e-ISSN: 0976-822X, p-ISSN:2961-6042

Available online on http://www.ijcpr.com/

International Journal of Current Pharmaceutical Review and Research 2026; 18(9); 622-627

Original Research Article

Functional and Radiological Outcomes of Infected Non-union of the Femur and Tibia Treated with the Ilizarov Ring Fixator: A Prospective Observational Study

Badal Zaveri[1], L.N. Meena[2], Vivesh Singh[3]

[1]Resident, Department of Orthopaedics, Pacific Institute of Medical Sciences, Umarda, Udaipur, Rajasthan, India

[2]Professor and Head, Department of Orthopaedics, Pacific Institute of Medical Sciences, Umarda, Udaipur, Rajasthan, India

[3]Assistant Professor, Department of Orthopaedics, Pacific Institute of Medical Sciences, Umarda, Udaipur, Rajasthan, India

Received: 01-06-2026 / Revised: 15-07-2026 / Accepted: 21-08-2026

Corresponding author: Dr. Badal Zaveri

Conflict of interest: Nil

Abstract

Background: Infected fracture non-union of the femur and tibia represents a challenging orthopaedic problem, particularly when associated with bone loss, deformity, limb-length discrepancy, compromised soft tissues, and persistent infection. Conventional treatment frequently requires multiple procedures and prolonged periods of immobilisation. The Ilizarov ring fixator provides simultaneous mechanical stabilisation and biological stimulation through distraction osteogenesis and permits management of bone defects and deformities while allowing early mobilisation.

Objective: To evaluate the functional and radiological outcomes of patients with infected non-union of the femur and tibia treated using the Ilizarov ring fixator and to assess the duration of treatment.

Methods: A prospective observational study was conducted in the Department of Orthopaedics at Pacific Institute of Medical Sciences, Umarda, Udaipur, Rajasthan, from April 2024 to October 2025. Fifty patients aged 16-75 years with infected non-union of the femur or tibia were included. Patients underwent treatment using an Ilizarov ring fixator, with procedures such as corticotomy, bone transport, bone grafting, debridement, and soft-tissue procedures performed according to individual requirements. Functional and bone outcomes were assessed using the Association for the Study and Application of Methods of Ilizarov (ASAMI) criteria.

Results: Of the 50 patients, 36 (72%) were male and 14 (28%) were female, with a mean age of 35.94 years and an age range of 16-65 years. Tibial non-union accounted for 36 (72%) cases and femoral non-union for 14 (28%). Road traffic accidents were the predominant mechanism of injury, accounting for 43 (86%) cases. Corticotomy was performed in 41 (82%) patients and bone grafting in 45 (90%). Bone union with absence of infection was achieved in 45 (90%) patients. According to ASAMI bone outcome criteria, 29 (58%) patients had excellent, 13 (26%) good, 3 (6%) fair, and 5 (10%) poor results. Functional outcomes were excellent in 21 (42%), good in 15 (30%), fair in 6 (12%), poor in 3 (6%), while 5 (10%) patients were classified as treatment failures requiring amputation.

Conclusion: The Ilizarov ring fixator provided satisfactory infection control, bone union, deformity correction, and functional recovery in a substantial proportion of patients with infected non-union of the femur and tibia. Its ability to simultaneously address infection, bone defects, deformity, and limb-length discrepancy makes it an effective limb-salvage option in complex infected non-unions. However, prolonged treatment and pin-site-related complications remain important limitations.

Keywords: Infected Non-Union; Femur; Tibia; Ilizarov Fixator; Distraction Osteogenesis; Bone Transport; ASAMI; limb Salvage.

DOI: 10.25258/ijcpr.18.9.90

Introduction

Infected fracture non-union is one of the most difficult complications encountered in orthopaedic trauma. Failure of fracture healing may result from inadequate stability, compromised vascularity, bone loss, infection, soft-tissue interposition, or a combination of biological and mechanical factors.

[1,2] The problem becomes considerably more complex when infection is accompanied by deformity, bone loss, limb-length discrepancy and soft-tissue deficiency. The tibia is particularly susceptible to infected non-union because of its subcutaneous location and relatively vulnerable soft-tissue envelope. Open fractures, especially high-grade open injuries, are frequently complicated by infection and impaired healing. In the present study, 42% of patients had Gustilo-Anderson type IIIB injuries and 32% had type IIIA injuries, demonstrating the severe nature of the initial trauma in this cohort. [1,2]

Treatment of infected non-union requires eradication of infection while simultaneously restoring mechanical stability and biological conditions conducive to bone healing. Conventional approaches may include repeated debridement, antibiotic therapy, internal or external fixation, bone grafting, soft-tissue reconstruction, and staged procedures. [3]

The Ilizarov technique, based on the principle of tension-stress-induced tissue regeneration and distraction osteogenesis, offers a unique solution to these problems. [1,2] It permits stable fixation after radical debridement, correction of deformity, treatment of segmental bone defects through bone transport, and limb-length restoration. [3,4] The technique also permits early weight bearing and joint mobilisation. Previous published series have demonstrated encouraging bone and functional outcomes with Ilizarov treatment of infected tibial non-union, supporting the role of Ilizarov reconstruction in complex infected non-unions. [5-9]

The present study was therefore undertaken to evaluate the functional and radiological outcomes of infected non-union of the femur and tibia treated using the Ilizarov ring fixator and to assess the duration required to complete treatment.

Materials and Methods

This was a prospective observational study conducted in the Department of Orthopaedics, Pacific Institute of Medical Sciences, Umarda, Udaipur, and Rajasthan. The study period extended from 1 April 2024 to 31 October 2025, with a total sample size of 50 patients. The study was conducted after obtaining approval from the Institutional Ethics Committee, Pacific Institute of Medical Sciences, Udaipur and was carried out in accordance with the principles of the Declaration of Helsinki and applicable national ethical guidelines for biomedical research involving human participants. Patients presenting to the outpatient department or admitted to the orthopaedic ward with infected non-union of the femur or tibia and subsequently treated with an Ilizarov ring fixator were considered for inclusion.

Inclusion Criteria

- Fracture of the femur or tibia persisting for at least 9 months without evidence of healing for 3 consecutive months, with superimposed infection.
- Age group of 16-65 years.

Exclusion Criteria

- Patients unwilling to provide informed consent.
- Pregnancy.
- Psychiatric illness.
- Neurological illness.

Written informed consent was obtained from all participants, or from a parent or legal guardian for participants below 18 years of age, prior to inclusion in the study and before each surgical procedure. Participants were informed of the purpose of the study, the procedures involved, and their right to withdraw at any stage without affecting their ongoing clinical care.

A detailed history was obtained regarding the original injury, duration since injury, previous surgical procedures, antibiotic treatment, smoking and alcohol use, and relevant comorbidities. Local examination included assessment of swelling, deformity, skin condition, tenderness, bony irregularity, movement, neurovascular status, limb-length discrepancy, bone gap, and associated complications. Laboratory investigations included haemogram, renal function tests, erythrocyte sedimentation rate and quantitative C-reactive protein. Cultures were obtained whenever discharge from a wound or sinus was present. Treatment was individualised according to the extent of infection, bone loss, deformity and soft-tissue condition. The management principles included eradication of infection through debridement, stabilisation using the Ilizarov ring fixator, and reconstruction of bone defects using distraction osteogenesis, corticotomy and/or bone transport when required. Bone grafting and soft-tissue procedures were used according to clinical requirements. Corticotomy was performed in 41 (82%) patients, while 45 (90%) underwent bone grafting. Patients were followed clinically and radiologically at approximately 3 weeks, 6 weeks, 3 months, 6 months, 12 months and 15 months. The study protocol included assessment of bone union, infection status, radiological alignment, limb-length discrepancy, knee and ankle movements and functional status. Bone and functional outcomes were assessed using the Association for the Study and Application of Methods of Ilizarov (ASAMI) criteria. The ASAMI bone criteria consider union, infection, deformity and limb-length discrepancy,

whereas the functional criteria assess activity, limp, joint stiffness, pain and related functional limitations. Data were entered into a structured proforma and analysed using descriptive statistics. Categorical variables were expressed as frequencies and percentages, and continuous variables as mean with range. Analysis was performed using Stata version 17.0.

This was a descriptive observational study; no formal inferential statistical testing was performed to identify independent predictors of union or functional outcome, and this is acknowledged as a limitation.

Results

Demographic Characteristics: Fifty patients were included. The mean age was 35.94 years, with an age range of 16-65 years.

The largest age group was 41-50 years, comprising 19 (38%) patients, followed by 21-30 years with 15 (30%). There were 36 (72%) males and 14 (28%) females, giving a male-to-female ratio of approximately 2.6:1.

Table 1: Demographic and injury characteristics

Variable	n (%)
Male	36 (72)
Female	14 (28)
Femur	14 (28)
Tibia	36 (72)
Road traffic accident	43 (86)
Workplace injury / fall from height	7 (14)

Anatomical Distribution: Of the 36 tibial non-unions, 12 (33.3%) were proximal, 8 (22.2%) were middle-third and 16 (44.4%) were distal. Among the 14 femoral non-unions, 2 (14.3%) involved the proximal femur, 3 (21.4%) involved the middle femur and 9 (64.3%) involved the distal femur.

Duration of Non-union: Twenty patients (40%) had an infected non-union of 12-18 months duration, 16 (32%) had a duration exceeding 18 months, and 14 (28%) had a duration of less than 12 months.

Microbiological Findings: Staphylococcus aureus was the most frequently isolated organism, identified in 34 (68%) patients.

Pseudomonas species were isolated in 8 (16%), Klebsiella species in 5 (10%), and E. coli in 1 (2%). No growth was obtained in 2 (4%) cases.

Table 2: Microbiological profile

Organism	n (%)
Staphylococcus aureus	34 (68)
Pseudomonas species	8 (16)
Klebsiella species	5 (10)
E. coli	1 (2)
No growth	2 (4)

Bone Reconstruction: Bone transport was performed in 41 patients, while 9 patients did not require bone transport. The most common amount of bone transport was 5 cm, occurring in 14 (28%) patients.

Treatment Duration: The duration of treatment with the Ilizarov fixator ranged from 5 to 18 months. The most frequently observed individual duration was 13 months, occurring in 6 patients (12%), while durations of 6, 8, 15, 16 and 17 months each occurred in 5 patients (10%) apiece. Together, these six duration categories accounted for 31 of the 50 patients (62%); the exact duration for the remaining 19 patients (38%) was not separately itemised in the available data. The overall treatment duration is therefore best summarised as a range of 5-18 months, with a central tendency in the 12-13 month range; a precise overall mean could not be reliably reconstructed from the categorised data available and should be verified against the complete patient-level dataset before final submission.

Infection Control and Union: Successful union with absence of persistent infection was achieved in 45 of 50 patients (90%), while 5 patients (10%) — including all patients who ultimately required amputation — did not achieve this outcome. Residual deformity greater than 7° was reported in 6 (12%) patients, whereas 44 (88%) had deformity less than 7°.

ASAMI Bone Outcome: According to ASAMI bone outcome criteria, 29 (58%) patients achieved an excellent result, 13 (26%) a good result, 3 (6%) a fair result and 5 (10%) a poor result. Thus, 84% of patients achieved excellent or good bone results.

Table 3: ASAMI bone outcome

Bone outcome	n (%)
Excellent	29 (58)
Good	13 (26)
Fair	3 (6)
Poor	5 (10)
Excellent + Good	**42 (84)**

Functional Outcome: The ASAMI functional outcome was excellent in 21 (42%) patients and good in 15 (30%), giving an excellent/good functional outcome in 72%. Six patients (12%) had fair outcomes and three (6%) had poor outcomes. Five patients (10%) were classified as failures because of amputation.

Table 4: ASAMI functional outcome

Functional outcome	n (%)
Excellent	21 (42)
Good	15 (30)
Fair	6 (12)
Poor	3 (6)
Failure (amputation)	5 (10)
Excellent + Good	**36 (72)**

Radiological Outcome: Radiological assessment demonstrated excellent union in 24 (48%), good union in 14 (28%), fair union in 7 (14%), delayed union in 3 (6%), and persistent non-union in 2 (4%).

Functional Parameters: A noteworthy limp was present in 18 (36%) patients, while 32 (64%) had no significant limp. Knee movement was >90° in 72.22% of tibial cases and 21.43% of femoral cases. Ankle dorsiflexion was restricted in a proportion of patients, reflecting the recognised risk of joint stiffness during distraction osteogenesis.

Complications: Pin-tract infection was the most frequently encountered complication, affecting all 50 patients to some degree. According to the Moore-Dahl classification, Grade I infection occurred in 27 patients, Grade II in 14, Grade III in 7 and Grade IV in 2 patients. Wire change was required in 5 patients.

Discussion

Infected non-union of the femur and tibia remains a major reconstructive challenge because infection frequently coexists with bone loss, soft-tissue compromise, and deformity and limb-length discrepancy.

The present study included 50 patients with a predominance of tibial involvement (72%), reflecting the well-recognised vulnerability of the tibia to severe open injuries and infection. The mean age of the patients in the present study was 35.94 years, with most patients belonging to the economically productive age groups. Road traffic accidents accounted for 86% of cases, suggesting that high-energy trauma was the principal mechanism underlying the infected non-unions in this series. The microbiological profile demonstrated S. aureus as the predominant organism, accounting for 68% of isolates. This finding is clinically relevant because successful management requires adequate debridement and appropriate antimicrobial therapy in addition to stable fixation.

An important advantage of the Ilizarov method is its ability to address several pathological components simultaneously. [1,2,4] Following radical debridement, the resulting bone defect can be treated by bone transport or distraction osteogenesis while the ring fixator maintains alignment and stability.

The method also permits gradual correction of deformity and restoration of limb length. In the present study, 90% of patients achieved union with absence of persistent infection. The ASAMI bone assessment showed excellent or good results in 84% of patients, while 72% achieved excellent or good functional outcomes.

These findings are broadly comparable with previously reported series. [5-14] Singh et al. reported excellent or good ASAMI bone outcomes in 86% and functional outcomes in 89% of patients with infected tibial gap non-union treated with bone transport. [7]

These findings support the observation that distraction osteogenesis can provide satisfactory biological and functional reconstruction in complex infected non-unions. The present study also demonstrated that Ilizarov treatment is a prolonged process. The treatment duration ranged from 5 to 18 months, with a central tendency in the 12-13 month range. Prolonged external fixation is one of the major disadvantages of the technique [4,10] and requires substantial patient motivation, regular follow-up and meticulous pin-site care. Pin-tract

infection was the most common complication in the present series. This is consistent with previous studies, where pin-site infection has been repeatedly reported as the most frequent complication of circular external fixation. [6,15]

Despite these limitations, the capacity of the Ilizarov system to permit early weight bearing and joint mobilisation represents an important advantage. Early gait training and intensive physiotherapy were emphasised to reduce knee and ankle contractures during distraction. The five treatment failures requiring amputation highlight that Ilizarov reconstruction cannot guarantee limb salvage in every patient. Severe infection, extensive bone and soft-tissue destruction, poor biological reserve and other patient-related factors may ultimately limit reconstructive success. The present study prospectively assessed 50 patients with infected non-union of both the femur and tibia, using standardised ASAMI criteria to evaluate bone and functional outcomes alongside infection control, deformity, and treatment duration and complications.

Limitations

The study was conducted at a single institution with a relatively small sample size of 50 patients. There was no control or comparison group treated with another reconstruction technique. The available study documentation also does not provide sufficient inferential statistical analysis to establish independent predictors of successful union or functional outcome.

The exact treatment duration for 19 of the 50 patients was not separately itemised in the available data, limiting the precision of the reported mean duration. Therefore, the results should primarily be interpreted as observational evidence of treatment outcomes rather than comparative effectiveness evidence.

Conclusion

The Ilizarov ring fixator is an effective limb-salvage technique for complex infected non-union of the femur and tibia. In this series of 50 patients, 90% achieved union without persistent infection, while 84% achieved excellent or good ASAMI bone outcomes and 72% achieved excellent or good functional outcomes. The principal advantages of the technique are its ability to provide stable fixation in the presence of infection, facilitate bone transport and regenerate bone, correct deformity and limb-length discrepancy, and permit progressive weight bearing. However, treatment is prolonged and requires meticulous pin-site care, rehabilitation and close patient cooperation. Overall, the findings support the Ilizarov technique as a valuable reconstructive and limb-salvage option for appropriately selected patients with infected non-union of the femur and tibia.

References

1. Paley D. Treatment of tibial non-union and bone loss with the Ilizarov technique. Instr Course Lect. 1990;39:185-97.
2. Maini L, Chadha M, Vishwanath J, Kapoor S, Mehtani A, Dhaon BK. The Ilizarov method in infected non-union of fractures. Injury. 2000;31:509-17.
3. Simard S, Marchant M, Mencio G. The Ilizarov procedure: limb lengthening and its implications. Phys Ther. 1992;72:25-34.
4. Paley D. Problems, obstacles, and complications of limb lengthening by the Ilizarov technique. Clin Orthop. 1990;250:81-104.
5. Testa G, Vescio A, Aloj DC, Costa D, Papotto G, Gurrieri L, et al. Treatment of infected tibial non-unions with Ilizarov technique: a case series. J Clin Med. 2020;9:1352.
6. Mankar S, Mohammed F, Bhutada G, Sakhare R. Outcomes of Ilizarov ring fixation in infected non-union of tibia. J Orthop Traumatol Rehabil. 2020;12:62-68.
7. Singh AK, Parihar M, Bokhari S. The evaluation of the radiological and functional outcome of distraction osteogenesis in patients with infected gap non-union of tibia treated by bone transport. Open Access Maced J Med Sci. 2019;7:559-66.
8. Fahad S, Habib AA, Awais MB, Umer M, Rashid HU. Infected non-union of tibia treated with Ilizarov external fixator: our experience. Malays Orthop J. 2019;13:36-41.
9. Bakhsh K, Atiq-Ur-Rehman, Zimri FK, Mohammad E, Ahmed W, Saaiq M. Presentation and management outcome of tibial infected non-union with Ilizarov technique. Pak J Med Sci. 2019;35:136-40.
10. McNally M, Ferguson J, Kugan R, Stubbs D. Ilizarov treatment protocols in the management of infected non-union of the tibia. J Orthop Trauma. 2017;31:S47-S54.
11. Sreeram PR. A study on functional outcome of Ilizarov fixation in the management of infected non-union of long bones. Indian J Orthop Surg. 2016;2:187-93.
12. Meleppuram JJ, Ibrahim S. Experience in fixation of infected non-union tibia by Ilizarov technique: a retrospective study of 42 cases. Rev Bras Ortop. 2016;52:670-675.
13. Sahu RL, Ranjan R. Treatment of complex non-union of the shaft of the tibia using Ilizarov technique and its functional outcome. Niger Med J. 2016;57:129-33.
14. Ravichandran S, Jose AK, Krishnagopal R. Management of complex non-union of shaft of

tibia using Ilizarov technique and its functional outcome. Int Surg J. 2014;1:84-97.

15. Wani NB, Syed B. Ilizarov ring fixator in the management of infected non-unions of tibia. SICOT J. 2015;1:22.