

Outcome Analysis of Intramedullary Interlock Nailing in Semiextended Knee Position for Extra Articular Distal Tibial Fractures

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Abstract:

Background: Distal tibial fractures often pose challenges due to soft tissue injury, malalignment, and infection. Intramedullary interlocking nailing in the semi-extended knee position offers better reduction, minimal soft tissue trauma, and fewer postoperative complications compared to the conventional flexed-knee approach. Present study was to evaluate the functional and radiological outcomes of intramedullary interlock nailing in the semi-extended knee position for extra-articular distal tibial fractures and to assess complications such as malalignment, malrotation, anterior knee pain, and infection.

Methods: This prospective observational study included 58 patients (mean age 42.6 years) treated between January 2021 and September 2023 at Gandhi Medical College, Bhopal. Patients were followed up for six months. Functional outcome was assessed using Johner and Wruh's criteria.

Results: Out of 58 patients, 50 completed follow-ups. The mean union time was 17.06 weeks. Complications included two superficial infections, one non-union, and one case of osteomyelitis. According to Johner and Wruh's criteria, 52% of cases were graded as excellent, 38% as good, and 10% as fair.

Conclusion: Intramedullary interlock nailing in the semi-extended knee position is a reliable and effective technique for distal tibial fractures, offering good alignment, early mobilization, and minimal complications.

Keywords: Semi-Extended Tibial Nailing, Distal Tibia Fracture, Intramedullary Nail, Functional Outcome.

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Introduction

Distal tibial fractures account for approximately 10–15% of all tibial fractures and are among the most challenging injuries for orthopedic surgeons due to limited soft tissue coverage, poor vascularity, and proximity to the ankle joint [1,2]. These fractures are often the result of high-energy trauma such as road traffic accidents or falls from height and are frequently associated with comminution and soft tissue compromise. The management of these injuries is complicated by difficulties in maintaining alignment, delayed union, and postoperative infections.

Traditional open reduction and internal fixation (ORIF) using plates provides stable fixation but has been associated with higher infection rates and soft tissue complications. Minimally invasive plate osteosynthesis (MIPO) techniques have reduced soft tissue damage but remain technically demanding and sometimes fail to achieve anatomic reduction, particularly in comminuted fractures [3]. In contrast, intramedullary interlocking nailing (IMIL) has

gained wide acceptance as a biological fixation method that preserves periosteal blood supply, minimizes soft tissue disruption, and allows early mobilization and weight-bearing [4].

However, the conventional infrapatellar nailing technique, performed with the knee in a hyperflexed position, has certain drawbacks. These include difficulties in achieving accurate reduction due to fracture displacement, and a high incidence of postoperative anterior knee pain, reported in up to 80% of cases [5,6]. To overcome these issues, the semi-extended or suprapatellar approach was developed around the early 2000s. This technique allows nail insertion with the knee in near extension, improving fluoroscopic visualization, facilitating reduction, and reducing strain on the extensor mechanism [7].

Recent clinical studies have demonstrated that the semi-extended approach results in improved alignment, reduced operative time, and lower rates of anterior knee pain compared to the traditional

approach [8–10]. Gao et al. (2022) and Wang et al. (2023) reported that the suprapatellar technique leads to fewer cases of malalignment and better patient satisfaction scores. Despite these advantages, limited Indian data exist evaluating the outcomes of this technique in distal tibial fractures.

Materials And Methods

This prospective observational study was conducted in the Department of Orthopaedics, Gandhi Medical College and Associated Hamidia Hospital, Bhopal (Madhya Pradesh, India), from January 2021 to September 2023, after obtaining approval from the Institutional Ethics Committee (IEC/Orth/2021/034). Written informed consent was obtained from all participants prior to inclusion.

Study Design and Population: A total of 58 consecutive patients aged between 18 and 65 years with extra-articular distal one-third tibial fractures were included in the study. The diagnosis was established based on clinical evaluation and standard anteroposterior and lateral radiographs. Both open Grade I and Grade II fractures according to the Gustilo–Anderson classification were eligible. Patients unfit or unwilling for surgery, those below 18 years of age, with proximal or mid-shaft tibial fractures, or with open Grade III injuries were excluded.

Surgical Technique: All surgeries were performed under spinal or combined spinal-epidural anesthesia by the same surgical team. Patients were placed supine on a radiolucent operating table with a bolster beneath the knee to maintain approximately 30° flexion. A midline incision was made from the upper pole of the patella, followed by splitting of the quadriceps tendon. Under fluoroscopic guidance, the entry point was created just medial to the lateral tibial spine.

A guidewire was advanced across the fracture site following manual or joystick-assisted reduction. Sequential reaming was performed, and an appropriately sized intramedullary nail—1 mm smaller than the last reamer—was inserted. Proximal locking was achieved using an attached jig, while distal locking was done using the free-hand technique under C-arm control. Fibular fixation was carried out when the fracture line extended within 8 cm of the ankle joint, using either plating or rush nailing based on the fracture pattern and stability (Figure 1).

Postoperative Management and Follow-Up:

Postoperatively, the limb was elevated and early ankle and toe mobilization exercises were initiated. Partial weight-bearing was allowed after radiographic evidence of early callus formation, typically at six weeks, and full weight-bearing after confirmation of fracture union. Patients were followed up at 3 weeks, 6 weeks, 3 months, and 6 months post-surgery, and clinical as well as radiological assessments were performed at each visit.

Outcome Measures: Functional outcomes were evaluated according to Johner and Wruh's criteria, which consider union, alignment, range of motion, gait, and the presence of complications such as infection or anterior knee pain. Radiological union was defined as the presence of bridging callus in at least three of four cortices on orthogonal views.

Statistical Analysis: All collected data were entered into Microsoft Excel and analyzed using SPSS version 27.0 (IBM Corp., Armonk, NY). Continuous variables were expressed as mean \pm standard deviation (SD), while categorical data were presented as frequencies and percentages. The Chi-square test was used to assess associations between categorical variables, and $p < 0.05$ was considered statistically significant.

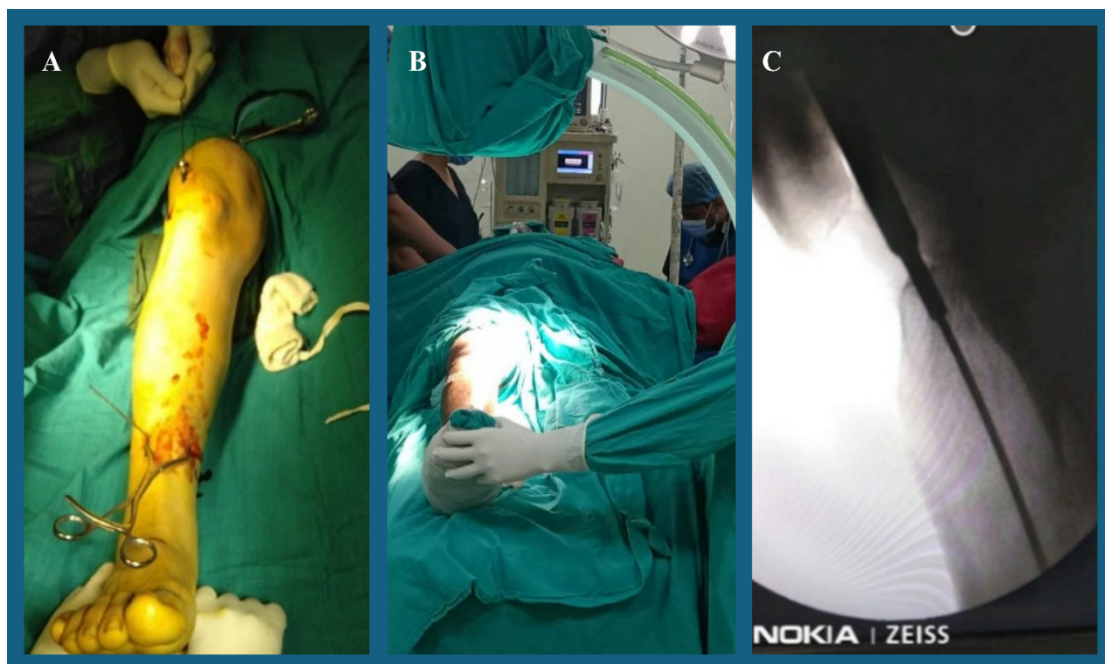


Figure 1: A- Showing Fluoroscopy Positioning; B- showing incision and reduction technique; C- Showing Fluoroscopic view of Guide Wire insertion

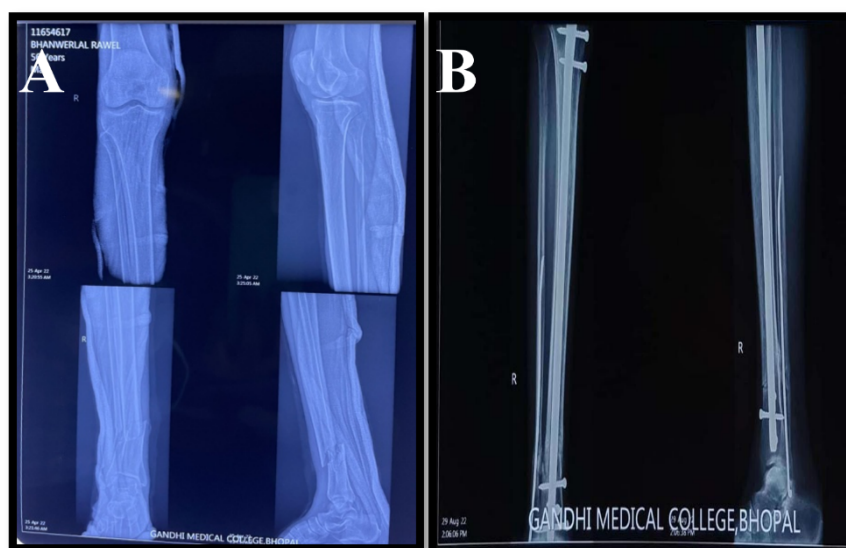


Figure 2: A and B showing preoperative Xray and post operative x ray after 4 months respectively

Results

A total of 58 patients with extra-articular distal one-third tibial fractures were enrolled in the study. Eight patients were lost to follow-up, and 50 patients were evaluated for clinical and radiological outcomes over an average duration of 24.38 weeks.

Demographic and Baseline Characteristics: The majority of patients were males (76%), and most belonged to the 31–50-year age group (68%), indicating that these injuries were common among the active working population. According to the Gustilo–Anderson classification, 52% of cases were

Grade II, 16% were Grade I, and 32% were closed fractures.

Associated fibular fractures were noted in 68% of patients, of which 4% underwent fibular plating, 68% were treated with rush nailing, and 28% were managed conservatively. The distal tip tibial interlocking nail was used in 76% of cases, whereas 24% underwent fixation with a conventional tibial interlocking nail. The mean union time was 17.06 ± 2.4 weeks.

Table 1: Baseline Demographic and Clinical Characteristics (n = 50)

Parameter	Category	Number (%)
Age group (years)	18–30	10 (20%)
	31–50	34 (68%)
	>50	6 (12%)
Sex	Male	38 (76%)
	Female	12 (24%)
Fracture type	Closed	16 (32%)
	Grade I (Gustilo–Anderson)	8 (16%)
	Grade II (Gustilo–Anderson)	26 (52%)
Associated fibula fracture	Present	34 (68%)
	Absent	16 (32%)
Type of tibial nail used	Distal-tip nail	38 (76%)
	Conventional nail	12 (24%)
Mean union time (weeks)	—	17.06 ± 2.4

Functional and Radiological Outcomes:

Functional outcomes were assessed using Johner and Wruh's criteria. Out of the 50 evaluated cases, 52% of patients achieved excellent, 38% had good, and 10% had fair functional results (Figure 2).

In terms of joint mobility, 78% of patients retained normal knee motion, while the remaining 22% maintained more than 80% of the normal range. Subtalar mobility exceeded 75% in 82% of patients.

Anterior knee pain was absent in 70% of patients and reported as occasional in 30%. Regarding gait, 84%

walked normally, 12% had an insignificant limp, and 4% showed a significant limp. Strenuous activity was possible in 88%, limited in 10%, and severely limited in 2% of cases.

The most frequent complications were superficial infection (4%), non-union (2%), and osteomyelitis (2%). All infections resolved with appropriate treatment, and the non-union and osteomyelitis cases were successfully managed by revision or staged nailing procedures.

Table 2: Functional and Radiological Outcomes (Johner & Wruh's Criteria)

Outcome Parameter	Observation	Number (%)
Functional grade	Excellent	26 (52%)
	Good	19 (38%)
	Fair	5 (10%)
Knee joint mobility	Normal (>90%)	39 (78%)
	>80% of normal	11 (22%)
Anterior knee pain	None	35 (70%)
	Occasional	15 (30%)
Gait pattern	Normal	42 (84%)
	Insignificant limp	6 (12%)
	Significant limp	2 (4%)
Complications	Superficial infection	2 (4%)
	Non-union	1 (2%)
	Osteomyelitis	1 (2%)

The mean fracture union time was approximately 17 weeks, with 90% of patients achieving excellent to good functional outcomes. Postoperative complications were minimal, and deformities such as varus, valgus, or rotational malalignment remained within acceptable limits in the vast majority of cases.

Overall, intramedullary interlocking nailing in the semi-extended knee position resulted in stable fixation, early union, and excellent functional recovery with low complication rates and minimal anterior knee discomfort.

Discussion

Distal tibial fractures are among the most challenging injuries in orthopaedic practice because of their limited soft-tissue coverage, poor vascularity, and proximity to the ankle joint, which predispose them to delayed union, malalignment, and infection. In the present study, intramedullary interlocking nailing performed in the semi-extended knee position provided encouraging results, with 90% of patients achieving excellent or good functional outcomes and a mean union time of 17.06 ± 2.4 weeks. The overall union rate was 98%, and postoperative complications were minimal,

demonstrating the reliability of this minimally invasive technique for extra-articular distal tibial fractures.

The results of this study suggest that the semi-extended approach allows easier reduction, better fluoroscopic visualization, and reduced complications compared with the conventional infrapatellar method. The mean union time in our series was comparable to that reported by Nork et al. [5] and Tyllianakis et al. [4], who documented fracture union within 16–18 weeks after intramedullary nailing. The demographic trend of our patients, with a predominance of males (76%) in the 31–50-year age group, was consistent with Singh et al. [1], who noted that such fractures are common among the active, working population exposed to high-energy trauma.

Recent literature further supports the clinical advantages of the semi-extended or suprapatellar approach. Gao et al. [10] and Lu et al. [9] demonstrated significantly lower rates of malalignment and anterior knee pain with the suprapatellar approach compared to the infrapatellar technique. Wang et al. [11] also reported superior radiological alignment and reduced operative time using the semi-extended infrapatellar approach. In a prospective study, Lakhani et al. [12] observed 94% satisfactory functional outcomes in patients treated with suprapatellar nailing for distal tibial fractures. These observations are in line with the present findings and collectively emphasize that the semi-extended technique offers improved mechanical alignment, reduced anterior knee discomfort, and faster rehabilitation.

The overall complication rate in this study was low (8%), with only two cases of superficial infection, one non-union, and one osteomyelitis. Similar favorable results were described by Vallier et al. [3] and Saini et al. [2], who reported lower infection rates and faster recovery following intramedullary nailing compared with plating. Fibular fixation, performed in 68% of our patients, helped maintain alignment and stability, as also emphasized by Gadegone et al. [6] and Teitz et al. [7]. The incidence of anterior knee pain in our series (30%) was considerably lower than the 40–80% rates reported after conventional infrapatellar nailing, consistent with Janssen et al. [8] and Saini et al. [2]. Biomechanical studies by Gelbke et al. [14] demonstrated that although suprapatellar nail insertion slightly increases patellofemoral contact pressures, these remain within physiological limits and are not clinically significant.

Overall, the present findings reinforce that intramedullary interlocking nailing in the semi-extended knee position ensures stable fixation, excellent alignment, and early postoperative mobilization with minimal soft-tissue disruption and

low complication rates. Nevertheless, a few limitations must be acknowledged, including the relatively small sample size, short follow-up period, and absence of a comparative infrapatellar control group. Postoperative CT evaluation was also not performed to assess subtle rotational malalignment. Despite these constraints, the favorable union rate, minimal infection, and high proportion of excellent-to-good outcomes underscore the efficacy and safety of the semi-extended approach in the management of extra-articular distal tibial fractures.

Conclusion

Intramedullary interlocking nailing performed in the semi-extended knee position is a safe, reliable, and minimally invasive technique for the management of extra-articular distal tibial fractures. It provides stable fixation, accurate alignment, early union, and satisfactory functional recovery with minimal postoperative complications such as anterior knee pain or infection. The technique also facilitates easier fracture reduction and improved fluoroscopic visualization without excessive strain on the patellar tendon. Although the present study was limited by a relatively small sample size, short follow-up duration, and absence of a comparative infrapatellar control group, the overall findings strongly support the clinical utility of the semi-extended approach as an effective alternative to conventional infrapatellar nailing. Larger multicentric, randomized controlled studies with longer follow-up are recommended to further validate these outcomes and assess long-term functional and radiological benefits.

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