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Original Research Article

OUTCOMES OF EARLY FIXATION AND SOFT TISSUE COVERAGE IN TYPE IIIB OPEN PROXIMAL TIBIA FRACTURES: A PROSPECTIVE STUDY

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ABSTRACT

Background: Type IIIB open proximal tibia fractures present significant challenges due to severe soft tissue damage and compromised bone healing. Early fixation and soft tissue coverage are critical in improving outcomes, yet the optimal timing of these interventions remains debated. This study aimed to compare the outcomes of early versus delayed fixation and soft tissue coverage in patients with Type IIIB open proximal tibia fractures, focusing on infection rates, time to fracture union, functional recovery, and complications.

Materials and Methods: This prospective cohort study was conducted between July 2023 and June 2024, including 56 patients with Type IIIB open proximal tibia fractures. Patients were divided into two groups: Early Fixation and Coverage (n=28) and Delayed Fixation and Coverage (n=28). The primary outcome measures included time to surgery, time to fracture union, infection rates, flap necrosis, and reoperation rates. Secondary outcomes included functional recovery, patient satisfaction, and the need for walking aids at 12 months. Data were analyzed using statistical tests, including t-tests and chi-square tests, with a significance level of $p<0.05$.

Results: The Early Fixation and Coverage group showed significantly better outcomes, with a shorter time to surgery (22 hours vs. 38 hours, p=0.004), faster time to fracture union (19.8 weeks vs. 25.2 weeks, p=0.006), and shorter hospital stay (12 days vs. 18 days, p=0.003). The Early Fixation group also had a higher Lower Extremity Functional Scale (LEFS) score (70.3 vs. 60.5, p=0.021) and better range of motion (114.8° vs. 105.5°, p=0.034). While infection rates and reoperation rates were higher in the Delayed Fixation group, the differences were not statistically significant. Patient satisfaction was higher in the Early Fixation group (8.1 vs. 6.9, p=0.018).

Conclusion: Early fixation and soft tissue coverage in Type IIIB open proximal tibia fractures lead to significantly better functional outcomes, faster fracture healing, and reduced hospital stays compared to delayed intervention. These findings emphasize the benefits of early surgical management in improving recovery and reducing complications. Further studies with larger sample sizes are warranted to confirm these results.

Keywords: Type IIIB open proximal tibia fracture, early fixation, delayed fixation, soft tissue coverage, fracture union, infection rates, functional recovery, patient satisfaction.

INTRODUCTION

Type IIIB open proximal tibia fractures represent a severe form of musculoskeletal injury, commonly resulting from high-energy trauma such as road traffic accidents, falls from height, and industrial incidents. These fractures involve extensive soft tissue damage, periosteal stripping, and exposed

bone, often with significant contamination, making these injuries highly susceptible to complications. Globally, lower extremity fractures account for approximately 40% of all open fractures, with tibial fractures comprising nearly 24% of these injuries.[1] In India, the incidence of high-energy tibial fractures has seen an increase, with road traffic accidents being a primary contributing factor.[2]

The management of type IIIB open fractures is particularly complex. According to the Gustilo-Anderson classification, type IIIB fractures involve a high degree of contamination and soft tissue damage, often necessitating soft tissue reconstruction to restore adequate coverage.[3] Traditional management protocols for type IIIB fractures have involved staged procedures, beginning with immediate debridement, temporary external fixation, and subsequent soft tissue and bony reconstruction.[4] However, these staged approaches have limitations: delayed definitive fixation and soft tissue coverage are associated with high rates of infection, reported between 15% and 50% globally,[5] and delayed healing or non-union, with an estimated 16-30% of cases experiencing prolonged non-union.[6] Studies also show that delayed coverage is associated with poor functional outcomes, with up to 40% of patients experiencing impaired limb function and joint stiffness.[7]

Recent advancements in the management of type IIIB fractures have highlighted the potential benefits of early bony fixation combined with immediate soft tissue coverage. Early fixation, defined as definitive internal fixation within 72 hours of injury, paired with soft tissue coverage, has been associated with significantly improved outcomes. For instance, early fixation and vascularized flap coverage have been shown to reduce infection rates to less than 10%, compared to nearly 30% with delayed coverage.[8] In a large cohort study, early fixation reduced the average healing time from 12 months to approximately 6–9 months, demonstrating the value of timely intervention in improving recovery.[9] Moreover, early soft tissue coverage has shown to decrease hospital stay duration and reduce overall healthcare costs, factors that are critical in resource-limited settings.[10]

Despite these advantages, early fixation and soft tissue coverage in type IIIB fractures remain controversial due to the high risk of infection associated with immediate internal fixation in contaminated wounds. Concerns around aseptic handling, the adequacy of vascularized flap techniques, and the suitability of the injury environment for early fixation contribute to hesitancy in adopting this approach universally.[11] This study aimed to evaluate the outcomes associated with early bony fixation and soft tissue coverage in type IIIB open proximal tibia fractures, with a focus on infection rates, healing time, and long-term functional outcomes. By investigating the feasibility and outcomes of this treatment approach, this study seeked to provide valuable insights into optimizing care for patients with severe open tibial fractures, ultimately aiming to reduce complication rates and improve recovery and limb function.

MATERIALS AND METHODS

Study Design and Setting

This prospective observational study was conducted over one year, from July 2023 to June 2024, in the department of Orthopedics at a tertiary care center in North India. The study was designed to assess the outcomes of early bony fixation and soft tissue coverage in type IIIB open proximal tibia fractures. Ethical approval was obtained from the Institutional Ethics Committee, and all participants provided written informed consent.

Study Population

The study enrolled a total of 56 patients aged 18-65 years who presented with type IIIB open proximal tibia fractures. Inclusion criteria required participants to have a type IIIB fracture, based on the Gustilo-Anderson classification, and eligibility for surgical intervention. Patients with type IIIC fractures, those with life-threatening polytrauma, severe comorbidities precluding surgery, or those who declined participation were excluded from the study.

Sample Size

The sample size of 56 was based on the estimated reduction in infection rates from approximately 30% to 10% with early fixation and coverage [12]. Using an alpha level of 0.05 and a power of 80%, this sample size was calculated to allow for sufficient statistical power in detecting a difference in primary outcomes between early fixation with coverage and alternative treatment timelines. A total of 56 patients with Type IIIB open proximal tibia fractures were included, divided into two groups: Early Fixation and Coverage group (n=28), where patients received bony fixation and soft tissue coverage within 72 hours of injury. Delayed Fixation and Coverage group (n=28), where patients received the same treatment protocol after a delay beyond 72 hours.

Surgical Protocol

On admission, each patient underwent a comprehensive evaluation, including a detailed clinical examination and radiological assessment, primarily through plain radiographs of the affected limb. Initial management adhered to Advanced Trauma Life Support (ATLS) guidelines, ensuring rapid stabilization, wound irrigation, and surgical debridement to reduce contamination and infection risk. Definitive internal fixation was consistently performed within 72 hours post-injury, using devices such as locking plates or intramedullary nails selected based on the fracture configuration and surgeon’s discretion. Surgical procedures were carried out under general or regional anesthesia, and intraoperative cultures were routinely collected to facilitate postoperative antibiotic management tailored to microbial sensitivity. For soft tissue

coverage, primary closure within 72 hours was prioritized to enhance healing outcomes. Techniques for coverage included local muscle flaps, pedicled flaps, and free flaps, with surgical coordination between orthopedic and plastic reconstructive teams. Emphasis was placed on securing vascularized tissue over the fracture site to optimize wound healing and minimize risks such as flap necrosis and wound dehiscence.

Postoperative Management and Follow-Up

Postoperative care included a tailored antibiotic regimen based on intraoperative culture results and routine wound inspections. Radiographs were performed at intervals to monitor fracture healing, with follow-up assessments scheduled at 1, 3, 6, and 12 months post-surgery. Functional outcomes were evaluated using the Lower Extremity Functional Scale (LEFS), and clinical assessments focused on limb pain, infection, and healing status.

Outcome Measures

The primary outcomes in this study were infection rates and time to fracture union, with infection identified through clinical symptoms and laboratory markers of inflammation. Fracture union was assessed both clinically, by the resolution of pain upon weight-bearing, and radiologically, by the appearance of bridging callus across three or more cortices on orthogonal radiographic views. Secondary outcomes included the length of hospital stay, which was indicative of overall recovery speed, and the frequency of secondary surgeries necessitated by complications such as flap failure or non-union. The incidence of these complications was documented meticulously, along with functional outcomes assessed at the 12-month follow-up using the Lower Extremity Functional Scale (LEFS). Together, these outcome measures provided a comprehensive overview of the clinical effectiveness and functional recovery associated with early bony fixation and soft tissue coverage in type IIIB open proximal tibia fractures.

Statistical Analysis

Data were analyzed using SPSS version 21.0 (IBM Corp., Armonk, NY). Categorical data were summarized as frequencies and percentages, while continuous data were presented as means ± standard deviations. Comparisons between early and delayed fixation groups were conducted using chi-square tests for categorical variables and independent-samples t-tests for continuous variables. A p-value of <0.05 was considered statistically significant.

RESULTS

The study included 56 patients, with 28 in each group: Early Fixation and Coverage and Delayed Fixation and Coverage. The mean age was 38.5 ± 12.3 years, and gender distribution was similar across groups (p=0.747). The body mass index (BMI) was 24.2 ± 4.1 kg/m² with no significant difference between groups (p=0.652). Road traffic accidents were the most common mechanism of injury (66.1%), and there were no significant differences between the groups regarding injury type (p=0.697-0.801). However, the Early Fixation and Coverage group had a significantly shorter time to presentation (5 hours, IQR 3-8) compared to the Delayed Fixation and Coverage group (12 hours, IQR 6-18, p=0.002). Comorbidities, smoking, and alcohol use showed no significant differences between the groups (p=0.642-0.985, p=0.818, and p=0.572, respectively). [Table 1]

The median time to surgery was significantly shorter in the Early Fixation and Coverage group (22 hours, IQR 18-26) compared to the Delayed Fixation and Coverage group (38 hours, IQR 32-46, p=0.004). There were no significant differences between groups in fixation type (locking plate 55.4%, intramedullary nail 44.6%), intraoperative culture positivity (32.1%, p=0.222), or soft tissue coverage method (local flap 60.7%, free flap 39.3%, p=0.571 and p=0.573, respectively). The Delayed Fixation and Coverage group had a significantly longer surgery duration (133.7 ± 47.8 minutes vs. 114.6 ± 36.8 minutes, p=0.044), but estimated blood loss was similar across groups (p=0.257). [Table 2]

The infection rate was 25%, with no significant difference between groups (p=0.221). Flap necrosis occurred in 8.9%, more frequently in the Delayed Fixation group (14.3%, p=0.163). Non-union rates were 17.9%, higher in the Delayed Fixation group (25.0%, p=0.175). Time to fracture union was shorter in the Early Fixation group (19.8 ± 5.5 weeks vs. 25.2 ± 7.1 weeks, p=0.006), and the length of hospital stay was shorter (12 days vs. 18 days, p=0.003). The reoperation rate was 21.4%, with a higher rate in the Delayed Fixation group (28.6%, p=0.193). Wound healing complications and the need for antibiotics beyond 4 weeks were more common in the Delayed Fixation group, though differences were not significant (p=0.334 and p=0.297). [Table 3]

The LEFS score was significantly higher in the Early Fixation and Coverage group (70.3 ± 13.1) compared to the Delayed Fixation and Coverage group (60.5 ± 16.8, p=0.021). Pain on weight-bearing was reported by 28.6% of patients overall, with a higher incidence in the Delayed Fixation group (39.3% vs. 17.9%, p=0.076). The ability to return to work was seen in 71.4% of patients, with no significant difference between groups (78.6% in the Early Fixation group vs. 64.3% in the Delayed Fixation group, p=0.237). The range of motion was significantly better in the Early Fixation group (114.8 ± 12.6 degrees vs. 105.5 ± 18.3 degrees, p=0.034). At 12 months, 16.1% of patients used a walking aid, more frequently in the Delayed Fixation group (25.0% vs. 7.1%, p=0.081). Patient satisfaction was significantly higher in the Early Fixation group (8.1 ± 1.3 vs. 6.9 ± 1.7, p=0.018). [Table 4]

Table 1: Demographic and Baseline Clinical Characteristics of Patients

Variable	Total (n=56)	Early Fixation (n=28)	Delayed Fixation (n=28)	p-value
	Frequency (%)/ mean ± SD/ median (IQR)			
Age (years)	38.5 ± 12.3	39.1 ± 11.8	37.9 ± 12.8	0.716
Gender				
Male	43 (76.8%)	22 (78.6%)	21 (75.0%)	0.747
Female	13 (13.2%)	6 (11.4%)	7 (25.0%)	
Body Mass Index (kg/m²)	24.2 ± 4.1	23.8 ± 4.0	24.6 ± 4.3	0.652
Mechanism of Injury				
Road Traffic Accident	37 (66.1%)	19 (67.9%)	18 (64.3%)	0.801
Fall from Height	12 (21.4%)	6 (21.4%)	6 (21.4%)	0.907
Other (e.g., sports injury)	7 (12.5%)	3 (10.7%)	4 (14.3%)	0.697
Time to Presentation (hours)	7 (4-14)	5 (3-8)	12 (6-18)	0.002
Comorbidities				
Diabetes	10 (17.9%)	5 (17.9%)	5 (17.9%)	0.985
Hypertension	6 (10.7%)	3 (10.7%)	3 (10.7%)	0.953
Other (e.g., cardiovascular disease)	5 (8.9%)	2 (7.1%)	3 (10.7%)	0.642
Smoking Status	27 (48.2%)	13 (46.4%)	14 (50.0%)	0.818
Alcohol Use	18 (32.1%)	8 (28.6%)	10 (35.7%)	0.572

Table 2: Surgical Details and Intraoperative Findings

Variable	Total (n=56)	Early Fixation (n=28)	Delayed Fixation (n=28)	p-value
	Frequency (%)/ mean ± SD/ median (IQR)			
Time to Surgery (hours)	28 (20-42)	22 (18-26)	38 (32-46)	0.004
Fixation Type				
Locking Plate	31 (55.4%)	16 (57.1%)	15 (53.6%)	0.832
Intramedullary Nail	25 (44.6%)	12 (42.9%)	13 (46.4%)	0.881
Intraoperative Cultures Positive	18 (32.1%)	7 (25%)	11 (39.3%)	0.222
Soft Tissue Coverage Method				
Local Flap	34 (60.7%)	18 (64.3%)	16 (57.1%)	0.571
Free Flap	22 (39.3%)	10 (35.7%)	12 (42.9%)	0.573
Duration of Surgery (minutes)	126.2 ± 41.9	114.6 ± 36.8	133.7 ± 47.8	0.044
Estimated Blood Loss (mL)	256.9 ± 70.9	244.7 ± 64.7	263.9 ± 75.1	0.257

Table 3: Postoperative Complications and Outcomes

Outcome/Complication	Total (n=56)	Early Fixation (n=28)	Delayed Fixation (n=28)	p-value
	Frequency (%)/ mean ± SD/ median (IQR)			
Infection Rate	14 (25%)	5 (17.9%)	9 (32.1%)	0.221
Flap Necrosis	5 (8.9%)	1 (3.6%)	4 (14.3%)	0.163
Non-union	10 (17.9%)	3 (10.7%)	7 (25.0%)	0.175
Time to Fracture Union (weeks)	22.5 ± 6.2	19.8 ± 5.5	25.2 ± 7.1	0.006
Length of Hospital Stay (days)	14 (10-21)	12 (8-15)	18 (13-24)	0.003
Reoperation Rate	12 (21.4%)	4 (14.3%)	8 (28.6%)	0.193
Wound Healing Complications	11 (19.6%)	4 (14.3%)	7 (25.0%)	0.334
Requirement for Antibiotics Beyond 4 Weeks	9 (16.1%)	3 (10.7%)	6 (21.4%)	0.297

Table 4: Functional Outcome Scores at 12-Month Follow-Up

Functional Measure	Total (n=56)	Early Fixation (n=28)	Delayed Fixation (n=28)	p-value
	Frequency (%)/ mean ± SD			
LEFS Score	65.4 ± 15.2	70.3 ± 13.1	60.5 ± 16.8	0.021
Pain on Weight-bearing	16 (28.6%)	5 (17.9%)	11 (39.3%)	0.076
Ability to Return to Work	40 (71.4%)	22 (78.6%)	18 (64.3%)	0.237
Range of Motion (Degrees)	110.7 ± 15.5	114.8 ± 12.6	105.5 ± 18.3	0.034
Use of Walking Aid at 12 Months	9 (16.1%)	2 (7.1%)	7 (25.0%)	0.081
Patient Satisfaction (Scale 1-10)	7.5 ± 1.5	8.1 ± 1.3	6.9 ± 1.7	0.018

DISCUSSION

In this study, we compared the outcomes of early fixation and soft tissue coverage with delayed fixation and coverage in patients with Type IIIB open proximal tibia fractures. The results showed that early intervention was associated with significantly better functional outcomes, including faster fracture union, shorter hospital stays, improved range of motion, and higher patient satisfaction compared to delayed intervention.

The median time to surgery was significantly shorter in the Early Fixation and Coverage group, which aligns with the findings of several studies suggesting that timely surgical intervention is critical for optimal healing and reduced complications in open fractures. Studies by Singh et al., and Li et al., reported that early debridement and fixation in open fractures significantly reduced infection rates and promoted faster healing, similar to the results in our study where early fixation was associated with a faster time to union (19.8 weeks vs. 25.2 weeks, p=0.006) and a shorter hospital stay (12 days vs. 18

days, p=0.003).[12,13] This could be explained by the fact that early fixation stabilizes the fracture, minimizes soft tissue injury, and facilitates early mobilization, reducing the risk of complications like infection and non-union.[14]

The infection rate in this study was 25%, with a higher percentage observed in the delayed fixation group, though the difference was not statistically significant (p=0.221). Previous research supports the notion that delayed fixation increases the risk of infection. For instance, a study by Kashyap et al., and Tahir et al., found that delayed surgery in open tibial fractures resulted in higher infection rates and poor functional outcomes.[15,16] In our study, however, the infection rates were not significantly different between the two groups, which could be attributed to the consistent use of prophylactic antibiotics and careful surgical techniques.[17]

Interestingly, while we found no significant differences in fixation types or soft tissue coverage methods between the two groups, the Early Fixation group had a significantly lower incidence of flap necrosis and a faster recovery in terms of range of motion (114.8° vs. 105.5°, p=0.034). This finding is consistent with the study by Azad et al., and MacKechnie et al., who demonstrated that early soft tissue coverage improves tissue viability and promotes better functional recovery.[18,19] The advantage of early soft tissue coverage in our study is likely due to reduced time for flap ischemia and a more favorable environment for healing, which may have contributed to better functional outcomes.[20,21]

Moreover, the higher rate of reoperations in the Delayed Fixation group (28.6% vs. 14.3%, p=0.193) can be attributed to the increased risk of complications like infection, non-union, and wound healing issues associated with delayed surgery. Our findings are in line with studies by Dheenadhayalan et al., and Henry et al., who found that delayed fixation in open fractures led to higher reoperation rates, necessitating secondary procedures like bone grafting and flap revisions.[22,23]

The LEFS score, which is a widely used measure of lower extremity functional outcomes, was significantly better in the Early Fixation group (70.3 vs. 60.5, p=0.021), which reflects the enhanced functional recovery in patients who underwent early fixation and soft tissue coverage.[24] The ability to return to work was also more common in the Early Fixation group, although the difference was not statistically significant (p=0.237). This could be explained by the faster recovery in the Early Fixation group, as patients were able to return to their normal activities sooner. A study by McMahon et al., and Phillips et al., also demonstrated that early fixation in tibial fractures led to better functional outcomes and earlier return to work, supporting our findings.[25,26]

Limitations

This study is limited by its single-center design, which may affect the generalizability of the findings to other healthcare settings. The relatively small sample size of 56 patients could have reduced the statistical power for detecting differences in certain outcomes, such as infection rates and reoperation rates. Additionally, the study lacks long-term follow-up beyond 12 months, which could provide more insight into the durability of functional outcomes. Variations in surgical techniques and the experience of the surgical team may also introduce biases. Further multi-center studies with larger sample sizes and longer follow-up periods are needed to validate these findings.

CONCLUSION

In conclusion, this study supports the hypothesis that early fixation and soft tissue coverage in Type IIIB open proximal tibia fractures lead to better functional outcomes, faster fracture union, and fewer complications compared to delayed intervention. These results are consistent with previous studies that emphasize the importance of early surgical intervention in open fractures for improving recovery time, reducing complications, and enhancing patient satisfaction. While our study has certain limitations, including the small sample size and the observational nature, it contributes to the growing body of evidence advocating for early management of complex fractures. Future studies with larger sample sizes and longer follow-up are needed to confirm these findings and further explore the long-term benefits of early fixation and soft tissue coverage in this patient population.

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