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Original Research Article

Functional outcome analysis of ilizarov ring fixator as definitive fixation of open tibial fractures

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ABSTRACT

Background: Ilizarov fixator for open tibia fractures permits axial micro mobility at fracture site to encourage bone regrowth. Literature search revealed dearth of studies from Indian centres which have evaluated its utility in open tibia fractures.

Materials and Methods: This was an observational prospective study conducted by Department of Orthopaedics at VVPF Medical College, Ahmednagar in Maharashtra, between July 2021 to June 2022. All patients who had open tibia fractures and managed by Ilizarov ring fixator were included. Duration of treatment with fixator was evaluated, along with range of motion at knee and ankle, union status and complications.

Results: 30 patients were enrolled, majority being males (n=22, 73.33%). Most patients suffered from fractures of right side (n=21, 70%) confined to metaphyseal region (n=16, 53.33%). Commonest mode of injury was road traffic accidents (n=26, 86.67%). Based on Gustilo-Anderson classification, majority cases were grade IIIA (n=16, 53.33%). 23 cases (76.67%) were managed initially with external fixators, while 7 cases were directly managed with Ilizarov ring fixator. Most cases (n=15, 50%) received definitive fixation on day-3 of injury. Commonest complication noted was pin site infection (n=11, 36.67%) and delayed union (n=4, 13.33%). Knee stiffness at $30^0$was noted in 3 cases, corrected by physiotherapy. All patients attained fracture union, with the earliest evidence of radiological union observed after 2 months of surgery.

Conclusion: As it allows for early full weight bearing mobilisation, has higher union rates and lesser incidences of malunion, use of Ilizarov external fixator maintains its importance in the management of open tibial fractures.

1. Introduction

The tibia is the most often broken long bone and is more prone to open fractures than any other long bone due to its position and flimsy soft-tissue covering.[1] Delay in union or non-union is commonly caused by open fractures and significant comminution. The best way to treat these fractures is still up for debate. The focus of current management theories is on complete debridement and prompt bone stabilisation for the restoration of optimum function.[2] According to studies, open fractures treated with traditional half pin fixators and afterwards plates have a high risk of non-union and usually require further surgeries.[3] In order to prevent the union issues, modern fixing techniques have evolved to maintain endosteal circulation in open fractures.

The method of treating open tibia fractures with the help of a “ring fixator” was developed by a Russian doctor named Gavril A. Ilizarov. The various holes in the Ilizarov ring can be used to attach trans-fusional K-wire or haft pins. The frame of the apparatus is made up of two or more linked rings. The additional frame components

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necessary for the dynamic bone therapy are carried by the rings. They fundamentally function as elastic external fixators that permit axial micro-motion that promotes fracture healing and regeneration. It has been demonstrated that circular external fixators (Ilizarov) and unreamed intramedullary nailing offer a "protective fixing" that keeps the endosteal circulation intact. Both modalities, however, have advantages and drawbacks of their own. When compared to an Ilizarov fixator, intramedullary nailing is less burdensome and enables early mobilisation and weight bearing. In contrast, using intramedullary implants in open fractures is linked to greater rates of infection and frequently necessitates further procedures.[4] The Ilizarov fixator is a kind of elastic external fixator that permits axial micro mobility at the fracture site to encourage bone regrowth. Additionally, it is a multiplanar and multilayer fixator, allowing for a more uniform distribution of stresses at the fracture site thanks to its circumferential design. Due to the inclusion of axial compression, distraction, and realignment, it enables three-dimensional correction of angular and translational displacements. Since it resists shear stresses at the fracture site, it offers a perfect environment for bone repair. Additionally, the tissues in the immediate vicinity sustain less harm. However, it comes with a few drawbacks, including the potential for pin tract infections, patients' limited acceptability, cumbersome equipment, and assembly challenges. The K-wires are also positioned across the muscle tissue and are kept in place for a long time. The nearby joints' range of motion is therefore limited as a result.[5]

Literature search revealed that there are studies from foreign centres which have evaluated the functional outcomes of open tibia fractures after using Ilizarov ring fixator, but such studies from Indian centres are scarce. Present study was conducted to evaluate the outcomes of open tibia fractures after managing with Ilizarov ring fixator at a tertiary care Indian centre, which will help the Indian orthopaedic surgeons in understanding the utility of the modality in Indian context.

2. Materials and Methods

This was an observational prospective study conducted by Department of Orthopaedics at Dr. Vitthalrao Vikhe Patil Medical College, Ahmednagar in Maharashtra, between July 2021 to June 2022. The participants' signed agreement was obtained prior to the intervention, and this study was authorised by the relevant medical college's ethics committee. All patients at the study centre who had open tibia fractures and were being treated with an Ilizarov ring fixator were included in the research. Gustilo's classification of open fractures was used to categorise the open tibia fractures.[6] Patients with closed fractures, pathological fractures, or those who did not provide their agreement to participate in the study were excluded. Compound tibial fracture patients were brought as quickly as feasible to the operation room for debridement. These fractures were treated conservatively with a window for dressing changes and either a long leg posterior slab or long leg posterior cast. Necessary fluids and electrolytes replacement or whole blood transfusion were administered as per requirement.

2.1. Surgical procedure for Ilizarov ring fixation

In a typical instance, a fracture would receive its final therapy within a week. Depending on the situation, patients had spinal or general anaesthesia during surgery. One day before the procedure, the frame was pre-assembled. The rings' spacing was altered in accordance with the fracture anatomy. A four-ring frame was often used to treat fractures with minor comminution and length loss of less than 1 cm; more complicated fractures required additional rings. After being tensioned using a dynamometer to 90–110 kg, the wires were fastened to the rings using ring fixator bolts. All around, the rings were kept two fingerbreadths away from the skin. With the C-arm image intensifier on the table, the reduction was examined, and changes were made in accordance with the same setting. The povidone iodine solution (10%) was used to cover and treat the pin tract wounds. Every day, the pin site was cleansed with spirit or a 10% solution of povidone iodine. Hydrogen peroxide (H2O2) in a mild solution was used to dissolve any clots or crust that were present. Oral antibiotics were administered when the pin tract wound became irritated or showed signs of discharge. As soon as the patient could handle the discomfort, axillary crutches were used to help the patient bear some weight. Every time a patient complained of discomfort or instability, the frame and wire were examined. The wire's tension was tested, and tensioning was done, if necessary.

2.2. Patient assessment

The demographic and baseline details of enrolled patients were noted. Details about mode of injury, classification of fracture were also noted. The Ilizarov external fixator was withdrawn when there was clinico-radiological union was found to be present. The duration of treatment with fixator, and average time of union were also evaluated. The range of motion at knee and ankle was also evaluated at follow-up. The patients were followed up at an interval of every month for 3 months after surgery, and subsequently 3 monthly till a period of 1 year.

The fracture was considered to be united is all the following criteria were met:

1. Patient could walk without support after loosening the frame crossing the fracture site and not tender at fracture site.
2. No mobility at fracture site after loosening the frame and

3. Radiologically, if there was enough callus across the fracture site and obliteration of the fracture line.

Once the fracture had joined, the frame was taken out either in the operating room or the outpatient department. If the frame was withdrawn before the fracture healed because of frame intolerance or a superficial infection, a patellar tendon-bearing POP cast was used.

The outcomes were assessed using Tucker's criteria. A fracture union with complete knee extension and more than 125° flexion, ankle range of motion greater than 75% of normal, limb length disparity less than 1 cm, no angulation greater than 7° in any plane, no rotation greater than 7°, and no infection were considered good results. Fracture union with one missing criterion was an excellent outcome, and fracture union with two missing criterion was a reasonable result. Poor results showed non-union or fracture union with three missing requirements.[7]

2.3. Statistical analysis

SPSS software was used to analysis data. Mean (+ SD) was calculated for all continuous variables, while the discrete data was described as numbers and percentages.

3. Results

3.1. Patient and fracture details

Demographic and baseline characteristics of open tibial fracture have been mentioned below in Table 1. A total of 30 patients were enrolled in study, majority being males (n=22, 73.33%). Majority of cases suffered from open tibia fractures of the right side (n=21, 70%). Commonest mode of injury was road traffic accidents, noted in 86.67%. Based on Gustilo-Anderson classification, majority cases were grade IIIA (n=16, 53.33%), followed by grade IIIB (n=7, 23.33%). Commonest pattern of open tibial fracture noted was communited (n=19, 63.33%), followed by oblique or spiral fractures (n=4 each, 13.33%). Most patients suffered from fractures which were confined to the metaphyseal region (n=16, 53.33%).

3.2. Treatment details

Of the 30 enrolled cases, 23 cases (76.67%) were managed initially with external fixators, while 7 cases were directly managed with Ilizarov ring fixator. In the external fixation category, 3 cases received application of knee spanning external fixator, and other cases were managed with tibial external fixator.

30% of the enrolled cases (n=9) were managed with calcaneal ring application. Most of the distal tibial fractures with articular involvement were managed with calcaneal ring application, while few distal fractures were managed with calcaneal ring application for stable construct.

Table 1: Demographic and baseline opentibial fracture characteristics of patients enrolled in study

Characteristics	
Age (years) (mean + SD)	40.89 + 7.67
Gender, n (%)	n=30
Male, n (%)	22 (73.33%)
Female, n (%)	8 (26.67%)
Laterality of open tibia fractures	n=30
Right side, n (%)	21 (70%)
Left side, n (%)	9 (30%)
Mode of injury	n=30
Road traffic accidents, n (%)	26 (86.67%)
Fall from height, n (%)	3 (10%)
Sports injuries, n (%)	1 (3.33%)
Gustilo-Anderson classification	n=30
Grade I, n (%)	1 (3.33%)
Grade II, n (%)	6 (20%)
Grade IIIA, n (%)	16 (53.33%)
Grade IIIB, n (%)	7 (23.33%)
Pattern of fracture	n=30
Communited, n (%)	19 (63.33%)
Oblique, n (%)	4 (13.33%)
Spiral, n (%)	4 (13.33%)
Segmental, n (%)	2 (6.67%)
Transverse, n (%)	1 (3.33%)
Site of Fracture	n=30
Metaphysis, n (%)	16 (53.33%)
Diaphysis, n (%)	9 (30%)
Metaphyseodiaphyseal, n (%)	5 (16.67%)

In 18 of the enrolled cases (60%), patients underwent secondary wound debridement on the day of application of Ilizarov ring fixator. Most of the enrolled cases (n=15, 50%) received definitive fixation on day-3 of injury, while 6 cases each (20% each) received fixation either with 2-days of injury or 5-days after injury. 3 cases (10%) received fixation on 4^{th} day after injury. The mean duration from injury to Ilizarov fixation was 3.11 days (SD: 1.2 days). The surgery time ranged from 90 minutes to 120 minutes, with a mean time calculated to be 102 ± 4 minutes.

3.3. Post-operative complications

elow gives complete details of post-operative complications. The commonest complication noted in study was pin site infection (n=11, 36.67%), followed by delayed union (n=4, 13.33%). Of two patients who suffered from limb shortening, one patient had 1 cmshortening while other had 1.5 cm shortening. None of the patients suffered from fracture non-union.

3.4. Range of motion at knee and ankle

The maximum range of knee motion recorded in our study ranged from 0 degree to 90 degrees. Beyond 90-degree, patient couldn't move because of proximal most ring which

Table 2: Post-operative complications noted in study

Complication	Number of patients (%)
Pin site infection	11 (36.67%)
Delayed union	4 (13.33%)
Knee stiffness	3 (10%)
Limb shortening	2 (6.67%)
Ankle stiffness	1 (3.33%)
Malunion	1 (3.33%)

restrict the further movements. Minimum range of knee motion ranged from 0 – 30 degrees. Average range of motion at knee joint in our study of 30 patients ranged from 50 - 90 degrees. Knee stiffness at 30 degree was noted in 3 cases, which was corrected by aggressive physiotherapy while on ring fixator.

Ankle range of motion was initiated on the next day. Maximum range of ankle motion recorded in our study ranged from 0 to 35 degree of dorsiflexion and 0 to 25 degrees of plantar flexion, the minimum range of ankle motion recorded in our study ranged from 0 to 10 degree of dorsiflexion and 0 to 10 degrees of plantar flexion.

3.5. Fixator removal and union status

All patients in study attained fracture union, with the earliest evidence of radiological union at the fracture site observed after 2 months of surgery. Earliest ring removal was noted at 6^{th} month after surgery, and for 2 cases ring fixator was removed after 8 months because of segmental fracture. A single case of delayed union was noted in study. Based on union of fracture, the grading of outcome is presented in Chart 1.

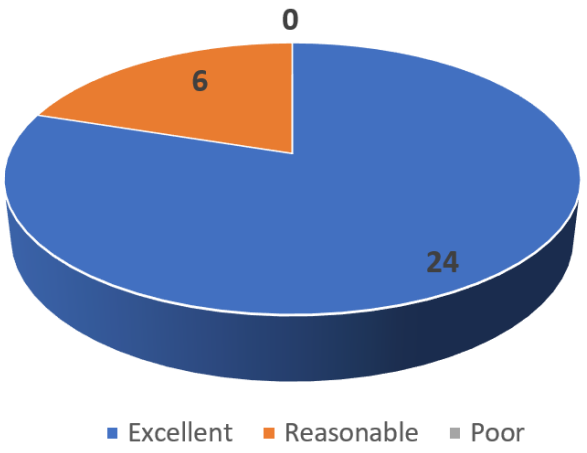

Chart 1: Outcome of patients based on Union of fracture

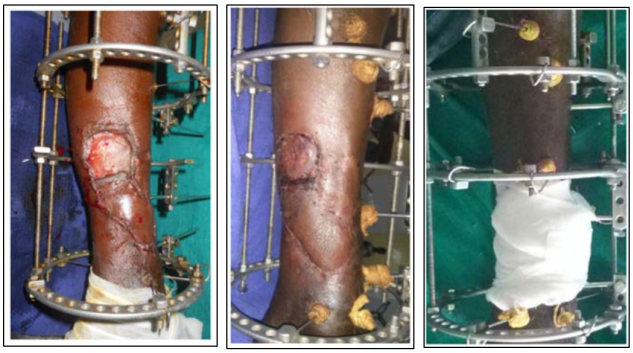

Fig. 1: Application of Ilizarov fixator in patients enrolled in study

4. Discussion

Due to insufficient soft tissue coverage at the front region of the leg and related tissue loss in high-energy accidents, open tibia fractures are renowned. The major determining factors in the outcome of such injuries are the degree of wound infection, the degree of soft tissue injury, and the surgeon's skill. In the past, immobilisation and casting were thought to be the best course of treatment for these fractures. With the current alternatives, however, many surgeons are now using external fixators, intramedullary nails, and fixation with plates and screws. The essential guidelines for care continue to be: prompt assessment of the open fracture, tissue debridement under sterile circumstances, beginning of the proper antibiotic cover, and fixing of the fracture.[5,8,9] Plate fixation has a multitude of side effects, particularly in comminuted fractures. According to Bach et al., osteomyelitis affected 19% of open tibial fractures fixed with plates.[10] In developed nations, primary intramedullary nailing is increasingly used as a therapy for open tibial fractures.[11] However, intramedullary devices are linked to issues with infections and slow unions. Due to the relatively simple nature of the treatment and the little disturbance of the tibia's blood supply, external fixators have emerged as the preferred method. These benefits, however, may be overshadowed by the high rate of pin-tract infections, non-unions, challenges in managing soft tissues, and risk of malunion.

The Ilizarov ring fixator is a safe and efficient treatment option for open tibial fractures despite the dangers and issues outlined above. All the enrolled patients in our study experienced fracture union, demonstrating excellent outcomes in 80% cases and reasonable outcomes in 20% cases. According to Hosny et al., all 34 open tibial fractures treated with Ilizarov demonstrated union.[12] As a result of Ilizarov's ability to treat high energy tibial fractures quickly and effectively, Sidharthan et al. reported success in union in all 42 of the high energy tibial fractures they treated.[13] All 60 open tibial fractures treated with an Ilizarov ring fixator have demonstrated union, according to Wani et al.[14] The

minimally invasive nature of the fixator, which necessitates less removal of soft tissues and limits eventual interference with the vascularity of the fracture, is primarily responsible for this high union rate.

Whether the incision is closed or not, the healing process continues for the first five to seven days. As a result, delayed suturing in wounds closed within five days results in the same level of wound strength as primary closure.[15] Thus, the use of an Ilizarov fixator three to five days after the injury reduces the number of subsequent surgeries needed to accomplish wound coverage. In our study, the fixator was applied after 3 days of injury in 70% of cases, which was in-line with the available published data and rationale.

When compared to other methods, Ilizarov requires less subsequent operations. In Ilizarov fixation, wound covering treatments often make up most of the secondary procedures. The replacement of pins typically necessitates further operations. In contrast, nailing carries a risk of infection, malunion, and non-union that may necessitate further treatments. The intramedullary circulation is hampered by tibial nailing, which increases the risk of infection. Ilizarov is related with lower incidence of infection and non-union since it is minimally intrusive and does not affect the biology of the fracture.

Ilizarov fixation can cause a variety of problems, however the majority of them are minor.[16] Most of the time, infections are superficial and minor. In our study, 36.67% cases experienced pin-site infections while 4 cases (13.33%) experienced delayed union. Due to the weight supported by the fixator, a nidus of infection raises the risk of wire loosening and frame instability. To avoid deep infections and septic arthritis, proper pin site care and vigorous surface infection control are crucial (in cases with wires close to the subchondral bone). Pin tract problems are more common when there is insufficient pin care.[17] Significant issues include muscle contracture and joint stiffness, which are particularly prevalent in patients who have the fixator placed for an extended length of time and in fractures close to the joints.[18] A successful functional result requires early and intensive range of motion exercises. Up to 8% of instances might result in the unpleasant complication of tibial refracture. The early removal of the frame is typically the cause of these fractures. Since Ilizarov allows for malalignment correction while the bone is undergoing union or lengthening, malunion, which is a frequent consequence with nailing, is far less prevalent.

The study had a few limitations. It was a limited sample size, single-centred research. The results of this study thus could not exactly represent the situation throughout the entire nation.

5. Conclusion

As it allows for early full weight bearing mobilisation, has higher union rates and lesser incidences of malunion, use of Ilizarov external fixator maintains its importance in the management of open tibial fractures. Few technical constraints such as pin site infections, restriction of wire placements near the joints are still a problem in the use of this fixator, which can be tackled by proper planning of patient rehabilitation post-surgery.

6. Source of Funding

None.

7. Conflict of Interest

None.

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