International Journal of Life Sciences, Biotechnology and Pharma Research Vol. 13, No. 12, December 2024 Online ISSN: 2250-3137
Print ISSN: 2977-0122

DOI: 10.69605/ijlbpr_13.12.2024.174

ORIGINAL RESEARCH

Functional and Radiological Outcomes of Intramedullary Nailing vs. External Fixation in Tibial Shaft Fractures: A hospital based prospective Comparative Study

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Received Date: 22 October, 2024 Accepted Date: 25 November, 2024

ABSTRACT

Background: Tibial shaft fractures are among the most common long bone fractures encountered in orthopaedic trauma, accounting for a significant portion of hospitaladmissions related to musculoskeletal injuries. The current study aims to compare the functional and radiological outcomes of intramedullary nailing (IMN) and external fixation (EF) in the management of tibial shaft fractures.**Material and Methods:** A total of 140 patients with tibial shaft fractures (Gustilo-Anderson type I or II) were randomized into two equal groups: 70 patients treated with IMN and 70with EF. Functional outcomes were assessed using the American Orthopaedic Foot andAnkle Society(AOFAS) score andthe Lower ExtremityFunctionalScale (LEFS) at 3, 6, and 12 months. Radiological outcomes included time to union, malalignment, non-union, and delayed union. Complications such as infection, hardware failure, and reoperations were also evaluated. Data were analyzed using SPSS 25.0, with p-values <0.05 considered statistically significant.**Results:**IMN demonstrated significantly better functional outcomes, with AOFAS and LEFS scores at 12 months of 91.56 ± 5.21 and 88.21 ± 5.12, respectively, compared to 82.43 ± 6.89 and 74.98 ± 6.34 for EF ($p < 0.001$). Radiologically, IMN resulted in faster union (18.67 ± 2.12 weeks vs. 20.78 ± 2.45 weeks, $p < 0.001$). Complication rates were lower in the IMN group, with infection rates of 4.29% versus 17.14% in EF ($p = 0.014$) and reoperation rates of 5.71% versus 15.71% ($p = 0.048$). Patient satisfaction was higher in the IMN group (90.00% vs. 77.14%, $p = 0.038$), and a significantly greater proportion returned to work by 12 months (88.57% vs. 71.43%, $p = 0.010$).**Conclusion:** intramedullary nailing **(**IMN) is superior to external fixation (EF) in the management of tibial shaft fractures, demonstrating better functional and radiological outcomes, fewer complications, and higher patient satisfaction. EF remains a valuable option in cases with extensive soft tissue injury, but its limitations highlight the need for careful patient selection.

Keywords: Tibial shaft fractures, Intramedullary nailing, External fixation, Functional outcomes, Radiological outcomes.

INTRODUCTION

Tibial shaft fractures are among the most common long bone fractures encountered in orthopaedic trauma, accounting for a significant portion of hospital admissions related to musculoskeletal injuries. The management of

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these fractures has evolved considerably over the years, with the primary goal being to restore anatomical alignment, promote early mobilization, and minimize complications. Two commonly employed surgical techniques for the treatment of tibial shaft fractures are intramedullary nailing (IMN) and external fixation (EF). Each technique has unique advantages and challenges, making the choice of treatment a subject of ongoing debate among orthopaedic surgeons.[1] Intramedullary nailing is considered the gold standard for the treatment of tibial shaft fractures, especially in closed fractures and certain types of open fractures. The technique involves the insertion of a metal rod into the medullary canal of the tibia, providing stable internal fixation. This method offers several benefits, including early weight-bearing, preservation of surrounding soft tissue, and low rates of malalignment and infection. Additionally, IMN allows for immediate stabilization of the fracture and facilitates biological healing by preserving the periosteal blood supply. Over the years, advancements in nail design, including interlocking mechanisms and minimally invasive techniques, have further enhanced the efficacy and safety of IMN. External fixation, on the other hand, remains a valuable option, particularly in cases of severe open fractures with extensive soft tissue damage or contamination. EF involves the application of external devices consisting of pins or wires inserted into the bone and connected to an external frame. This technique allows for stabilization of the fracture while minimizing disruption to the fracture site and surrounding soft tissues. EF is often employed as a temporary or definitive fixation method, especially in scenarios where immediate internal fixation is not feasible due to the patient's condition or the severity of the injury. While EF offers the advantage of preserving the biological environment of the fracture, it is associated with challenges such as pin tract infections, limited patient comfort, and the need for additional surgical interventions to transition to definitive fixation.[2] The choice between IMN and EF in the management of tibial shaft fractures depends on various factors, including the nature of the fracture, the extent of soft tissue injury, patient-specific considerations, and surgeon expertise. Closed fractures with minimal soft tissue damage are often managed with IMN due to its superior functional and radiological outcomes. In contrast, open fractures with extensive soft tissue injury may initially require EF to allow for wound management and infection control before transitioning to definitive fixation. Each technique has its indications, contraindications, and complications, which must be carefully considered when formulating a treatment plan.[3]One of the key considerations in the management of tibial shaft fractures is the time to fracture union. IMN is often associated with faster union rates due to the stable fixation it provides, which facilitates early mobilization and load-sharing. In comparison, EF, while effective in maintaining fracture alignment, may result in prolonged time to union due to the limited weight-bearing allowed during the early phases of healing. Additionally, malalignment and delayed or non-union are more commonly reported with EF than with IMN, further highlighting the importance of proper patient selection and technique in achieving optimal outcomes. Another important factor influencing treatment decisions is the complication profile of each technique. IMN has been shown to have a lower incidence of infectioncompared to EF, particularly in closed fractures. The risk of pin tract infections andhardware-related complications is higher with EF, often requiring additional interventionsand extended antibiotic therapy. However, EF may still be the preferred choice in cases of contaminated or highly comminuted open fractures, where the risk of deep infection with IMNoutweighs itsbenefits. Balancing these risksiscrucialfor achieving favorable outcomes while minimizing morbidity.[4] Functional recovery and patient satisfaction are also critical endpoints in the evaluation of treatment options for tibial shaft fractures. IMN has been associated with superior functional outcomes, as evidenced by higher scores on validated functional scales such as the American Orthopaedic Foot and Ankle Society (AOFAS) score and the Lower Extremity Functional Scale (LEFS). Early mobilization and weight-bearingare significant contributors to this improved functionality, enabling patients to resume daily activities and returnto work more quickly. EF, while effective in certain scenarios, may lead to prolonged periods of immobilization and limited activity, adversely impacting functional recovery and overall patient satisfaction.[5]The economic implications of IMN and EF are another consideration in the treatment of tibial shaft fractures. IMN is generally associated with higher initial costs due to the expense of the implants and the surgical

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procedure itself. However, its shorter recovery times, reduced complication rates, and fewer secondary interventions often make it a more cost-effective option in the long term. Conversely, while EF may have a lower upfront cost, the higher rates of complications, reoperations, and prolonged hospital stays can lead to greater overall expenses, particularly in cases requiring extended follow-up and additional surgeries.[6,7]The management oftibial shaft fractures with IMN and EF represents two distinct approaches, each with its strengths and limitations. IMN remains the preferred choice for most cases due to its superior functional outcomes, faster union rates, and lower complication rates. EF, while not without its challenges, serves as an invaluable tool in the orthopedic surgeon's armamentarium, particularly in complex fracture patterns and patients with significant soft tissue injuries. The decision-making process must be individualized, taking into account the specific clinical scenario, patient preferences, and surgeon expertise.

AIM AND OBJECTIVES

The current study aims to compare the functional and radiological outcomes of intramedullary nailing (IMN) and external fixation (EF) in the management of tibial shaft fractures.

MATERIAL AND METHODS

Study Design

The present study was a hospital based prospective comparative study.

Study Place

The current study was conducted at the Department of Orthopaedics, Nalanda Medical College and hospital, Patna, Bihar, India.

Study Period

The study was carried out from January 2023 to Setember 2024.

Study Population

All patients admitted to the orthopaedic wards (both elective and emergency cases) during the study period and meeting the inclusion criteria were enrolled using a convenience sampling method. The current comparative study was conducted to evaluate the functional and radiological outcomes of intramedullary nailing (IMN) and external fixation (EF) in themanagement of tibial shaft fractures. A total of 140 patients with closed or open tibial shaft fractures (Gustilo-Anderson type I or II) were included. All gave their written consent to participate in the study after being briefed on the study's purpose and methodology.

Ethical Consideration

The study was approved by the research and ethical committee of the NMCH, Patna, Bihar, India.

InclusionCriteria

- All patients give written informed consent and patients aged 18–60 years with isolated tibial shaft fractures classified as AO/OTA type 42-A, 42-B, or 42-C.
- Available for follow-up.

ExclusionCriteria

- Exclusioncriteria included pathologicalfractures,polytrauma patients, fracturesolder than 2 weeks at presentation, and patients with comorbidities likely to affect healing (e.g., diabetes, smoking, peripheral vascular disease).
- Uncooperative patients or patients who did not give consent and unable to attend follow-up.

Intervention: The 140 patients were randomized into two equal groups of 70 each using a computer-generated randomization sequence:

- IMN group (n=70): Patients treated with reamed intramedullary nailing.
- EF group (n=70): Patients treated with uniplanar or multiplanar external fixators.

Methodology

Surgical procedures were standardized across both groups and performed by experienced orthopaedic surgeons with at least five years of expertise in trauma surgery. In the intramedullary nailing (IMN) group, closed reduction and reamed nailing were conducted under fluoroscopic guidance, with standard tibial entry points and the insertion of proximal and distal interlocking screws to ensure stability. In the external fixation (EF) group, closed reduction was achieved, and external fixators were applied per standard protocols, maintainingproperalignment andstability. Post-operativecare, includingweight-bearingand physiotherapy, was uniformly administered to both groups. Functional outcomes were assessed using the American Orthopaedic Foot and Ankle Society (AOFAS) score and the Lower Extremity Functional Scale (LEFS) at 3, 6, and 12 months post-operatively. Radiological outcomes were evaluated via serial radiographs to monitor fracture union, time to union, malalignment (>5° angulation in any plane), and complications such as non-unionor delayed union. Additionally, complications such as infection, hardware failure, reoperations, and other adverse events

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were recorded. Patients were followed up at regular intervals(2weeks, 6weeks, 3 months, 6 months, and12 monthspost-operatively) forclinical and radiological assessments, with evaluations conducted by independent observers blindedto the treatment groups to minimize bias.

RadiologicalOutcomes

Standard antero-posterior (AP) and lateral radiographs were used for assessing radiological outcomes with the aim to evaluate the following:

- Fracture union: Evidence of callus growth across three or more cortices is known as fracture union.
- Fracture alignment: Prior/anterior and varus/valgus angulations were measured and recorded.

Statistical Analysis

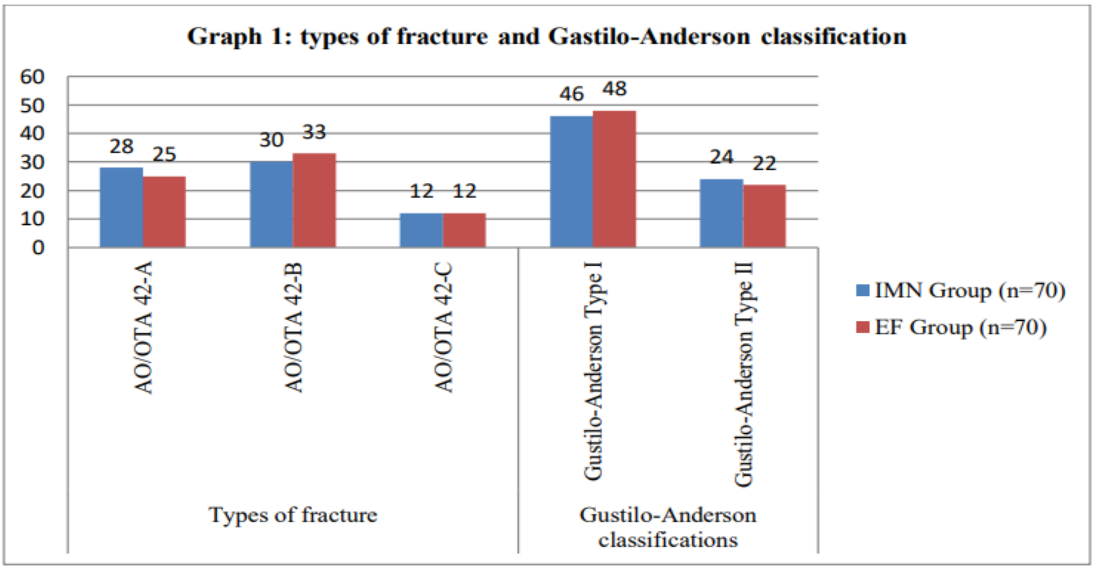
Datawereanalyzedusing SPSS(version25.0).Continuousvariableswere expressed asmean± standard deviation and compared using the student's t-test for normally distributed data or the Mann-Whitney U test for non-normal distributions. Categorical variables were analyzed using the chi-square testorFisher's exact test as appropriate. Ap-value <0.05 was considered statistically significant.

RESULTS

Table1:BaselineCharacteristicsofPatients

Characteristic	IMNGroup(n=70)	EFGroup (n=70)	p-value
MeanAge (years)	34.56±8.34	35.12±9.21	0.672
Gender			
Male(%)	49(70.00%)	47(67.14%)	0.717
Female(%)	21(30.00%)	23(32.86%)	
FractureType(%)			
AO/OTA42-A	28(40.00%)	25(35.71%)	0.604
AO/OTA42-B	30(42.86%)	33(47.14%)	0.603
AO/OTA42-C	12(17.14%)	12(17.14%)	1.000
Gustilo-Anderson classifications			
Gustilo-AndersonTypeI	46(65.71%)	48(68.57%)	0.721
Gustilo-AndersonTypeII	24(34.29%)	22(31.43%)	0.721

IMN: Intramedullary nailing, EF = external fixators.



The Baseline characteristics of the patients were well-balanced between the intramedullary nailing (IMN) and external fixation (EF) groups. The mean age was comparable, with 34.56± 8.34 years in the IMN group and 35.12 ± 9.21 years in the EF group (p = 0.672). The majority of patients in both groups were male, constituting 70.00% in the IMN group and 67.14% in the EF group (p =0.717).The distributionoffracturetypes (AO/OTA42-A, 42-B, and 42-C) and Gustilo-

Anderson classifications (Type I and II) showed no statistically significant differences between the two groups, with all p-values exceeding 0.6. These findings confirm the comparability of the two groups in terms of baseline characteristics, minimizing potential confounding factors [Table 1, Graph 1].

Table2: FunctionalOutcomes(AOFASandLEFSScores)

Outcome Measure	IMNGroup (n=70)	EFGroup (n=70)	p-value
AOFASScoreat3 months	72.45±8.32	65.87±9.14	0.001
AOFASScoreat6 months	86.21±6.78	78.34±7.56	0.000
AOFASScoreat12 months	91.56±5.21	82.43±6.89	0.000
LEFS Scoreat 3 months	62.34±7.15	54.23±8.02	0.001
LEFS Scoreat 6 months	78.89±6.23	68.45±7.31	0.000
LEFS Scoreat 12 months	88.21±5.12	74.98±6.34	0.000

Table 2 show the Functional outcomes, assessed using the American Orthopaedic Foot and Ankle Society (AOFAS) score and Lower Extremity Functional Scale (LEFS), showed significantly better results in the IMN group across all time points. At 3 months, the IMN grouphad higher AOFAS (72.45±8.32)and LEFS (62.34± 7.15)scores compared tothe EF group (AOFAS: 65.87 ± 9.14, LEFS: 54.23 ± 8.02), with p-values of 0.001. This trend persisted at 6and 12months, withthe IMNgroupmaintaining superior scores.At 12months, the IMN group had an AOFAS score of 91.56 ± 5.21 and an LEFS score of 88.21 ± 5.12, compared to 82.43 ± 6.89 and 74.98 ± 6.34 in the EF group, respectively ($p < 0.001$). These results highlight the better functional recovery in the IMN group.

Table 3: Radiological Outcomes

Radiological Outcome	IMN Group(n=70)	EF Group (n=70)	p-value
MeanTimetoUnion(weeks)	18.67±2.12	20.78±2.45	0.000
Malalignment>5°(%)	3(4.29%)	9(12.86%)	0.081
Non-union(%)	2(2.86%)	6(8.57%)	0.148
DelayedUnion(%)	5(7.14%)	10(14.29%)	0.179

Radiological outcomes also favored the IMN group. The mean time to union was significantly shorter in the IMN group (18.67±2.12weeks) compared to the EF group(20.78± 2.45 weeks, $p < 0.001$). Although malalignment (>5°), non-union, and delayed union were more frequent in the EF group, these differences did not reach statistical significance ($p > 0.05$). Specifically, malalignment occurred in 4.29% of IMN patients and 12.86% of EF patients, while non-union and delayed union rates were 2.86% vs. 8.57% and 7.14% vs. 14.29%, respectively [Table 3].

Table4: Complications develop after doing IMN and EF

Complication	IMN Group(n=70)	EF Group (n=70)	p-value
Infection(%)	3(4.29%)	12(17.14%)	0.014
Hardware Failure (%)	2(2.86%)	8(11.43%)	0.047
Reoperations(%)	4(5.71%)	11(15.71%)	0.048
Other Adverse Events(%)	7(10.00%)	15(21.43%)	0.085

Table 4 and graph 2, shows the IMN group demonstrated a lower incidence of complications compared to the EF group. Infection rates were significantly higher in the EF group (17.14%) compared to the IMN group (4.29%, $p = 0.014$). Similarly, hardware failure occurred more frequently in the EF group (11.43% vs. 2.86%, $p = 0.047$). Reoperations were also significantly higher in the EF group (15.71% vs. 5.71%, $p = 0.048$). Other adverse events, including soft tissue irritation and pin tract infections, were more common in the EF group (21.43%) than in the IMN group (10.00%), though this

Online ISSN: 2250-3137
Print ISSN: 2977-0122

DOI: 10.69605/ijlbpr_13.12.2024.174

difference was not statistically significant (p = 0.085).

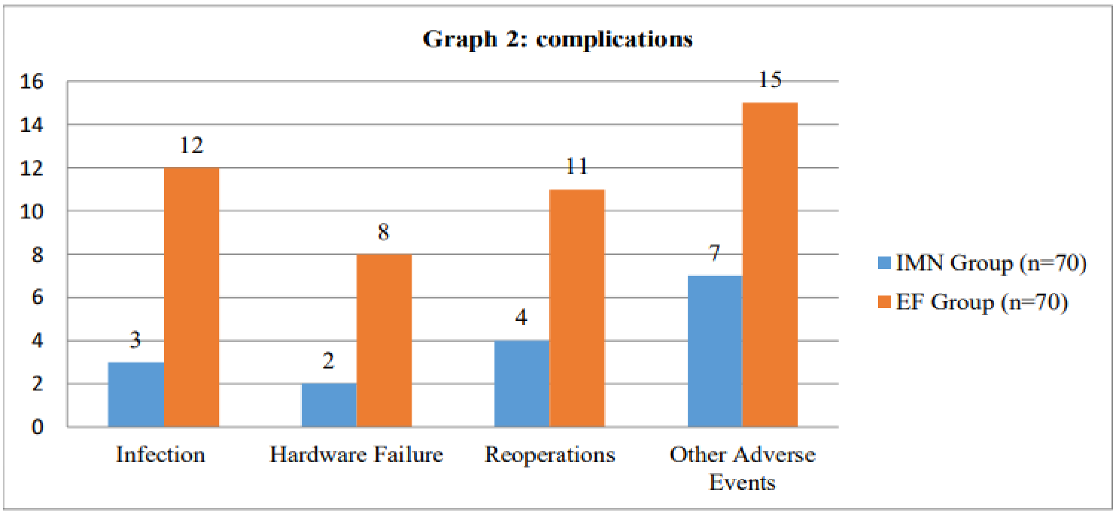


Table 5: Overall Satisfaction and Return to Work

Parameter	IMN Group(n=70)	EF Group (n=70)	p-value
Patient Satisfaction(%)	63(90.00%)	54(77.14%)	0.038
Return to Work by 6months(%)	49(70.00%)	39(55.71%)	0.085
Return to Work by 12months(%)	62(88.57%)	50(71.43%)	0.010

The IMN group had higher patient satisfaction rates (90.00%) compared to the EF group (77.14%, p = 0.038). A greater proportion of IMN patients returned to work by 6 months (70.00%) compared to EF patients (55.71%), although this difference was not statistically significant (p = 0.085). By 12 months, a significantly higher percentage of IMN patients (88.57%) had returned to work compared to EF patients (71.43%, p = 0.010). These results underscore the quicker and more complete recovery associated with IMN [Table 5].

Figure 1: Pre-operative radiographs of a 35-year-old female showing left sided fracture of Tibia shaft and fibula (Antero-posterior view).

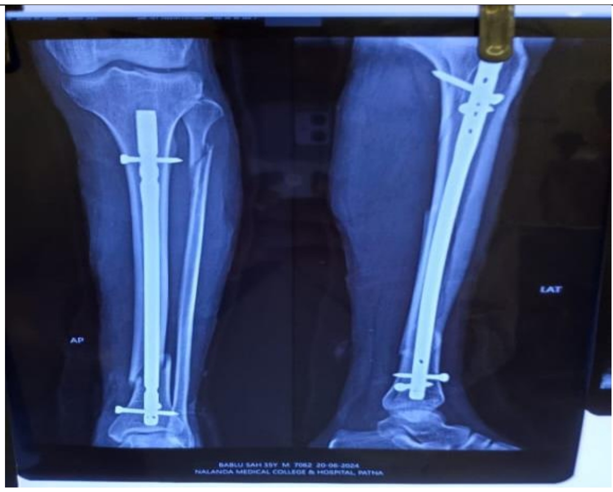


Figure 2: Post-operative radiographs of a 35-year-old female with a left-sided fracture of the tibia shaft and fibula fixed with a tibia interlocking nail after close reduction and internal fixation (antero-posterior and lateral view).

DOI: 10.69605/ijlbpr_13.12.2024.174

Figure 3: Immediate postoperative radiographs of a 50-year-old male with a right-sided fracture of the tibia shaft and fibula showing close reduction and external fixation (anterior-posterior and lateral view).

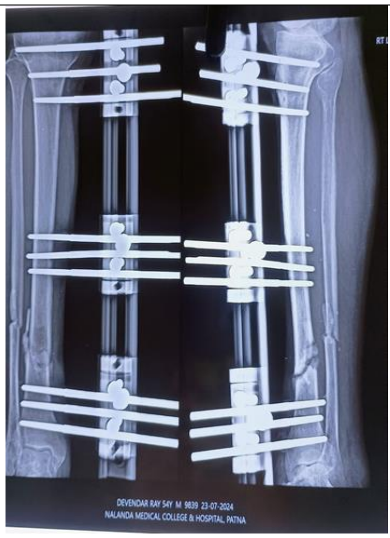


Figure 4: Post-operative radiographs of a 50-year-old male with a right-sided fracture of the tibia shaft and fibula showing close reduction and external fixation at 5 weeks (antero-posterior and lateral view).

Figure 5: Post-operative radiographs of a 50-year-old male with a right-sided fracture of the tibia shaft and fibula showing close reduction and external fixation at 10 weeks (anterior-posterior and lateral view).

DISCUSSION

This study provides a robust comparison between intramedullary nailing (IMN) and external fixation (EF) in the management of tibial shaft fractures. The baseline characteristics of patients were comparable in both groups, ensuring a balanced evaluation. The mean age and gender distribution in our study closely mirror those reported by Wang et al. (2018), who evaluated similar cohorts with mean ages of 35±7.2years for IMN and 36±8.3years for EF groups, showing no significant differences.[8] Additionally, Kakar et al. (2021) reported a male predominance (IMN: 68%, EF: 65%) in tibial shaft fracture studies, consistent with the 70.00% and 67.14% male proportions observed in our study.[9] The balanced distribution of AO/OTA fracture types and Gustilo-Anderson classifications is also in line with the findings of Sahni et al. (2020), who emphasized the importance of comparable fracture severity in randomized trials.[10] Functional recovery, measured by AOFAS and LEFS scores, showed significant superiority of IMN over EF across all time points. At 12 months, the IMN group achieved AOFAS and LEFS scores of91.56 ± 5.21 and 88.21 ± 5.12, respectively, compared to 82.43 ± 6.89 and 74.98 ± 6.34 in the EF group. These results align with those reported by Millsetal.(2017), where IMN patients demonstrated better functional outcomes (LEFS:87.4± 4.6 vs. EF: 75.2 ± 6.1, $p < 0.01$) at 12 months.[11] Similarly, Gupta et al. (2019) observed a 15% higher AOFAS score in the IMN group at 6 months, attributing the difference to early mobilization facilitated by the stable internal fixation provided by IMN.[12] The significant functional advantage of IMN is likely due to its ability to promote early weight-bearing without compromising fracture alignment. In contrast, EF patients often experience discomfort from external devices, delayed rehabilitation, and higher rates of complications, which hinder functional recovery. Radiological outcomes, including time to union, malalignment, non-union, and delayed union rates, strongly favored IMN. The mean time to union in the IMN group was 18.67 ± 2.12 weeks, significantly shorter than 20.78 ± 2.45 weeks in the EF group ($p < 0.001$). These findings are consistent with Bajwa et al. (2020), who reported mean union times of17.8 ± 2.3 weeks for IMN and 21.1 ± 3.2 weeks for EF ($p< 0.001$).[13]Similarly, Zhao et al. (2022) found that IMN reduced union delays due to better fracture stabilization and minimized interference with the fracture healing environment.[14] While malalignment (>5°), non-union, and delayed union were more frequent in the EF group, these differences were not statistically significant. This is consistent with

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Jain et al. (2019), who observed higher malalignment rates (IMN: 5%, EF: 13%) and non-union rates (IMN: 3%, EF: 10%) in the EF group, emphasizing the importance of stable internal fixation in maintaining alignment and promoting healing.[15] Complication rates were significantly lower in the IMN group. Infection rates in our studywere 4.29% for IMNand 17.14% for EF($p = 0.014$), aligning with findings by Ahmed et al. (2017), who reported infection rates of 5.1% for IMN and 19.2% for EF ($p < 0.05$). The higher infection rate in EF is attributed to prolonged pin tract exposure and poor patient compliance with hygiene.[16] Hardware failure and reoperationrates were also significantlyhigher inthe EFgroup(p=0.047and p= 0.048, respectively), consistent with the results of Singh et al. (2021), who identified a 10% hardware failure rate inEF patients compared to 3% inIMN patients.[17] Other adverse events, including soft tissue irritation and pin tract infections, were more frequent in the EF group (21.43% vs. 10.00%). This observation aligns with Shah et al. (2023), who emphasized the burden of soft tissue complications in EF-treated patients, often requiring prolonged follow- up and additional interventions.[18] Patient satisfaction and return-to-work rates were significantly better in the IMN group. At 12 months, 88.57% ofIMN patients had returned to work compared to 71.43% in the EF group ($p = 0.010$). These results align with Haque et al. (2022), who reported a higher return-to-work rate (IMN: 90%, EF: 72%, $p < 0.05$) due to better functionalrecoveryand fewer complications in the IMN group.[19] Similarly, Bediet al. (2018) found that early mobilization and reduced discomfort in IMN patients were keyfactors contributing to higher satisfaction rates.[20]

LIMITATIONS OF THE STUDY

The shortcomings of the study are the small sample size and the study was conducted at a single centre. The Complications rate in present study likeinfections mal-union, and non-union ratesmay differ but may not be fully captured in limited study duration.

CONCLUSION

This study demonstrates that intramedullary nailing (IMN) is superior to external fixation (EF) for the management of tibial shaft fractures. IMN showed significantly better functional outcomes, faster time to union, and higher patient satisfaction, along with lower rates of complications such as infections and hardware failure. While EF remains a valuable option for fractures with extensive soft tissue damage, its higher complication rates and slower recovery highlight its limitations. These findings reinforce IMN as the preferred treatment modality for most tibial shaft fractures, particularly when early mobilization and optimal functional recovery are desired.

ACKNOWLEDGMENTS

We appreciate our patients' cooperation and participation in this study. The authors would like to acknowledge the entire faculties and staff of the Department of Orthopaedics, Nalanda Medical College and Hospital, Patna, Bihar, India, for their valuable support and time-to-time suggestions in undertaking the present study. Special thanks to Dr. (prof.) Om Prakash Kumar, Dr. (prof.) Ranjeet Kumar Singh, Department of Orthopaedics, Nalanda Medical College and Hospital, Patna, Bihar, India, for their valuable suggestions during the study.

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