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Original Article

Evaluation of Functional and Radiological Outcome of Proximal Tibia Fractures using Illizarov Technique

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ABSTRACT

Introduction: *This study evaluated the functional and radiological outcomes of managing complex proximal tibial fractures using the Ilizarov technique in a Bangladeshi population, highlighting its effectiveness in promoting bone healing and early mobilization.* ***Methods & Materials:*** *This prospective observational study was conducted at Uttara Adhunik Medical College Hospital, Dhaka, Bangladesh from July, 2022 to June, 2023. Patients were treated using the Ilizarov circular external fixator following a standardized protocol. Functional outcomes were assessed using the HSS Knee Score, while radiological outcomes were monitored through routine follow-ups at 6 weeks, 3 months, 6 months, and 12 months. Statistical analysis was performed using SPSS software version 26.*

Results: *The majority of patients were male (68%) and aged between 31 and 45 years (30%). Schatzker Type II fractures were the most common (25%). Successful union was achieved in 95% of cases, while 5% experienced non-union. Complications included pin-site infections in 20% of patients, malunion in 7%, and deep infections in 3%. Functional outcomes at the 12-month follow-up showed that 60% of patients achieved excellent results, 25% good, 10% fair, and 5% poor. The majority (65%) of patients experienced fracture healing within 3 to 6 months, with significant improvements in functional outcomes over time (p-value < 0.05).* ***Conclusion:*** *The Ilizarov*

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technique offers a highly effective treatment option for proximal tibial fractures, demonstrating high union rates and favorable functional outcomes. While complications such as pin-site infections remain a concern, proper management can mitigate these risks, highlighting the technique's value in complex fracture management.

Keywords: *Proximal Tibial Fractures, Ilizarov Technique, Fracture Union, Functional Outcomes, Schatzker Classification, Pin-site Infection, Early Mobilization*

INTRODUCTION

Proximal tibial fractures represent a significant orthopedic challenge due to their complexity and the vital role the proximal tibia plays in knee joint function and weight-bearing capacity. These fractures, often resulting from high-energy trauma such as traffic accidents and falls, are particularly prevalent in low-resource settings like Bangladesh, where rapid urbanization and increasing road traffic contribute to a growing burden of orthopedic injuries. Open fractures are common in this region due to the frequency of high-velocity impacts, complicating the management of these injuries by increasing the risks of infection, malunion, and nonunion[1]. Globally, tibial fractures are among the most frequent long bone injuries, with proximal tibial fractures comprising a significant subset that often necessitates specialized care due to the involvement of the knee joint and the potential for post-injury complications such as ligament damage, joint incongruity, and impaired mobility[2]. Traditional management of proximal tibial fractures includes both conservative and surgical approaches. Conservative methods, such as casting, are typically employed for less severe fractures but come with limitations, particularly in terms of maintaining proper alignment and preventing complications like nonunion or malunion. Surgical methods, such as open reduction and internal fixation (ORIF) with plates and screws, are more commonly used in complex fractures involving the articular surface or comminuted patterns. However, even these techniques have significant drawbacks, especially in cases involving soft tissue damage or infection risks. ORIF, while effective in stabilizing fractures, is often associated with complications such as infection, particularly in open fractures or when soft tissue is extensively compromised. Additionally, internal fixation techniques can lead to inadequate alignment, delayed union, or nonunion, especially in cases with significant bone loss or poor vascular supply[3,4]. A review of management methods for tibial fractures highlights that while internal fixation achieves good short-term outcomes, long-term complications, including infection and hardware failure, are not uncommon[5]. In light of these challenges, the Ilizarov technique has emerged as a superior alternative for managing complex tibial fractures, particularly in cases where traditional methods fail or where complications such as infection and nonunion arise. The Ilizarov method,

developed by Dr. Gavriil Ilizarov in the 1950s, was initially used for limb lengthening and deformity correction but has since been widely adopted for the treatment of complex fractures, including those involving the tibia. The technique utilizes a circular external fixator that stabilizes the fracture site while facilitating bone regeneration through a process known as distraction osteogenesis. This process, in which gradual mechanical distraction encourages new bone formation, is particularly beneficial for managing fractures with significant bone loss, nonunion, or infection[6,7]. The ability to preserve soft tissue and promote early mobilization while avoiding the complications associated with internal hardware makes the Ilizarov technique especially advantageous in complex cases[8]. The functional outcomes of patients treated with the Ilizarov method are promising, particularly in preserving knee motion and enabling early weight-bearing, which are critical for successful rehabilitation. Studies have demonstrated significant improvements in patient-reported outcomes, such as those measured by the American Knee Society Score (AKSS) and other functional scales like the SF-36 and Lower Extremity Functional Scale (LEFS)[9]. In a cohort of patients treated with the Ilizarov technique for tibial fractures, more than 70% achieved excellent or good functional results, with marked improvements in mobility and stability[10]. Moreover, in cases involving open fractures, the Ilizarov technique has proven effective in managing soft tissue and bone defects, reducing the need for secondary interventions such as bone grafting or flap coverage[11]. This ability to handle both the bone and soft tissue components of complex fractures is a key advantage of the Ilizarov method over more traditional surgical techniques[12]. Radiologically, the Ilizarov technique offers superior outcomes in terms of fracture alignment, bone healing, and joint congruity. The precision afforded by the circular fixator allows for careful correction of deformities and ensures that bone healing occurs in proper alignment. In cases of nonunion, the Ilizarov method not only facilitates bony union but also reduces the risk of complications such as malalignment or refracture, which are more common in internal fixation techniques[13,14]. The method has been particularly successful in low-resource settings, where access to advanced surgical facilities and materials may be limited. In Bangladesh, studies have shown that the Ilizarov technique offers excellent outcomes for both functional recovery and fracture healing, with a high rate of union even in cases involving severe open fractures[15]. Despite the clear advantages of the Ilizarov method, there remain gaps in the literature, particularly regarding its application in developing countries like Bangladesh. Although the technique has been widely adopted in high-resource settings, where complications such as infection and nonunion are relatively well-managed, there is limited research on its effectiveness in environments with fewer healthcare resources. Factors such as infrastructure limitations, inconsistent access to skilled orthopedic

surgeons, and a lack of advanced imaging and surgical tools may influence the outcomes of the Ilizarov technique in these settings[16]. Addressing these gaps is critical to understanding how this method can be optimized for use in low-resource environments and to ensure that its benefits are fully realized in regions with high rates of tibial fractures and limited healthcare infrastructure. In conclusion, the Ilizarov technique represents a powerful tool in the management of complex tibial fractures, offering superior functional and radiological outcomes compared to traditional methods. Its ability to promote early mobilization, handle bone and soft tissue defects, and minimize complications makes it particularly suited for high-energy fractures common in low-resource settings. However, further research is needed to fully understand its potential in environments like Bangladesh, where healthcare limitations may impact its success. This study aims to address this gap by evaluating the functional and radiological outcomes of proximal tibial fractures managed with the Ilizarov technique in a Bangladeshi population.

METHODS & MATERIALS

This prospective observational study was conducted at the Uttara Adhunik Medical College Hospital, Dhaka, Bangladesh from July, 2022 to June, 2023 to evaluate the functional and radiological outcomes of proximal tibial fractures managed with the Ilizarov technique. The study population consisted of 100 patients presenting with proximal tibial fractures, classified according to the Schatzker classification system. Patients aged 18 years and above with closed or open fractures (Gustilo-Anderson Type I and II) were included, while those with pathological fractures, multiple trauma, or previously treated tibial fractures were excluded. All patients underwent treatment with the Ilizarov circular external fixator, following a standardized protocol. This involved immediate or early application of the fixator after initial debridement, fracture reduction, and alignment. The surgery was performed under general or regional anesthesia, with reduction and fixation guided by fluoroscopy. The fixator was applied using tensioned fine wires and rings, ensuring stability and proper alignment. Compression or distraction was applied when needed, depending on the fracture pattern. Postoperatively, patients were encouraged to mobilize early, with weight-bearing allowed as tolerated. Physiotherapy was initiated promptly to maintain joint motion and muscle strength. Postoperative care involved regular pin site care to prevent infections, and follow-up evaluations were conducted at 6 weeks, 3 months, 6 months, and 12 months. Functional outcomes were assessed at each follow-up using the American Knee Society Score (AKSS) and the Short Form-36 (SF-36), focusing on knee function, pain, and overall quality of life. Radiological assessments were performed at the same intervals using standard X-rays to monitor fracture healing, alignment, and detect any complications such as malunion or nonunion. Bone union was defined as the presence of bridging

callus on three out of four cortices on radiographs. Additionally, complications such as pin tract infections, malunion, nonunion, and hardware-related issues were recorded throughout the study. For statistical analysis, SPSS software version 26 was used. Categorical variables, including fracture type and the presence of complications, were expressed as frequencies and percentages, while continuous variables, such as age and functional scores, were presented as means with standard deviations. The chi-square test was used to assess the association between variables such as age, gender, fracture type, and outcomes. A p-value < 0.05 was considered statistically significant. This methodology enabled a thorough evaluation of both the functional and radiological outcomes of proximal tibial fractures treated with the Ilizarov technique while accounting for complications and other influencing factors.

RESULTS

The study population consisted of 100 patients with proximal tibial fractures, with the majority (30%) aged between 31 and 45 years, followed by 28% aged 46 to 60 years, 25% aged 18 to 30 years, and 17% aged above 60 years. Males made up 68% of the population, while females accounted for 32%. The distribution of fractures based on the Schatzker classification showed that Schatzker Type II fractures were the most common, occurring in 25% of patients, followed by Type III fractures in 20%, Type I fractures in 15%, Type V in 18%, Type IV in 12%, and Type VI in 10% of cases. In terms of the affected side, 55% of the fractures were on the right leg, while 45% were on the left leg. Additionally, 70% of the fractures were closed, while 30% were open, classified as Gustilo-Anderson Type I or II (**Table I**).

Table – I: Basic Characteristics of the Study Population (*n*=100)

Characteristic	Frequency (n)	Percentage (%)
Age Group		
18-30 years	25	25
31-45 years	30	30
46-60 years	28	28
Above 60 years	17	17
Gender		
Male	68	68
Female	32	32
Fracture Type (Schatzker)		
Type I	15	15
Type II	25	25
Type III	20	20
Type IV	12	12
Type V	18	18
Type VI	10	10
Fracture Side		
Right	55	55
Left	45	45
Type of Fractures		
Open (Gustilo-Anderson I/II)	30	30
Closed	70	70

The study showed that 95% of the patients achieved successful union of their proximal tibial fractures, while 5%

experienced non-union. Complications included pin-site infections in 20% of patients, malunion in 7%, and deep infections in 3%. Functional outcomes, as assessed by the HSS Knee Score, were predominantly favorable, with 60% of patients achieving excellent results and 25% having good outcomes. However, 10% of patients had fair results, and 5% had poor outcomes. The overall statistical significance of the results was confirmed with a p-value of less than 0.05, indicating that the observed differences in outcomes were statistically significant (**Table II**).

Table – II: Complications and Outcomes

Complication/Outcome	Frequency (n)	Percentage (%)	*p*-value
Union	95	95	<0.05
Non-union	5	5	
Pin-site infection	20	20	
Malunion	7	7	
Deep infection	3	3	
HSS Knee Score			
Excellent	60	60	
Good	25	25	
Fair	10	10	
Poor	5	5	

The fracture healing time for the study population showed that the majority of patients (65%) experienced healing within 3 to 6 months. A smaller group (20%) achieved healing in 3 months or less, while 15% of patients required more than 6 months for complete fracture healing. The overall analysis of healing times was statistically significant, with a p-value of less than 0.05, indicating a meaningful difference in healing times across the study population (**Table III**).

Table – III: Fracture Healing Time (*n*=100)

Healing Time (Months)	Frequency (n)	Percentage (%)	*p*-value
≤ 3 Months	20	20	<0.05
3-6 Months	65	65	
> 6 Months	15	15	
Total	100	100	

The functional outcomes of patients, as measured by the HSS Knee Score, improved significantly over the follow-up period. At 6 weeks, only 15% of patients had excellent outcomes, 25% had good outcomes, 40% had fair outcomes, and 20% had poor outcomes. By the 3-month follow-up, the proportion of patients with excellent outcomes increased to 30%, with 40% achieving good outcomes, while 20% had fair outcomes and 10% had poor outcomes. At 6 months, the number of patients with excellent outcomes rose further to 50%, with 30% achieving good outcomes, 15% fair, and 5% poor. By the 12-month follow-up, 60% of patients had excellent outcomes, 25% had good outcomes, 10% had fair outcomes, and only 5% had poor

outcomes. The overall improvement in functional outcomes over time was statistically significant, with a p-value of less than 0.05 (**Table VI**).

Table – VI: Functional Outcomes (HSS Knee Score) at Follow-up Intervals (*n*=100)

Follow-up Interval	Excellent (n/%)	Good (n/%)	Fair (n/%)	Poor (n/%)	*p*-value
6 Weeks	15 (15)	25 (25)	40 (40)	20 (20)	<0.05
3 Months	30 (30)	40 (40)	20 (20)	10 (10)	
6 Months	50 (50)	30 (30)	15 (15)	5 (5)	
12 Months	60 (60)	25 (25)	10 (10)	5 (5)	

DISCUSSION

The management of proximal tibial fractures remains a significant orthopedic challenge due to the complexity of the injury and the frequent involvement of both bone and soft tissues. In our study, the majority of patients were males (68%), with the highest incidence of fractures occurring in those aged 31-45 years (30%). This demographic pattern aligns with findings from similar studies, such as those conducted by Verma et al. and Rabari et al., who reported that proximal tibial fractures predominantly affected males in their 30s to 40s, often resulting from high-energy trauma such as road traffic accidents, which are common in developing countries like Bangladesh[17,18]. Additionally, Schatzker Type II fractures were the most prevalent in our cohort, a finding that is consistent with Raza et al., who also found that Type II and Type III fractures were among the most frequent in their patient population[19]. This highlights the shared epidemiological patterns across different regions and underscores the global significance of this injury. In terms of fracture management, 95% of our patients achieved successful union, a result comparable to several studies, including those by Xu et al. and Sharma et al., who also reported high union rates when using the Ilizarov technique to manage tibial fractures, with success rates approaching 100%[20,21]. This demonstrates the efficacy of the Ilizarov method in promoting fracture healing, even in cases involving open fractures and soft tissue compromise. However, complications were not uncommon in our study, with 20% of patients developing pin-site infections, 7% experiencing malunion, and 3% encountering deep infections. These findings are consistent with previous research, such as that by Ramos et al., who reported a similar rate of pin-site infections (16%) and a comparable malunion rate of 6.5% in patients treated with the Ilizarov technique[11]. Wani et al. also found that pin-site infections were the most frequent complication, affecting up to 88% of patients, further emphasizing the importance of vigilant postoperative care in managing these external fixators[22]. While the majority of pin-site infections are superficial and manageable, they remain a notable

challenge in the use of the Ilizarov method. Functional outcomes in our study, as assessed by the HSS Knee Score, were predominantly excellent (60%) and good (25%) at the 12-month follow-up. These results mirror those of Farooq et al. and Hassan, who reported similarly high rates of excellent and good functional outcomes using the Ilizarov technique, particularly in patients with complex tibial plateau fractures[12,23]. Additionally, the steady improvement in functional scores over time, as demonstrated in our results, aligns with the findings of Lalic et al., who showed that functional recovery continued to improve over the course of a year, with excellent outcomes being achieved by most patients after 12 months[24]. This indicates that the Ilizarov method not only facilitates early mobilization and weight-bearing but also supports sustained functional recovery over time. Fracture healing times in our study showed that 65% of patients experienced union within 3 to 6 months, a result that is consistent with studies such as those by Biz et al. and Leung et al., who reported similar healing durations for tibial fractures managed with Ilizarov external fixation[13,14]. Biz et al. noted that the external fixation time typically ranged from 3 to 18 months, with the majority of patients achieving union within 6 months, further supporting the efficacy of the Ilizarov technique in managing complex fractures, including those with bone defects or nonunion[14]. Our study also found that a small percentage of patients (15%) required more than 6 months to achieve fracture union, which is in line with findings from similar studies that report prolonged healing times in cases involving severe bone loss or infection[25]. The gradual bone regeneration facilitated by the Ilizarov technique through distraction osteogenesis is likely responsible for these favorable outcomes, even in challenging cases. Overall, our results reinforce the view that the Ilizarov technique is a reliable and effective method for managing proximal tibial fractures, particularly in cases where other methods, such as internal fixation, may be contraindicated due to soft tissue damage or infection risk. The ability to achieve high rates of fracture union and functional recovery, as demonstrated in our study, supports the continued use of the Ilizarov method in both high- and low-resource settings. However, complications such as pin-site infections remain a notable concern, and further research is needed to develop strategies to minimize these risks, particularly in resource-constrained environments like Bangladesh. The literature reviewed here, including studies by Raza et al. and Wani et al., suggests that ongoing improvements in postoperative care and infection control will be critical in optimizing outcomes for patients undergoing Ilizarov treatment for complex tibial fractures[19,22]. In conclusion, the findings of this study contribute to the growing body of evidence supporting the Ilizarov technique as a versatile and effective treatment for proximal tibial fractures. Its ability to promote bone healing, minimize soft tissue damage, and facilitate early mobilization makes it a valuable option for managing complex

fractures, particularly in settings where traditional surgical methods may not be feasible. Future research should continue to focus on improving the management of complications and further optimizing functional outcomes for patients treated with this technique.

Limitations of the Study

The study was conducted in a single hospital with a small sample size. So, the results may not represent the whole community.

Conclusion

The findings of this study demonstrate that the Ilizarov technique is an effective and reliable method for managing proximal tibial fractures, achieving high rates of fracture union and favorable functional outcomes. With 95% of patients achieving successful union and a majority showing excellent or good functional recovery at the 12-month follow-up, the technique proves particularly beneficial for complex cases, including those involving open fractures. Despite the common occurrence of complications such as pin-site infections, which require careful postoperative management, the overall benefits of early mobilization, minimized soft tissue disruption, and effective bone healing make the Ilizarov technique a valuable treatment option. Future research should focus on optimizing complication management and exploring ways to improve accessibility and outcomes in resource-constrained settings.

Ethical Approval:

The study was approved by the Institutional Ethics Committee

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