilizarov-assisted ankle arthrodesis for advanced post-traumatic ankle osteoarthritis, particularly in complex cases with deformity, infection, or bone loss. 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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CONFLICT OF INTEREST

None declared

ETHICAL APPROVAL

The study was approved by the Institutional Ethics Committee

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