DOI: https://doi.org/10.54393/pjhs.v7i9.4281

PAKISTAN JOURNAL OF HEALTH SCIENCES
(LAHORE)
https://thejas.com.pk/index.php/pjhs
ISSN (E): 2790-9352, (P): 2790-9344
Volume 7, Issue 09 (September 2026)



OPEN ACCESS
Check for updates

Original Article

Functional Outcome of Intramedullary Nailing vs Plating in Tibial Shaft Fracture

Aamir Zareen[1], Muhammad Salar Khan[1*], Hassan Khan[1], Muhammad Khan[1] and Sajawal Mukhtiar[1]

[1]Department of Orthopedics, Hayatabad Medical Complex, Peshawar, Pakistan

ARTICLE INFO

Keywords:
Tibial Shaft Fracture, Intramedullary Nailing, Plate Fixation, Functional Outcome, Johner-Wruhs Criteria

How to Cite:
Zareen, A., Khan, M. S., Khan, H., Khan, M., & Mukhtiar, S. (2026). Functional Outcome of Intramedullary Nailing vs Plating in Tibial Shaft Fracture: Functional Outcome of Intramedullary Nailing vs Plating in Tibial Shaft Fracture. Pakistan Journal of Health Sciences, 7(9), 42-48. https://doi.org/10.54393/pjhs.v7i9.4281

Corresponding Author:
Muhammad Salar Khan
Department of Orthopedics, Hayatabad Medical Complex, Peshawar, Pakistan
drmskj@gmail.com

Received Date: 20th April, 2026
1st Revision Received: 25th May, 2026
Acceptance Date: 11th June, 2026
Published Date: 30th September, 2026

ABSTRACT

Fractures of the tibial shaft are typical long-bone injuries that are accompanied by a high rate of morbidity. Surgical procedures such as intramedullary nailing and plate fixation are common, although there is controversy over the most effective approach owing to variations in healing rates and complication rates. **Objective:** To compare the functional outcomes of intramedullary nailing and plate fixation in patients with tibial shaft fractures. **Methods:** This was a prospective comparative study conducted in the Department of Orthopedics, Hayatabad Medical Complex, Peshawar, from March 2023 to August 2024. 110 patients aged between 18 and 60 years were enrolled. Both closed fractures and Gustilo-Anderson type I and II open fractures were considered eligible. Pathological fracture, polytrauma with intensive care, neurovascular injury, Gustilo type III open fracture, or previous surgery of the affected limb in patients were excluded. **Results:** A total of 110 patients were included. Mean time to union was significantly shorter in the intramedullary nailing group than in the plating group (16.2 ± 3.8 vs. 19.1 ± 4.5 weeks; p=0.001). Overall, union was achieved in 92.7% of patients. Excellent to good functional outcomes were higher in the intramedullary nailing group compared with the plating group (83.6% vs. 72.7%), although the difference was not statistically significant (p=0.180). **Conclusions:** Intramedullary nailing offers earlier fracture union and faster recovery, while both techniques provide comparable functional outcomes. The choice of fixation should be individualized based on patient and fracture characteristics.

INTRODUCTION

The tibial shaft fracture is one of the most common long-bone injuries in orthopedic practice and accounts for a significant percentage of lower-limb fractures worldwide. Due to the subcutaneous location of the tibia throughout the majority of its length, these fractures are especially prone to high-energy trauma, such as road traffic injuries, as well as low-energy forces, such as falls and sporting injuries [1]. The tibia has unique anatomical features that predispose these fractures to complications and delay union, non-union, malunion, and even infection, which is a critical problem in management [2]. The main objectives of therapy in tibial shaft fractures are the restoration of limb positioning, attainment of stable fixation, early fracture union, and fast functional restoration. Although conservative management could be suitable in isolated situations, surgery is usually favored in cases of displaced, unstable, or open fractures [3]. Intramedullary nailing (IMN) and plate fixation have been the most popular techniques used and accepted [4]. Intramedullary nailing has been proposed as the gold standard when dealing with most tibial fractures of the diaphyseal nature because of its minimally invasive nature, maintenance of blood supply to the periosteal, and the fact that it allows early weight-bearing/mobilization [5]. Additionally, IMN has the biomechanical advantage, and it provides load-sharing fixation, and this aspect facilitates enhanced fracture healing. However, it has been noted to cause complications such as anterior knee pain, malalignment (particularly in proximal and distal fractures), and problems during insertion [6]. Plate fixation, particularly with the

Copyright© 2026 The Authors. Published by CrossLinks International Publishers LLC, USA
This work is licensed under a Creative Commons Attribution 4.0 International License (CC BY 4.0)

DOI: https://doi.org/10.54393/pjhs.v7i9.4281

introduction of minimally invasive plate osteosynthesis (MIPO), is also gaining popularity due to its ability to allow anatomical reduction and alignment, particularly in cases of fracture that entail metaphyseal extensions and intricate patterns [7, 8]. Irrespective of these benefits, plating methods might necessitate increased soft tissue dissection, which could lead to increased vulnerability to wound-related complications and infection, and in many cases, delayed weight-bearing compared to IMN [9, 10].

The optimal fixation method for tibial shaft fractures is still a subject of debate, and differences in reported results have been noted in the literature. While both intramedullary nailing and plate fixation are common methods, there is no definitive evidence to determine which approach yields better functional results, fracture union, and complication rates, especially when applied to different fracture types and conditions. This literature gap emphasizes the need for other comparative studies to provide locally relevant and locally evidence-based data. From a clinical point of view, it is crucial to identify the most effective method of fixation to optimize fracture healing, reduce the risk of complications, facilitate early mobilization, mitigate the burden on the hospital, and improve outcomes for the patient. Therefore, this study aims to compare functional results of intramedullary nailing and plate fixation in tibial shaft fractures and to provide evidence-based data for clinical decision-making and patient-centered care.

METHODS

This prospective comparative study was conducted in the Department of Orthopedics, Hayatabad Medical Complex, Peshawar, from March 2023 to August 2024. Ethical approval was obtained prior to the study being conducted by the institutional review board (Ref no: 1989, dated 10-2-2023), and informed consent was signed by all the participants. The sample size was calculated based on an anticipated difference in fracture union between the two treatment groups. A minimum sample of 96 patients was estimated using a 95% confidence level and 80% statistical power. To compensate for potential loss to follow-up, 110 patients were recruited using non-probability consecutive sampling. The probability of 96 patients was determined by computing the required sample size with a 95% level of confidence and 80% power. To enhance the validity of the study and to compensate for any possible follow-up loss, 110 patients were recruited into the study, with non-probability consecutive sampling. No patient was lost to follow-up; therefore, all 110 patients completed the study and were included in the final analysis (Figure 1).

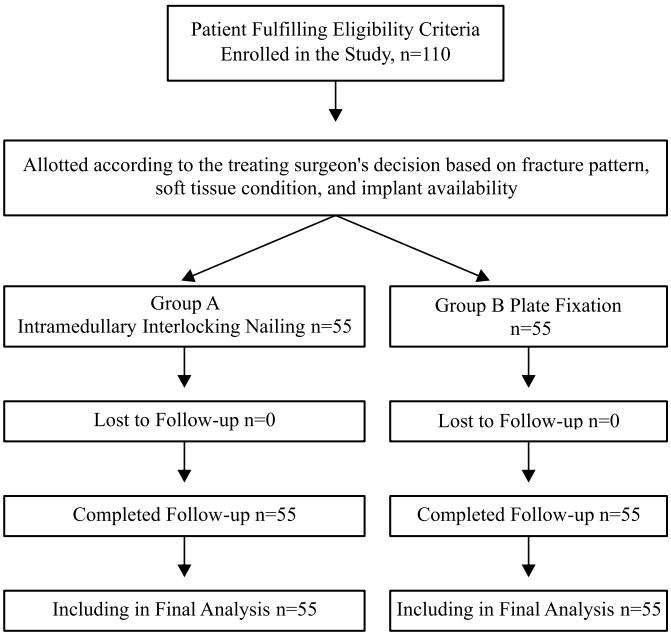


Figure 1: Enrolment, Group Allocation, Follow-Up, and Final Analysis of Patients with Tibial Shaft Fractures

Adult patients who had acute fractures of the tibial shaft and at the diaphyseal region were considered. Both closed fractures and Gustilo-Anderson type I and II open fractures were considered eligible. The classification of fractures was in line with the AO/OTA classification system. Patients with pathological fractures, polytrauma requiring intensive care, neurovascular injury, compartment syndrome, Gustilo-Anderson type III open fractures, or previous surgery of the affected limb were excluded because these conditions could independently influence fracture healing, complications, and functional outcomes [11]. Patients were allocated to either intramedullary nailing or plate fixation according to the treating surgeon's decision, based on fracture pattern, soft-tissue condition, and implant availability. Therefore, the study was non-randomized, and allocation concealment was not performed. This approach may have introduced selection bias and residual confounding despite comparison of baseline characteristics between the groups. Baseline demographic and fracture-related characteristics were compared between the two groups to assess comparability. Group A (n=55) was subjected to intramedullary interlocking nailing with a reamed technique, whereas Group B (n=55) was subjected to plate fixation with the main use of minimally invasive plate osteosynthesis (MIPO) principles to avoid damaging soft tissues and their blood supply. All the practices were done according to the standard aseptic environment with qualified orthopedic surgeons. All baseline, clinical, operative, radiological, and follow-up variables were recorded on a predesigned data collection proforma.

Copyright© 2026 The Authors. Published by CrossLinks International Publishers LLC, USA
This work is licensed under a Creative Commons Attribution 4.0 International License (CC BY 4.0)

DOI: https://doi.org/10.54393/pjhs.v7i9.4281

Demographic and clinical information were extracted from interviews with patients and hospital records, and fracture-related and outcome information were collected from the radiological, clinical, microbiological, and functional assessment tools outlined in the follow-up/outcome assessment section. All patients were subjected to a standardized rehabilitation protocol that involved early joint mobilization and progressive weight-bearing when tolerated postoperatively. At 6 weeks, 3 months, 6 months, and 12 months after the operation, clinical and radiological follow-ups were carried out. Radiological union had the meaning that the bridging callus in at least three out of four cortices on anteroposterior and lateral radiographs. Delayed union was regarded when no progress in healing was observed after 6 months, whereas non-union was defined as no progress in healing after 9 months. Malunion was considered to have angulation of more than 5 degrees in either plane of rotation or more than 10 degrees. The diagnoses of superficial and deep infections were made on clinical and microbiological criteria. The primary outcome measure was functional outcome assessed at 6 months using the Johner-Wruhs criteria and categorized as excellent, good, fair, or poor. The secondary outcomes were time to radiological union, rate of delayed union and non-union, malalignment, rate of infections, and other complications during the procedure. Outcome assessors were not blinded to the treatment allocation. Radiological union was assessed using predefined radiographic criteria, while functional outcomes were assessed using the Johner-Wruhs criteria. The absence of assessor blinding may have introduced detection or measurement bias.

SPSS version 25.0 was used to analyze the data. The quantitative variables age and time to union were presented in the form of mean ± standard deviation, whereas the qualitative variables, which included gender, fracture type, and complication rates, were expressed in terms of frequency and percentage. The chi-square test was used for categorical variables where assumptions were met, while Fisher's exact test was applied when expected cell counts were small. The potential confounders (age, gender, fracture type (open vs closed), and AO classification) were stratified, and post-stratified chi-square testing was conducted. The Johner-Wruhs functional outcome scale was used as an ordinal variable and compared between groups with the Mann– Whitney U test. Interrater reliability for the Johner-Wruhs functional assessment and radiological union assessment was not formally evaluated. To test the association of fixation method and functional outcome, in addition, ordinal logistic regression was used, recognizing the ordered nature of the functional outcome categories. Time to radiological union was also assessed as a time-to-event outcome with Kaplan–Meier survival analysis with radiological union as the event and patients without union at final follow-up as censored observations. The Log Rank test was used to compare the two groups. Because treatment allocation was non-randomized, age, gender, fracture type, open versus closed injury, and AO/OTA classification were considered potential confounders and were evaluated in stratified and regression analyses. Functional outcome according to Johner-Wruhs criteria was also analyzed as an ordinal variable and compared with a chi-square test. For a number of outcomes, effect sizes with 95% confidence intervals were reported. The p-value ≤0.05 was taken to be statistically significant.

RESULTS

The mean age of the study population was 32.8 ± 10.4 years. In Group A, the mean age was 33.1 ± 10.2 years, while in Group B, it was 32.5 ± 10.7 years. The majority of patients were male, with 78 (70.9%) males and 32 (29.1%) females. Baseline demographic, clinical, and fracture-related characteristics were comparable between the two groups (p>0.050)(Table 1).

Table 1: Baseline Demographic, Clinical, and Fracture-Related Characteristics of the Study Groups

Variables	Group A, Mean ± SD / n (%)	Group B, Mean ± SD / n (%)	Total, Mean ± SD / n (%)	p-value
Age, Years	33.1 ± 10.2	32.5 ± 10.7	32.8 ± 10.4	0.760
Age Group				
18–30 Years	26 (47.3%)	24 (43.6%)	50 (45.5%)	0.910
31–45 Years	19 (34.5%)	21 (38.2%)	40 (36.4%)	
>45 Years	10 (18.2%)	10 (18.2%)	20 (18.2%)	
Gender				
Male	39 (70.9%)	39 (70.9%)	78 (70.9%)	1.000
Female	16 (29.1%)	16 (29.1%)	32 (29.1%)	
Smoking Status				
Smoker	17 (30.9%)	16 (29.1%)	33 (30.0%)	0.830
Non-Smoker	38 (69.1%)	39 (70.9%)	77 (70.0%)	

Copyright© 2026 The Authors. Published by CrossLinks International Publishers LLC, USA
This work is licensed under a Creative Commons Attribution 4.0 International License (CC BY 4.0)

DOI: https://doi.org/10.54393/pjhs.v7i9.4281

Comorbidities				
Diabetes Mellitus	8 (14.5%)	7 (12.7%)	15 (13.6%)	0.780
Hypertension	5 (9.1%)	4 (7.3%)	9 (8.2%)	0.730
Mechanism of Injury				
Road Traffic Accident	42 (76.4%)	41 (74.5%)	83 (75.5%)	0.950
Fall	9 (16.4%)	10 (18.2%)	19 (17.3%)	
Sports/Other Injury	4 (7.3%)	4 (7.3%)	8 (7.3%)	
Injury Severity				
High-Energy Injury	31 (56.4%)	30 (54.5%)	61 (55.5%)	0.840
Low-Energy Injury	24 (43.6%)	25 (45.5%)	49 (44.5%)	
Fracture Type				
Closed Fracture	42 (76.4%)	40 (72.7%)	82 (74.5%)	0.660
Open Fracture, Gustilo-Anderson Type I–II	13 (23.6%)	15 (27.3%)	28 (25.5%)	
AO/OTA Classification				
AO Type A	28 (50.9%)	26 (47.3%)	54 (49.1%)	0.890
AO Type B	17 (30.9%)	19 (34.5%)	36 (32.7%)	
AO Type C	10 (18.2%)	10 (18.2%)	20 (18.2%)	

The mean time to radiological union was significantly shorter in the intramedullary nailing group (16.2 ± 3.8 weeks) compared to the plating group (19.1 ± 4.5 weeks) (p=0.001). Overall, union was achieved in 102 (92.7%) patients. Delayed union was observed in 6 (5.5%) patients, while non-union occurred in 2 (1.8%) patients, with no statistically significant difference between groups (p>0.050) (Table 2).

Table 2: Radiological Outcomes

Variables	Group A, Mean ± SD / n (%)	Group B, Mean ± SD / n (%)	Total, Mean ± SD / n (%)	p-value
Time to Union (Weeks)	16.2 ± 3.8	19.1 ± 4.5	17.6 ± 4.3	0.001
Union Achieved	52 (94.5%)	50 (90.9%)	102 (92.7%)	0.670
Delayed Union	2 (3.6%)	4 (7.3%)	6 (5.5%)	
Non-Union	1 (1.8%)	1 (1.8%)	2 (1.8%)	

Intramedullary nailing had a mean difference of 2.9 weeks in time to radiological union compared to screw fixation (95% CI: -4.47 to -1.33 weeks). Also, the Kaplan–Meier analysis revealed that the intramedullary nailing group had a radiological union rate earlier than the plating group. Functional outcomes assessed at 6 months using Johner-Wruhs criteria showed that excellent to good results were achieved in 46 (83.6%) patients in the IMN group compared to 40 (72.7%) in the plating group. Fair to poor outcomes were more frequent in the plating group; however, the difference did not reach statistical significance (p=0.180) (Table 3).

Table 3: Functional Outcome (Johner-Wruhs Criteria)

Outcomes	Group A, n (%)	Group B, n (%)	Total, n (%)	p-value
Excellent	24 (43.6%)	18 (32.7%)	42 (38.2%)	0.180
Good	22 (40.0%)	22 (40.0%)	44 (40.0%)	
Fair	6 (10.9%)	9 (16.4%)	15 (13.6%)	
Poor	3 (5.5%)	6 (10.9%)	9 (8.2%)	

The difference between the two groups (intramedullary nailing vs plating) was not statistically significant when functional outcome was analyzed as an ordinal variable, which corroborates the finding of similar overall functional outcomes between the two groups. Complication rates differed between the two groups. Anterior knee pain was significantly more common in the IMN group (21.8%), whereas superficial and deep infections were more frequently observed in the plating group (18.2%). Malalignment was slightly higher in the IMN group but did not show statistical significance (Table 4).

Table 4: Postoperative Complications

Complications	Group A, n (%)	Group B, n (%)	Total, n (%)	p-value
Anterior Knee Pain	12 (21.8%)	3 (5.5%)	15 (13.6%)	0.001
Superficial Infection	3 (5.5%)	6 (10.9%)	9 (8.2%)	–
Deep Infection	1 (1.8%)	4 (7.3%)	5 (4.5%)	–
Malalignment	5 (9.1%)	3 (5.5%)	8 (7.3%)	0.220

The odds of a good to excellent functional outcome were 1.92 times greater with intramedullary nailing (95% CI: 0.76–4.85). Intramedullary nailing had a relative risk of 4.00 (95% CI: 1.19–13.40) for anterior knee pain

DISCUSSION

In this study, the functional and radiological outcomes of the intramedullary nailing and plate fixation of the tibial shaft fractures were compared, and it was proven that both methods demonstrate satisfactory results with some advantages of the procedures. The intramedullary nailing demonstrated a much shorter time to union, but there were no major differences in terms of overall functional results at six months. In the current study, 70.9% (94) of patients were male, and the mean age of the patients was 32.8 ± 10.4 years. This is similar to Turley *et al.* study, reporting a higher incidence of tibial shaft fractures in young adult males, predominantly as a result of increased exposure to road

Copyright© 2026 The Authors. Published by CrossLinks International Publishers LLC, USA
This work is licensed under a Creative Commons Attribution 4.0 International License (CC BY 4.0)

DOI: https://doi.org/10.54393/pjhs.v7i9.4281

traffic accidents, occupational injuries, and outdoor activities [12]. Closed fracture was the common type compared with open fracture (74.5 % vs 25.5 %). This is in line with the findings of Hendrickx *et al.* study that has documented an increased incidence of closed tibial shaft fractures in the general orthopedic setting [13]. The most frequent fracture type in our patients was AO type A fractures, followed by type B fractures, and then type C fractures. However, the proportion of open and complex fractures has been reported to be higher in major trauma or referral centers, which might be attributed to the differences in the mechanism of injury, referral pattern, and inclusion criteria. One important result of the current study was the decrease in the time of radiological union in the group of intramedullary nailing patients by a significant margin over plating. This may be related to the less invasive nature of intramedullary fixation and its reduced disruption of the soft-tissue envelope around the fracture site [14]. Conversely, even state-of-the-art plate fixation, may be associated with a greater risk of soft-tissue complications in some tibial fracture populations, although outcomes vary according to fracture location and surgical technique. [15]. Nevertheless, the general percentage of union between the two groups during our trial was similar, which correlates with past studies showing comparable long-term healing results between the two techniques [16, 17]. The comparison of the functional outcome analysis in terms of the Johner Wruhs criteria demonstrated that there was no statistically significant difference in terms of the excellent to good outcomes in the two groups, but there was a higher proportion of excellent to good outcomes in the intramedullary nailing group. Both techniques have demonstrated satisfactory clinical and radiological outcomes, although differences in union time and complication profiles have been reported in comparative studies [18]. The fact that there is no substantial difference in functional outcome underlines that the two techniques are useful provided that they are well chosen, depending on the nature of the fracture and the patient's factors. Anterior knee pain was more prevalent in the IMN group, consistent with previous reports identifying anterior knee pain as a common complication following tibial intramedullary nailing [19]. The plating group showed a higher incidence of superficial and deep infections in our cohort, consistent with previous comparative evidence reporting a higher risk of wound infection following minimally invasive plate fixation than intramedullary nailing [20]. The IMN group also had a slightly higher incidence of malalignment, especially in fractures nearer to the metaphyseal area, as has been reported extensively in the literature [21]. The stratification analysis of the current study revealed that there was no significant impact on the selection of age, gender, fracture type, open versus closed injury, and the fixation method did not necessarily influence the functional outcomes of the study, so the fixation method used by patients may be a factor that influences recovery more significantly than patient demographics. However, patient screening and adherence to the principles of surgery are still crucial as they can maximize the results. The research offers useful regional statistics of a tertiary care unit in Peshawar on the relative functional result of intramedullary nailing and plating in tibia shaft fractures. The prospective study design, standardized operating methods, and periodic follow-up enhance methodological rigor and reliability of the results. A validated functional outcome measure is also used to augment the overall evaluation of the treatment effectiveness as well as the integrated clinical assessment and radiology assessment.

However, some limitations need to be addressed. The study was conducted at a single center with a relatively small sample size, which may limit generalizability. The non-randomized, surgeon-dependent allocation may have introduced selection bias and residual confounding despite comparable measured baseline characteristics. Outcome assessors were not blinded, and interrater reliability for functional and radiological assessments was not formally evaluated, which may have introduced measurement bias. The exclusion of Gustilo-Anderson type III open fractures, pathological fractures, and severe polytrauma further limits applicability to these patient groups. Although all patients completed follow-up, longer-term multicenter randomized studies with larger samples are needed to confirm these findings.

CONCLUSIONS

In both intramedullary nailing and plate fixation, satisfactory functional results were obtained in tibial shaft fractures. Intramedullary nailing had significantly shorter radiological healing time, and plating had relatively higher infection-associated complications. There was no difference in overall functional outcomes between the 2 groups. Consideration should be given to the type of fracture, the soft tissue status, and the surgeon's experience before deciding on the method of fixation.

Authors' Contribution

Conceptualization: AZ, MSK
Methodology: AZ, MSK, MK, SM
Formal analysis: HK, MK
Writing and Drafting: AZ, HK, MK, SM
Review and Editing: AZ, MSK, HK, MK, SM

All authors approved the final manuscript and take responsibility for the integrity of the work

Copyright© 2026 The Authors. Published by CrossLinks International Publishers LLC, USA
This work is licensed under a Creative Commons Attribution 4.0 International License (CC BY 4.0)

DOI: https://doi.org/10.54393/pjhs.v7i9.4281

Conflict of Interest

All the authors declare no conflict of interest.

Source of Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

REFERENCES

[1] Li X, Chen K, Xue H, Cheng J, Yu X. Efficacy Comparison Between Intramedullary Nail Fixation and Plate Fixation in Distal Tibia Fractures: A Meta-Analysis of Randomized Controlled Trials. Journal of Orthopedic Surgery and Research. 2024 Jul; 19(1) :403. doi: 10.1186/s13018-024-04900-y.

[2] Xu H, Chen P, Zhang Y, Huang H, Xie X, Ren Z. Intramedullary Nailing Versus Minimally Invasive Plate Osteosynthesis for Proximal Tibial Fracture: A Systematic Review and Meta-Analysis. Journal of Orthopaedic Surgery and Research. 2025 Jul; 20(1): 663. doi: 10.1186/s13018-025-06094-3.

[3] Dragonas CG, Fontalis A, Iliadis A, Vris A, Mavrogenis A. Intramedullary Nailing Versus Plate Fixation for the Treatment of Proximal Tibia Extra-Articular Fractures: A Meta-Analysis. European Journal of Orthopaedic Surgery and Traumatology. 2025 Sep; 35(1): 410. doi: 10.1007/s00590-025-04536-6.

[4] Garabano G, Pereira S, Perez Alamino L, Ernst G, Pesciallo CA, Bidolegui F. The Relevance of the Number of Distal Locking Planes and Nail to Canal Ratio in Bone Healing After Intramedullary Nailing in Tibial Shaft Fractures. European Journal of Orthopedic Surgery and Traumatology. 2023 Jul; 33(5): 2111-9. doi: 10.1007/s00590-022-03401-0.

[5] Dunbar RP, Egol KA, Jones CB, Ostrum RF, Humphrey CA, Ricci WM *et al.* Locked Plating Versus Nailing for Proximal Tibia Fractures: A Multicenter Randomized Controlled Trial. Journal of Orthopedic Trauma. 2023 Apr; 37(4): 155-60. doi: 10.1097/BOT.0000000000002537.

[6] Cheng L, Li YH, Chu Y, Yang G, Zhu D, Tan L. Intramedullary Nailing Via Suprapatellar Approach Versus Locked Plating of Proximal Extra-Articular Tibial Fractures: A Randomized Control Trial. International orthopedics. 2021 Jun; 45(6): 1599-608. doi: 10.1007/s00264-020-04821-5.

[7] Radaideh A, Alrawashdeh MA, Al Khateeb AH, Obeidat O, Tabar MA, Essa SM *et al.* Outcomes of Treating Tibial Shaft Fractures Using Intramedullary Nailing Versus Minimally Invasive Percutaneous Plate Osteosynthesis. Medical Archives. 2022 Feb; 76(1): 55. doi: 10.5455/medarh.2022.76.55-61.

[8] O'Neill CN, Hooper N, Wait J, Satalich J, Cinats D, Toney C *et al.* No Difference in Short-Term Complications Following Treatment of Closed Tibial Shaft Fractures with Intramedullary Nailing Versus Plate Fixation. Advances in Orthopedics. 2023 Oct; 1: 1627225. doi: 10.1155/2023/1627225.

[9] Upfill-Brown A, Hwang R, Clarkson S, Brodke D, Devana S, Mayer E *et al.* Rates and Timing of Short-Term Complications Following Operative Treatment of Tibial Shaft Fractures. Orthopedic Trauma Association International. 2021 Dec; 4(4): e158. doi: 10.1097/OI9.0000000000000158.

[10] Balbachevsky D, Gomes PS, Credídio MV, Cruz BA, Fernandes HJ, Dos Reis FB *et al.* Intramedullary Nail Versus Bridge Plate in Open Tibial Fractures: A Randomized Clinical Trial. Injury. 2021 Jul; 52: 77-83. doi: 10.1016/j.injury.2021.06.015.

[11] Radaideh A, Alrawashdeh MA, Al Khateeb AH, Obeidat O, Tabar MA, Essa SM *et al.* Outcomes of Treating Tibial Shaft Fractures Using Intramedullary Nailing Versus Minimally Invasive Percutaneous Plate Osteosynthesis. Medical Archives. 2022 Feb; 76(1): 55. doi: 10.5455/medarh.2022.76.55-61.

[12] Turley L, Barry I, Sheehan E. Frequency of Complications in Intramedullary Nailing of Open Tibial Shaft Fractures: A Systematic Review. Effort Open Reviews. 2023 Feb; 8(2): 90-9. doi: 10.1530/EOR-22-0076.

[13] Morello V and Gamulin A. Clinical and Radiological Risk Factors Associated with the Occurrence of Acute Compartment Syndrome in Tibial Fractures: A Systematic Review of the Literature. EFORT Open Reviews. 2023 Dec; 8(12): 926-35. doi: 10.1530/EOR-23-0067.

[14] Kalhor M, Elahifar O, Eslami A, Gharehdaghi J. Anatomy and Pattern of Tibial Periosteal Circulation: Implications for Tibial Plating: A Cadaveric Study. Bone and Joint Research. 2025 Se3; 14(9): 769. doi: 10.1302/2046-3758.149.BJR-2024-0547.R2.

[15] Monahan KT, Zavras AG, Angelides GW, Altman GT, Altman DT, Westrick ER. Extra-Articular Proximal Tibia Fracture Fixation with Locked Plating Versus Intramedullary Nailing: A Meta-Analysis. Injury. 2024; 55(10): 111718. doi: 10.1016/j.injury.2024.111718.

[16] Thwaites S, Abrahams J, Thewlis D, Rickman M. The Absence of Reporting Standards and a Lack of Objective, Performance-Based Outcomes Following Intramedullary Nailing of Tibial Shaft Fractures: Findings from a Scoping Review Into 179 Articles. European Journal of Trauma and Emergency Surgery. 2024 Feb; 50(1): 59-70. doi: 10.1007/s00068-023-02338-1.

[17] Oliveira PR, Leonhardt MC, Panico CT, Silva JB, Carvalho VC, Kojima KE *et al.* Infection After

Copyright© 2026 The Authors. Published by CrossLinks International Publishers LLC, USA
This work is licensed under a Creative Commons Attribution 4.0 International License (CC BY 4.0)

DOI: https://doi.org/10.54393/pjhs.v7i9.4281

Intramedullary Nailing of Femoral and Tibial Diaphyseal Fractures. Injury. 2023 Nov; 54: 110821. doi: 10.1016/j.injury.2023.05.052.

[18] Karthik MV and Kiran Kumar V. Functional Outcomes of Intramedullary Nailing Versus Plating in Tibial Shaft Fractures: A Prospective Comparative Study. Journal of Advanced Healthcare and Medical Sciences. 2025 Mar; 5: 7-12.

[19] Choudri MJ, Hussain S, Bleibleh S, Remtulla M, Karthikeyan R, Cooper J. Semi-Extended Extra-Synovial (SEES) Tibial Intramedullary Nailing Technique: Up to 10 Year Retrospective Analysis of Outcomes and Anterior Knee Pain Rates. Journal of Clinical Orthopedics and Trauma. 2023 Oct; 45: 102274. doi: 10.1016/j.jcot.2023.102274.

[20] Liu H, Xu W, Xiong Y, Zhang J, Xu Z, Wu J. Retrograde Tibial Intramedullary Nail Versus Minimally Invasive Locking Plate for Extra-Articular Distal Tibial Fractures: A Comparative and Retrospective Study. Journal of Orthopedic Surgery and Research. 2024 Aug; 19(1): 481. doi: 10.1186/s13018-024-04979-3.

[21] Chaudhry YP, Gutierrez-Naranjo JM, Raad M, Ghanem D, Salazar LM, Goodrum JT *et al.* Risk Factors for Malalignment After Intramedullary Nail Treatment of Distal Tibia Fractures with Associated Fibula Fractures. European Journal of Orthopedic Surgery and Traumatology. 2024 Aug; 34(6): 3265-73.

Copyright© 2026 The Authors. Published by CrossLinks International Publishers LLC, USA
This work is licensed under a Creative Commons Attribution 4.0 International License (CC BY 4.0)