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Original Research

To evaluate the functional and radiological outcomes of using the I lizarov external fixator in the treatment of proximal tibial fractures with compromised skin condition at a tertiary centre

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ABSTRACT

Background: The major objective in treating proximal tibia fractures is to accurately reduce and stabilize the injured area while preserving as much soft tissue and vascularity as possible.

Aim and objectives: To evaluate the functional and radiological outcomes of using the Ilizarov external fixator in the treatment of proximal tibial fractures with compromised skin condition.

Materials and Methods: This research was a prospective observational study done to assess the functional and radiological results of proximal tibial fractures with impaired skin conditions treated with an Ilizarov external fixator. The research includes a cohort of 80 participants. This research covered patients with Schatzker V and VI type tibial plateau fractures, regardless of their gender or age, as long as they were above 18 years old. The radiographic imaging involved the use of anteroposterior and lateral view X-rays, as well as CT scans, to evaluate the number, size, arrangement, and depression of fracture fragments on the articular surface. X-rays of the unaffected knee were also taken for comparison. Additionally, condylar widening was determined by comparing the total width of the tibial plateau just below the joint line with the width of the unaffected leg.

Results: The Pre-operative examinations of 80 patients, indicated an average condylar widening of 10.67 mm (± 1.36 mm). The average number of fracture pieces was 4.33 with a standard deviation of 0.98, and the mean articular surface depression was 8.87 mm with a standard deviation of 1.16 mm. The Functional outcomes were assessed using the range of motion (ROM) of the knee at various time intervals after the surgery. The average knee range of motion (ROM) at 3 weeks was 45 degrees, with a standard deviation of 5 degrees. The range of motion showed a substantial improvement, reaching 70 degrees (with a margin of error of ± 10 degrees) at 6 weeks, and continuing to rise to 90 degrees (with a margin of error of ± 15 degrees) at 12 weeks. At 24 weeks, the average range of motion (ROM) was 110 degrees with a deviation of 10 degrees. This improved to 120 degrees with a deviation of 15 degrees at 48 weeks, and eventually reached 130 degrees with a deviation of 10 degrees at 72 weeks. The most prevalent complication observed was pin tract infection, which occurred in 9 individuals, accounting for 11.25% of the cases. Additional problems were non-union and malunion, which were each reported in one patient, accounting for a prevalence of 1.25%. Four patients (5%) had joint stiffness, and one patient (1.25%) developed deep vein thrombosis.

Conclusion: We concluded that the use of the Ilizarov external fixator effectively treated proximal tibial fractures with damaged skin, leading to positive functional and radiological results. Most patients saw favourable outcomes in terms of knee range of motion and fracture healing, with few problems. The enhancements in knee range of motion (ROM) and the notable proportion of successful fracture unions underscore the efficacy of this therapeutic approach.

Keywords: Ilizarov external fixator, Proximal tibial fractures, compromised skin

Introduction

Tibial plateau fractures constitute roughly 1% of fractures in the adult population. Men have fractures at a younger age and these fractures are often caused by high-energy trauma. On the other hand, women have a higher occurrence of fractures in their sixth and seventh decades of life. Open fractures of the tibia often develop after severe trauma due to its placement just below the skin, which makes it more susceptible to soft tissue injuries. These fractures have a significant risk of not healing properly or healing in a misaligned manner due to the tibia's delicate blood supply.[1] Possible complications of this condition include limited range of motion in the joints, fusion of the joints, surgical fusion of the joints, improper healing of fractures, infections in the skin and bones, removal of a body part, and potentially fatal outcomes.[2,3] The suggested treatment options for open fractures of the proximal tibia are open reduction and internal fixation using plate and screws, conservative therapy, and external fixation of the fracture fragments. Nevertheless, if open reduction procedures are used, all of these issues are worsened.[4,5] The objectives in managing complex proximal tibial fractures are to prevent infection, maintain the normal length, alignment, and rotation of the extremity, minimize further damage to soft tissue and bone, preserve the remaining circulation, and create a mechanical environment that promotes periosteal and endosteal responses to facilitate bone healing.[6-8] The aims of ilizarov fixation are effectively accomplished because to its closed technique, which prevents any further damage to the blood vessels, soft tissues, and already weakened bone tissue. This reduces the risk of infection and promotes bone development via the concept of ligamentotaxis.[9] The primary benefit of this method is its ability to be employed regardless of the skin state, such as fracture blisters or significant subcutaneous haemorrhage and bruises.[10] After achieving proper alignment of the limb, the knee may be mobilized immediately after surgery and weight bearing ambulation can begin. This system is very stable and stiff, offering both rotational and angular stability. The mechanical axis may be continuously checked by making adjustments to the frame.

Various global studies have consistently shown a lower occurrence of infections (ranging from 0-6%) and a high success rate of bone healing (96-100%) in patients treated with the ilizarov external fixation method, as compared to the traditional approach of open reduction and internal fixation.[9]

Aim and objectives: To evaluate the functional and radiological outcomes of using the Ilizarov external fixator in the treatment of proximal tibial fractures with compromised skin condition

Materials and Methods

The present randomised prospective study included 60 patients with proximal tibial fractures with impaired skin conditions of both genders attaining opd/emergency in the orthopaedic department. The study was conducted in the orthopaedic department at Anugrah Narayan Magadh Medical College and Hospital, Gaya, Patna, Bihar, India, after approval from the institutional ethical committee. All the study participants were briefed about the study, and written informed consent was obtained. This study was done between January 2023 and December 2023. The research cohort included individuals who had high-energy trauma leading to Schatzker V and VI type tibial plateau fractures and sought medical attention at the emergency or outpatient department.

Demographic details such as age and gender were noted in all the cases. Keeping power (1-beta error) at 80% and confidence interval (1-alpha error) at 95%, the minimum sample size required was 60 patients; therefore, we included 80 (the minimum required number of cases) patients in present study.

Inclusion Criteria

- Patients to give written informed consent.
- Patient’s age between 18-65 years.

- Tibial fracture with extensive subcutaneous haemorrhage, damaged skin condition, bruise or open fractures and severely comminuted compound proximal tibia fractures.
- Available for follow up.

Exclusion Criteria:

- Patients not give written informed consent.
- Patients having fracture with good skin condition and multiple fractures.
- Under 18 years of age and those who had pre-existing significant knee abnormalities.
- Patients with immunocompromised status and patients on chemotherapy or steroid treatment.
- Those unable to attend follow-up.

This research covered patients with Schatzker V and VI type tibial plateau fractures, regardless of their gender or age, as long as they were above 18 years old.The pre-operative examinations consisted of documenting the clinical findings. The radiographic imaging involved the use of anteroposterior and lateral view X-rays, as well as CT scans, to evaluate the number, size, arrangement, and depression of fracture fragments on the articular surface. X-rays of the unaffected knee were also taken for comparison. Additionally, condylar widening was determined by comparing the total width of the tibial plateau just below the joint line with the width of the unaffected leg.

Methodology

The entire lower limb and the ipsilateral iliac crest were prepared for surgery. Fractures were reduced using traction, the principle of ligamentotaxis, or manipulation with wires. If needed, the plateau was elevated using a limited incision and a cortical window, followed by bone graft application. Olive wires (1.8 mm Kirschner wires with a 4 mm eccentrically located bead) were used for interfragmentary compression of the condylar articular surface. Some patients also received cannulated screws (6.5 mm and 4.5 mm) with washers. Periarticular wire placement and wire tensioning were performed under fluoroscopy to ensure proper intercondylar compression and articular surface reduction. Fixator rings were positioned to allow for postoperative swelling: 1.5 cm clearance over the anterior tibial crest and 3-4 cm clearance around the calf. The proximal tibial ring was attached to the first olive wire, with another olive wire securing the reduced tibial condyle. A middle ring was placed just distal to the fracture, and a distal ring was placed above the level of the ankle joint. Alignment of the mechanical axis was ensured by making the proximal and distal rings parallel. For cases with unstable knee joints due to ligament injury (confirmed intraoperatively by valgus-varus stress tests in 20-degree knee flexion), an additional 5/8 distal femoral ring was applied to provide angular stability.

Patients were followed up at 3, 6, 12, and 24 weeks, and then every 6 months until 18 months. Clinical evaluations included measuring the knee range of motion. Radiological evaluations included X-rays at each visit. In cases where a distal femur ring was applied, a hinge was added between the femoral and proximal tibial rings at 3 weeks to allow knee motion. The femoral ring was removed at 6 weeks. Toe-touch weight-bearing was permitted from postoperative day one. The tibial fixator was removed after 8-12 weeks, guided by radiological signs of union. Full weight-bearing was allowed 2-4 weeks after fixator removal. The outcomes were evaluated based on functional and radiological parameters to assess the efficacy of the Ilizarov external fixator in managing proximal tibial fractures with compromised skin conditions.

Statistical Analysis

The data was entered using Microsoft Windows Excel, and the statistical analysis was done using the Statistical Package for Social Sciences (SPSS) version 22.0. In order to investigate the distribution of a number of quantitative and categorical variables, an SPSS descriptive statistical analysis was done. We used frequency (%) and mean ± standard deviation to summarise categorical data. To determine

whether there is a statistically significant difference the Chi square test was employed. A p-value of less than 0.05 indicates statistical significance for the study.

Results

Table 1: Patient Demographics and Baseline Characteristics

Characteristic	Number	Percentage (%)
Age (years)		
Below 30 years	6	7.5
30-40 years	17	21.25
40-50 years	34	42.50
50-60 years	18	22.5
Above 60 years	5	6.25
Gender		
Male	56	70
Female	24	30
Mean age (years)	46.32 ± 5.36	

Table 1 and figure 1 displays the demographic parameters of the patients. The research comprised a total of 80 patients. The age distribution revealed that the predominant proportion of patients fell between the 40-50 age ranges (42.5%), with an average age of 46.32 years (± 5.36 years). The gender distribution was largely male, with 70% (56 patients) being male and 30% (24 patients) being female.

Figure 1: Gender wise distribution of patients

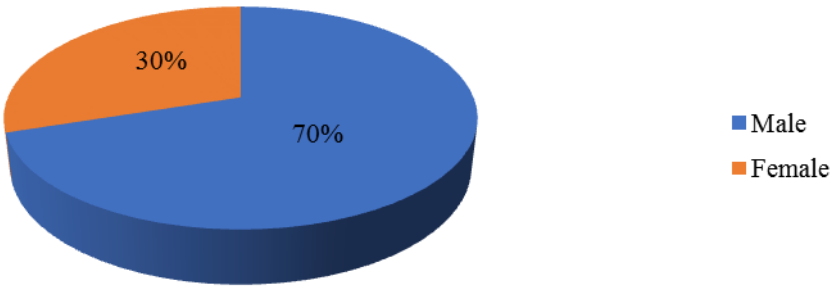


Table 2: Type, side of fracture

Type of Fracture	Number	Percentage (%)
Schatzker V	45	56.25
Schatzker VI	35	43.75
Side of Fracture (Left/Right)		
Left side	37	46.25
Right side	43	53.75
Mean Follow-up Period (months)	18.12±2.36	

On the basis of the type of fracture, 56.25% (45 patients) exhibited Schatzker V type fractures, while 43.75% (35 patients) presented with Schatzker VI type fractures. The fractures were almost equally

distributed across the left and right sides, with 46.25% (37 patients) exhibiting fractures on the left side and 53.75% (43 patients) on the right side. The average duration of follow-up was roughly 18.12 months, with a standard deviation of 2.36 months (Table 2).

Table 3: Pre-operative Assessments

Assessment	Mean ± SD
Condylar Widening (mm)	10.67 ± 1.36
Number of Fracture Fragments	4.33 ± 0.98
Articular Surface Depression (mm)	8.87 ± 1.16

Table 3, demonstrates that the Pre-operative examinations indicated an average condylar widening of 10.67 mm (± 1.36 mm). The average number of fracture pieces was 4.33 with a standard deviation of 0.98, and the mean articular surface depression was 8.87 mm with a standard deviation of 1.16 mm. These evaluations aided in strategizing the surgical procedure and assessing the extent of the fractures.

Table 4: Functional Outcomes

Time Point (weeks)	Range of Motion (degrees, mean ± SD)
3	45 ± 5
6	70 ± 10
12	90 ± 15
24	110 ± 10
48	120 ± 15
72	130 ± 10

Table 4, demonstrates that the Functional outcomes were assessed using the range of motion (ROM) of the knee at various time intervals after the surgery. The average knee range of motion (ROM) at 3 weeks was 45 degrees, with a standard deviation of 5 degrees. The range of motion showed a substantial improvement, reaching 70 degrees (with a margin of error of ± 10 degrees) at 6 weeks, and continuing to rise to 90 degrees (with a margin of error of ± 15 degrees) at 12 weeks. At 24 weeks, the average range of motion (ROM) was 110 degrees with a deviation of 10 degrees. This improved to 120 degrees with a deviation of 15 degrees at 48 weeks, and eventually reached 130 degrees with a deviation of 10 degrees at 72 weeks.

Table 5: Radiological Outcomes

Time Point (weeks)	Signs of Union (%)	Mean Time to Union (weeks)
8	50	15.12 ± 2.14
12	75	
24	90	

Table 4 demonstrates that the Radiological examinations showed gradual indications of fracture union as time progressed. By the 8th week, half of the fractures exhibited indications of union. The percentage rose to 75% after 12 weeks and then jumped to 90% after 24 weeks. The average duration for completing union was 15.12 weeks (± 2.14 weeks), suggesting a generally positive result for the majority of patients.

F1: Figure showing a high-energy tibial plateau fracture with severe soft tissue injury

F2: Pre-operative x-ray

F3: Pot operative x-ray after ilizarov fixator

F4: 6 weeks post-operative x-ray

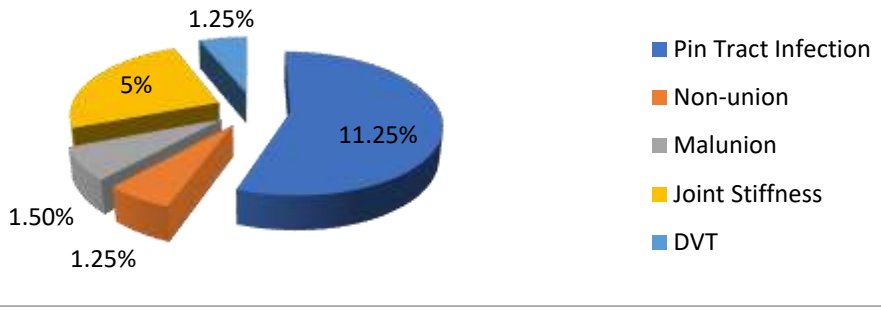
F5: After 3 months fracture united

Table 5: Complications

Complication	**Number of Patients**	**Percentage (%)**
Pin Tract Infection	9	11.25
Non-union	1	1.25
Malunion	1	1.25
Joint Stiffness	4	5
Deep Vein Thrombosis	1	1.25

Table 5, demonstrates that a number of problems were detected over the follow-up period. The most prevalent complication observed was pin tract infection, which occurred in 9 individuals, accounting for 11.25% of the cases. Additional problems were non-union and malunion, which were each reported in one patient, accounting for a prevalence of 1.25%. Four patients (5%) had joint stiffness, and one patient (1.25%) developed deep vein thrombosis.

Figure 2: Complications



Discussion

The management of proximal tibial fractures presents distinct challenges due to the fracture's position near the joint and the limited amount of soft tissue covering the broken bone. The ultimate outcome is contingent upon several factors, including the extent of injury to soft tissues and articular cartilage, precise realignment, the stability of the knee joint, secure fixation, and the alignment of the limb.[11] The treatment options were conventional dual plating with a single incision, dual plating with dual incision, single lateral column plating, less invasive internal stabilization system (LISS) plating, and fixation using Ilizarov fixator with or without minor open reduction. ORIF with dual plating using a single incision provided a wide view of the fracture, enabling a nearly perfect alignment of the broken bones. However, the substantial removal of soft tissue resulted in severe consequences such as wound separation and infections at the surgical site. Another drawback is that the soft tissue damage must heal enough in order to enable internal fixation. Consequently, the duration between the damage and the fixation was extended. The research found that the average condylar widening was 10.67 mm (± 1.36 mm), which suggests a significant lateral displacement.

This is a frequent observation in fractures caused by high-energy impacts. The average number of fracture pieces (4.33 ± 0.98) and the depth of the articular surface depression (8.87 mm ± 1.16 mm) highlight the seriousness of the fractures, which are similar to the observations made by Marsh et al. in their study on complicated tibial plateau fractures.[12]

The gradual improvement in knee range of motion (ROM) after surgery illustrates the efficacy of the Ilizarov external fixator in promoting prompt mobilization and recuperation. The average range of motion (ROM) was 45 degrees at 3 weeks, and it increased to 130 degrees by 72 weeks. The progressive improvement seen in this study aligns with the findings published by Ali et al., who saw comparable increases in range of motion (ROM) in patients treated with the Ilizarov fixator.[13] In comparison, the findings of our study's range of motion (ROM) are positive when compared to those of studies that use internal fixation techniques. For example, a research conducted by Lee et al. found that patients treated with plate fixation had an average range of motion (ROM) of 120 degrees one year after the surgery.[14] This suggests that the Ilizarov fixator is as, if not more, successful in attaining functional mobility, while also being less intrusive. The radiological evaluations revealed a significant incidence of fracture union, with 90% of fractures showing evidence of union after 24 weeks. The average duration for union, which is 15.12 weeks, aligns with the healing durations seen by Catagni et al[15], who recorded comparable union times using the Ilizarov approach. The results demonstrate the fixator's capacity to provide secure immobilization and facilitate bone regeneration, especially in situations when the epidermis is impaired. The rates and durations of union are similar to those found in investigations using internal fixation, such as the study conducted by Yang et al.[16], which showed an average union period of 14.5 weeks using locking plates. The research identified many problems, including pin tract infections (11.25%), non-union (1.25%), malunion (1.25%), joint stiffness (5%),

and deep vein thrombosis (1.25%). The most prevalent consequence seen with external fixators is pin tract infection, a well-documented concern. Nevertheless, the rate seen in our study is within the range described by other researchers, such as Paley et al.[17], who documented pin tract infection rates of up to 15%.The rates of non-union and malunion were minimal, suggesting that the surgical method and post-operative care were successful. Only a small percentage (5%) of patients have joint stiffness, which is a very modest risk compared to the possibility of severe long-term impairment associated with other techniques. One patient had deep vein thrombosis, which was effectively treated with anticoagulant medication following the methods recommended by Koval et al.[18] According to Moore et al, there was a 23% incidence of infection in cases with bicondylar fractures after internal fixation. They encountered wound dehiscence in 8 out of 11 knees that had been treated with bi-columnar plating.[19] Following open reduction and internal fixation (ORIF), Mallik et al.[20] discovered infection in 80% of bicondylar tibia fractures . Young et al.[21] documented a deep infection in 7 out of 8 fractures that underwent bi-columnar plating. In 13.8% of the instances, the use of dual incision resulted in deep infection.[22] Jiang et al.[23] documented a deep infection incidence of 4.7% when using dual plating. In Lee et al.[14] research, tibial plateau fractures were managed using the LISS technique. Out of the 36 patients, two had severe infection, while one patient developed extensive skin necrosis and eventually needed cosmetic surgery. Jiang et al.[18] observed a deep infection rate of 7.3% while using the LISS technique.The study found that LISS was linked to a greater likelihood of experiencing implant-associated discomfort compared to standard plates.The circular build had many benefits. Firstly, it ensured an equal distribution of the weight to both plateaus. Additionally, it decreased cantilever bending on the pins. This decreased the likelihood of both angular deformity and infection of the pin-tracts. Weight-bearing at an early stage caused little movements along the axis of the fracture, which in turn promoted the healing process without causing any further sideways movement. This, together with distraction on both sides of the joint, facilitated a decrease of the ligament.[16] Compression may be applied directly to the area of bone loss or fracture gap without the need for further bone grafting. As consolidation develops, it is possible to repair any rotational and translational abnormalities.

Limitation of the study

The shortcoming of the study is small sample size and short duration of the study.

Conclusion

We concluded that the use of the Ilizarov external fixator effectively treated proximal tibial fractures with damaged skin, leading to positive functional and radiological results. Most patients saw favourable outcomes in terms of knee range of motion and fracture healing, with few problems. The enhancements in knee range of motion (ROM) and the notable proportion of successful fracture unions underscore the efficacy of this therapeutic approach. Although there were some difficulties, they were largely controllable and did not have a major effect on the overall excellent results of the trial.

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