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Analysis of results of huge segmental bone loss of tibia treated with Ilizarov external fixator: our experience in Indian population

Vishal Patil[1]*, Sandeep Reddy[1], Sujith Patil B.[2], Sahana Patil[3], Karthik Kolli[1], Prajwal K.[1], Ronak N. Kotian[1]

[1]Department of Orthopaedics, Ramaiah Medical College Hospital, Bangalore, Karnataka, India
[2]Jindal Sanjeevini Hospital, Toranagallu, Ballari, Karnataka, India
[3]Department of Anaesthesiology, Vijayanagar Institute of Medical Sciences, Ballari, Karnataka, India

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***Correspondence:**
Dr. Vishal Patil,
E-mail: vishalmpatil1209@gmail.com

ABSTRACT

Background: Orthopaedic surgeons face challenges in treating complex tibial fractures with bone loss due to complications like infection, repeat surgeries, and patient psychological burden. The Ilizarov external fixator approach offers better clinical and radiological results, addressing these issues. The purpose of this study was to examine the outcome of tibial segmental loss treated with the Iliazrov external fixator.
Methods: The study was done between January 2015 to December 2021. It's a prospective as well as retro-prospective study. The age group of 18-65 years was considered. Patients were monitored monthly, up to nine months post-surgery, or until bone union. Functional and bone outcomes of the patients were evaluated using ASAMI criteria, knee society score, and St. Pierre ankle scoring system.
Results: The study included 20 patients, all of them were male and had a mean age of 34.1±10.1. Bone union was achieved in all cases. After ilizarov application, the average bone defect was 82.6±42.9 mm. The final regeneration attained was 75.1±47.5 mm. The average limb length difference was 20.41±6.55 mm after achieving union. Out of 20 patients, 13 and 4 had good and fair ASAMI score, 1, 4, and 13 had fair, good, and excellent knee society score, and17 had fair St. Pierre score and 3 patients were lost to follow-up.
Conclusions: Ilizarov technique is an excellent way for treating complicated tibial fractures. The difficulties, challenges, and complications associated with Ilizarov external fixation are negligible compared to the significant difficulties associated with open techniques.

Keywords: Complex tibia fracture, Ilizarov external fixator, ASAMI score, Knee society score, St. Pierre scoring system

INTRODUCTION

The Edwin Smith Papyrus, an ancient Egyptian medical book from 1500 to 1600 BC, describes the treatment for tibial fractures, which are more frequent.[1] Tibia fractures occur 5.6 per 100,000 people annually in the USA.[2] They are connected to a variety of damage mechanisms and degrees of severity. Open fractures are more frequent since the tibia is a subcutaneous bone. Tibial fractures have a high rate of non-union and malunion due to the fragile blood supply compared to any other fractures in the body, making treatment particularly difficult. Tibial fractures have been classified topographically as proximal, shaft, and distal.

Complex tibial shaft fractures require maintaining normal length, alignment, preventing infection, minimizing soft tissue damage, preserving circulation, and providing a mechanical environment for bone healing.[3] Fractures of the tibial shaft constitute a spectrum of injuries that result in a loss of the normal unrestricted load-bearing capacity of the extremity.[4] Hoaglund and States suggested that tibial shaft fractures are caused by indirect or direct violence. Direct violence is all high-energy traumas which have worse prognosis. On the other hand, low energy fractures have a good prognosis and the fracture line is more likely to be spiral or oblique.[5] Tibia nailing causes malunions in 37% of procedures, often resulting in proximal tibia fractures.[6,7]

Several authors have described different techniques of bone transport for segmental bone loss, including the use of an Ilizarov fixator, monolateral external fixators, and an intramedullary nail.[8] Ilizarov external fixator offers versatile treatment for various problems, utilizing ligamentotaxis principle and avoiding soft tissue injuries. The advantage of Ilizarov over internal fixation is that it allows closed reduction and early mobilisation of the joint. It is always possible to treat patients with an immediate one-stage procedure because reduction is less invasive, with minimal soft tissue exposure, there is little interference to the biology of the fracture, and thus the chances of infections and nonunion are lower. This fixator also enables alignment modification, compression, and distraction, if necessary, both during and after surgery. The Ilizarov apparatus is stable and dynamic, allowing functional axial loading and early weight bearing for injured limbs. This stimulates bone angiogenesis and osteogenesis, promoting quicker re-modelling.[9] Monolateral external fixators are only a temporary solution, with added morbidity linked with pin tract infections.[10] Additionally, it has been demonstrated that intramedullary nail therapy affects the diaphyseal cortex's ability to circulate.[11,12] Considering the above situations, this study was performed to analyse results of segmental bone loss of tibia treated with Ilizarov external fixator.

METHODS

Patients and collection of data

Its a prospective as well as a retrospective study. The study involved inpatients admitted from the year 2015 to 2021 at Ramaiah medical college hospital Bangalore, Karnataka and included fractures with internal fixation and Ilizarov external fixator. Ethical committee clearance was taken in November 2019 from hospital research committee. Post-op, patients were evaluated for functional and radiological issues using ASAMI criteria, knee society scoring, and St Pierre ankle scoring systems. Results were assessed monthly till 9 months/ till bone union was achieved. Patients with traumatic or infection-related bone loss were placed on Ilizarov external fixator and followed up.

Inclusion criteria

Patients aged from 18 to 65 years, with bone loss of more than 5 cm due to various causes and with failed segmental bone loss treated by other modalities were included in the study.

Exclusion criteria

Patients with ipsilateral bone defects, polytrauma, thyroid disorders, and diabetes were excluded from the study.

Sample size calculation

Based on a study by Dror Paley titled “Ilizarov bone transport treatment for tibial defects” published in journal of orthopedic trauma in March 2000, 19 patients with tibial bone defects were treated by the Ilizarov bone transport method. Sample size is calculated based on the above study in which it was found that 78% of patient had improved functional outcome in the present study, considering the population proportion of improved functional outcome as 95%, considering power of 80% and alpha error of 5%, minimum sample size is calculated to be 21. Considering loss to followup of 15%, final sample size is estimated to be 24. Considering the covid situation in the country from 2020-2022 with reduced patient inflow, sample size of 20 was considered (excluding those who were lost to followup).

Pre-operative technique

Bone loss was calculated with hospital’s iPacx system and clinically intra-op as well. Ilizarov ring constructs were pre-operatively made, with ring circumference determined by leg circumference. This reduces intraoperative timings and complications. Rings are autoclaved and radiographs traced to determine ring position, direction, and angle for correction (Figure 1 and 2).

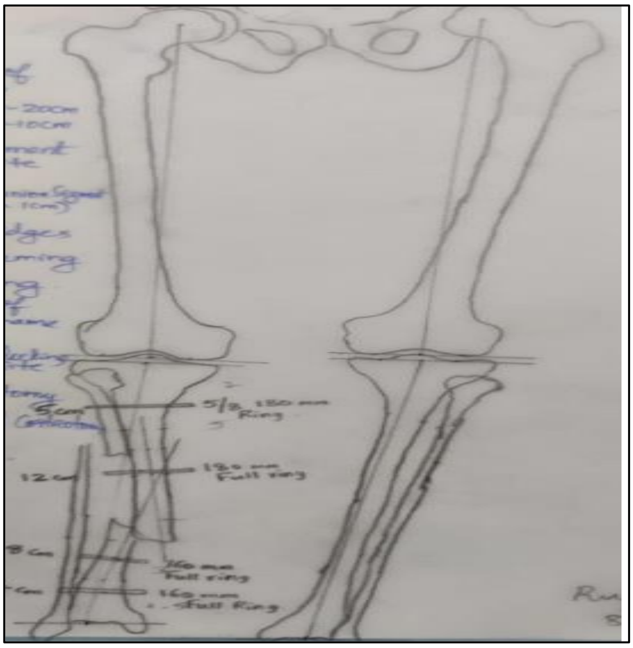

Figure 1: Pre op X-ray tracing.

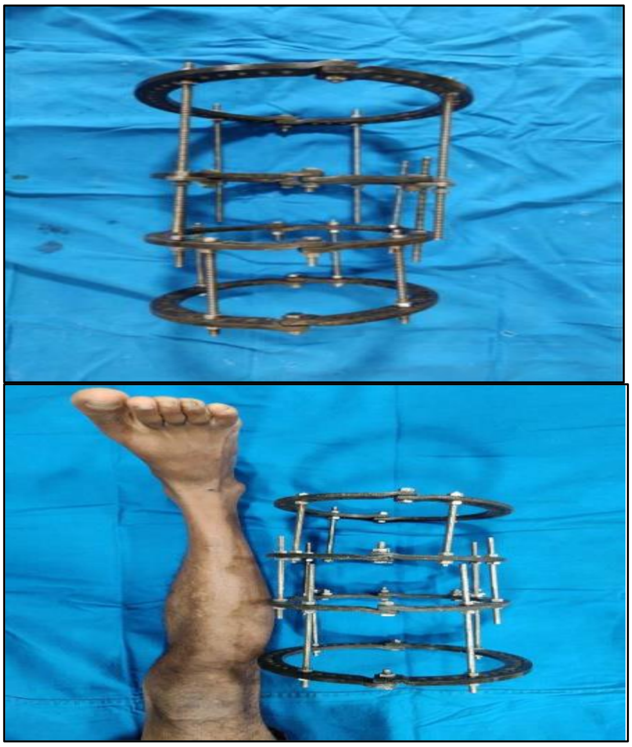

Figure 2: Pre-operative ring construct.

Operative technique

SOP followed as per hospital guidelines and Ilizarov rings applied to affected limb (Figure 3 and 4).

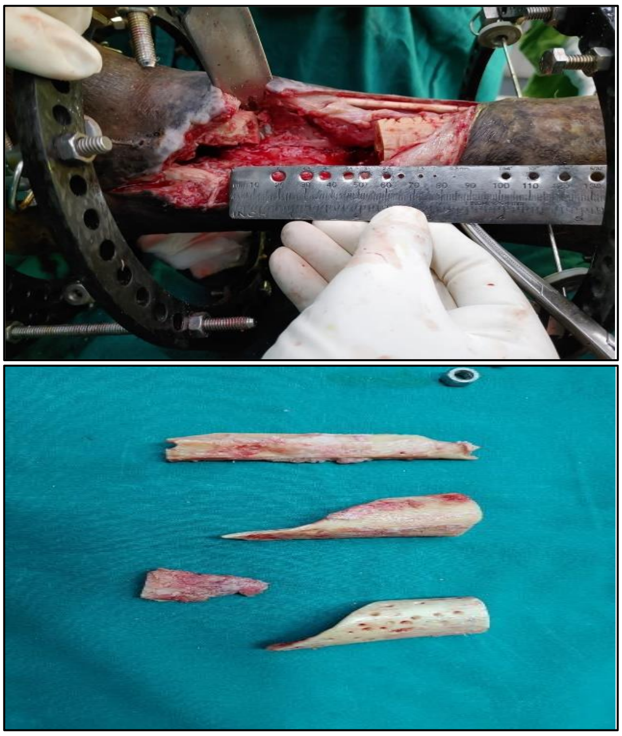

Figure 3: Representative image of infected non-union with segmental bone loss of ~6 cm after removal of sequestrum.

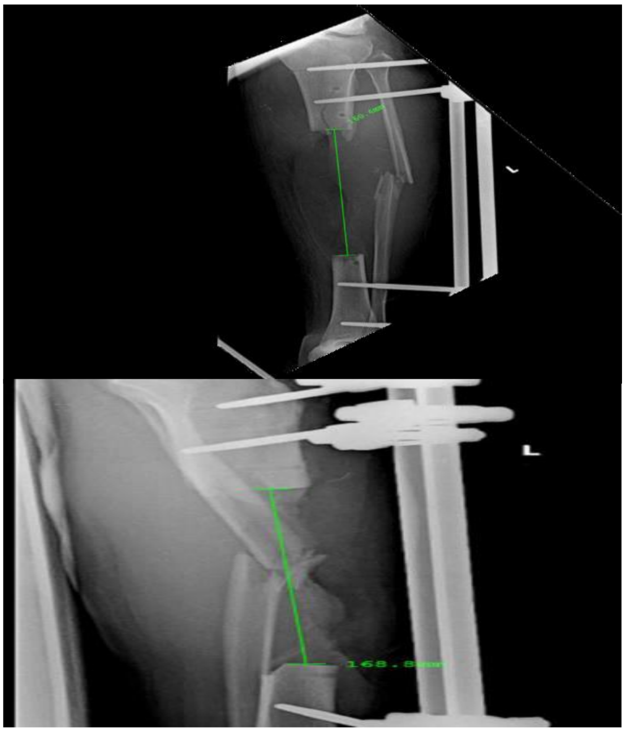

Figure 4: Representative image of a patient showing segmental bone loss of ~16 cm following trauma.

Post-operative technique

Distraction rate was 1mm per day and physiotherapy, weight bearing, knee and ankle ROM, and isometric quadriceps exercises were initiated based on pain tolerance and fixation adequacy immediately post-operatively.

Functional and radiological assessments of the patients were done every month. During the follow-up period functional and bone results were assessed using ASAMI criterion, Knee society scoring, and St Pierre ankle scoring system for the functional assessment of the ankle.

Removal of the construct

Radiological criterion

Radiographs of the affected limb were collected in anteroposterior and lateral views during follow-up. When antero-posterior and lateral radiographs revealed bridging callus in three of the four cortices, the fractures were judged to be united. For the removal of the Ilizarov equipment, radiological union at the non-union site and corticalisation of regeneration were considered.

Functional criterion

After confirming radiological union, the frame was dynamized to reduce pin bone tensions and deliver weight-bearing forces to the bone. When discomfort and mild radiographic changes were detected following frame dynamization, it was thought that fracture healing was incomplete. The frame is then tightened again to allow for additional consolidation. Clinical healing was hence defined as the ability to bear full weight over the injured tibia without pain.

Intra-operative criterion

In the operation theatre, the connecting rods across the fracture site were removed and abnormal mobility was checked in both medio-lateral direction and antero-posterior direction. If there was no abnormal mobility, then it further confirms that the fracture has united.

Statistical analysis

All the quantitative variables such as age, duration of hospital stay etc., were analysed using descriptive statistics like mean and standard deviation. All the qualitative variables like functional results, gender etc., were analysed using frequency and percentage. Percentage of excellent functional results, good functional results will be calculated. The bone union rate expressed in number, out of the total sample size or percentage.

RESULTS

It was prospective as well as retrospective research, and the study population comprised of 20 males with an average age of 34.1±10.1. In 15 of the 20 patients, the right tibia was affected, while the left tibia was involved in 5 patients. The most prevalent mechanism of injury was a road traffic accident, which accounted for approximately 68.42% (13 cases), with infected non-union accounting for 31.57% (7 patients). There were 5 closed fractures (26.31%) and 14 open fractures (73.68%), 8 (42.1%) of the 20 patients had AO exfix application, 6(31.57%) had open reduction and internal fixation with plating, 4 (21.05%) had closed reduction and intramedullary nailing, and 2 (10.52%) had conservative therapy with slab application (Figure 5).

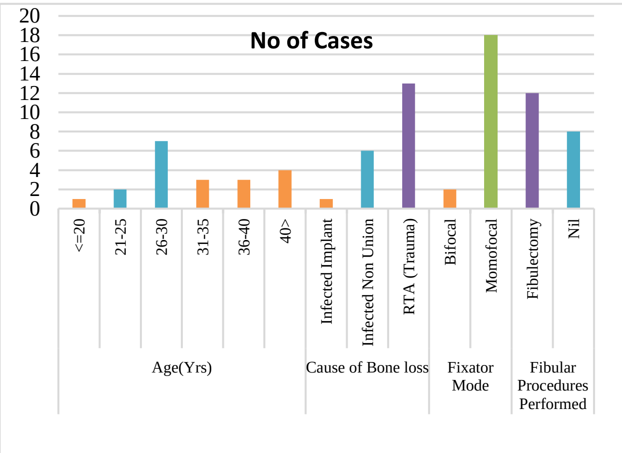

Figure 5: Distribution of cases according to age, cause of bone loss, fixator mode and fibular procedures performed.

After Ilizarov application, average bone defect was 82.6±42.9 mm, with a limb length difference of 20.41±6.55 mm. There were 18 monofocal distraction patients and 2 bifocal distraction patients (Figure 6 and 7).

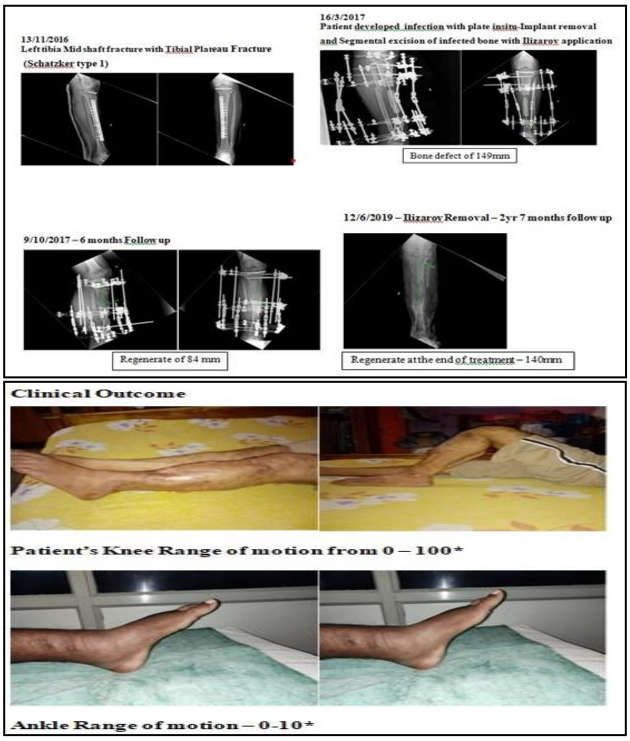

Figure 6: A case with 149 mm bone defect treated with Ilizarov with monofocal transport.

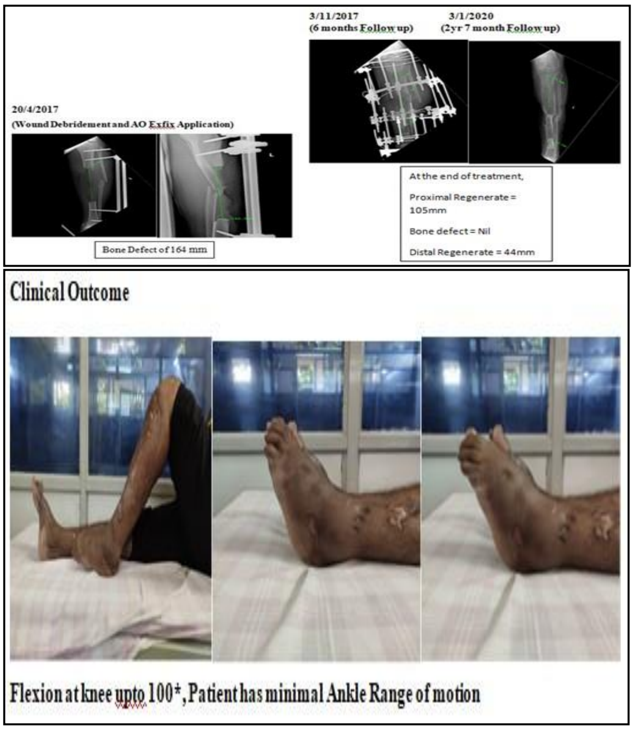

Figure 7: A case with bone defect of 164 mm treated with Ilizarov with bifocal transport.

Fibulectomy was performed on 12 of the 20 patients. During treatment, 3 patients received antibiotic spacers, 7 patients received autograft bone grafting, 3 patients received bone marrow infiltration, and 2 patients received stimulan application (Figure 8 and Table 1).

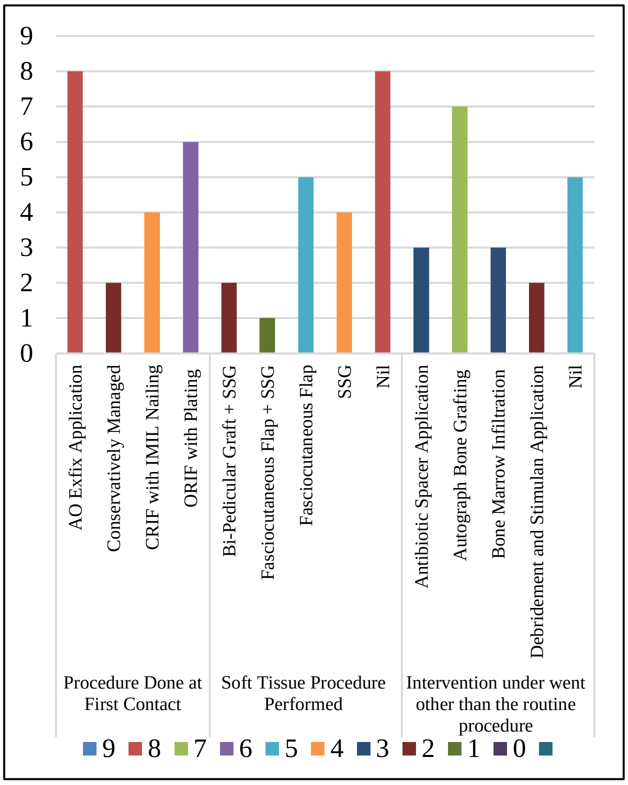

Figure 8: Distribution of cases according to procedure done at first contact, soft tissue procedure performed and intervention underwent other than the routine procedure.

Table 1: Association of IEF time with bone defect, regenerate obtained at the end of treatment and no. of surgeries underwent.

Duration of treatment with IEF (In years)	Bone defect (mm)	Regenerate obtained at the end of treatment (mm)	No. of surgeries underwent
<1	101.5±65.9	77.8±72.0	5.5±1.3
1-2	68.5±22.7	61.4±17.4	6.6±2.5
2-3	106.3±58.4	103.3±72.8	5.5±1.3

Three patients were subjected to the accordion method of distraction twice, two patients three times, and one patient four times. At the end of treatment, the regeneration measured 75.1±47.5 cm. Total treatment time was 2±0.7 years, while total treatment time with Ilizarov was 1.3±0.7 years. The average number of procedures performed per patient was 6.2±2.1, and the majority of patients had a 1-2 cm leg length disparity at the end of treatment (Figure 9 and Table 2).

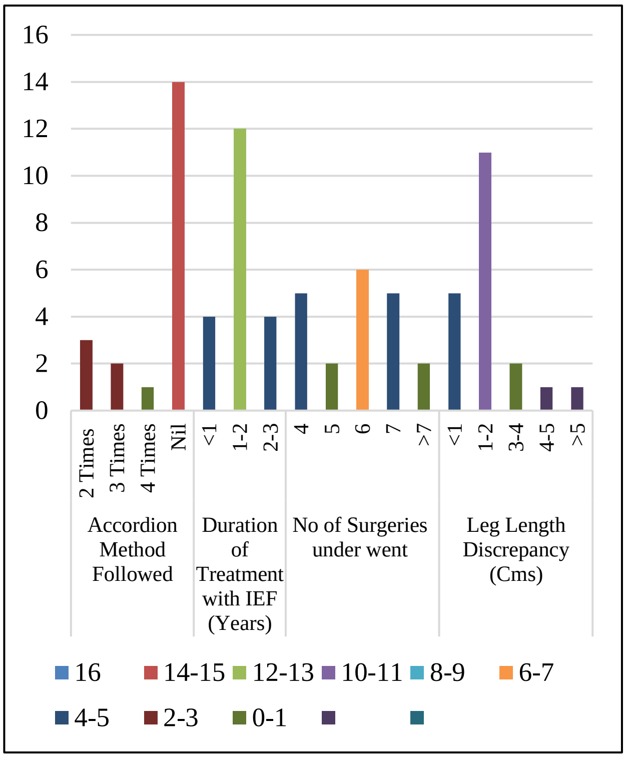

Figure 9: Distribution of cases according to accordion method followed, duration of treatment with IEF, no. of surgeries underwent and leg length discrepancy.

Thirteen of the twenty patients had good ASAMI scores, four had fair ASAMI scores, and three were lost to follow up. One patient had a fair knee society score, four had a good knee society score, twelve had an excellent score, and three were lost to follow up. 17 of the 20 patients had a fair St Pierre score, while three were lost to follow up (Table 3). Various complications faced by the patients during the course of treatment were delayed union at docking site due to sclerosis of ends, docking malalignment, soft tissue invagination, hampered ankle range of motion and large bone defect (Figure 10).

Table 2: Association of Ilizarov external fixator time with fixator mode, intervention underwent other than the routine procedure and accordion method followed.

Duration of treatment with IEF	Fixator mode		Intervention underwent other than the routine procedure				Accordion method followed				
	Bifocal	Mono-focal	Antibiotic spacer application	Autograft bone grafting	Bone marrow infiltration	Debridement and stimulant application	Nil	2 times	3 times	4 times	Nil
<1	1	3	1	1	0	1	1	0	0	1	3
1-2	0	12	2	4	2	1	3	3	0	0	9
2-3	1	3	0	2	1	0	1	0	2	0	2

Table 3: Distribution of cases according to ASAMI scoring, knee society scoring and St. Pierre scoring.

Scoring	ASAMI scoring		Knee society scoring		St. Pierre scoring	
	N	%	N	%	N	%
Fair	4	20	1	5	17	85
Good	13	65	4	20	-	-
Excellent	-	-	12	60	-	-
Lost to follow up	3	15	3	15	3	15

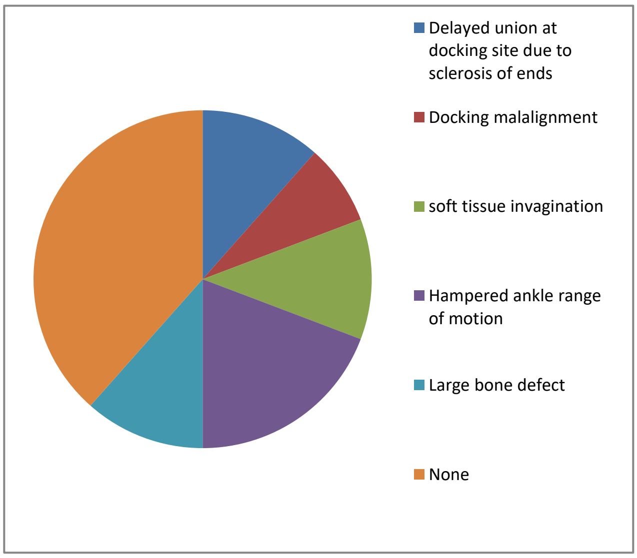

Figure 10: Complications during treatment.

DISCUSSION

The use of the Ilizarov apparatus has been widely reported for congenital and acquired problems such as club-foot, radial clubhand, joint contracture, leg-length discrepancy, and infected and non-infected-non-union of fractures.[13-15] Tibial fractures are common in long bone fractures due to their subcutaneous location. Orthopaedicians face challenges in treating infected non-union and segmental tibial bone loss due to trauma. Treatments include intramedullary nails and plates for defects up to 6 cm, and uniaxial and circular external fixators for more than 6 cm.

In this study, 20 male patients with complex tibia fractures used Ilizarov external fixator as a definitive treatment. The maximum bone loss was 193 cm, and the outcome variables were comparable to other studies. Dagher and Roukoz treated 9 cases with 6.3 cm bone defects using Ilizarov tibial transport, gaining 1 cm in length per 1.8 months. All patients healed without infection.[16] Dendrinos et al treated 28 tibial fracture patients using the ilizarov bone transport method, with a mean bone defect of 6 cm and the mean duration of treatment was 10 months. The bone results were fourteen excellent, eight good, one fair, and five poor. The functional results were seven excellent, eleven good, four fair, and six poor.[17] Naggar et al operated on 10 patients with 6.7 cm infected preoperatively, all resolved with Ilizarov treatment. Six had difficulty with union at docking site, and three required bone grafting.[18] Polyzios et al operated on 42 patients with bone defects, with 19 preoperative infections. Mean bone defect was six centi-meters, and mean duration of treatment was ten months. Four of the patients required bone grafting. The final Limb length discrepancy was 1.5 cm, all of them achieved union and two had malalignment.[19] Marsh et al compared 15 bone defects treated with external fixation, bone grafting, and soft tissue coverage with ten bone defects treated with monolateral transport. Results showed fewer angular deformities and less LLD in the transport group.[20]

Bone transport complications can be categorized into distraction and docking processes. Docking process complications can be further divided into hardware, bone and soft tissue related complications. Docking site malalignment is a common minor issue that prolongs treatment time. Two of our patients had docking site malalignment, 3 of our patients had major complications of delayed healing due to bone end sclerosis, which can be addressed through opening the docking site, debridement, and bone grafting. Soft tissue invagination, another docking-related issue, occurred in 3 of our patients. Distraction complications can be hardware, bone, or soft tissue-related, with delayed consolidation being uncommon.

Limitations

The limitations of Ilizarov are the prolonged external fixator period, which results in tension, pain, psychosocial difficulties, and long-term impairment. Our hospital's iPacx system was used to measure the segmental bone loss of tibia radiologically and clinically the bone loss was measured after giving adequate traction and getting the limb length same as normal contralateral limb, both of which are not standardized methods of calculating the bone loss. Sporting activities and daily routines are also hampered. The effects of these are experienced by the patient as well as patient's family, friends and co-workers. Amputation was suggested as an alternative to shorten the treatment time. This report discusses the experience of twenty patients and suggests using a foot plate and calcaneal frame with prophylactic k wiring for phalanges to prevent clawing of toes and equinus deformity of the ankle. It suggests using bifocal transport and accordion methods to reduce external fixator time and improve the range of motion.

CONCLUSION

The present study concludes that the Ilizarov external fixator is a minimally invasive procedure that effectively treats complex tibia fractures, such as those caused by polytrauma. Invariably fractures of tibia are complex as it is subcutaneous in the whole of its length. These fractures indeed are a daunting task for the surgeon to treat. Ilizarov external fixator is a very good modality in treating such kinds of fractures where internal fixation can lead to disasters. It is versatile and can address issues like malunion, non-union, infection, and limb length discrepancy. This fixator provides three-dimensional stability and is equally effective as internal fixation in treating periarticular fractures. The surgeon must understand the biomechanical principles of the apparatus to achieve desired results. The problems, obstacles and complications of using the Ilizarov external fixation itself are a small price to pay to minimize major complications of open methods.

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Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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