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(3); 90-96

Original Research Article

A Prospective Study on the Outcome of Ilizarov Technique in Tibial Non-Union

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Received: 01-02-2025 / Revised: 15-02-2026 / Accepted: 26-02-2025
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Conflict of interest: Nil

Abstract

Introduction: Tibial non-union, particularly when associated with infection, remains a challenging problem in orthopaedic practice due to bone loss, soft tissue compromise, deformity, and limb length discrepancy. The Ilizarov circular external fixator offers stable fixation and allows correction of these associated problems through the principles of distraction osteogenesis. However, prospective data evaluating both bone and functional outcomes using standardized scoring systems are limited. Objective- To evaluate the clinical, radiological, and functional outcomes of Ilizarov ring fixation in patients with tibial non-union.

Materials and Methods: This prospective observational study was conducted at a tertiary care teaching hospital from August 2017 to October 2018. Fifteen patients aged 11–70 years with diaphyseal tibial non-union, including infected and aseptic cases, were treated using the Ilizarov circular external fixator. Preoperative evaluation included clinical, laboratory, and radiological assessment. Corticotomy and bone transport were performed when indicated. Patients were followed up at regular intervals, and outcomes were assessed using the Association for the Study and Application of the Method of Ilizarov (ASAMI) scoring system.

Results: Most patients were aged 21–40 years, with right-sided involvement being more common. Middle-third tibial non-union was the most frequent site. Corticotomy was performed in 60% of patients. The mean time to union was 6.03 ± 1.47 months (range 4–9 months). Complications included pin tract infection (26.67%), non-union site infection (26.67%), ankle stiffness (40%), and knee stiffness (13.33%), all managed conservatively. Excellent to good bone and functional outcomes were achieved in 93.34% of patients according to ASAMI criteria.

Conclusion: Ilizarov ring fixation is an effective method for managing tibial non-union, providing satisfactory union rates and functional outcomes while allowing correction of associated deformities and limb length discrepancy with acceptable complications.

Keywords: ASAMI score, Ilizarov fixation, infected non-union, Tibial fracture, Tibial non-union.

DOI: 10.25258/ijcpr.18.3.16

Introduction

India has one of the highest rates of road traffic accidents globally, with the lower limbs involved in more than 45% of cases. Among long bones, the tibia is particularly susceptible to injury. High-energy tibial fractures are frequently associated with complications such as compartment syndrome, vascular injury, and neurological damage. Closed fractures generally have a lower risk of infection compared to open fractures.

Tibial non-union significantly affects functional capacity and is often associated with economic burden and loss of self-esteem. Infected non-union is defined as failure of fracture union for a period of 6–8 months in the presence of persistent infection at the fracture site. [1] Infected tibial non-union is commonly encountered in clinical practice [2] and is often associated with additional problems such as bone and soft tissue loss, deformity, limb length discrepancy, and polymicrobial infection. [3] Management of infected tibial non-union continues to pose a challenge for orthopaedic surgeons. [4]

Non-union may also occur following low-energy fractures that were initially expected to heal. It represents a chronic condition that leads to functional deformity and is frequently associated with psychosocial impairment. Management is further complicated by wide variations in individual patient responses to mechanical and biological stresses. Although approximately 90–

95% of fractures unite uneventfully, tibial fractures have a higher tendency for non-union. The tibia is a superficial bone and is therefore more vulnerable to trauma, making it one of the most commonly fractured long bones. As most of the tibial surface is subcutaneous, open fractures are relatively common. In addition, the blood supply to the tibia is less robust compared to bones surrounded by bulky muscle masses, which further compromises fracture healing. [5]

The U.S. Food and Drug Administration defines non-union as a fracture that is at least nine months old with no radiological evidence of healing for three consecutive months. [6] Müller defined non-union as failure of a tibial fracture to unite after eight months of non-operative treatment. [7] These definitions are widely accepted. From a practical perspective, non-union refers to a fracture that, in the opinion of the treating surgeon, has little or no potential to heal without further intervention.

Infection at the fracture site increases the risk of non-union. [8] Infection may lead to instability due to loosening of implants, while avascular and necrotic bone (sequestrum) reduces the biological potential for union. In addition, osteolysis caused by infected granulation tissue results in poor bony contact at the fracture site. [9] Staphylococcus aureus is the most commonly isolated organism in infected non-unions.

A major advancement in the treatment of complex non-unions was introduced by Sir Gavriil Abramovich Ilizarov with the development of the circular ring fixator. The stability provided by this fixation allows early weight-bearing, ambulation, and joint mobilization. Progressive bone histiogenesis following corticotomy and bone transport facilitates bridging of bone defects, helps control infection, and promotes fracture union. [10]

Despite the widespread use of the Ilizarov technique for tibial non-union, there is limited prospective evidence, particularly from the Indian setting, evaluating both bone and functional outcomes using standardized scoring systems such as ASAMI. Most existing studies are retrospective or focus mainly on union rates, with inadequate reporting of complications and functional recovery. This highlights the need for a prospective assessment of clinical, radiological, and functional outcomes of Ilizarov fixation in tibial non-union. Therefore, present study aimed to evaluate the clinical, radiological, and functional outcomes of Ilizarov ring fixation in patients with tibial non-union.

Materials and Methods

This Prospective Observational study was conducted at a tertiary care teaching hospital over a period of 14 months, from August 2017 to October 2018. A total of 15 patients diagnosed with tibial non-union were enrolled in the study after fulfilling predefined inclusion and exclusion criteria. Patients aged between 11 and 70 years with diaphyseal tibial non-union, as defined by Brinker's criteria, were included. Both infected and aseptic non-union cases were considered were included in the study. Only patients who were psychologically stable, capable of understanding the treatment protocol, willing to undergo Ilizarov fixation, and compliant with the planned follow-up schedule were included. Patients with pathological fractures, associated head injuries, significant neurological or vascular injuries in the affected limb, inability to perform self-care or manage the external fixator, refusal to undergo surgery after adequate counselling regarding treatment course and prognosis, or unwillingness to continue with the Ilizarov fixator during treatment were excluded from the study. The study was approved by the Institutional Ethics Committee. Written informed consent was obtained from all participants or their guardians in the case of minors prior to enrolment. The study was conducted in accordance with institutional guidelines and ethical principles.

Preoperative Evaluation: All patients underwent a detailed clinical, laboratory, and radiological evaluation prior to surgery. Clinical assessment included documentation of patient-related and injury-related variables such as age, sex, side of limb affected, mode of injury, type of fracture (open or closed), previous methods of fracture management, duration of non-union, presence or absence of infection, condition of the surrounding soft tissues, and limb length discrepancy. A thorough physical examination was performed to assess local limb status and general fitness for surgery.

Laboratory investigations were carried out in all patients and included complete haemogram, renal function tests, bleeding time and clotting time, and screening for infectious diseases such as human immunodeficiency virus (HIV) and hepatitis B surface antigen (HBsAg). In cases of infected non-union, pus culture and sensitivity testing were performed to guide appropriate antibiotic therapy.

Radiological evaluation included plain radiographs of the affected tibia in anteroposterior and lateral views for assessment of the non-union site, alignment, and bone quality. Computed tomography was used when required to assess the extent of non-union and quantify bone loss. Magnetic resonance imaging was performed selectively in cases where evaluation of soft tissue status or underlying infection was clinically indicated. Chest radiograph and electrocardiogram were obtained as part of routine pre-anaesthetic assessment.

Surgical Procedure: All patients were treated using the Ilizarov circular external fixator under spinal or general anaesthesia, following established principles described in the literature. After adequate exposure, thorough debridement of fibrotic tissue at the non-union site was performed, and bone ends were freshened until punctate bleeding was observed. In cases of infected non-union, all necrotic bone and infected soft tissue were meticulously excised. Stable fixation was achieved using tensioned transosseous wires and half-pins mounted on circular rings to obtain appropriate alignment and stability.

The surgical strategy was tailored according to the type of non-union and the extent of bone loss. Compression at the non-union site was applied in cases of hypertrophic non-union, while corticotomy at a metaphyseal site was performed in selected cases requiring bone transport or limb lengthening. Gradual distraction was initiated after an appropriate latency period, following standard distraction protocols. Postoperative radiographs were obtained to confirm alignment and adequacy of fixation.

Postoperative Management and Follow-Up: Postoperatively, patients were encouraged early mobilization and weight-bearing as tolerated. Pin site care was explained and demonstrated to both patients and attendants. Regular follow-up visits were scheduled at monthly intervals to monitor progress. During follow-up, parameters such as progression of fracture union, length of bone regeneration achieved, duration of fixator application, limb length discrepancy, and complications including pin tract infection, joint stiffness, or deformity were recorded.

Outcome Assessment: Final outcomes were evaluated using the Association for the Study and Application of the Method of Ilizarov (ASAMI) scoring system, which assesses both bone and functional results. Bone results were evaluated based on union, presence of infection, deformity, and limb length discrepancy, while functional results were assessed based on pain, gait, joint mobility, and ability to perform daily activities.

Outcomes were categorized as excellent, good, fair, or poor according to ASAMI criteria.

Results

[Table-1] In this study, most patients belonged to the 21–40 years age group (53.32%). Right-sided tibial involvement was more common, seen in 73.33% of patients. Middle-third tibial non-union was the most frequent site (60%), followed by distal tibial involvement (33.33%). According to the Gustilo–Anderson classification, Grade IIIB fractures constituted the majority of cases (53.33%). In this study, external fixation was the most commonly used method of primary fixation following the initial tibial fracture in 11 patients (73.33%), Plate fixation in 2 patients (13.33%). Primary Ilizarov fixation was performed in 1 patient (6.67%), while a combination of fixation methods was used in 1 patient (6.67%). Lag screw fixation was not used in any patient. Plastic surgery intervention (flap cover) was done in 5 patient for soft tissue coverage.

[Figure-1] In this study, pre-operative limb shortening of 1–5 cm was observed in the majority of patients (46.67%), followed by shortening of <1 cm in 40% of cases, and shortening > 5 cm was seen in 13.33% of patients. With respect to bone defect, defects measuring <10 mm were most common (40%), followed by defects of 21–30 mm (26.67%) and 31–40 mm (20%). Larger bone defects >40 mm were observed in a small proportion of patients.

In this study, Tibial Corticotomy was performed in 9 patients (60%) following a latency period of 7 days after application of the Ilizarov external fixator. In all cases, corticotomy was carried out at the junction of the proximal metaphysis and diaphysis. The duration of distraction ranged from 19 to 37 days depending on the size of the bone gap, with a mean distraction period of 27 days. Pin tract infection was observed in 4 patients (26.67%). Infection at the non-union site was noted in 4 patients (26.67%). Of these, 3 patients (75%) had superficial infection, while 1 patient (25%) developed deep infection. All cases were managed with appropriate wound care and antibiotic therapy guided by culture and sensitivity findings.

In this study, Ankle stiffness was observed in 6 patients (40%). This complication showed gradual improvement over time and was managed with toe slings and structured physiotherapy. Knee stiffness was noted in 2 patients (13.33%) and was managed with regular physiotherapy, resulting in gradual improvement in joint mobility. [Figure -2] In this study, the time to union ranged from 4 to 9 months. The mean time to union was 6.03±1.47 months, indicating moderate variability in healing duration among patients.

[Figure -3] In this study, assessment using the Association for the Study and Application of the Method of Ilizarov (ASAMI) scoring system demonstrated excellent bone and functional outcomes in 10 patients (66.67%), good outcomes in 4 patients (26.67%), and fair outcomes in 1 patient (6.67%). No patient (0%) had a poor bone or functional result.

Table 1: Demographic and Clinical Characteristics of Patients with Tibial Non-Union (n = 15)

Variable	Category	Number (n)	Percentage (%)
Age group (years)	11–20	1	6.66
	21–30	4	26.66
	31–40	4	26.66
	41–50	2	13.33
	51–60	3	20
	61–70	1	6.66
Side involved	Right	11	73.33
	Left	4	26.67
Site of non-union	Proximal tibia	1	6.67
	Middle third tibia	9	60
	Distal tibia	5	33.33
Type of Fracture (Gustilo–Anderson Grade)	Grade I	1	6.67
	Grade II	1	6.67
	Grade IIIA	5	33.33
	Grade IIIB	8	53.33

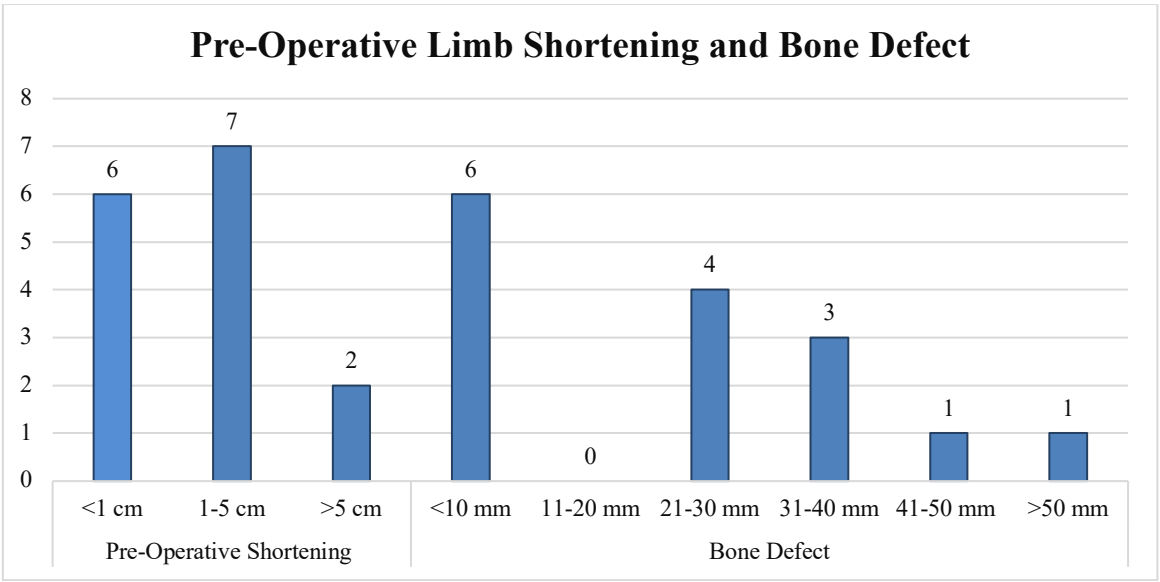

Figure 1: Distribution of Pre-Operative Limb Shortening and Bone Defect in Patients with Tibial Non-Union (n = 15)

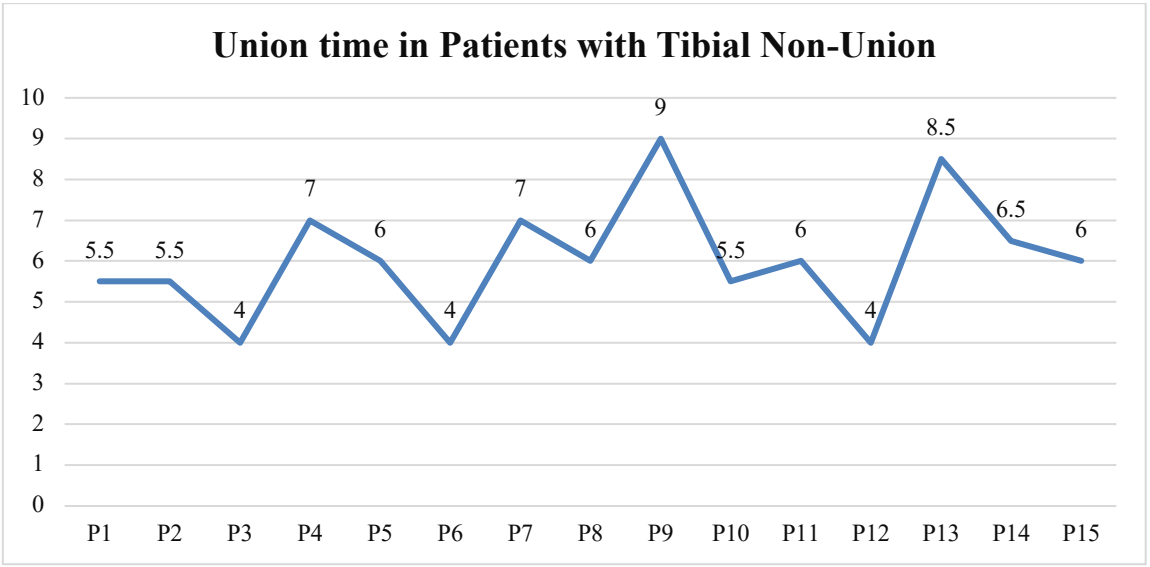

Figure 2: Time to Union Following Ilizarov Fixation in Patients with Tibial Non-Union

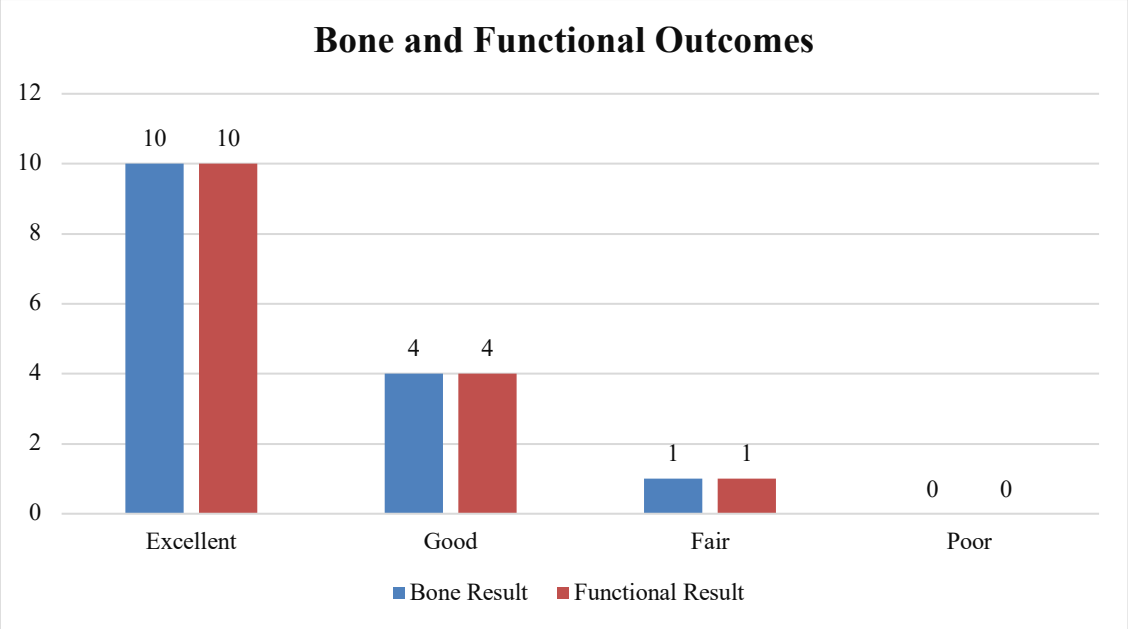

Figure 3: Bone and Functional Outcomes According to ASAMI Scoring System

Table 2: Bone and Functional result (ASAMI Score)

Outcome	Present Study (n = 15)		Dendrinos et al (n = 28)		Paley et al (n = 25)	
	Bone (%)	Functional (%)	Bone (%)	Functional (%)	Bone (%)	Functional (%)
Excellent	66.67	66.67	50	25	72	64
Good	26.67	26.67	28.5	47	20	28
Fair	6.66	6.66	3.5	14	8	4
Poor	0	0	18	14	0	4

Discussion

Non-union remains a difficult clinical problem despite advances in fracture fixation, soft tissue management, and antibiotic therapy. Infection at the fracture site interferes with the biological process of healing, and smoking further delays union. Nicotine causes vasoconstriction and impairs tissue differentiation required during the early stages of fracture repair. In addition, nicotine inhibits osteoblastic activity, leading to delayed union. Therefore, effective control of infection and cessation of smoking are important components in the management of tibial non-union.

Adequate surgical debridement is the first and most important step in controlling infection, following which stable fixation can be planned. The Ilizarov technique is based on the principles of tension–stress effect and distraction histogenesis, whereby controlled distraction of living tissue results in the formation of new tissue of the same type. The Ilizarov external fixator provides multiplanar stability and is particularly useful in the management of infected tibial non-union, which is often associated with complications such as fibrosis, sinus formation, deformity, limb shortening, and persistent infection. The superficial location of the tibia further predisposes it to infection and delayed healing, making management challenging for both the patient and the surgeon. In the present study, Ilizarov fixation was used in cases with adverse local conditions at the fracture site, including chronic osteomyelitis, poor skin condition, severe soft tissue injury, and large bone defects that were not amenable to bone grafting alone.

The Ilizarov fixator is well suited for infected tibial non-union as it provides stable fixation, allows bone transport, corrects deformities, and permits weight-bearing during treatment. [11] The technique has been reported as a reliable method for achieving union in infected non-unions of long bones of the lower limb, while simultaneously addressing bone defects and limb length discrepancies. [12] Early mobilization and weight-bearing help prevent disuse osteoporosis and muscle atrophy. Compared to limb reconstruction systems, which are uniplanar and less affordable in resource-limited settings, Ilizarov rings can be sterilized and reused, thereby reducing treatment costs.

In the present study, union was achieved in all patients, with union time ranging from 4 to 9 months. The mean union time was approximately six months, which is comparable to the findings of Dendrinos et al [13], who reported a similar mean union time in patients treated with Ilizarov fixation.

In previous literature, smoking was identified as an important modifiable factor influencing union, and all patients were advised smoking cessation. No refractures were observed in the present study. Pin tract infection was noted in four patients, while infection at the non-union site was observed in four patients, including three superficial and one deep infection. These infections were managed successfully with regular wound care and antibiotics based on culture sensitivity. Pin site infection has been attributed to excessive movement at the pin–bone interface, as reported by Ceroni et al. [14] Regular pin site care has been emphasized as a key factor in preventing and managing such infections. [15] Limb edema was managed with elevation.

Joint stiffness was observed in six patients, predominantly involving the ankle, with knee stiffness noted in two cases. This is attributed to the limited adaptive response of muscles to distraction osteogenesis. Joint stiffness improved with appropriate physiotherapy. No major vascular or neurological complications were encountered. In comparison, Dendrinos et al [13] reported higher rates of complications, including joint stiffness, axial deviation, refracture, and persistent non-union.

In the present study, distraction osteogenesis was performed in nine patients. The external fixation index was 121 days/cm. A longer fixation duration was observed in smokers, likely due to the vasoconstrictive and anti-osteogenic effects of nicotine. Bobroff et al reported a mean external fixation index of 2 months/cm, with longer duration noted in smokers compared to non-smokers. [16] According to ASAMI scoring, excellent bone results were observed in 66.6% of patients, good results in 26.6%, and fair results in 6.6%, with union achieved in all cases. Functional assessment showed excellent results in 26.6%, good results in 66.6%, and fair results in 6.6% of patients. Residual problems included limping in eight patients and joint stiffness in five patients.

[Table-2] When compared with previous studies, the proportion of excellent bone results in the present study was higher than that reported by Dendrinos et al [13] (50%) and comparable to Paley et al [17] (72%). Functional outcomes were similar to those reported by Dendrinos et al [13] and lower than those reported by Paley et al [17], which may be related to differences in patient selection, severity of infection, and extent of associated deformities.

Conclusion

This prospective observational study shows that the Ilizarov circular external fixator is an effective method for the management of tibial non-union. Fracture union was achieved in most patients, with a mean time to union of approximately six months. The majority of patients had excellent to good bone and functional outcomes based on the ASAMI scoring system. The technique was useful in managing associated problems such as infection, limb length discrepancy, and bone defects through controlled compression, distraction, and bone regeneration.

Complications including pin tract infection, infection at the non-union site, and joint stiffness were observed but were managed with conservative treatment and physiotherapy. Early mobilization and weight-bearing supported functional recovery in most patients. Overall, the Ilizarov method provides stable fixation and allows correction of deformity and limb length discrepancy, resulting in satisfactory functional outcomes in patients with tibial non-union when appropriate surgical technique and follow-up are maintained.

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