

Functional Outcome of Ilizarov Ring Fixator for Definitive Fixation of Open Tibial Fractures

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Abstract

Background: Tibia is most frequently fractured long bone. Ilizarov technique involves a ring fixator based on principle of distraction osteogenesis that permits axial micro mobility at the fracture site to encourage bone regrowth. It is ideal for management of open tibial fractures.

Objectives: To analyse the functional outcome of definitive management of open tibial fractures with Ilizarov ring fixator and evaluate the complications associated with its use.

Methods: The study was conducted at Department of Orthopaedics, NIMS Hospital Jaipur and included 32 patients of open tibial fractures treated with Ilizarov ring fixator. The post operative complications, functional outcome and bone healing were assessed.

Results: Average age of patients was 41.34 years with a male to female ratio of 2.2 : 1. Commonest fracture grade was Grade IIIA (n=19, 59.3%). The commonest post operative complication was Pin tract infection (n=18, 56.2%). Our study reported 100 % union rate. Average time for union was 28 weeks. Functional outcome was excellent in 16 cases (50%), Good in 11 cases (34.3%) and fair in 5 cases (15.6%). Bone healing was excellent in 14 cases (43.7%), good in 13 cases (40.6%), fair in 4 cases (12.5%) and poor in one case (3.1%).

Conclusion: Even though the complications are encountered, they can be easily managed with the external fixator in place resulting in healing and union of the fracture. Ilizarov's external fixator is valuable management choice for patients with open tibial fractures.

Keywords: Ilizarov external fixator, Tibial fracture, Functional outcome, Bone healing

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Introduction

The tibia is the most frequently fractured long bone, is particularly prone to open fractures due to its positioning and relatively delicate soft-tissue covering. These open fractures pose a significant challenge for trauma surgeons due to the prolonged period of morbidity, pain, infection, and subsequent functional impairment ultimately impacting patient care, productivity, time, and overall quality of life. Current treatment options include intramedullary nailing, plate fixation, and external fixation. [1-4] Gavriil Abramovich Ilizarov (1921-1992), a Soviet Physician, and Surgeon devised the Ilizarov technique. The construct is a ring fixator and relies on the principle of distraction osteogenesis. The Ilizarov fixator is a kind of elastic external fixator that permits axial micro-mobility at the fracture site to encourage bone regrowth. Due to the inclusion of axial compression, distraction, and realignment, it

enables three-dimensional correction of angular and translational displacements. [2,3]

The Ilizarov method presents a minimally invasive option, necessitating several small stab incisions for effective intervention while minimizing damage to soft tissues and blood loss. This technique offers advantages in terms of mechanics, ensuring stability and allowing for precise alignment through adjustments during and after surgery and also enables early weight-bearing. Patients undergoing circular fixation seem to achieve superior outcomes as compared to other fixation methods according to reported data. [3] The ring fixator has been used for non-unions, or secondary to other available techniques after development of complications especially infections.

There are many articles reporting clinical and radiological outcome after Ilizarov fixation as a definitive treatment of open tibia fractures, most of which miss the point of functional outcome, i.e., how the individual would live his life post treatment? This study evaluates the functional outcome of using Ilizarov ring fixator as a definitive management option in open tibial fractures. The key components of our approach have been aggressive debridement; primary Ilizarov fixation and soft tissue coverage. This study also focuses on the post operative complications in these patients and how Ilizarov fixator has allowed easy management for such cases.

METHODS:

The present study was an observational study conducted at the Department of Orthopaedics, NIMS Hospital Jaipur. The study included 32 patients of open tibial fractures over a time period of 18 months from April 2022 to October 2023 to analyse the functional outcome of the Ilizarov ring fixator for these fractures.

Inclusion criteria-

- Patients with compound fractures of tibial diaphysis – Gustilo-Anderson type I, II and IIIa with all tibial fracture patterns.
- Patients of either sex aged between 18 -60 years.

Exclusion criteria-

- Polytrauma patients and patients with vascular injury
- Patients with intra articular fracture or pathological fractures.
- Patients requiring plastic surgery or contralateral leg flap surgery.

The patient coming in emergency department of NIMS hospital was primarily stabilized and assessment of fracture was done. The wound was

washed and packed. A high above knee slab was placed. Broad spectrum antibiotics and analgesics were started. Injection tetanus toxoid 0.5 ml stat was given. Appropriate radiographs including antero-posterior and lateral view of the involved leg were taken. Patients and attendants were given counselling regarding Ilizarov fixator and consent was taken. The frame was planned according to the fracture pattern and soft tissue injury assessed in accordance with Gustilo Anderson classification of open fracture.[5] Under appropriate anaesthesia, **Ilizarov external fixator** was applied to the involved leg according to principles of ASAMI Group of Surgeons (Association for the Study and Application of the Method of Ilizarov).[6]

Post operatively, radiographs were taken and antibiotics, analgesia and oedema controlling measures were done. Limb was kept elevated for 3-4 days. Patients were encouraged to do isometric quadriceps exercises as well as knee, ankle and toe range of motion both actively as well as passively. Ilizarov frame adjustments, if needed, were done post-operatively. Patient was allowed weight bearing from 2nd post-operative day. Distraction was started on day 7-8. Patients and their attendants were trained to distract on his/her own and were given instruction regarding pin tract care, mobilization exercises and follow up.

Serial follow-ups, including AP and lateral view X-rays were conducted at 4 weeks, 6 weeks, 3 months, 6 months, and one year to assess bone union and to analyse the functional outcomes of the patients.

We removed the Ilizarov fixator on Union. Union was considered when there was absence of pain at rest, absence of pain on movement with the patient bearing full weight on the limb, the fixator attached but dynamized and there is presence of bridging callus on X-ray. Bone healing and functional results were evaluated according to the modified classification of ASAMI as seen in Table 1. [6]

Table 1: Bone healing evaluation:

Criteria: - union with-	Result
1.without infection 2.less than 7° deformity 3.less than 2.5 cm leg-length inequality.	Excellent
2 out of above three criteria	Good
1 out of above three criteria	Fair
None of the above three criteria	Poor

Functional assessment was based on five criteria:

- Observable limp
- Stiffness of knee (loss of >70° of knee flexion, or loss of >15° of extension)
- Soft tissue sympathetic dystrophy
- Pain, that reduced activity or disturbed sleep

- Inactivity (because of unemployment or an inability to return to daily activities due to the injury).

The functional result - classified according to the following criteria:

- All 5 criteria absent - Excellent

- 1 or 2 criteria present but patient active - Good
- 3 or 4 criteria present but patient active - Fair
- Patient inactive regardless other criteria -Poor

Results:

The study included a total of 32 patients of open tibial fractures who were given Ilizarov external fixation and were followed for over 18 months. Average age of patients in our study was 41.34 years. The most common age group of presentation was 41-50 years. (12 patients, 37.5%). The majority of patients included in our study were males with a male to female ratio of 2.2 : 1 (22 male,10 female). Most patients of right sided tibial fracture were encountered (19 patients). All 32 patients had a history of road traffic accident-causing high velocity trauma and collision injuries leading to tibial fractures. A preoperative radiograph of distal one third fracture of tibial shaft is shown in Image 1.

37.5% cases (12 patients) presented with comminuted fractures and 25% (8 patients) presented with oblique fractures. Most cases in our study had diaphyseal fractures (13 patients,40.6%), 11 cases had meta-diaphyseal fractures (34.4%) while 8 cases had metaphyseal fractures (25%). All cases were classified according to the Gustilo–Anderson classification of open fractures. 19 cases (59.3%) had a GA Grade IIIA. 12 cases had Grade II fracture (37.5%) while one case was of Grade I (3.1%).

The average time for fixation was 2.4 days. The arrival to fixation time for most of the patients was on day One i.e., 11 patients (34.3%). 7 patients got their fixation done on day 2 (21.8%), while 9 patients got their fixation done on day 3 (28.1%). Figure 2 shows intraoperative placement of Ilizarov fixator and Figure 3 shows a radiograph of Ilizarov fixator in place. In our study, proper wound debridement was done during the Ilizarov fixation. Among these 9 patients (28%) required second debridement as the wounds were very dirty at presentation and primary debridement was unsuccessful in eradicating the infection completely. Although most of the patients (18 patients) did not require any additional procedure, 10 patients (31.2%) had to also undergo split skin grafting. 4 patients underwent corticotomy and bone transport.

Post operative complications: A variety of post operative complications were encountered in our study as shown in Table 2. The commonest post operative complication was Pin tract infection (18 patients, 56.2%). 46.8% patients (15 patients) developed angulation of more than 7 degrees, 12 Patients (37.5%) had pain and 10 patients (31.2%) developed Limp. 10 patients (31.2%) developed knee stiffness. This was successfully addressed through intensive physiotherapy while the ring fixator was still in place. 6 cases (18.7%) with shortening of limb were encountered where limb length discrepancy was >2.5 cm. These cases were compensated with shoe raises.

Table 2: Post operative complications

Complication	Number of cases	Percentage of total cases
Pin tract infection	18	56.2%
Angulation > 7 degrees	15	46.8%
Pain	12	37.5%
Limp	10	31.2%
Knee stiffness	10	31.2%
Limb Length Discrepancy >2.5 cm	6	18.7%
Infection	3	9.3%
Sympathetic dystrophy	2	6.2%
Inactivity	0	0

Union and Fixator removal: In our study union was achieved in all cases (100%), the earliest evidence of radiological union at the fracture site was observed after 5 months of surgery. The average time taken for union of open tibial fracture cases was 7 months (28 weeks). 14 out of 32 cases had union within 6 months of fixation and 14 cases has union withing 7 to 9 months. Union was delayed in few cases with infection and Pin site infection. We found that clinical union was 4- 6 weeks earlier than then radiological evidence. There were no cases of non-union. In most of the cases (46.9%), the Ilizarov

fixator was removed between 7-9 months, with the average time on fixator being 7.3 months i.e., 31 weeks.

Range of motion: In our study, the observed maximum range of knee motion varied from 0 to 110 degrees. Movement beyond 100 degrees was impeded by the proximal most ring, restricting further mobility. The minimum range of knee motion spanned from 0 to 50 degrees. The average knee joint range of motion ranged from 50 to 110 degrees.

Functional outcome and Bone healing: The Functional outcome of the patients was assessed starting from 4-6 weeks of fixator application and it was found that maximum patients had excellent outcome that is 16 out of total 32 cases (50%). Good

outcome was recorded in 11 cases (34.3%) while remaining 5 patients (15.6%) had Fair functional outcome. No cases of poor outcome were noted. (Table 3)

Table 3: Functional outcome

Functional Outcome	Number of cases	Percentage
Poor	0	0
Fair	5	15.6%
Good	11	34.3%
Excellent	16	50%
Total	32	100

It was found that most of the patients had excellent bone healing. 14 out of 32 patients (43.7%) has excellent bone healing with the technique. 13 patients (40.6%) had good bone healing, 4 patients had fair and only one patient was noted with poor bone healing.



Figure 1: Pre operative Xray showing distal 1/3rd diaphyseal fracture of tibia.



Figure 2: Intraoperative image showing placement of Ilizarov fixator

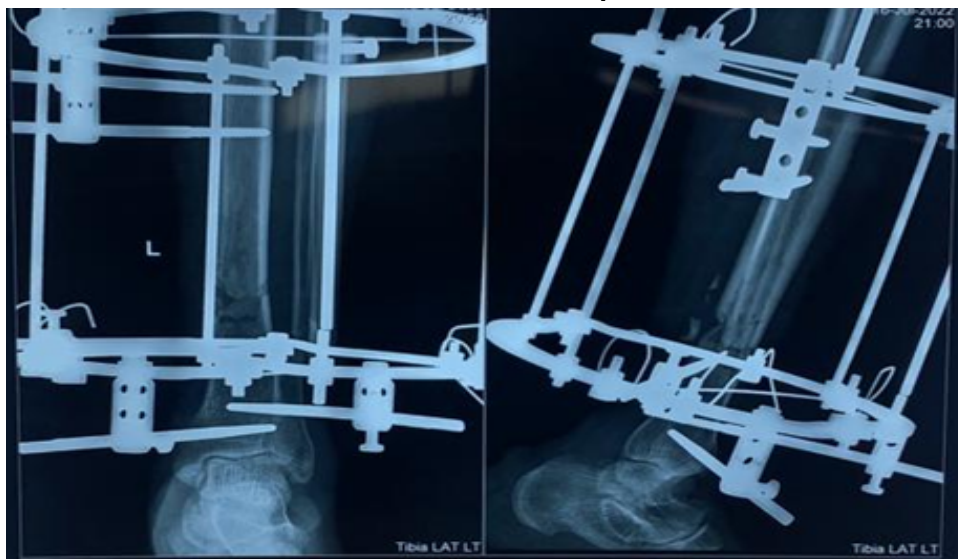


Figure 3: Post operative radiograph with Ilizarov fixator in place.

Discussion:

The management of open tibial injuries has gradually evolved due to, better understanding of surgical and functional anatomy and biomechanics of the tibia, the advent of external fixation devices. The Ilizarov fixator is an external fixation device characterized by its elasticity which features a multiplanar and multilayer design that ensures a more uniform distribution of stress at the fracture site. [2] The fundamental biomechanical principle underlying this technique is the "law of tension stress" (LTS) according to which, the gradual and sustained application of traction can stimulate the regeneration and active development of biological tissue. This remarkable regenerative capacity and adaptability of bone tissue enable it to extend into the surrounding areas, reaching nerves, blood vessels, muscles, and skin when subjected to appropriate tensile stress.²⁵ This principle is known as distraction osteogenesis (DO).

In 2015, Satish Nesari conducted a study, determining that Ilizarov circular fixation is an optimal approach for fractures, especially when extensive dissection and internal fixation are not advisable due to factors such as trauma to soft tissue, inadequate bone stock, or comminuted fractures. [7] Dagher F. determined the Ilizarov technique to be effective in managing complex compound fractures with bone loss, allowing for simultaneous treatment of bone loss, infection, nonunion, and deformity. [8]

On the basis of GA Classification, the comparison with other studies showed similarity with Bhosale N.D. which also had mostly Grade III fractures, but study done by SK Irfan Ali had a higher presentation of Grade II patients. [2,9] It was observed in our study that patients with lower grade of fracture had a shorter union time as compared to patients with higher grade whose union time was longer. 1 case with Grade I fracture united in less than 6 months. 8 cases out of 12 with Grade II fractures united in less than six months and the remaining 4 united within 7-9 months. On the other hand, 3 patients with Grade III fractures took 10-12 months to unite while 1 patient took more than 12 months.

Our study has reported 100% union rate with the average time taken for union was 28 weeks. This

mean union time was comparable to union time of study done by Hussain A. in 2021 which was 23.61 weeks. Tucker observed 100% union of tibial fractures treated with Ilizarov external fixator with mean union time of 25.6 weeks.⁴⁷ SK Irfan Ali in 2015 reported the average union time of 20.76 weeks. The average time for bone healing according to Vasileios P in 2021 was 5.5 months while it was 3.6 months in a study done by Messner J in 2018. [10-13]

The average duration on fixator in our study was 31 weeks. In the study done by Bhosale N.D. the earliest instance of ring removal was observed at the 6th month post-surgery, and in two cases, the ring fixator was removed after a duration of 8 months. Wani N. in 2011 reported the duration of fixator application between 24 weeks and 45 weeks and the mean time to union was 29.1 weeks. [2,14]

In our study it was noted that 12 patients (38%) who had history of tobacco intake had relatively more percentage of patients in the Fair (25%) and Good (33.3%) category of functional outcome. While patients who did not have history of tobacco intake had a higher percentage of patients with excellent outcome (55%). In a study conducted by Petre in 2014, it was found that fractures exhibit a prolonged healing process in individuals who smoke. The delayed bone healing in smokers is attributed to the adverse impact of nicotine on the production of bone-forming cells that leads to higher likelihood of persistent pain and other complications in the post-healing phase as well. [15]

Pin tract infection was the most commonly encountered post-operative complication in our study which is similar to the studies done by Bhosale N.D., SM Mohammed and Hussain A. [2,10,16]

The Functional outcomes of our study when compared to other studies showed similarities as shown in Table 4. Most studies with Ilizarov fixation for open tibial fractures resulted in Excellent results. Similar to our study, mostly excellent results were found by SM Mohammed in 2022, Wani N. in 2010 and Latif P.A. in 2006. [14,16,17]

Table 4

Study	Total cases	Excellent	Good	Fair	Poor
Present study, 2023	32	16 (50%)	11(34.3%)	5 (15.6%)	0
SM Mohammed, 2022	30	15 (50%)	7 (23%)	5(17%)	3 (10%)
Hussain, 2021	40	12 (30%)	22 (55%)	2 (5%)	4 (10%)
Wani N., 2010	60	48 (80%)	10 (16.6%)	2 (3.3%)	0
Sk Irfan ali, 2015	20	6 (30%)	11 (55%)	1 (5%)	2 (10%)
Latif P.A., 2006	30	15 (50%)	10 (33%)	3 (10%)	2 (7%)

Similarly, it was noted that the bone healing results in our study were comparable with other studies as

most patients had excellent and good results. Hussain A., 2021 and SK Irfan Ali, 2015 reported,

good outcome category as the commonest outcome in bone healing. [9,10] Our study revealed mostly Excellent bone healing (n=14, 43.7%).

Final outcome showing mostly excellent results of functional outcome and bone healing is indicative of the fact that Ilizarov is a great treatment option for open tibial fractures. Patients who had post operative complications were managed easily as Ilizarov fixation gave opportunity for second debridement without the need to compromise with the fixation. As we focused on early weight bearing patients were benefited with faster union and higher functional outcomes.

Conclusion: Our study done on 32 open tibial fracture patients treated with Ilizarov's external fixator has shown 100% union of the fracture with mostly Excellent functional outcomes and Excellent bone healing. Thus, we conclude that even though the complications are encountered during this treatment modality, they can be easily managed with the external fixator in place resulting in subsequent healing and union of the fracture. Therefore, Ilizarov's external fixator is a valuable management choice for patients with open tibial fractures.

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