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Research Article

Effectiveness of Ilizarov Ring Fixator in the Treatment of Infected Non-Union of Tibial Fractures

Dr. S.K. Bhaskar[1], Dr. Hemeshwar Harshwardhan[2], Dr. Sunil Paliwal[3], Dr. Priyank Sharma[4], Dr. Mahesh Saini[5]

[1]Senior Professor, Department of Orthopaedics, J.L.N Medical College Ajmer, Rajasthan
[2]Senior Professor, Department of Orthopaedics, J.L.N Medical College Ajmer, Rajasthan
[3]Resident, Department of Orthopaedics, J.L.N Medical College Ajmer, Rajasthan
[4]Resident, Department of Orthopaedics, J.L.N Medical College Ajmer, Rajasthan
[5]Resident, Department of Orthopaedics, J.L.N Medical College Ajmer, Rajasthan

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Corresponding Author:

Dr. Priyank Sharma
Resident, Department of Orthopaedics, J.L.N Medical College Ajmer

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ABSTRACT

Aim: The aim of the present study was to assess and analyze the effectiveness of Ilizarov ring fixator in the treatment of infected nonunion in adult tibial fractures.
Methods: This was a hospital-based prospective study was conducted from July 2023 to December 2024 at the Department of Orthopaedics, J.L.N. Medical College and Associated Group of Hospitals, Ajmer, Rajasthan. The study population consisted of patients presenting with infected non-union tibial fractures at the Department of Orthopaedics, JLN Medical College & Hospital, Ajmer.
Results: A total of 20 patients were included in the study, with the majority falling into three age categories: less than 30 years (25%), 31–40 years (25%), and over 60 years (25%). Out of 20 patients, 17 (85%) were male and 3 (15%) were female, indicating a male predominance in the study population. Road traffic accidents were the most common cause, accounting for 90% of cases, while falls from height contributed to 10% of cases. Mid tibia fractures were the most common, observed in 40% of cases, followed by distal tibia fractures in 35% and proximal tibia fractures in 20% of patients. Segmental fractures involving both the proximal and distal tibia were seen in 5% of cases. Bone transport was not performed in 30% of patients. Among those who underwent bone transport, the most common distances were 4 cm, 8 cm, and 12 cm, each observed in 10% of cases. Bone grafting was performed in 75% of patients, while 25% did not require the procedure.
Conclusion: Overall, the Ilizarov technique remains a robust and adaptable solution for complex tibial non-unions, particularly in the presence of infection. Its application, though demanding in terms of surgical expertise and patient compliance, delivers promising outcomes in terms of limb salvage, structural integrity, and functional recovery.

Keywords*: Ilizarov ring fixator, treatment, infected non union, adult tibial fractures.*

INTRODUCTION

The tibia, commonly known as the shinbone, is one of the two long bones in the lower leg, with the fibula serving as its smaller counterpart. As the primary weight-bearing bone of the lower limb, the tibia is essential for supporting body weight and transmitting forces from the upper body to the foot, facilitating movement and maintaining balance. Anatomically, it articulates with the femur at the knee joint and the talus at the ankle joint, forming critical connections that enable locomotion and distribute load. The tibial plateau, situated at the proximal end, is crucial for knee joint functionality, while the distal end plays a key role in stabilizing the ankle joint. Proximal tibial fractures constitute approximately 1% of all fractures[1] with the majority occurring between the ages of 40 and 60 in both genders[2] highlighting their prevalence in midlife. The tibia's anatomical and functional significance makes it indispensable for everyday activities such as walking, running, and jumping.

Non-union in tibial fractures occurs when the fractured bone fails to heal within the expected timeframe, typically defined as the absence of healing signs for at least nine months, with no further progress in the preceding three months. The incidence of non-union varies depending on the fracture's anatomical location,[3] with an average rate of occurrence of

4.93%.[4] Non-union is broadly categorized into two types based on the biological activity at the fracture site: atrophic and hypertrophic. Atrophic non-union is characterized by insufficient biological activity and poor callus formation, often due to inadequate blood supply, appearing "cold" and inactive on imaging. In contrast, hypertrophic non-union is associated with sufficient biological activity but inadequate mechanical stability, leading to excessive callus formation. This condition creates an "elephant foot" appearance on radiographs as the body attempts to heal the fracture despite ongoing instability. Non-union can result in chronic pain and significant functional as well as psychosocial disabilities.[5]

Infected non-union occurs when a bone fracture fails to heal due to persistent infection at the fracture site, characterized by chronic inflammation, impaired blood supply, and mechanical instability, often requiring a multidisciplinary approach for effective management.[6] Surgical expertise in limb lengthening, deformity correction, and bone transport techniques is essential to address its complexities.[7] The condition's pathophysiology involves bacterial colonization, biofilm formation, and the host immune response. Pathogens can invade the fracture site through trauma, surgery, or hematogenous spread, adhering to exposed bone or implants and forming biofilms—structured bacterial communities encased in a protective extracellular matrix that shields bacteria from antibiotics and immune clearance. This persistent infection triggers an inflammatory response, releasing cytokines and enzymes that cause bone degradation (osteolysis), delayed healing, and sequestrum formation. Compromised vascularity further hampers healing by limiting nutrient and immune cell delivery. Elevated acute phase reactants indicate active infection and help monitor treatment progress. Investigations commonly reveal anemia, hypoproteinemia, and comorbid conditions, while serological testing for hepatitis B, HIV, and hepatitis C is critical in such cases.[8]

The Ilizarov technique has proven to be highly effective in managing complex orthopedic conditions, especially in the treatment of infected non-union. Clinical studies consistently highlight its success in achieving bone union, controlling infection, and restoring function in cases where conventional treatments often fall short. The mechanical axis deviation, typically ranging from 0–8 mm medial to the knee center, is crucial in evaluating alignment during treatment.13 By combining careful debridement, dynamic external fixation, and distraction osteogenesis, the Ilizarov method addresses both the mechanical and biological challenges of infected non-unions. This comprehensive approach eliminates infection while simultaneously fostering bone regeneration and vascularization. Studies show bone union rates surpassing 90% with the Ilizarov method, even in cases with severe deformities, significant bone loss, or long-standing infections. The center of rotation and angulation (CORA), determined by the intersection of specific lines, quantifies deformities for correction, ensuring precise outcomes.[9] Infection control rates are similarly high, with most patients experiencing complete resolution after thorough debridement and targeted antibiotic therapy.

The aim of the present study was to assess and analyze the effectiveness of Ilizarov ring fixator in the treatment of infected non union in adult tibial fractures.

MATERIALS AND METHODS

This was a hospital-based prospective study was conducted from July 2023 to December 2024 at the Department of Orthopaedics, J.L.N. Medical College and Associated Group of Hospitals, Ajmer, Rajasthan. The study population consisted of patients presenting with infected non-union tibial fractures at the Department of Orthopaedics, JLN Medical College & Hospital, Ajmer.

Inclusion Criteria

1. Patients with infected non-union of tibial fractures treated using the Ilizarov method.
2. Both male and female patients aged between 20 to 65 years, with regular post-operative follow-up throughout the study.

Exclusion Criteria

1. Patients with severe damage to the tibial nerve, peripheral vascular disease, psychiatric disorders (including senile dementia), or those anticipated to have poor cooperation.

Method of Data Collection

A detailed history regarding the mode of injury, previous treatment history, time since the initial injury, and disease progression was recorded. Following a thorough general physical examination and local examination, events such as the duration of non-union and infection, degree of shortening, and any prior interventions were documented. Based on this, the decision was made to treat the patient with the Ilizarov method. The Ilizarov ring, wires, and model frame were shown to the patients, and they were informed about the need for multiple operative interventions, including debridement, bone grafting/bone marrow infiltration, corticotomy, and changes to wires/pins. A thorough preoperative evaluation and pre-anesthetic check-up were conducted. The Ilizarov frame was pre-constructed one day before surgery and sterilized. Antibiotics were discontinued two days prior to surgery to allow for intraoperative cultures. The patient was positioned in a supine position on a radiolucent operating table, using sterile draped sandbags to position the limb for easy ring assembly under C-arm guidance. The standard Ilizarov technique was followed for wire placement and frame construction. At each follow-up, the progression of events was documented on a proforma.

Follow-up

Patients were followed up with radiographs every 6 weeks for up to 6 months to monitor for union, infection, limb length discrepancy, and residual bone deformity.

RESULTS

Table 1: Baseline characteristics

Age Group (in years)	No. of Patients	Percentage
<30	5	25
31-40	5	25
41-50	2	10
51-60	3	15
>60	5	25
Gender		
Female	3	15
Male	17	85
Mode of Injury		
Road Traffic Accident	18	90
Fall from height	2	10
Fracture Site		
Distal Tibia	7	35
Mid Tibia	8	40
Proximal and Distal Tibia (Segmental)	1	5
Proximal Tibia	4	20

A total of 20 patients were included in the study, with the majority falling into three age categories: less than 30 years (25%), 31–40 years (25%), and over 60 years (25%). Patients aged 41–50 years comprised 10% of the cohort, while those aged 51–60 years accounted for 15%. The mean age of the patients was 43.11 ± 7.12 years. Out of 20 patients, 17 (85%) were male and 3 (15%) were female, indicating a male predominance in the study population. Road traffic accidents were the most common cause, accounting for 90% of cases, while falls from height contributed to 10% of cases. Mid tibia fractures were the most common, observed in 40% of cases, followed by distal tibia fractures in 35% and proximal tibia fractures in 20% of patients. Segmental fractures involving both the proximal and distal tibia were seen in 5% of cases.

Table 2: Bone Transport Distance and Bone Grafting in Patients

Bone Transport (in cm)	No. of Patients	Percentage
Two	1	5
Three	1	5
Four	2	10
Five	1	5
Six	1	5
Seven	1	5
Eight	2	10
Ten	1	5
Twelve	2	10
Thirteen	1	5
Fourteen	1	5
No	6	30
Bone Grafting		
No	5	25
Yes	15	75

Bone transport was not performed in 30% of patients. Among those who underwent bone transport, the most common distances were 4 cm, 8 cm, and 12 cm, each observed in 10% of cases. Other bone transport distances ranged from 2 cm to 14 cm, each accounting for 5% of patients. Bone grafting was performed in 75% of patients, while 25% did not require the procedure.

Table 3: Moore Dahl Grading for Pin Site Infection

Moore Dahl Grading (Pin Site Infection)	No. of Patients	Percentage
Grade 2	7	35
Grade 3	5	25
Grade 4	8	40

The majority of patients had Grade 4 infections (40%), followed by Grade 2 infections in 35% of cases and Grade 3 infections in 25%.

Table 4: Wire Change and Cortectomy in Patients

Wire Change	No. of Patients	Percentage
Done	8	40
No	12	60
Cortectomy		
Done	11	55
No	9	45

Wire changes were performed in 40% of cases, while 60% of patients did not require a wire change. Cortectomy was done in 55% of cases, while 45% of patients did not undergo this procedure.

Table 5: Bone Healing Results and Outcome of Treatment in Patients

Bone Results	No. of Patients	Percentage
Excellent	12	60
Good	7	35
Poor	1	5
Outcome		
Excellent	5	25.9
Fair	3	14.8
Good	11	51.9
Poor	1	7.4

The majority of patients (60%) had excellent results, while 35% had good outcomes and 5% had poor results. The majority of patients (51.9%) had good outcomes, followed by excellent outcomes in 25.9%, fair outcomes in 14.8%, and poor outcomes in 7.4%.

DISCUSSION

The Ilizarov ring fixator is a versatile technique that holds great promise in the management of non-unions after soft tissue repair when needed. A limb that would have been non-salvageable and proceeded to amputation in the past is given a chance and made salvageable by plastic surgeons by soft tissue reconstruction.[10] Non-union is one of the greatest challenges associated with limb length discrepancy, multi drug resistant organisms, soft tissue defects, deformities etc. Although many techniques are available for the treatment of infected non-union, all of them cannot be addressed simultaneously. By using the Ilizarov method most the problems associated with infected non-union can be handled. But it is technically demanding and time consuming.[11] The patient's acceptance plays a crucial role in the success of this modality of treatment. The psychological and physical trauma to the patient when presented to with the thought of another surgery is often underestimated. In this study of 20 patients, the majority were either under 30, between 31–40, or over 60 years old (each 25%), with fewer in the 41–50 (10%) and 51–60 (15%) age groups. The mean age was 43.11 ± 7.12 years, reflecting a distribution concentrated in both younger and older adults. In a similar study, Fahad S et al[12] assessed 51 patients with a broader age range of 18 to 75 years, resulting in a higher mean age of 45.65 ± 16.69 years. This reflects a more diverse age spread among the study population. In the current study involving 20 patients, a clear male predominance was observed, with 17 males (85%) and only 3 females (15%) comprising the cohort. This male-to-female ratio aligns with trends seen in similar research. For instance, Fahad S et al[12] also reported a male-dominated sample, where 80% of the 51 participants were men and 20% were women.

In the present study, road traffic accidents emerged as the leading cause of injury, accounting for 90% of cases, while falls from height were responsible for the remaining 10%. Similarly, Fahad S et al[12] reported road traffic accidents as the predominant cause (64.7%), with falls comprising 12.62%, followed by less common mechanisms such as gunshots (8.73%) and blast injuries (3.9%). In a comparable study, Gundavarapu A et al[13] observed that all patients sustained high-velocity trauma due to road traffic accidents, predominantly presenting with Type III compound fractures (60%), while Type II and I injuries constituted 16.67% and 10%, respectively; closed fractures were noted in only 13.34% of cases. In the current study, fracture distribution revealed that mid-tibia involvement was most frequent, affecting 40% of patients. Distal tibia fractures followed closely at 35%, while proximal tibia fractures accounted for 20% of cases. Segmental fractures, involving both proximal and distal segments, were relatively uncommon, seen in only 5% of the cohort. Similarly, Fahad S et al[12] noted that the distal third of the tibia was the most affected site, with 50% of patients showing non-unions in this region, while 40% were involved of the middle third and 10% of the proximal third. In a comparable observation, Sakale H et al[14] also found the middle third to be the most fractured area (56.25%), followed by the lower third (31.25%) and the upper third (12.5%).

In the present study, bone transport was not required in 30% of the patients. Among the remaining cases, the most frequently observed transport distances were 4 cm, 8 cm, and 12 cm, each accounting for 10% of patients. Additionally, smaller and larger transport lengths—ranging between 2 cm and 14 cm—were noted in 5% of cases each, reflecting a broad variability based on individual defect size. Similarly, Kingsly P et al[15] reported an average bone transport length of approximately 6.5 cm, highlighting the effectiveness of external fixation in achieving segmental bone reconstruction. In this study, bone grafting was required for 75% of the patients, while the remaining 25% did not need the procedure. Similarly, Wani B et al[16] reported that bone grafting was performed in 5 out of 25 patients (20%) before the application of the Ilizarov Ring

Fixator (IRF). This technique is commonly employed to assist in bone healing, especially in cases with significant bone loss or nonunion, by providing both structural support and stimulating bone formation. In the present study, the majority of patients experienced Grade 4 pin site infections (40%), followed by Grade 2 infections in 35% and Grade 3 infections in 25%. Similarly, Wahid A A et al[17] reported that pin track infections occurred in 6 patients, representing 16.2% of cases. This complication is frequently observed in patients with external fixation, where irritation or infection can arise at the insertion sites of the pins or wires. The occurrence of wire changes in the current study is outlined in the table, where 40% of patients required wire changes, while the remaining 60% did not undergo this procedure. Similarly, Gundavarapu A et al[13] reported that infections leading to the replacement of wires, pins, or rings were observed in 5 patients, while wire breakage was noted in 2 patients, both situations requiring additional surgical interventions. The table presents the distribution of cortectomy procedures performed in the study, with 55% of patients undergoing the procedure and 45% not requiring it. Similarly, in a study by Kingsly P et al[15] of 20 patients, 45% underwent proximal metaphyseal corticotomy, 35% had proximal diaphyseal corticotomy, and 20% underwent distal diaphyseal corticotomy. Additionally, recorticotomy was performed in 10% of patients due to premature consolidation of the corticotomy site. In the current study, bone healing outcomes were assessed using the ASAMI criteria. The majority of patients (60%) achieved excellent results, while 35% had good outcomes, and 5% experienced poor results. These findings are consistent with those of Fahad S et al[12] who reported that 73.33% of patients had excellent outcomes, 63.33% had good results, 23.33% had fair results, and 10% had poor outcomes due to nonunion, infection, or significant deformity. In the present study, the majority of patients (60%) achieved excellent bone healing outcomes, while 35% had good results and 5% had poor outcomes. This distribution is consistent with findings from Fahad S et al[12] who reported excellent outcomes in 73.33% of cases, good results in 63.33%, fair outcomes in 23.33%, and poor outcomes in 10% due to nonunion, infection, or significant deformity.

CONCLUSION

The Ilizarov ring fixator proves to be a highly effective treatment modality for managing infected non-union of tibial fractures. Its success lies in its ability to promote bone union while simultaneously addressing infection, limb alignment, and functional recovery. Most patients in the study experienced satisfactory healing, with a majority achieving excellent or good outcomes. Importantly, the fixator allowed for bone transport in cases of segmental loss and reduced the need for extensive bone grafting in a subset of patients. Overall, the Ilizarov technique remains a robust and adaptable solution for complex tibial non-unions, particularly in the presence of infection. Its application, though demanding in terms of surgical expertise and patient compliance, delivers promising outcomes in terms of limb salvage, structural integrity, and functional recovery.

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