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Research Article

Outcomes of Primary Ilizarov Ring Fixator for Segmental Tibial Fracture with Compromised Skin: A Prospective Study

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Abstract

Background: Tibial diaphyseal fracture is the most commonly encountered fracture in orthopedic practice. There are various methods to treat the same, ranging from conservative to operative treatment. The operative methods include internal fixation using nailing and plating and external fixation using fixator/ring fixator. This study aims to evaluate the results of primary treatment of segmental tibial fracture in patients with a compromised skin condition using the Ilizarov fixator and look for complications.

Methods: This prospective study was conducted at a tertiary level health care center. It included a series of 40 patients with segmental tibial fractures. Classification of the segmental tibial fractures was done according to Melis et al. The fixator was designed with three fixation blocks and two working length sections. The patients were evaluated for the progression clinically and radiographically at 2-week intervals for the first 2 months and were then followed by 4-week intervals. Results were evaluated according to the Association for the Study and Application of the Methods of Ilizarov (ASAMI) classification.

Results: We treated 40 patients with a segmental tibial fracture with compromised skin using the Ilizarov ring fixator. Patients were followed up after surgery with an average follow-up of 13.8 months. The average union time came out to be 27.6 weeks for the proximal segment and 33.31 weeks for the distal segment. Out of the total patients, 15 (37.5%) patients had pin tract infection, and one (2.7%) patient had nonunion, which later required bone grafting. Bone results of patients at final follow-up as evaluated by ASAMI score were 91.7% excellent, 5.6% good, and 2.7% poor. Functional results of patients at final follow-up as evaluated by ASAMI score were 80.5% excellent, 1.7% good, and 2.8% poor.

Conclusion: In the existing literature, segmental tibial fractures have always been difficult to treat. They are associated with high complication rates due to the lack of surrounding soft tissues. The proximal and distal fragments may be more difficult to treat because of the serious direct injury to the soft tissues overlying the segment and the difficulty stabilizing this bone segment with implants. With the use of Ilizarov technique, there is a good mean time to union, a low rate of reoperations, and good functional and general health-status outcome.

Keywords: Fractures; Multiple; Tibia; Ilizarov Technique

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Background

Tibial diaphyseal fracture is the most commonly encountered fracture in orthopedic practice. A segmental diaphyseal fracture occurs when a long bone is fractured at two levels, forming an intermediate free fragment with an intact circumferential cortex. Although tibial fractures are found very commonly, the incidence of segmental fractures is very low and is difficult to treat (1). These fractures are often associated with a high rate of complications such as soft tissue damage, nonunion, osteonecrosis, or osteomyelitis (2). The tibia is notorious for such complications, because it is a subcutaneous bone with poor soft tissue coverage and limited blood supply, particularly at the distal end (3).

Conservative treatment has been attempted in literature, but the results are limited due to inadequate stability. These fractures are most commonly treated with intramedullary nailing (4). However, nailing cannot be used in patients with compromised skin; thus, we used the Ilizarov apparatus for the same. The Ilizarov apparatus is a construct that allows functional axial loading to the bones of the injured limb. It is followed by angiogenesis and thus promotes osteogenesis, leading to union (5).

It is also a versatile option for the correction of any residual deformity. Other advantages include the ability to provide multilevel and multiplanar stabilization, with immediate weight-bearing and movement permitted in the adjacent joints. The Ilizarov fixator can thus be used to treat a segmental tibial fracture with minimal complications such as infection and nonunion. In India, like developing countries, where patients present late to the hospital and all proper facilities are not always available for early management, segmental tibial fractures are usually managed with a uniplanar external fixator, which leads to a high failure rate because of early pin loosening and not good stability. It made us look to the Ilizarov ring fixator as an alternative option for managing segmental tibial fractures (6-8). This study aims to evaluate the results of primary treatment of segmental tibial fracture using the Ilizarov fixator and look for complications of the same.

Methods

This study was a prospective study conducted at a tertiary level health care center from April 2018 to November 2019. The study included a series of 40 patients

with segmental tibial fractures accompanied with compromised skin conditions. Prior approval from the Institutional Ethical Committee was obtained. We included the patients after obtaining the informed consent. We excluded the patients with a pathological fracture or having any contraindication to surgery and with associated injury or neurovascular injury to the affected limb.

A segmental fracture is defined as a tibial fracture with two completely distinct fracture lines leaving an intermediate fragment in between with an intact circumferential cortex of the intermediate segment [Orthopedic Trauma Association (OTA) type 42-C2] (5). Segmental fractures of the tibia were classified according to the classification of Melis et al. (7) (Table 1).

Table 1. Classification of the segmental tibial fractures according to Melis et al. (7)

Type	Characteristic features of fracture
I	The fracture lines are situated proximally, so that the proximal fracture lies in the upper third of the shaft and the distal fracture lies in the middle third
II	The fracture lines are situated distally, so that the proximal fracture lies in the middle third of the shaft and the distal fracture lies in the lower third
III	The fracture lines are at the extremes of the shaft, and there is a long intermediate fragment
IV	The fracture lines are close to one another, and there is a short, intermediate fragment in the middle third of the shaft

The Ilizarov fixator was aimed to achieve distraction between reference wires with compression at fracture sites while maintaining the alignment between all the fragments. It was prepared with 3 blocks and 3 working lengths. The proximal fragment was fixed with wires perpendicular to the axis of the long bone and the distal fragment was fixed with the wires parallel to the ankle joint. The axis of the distal metaphysis was then aligned with the axis of the proximal fragment. In the lateral fluoroscopic view, the metaphyseal fragments were also rotated into axial alignment. Once proximal and distal blocks were aligned, they were stabilized, and the segmental fragment was then reduced to the proximal and distal blocks. In some cases, the technique of opposed olive wires was used to reduce the segmental fragment (Figures 1-3). Care of the pin track site involved betadine solution followed by pressure dressing.

Figure 1. Anteroposterior (AP) fluoroscopic image of a type IV segmental tibial fracture; the fragment reduced with the help of olive wire used as drop wire.

It was followed by active knee and ankle movements.

Figure 2. Post-operative image following Ilizarov fixator application

Patients were allowed to bear complete weight (supplemented with crutches/walker) on the second day of surgery with no weight-bearing restrictions (Figure 4). The patients were evaluated at 2-week intervals for the initial 2 months and then followed up at 4-week intervals. Follow-up radiographs were used to assess alignment, bone contact, and callus formation. The minimum time to follow-up was 12 months (range: 12-18).

Figure 3. 24-year-old man, Melis type II close fracture, Ilizarov fixator application; a and b: Pre-operative X-ray; c and d: Post-operative clinical picture and X-ray; e and f: Bony union at proximal fracture site at 21 weeks and distal site at 23 weeks

Results were evaluated based on the Association for the Study and Application of the Methods of Ilizarov (ASAMI) method. The union status, deformity, infection, and limb length discrepancy were studied (Figure 3). Other factors taken into consideration were pain, soft tissue injury, ability to perform routine activities, stiffness at ankle/knee, and presence of limp to evaluate the functional status of limb. Infections at the pin site were noted according to Paley's criteria (9). Statistical analysis was done using SPSS software (version 23, IBM Corporation, Armonk, NY, USA).

Figure 4. 45-year-old women, Melis type III close fracture, patient taking partial weight-bearing on the second day after surgery

Results

This study included 40 patients with segmental tibial fracture treated using the Ilizarov ring fixator. The mean age of the patients was 36.7 years. Out of 40 patients, 38 (95%) patients were men, and 2 (5%) patients were women, showing male predominance. Fracture pattern was classified based on the Melis classification; nine injuries (22.5%) were found to be Melis I, eight (20%) Melis II, eighteen (45%) Melis III, and five (12.5%) Melis IV.

Time of union was recorded as the time taken to attain full radiological and clinical union, which on average came out to be 27.61 weeks for the proximal fracture site and 33.31 weeks for the distal fracture site (Table 2). Association of time of union of proximal fracture site with distal fracture site came out to be significant during statistical analysis.

Table 2. Fracture healing time among study subjects

	Mean ± SD (week)	t	df	P-value
Proximal fracture site	27.61 ± 5.82	-3.98	69	< 0.001
Distal fracture site	33.31 ± 6.38			
Complete	33.31 ± 6.38			

P-value < 0.05 was statistically significant
SD: Standard deviation; df: Degree of freedom

Two patients were reported with nonunion. In one case with a Melis I type fracture, bone grafting with autogenous cortico-cancellous bone from the iliac crest was needed to promote fracture healing. The complete union was achieved in this patient. In another case with a Melis I type fracture, bone grafting was not done due to the limitation of the study period.

In this study, 15 (41.7%) patients had pin tract infections which were grade I and were treated with oral antibiotics. 3 patients (8.3%) had a deformity, and 3 (8.3%) had shortening (Figure 5). Malalignment was identified in three patients measuring 8° and 6° valgus and 7° procurvatum, respectively. The patient with 8° valgus deformity had 10 mm of shortening.

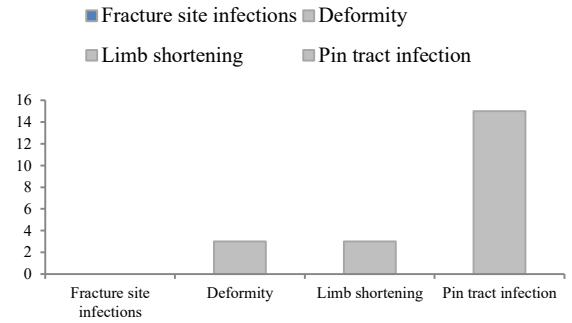

Figure 5. Complications among patients

At the last follow-up of patients, bone results and functional results were evaluated using ASAMI grade (Tables 3 and 4).

Table 3. Bone results [Association for the Study and Application of the Methods of Ilizarov (ASAMI) score] in relation to the type of fracture

ASAMI score	Type I n (%)	Type II n (%)	Type III n (%)	Type IV n (%)	χ^2	df	P-value
Excellent	7 (77.8)	6 (85.7)	15 (100)	5 (100)	5.939	6	0.430
Good	1 (11.1)	1 (14.3)	0 (0)	0 (0)			
Poor	1 (11.1)	0 (0)	0 (0)	0 (0)			
Total	9 (100)	7 (100)	15 (100)	5 (100)			

Not significant
ASAMI: Association for the Study and Application of the Methods of Ilizarov; df: Degree of freedom

For bone results, 33 (91.7%) patients had excellent results, 2 (5.6%) had good results, and 1 (2.7%) had a poor outcome and for functional results, 29 patients had excellent results and a poor outcome was obtained for 1 patient.

Table 4. Functional outcome [Association for the Study and Application of the Methods of Ilizarov (ASAMI) score] in relation to the type of fracture

ASAMI score	Type I n (%)	Type II n (%)	Type III n (%)	Type IV n (%)	χ^2	df	P-value
Excellent	7 (77.8)	6 (85.7)	11 (73.3)	5 (100)	5.287	6	0.508
Good	1 (11.1)	1 (14.3)	4 (26.7)	0 (0)			
Poor	1 (11.1)	0 (0)	0 (0)	0 (0)			
Total	9 (100)	7 (100)	15 (100)	5 (100)			

Not significant
ASAMI: Association for the Study and Application of the Methods of Ilizarov; df: Degree of freedom

Discussion

Segmental tibial fracture is a special type of injury associated with high complication rate (10). The segmental fracture patterns are rotationally unstable, and their stabilization is a challenge. The results of non-operative treatment are reported as not good and are thus not used in clinical practice (8, 11). The major reason for this is due to serious damage to surrounding soft tissues. Thus, they require optimum biomechanical fixation without the additional devascularization that may occur with internal fixation methods (11, 12).

The present study was undertaken to determine the efficacy of the Ilizarov fixator in the treatment of the segmental fractures with the compromised skin condition of the tibia. We evaluated our results, and various factors were discussed. Our study revealed the average age of patients with such injuries to be 36.7 years (range: 18-56 years) which is comparable to that of other studies. Abdelsatar et al. evaluated 30 patients with ages ranging from 13 to 69 years and a mean age of 33.47 years (10) (Table 5).

Table 5. Comparison of time taken for union in other studies

Study	Time to union in weeks	
	Proximal	Distal
Bari et al. (12)	36.5	38.2
Giotakis et al. (8)	21.7	21.7
O'Connor et al. (13)	25.0	25.0
Abdelsatar et al. (10)	20.0	30.8
Present study	27.6	33.3

Giotakis et al. treated 20 adult patients (15 men, five women) with segmental tibial injuries between January 2000 and February 2006. Their mean age was 47.2 years (25 to 79). In 17 patients, the fracture had been sustained in a road traffic accident and in 3, by a fall (8). In our study, road traffic accident (95%) was the predominant mode of violence, while the rest were due to fall, which shows that segmental tibial fractures predominantly occur in high-velocity traumas like road traffic accidents.

The average time for fracture union in various studies conducted using various strategies was 20-40 weeks. Our study had an average time of union came out to be 27.61 weeks for proximal segment and 33.31 weeks for distal segment, which were comparable with other studies.

According to Audige et al., the distal fracture is the most unstable fracture. The distal third tibia is notorious for slow union rates. In this site, therefore, the fixation has to be as firm as possible. It is not usually possible with intramedullary fixation (2).

In the present study, there were 15 cases of pin tract infections that were healed with regular dressing and antibiotics and one case (2.7%) of nonunion. Malalignment was identified in three patients measuring 8° and 6° valgus and 9° procurvatum, respectively. The patient with 8° valgus deformity had 10 mm of shortening. None of the measured deformities was clinically visible. We could not determine the effect of any malalignment on the mechanical axis of the limb, since taking full-length standing radiographs was not a routine procedure.

Abdelsatar et al., in their study, had seven patients with fair bone results; five patients had shortness of the limb with additional infection, and one patient had shortness of the limb with associated valgus deformity more than 7°. Two patients were considered to have poor bone results due to nonunion and infection (10).

Giotakis et al.'s study of 20 segmental tibia fractures treated by Ilizarov fixator had two patients with nonunion at the distal level, which was managed successfully by further circular external fixation in one and open autogenous bone grafting and revision of external fixation in the other. Malalignment was identified in three patients measuring 5° and 8° valgus and 5° procurvatum, respectively. The patient with 8° valgus deformity had 15 mm of shortening (8).

Robertson et al. used undreamed tibial nailing as a primary treatment method in 14 of 27 patients; however, deep infection developed in 3 of these 14 patients. Seven of the 14 patients needed a second operation, and in three, an Ilizarov type fixator was used as a secondary procedure. Five of the 27 patients needed a third operation, and the Ilizarov type fixator was used in two of them. They used different primary treatment methods other than the undreamed tibial nail, including external fixators, open reduction and internal fixation, and reamed tibial nailing. In their study, the open fracture ratio was high in patients with severe soft tissue injury. An Ilizarov type fixator was not the first choice in their patients (14).

Woll and Duwelius used external fixators in 20 patients, where 8 developed a non-union (15). Ozturkmen et al. used Ilizarov for treatment in 24 patients and obtained excellent results in 20 and good results in four patients. At the end of the study, the complete union was achieved in all patients (16).

In this study, three patients developed decreased knee range of motion (ROM); one patient developed ankle dorsiflexion deficit, and one patient equinus deformity. This deformity was improved by physiotherapy in the form of passive stretching exercises of the affected muscle groups, active exercises, and electrical stimulation to stimulate muscle regeneration.

In the present study, we had 40 segmental tibial fractures managed by Ilizarov external fixator. All the fractures except one united at an average of 27.61 weeks for proximal fracture site and 33.31weeks for distal fracture site. There were good to excellent and fair results as well as poor results in our study. There were 15 (36.58%) cases of pin tract infection, 3 (8.30%) deformities, and 1 (2.70%) case of nonunion.

Conclusion

The treatment of segmental tibial fractures is associated with high complication risks due to the high energy of this injury and damage to surrounding soft tissues. The proximal and distal fragments may be more difficult to treat because of the serious direct injury to the soft tissues overlying the segment and the difficulty stabilizing this intermediate free bone segment with implants commonly used. With the use of Ilizarov ring fixator, there is a good mean time to union, a low rate of reoperations, and good functional and general health-status outcomes. We, therefore, conclude that Ilizarov external fixator is a successful method for the primary treatment of segmental tibial fractures.

Limitations: This study was not without limitations. Some of them include small sample size and a short follow-up period. Besides, the incidence of compound segmental fractures is very low, and the representative population was limited.

Conflict of Interest

The authors declare no conflict of interest in this study.

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