

Original Research Article

Primary locked intramedullary nailing versus ilizarov fixation for gustilo type I–IIIA open tibial shaft fractures: a prospective comparative study

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ABSTRACT

Background: Open tibial shaft fractures are challenging injuries with substantial risks of infection, delayed union, and functional impairment. Primary locked intramedullary nailing (PLIN) and Ilizarov fixation are commonly used definitive treatment options. The objective of the study is to compare the clinical, radiological, functional outcomes and complications of these two techniques in Gustilo–Anderson type I–IIIA open tibial shaft fractures.

Methods: This prospective comparative observational study was conducted at Sylhet M.A.G. Osmani Medical College Hospital, Bangladesh, from April 2023 to March 2025. Seventy patients aged 18–65 years were included and equally allocated to PLIN (Group A, n=35) and Ilizarov fixation (Group B, n=35). Operative time, postoperative pain, weight-bearing status, fracture union, complications, and functional outcomes were assessed. Functional outcome was evaluated using the Karlström–Olerud score.

Results: The mean operative time was significantly shorter with PLIN than Ilizarov fixation (71.14±10.92 vs. 101.86±20.51 minutes; p=0.001). At one-month, full weight bearing was achieved in 51.4% of PLIN patients versus 100.0% of Ilizarov patients (p=0.001). At six months, union was achieved in 100.0% and 94.3% of patients, respectively (p=0.493), with mean union times of 18.25±2.17 and 19.42±2.82 weeks (p=0.094). Complications were significantly more frequent with Ilizarov fixation (p=0.002). Good functional outcomes were observed in 77.1% of PLIN and 51.4% of Ilizarov patients (p=0.079).

Conclusions: Both techniques achieved satisfactory outcomes; however, PLIN demonstrated shorter operative time and fewer complications, while Ilizarov fixation provided earlier full weight bearing.

Keywords: Open tibial fracture, Intramedullary nailing, Ilizarov fixation, Fracture union, Gustilo–Anderson classification

INTRODUCTION

Open fractures are characterized by disruption of the skin and underlying soft tissues, creating communication between the fracture site and the external environment, thereby increasing the risk of contamination and infection.¹ Among long bone fractures, the tibial shaft is one of the most frequently affected sites because of its

subcutaneous location and limited soft tissue coverage. Open tibial shaft fractures account for approximately 25% of all open fractures and occur predominantly in young adult males, with a male-to-female ratio of approximately 3:1.² Most injuries result from high-energy trauma such as road traffic accidents, falls from height, sports injuries, assaults, and firearm-related trauma.³

Open tibial shaft fractures remain a major challenge for orthopedic surgeons because of the associated soft tissue damage, contamination, and high risk of complications. High-energy injuries may be accompanied by vascular injury, nerve damage, and compartment syndrome, which further complicate treatment.⁴ Delayed union, nonunion, malunion, chronic osteomyelitis, and deep infection are common complications. Previous studies have reported rehospitalization rates as high as 57%, while surgical site infection and osteomyelitis rates range from 14.3% to 60.0% in severe open tibial fractures.⁵ Therefore, the primary goals of management are to achieve fracture union, restore limb alignment and length, permit early weight bearing, preserve joint function, and minimize complications, particularly infection.⁶

Modern treatment strategies for open fractures include early administration of prophylactic antibiotics, urgent debridement, fracture stabilization, and timely soft tissue coverage.⁷ Both non-operative and operative methods have been utilized for management, including plaster casting, bracing, plate fixation, intramedullary nailing, and external fixation.⁸ Historically, plaster immobilization was widely used; however, it often failed to maintain fracture alignment and limited access to soft tissue wounds. Open reduction and internal fixation with plates have been associated with high infection rates and therefore has limited application in open fractures.⁹ External fixation has traditionally been employed for initial stabilization of open tibial fractures. Uniplanar external fixators provide rapid fracture stabilization but are associated with disadvantages such as bulky frames, pin tract infections, malunion, nonunion, and the frequent need for secondary procedures.⁹ Delayed conversion from external fixation to intramedullary nailing remains controversial because infection rates have been reported to be as high as 44%.¹⁰

Primary locked intramedullary nailing (PLIN) has become the preferred treatment modality for Gustilo type I, II, and IIIA open tibial shaft fractures.⁶ Locking screws provide excellent control of length, rotation, and alignment, thereby creating favorable conditions for fracture healing and soft tissue recovery.¹¹ Several studies have demonstrated that PLIN offers advantages including stable fixation, minimal soft tissue disruption, early mobilization, early weight bearing, and rapid return to functional activities.^{11,12} Nevertheless, complications such as infection, hardware failure, nonunion, and anterior knee pain have been reported. Infection rates vary according to fracture severity, ranging from 1.8% in Gustilo type I fractures to 12.5% in type IIIB injuries.⁶

The Ilizarov external fixator represents another important treatment option for open tibial fractures, particularly those with significant soft tissue damage or comminution. This circular external fixation system allows stable fixation with minimal disruption of blood supply and soft tissues, facilitates wound management, and permits early weight bearing.^{13,14} In addition, the Ilizarov technique enables correction of deformity, limb length adjustment,

and postoperative modification of alignment if required.¹⁴ However, complications such as pin tract infection, malunion, neurovascular injury, joint stiffness, delayed union, and refracture after frame removal remain concerns.^{5,6}

Previous comparative studies have produced inconsistent results regarding the superiority of PLIN or Ilizarov fixation. In a study from Turkey involving 61 patients, bone healing occurred at an average of 21 weeks in the intramedullary nail group and 19 weeks in the Ilizarov group, with similar rates of malunion and infection.¹⁵ A randomized trial conducted in the United States reported higher overall complication and implant failure rates in the Ilizarov group, although no significant differences were observed in deep infection, nonunion, or union time.⁵ In Bangladesh, Siddiqui et al reported favorable outcomes with the Ilizarov method, including satisfactory union rates and absence of deep infection.¹⁶ Despite advances in fracture management, evidence comparing primary locked intramedullary nailing and Ilizarov fixation in Gustilo type I–IIIA open tibial shaft fractures remain limited, particularly in the context of developing countries. Therefore, this prospective comparative observational study was undertaken to evaluate and compare the clinical and functional outcomes, union rates, complications, and overall effectiveness of primary locked intramedullary nailing versus Ilizarov fixation in the management of Gustilo type I–IIIA open tibial shaft fractures.

The main objective was to compare the outcomes of primary locked intramedullary nailing and Ilizarov fixation in Gustilo type I–IIIA open tibial shaft fractures.

METHODS

The prospective comparative observational study was conducted in the Department of Orthopaedic Surgery and Department of Casualty, Sylhet M.A.G. Osmani Medical College Hospital, Sylhet, Bangladesh. The study was carried out over a period of 24 months, from April 2023 to March 2025.

Inclusion criteria

Patients with open tibial shaft fractures classified as Gustilo–Anderson Type I, II, or IIIA; Patients presenting within 12 hours of injury; Patients aged 18–65 years; Both male and female patients; Patients who provided informed written consent.

Exclusion criteria

Patients with Gustilo–Anderson Type IIIB or IIIC open fractures; Fractures located within 5 cm of the ankle, proximal to the tibial tubercle, or with intra-articular extension; Pathological fractures; Polytrauma patients; Patients with severe systemic illnesses, including uncontrolled diabetes mellitus or significant cardiovascular disease; Pregnant patients; Patients with

major psychiatric illness or drug abuse that could interfere with treatment or follow-up.

A total of 70 eligible patients with open tibial shaft fractures were enrolled during the study period using convenience sampling. The patients were equally divided into two groups, with 35 patients in each group. Group A (n=35) received primary locked intramedullary nailing, while Group B (n=35) received Ilizarov fixation. The first eligible patient was allocated to either Group A or Group B by toss, and subsequent eligible patients were allocated alternately to maintain equal group sizes.

All patients underwent initial assessment and stabilization, including hemodynamic stabilization, intravenous antibiotics, tetanus prophylaxis, wound irrigation, and removal of grossly contaminated and devitalized tissue. Detailed history and clinical examination were performed, including assessment of the wound, distal vascularity, and neurovascular status. Radiographs of the affected leg, including the knee and ankle joints in anteroposterior and lateral views, were obtained, and fractures were classified according to the Gustilo–Anderson classification. A wound swab was collected for culture and sensitivity testing where indicated. The wound was covered with a sterile dressing, and the affected limb was temporarily immobilized with an above-knee plaster of Paris slab.

After necessary preoperative investigations, definitive fixation was performed at the earliest appropriate time. All operations were performed under spinal anesthesia with the patient in the supine position by orthopedic surgeons of Assistant Professor rank or above. Patients in Group A underwent primary locked intramedullary nailing, while patients in Group B underwent Ilizarov circular external fixation, according to standardized institutional operative protocols. The total duration of each operation was recorded.

Following surgery, postoperative X-rays were obtained. All patients received intravenous antibiotics for approximately five days, followed by oral antibiotics according to clinical condition and culture and sensitivity results where available. Delayed primary wound closure was performed at 2-3 post-operative days when required, and sutures were removed on the 14th postoperative day. Active and passive knee and ankle movements were initiated from the first postoperative day.

Crutch-assisted partial weight bearing was initiated from the third postoperative day in the primary locked intramedullary nail group, while weight bearing as tolerated was permitted in the Ilizarov group according to fracture stability and clinical condition. Weight bearing in the intramedullary nail group was gradually progressed following early callus formation, generally after 4–6 weeks. Regular pin-site care was provided to patients treated with Ilizarov fixation.

Data were collected using a structured and pre-tested data collection form. Baseline demographic and clinical variables, operative duration, postoperative pain, range of motion of the knee and ankle, time to full weight bearing, radiological progression of fracture healing, time to bony union, and postoperative complications were recorded. Patients were followed clinically and radiologically at monthly intervals until bony union was achieved. Complications including infection, pin-tract infection, delayed union, nonunion, malunion, shortening, refracture, joint contracture, implant or fixator failure, and the need for additional surgical intervention were documented. At the end of the follow-up period, functional outcome was assessed using the Karlström–Olerud score and categorized as excellent, good, satisfactory, moderate, or poor.

Ethical approval was obtained from the Institutional Ethical Review Board and concerned authority of Sylhet M.A.G. Osmani Medical College, Sylhet. Written informed consent was obtained from all participants before enrollment. Participants were informed about the nature, purpose, potential benefits, and possible risks of the study and their right to withdraw at any time without affecting their treatment. Confidentiality of patient information was strictly maintained, and the collected data were used solely for research purposes.

Statistical analysis

All data were recorded systematically in a preformed data collection form and checked for completeness, accuracy, and consistency before analysis. Quantitative variables were expressed as mean $\pm$ standard deviation (SD), while qualitative variables were expressed as frequency and percentage. Statistical analysis was performed using SPSS (Statistical Package for the Social Sciences), version 25.0. The Mann–Whitney U test was used to compare continuous variables between the two groups, while the Chi-square test or Fisher's exact test was used for categorical variables, as appropriate. A $p < 0.05$ was considered statistically significant.

RESULTS

Table 1 shows the demographic characteristics between the two groups. The mean age was 39.37 ± 13.40 years in Group A and 37.09 ± 13.44 years in Group B. Male patients predominated in both groups (82.9% vs. 80.0%). Right-sided tibial fractures were more common in both groups (57.1%). There were no statistically significant differences between the groups regarding age, sex, or side involvement ($p > 0.05$).

Table 2 shows the injury characteristics between the two groups. Road traffic accidents were the most common mechanism of injury in both groups (80.0% vs. 77.1%), with no significant difference ($p = 0.432$). Type II was the most common fracture type in Group A (37.1%), while Type IIIA was most common in Group B (45.7%). The

distribution of Gustilo–Anderson fracture types were not significantly different between the groups ($p=0.565$).

Table 3 shows the operative time and immediate postoperative pain between the two groups. The mean operative time was significantly shorter in Group A than in Group B (71.14 ± 10.92 vs. 101.86 ± 20.51 minutes, $p=0.001$). However, the mean immediate postoperative VAS pain score was comparable between the groups (6.89 ± 1.15 vs. 6.77 ± 0.91 , $p=0.581$).

Table 4 shows the full weight-bearing status between the two groups at 1- and 6-months follow-up. At 1-month, full weight bearing was achieved by 100.0% of patients in Group B compared with 51.4% in Group A, showing a statistically significant difference ($p=0.001$). At 6 months, all patients in both groups achieved full weight bearing.

Table 5 shows the pain and fracture healing outcomes between the two groups at 6 months follow-up. The mean VAS pain score was slightly lower in Group A than in Group B (0.54 ± 0.56 vs. 0.69 ± 0.67), but the difference

was not statistically significant ($p=0.423$). Bony union was achieved in 100.0% of patients in Group A and 94.3% in Group B ($p=0.493$). The mean union time was 18.25 ± 2.17 weeks in Group A and 19.42 ± 2.82 weeks in Group B, with no statistically significant difference ($p=0.094$).

Table 6 shows the postoperative complications between the two groups at 6 months follow-up. Pin-tract infection occurred in 22.9% of patients in Group B, while screw-site infection occurred in 11.4% of patients in Group A. Delayed union occurred in 5.7% of patients in Group B and was not observed in Group A. The difference in complications between the groups was statistically significant ($p=0.002$).

Table 7 shows the Karlström–Olerud functional outcomes between the two groups at 6 months follow-up. Good functional outcomes were more frequent in Group A than in Group B (77.1% vs. 51.4%), while excellent outcomes were observed in 11.4% of patients in both groups. However, the overall difference in functional outcomes was not statistically significant ($p=0.079$).

Table 1: Demographic characteristics of the respondents (n=70).

Characteristics	Group A (n=35)	Group B (n=35)	P value
Age (years), N (%)			
18–30	11 (31.4)	15 (42.9)	0.645*
31–40	11 (31.4)	8 (22.9)	
41–50	6 (17.1)	7 (20.0)	
51–60	6 (17.1)	3 (8.6)	
>60	1 (2.9)	2 (5.7)	
Mean age ± SD	39.37±13.40	37.09±13.44	
Sex, N (%)			
Male	29 (82.9)	28 (80.0)	0.759*
Female	6 (17.1)	7 (20.0)	
Side involvement, N (%)			
Left tibia	15 (42.9)	15 (42.9)	1.000*
Right tibia	20 (57.1)	20 (57.1)	

* Chi-square test

Table 2: Injury characteristics between the two groups (n=70).

Characteristics	Group A (n=35) N (%)	Group B (n=35) N (%)	P value
Mechanism of injury			
Road traffic accident	28 (80.0)	27 (77.1)	0.432*
Fall from height	6 (17.1)	4 (11.4)	
Fall of object	1 (2.9)	2 (5.7)	
Others	0 (0.0)	2 (5.7)	
Gustilo–Anderson fracture type			
Type I	10 (28.6)	7 (20.0)	0.565*
Type II	13 (37.1)	12 (34.3)	
Type IIIA	12 (34.3)	16 (45.7)	

* Chi-square test

Table 3: Operative time and immediate postoperative pain between the two groups.

Characteristics	Group A (n=35) Mean ± SD	Group B (n=35) Mean ± SD	P value
Operative time (minutes)	71.14±10.92	101.86±20.51	0.001*
Immediate postoperative VAS pain score	6.89±1.15	6.77±0.91	0.581*

* Chi-square test

Table 4: Comparison of full weight-bearing status between the two groups at 1- and 6-months follow-up.

Full weight-bearing status	Group A (n=35) N (%)	Group B (n=35) N (%)	P value
At 1 month			
Yes	18 (51.4)	35 (100.0)	0.001*
No	17 (48.6)	0 (0.0)	
At 6 months			
Yes	35 (100.0)	35 (100.0)	—

* Chi-square test

Table 5: Comparison of pain and fracture healing outcomes at 6 months between the two groups (n=70).

Outcome	Group A (n=35)	Group B (n=35)	p value
VAS pain score, mean ± SD	0.54±0.56	0.69±0.67	0.423*
Bony union status, n (%)			
United	35 (100.0)	33 (94.3)	0.493†
Not united	0 (0.0)	2 (5.7)	
Total union time, mean ± SD (weeks)	18.25 ± 2.17	19.42 ± 2.82	0.094*

* Chi-square test, † Fisher's exact test.

Table 6: Comparison of postoperative complications between the two groups at 6 months follow-up.

Complications	Group A (n=35) N (%)	Group B (n=35) N (%)	P value
Delayed union	0 (0.0)	2 (5.7)	0.002*
Pin-tract infection	0 (0.0)	8 (22.9)	
Screw-site infection	4 (11.4)	0 (0.0)	
No complication	31 (88.6)	25 (71.4)	

* Chi-square test.

Table 7: Comparison of Karlström–Olerud functional outcome between the two groups at 6 months follow-up (n=70).

Karlström–Olerud outcome	Group A (n=35) N (%)	Group B (n=35) N (%)	P value
Excellent	4 (11.4)	4 (11.4)	0.079*
Good	27 (77.1)	18 (51.4)	
Satisfactory	4 (11.4)	12 (34.3)	
Moderate	0 (0.0)	1 (2.9)	

* Chi-square test.

DISCUSSION

Open tibial shaft fractures remain challenging injuries because they combine fracture instability with varying degrees of soft-tissue damage and contamination. The choice of definitive fixation is therefore influenced not

only by fracture stabilization and union but also by operative efficiency, rehabilitation, functional recovery, and postoperative complications. The present prospective comparative observational study was conducted at Sylhet M.A.G. Osmani Medical College Hospital between April 2023 and March 2025 to compare primary locked intramedullary nailing (PLIN) with Ilizarov fixation in

patients with Gustilo–Anderson type I–IIIA open tibial shaft fractures. A total of 70 patients were included, with 35 patients treated by PLIN (Group A) and 35 treated by Ilizarov fixation (Group B). The mean follow-up period was 14.2 months, ranging from 6 to 18 months. Overall, the findings demonstrated that both techniques achieved satisfactory fracture healing and functional recovery; however, PLIN was associated with significantly shorter operative time and fewer postoperative complications, whereas Ilizarov fixation allowed earlier full weight bearing.

The demographic characteristics of the two groups were comparable. The mean age was 39.37 ± 13.40 years in the PLIN group and 37.09 ± 13.44 years in the Ilizarov group, with no statistically significant difference. Male patients predominated in both groups, accounting for 82.9% and 80.0%, respectively ($p=0.759$). Right-sided fractures were more common in both groups (57.1%), while the remaining patients had left-sided involvement. This similarity in baseline demographic characteristics suggests that the two treatment groups were reasonably comparable and that the observed differences in treatment outcomes were less likely to be explained by age, sex, or side of injury. Similar demographic comparability was reported by Jeremic et al where the proportion of males was 62.1% in the intramedullary nail group and 63.5% in the external fixation group, with no significant difference in mean age between the groups.¹⁷ Comparable demographic patterns were also reported in randomized controlled trials by Kisitu et al, Rohilla and Cortez where open tibial fractures predominantly affected younger adult males.¹⁸⁻²⁰

Road traffic accidents were the predominant mechanism of injury in the present study, accounting for 80.0% of cases in Group A and 77.1% in Group B, with no significant difference between the groups ($p=0.432$). Falls from height represented 17.1% and 11.4% of injuries, respectively. The predominance of road traffic accidents reflects the high-energy mechanism commonly associated with open tibial shaft fractures. The distribution of Gustilo–Anderson fracture severity was also comparable between the groups. Type I fractures accounted for 28.6% in Group A and 20.0% in Group B, type II for 37.1% and 34.3%, and type IIIA for 34.3% and 45.7%, respectively ($p=0.565$). Therefore, there was no statistically significant difference in fracture classification between the treatment groups.

A major finding of the present study was the significant difference in operative duration. The mean operative time was substantially shorter in the PLIN group than in the Ilizarov group (71.14 ± 10.92 vs. 101.86 ± 20.51 minutes, $p=0.001$). This finding indicates an operative efficiency advantage for primary locked intramedullary nailing in the present setting. Application of an Ilizarov frame requires placement of multiple rings and wires, appropriate tensioning, alignment assessment, and careful adjustment of the construct, which may contribute to longer operative duration. The finding is consistent with the meta-analysis

by Li which reported shorter operative times with intramedullary nailing compared with alternative fixation techniques.²¹ Szelerski also emphasized that the Ilizarov technique may require considerable operative time because of its technically demanding frame application and precise adjustment.²² However, the literature is not completely consistent; Jeremic reported a different operative-time pattern, emphasizing that operative duration may depend on surgeon experience, fracture characteristics, and the specific external fixation technique used.¹⁷

Immediate postoperative pain was comparable between the two groups. The mean VAS score was 6.89 ± 1.15 in the PLIN group and 6.77 ± 0.91 in the Ilizarov group, with no statistically significant difference ($p=0.581$). At six months, pain had markedly decreased in both groups, with mean VAS scores of 0.54 ± 0.56 and 0.69 ± 0.67 , respectively ($p=0.423$). Although the PLIN group demonstrated a numerically lower pain score, the difference was not statistically significant. Therefore, the present findings do not establish a definite superiority of either fixation technique regarding postoperative pain. Yang highlighted the importance of appropriate postoperative pain management in improving patient satisfaction and recovery following intramedullary nailing.²³ The current findings suggest that regardless of the fixation method, pain can substantially improve during follow-up as fracture healing progresses and limb function is restored.

An important difference was observed in early weight-bearing ability. At one month, all patients in the Ilizarov group had achieved full weight bearing compared with 51.4% of patients in the PLIN group, and this difference was statistically significant ($p=0.001$). By six months, however, all patients in both groups had achieved full weight bearing. The earlier weight-bearing capacity associated with Ilizarov fixation represents an important functional advantage of the technique. The circular frame provides stable fixation and can permit controlled loading across the fracture while maintaining alignment. This feature may be particularly useful in selected open fractures where early mobilization is desirable. Nevertheless, the advantage in early weight bearing should be considered alongside the greater frequency of pin-related complications observed in the Ilizarov group.

Fracture healing was satisfactory in both groups. At six months, bony union was achieved in all 35 patients (100.0%) in the PLIN group and in 33 patients (94.3%) in the Ilizarov group, with no statistically significant difference ($p=0.493$). The mean union time was 18.25 ± 2.17 weeks in Group A and 19.42 ± 2.82 weeks in Group B ($p=0.094$). Although union occurred approximately 1.2 weeks earlier in the PLIN group, this difference did not reach statistical significance. These findings indicate that both techniques are capable of achieving high union rates in appropriately selected Gustilo type I–IIIA open tibial shaft fractures. Sakaki et

al., in 2007 similarly reported comparable healing durations between fixation methods, with mean union times of 20.87 weeks and 21.50 weeks and no significant difference ($p=0.95$).²⁴ Thus, the present study supports the view that the choice between PLIN and Ilizarov fixation may not substantially influence final union time when appropriate fracture management and follow-up are provided.

The complication profile, however, differed considerably between the two groups. In the Ilizarov group, pin-tract infection occurred in 8 patients (22.9%), while delayed union occurred in 2 patients (5.7%). In contrast, screw-site infection was observed in 4 patients (11.4%) in the PLIN group, with no cases of delayed union. Overall, the difference in postoperative complications was statistically significant ($p=0.002$). The higher frequency of pin-tract infection represents an important disadvantage of Ilizarov fixation. Pin-related problems are well recognized with circular external fixation and may be related to local skin irritation, soft-tissue tension, and pin-site care. Sun described pin-tract infection as a common complication of Ilizarov fixation.²⁵ Similarly, Hussain reported pin-tract infection in 25% of patients treated with Ilizarov fixation, along with superficial skin infection and chronic osteomyelitis.²⁶ These findings are broadly consistent with the current study, in which pin-tract infection was the most frequent complication in the Ilizarov group. Importantly, the complications in the present study were managed appropriately, and all patients were reported to be free from complications by the end of follow-up.

Functional recovery was assessed using the Karlström–Olerud score at six months. Excellent outcomes were observed in 11.4% of patients in each group. However, good outcomes were more frequent in the PLIN group than in the Ilizarov group (77.1% vs. 51.4%), while satisfactory outcomes occurred in 11.4% and 34.3%, respectively. One patient in the Ilizarov group had a moderate outcome. Although the overall difference did not reach statistical significance ($p=0.079$), the distribution favored PLIN, particularly because a greater proportion of patients achieved a good functional result. Pancholiya reported favorable functional outcomes following intramedullary fixation of tibial fractures and emphasized the contribution of improved fixation techniques and understanding of functional anatomy to postoperative recovery.²⁷ Li also reported favorable outcomes associated with intramedullary nailing.²¹ The present findings therefore suggest a possible functional advantage of PLIN, although the sample size may have limited the statistical power to demonstrate a significant difference.

The present findings are also broadly consistent with previous comparative evidence. Inan reported comparable union and malunion outcomes between primary intramedullary nailing and Ilizarov fixation but observed a greater need for additional surgery in the intramedullary nail group. In contrast, the randomized trial reported by O'Toole demonstrated higher overall complication and

implant failure rates with Ilizarov fixation, although deep infection, nonunion, and union time were not appreciably different. The current study similarly found comparable union outcomes but a significantly higher overall complication burden in the Ilizarov group. The findings of Siddiqui who reported satisfactory union with Ilizarov fixation in Bangladesh without deep infection, demonstrate that Ilizarov fixation can nevertheless provide excellent results when appropriately applied and followed.¹⁶

Overall, the present study demonstrates that both primary locked intramedullary nailing and Ilizarov fixation are effective treatment options for Gustilo type I–IIIA open tibial shaft fractures. PLIN provided significantly shorter operative time and was associated with fewer postoperative complications, while Ilizarov fixation offered a significant advantage in achieving earlier full weight bearing. Although union rates and mean union time were not significantly different, functional outcomes showed a favorable trend toward PLIN. Therefore, in appropriately selected Gustilo type I–IIIA open tibial shaft fractures, primary locked intramedullary nailing may be considered a preferable definitive fixation method because of its operative efficiency, satisfactory union, lower complication burden, and favorable functional recovery. Ilizarov fixation remains an important alternative, particularly when early weight bearing or specific fracture and soft-tissue considerations make circular external fixation advantageous.

Limitations

This study had several limitations, including a relatively small sample size and a single-center design, which may limit the generalizability of the findings. Convenience sampling and non-randomized allocation may have introduced selection bias. The follow-up duration varied from 6 to 24 months, and only Gustilo type I–IIIA fractures were included. Additionally, longer-term functional outcomes and late complications could not be fully assessed.

CONCLUSION

Primary locked intramedullary nailing and Ilizarov fixation were both effective methods for the management of Gustilo–Anderson type I–IIIA open tibial shaft fractures, achieving high rates of fracture union and satisfactory functional recovery. However, primary locked intramedullary nailing demonstrated several advantages, including significantly shorter operative time, fewer postoperative complications, and a favorable trend toward better functional outcomes. Although the Ilizarov group achieved significantly earlier full weight bearing, this benefit was accompanied by a higher incidence of pin-tract infection and delayed union. There was no statistically significant difference between the two groups in terms of postoperative pain, union rate, or mean time to bony union.

Therefore, primary locked intramedullary nailing may be considered a preferable definitive fixation method for appropriately selected Gustilo type I–IIIA open tibial shaft fractures, particularly when early mobilization, operative efficiency, and reduction of fixation-related complications are priorities. Nevertheless, Ilizarov fixation remains a valuable alternative, particularly in cases where early weight bearing and minimally invasive stabilization are advantageous. Larger, multicenter randomized controlled studies with longer follow-up are recommended to further establish the comparative effectiveness and long-term outcomes of these two techniques.

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