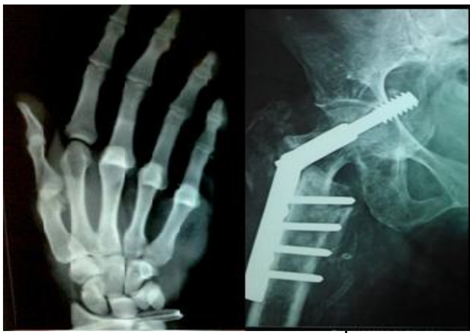

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Evaluation of Ilizarov Fixation Technique in Infected Non-Union Tibial Fractures

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Abstract
Background: The Ilizarov fixation method is crucial in studying infected non-union tibial fractures in orthopedics. It deals with the complex challenge of bone healing failure combined with infection. Named after Gavriil Abramovich Ilizarov, this technique stabilizes fractures and fosters bone healing using circular external fixators.
Aim of the Study: This study aimed to evaluate the Ilizarov fixation technique in infected non-union tibial fractures.
Methods: This prospective observational study was conducted at the Department of Department of Orthopaedics North Bengal Medical College and Hospital, Sirajgonj, Bangladesh from January 2023 to December 2023. The study involved 37 patients with infected non-union tibial fractures treated with the Ilizarov fixator. A purposive sampling method was employed. Patient records were assessed for bone union, functional outcomes, and complications. Data analysis was conducted using MS Office tools.
Results: Staphylococcus aureus was the predominant causative organism for infections. According to the Association for the Study and Application of the Method of Ilizarov (ASAMI) classification, bone outcomes were excellent in 45.9% and good in 35.1% of cases, while functional outcomes were rated as excellent in 48.6% and good in 37.8% of cases. Pin track infection occurred in 16.2% of cases, and limb length discrepancy in 13.5%. The mean compression duration was 37.8 weeks, with the frame remaining in place for an average of 7.4 months.
Conclusion: The Ilizarov technique effectively achieves bony union and controls infection. Infected tibial non-union often leads to limb length discrepancy, deformity, sinuses, osteomyelitis, bone loss, and joint stiffness, all of which the Ilizarov technique effectively treats.

Keywords: Ilizarov Fixator, Infected, Non-Union, Tibial Fracture, Outcome, Bone.

Introduction
Open fractures and fractures resulting from high-energy trauma are prone to infection and may lead to non-union [1]. Infected non-union is characterized by the failure of bone union along with persistent infection at the fracture site for a duration typically ranging from 6 to 8 months [2]. The tibia, being a subcutaneous bone, is particularly susceptible to open comminuted fractures and infected non-union, often resulting from its weight-bearing function [3, 4]. The prevalence of non-union in closed tibial shaft fractures is around 2.5%, but this figure increases substantially, by 5 to 7 times, for open fractures characterized by significant contamination and extensive soft tissue damage [5]. Infected non-union of the tibia presents a significant challenge for orthopedic surgeons. Achieving bone union is often hindered by the persistence of infection, which must be effectively eradicated before a successful union can be achieved [6]. Amputation is a potential risk in cases of infected non-union, making it a crucial concern for patients and surgeons alike. The Ilizarov method offers a valuable approach to minimize the risk of amputation in such cases [7]. Non-union of fractures often presents with additional challenges such as persistent infection, soft tissue and bone loss, limb length inequality, and limb deformity [3]. Infected non-union of the tibia has long been a complex issue for orthopedic surgeons to address [8]. Treatment options for managing chronic diaphyseal infections associated with non-union include extensive debridement with local soft tissue rotational flaps [9], placement of antibiotic cement beads within the defect, Papineau-type open cancellous bone grafting [10], tibiofibular synostosis, free microvascular soft tissue

and bone transplants, and the utilization of the Ilizarov method. These approaches aim to address the multifaceted nature of infected non-union and its associated complications. The Ilizarov method offers distinct advantages, as it can address numerous challenges associated with non-union. It can help overcome bony defects, facilitate bony union via bone histogenesis, and eradicate infection.

Methodology: This was a prospective observational study that was conducted at the Department of Orthopaedics North Bengal Medical College and Hospital, Sirajgonj, Bangladesh from January 2023 to December 2023. The study included 37 patients with infected non-union tibial fractures who underwent treatment with the Ilizarov fixator, selected through purposive sampling. Properly written informed consent was obtained from all participants before data collection. The entire intervention adhered to the principles outlined in the Helsinki Declaration [11] and complied with current regulations and the provisions of the General Data Protection Regulation (GDPR) [12]. The study included tibial non-union lasting at least six months with infection and a bone defect over 2.5 cm or failed healing after intervention. Excluded were non-union without infection and infected fractures under six months. Data collected included demographics, injury causes, previous surgeries, fixation types, and isolated organisms. The Ilizarov fixator was applied to the tibial shaft with rings on proximal and distal fragments aligned with joints, and pins inserted perpendicular to the mechanical axis of the tibia under image intensifier guidance. Radical debridement cleared necrotic bone and infected tissue. Post-op, patients received two weeks of IV antibiotics based on culture sensitivity. Patients were encouraged to engage in full weight bearing with crutches and perform isometric and range of motion exercises starting from the day after surgery. The latency period before bone transport was 5-7 days, with a distraction rate of 0.25mm per 6 hours. Duration of external fixation, bone transport time, external fixation index, and any complications were documented. Radiographs were taken every two weeks during distraction and monthly during consolidation. Pre- and post-operative radiographs, as well as final follow-up images of two treated patients, were recorded. The Ilizarov fixator was scheduled for removal upon evidence of solid docking site union with the regenerated area possessing at least three complete cortices. Objective assessment of bone and functional outcomes was conducted using the Association for the Study and Application of the Method of Ilizarov (ASAMI) classification [13].

Table 1: ASAMI system

Results	Criteria of bone results
Excellent	Union, no infection, deformity < 7˚, limb-length discrepancy < 2.5 cm
Good	Union + any two of the following: absence of infection, < 7˚ deformity and limb-length inequality of < 2.5 cm
Fair	Union + only one of the following: absence of infection, deformity < 7˚ and limb-length inequality < 2.5 cm
Poor	Nonunion/re-fracture/union + infection + deformity > 7˚ + limb-length inequality > 2.5 cm
Results	Criteria of functional results
Excellent	Active, no limp, minimum stiffness (loss of < 15˚ knee extension/< 15˚ dorsiflexion of the ankle), no reflex sympathetic dystrophy (RSD), insignificant pain
Good	Active, with one or two of the following: limp, stiffness, RSD, significant pain
Fair	Active, with three or all of the following: limp, stiffness, RSD, significant pain
Poor	Inactive (unemployment or inability to return to daily activities because of injury)

Patient records were assessed for bone union, functional outcomes, and complications. Data analysis was conducted using MS Office tools.

Result: The mean ±SD age of our participants was 33.7 ±11.4 years; the majority (75.7%) were male while the rest 24.3% were female. In most of the cases (73%), the mechanism of injury was a road traffic accident followed by a fall from height (19%) and sports (8%). Open fractures were 68% whereas closed fractures contributed 32%. Cases with atrophic non-union was 65% and cases with hypertrophic were 35%. In most of the cases, *Staphylococcus aureus* was found as the causative organism. In some cases, *Pseudomonas aeruginosa* (13.5%), *Escherichia coli* (5.4%) and *Proteus mirabilis* (2.7%) were involved. Using the Association for the Study and Application of the Method of Ilizarov (ASAMI) classification system to assess bone and functional outcomes, bone results were categorized as excellent in 45.9% of cases, good in 35.1%, fair in 13.5%, and poor in 5.4%. Meanwhile, functional outcomes were rated as excellent in 48.6% of cases, good in 37.8%, fair in 8.1%, and poor in 5.4% of cases. The distribution of complications among the cases included pin track infection in 16.2%, limb length discrepancy in 13.5%, and non-union, wire loosening/broken, Schanz screw broken, re-infection, and septic arthritis each in 2.7% of cases. The mean duration of compression was 37.8 weeks, while the frame was in place for a mean of 7.4 months. The plaster cast remained for a mean of 2.1 months, and the follow-up period extended for 18 months.

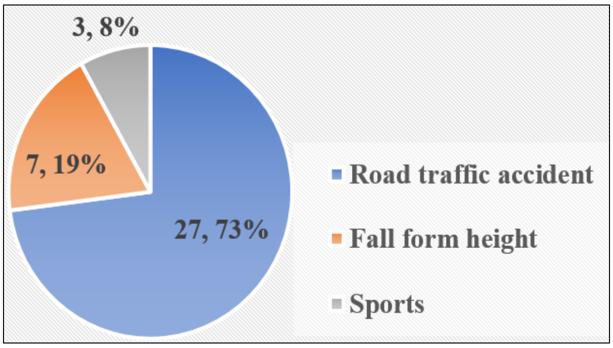

Fig 1: Mechanism of injury

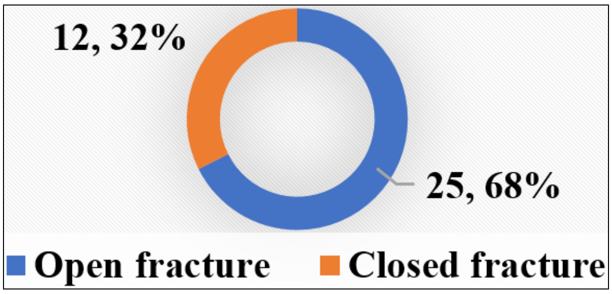

Fig 2: Types of fractures

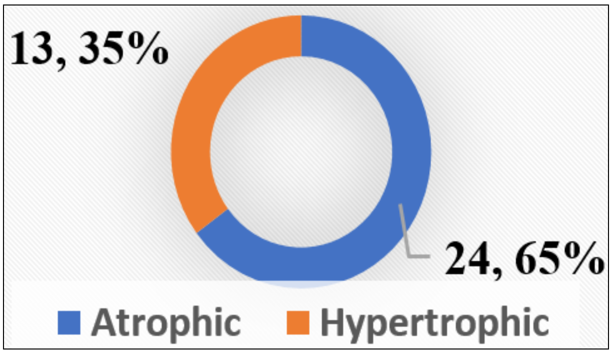

Fig 3: Types of non-union

Table 1: Causative organisms

Organisms	n	%
Staphylococcus aureus	29	78.4%
Pseudomonas aeruginosa	5	13.5%
Escherichia coli	2	5.4%
Proteus mirabilis	1	2.7%

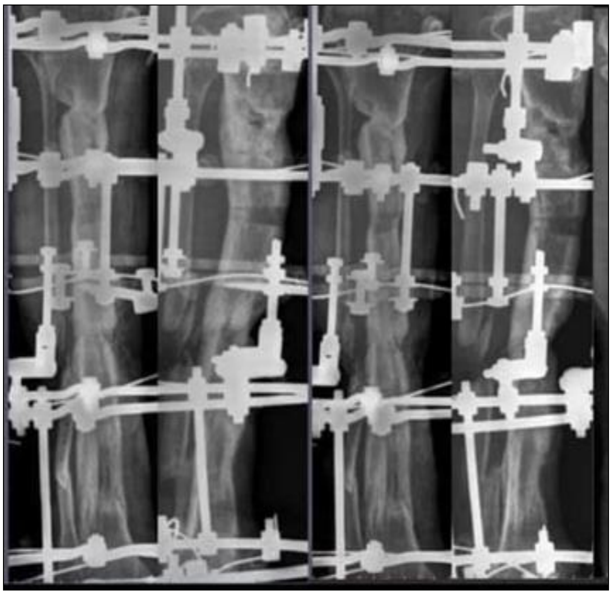

Fig 4: Per operative picture of Ilizarov Fixation Technique in Infected Non-union Tibial Fractures

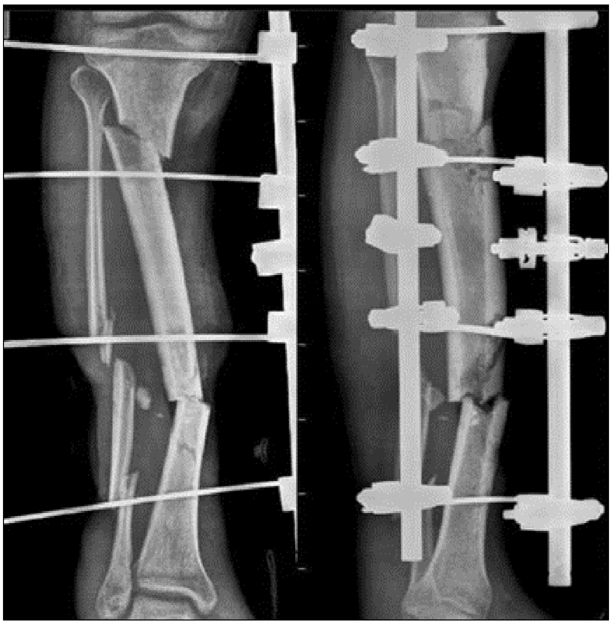

Fig 5: Per operative picture of Ilizarov Fixation Technique in Infected Non-union Tibial Fractures

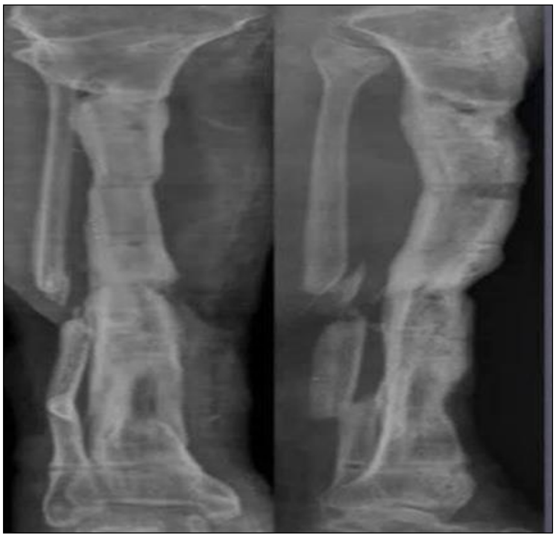

Fig 6: Post-operative picture of Ilizarov Fixation Technique in Infected Non-union Tibial Fractures

Fig 7: Post-operative picture of Ilizarov Fixation Technique in Infected Non-union Tibial Fractures

Table 2: Bone and functional outcomes using the ASAMI system

Results	n	%
Bone results		
Excellent	17	45.9%
Good	13	35.1%
Fair	5	13.5%
Poor	2	5.4%
Functional results		
Excellent	18	48.6%
Good	14	37.8%
Fair	3	8.1%
Poor	2	5.4%

Table 3: Distribution of complications

Complications	n	%
Pin track infection	6	16.2%
Limb length discrepancy	5	13.5%
Non-union	1	2.7%
Wire loosening/broken	1	2.7%
Schanz Screw broken	1	2.7%
Re-infection	1	2.7%
Septic arthritis	1	2.7%

Discussion

The mean age of our participants was 33.7 years with a standard deviation of 11.4 years. The majority, comprising 75.7%, were male, while the remaining 24.3% were female. Nearly similar settings were observed in some other studies [1, 14]. In most of the cases (73%), the mechanism of injury was a road traffic accident. Ghosh *et al*. also found nearly 60% of road traffic accident cases [15]. In this study, open fractures accounted for 68% of cases, while closed fractures comprised 32%. Additionally, cases with atrophic non-union constituted 65% of the total, whereas cases with hypertrophic non-union made up 35%. These results were consistent with those reported in the study conducted by Ghosh *et al*. [15]. In most of our patients, *Staphylococcus aureus* was found as the causative organism for infections. Fahad *et al*. also found similar involvement of causative organisms. In this present study, bone and functional outcomes were evaluated using the Association for the Study and Application of the Method of Ilizarov (ASAMI) classification system. Regarding bone results, 45.9% of cases were categorized as excellent, 35.1% as good, 13.5% as fair, and 5.4% as poor. Similarly, functional outcomes were assessed, with 48.6% of cases rated as excellent, 37.8% as good, 8.1% as fair, and 5.4% as poor. All these findings were comparable with the findings of some previous studies [1, 14, 15]. In our study, complications were observed, with pin track infection occurring in 16.2% of cases, limb length discrepancy in 13.5%, and non-union, wire loosening/breakage, Schanz screw breakage, re-infection, and septic arthritis each noted in 2.7% of cases. So, the frequency of complications was not so high. Certainly, the Ilizarov fixator is regarded as a superior treatment method for complex non-unions, particularly those with defects larger than 4cm [16]. In our study, we observed a notable difference from most studies of this nature, such as those conducted by Magadum *et al*. [17] and Farmanullah *et al*. [18], where the bone score was superior to the functional score. Interestingly, a previous study [19] also reported results similar to ours, with a superior functional score compared to the bone score. This variation could be attributed to the fact that the functional score is influenced by a range of factors, including the patient's pain tolerance and the condition of the muscles, bones, and joints [16]. The findings of this current study may provide valuable insights for future research in similar areas.

Limitation of the study

The limitations of this study include its single-center design and small sample size. Additionally, the relatively short duration of the study may limit the generalizability of the findings to the entire country.

Conclusion

The Ilizarov technique stands out for its effectiveness in achieving bony union and controlling infection, particularly in cases of infected tibial non-union. This innovative approach addresses a range of complications associated with infected non-unions, including limb length discrepancy, deformity, sinuses, osteomyelitis, bone loss, and joint stiffness. By employing principles of distraction osteogenesis and external fixation, the Ilizarov technique promotes bone regeneration, eradicates infection, corrects deformities, and restores function. Its versatility and success in managing complex orthopedic conditions make it a valuable treatment option for patients with infected tibial non-unions, offering the potential for improved outcomes and enhanced quality of life.

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Conflict of interest: None declared.

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