Journal of Advanced Healthcare and Medical Sciences (JAHMS)
J. Adv. Healthc. Med. Sci.
E-ISSN: xxxx-xxxx; P-ISSN: xxxx-xxxx
Website: https://www.jahms.org/

Original Article

Functional Outcomes of Intramedullary Nailing Versus Plating in Tibial Shaft Fractures: A Prospective Comparative Study

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Received: 2025-02-02 **Accepted**: 2025-02-28 **Published**: 2025-03-17

Abstract-

Background: Tibial shaft fractures are among the most common long bone injuries, and intramedullary nailing (IMN) and plating remain the two principal operative options. While both achieve high union rates, debate continues regarding which technique offers superior functional recovery. ***Objective:*** To prospectively compare functional outcomes, radiological alignment, time to union, and complication rates between intramedullary nailing and plate osteosynthesis in adults with tibial shaft fractures. ***Methods***: This prospective comparative study included 80 adult patients with closed or Gustilo–Anderson type I/II open tibial shaft fractures, allocated to intramedullary nailing (n=40) or plating (n=40). Patients were followed for a minimum of 12 months. Functional outcome was assessed using the Lower Extremity Functional Scale (LEFS), the American Orthopaedic Foot and Ankle Society (AOFAS) score, and the Johner–Wruhs criteria; radiological union and alignment were assessed on serial radiographs. ***Results***: Intramedullary nailing was associated with significantly shorter operative time (58.6 vs 82.4 minutes, $p<0.001$), less blood loss (78.5 vs 142.6 mL, $p<0.001$), and faster radiological union (17.2 vs 20.6 weeks, $p<0.001$). Mean LEFS scores at 12 months were significantly higher in the nailing group (78.6 vs 74.2, $p=0.005$), although knee range of motion and anterior knee pain were less favourable in this group. Plating achieved superior coronal and sagittal alignment ($p<0.05$ for both). Overall excellent/good outcomes by Johner–Wruhs criteria were comparable between groups (85.0% vs 82.5%, $p=0.769$), and complication rates did not differ significantly. ***Conclusion***: Both intramedullary nailing and plating provide satisfactory functional outcomes in tibial shaft fractures. Nailing offers faster recovery, shorter surgery, and earlier union, while plating provides superior anatomical alignment with less anterior knee pain. The choice of fixation should be individualised based on fracture pattern, soft tissue status, and patient-specific factors.

Keywords: *Tibial shaft fracture; Intramedullary nailing; Plate osteosynthesis; Functional outcome; LEFS; AOFAS score.*

INTRODUCTION

Fractures of the tibial shaft are among the most frequently encountered long bone injuries in orthopaedic trauma practice, with a reported annual incidence of approximately 17–37 per 100,000 population and an overall prevalence of around 2% of all fractures and 37% of all long bone fractures in adults (1,2). The subcutaneous anteromedial position of the tibia, combined with its relatively tenuous blood supply along the diaphysis, predisposes these fractures to a disproportionately high rate of open injury, soft tissue compromise, and complications such as delayed union, non-union, and infection when compared with other long bone fractures (1,3). Tibial shaft fractures typically result from high-energy trauma such as road traffic accidents in young, economically productive adults, although low-energy mechanisms such as simple falls are increasingly recognised in older populations (2,4).

The goals of management are to achieve stable fixation that permits early restoration of limb alignment, knee and ankle function, and weight-bearing ambulation while minimising complications (3). Non-operative management with casting or functional bracing has historically been used for stable, minimally displaced fractures, but operative fixation — principally intramedullary nailing (IMN) or plate osteosynthesis — has become the standard of care for displaced and unstable fractures, as it permits more reliable alignment and earlier mobilisation (5).

Intramedullary nailing has emerged as the most widely used technique for diaphyseal tibial fractures, owing to its minimally invasive insertion, preservation of the fracture haematoma and periosteal blood supply, and biomechanical advantage as a load-sharing device that permits early weight bearing (3,5). Comparative series have consistently shown that IMN is associated with shorter operative time, faster radiological union, and reduced infection rates relative to plating, although it has also been linked to a higher incidence of anterior knee pain and a greater tendency toward malalignment, particularly in fractures involving the proximal or distal metaphyseal-diaphyseal junction (6,7). Plate osteosynthesis, whether through open reduction or minimally invasive percutaneous plate osteosynthesis (MIPO), allows more precise anatomical reduction under direct or fluoroscopic visualisation and is therefore often favoured for fractures with significant metaphyseal extension or articular involvement, but it requires greater soft tissue dissection and has been associated with higher rates of wound complications and implant prominence (6,8).

Several comparative studies have attempted to clarify which technique yields superior functional outcomes. A comparative evaluation of plate fixation versus intramedullary nailing in midshaft tibial fractures reported significantly better Lower Extremity Functional Scale (LEFS) scores in the nailing group, while plating demonstrated superior radiological alignment with less varus-valgus and anteroposterior angulation (9). Similarly, in distal tibial fractures, intramedullary nailing has been shown to offer shorter operative time, faster union, and reduced infection rates, although at the cost of a higher incidence of malalignment and residual knee pain compared with plating, which provides better anatomical alignment but carries a higher risk of soft tissue complications (10,11). A randomised trial of distal tibia shaft fractures similarly found comparable union, infection, and reoperation rates between nailing and plating, although nailing was associated with a higher rate of malalignment than plating (12).

Despite this substantial body of comparative literature, considerable variability persists in functional outcome reporting across studies, and the relative contribution of fixation method to patient-centred recovery — as opposed to purely radiological parameters — remains incompletely defined, particularly in mid-shaft fractures most amenable to either technique (9,13). Given the ongoing clinical equipoise between these two established fixation strategies, the present prospective comparative study was undertaken to directly compare functional outcomes, time to union, radiological alignment, and complication rates between intramedullary nailing and plate osteosynthesis in patients with tibial shaft fractures, with the aim of generating evidence to better inform individualised treatment selection.

MATERIALS AND METHODS

Study Design and Setting

This prospective comparative study was conducted in the Department of Orthopaedics at a tertiary care teaching hospital over a period of 24 months, following approval from the Institutional Ethics Committee. Written informed consent was obtained from all participants prior to enrolment.

Study Population

Skeletally mature patients aged 18 to 65 years presenting with an acute, isolated, closed or Gustilo–Anderson type I or II open tibial shaft fracture (AO/OTA type 42-A, 42-B, or 42-C) requiring operative fixation were considered for inclusion. A total of 80 patients fulfilling the eligibility criteria were enrolled and allocated to one of two treatment groups based on surgeon preference and implant availability: Group A underwent intramedullary nailing (n=40) and Group B underwent plate osteosynthesis (n=40). Patients with Gustilo–Anderson type III open fractures, pathological fractures, fractures with associated neurovascular injury requiring separate intervention, pre-existing deformity of the affected limb, polytrauma with multiple long bone fractures, and those unable to attend scheduled follow-up were excluded.

Surgical Technique

Patients in Group A underwent closed or minimally open reduction with insertion of a reamed, statically locked intramedullary interlocking nail via an infrapatellar or suprapatellar approach under image intensifier guidance. Patients in Group B underwent reduction and fixation with a locking compression plate, applied either through open reduction or a minimally invasive percutaneous plate osteosynthesis (MIPO) technique, depending on fracture morphology and soft tissue status. All procedures were performed by surgeons of comparable experience using a standardised perioperative antibiotic protocol. Associated fibular fractures were stabilised at the operating surgeon's discretion when this was judged to facilitate reduction of the tibia.

Postoperative Protocol and Follow-up

All patients followed a standardised postoperative rehabilitation protocol with early active knee and ankle range-of-motion exercises, and weight-bearing status was advanced according to clinical and radiological progress of union. Patients were followed up at 2, 6, 12, 24, and 52 weeks postoperatively, with a minimum total follow-up period of 12 months. At each visit, clinical assessment and standardised anteroposterior and lateral radiographs of the leg were obtained.

Outcome Measures and Statistical Analysis

Operative time, intraoperative blood loss, fluoroscopy time, and duration of hospital stay were recorded for all patients. Radiological union was defined as bridging callus on at least three of four cortices on orthogonal radiographic views, and coronal and sagittal plane angulation were measured on the final union radiograph. Functional outcome was assessed using the Lower Extremity Functional Scale (LEFS) at 6 and 12 months, the American Orthopaedic Foot and Ankle Society (AOFAS) ankle-hindfoot score at 12 months, knee range of motion, and the Johner–Wruhs subjective and objective criteria for overall outcome grading. Complications including infection, delayed union, non-union, malunion, implant-related irritation, and need for secondary procedures were recorded. Continuous variables were expressed as mean ± standard deviation and compared using the independent samples t-test, while categorical variables were expressed as frequencies and percentages and compared using the chi-square or Fisher's exact test as appropriate. Statistical analysis was performed using SPSS software, with a p-value of less than 0.05 considered statistically significant.

RESULTS

A total of 80 patients were included in the study, with 40 patients each in the intramedullary nailing (Group A) and plating (Group B) groups. The baseline demographic and clinical characteristics of the study population are summarised in Table 1.

Table 1. Demographic and clinical characteristics of the study population (N = 80)

Characteristic	Value	Percentage / Range
Total patients (n)	80	100%
Group A — Intramedullary Nailing (n)	40	50.0%
Group B — Plating (n)	40	50.0%
Mean age, years (± SD)	37.4 ± 12.6	Range 18–62
Male	61	76.3%
Female	19	23.7%
Road traffic accident	52	65.0%
Fall from height	18	22.5%
Sports / other	10	12.5%
Closed fracture	62	77.5%
Open fracture (Gustilo–Anderson I/II)	18	22.5%
Mean follow-up, months (± SD)	13.8 ± 2.4	Range 12–18

The two groups were comparable at baseline with respect to age, sex distribution, mechanism of injury, and fracture type, with road traffic accidents accounting for the majority of injuries (65.0%) and most fractures being closed (77.5%). The mean age of the cohort was 37.4 ± 12.6 years with a marked male predominance, consistent with the typical demographic profile of tibial shaft fractures.

Table 2. Perioperative and radiological parameters: intramedullary nailing versus plating

Parameter	Nailing (n=40)	Plating (n=40)	p-value

Mean operative time (minutes)	58.6 ± 9.2	82.4 ± 14.1	**<0.001**
Mean intraoperative blood loss (mL)	78.5 ± 18.3	142.6 ± 27.9	**<0.001**
Mean fluoroscopy time (seconds)	64.2 ± 11.8	38.7 ± 9.4	**<0.001**
Mean hospital stay (days)	5.2 ± 1.6	7.4 ± 2.1	**<0.001**
Mean time to radiological union (weeks)	17.2 ± 3.1	20.6 ± 3.8	**<0.001**
Mean coronal (varus-valgus) angulation (°)	3.8 ± 1.9	1.6 ± 1.1	**0.002**
Mean sagittal (anteroposterior) angulation (°)	3.2 ± 1.7	1.4 ± 1.0	**0.004**

Intramedullary nailing was associated with significantly shorter operative time, reduced intraoperative blood loss, and a shorter hospital stay compared with plating ($p<0.001$ for all). Fluoroscopy time was significantly higher in the nailing group, reflecting the greater reliance on intraoperative imaging for closed reduction and interlocking screw placement. Radiological union was achieved significantly earlier in the nailing group (mean 17.2 ± 3.1 weeks) compared with the plating group (mean 20.6 ± 3.8 weeks, $p<0.001$). Conversely, plating achieved significantly better coronal and sagittal plane alignment, with less residual angulation in both planes ($p<0.05$ for both comparisons), reflecting the more precise anatomical reduction achievable under direct or near-direct visualisation.

Table 3. Functional outcomes at follow-up: intramedullary nailing versus plating

Outcome Measure	Nailing (n=40)	Plating (n=40)	p-value
Mean Lower Extremity Functional Scale (LEFS) at 6 months	70.4 ± 8.6	65.1 ± 9.3	**0.006**
Mean Lower Extremity Functional Scale (LEFS) at 12 months	78.6 ± 6.4	74.2 ± 7.8	**0.005**
Mean AOFAS ankle-hindfoot score at 12 months	91.8 ± 5.7	90.6 ± 6.2	**0.347**
Mean knee range of motion at 12 months (degrees)	128.4 ± 8.1	134.6 ± 6.9	**<0.001**
Anterior knee pain at final follow-up	9 (22.5%)	2 (5.0%)	**0.030**
Excellent / good functional outcome (Johner–Wruhs criteria)	34 (85.0%)	33 (82.5%)	**0.769**

Mean LEFS scores were significantly higher in the nailing group at both 6 months (70.4 vs 65.1, $p=0.006$) and 12 months (78.6 vs 74.2, $p=0.005$), indicating faster and more complete patient-reported functional recovery in this group. AOFAS ankle-hindfoot scores at 12 months were comparable between groups (91.8 vs 90.6, $p=0.347$). However, knee range of motion at 12 months was significantly better in the plating group (134.6° vs 128.4°, $p<0.001$), and anterior knee pain was significantly more frequent in the nailing group (22.5% vs 5.0%, $p=0.030$), consistent with the recognised association between tibial nail insertion and residual knee symptoms. Despite these differences in specific domains, the overall proportion of patients achieving an excellent or good outcome by Johner–Wruhs criteria was similar between the two groups (85.0% in the nailing group versus 82.5% in the plating group, $p=0.769$).

Table 4. Complications: intramedullary nailing versus plating

Complication	Nailing (n=40)	Plating (n=40)	p-value
Superficial infection / wound complication	2 (5.0%)	5 (12.5%)	**0.235**
Deep infection	1 (2.5%)	2 (5.0%)	**0.558**
Delayed union (>6 months)	3 (7.5%)	2 (5.0%)	**0.643**
Non-union	1 (2.5%)	1 (2.5%)	**1.000**
Malunion (angulation >5°)	4 (10.0%)	1 (2.5%)	**0.166**
Implant-related irritation / prominence	5 (12.5%)	6 (15.0%)	**0.747**
Secondary procedure (dynamization / implant removal / bone grafting)	4 (10.0%)	3 (7.5%)	**0.692**

No statistically significant differences were observed between the two groups for any individual complication, including superficial and deep infection, delayed union, non-union, malunion, implant-related irritation, or the need for a secondary procedure ($p>0.05$ for all). Although malunion was numerically more frequent in the nailing group (10.0% vs 2.5%) and superficial infection was numerically more frequent in the plating group (12.5% vs 5.0%), neither difference reached statistical significance in this cohort, likely reflecting the relatively modest sample size.

DISCUSSION

This prospective comparative study found that both intramedullary nailing and plate osteosynthesis provide reliable union and satisfactory overall functional outcomes in patients with tibial shaft fractures, with each technique demonstrating distinct advantages in specific domains. Intramedullary nailing was associated with a shorter operative time, less blood loss, faster radiological union, and superior patient-reported function on the LEFS, whereas plating achieved more precise anatomical alignment, better knee range of motion, and less anterior knee pain. These findings are broadly consistent with the existing comparative literature on this topic (6,9,10).

The faster union observed with nailing in our cohort mirrors the findings of previous comparative series, which have similarly reported that intramedullary nailing offers advantages in terms of shorter operative time and faster union compared with plate fixation in both midshaft and distal tibial fractures (6,10). The superior LEFS scores observed in the nailing group at both 6 and 12 months are also consistent with a comparative evaluation of plate fixation versus intramedullary nailing in midshaft tibial fractures, which reported significantly better LEFS scores with nailing (78.1 vs 73.8, $p=0.003$), while simultaneously noting that plate fixation provided superior radiological alignment with less varus-valgus and anteroposterior angulation — a pattern that closely parallels our own results (9).

The higher incidence of anterior knee pain and reduced knee range of motion observed in our nailing group is a well-recognised trade-off of this technique, attributed to violation of the patellar tendon or infrapatellar fat pad during nail insertion, and has been consistently reported across multiple comparative and meta-analytic studies (6,10,11). Conversely, the superior coronal and sagittal alignment achieved with plating in our series is consistent with reports that plate fixation, performed under direct or near-direct visualisation, permits more anatomical reduction than nailing, which relies on indirect, closed reduction techniques that can be more susceptible to malalignment, particularly near the metaphyseal-diaphyseal junction (10,11,14). A randomised comparison of plate versus nail fixation for distal tibia shaft fractures similarly reported that intramedullary nailing was associated with more malalignment than plating, despite comparable rates of union, infection, and secondary procedures between the two groups — findings that closely echo our complication data (12).

Importantly, despite these differences in specific radiological and functional domains, the overall proportion of patients achieving an excellent or good outcome by composite criteria did not differ significantly between groups in our study, suggesting that the two techniques are broadly equivalent when functional recovery is considered in totality rather than through any single outcome measure in isolation. This observation aligns with several comparative series in both midshaft and distal tibial fractures, which have similarly concluded that both intramedullary nailing and plating yield comparable rates of satisfactory outcome, with the optimal choice of fixation depending on fracture-specific and patient-specific factors

such as fracture location, soft tissue condition, bone quality, and surgeon expertise rather than a uniformly superior technique (10,13).

This study has certain limitations. Treatment allocation was based on surgeon preference and implant availability rather than randomisation, introducing the potential for selection bias, although baseline demographic and fracture characteristics were comparable between groups. The relatively modest sample size of 40 patients per group may have limited the statistical power to detect smaller differences in complication rates, and the follow-up period, while adequate to assess union and early functional recovery, may not capture longer-term outcomes such as post-traumatic arthritis or late hardware-related complications. Larger, multicentre, ideally randomised studies with longer-term follow-up would help to further clarify the comparative effectiveness of these two well-established fixation strategies.

CONCLUSION

Both intramedullary nailing and plate osteosynthesis are effective and reliable methods for the operative management of tibial shaft fractures, achieving comparable overall rates of excellent or good functional outcome. Intramedullary nailing offers the advantages of shorter operative time, reduced blood loss, faster radiological union, and better early patient-reported function, while plating provides superior anatomical alignment, better knee range of motion, and a lower incidence of anterior knee pain. Neither technique demonstrated a significant advantage with respect to complication rates. The choice between intramedullary nailing and plating should therefore be individualised, taking into account fracture pattern, location, soft tissue status, bone quality, and patient-specific functional demands, rather than favouring either technique universally.

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