The Clinical Efficacy and Safety of Intramedullary Nailing for Traumatic Fractures of the Femur and Tibia: A Retrospective Cohort Study

Weiqiang Cheng, He Li, Dingguo Zhu
Guangzhou Heping orthopedic hospital, Guangzhou 510000, Guangdong, China

Abstract: Intramedullary nailing is the standard for stabilizing femoral and tibial diaphyseal fractures. This study evaluated its effectiveness and safety in adults with traumatic long-bone injuries. Methods: Retrospective cohort of adult inpatients treated at a single center (January 2021–July 2024). Demographics, fracture features, intraoperative variables, and outcomes were extracted from electronic records. Primary endpoints were 6-month radiographic union and overall postoperative complications. Secondary endpoints included time to union, time to full weight-bearing, 12-month Lower Extremity Functional Scale (LEFS), and specific complications. Results: A total of 100 patients (65 males and 35 females) with 155 fractures (85 femoral and 70 tibial) were analyzed. Union at 6 months was achieved in 145/155 fractures (93.5%); mean time to union was 16.8±4.5 weeks. Overall complications occurred in 25/155 fractures (16.1%), most commonly delayed union (5.2%), superficial infection (3.9%), and malunion (3.2%); deep infection occurred in 1.9%. The mean 12-month LEFS was 70.5±9.8. Conclusion: Intramedullary nailing yields high union rates, acceptable complication profiles, and good functional recovery in femoral and tibial shaft fractures, supporting its continued use as standard care.

***Keywords*:** intramedullary nailing, long bone fracture, femur fracture, tibia fracture, clinical outcome, fracture healing

1. Introduction

Traumatic long-bone fractures, particularly of the femur and tibia, are major causes of morbidity and functional impairment [1]. Femoral fractures typically result from high-energy trauma and are frequently associated with systemic injuries [1]. Management priorities are rigid fixation, restoration of alignment and limb length, and early mobilization to limit immobilization-related complications and promote recovery [2].

Since Küntscher, intramedullary (IM) nailing has reshaped fracture care [1]. As a load-sharing device within the medullary canal, it resists angular, translational, and torsional stresses, promoting secondary (callus) healing and early weight-bearing [3]. IM nailing is the preferred treatment for adult femoral and tibial diaphyseal fractures [1,4]. Advantages include minimal invasiveness, reduced blood loss, preservation of periosteal/endosteal perfusion, and high union rates [5]. Complications include infection, malalignment/malunion, delayed/nonunion, implant failure, and neurovascular injury. Reported nonunion rates are 2.6%–16% (tibia) and 0.9%–6% (femur); infection is ~1.1%–6.9% for the tibia and slightly lower for the femur.

We retrospectively evaluated the clinical efficacy and safety of IM nailing for traumatic femoral and tibial diaphyseal fractures at our institution.

2. Materials And Methods

2.1 Study Design and Patient Population

Single-center retrospective cohort with IRB approval and consent waiver. Consecutive adults (≥18 years) with traumatic diaphyseal femur or tibia fractures (AO/OTA 32-A/B/C or 42-A/B/C) treated by intramedullary nailing from January 2021 to July 2024 were included; minimum follow-up, 12 months. Exclusions: pathological or periprosthetic fractures; substantial metaphyseal/intra-articular extension requiring adjunct fixation; incomplete records or follow-up <12 months.

2.2 Surgical Technique

Fellowship-trained trauma surgeons performed antegrade femoral nailing on a fracture table and suprapatellar or infrapatellar tibial nailing per fracture morphology. The canal was reamed in most cases; a statically locked titanium nail of appropriate size was implanted. Standardized antibiotic prophylaxis, pharmacologic VTE prevention, and rehabilitation from postoperative day 1 were used. Weight-bearing progression was individualized by fixation stability, fracture characteristics, and patient factors.

2.3 Data Collection and Outcome Measures

Data from EMR and PACS included age, sex, injury mechanism; fracture site (femur/tibia), AO/OTA pattern, Gustilo–Anderson grade; time to surgery, operative duration, and estimated blood loss.

(1) Efficacy endpoints: primary — radiographic union at 6 months (bridging callus across ≥3/4 cortices on orthogonal radiographs); time to union; LEFS (0–80) at 12 months; time to full weight-bearing (independent ambulation without pain/assistive devices).

(2) Safety endpoints: healing complications — nonunion (no union by 9 months or no progression), delayed union (no union by 6 months), malunion (>5° coronal, >10° sagittal/rotation, or limb-length discrepancy >1.5 cm); surgical-site infection (superficial vs deep); implant-related events (hardware failure or symptomatic implants requiring unplanned removal); other adverse events (compartment syndrome, iatrogenic nerve palsy, venous thromboembolism)

2.4 Statistical Analysis

Statistical analyses were performed using IBM SPSS Statistics, version 28.0 (IBM Corp., Armonk, NY, USA). Continuous variables were summarized as mean ± standard deviation (SD), whereas categorical variables were expressed as frequencies and percentages.

3. Results

3.1 Patient and Fracture Characteristics

The study included 100 patients with 155 fractures. The mean age was 38.5 years, and 65.0% were male. Motor vehicle accidents were the most common mechanism (63.0%). Of the fractures, 54.8% were femoral, and 20.6% were open (Table 1).

3.2 Clinical Efficacy Outcomes

At 6 months, 93.5% (145/155) of fractures achieved radiographic union. The mean time to union was 16.8 weeks. The mean 12-month LEFS score was 70.5 ± 9.8 (Table 1).

3.3 Safety and Complications

Complications in 22 patients (25/155, 16.1%): delayed union 8 (5.2%), nonunion 3 (1.9%; exchange nailing ± graft), malunion 5 (3.2%; predominantly rotational), superficial infection 6 The overall complication rate was 16.1% (25/155 fractures). This included delayed union (5.2%), nonunion (1.9%), malunion (3.2%), superficial infection (3.9%), and deep infection (1.9%) (Table 1).

Table 1. Baseline Characteristics, Clinical Outcomes, and Postoperative Complications

Category	Variable	Value
Patient-level (N = 100)	Age (years), mean ± SD	38.5 ± 15.2
	Sex, n (%)	Male 65 (65.0)
		Female 35 (35.0)
	Mechanism of injury, n (%)	Motor vehicle accident 63 (63.0)
		Fall 27 (27.0)
		Other 10 (10.0)
Fracture-level (n = 155)	Fractured bone, n (%)	Femur 85 (54.8)
		Tibia 70 (45.2)
	AO/OTA type, n (%)	A 85 (54.8)
		B 53 (34.2)
		C 17 (11.0)
	Open fracture, n (%)	32 (20.6)
Efficacy outcomes	Union at 6 months, n/N (%)	145/155 (93.5)
	Time to union (weeks), mean ± SD	16.8 ± 4.5
	Time to full weight-bearing (weeks), mean ± SD	12.5 ± 3.8
	LEFS at 12 months, mean ± SD	70.5 ± 9.8
Complications (per fracture, n = 155)	Total complications, n (%)	25 (16.1)
	Delayed union, n (%)	8 (5.2)

Category	Variable	Value
	Nonunion, n (%)	3 (1.9)
	Malunion, n (%)	5 (3.2)
	Superficial infection, n (%)	6 (3.9)
	Deep infection, n (%)	3 (1.9)
	Implant-related, n (%)	3 (1.9)

Notes: Patient-level variables are summarized by patients (N=100); fracture-level variables are summarized by fractures (N=155). Complications occurred in 22 patients, involving 25 fractures. The Lower Extremity Functional Scale (LEFS) is a patient-level outcome measure. LEFS = Lower Extremity Functional Scale; FWB = full weight-bearing.

4. Discussion

Our findings reaffirm that intramedullary nailing is a highly effective treatment for femoral and tibial diaphyseal fractures. The 93.5% union rate at 6 months aligns with large clinical series, and the mean time to union of approximately 17 weeks reflects the expected course of secondary healing with a load-sharing implant.

Modern fracture care prioritizes functional restoration. The mean 12-month LEFS score of 70.5 indicates that most patients achieve near-normal lower extremity function [2]. However, residual deficits, such as quadriceps weakness after femoral nailing, remain relevant and underscore the need for targeted rehabilitation.

The overall complication rate of 16.1% is comparable to published reports [4,5]. Notably, the nonunion rate of 1.9% is at the lower end of the reported spectrum, a finding likely attributable to standardized techniques, including reamed nailing, which promotes higher union rates. Malunion (3.2%) continues to be a technical challenge, particularly in maintaining rotational alignment in multifragmentary fractures. The deep infection rate of 1.9% is consistent with accepted standards, reinforcing the importance of strict adherence to aseptic protocols. The primary limitations of this study are its retrospective, single-center design and the absence of a control group.

5. Conclusion

This analysis confirms that intramedullary nailing for femoral and tibial diaphyseal fractures provides excellent clinical and functional outcomes, with high union rates and a low incidence of major complications. These findings reinforce IM nailing as the gold standard for these injuries.

References

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