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Original Research Article

Efficacy of Ilizarov Technique in the Treatment of Infected Nonunion of the Tibia

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Abstract: *Infected non-union of the tibia remains a significant clinical challenge due to the bone's subcutaneous location and high risk of complications such as delayed healing and infection. The Ilizarov external fixator is increasingly recognized as an effective method for managing such cases, offering biomechanical stability and facilitating bone regeneration.* ***Objective:*** *To evaluate the outcomes of Ilizarov external fixation in treating infected tibial non-unions, focusing on bone healing, functional results, and complications.* ***Methods:*** *A retrospective study was conducted at the Department of Orthopaedic Surgery, Shaikh Zayed Hospital, Lahore, from January 2022 to December 2023. A total of 52 patients with infected tibial non-union were included. Patient records were reviewed for microbiological findings, duration of treatment, union rates, bone and functional outcomes using the ASAMI (Association for the Study and Application of the Method of Ilizarov) grading system, and complication rates.* ***Results:*** *Staphylococcus aureus was the most commonly isolated organism. At final follow-up, union was achieved in 50 out of 52 patients (96.2%). One patient required amputation due to persistent non-union and sepsis. Based on ASAMI bone results, 23 patients (44.2%) had excellent outcomes, 20 (38.5%) had good outcomes, 6 (11.5%) had fair outcomes, and 3 (5.8%) had poor outcomes. Functional outcomes were satisfactory in the majority of patients.* ***Conclusion:*** *The Ilizarov technique is highly effective for managing infected tibial non-unions. It enables bone union, deformity correction, infection control, and early weight-bearing. Its use should be strongly considered in treating complex tibial non-unions secondary to infection.*

Keywords: Ilizarov Technique, Tibial Fractures, Nonunion, Infection, External Fixators, Bone Regeneration, Staphylococcus aureus, Orthopedic Procedures

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Introduction

Infected nonunion of the tibia is one of the most complex and challenging complications in orthopedic trauma, especially in developing countries like Pakistan, where delayed diagnosis, inadequate initial management, and limited access to specialized care contribute to poor outcomes. Nonunion, particularly when accompanied by infection, often results from open fractures, repeated surgeries, or the presence of implants, leading to prolonged disability, chronic pain, and compromised limb function (1). The subcutaneous nature of the tibia, compounded by compromised blood supply in traumatic injuries, further predisposes this bone to complications such as osteomyelitis and delayed healing (2). In Pakistan, the burden of traumatic injuries resulting in open tibial fractures is high due to road traffic accidents, falls, and occupational hazards (3). Rural populations and under-resourced healthcare systems often lack immediate access to orthopedic expertise, resulting in mismanagement of fractures and a higher incidence of infected nonunion (4). This condition not only imposes a physical and psychological toll on patients but also creates a significant socioeconomic burden through repeated hospitalizations, prolonged rehabilitation, and loss of productivity (5). Based on distraction osteogenesis principles, the Ilizarov technique has gained global recognition for its ability to address complex orthopedic pathologies, including infected nonunion. The Ilizarov method offers a comprehensive solution that promotes bone regeneration and infection control by providing a stable mechanical environment while simultaneously addressing infection, bone loss, and deformity (6). Its application in resource-limited settings has been particularly effective due to its adaptability, cost-effectiveness, and ability to manage multiple challenges—nonunion, infection, and limb shortening—within a single intervention (7). Recent studies have demonstrated promising outcomes with the Ilizarov technique in achieving bone union, eradicating infection, and restoring limb function, even in cases with segmental bone loss and extensive soft tissue compromise (8,9). However, most of this literature stems from high-income countries, and evidence from local populations remains limited. In Pakistan, only a few institutions have adopted the technique systematically, and comprehensive outcome data from these centers are scarce (10). Therefore, this study aims to evaluate the Ilizarov technique's efficacy in managing infected tibial nonunion in a Pakistani tertiary care setting. By assessing bone union rates, infection control, limb function, and complication profiles, this research seeks to contribute localized evidence for orthopedic practice and support broader adoption of this technique in complex post-traumatic limb reconstruction.

Methodology

This retrospective study evaluated hospital records of 52 patients treated for infected non-union of the tibia using the Ilizarov method at a tertiary care hospital. Ethical approval was obtained from the Institutional Review Board prior to data collection. The study included cases treated between January 2022 and December 2023. Inclusion criteria for the study consisted of tibial non-union persisting for a minimum duration of six months, confirmed infection at the non-union site, and either a bone defect exceeding 2.5 cm or a previously unsuccessful surgical intervention such as exchange nailing or bone grafting. Patients with non-infected tibial non-union and those with infected fractures lasting less than six months were excluded from the study. Fellowship-trained orthopedic surgeons conducted all procedures with at least five years of experience in the Ilizarov technique. Patient demographic data, the etiology of the initial injury, total number of prior surgeries, type of previous fixation methods (internal or external), and microbiological culture results were documented. The severity and classification of the non-union were determined based on the presence and activity of infection and the extent of bone loss. A standardized proforma systematically collected information regarding perioperative complications and subsequent procedures.

Initial fracture management included open reduction and internal fixation (ORIF) in 17 patients, external fixation in 15 patients, intramedullary nailing in 11 patients, and casting in seven patients. Two patients experienced non-union following initial Ilizarov fixation as their primary treatment method. The average number of previous surgical interventions was two (0–14).

Patients underwent surgery under general anesthesia on a radiolucent table in a supine position. Preoperative planning included assessment of limb length, location of infected non-union, and joint functionality (ankle and knee). Surgical landmarks, including incision lines, scope of resection, and osteotomy sites, were marked preoperatively. The Ilizarov fixator was assembled and fixed onto the tibial shaft, ensuring parallel alignment of Ilizarov rings to the adjacent joints and maintaining pins perpendicular to the tibia's mechanical axis under fluoroscopic guidance. Radical debridement of infected bone and soft tissues was performed following fixation placement until bleeding bone edges were visible. Fibular osteotomy, with segment excision, was performed through a sub-periosteal transverse osteotomy in cases presenting with deformity or shortening. Postoperatively, all patients received intravenous antibiotics for two weeks, guided by culture and sensitivity results. Patients with negative cultures received empirical broad-spectrum antibiotics covering gram-positive and gram-negative pathogens for four weeks. Patients were encouraged to commence full weight-bearing using crutches, alongside initiating isometric and range-of-motion exercises from the first postoperative day. Bone distraction began after a latency period of 5–7 days, with a distraction rate of 0.25 mm every 6 hours. Upon completion of distraction, compression at the tibial docking site was performed at 0.25 mm daily, ensuring full contact without causing discomfort. Data on external fixation duration, bone transport duration, external fixation index, and complications were recorded. Radiographic monitoring was conducted every two weeks during distraction and monthly throughout consolidation until evidence of robust union at the docking site and at least three cortices in regenerated bone was confirmed, after which the fixator was removed. Bone and functional outcomes were objectively evaluated using the Association for the Study and Application of the Methods of Ilizarov (ASAMI) classification system.

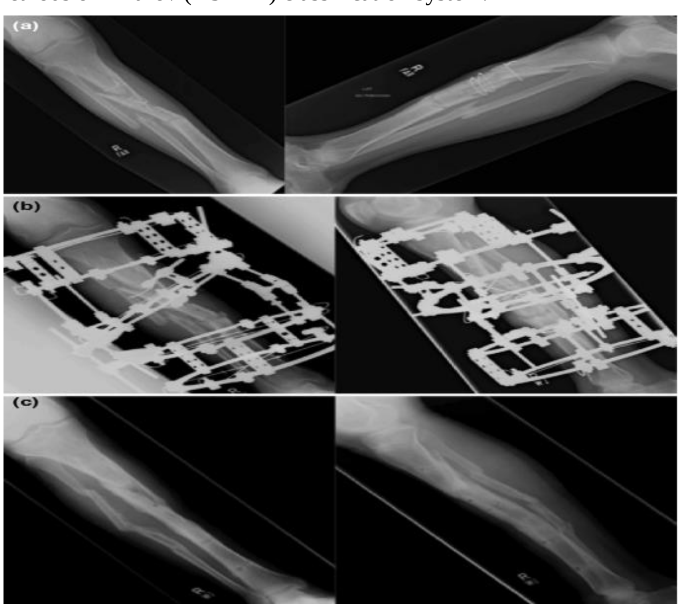

Figure 1: Patient 1's radiographs. (a) Anteroposterior and lateral images of the tibia before surgery demonstrate tibia nonunion. (b) Antero-posterior and lateral views following Ilizarov application. (c) Antero-posterior and lateral images at the last follow-up, demonstrating bony union.

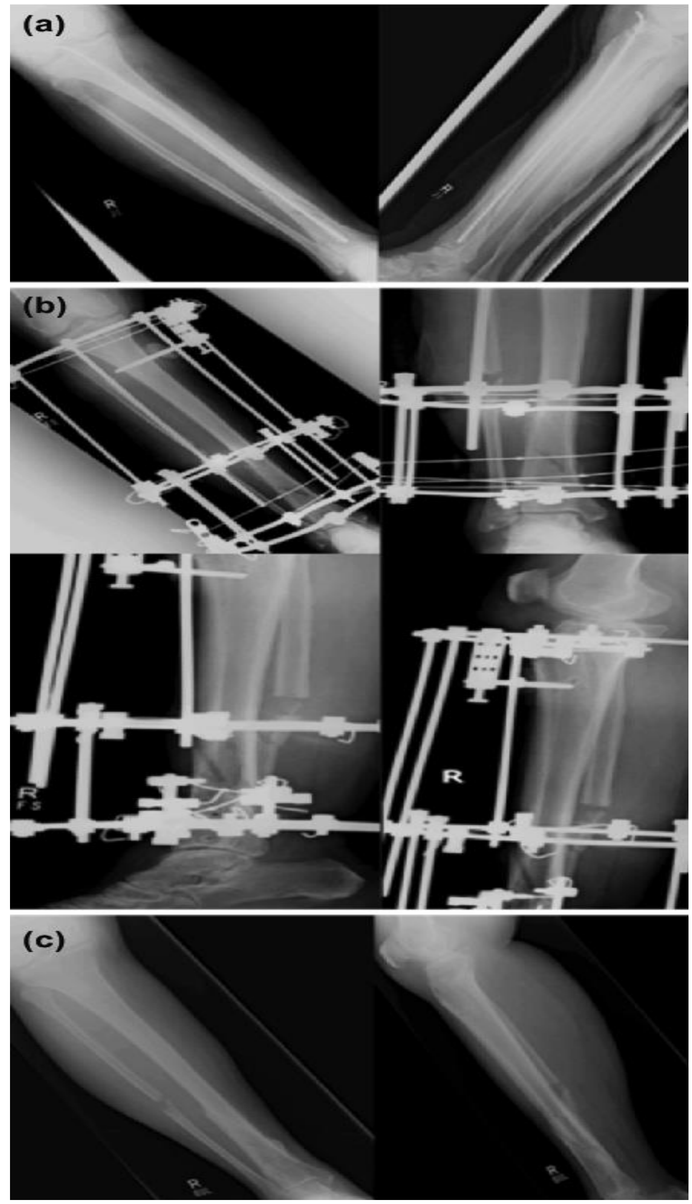

Figure: 2 Patient 2's radiographs. (a) Anteroposterior and lateral images of the tibia before surgery demonstrate tibia nonunion. (b) Anteroposterior and side (bottom row) views following Ilizarov application. (c) Final follow-up: Anteroposterior and lateral images demonstrating bony union.

Results

The study included 52 patients, with a mean age of 46.65 ± 17.69 years. The majority were males (n=44, 84.61%), while females accounted for a smaller proportion (n=8, 15.38%). The average duration of Ilizarov external fixation was approximately 11 months, with an average follow-up period of 37.84 months (range: 3-46 months). The predominant cause of tibial nonunion was road traffic accidents (63.46%), followed by falls from height (21.15%), gunshot injuries (11.53%), and blast injuries (3.84%) (Table 1).

Microbiological analysis revealed positive cultures in 29 patients (55.76%), with Staphylococcus aureus being the most common organism (34.61%). Escherichia coli, Pseudomonas aeruginosa, and Proteus mirabilis were less frequently isolated (Table 2).

At the final follow-up, 50 patients (96.15%) achieved full weight-bearing capacity. However, 13 patients (25%) continued to experience pain during weight-bearing activities. The mean bone defect length was 3.6 cm (2-6 cm), and the external fixation index averaged 62 days/cm (45-120 days/cm). Soft tissue defects requiring coverage were present in eight patients (15.38%); local flaps were used in seven patients, while one required a free flap. The mean duration of surgery was 185 minutes (range: 120-300 minutes).

Preoperative limb length discrepancy was observed in 30 patients, of whom correction was achieved in 23 (76.67%). Seven patients (13.46%) had residual limb length discrepancies postoperatively, with five patients having discrepancies less than 2 cm. Clinical and radiological evidence confirmed infection eradication in 50 patients (96.15%). Based on the ASAMI bone grading system, outcomes were excellent in 23 patients (44.23%), good in 20 (38.46%), fair in six (11.53%), and poor in three patients (5.76%). Functional outcomes were excellent in 25 patients (48.07%), good in 21 (40.38%), fair in four (7.69%), and poor in two patients (3.84%) (Table 3).

Postoperative complications were noted in several cases, with pin-track infection being the most common (19.23%). Non-union and wire loosening were observed in two patients each (3.84%), while reinfection, leg abscess, Schanz screw fracture, and septic arthritis were less frequent complications (Table 4)

Table 1: Primary Causes of Tibial Nonunion (N=52)

Cause of Injury	Frequency	Percentage (%)
Road traffic accident	33	63.46
Fall from height	11	21.15
Gunshot injury	6	11.53
Blast injury	2	3.84

Table 2: Microorganisms Isolated from Cultures

Microorganism	Frequency	Percentage (%)
Staphylococcus aureus	18	34.61
Pseudomonas aeruginosa	7	13.46
Escherichia coli	3	5.76
Proteus mirabilis	1	1.92

Table 3: Bone and Functional Outcomes (ASAMI Criteria)

Outcome Grade	Bone Results n (%)	Functional Results (%)
Excellent	23 (44.23%)	25 (48.07%)
Good	20 (38.46%)	21 (40.38%)
Fair	6 (11.53%)	4 (7.69%)
Poor	3 (5.76%)	2 (3.84%)

Table 4: Postoperative Complications

Complication	Frequency	Percentage (%)
Pin-track infection	10	19.23
Limb length discrepancy	7	13.46
Non-union	2	3.84
Wire loosening/broken	2	3.84
Reinfection	1	1.90
Leg abscess	1	1.90
Schanz screw fracture	1	1.90
Septic arthritis	1	1.90

Discussion

The Ilizarov technique has demonstrated high efficacy in managing infected tibial nonunion, with our study showing bone union in 96.15% of patients and infection eradication in a similar proportion. These outcomes align with several previous studies. For example, a study by Sharma et al. reported a bone union rate of 94.5% and functional recovery in 87.2% of cases treated with the Ilizarov method for infected tibial nonunion (11). Similarly, Harshwal et al. also reported favorable outcomes, with 92% of patients achieving union and infection control (12).

The mean age in our cohort (46.65 ± 17.69 years) and male predominance (84.61%) are consistent with trends noted in earlier research. Men are more likely to be involved in high-energy trauma, particularly road traffic accidents, which were the leading cause of injury in our study (63.46%). Comparable data have been reported in studies conducted in both regional and international settings (13, 14).

Staphylococcus aureus was the predominant microorganism isolated (34.61%), a finding echoed by earlier works indicating its leading role in chronic osteomyelitis and infected nonunions (15, 16). Gram-negative organisms like Pseudomonas aeruginosa and Escherichia coli also reflect the polymicrobial nature of chronic bone infections in our setup, particularly in cases following open fractures or surgical interventions.

Our average external fixation index was 62 days/cm, which is slightly higher than that reported by Yin et al., who noted an index of around 55 days/cm. This is likely due to variability in patient compliance, soft tissue involvement, and defect size (17). However, our rate of successful limb length equalization (76.67%) and correction of deformities is encouraging and reflects effective use of the Ilizarov frame.

In terms of ASAMI criteria, we achieved excellent to good bone results in 82.69% of patients, and functional outcomes were excellent to good in 88.45%, comparable to those documented by Rijal et al., who reported 86% excellent-to-good bone results using a similar approach (18).

The most common complication in our cohort was pin-track infection (19.23%), which aligns with global incidence rates ranging from 10% to

30% (19). Rigorous pin site care protocols and patient education can help minimize this risk. Other complications, such as wire loosening, limb length discrepancy, and reinfection, were relatively infrequent, reflecting the technical proficiency of the surgical team and diligent follow-up.

In the Pakistani context, these findings emphasize the practical utility of the Ilizarov method in resource-limited environments where repeated internal fixation may not be feasible due to economic constraints or high infection risk. Our study reinforces the role of this technique not just in achieving bone union and restoring function and quality of life for patients with complex orthopedic infections.

Conclusion

The Ilizarov technique proved to be a highly effective modality for treating infected tibial nonunion in our cohort, with high rates of bone union (96.15%), infection eradication, and satisfactory functional outcomes. Despite the prolonged duration of treatment and associated complications such as pin-track infections, the method remains a viable and reliable option, especially in complex cases involving bone defects and limb length discrepancies. In resource-limited settings like Pakistan, where treatment options for chronic bone infections are limited, the Ilizarov method offers a cost-effective, limb-saving solution that facilitates structural and functional restoration.

Declarations

Data Availability statement

All data generated or analysed during the study are included in the manuscript.

Ethics approval and consent to participate

Approved by the department concerned. (IRBEC-24)

Consent for publication

Approved

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Conflict of interest

The authors declared the absence of a conflict of interest.

Author Contribution

AF (Medical Officer),
Manuscript drafting, Study Design,
MHS (Postgraduate Resident)
Review of Literature, Data entry, Data analysis, and article drafting.
AM (Trainee Registrar)
Conception of Study, Development of Research Methodology Design, Study Design, manuscript review, and critical input.

All authors reviewed the results and approved the final version of the manuscript. They are also accountable for the integrity of the study.

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