

Original Research Article

Clinical outcomes of Ilizarov external fixation in the management of infected tibial non-union: an observational study from Bangladesh

Mohammad Mohsin Mia^{1*}, Muhammad Anwar Hossen¹, Shahnewas²,
M. Sahidur Rahman Khan³, M. Samsul Arefin⁴, M. Azizur Rahman²

¹Department of Ilizarov & Deformity Correction, National Institute of Traumatology and Orthopedic Rehabilitation (NITOR), Dhaka, Bangladesh

²Department of Orthopaedic Surgery, National Institute of Traumatology and Orthopedic Rehabilitation (NITOR) Dhaka, Bangladesh

³Department of Orthopaedics & Traumatology, National Institute of Traumatology and Orthopaedic Rehabilitation (NITOR), Dhaka, Bangladesh

⁴Department of Orthopaedic Surgery, Kushtia Medical College, Kushtia, Bangladesh

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*Correspondence:

Dr. Mohammad Mohsin Mia,

E-mail: drmohsinsbmc34@gmail.com

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ABSTRACT

Background: Infected tibial nonunion involves persistent infection, impaired bone biology, mechanical instability, and often bone loss or deformity. Ilizarov fixation enables debridement, stable fixation, compression, and bone transport but may require prolonged treatment and carries frequent complications.

Objective: To evaluate union, infection eradication, Association for the Study and Application of Methods of Ilizarov (ASAMI) outcomes, external fixation duration, and complications following Ilizarov treatment of infected tibial nonunion at a tertiary orthopaedic centre in Bangladesh.

Methods: This observational study reviewed 37 adults treated at the Department of Orthopaedic Surgery, National Institute of Traumatology and Orthopaedic Rehabilitation, Dhaka, from 1 July 2022 to 31 July 2025. Radical debridement, individualized Ilizarov fixation, and culture-directed antibiotics were used; bone transport was performed when required. Patients were followed for 12 months, with descriptive analysis based on last follow-up data.

Results: Mean age was 33.7±11.4 years; 28 (75.7%) were men. Initial fractures were open in 25 (67.6%), and 15 (40.5%) had bone defects >2 cm. Union occurred in 34 (91.9%) after 5.8±1.4 months, and infection was eradicated in 33 (89.2%). Excellent/good ASAMI bone and functional outcomes occurred in 30 (81.1%) and 32 (86.5%), respectively. Mean external fixation duration was 7.4±1.5 months. Complications occurred in 28 (75.7%); pin-tract infection affected 16 (43.2%). One patient underwent amputation for persistent infection and sepsis.

Conclusion: Ilizarov treatment achieved high observed union, infection eradication, and favourable ASAMI outcomes, but complications and prolonged frame treatment remained substantial.

Keywords: Ilizarov technique, Infected tibial nonunion, Fracture-related infection, Distraction osteogenesis, External fixation, ASAMI

INTRODUCTION

Tibial fractures are particularly vulnerable to impaired healing because the anteromedial surface has limited soft-tissue coverage and is readily exposed during high-energy

injury. Across observational studies synthesized in a systematic review, the pooled prevalence of tibial nonunion was 6.8%, with open injury, severe soft-tissue damage, high-energy mechanisms and infection among the factors associated with nonunion.¹ Once infection

complicates a nonunion, treatment must address bacterial persistence, devitalized bone, soft-tissue compromise, deformity, limb shortening and mechanical instability, often in patients who have already undergone several procedures. Modern fracture-related infection guidance distinguishes confirmatory findings, such as a draining sinus, purulence or microbiological evidence from deep tissue samples, from suggestive clinical and laboratory features.^{2,3} Successful management therefore depends on more than antimicrobial therapy. Thorough debridement, reliable stabilization, dead-space management, appropriate soft-tissue coverage and culture-directed antibiotics form a coordinated treatment strategy.⁴ Applying all elements consistently can be difficult where microbiology, plastic surgery, specialist implants and longitudinal follow-up are constrained. The review by Tissingh et al. emphasized that consensus principles remain relevant in low-resource settings, although local pathways must account for access and capacity.⁵ The Ilizarov method combines tensioned circular fixation with compression or distraction osteogenesis. It can stabilize the tibia while allowing gradual correction of deformity, restoration of length and transport of viable bone across a segmental defect. Because the infected focus can be radically excised without relying on permanent internal fixation at that site, the technique is attractive for complex infected nonunion. Its biological and mechanical versatility is well described, but treatment can be prolonged and demanding, with pin-site infection, wire problems, joint stiffness, regenerate or docking-site complications and patient intolerance among the recognized burdens.^{6,7} Available clinical evidence is derived mainly from heterogeneous observational cohorts. In a systematic review of 24 Ilizarov studies involving 590 infected tibial or femoral nonunions, mean union was 97.3%, although definitions, case mix and reporting varied substantially.⁸ More recent syntheses have placed Ilizarov treatment alongside other reconstructive options. No statistically significant difference in union or infection clearance was identified between distraction osteogenesis and the induced membrane technique in the meta-analysis by Wakefield et al.⁹ Similarly, comparable infection clearance was reported for Ilizarov methods and antibiotic cement-coated intramedullary nails in the systematic review by Piercey et al.¹⁰ These findings support individualized treatment selection and caution against interpreting high observational success rates as comparative superiority. Published South Asian cohorts demonstrate that Ilizarov reconstruction is feasible in specialist centres, but sample sizes are usually small and complication definitions are inconsistent.¹¹⁻¹⁴ Evidence from Bangladesh is even more limited. A small open-access report from Chattogram described tibial nonunion outcomes after Ilizarov fixation, but its 12-patient sample and mixed nonunion characteristics restrict inference about infected cases.¹⁵ A larger, internally consistent description from a national referral centre would therefore add useful local evidence, particularly if outcomes and complications are reported transparently. This study aimed to describe the clinical outcomes of Ilizarov external fixation for infected tibial nonunion at a tertiary

orthopaedic referral centre in Dhaka. The prespecified outcomes were bone union, time to union, infection eradication, ASAMI bone and functional results, duration of external fixation and treatment-related complications.

METHODS

This prospective observational study reviewed records of patients treated in the Department of Orthopaedic Surgery at the National Institute of Traumatology and Orthopaedic Rehabilitation, Dhaka, Bangladesh, from 1 July 2022 to 31 July 2025. Records of 37 adults with infected tibial nonunion were included. Diagnosis required clinical and radiographic failure of union, including absent bridging on at least three cortices, together with clinical and/or microbiological evidence of infection. Records were excluded where systemic sepsis was documented at presentation, where severe peripheral vascular disease was recorded, or where the record was too incomplete to establish the diagnosis and the prespecified outcomes. Withdrawal from frame treatment after the index procedure was treated as an outcome rather than an exclusion criterion. Clinical, radiological, laboratory, operative and follow-up data were extracted from the available records. Treatment comprised radical debridement, sequestrectomy, removal of previous implants when present and individualized two-to-four-ring Ilizarov fixation. Hypertrophic nonunions were compressed; defects greater than 2 cm were treated with metaphyseal corticotomy and bone transport at approximately 1 mm/day when indicated. Soft-tissue defects were closed primarily or treated with graft or flap coverage. Culture-directed intravenous antibiotics were administered for approximately two weeks, followed by oral therapy for four to six weeks. Pin-site care, progressive weight-bearing and physiotherapy were instituted. Follow-up duration was 12 months. Outcomes were assessed using data recorded at each patient's last documented follow-up during this 12-month period. During active treatment, follow-up intervals varied according to clinical need; frame removal required bridging across at least three cortices and clinical stability. Primary outcomes were union and infection eradication; secondary outcomes included time to union, ASAMI bone and functional grades, external fixation duration and complications. Bone and functional results were graded using the Association for the Study and Application of Methods of Ilizarov criteria, in which a nonunion is classified as a poor bone result irrespective of the remaining criteria.¹⁶ Data were analysed descriptively in SPSS version 26 using mean, standard deviation, range, frequency and percentage. Institutional ethical approval was obtained from the study hospital.

RESULTS

Participant and injury characteristics

The study included 37 adults with infected tibial nonunion. Their mean age was 33.7±11.4 years, and 28 (75.7%) were

men. Road traffic injury accounted for 27 cases (73.0%). The initial fracture was open in 25 patients (67.6%), and

the mean interval from injury to presentation was 7.4 ± 3.2 months (Table 1).

Table 1: Demographic and injury characteristics, (n=37).

Characteristics	Values
Age, years	33.7 $\pm$ 11.4 (18 to 58)
Male sex	28 (75.7%)
Female sex	9 (24.3%)
Road traffic injury	27 (73.0%)
Fall from height	7 (18.9%)
Sports-related injury	3 (8.1%)
Initially open fracture	25 (67.6%)
Initially closed fracture	12 (32.4%)
Time from injury to presentation, months	7.4 $\pm$ 3.2 (4 to 18)

Continuous variables are shown as mean $\pm$ standard deviation (range); categorical variables are shown as number (percentage).

Nonunion characteristics and microbiology

Atrophic non-union was present in 24 patients (64.9%). Fifteen patients (40.5%) had a recorded bone defect greater

than 2 cm. The reported mean defect was 4.3 ± 2.7 cm, with a range of 2 to 9 cm. Staphylococcus aureus was the most frequent isolate, recovered in 18 patients (48.6%). No growth was recorded in 11 cases (29.7%) (Table 2).

Table 2: Nonunion characteristics and intraoperative microbiology, (n=37).

Characteristics	N (%) or mean $\pm$ SD (range)
Atrophic nonunion	24 (64.9%)
Hypertrophic nonunion	13 (35.1%)
Recorded bone defect >2 cm	15 (40.5%)
Reported bone-defect length, cm	4.3 $\pm$ 2.7 (2 to 9)
Staphylococcus aureus	18 (48.6%)
Pseudomonas aeruginosa	5 (13.5%)
Escherichia coli	2 (5.4%)
Proteus mirabilis	1 (2.7%)
No growth	11 (29.7%)

Microbiology categories total 37. The reported defect-length denominator was not separately documented in the source record.

Bone union, infection control and frame duration

Union was achieved in 34 patients (91.9%) after a mean of 5.8 ± 1.4 months. Infection was eradicated in 33 patients (89.2%). Mean external fixation duration was 7.4 ± 1.5 months. At the last documented follow-up, of the three patients without union, one underwent amputation because of persistent infection and sepsis, one underwent revision

Ilizarov fixation and one was converted to intramedullary nailing (Table 3).

ASAMI outcomes

ASAMI bone results were excellent or good in 30 patients (81.1%). Functional results were excellent or good in 32 patients (86.5%). The complete distributions are presented in (Table 4).

Table 3: Primary clinical outcomes, (n=37).

Outcomes	Values
Bone union	34 (91.9%)
Nonunion at last documented follow-up	3 (8.1%)
Time to union, months	5.8 $\pm$ 1.4 (3.5 to 9.0)
Infection eradication	33 (89.2%)
Infection not eradicated	4 (10.8%)
External fixation duration, months	7.4 $\pm$ 1.5 (5.0 to 12.0)

Note: Values are number (percentage) or mean $\pm$ standard deviation (range). Time to union applies to patients who achieved union.

Complications

At least one complication was documented in 28 patients (75.7%). Pin-tract infection was the most frequent event, affecting 16 patients (43.2%); four of these patients

required intravenous antibiotics and wire exchange. Limb-length discrepancy occurred in five patients, with a mean of 1.8 ± 0.9 cm. Complication categories overlapped because individual patients could experience more than one event (Table 5).

Table 5: Treatment-related complications, (n=37).

Complications	N (%)
Any recorded complication	28 (75.7%)
Pin-tract infection	16 (43.2%)
Pin-tract infection requiring intravenous antibiotics and wire exchange	4 (10.8%)
Infection not eradicated at last documented follow-up	4 (10.8%)
Limb-length discrepancy	5 (13.5%)
Ankle stiffness	3 (8.1%)
Knee stiffness	2 (5.4%)
Wire loosening or breakage	2 (5.4%)

Patients could have more than one complication; percentages therefore do not sum to 100%. The severe pin-tract infection row is a subset of all pin-tract infections

Anteroposterior radiographs of right lower extremities display structural asymmetry, featuring a normal shaft alignment of the right tibia and fibula contrasting with distal metaphyseal-diaphyseal irregular osseous expansion, cortical thickening, and localized sclerosis near the distal ankle joint, along with compensatory hyperostosis in the adjacent fibula and preserved proximal knee joint space (Figure 1).



Figure 1: Anteroposterior radiograph of right leg (Tibia/Fibula).

Leg shows a segmental tibial bone graft/intercalary construct in situ, featuring a central non-vascularized fibular strut or intercalary bone graft flanked by periosteal and endosteal bridging calluses at both proximal and distal junctional interfaces, accompanied by an associated healing mid-shaft fibular fracture and alignment maintenance across the ankle joint within an external cast/splint immobilizer (Figure 2).

Anteroposterior and lateral radiographs of the right lower limb demonstrate a multi-ring Ilizarov external fixator construct stabilized with transfixion wires and threaded

rods, managing a significant mid-to-distal segmental bone defect of the tibia with early distraction gap formation, alongside a concomitant healing fibular osteotomy/fracture (Figure 3).



Figure 2: Anteroposterior and lateral radiographs of the right leg.

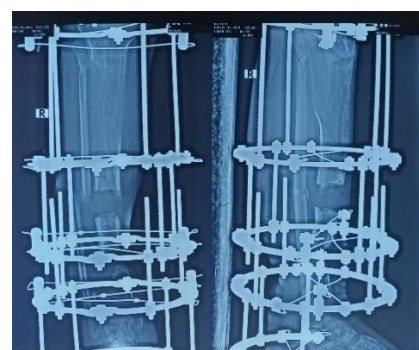


Figure 3: Postoperative radiographs of the right leg with ring fixator.

Clinical photograph demonstrating a seated patient with a multi-ring Ilizarov circular external fixator applied to the right lower leg for distraction osteogenesis/limb reconstruction, showing multiple pin-site dressing pads

along the transfixion wires, an anterior longitudinal surgical/skin graft scar along the leg, and preserved weight-bearing alignment compared to the contralateral uninjured left lower extremity (Figure 4).



Figure 4: Circular external fixator applied to the right lower extremity.

DISCUSSION

In this observational study, records of 37 infected tibial nonunions treated with Ilizarov external fixation were reviewed at a national tertiary orthopaedic centre in Bangladesh. The principal findings were union in 91.9%, infection eradication in 89.2%, excellent or good ASAMI bone results in 81.1% and excellent or good functional results in 86.5%. These outcomes were achieved with a mean frame duration of 7.4 months. Treatment burden was substantial, however, because three-quarters of patients had at least one recorded complication and pin-tract infection affected 43.2%. The case mix was typical of high-energy tibial trauma in working-age adults. Men comprised 75.7% of the cohort, road traffic injury accounted for 73.0%, and two-thirds of initial fractures were open. The systematic review by Tian et al. identified male sex, high-energy trauma, open fracture and infection among factors associated with tibial nonunion.¹ The predominance of atrophic nonunion and the presence of defects greater than 2 cm in 40.5% further indicate biologically and mechanically complex disease. Because no comparison group was available, these characteristics should be viewed as a description of referral practice rather than predictors of outcome. The observed union rate falls within the broad range reported for Ilizarov reconstruction. A pooled mean union rate of 97.3% was reported in the meta-analysis by Yin et al., but the contributing studies varied in anatomical site, defect size, operative strategy and outcome definition. High union proportions have also been reported in prospective and retrospective South Asian studies, including cohorts described by Madhusudhan et al., Wani and Syed, Fahad et al. and Bakhsh et al.^{8,11,12,13} In patients with defects of at least 5 cm, the prospective study by Kukreja et al. further illustrates the reconstructive

reach of bone transport, although that cohort was more severe than the present sample.¹⁷ Such comparisons are useful for context, but they do not establish equivalence because referral thresholds, debridement protocols and follow-up differ. Infection eradication in 89.2% is also broadly compatible with contemporary syntheses. The systematic review by Piercey et al. reported infection clearance of 93.8% across Ilizarov cohorts used in single-stage revision, while the meta-analysis by Wakefield et al. reported pooled infection elimination of 93.0% after distraction osteogenesis.^{9,10} Neither review supports a claim that Ilizarov fixation is universally superior. In the Wakefield analysis, differences from the induced membrane technique were not statistically significant, and evidence quality was limited by heterogeneity and mostly nonrandomized studies. In the Piercey analysis, antibiotic cement-coated intramedullary nails produced statistically comparable clearance and union. Choice of reconstruction should therefore reflect defect size, soft-tissue condition, microbial factors, local expertise and patient preference. The microbiological distribution requires careful interpretation. *Staphylococcus aureus* was isolated most often, while 29.7% of cultures showed no growth. Current diagnostic recommendations favour multiple deep tissue specimens obtained with separate instruments and caution against relying on superficial sinus swabs.^{2,3} The source record did not document the number of specimens, incubation conditions or prior antibiotic exposure, so culture-negative results cannot be distinguished from sampling limitations. Future prospective work should embed standardized fracture-related infection sampling and record resistance profiles, including the organisms described as multidrug resistant. Bone and functional status were favourable in most patients, although bone scores were modestly lower than functional scores. The combined excellent-or-good proportions of 81.1% for bone and 86.5% for function are consistent with the generally favourable ASAMI distributions summarized by Yin et al.⁸ In a recent synthesis of infected tibial nonunions with segmental loss, excellent-or-good pooled bone and functional results after distraction osteogenesis were approximately 89% and 87%, respectively.⁹ These cross-study comparisons remain approximate because ASAMI components, follow-up timing and handling of reoperations are not always uniform. Complications were common, as expected during prolonged circular fixation. Pin-tract infection was documented in 43.2%, although only four patients required intravenous antibiotics and wire exchange. Across prevention trials reviewed by Shields et al, reported pin-site infection rates varied widely because definitions and care protocols differed; no single cleansing or dressing strategy was consistently superior across all settings.¹⁸ The 75.7% overall complication proportion in this series should not be interpreted as treatment failure, because categories included manageable events and could overlap. It nevertheless demonstrates that surveillance, access to early treatment and patient education are integral to the procedure. The larger bone-transport cohort analysed by Feng et al. also showed that complication risk is influenced by treatment duration,

defect characteristics and previous procedures.⁷ This study has practical relevance for a resource-constrained referral service. Ilizarov reconstruction can combine stability, defect management and limb-length restoration in one platform, but it demands trained surgeons, reliable follow-up, physiotherapy, microbiology support and capacity for soft-tissue reconstruction. Consensus recommendations place debridement, stability, dead-space management, soft-tissue cover and culture-directed antibiotics at the centre of fracture-related infection care.⁴ The review by Tissingh et al. further stresses that low-resource pathways should preserve these principles while adapting referral networks and multidisciplinary input to local availability.⁵ The study also highlights the need to report outcomes beyond union. Mean frame duration exceeded mean time to union, and at least one patient ultimately underwent amputation. Future cohorts should prospectively record quality of life, pain, return to work, treatment cost, time to independent weight bearing, psychological burden, reoperation, refracture and recurrence after antibiotic cessation. A multicentre registry with agreed fracture-related infection definitions and a complete screening log would allow risk-adjusted analyses and more credible comparisons between Ilizarov fixation, antibiotic-coated nails and induced membrane reconstruction.

Limitations of the study

Important limitations are the observational design, small single-centre sample, absence of a control group, feasibility-based record selection and lack of adjustment for defect size, host status, previous operations or microbiology. Follow-up duration was 12 months, and outcomes were assessed using data recorded at each patient's last documented follow-up; events occurring after 12 months, including late recurrence and refracture, were not captured. The available records did not provide a complete screening log, patient-reported outcomes, a detailed deep-sampling protocol or recurrence data after antimicrobial cessation. Complications specific to bone transport, including docking-site problems, regenerate deficiency and axial deviation, were not separately recorded in the source documentation and are therefore not reported; their absence from Table 5 should not be read as an absence of such events.

CONCLUSION

Ilizarov external fixation was associated with union in 91.9% and infection eradication in 89.2% of 37 adults treated for infected tibial nonunion at a tertiary centre in Bangladesh. Most patients achieved excellent or good ASAMI outcomes, but complications were frequent and mean frame treatment exceeded seven months. These data support Ilizarov reconstruction as a viable limb-salvage option in appropriately selected complex cases. Confirmation in larger multicentre cohorts using standardized fracture-related infection definitions, complete longitudinal follow-up and patient-reported outcomes is needed.

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Conflict of interest: None declared

Ethical approval: The study was approved by the Institutional Ethics Committee

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