

A Comparative Analysis of Suprapatellar and Infrapatellar Techniques in Tibial Shaft Fracture Fixation

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Abstract

Background: Intramedullary interlocking nailing is the standard treatment for tibial shaft fractures; however, the optimal surgical approach remains controversial. The suprapatellar approach has recently gained popularity because of easier fracture reduction and improved alignment, while concerns regarding intra-articular injury persist. The present study compared suprapatellar and infrapatellar approaches for tibial intramedullary nailing with respect to operative, radiological, functional, and complication-related outcomes.

Methods: This prospective comparative observational study included 87 patients with tibial shaft fractures managed with intramedullary interlocking nailing. Patients were divided into suprapatellar (Group A, n=44) and infrapatellar (Group B, n=43) groups based on the surgical approach used. Operative parameters including operative time, fluoroscopy duration, blood loss, and hospital stay were recorded. Radiological outcomes, fracture union, malalignment, knee range of motion, Lysholm Knee Score, and postoperative complications were evaluated during follow-up. Statistical analysis was performed using SPSS version 25.0, and $p < 0.05$ was considered statistically significant.

Results: The suprapatellar group demonstrated significantly shorter operative time (78.4 ± 11.2 vs 92.6 ± 13.8 minutes; $p < 0.001$), reduced fluoroscopy exposure (78.9 ± 16.5 vs 104.3 ± 21.6 seconds; $p < 0.001$), and lower blood loss (108.5 ± 28.7 vs 126.4 ± 31.5 mL; $p = 0.007$). Mean fracture union time was significantly lower in the suprapatellar group (18.6 ± 3.1 vs 20.4 ± 3.8 weeks; $p = 0.019$). Malalignment was significantly less frequent in Group A (4.5% vs 18.6%; $p = 0.041$). Functional outcomes were superior in the suprapatellar group with higher Lysholm Knee Scores (91.8 ± 5.7 vs 84.6 ± 7.9 ; $p < 0.001$) and lower incidence of anterior knee pain (13.6% vs 37.2%; $p = 0.011$).

Conclusion: The suprapatellar approach for tibial intramedullary nailing offers significant advantages over the infrapatellar approach, including improved operative efficiency, better fracture alignment, superior functional outcomes, and reduced anterior knee pain without increasing complication rates. It represents a safe and effective alternative for the management of tibial shaft fractures.

Keywords: Tibial shaft fracture; Intramedullary interlocking nail; Anterior knee pain; Functional outcome; Tibial nailing.

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Introduction

Tibial shaft fractures are among the most common long-bone injuries encountered in orthopedic trauma practice, accounting for nearly 2–3% of all

fractures and approximately 15–20% of lower extremity fractures worldwide [1].

These fractures commonly result from high-energy trauma such as road traffic accidents and are

frequently associated with significant morbidity due to the subcutaneous location and limited soft tissue coverage of the tibia [2].

Complications including malalignment, delayed union, nonunion, infection, and postoperative functional limitation remain major concerns in management [2].

Intramedullary interlocking nailing is considered the gold standard treatment for displaced and unstable tibial shaft fractures because it provides stable fixation, preserves fracture biology, and allows early mobilization with high union rates [3]. Traditionally, tibial nailing has been performed using the infrapatellar (IP) approach with the knee in flexion [4]. Although widely accepted, the infrapatellar technique is associated with several limitations, including difficulty in maintaining reduction in proximal tibial fractures, increased fluoroscopy exposure, technical challenges in obese patients, and postoperative anterior knee pain, which has been reported in up to 70% of patients following tibial nailing [4,5].

The suprapatellar (SP) approach has recently gained popularity as an alternative technique for tibial intramedullary nailing [6]. In this method, the nail is inserted through the quadriceps tendon with the knee maintained in a semi-extended position. This facilitates fracture reduction by minimizing deforming quadriceps forces and may improve alignment, especially in proximal and metaphyseal fractures [6]. Additionally, the SP approach has been associated with reduced operative time, easier fluoroscopic visualization, and lower rates of malalignment [7].

Despite these advantages, concerns remain regarding possible intra-articular cartilage injury, septic arthritis, knee stiffness, and postoperative knee pain due to instrumentation through the patellofemoral joint [8]. It is being previously reported that conflicting findings regarding functional outcomes, anterior knee pain, and complication rates between the suprapatellar and infrapatellar techniques [9,10].

Therefore, the present study was aimed to compare the suprapatellar and infrapatellar approaches for intramedullary nailing in tibial shaft fractures with respect to operative parameters, radiological alignment, fracture union, postoperative pain, functional outcomes, and complications.

Materials and Methods

Study Design and Setting: This prospective comparative observational study was conducted in the Department of Orthopaedics at a tertiary care teaching hospital over a period of 24 months between May 2023 to April 2025 after obtaining approval from the Institutional Ethics Committee.

The study was designed to compare the clinical, radiological, and functional outcomes of suprapatellar and infrapatellar approaches for intramedullary interlocking nailing in tibial shaft fractures. Written informed consent was obtained from all patients prior to inclusion in the study.

Study Population: Patients aged between 18 and 65 years presenting with acute tibial shaft fractures requiring operative fixation with intramedullary interlocking nailing were included in the study. Both closed fractures and Gustilo–Anderson type I and II open fractures involving the tibial diaphysis were considered eligible. Patients with pathological fractures, fractures with intra-articular extension, associated neurovascular injury, previous knee surgery, ipsilateral femoral fractures, Gustilo–Anderson type III open fractures, polytrauma requiring prolonged intensive care management, and patients medically unfit for surgery were excluded from the study.

A total of 87 patients fulfilling the inclusion criteria were enrolled and divided into two groups of 30 patients each according to the surgical approach used. Group A consisted of patients managed using the suprapatellar approach, while Group B included patients treated with the infrapatellar approach.

Preoperative Assessment: Detailed demographic and clinical data including age, sex, mode of injury, side involved, fracture pattern, and fracture location were recorded at admission. All patients underwent thorough clinical examination and radiographic assessment using anteroposterior and lateral radiographs of the leg including the knee and ankle joints. Fractures were classified according to the AO/OTA classification system. Routine preoperative hematological and biochemical investigations were performed in all patients prior to surgery.

Surgical Technique: All surgical procedures were performed under spinal or combined spinal-epidural anesthesia with the patient positioned supine on a radiolucent operating table under fluoroscopic guidance. In the suprapatellar group, the knee was maintained in approximately 15–20 degrees of flexion using a bolster placed beneath the knee. A longitudinal incision was made proximal to the superior pole of the patella, and the quadriceps tendon was split longitudinally. A protective cannula system was inserted through the patellofemoral joint to facilitate safe guidewire insertion and nail passage while minimizing intra-articular cartilage injury.

In the infrapatellar group, the knee was flexed to nearly 90 degrees, and a transpatellar or medial parapatellar tendon approach was utilized for nail insertion. After fracture reduction and guidewire placement, sequential reaming was performed, followed by insertion of an appropriately sized

tibial intramedullary interlocking nail. Proximal and distal locking screws were inserted under fluoroscopic guidance in both groups.

Postoperative Management and Follow-up:

Postoperatively, all patients received standardized antibiotic prophylaxis, analgesics, and physiotherapy protocols. Early active and passive knee and ankle mobilization exercises were initiated as tolerated. Partial weight-bearing was allowed depending on fracture stability and radiological evidence of healing, followed by progression to full weight-bearing. Patients were followed up clinically and radiologically at 6 weeks, 3 months, and 6 months after surgery. Outcome parameters evaluated included operative time, fluoroscopy duration, intraoperative blood loss, fracture union time, malalignment, anterior knee pain, knee range of motion, and postoperative complications including infection, delayed union, nonunion, and implant failure. Functional outcome was assessed using the Lysholm Knee Scoring Scale at final follow-up. Radiological union was defined as bridging callus formation across at least three cortices on orthogonal radiographs along with painless full weight-bearing.

Statistical Analysis: The collected data were entered into Microsoft Excel and analyzed using Statistical Package for Social Sciences (SPSS) software version 25.0. Quantitative variables were expressed as mean \pm standard deviation, while qualitative variables were presented as frequencies

and percentages. Student's t-test was used for comparison of continuous variables, whereas Chi-square test or Fisher's exact test was used for categorical variables. A p-value of less than 0.05 was considered statistically significant.

Results

A total of 87 patients with tibial shaft fractures were included in the study, comprising 44 patients in the suprapatellar group and 43 patients in the infrapatellar group. The mean age of patients was comparable between Group A and Group B (38.6 ± 12.4 vs 40.1 ± 11.7 years; $p=0.564$). The majority of patients belonged to the 31–45 years age group in both cohorts.

Male predominance was observed in both groups, accounting for 77.3% in the suprapatellar group and 76.7% in the infrapatellar group ($p=0.948$). Road traffic accidents were the most common mode of injury, reported in 70.5% and 67.4% of patients in Groups A and B respectively. Most fractures were closed injuries, while open fractures (Gustilo–Anderson type I/II) constituted 20.5% in Group A and 18.6% in Group B.

No statistically significant differences were observed between the groups regarding demographic profile, injury characteristics, side involved, or duration from injury to surgery, indicating baseline comparability of the study population (Table 1).

Table 1: Baseline Demographic and Clinical Characteristics of Patients Undergoing Suprapatellar and Infrapatellar Tibial Intramedullary Nailing

Variable	Group A (Suprapatellar) n=44	Group B (Infrapatellar) n=43	p-value
	Frequency (%) / Mean \pm SD		
Age (years)	38.6 ± 12.4	40.1 ± 11.7	0.564
Age group (years)			
18–30	13 (29.5%)	11 (25.6%)	0.781
31–45	19 (43.2%)	18 (41.9%)	
46–60	9 (20.5%)	11 (25.6%)	
>60	3 (6.8%)	3 (7.0%)	
Gender			
Male	34 (77.3%)	33 (76.7%)	0.948
Female	10 (22.7%)	10 (23.3%)	
Mode of injury			
Road traffic accident	31 (70.5%)	29 (67.4%)	0.837
Fall from height	8 (18.2%)	10 (23.3%)	
Assault/sports injury	5 (11.3%)	4 (9.3%)	
Side involved			
Right	26 (59.1%)	24 (55.8%)	0.689
Left	18 (40.9%)	19 (44.2%)	
Type of fracture			
Open fractures (Type I/II)	9 (20.5%)	8 (18.6%)	0.827
Closed fractures	35 (79.5%)	35 (81.4%)	
Duration from injury to surgery (days)	3.8 ± 1.6	4.1 ± 1.8	0.411

Assessment of fracture morphology demonstrated that middle-third tibial shaft fractures were the most common pattern in both groups, accounting for 54.5% in the suprapatellar group and 58.1% in the infrapatellar group. Proximal-third fractures were observed slightly more frequently in Group A (25.0%) compared to Group B (20.9%).

According to AO/OTA classification, type 42-A fractures constituted the majority of cases in both

groups, followed by type 42-B and type 42-C fractures. Associated fibular fractures were present in 68.2% of patients in the suprapatellar group and 72.1% in the infrapatellar group.

No statistically significant intergroup differences were identified regarding fracture location, fracture type, or associated fibular injury ($p>0.05$), suggesting uniform fracture distribution between the study cohorts (Table 2).

Table 2: Fracture Characteristics According to AO/OTA Classification in Both Study Groups

Variable	Group A (Suprapatellar) n=44	Group B (Infrapatellar) n=43	p-value
	Frequency (%)		
Fracture location			
Proximal third	11 (25.0%)	9 (20.9%)	0.612
Middle third	24 (54.5%)	25 (58.1%)	
Distal third	9 (20.5%)	9 (20.9%)	
AO/OTA fracture type			
42-A	21 (47.7%)	20 (46.5%)	0.903
42-B	15 (34.1%)	16 (37.2%)	
42-C	8 (18.2%)	7 (16.3%)	
Associated fibula fracture	30 (68.2%)	31 (72.1%)	0.691

AO/OTA: Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Association classification.

The suprapatellar approach demonstrated significantly superior operative parameters compared with the infrapatellar approach. Mean operative time was significantly shorter in Group A than in Group B (78.4 ± 11.2 vs 92.6 ± 13.8 minutes; $p<0.001$). Similarly, fluoroscopy duration was markedly reduced in the suprapatellar group (78.9 ± 16.5 vs 104.3 ± 21.6 seconds; $p<0.001$). Intraoperative blood loss was also significantly

lower in patients treated with the suprapatellar approach (108.5 ± 28.7 mL vs 126.4 ± 31.5 mL; $p=0.007$). Although open reduction was required less frequently in Group A (9.1%) than Group B (23.3%), the difference did not reach statistical significance ($p=0.071$). Mean hospital stay was significantly shorter in the suprapatellar group compared to the infrapatellar group (6.4 ± 1.8 vs 7.5 ± 2.1 days; $p=0.011$) (Table 3).

Table 3: Comparison of Operative Parameters Between Suprapatellar and Infrapatellar Approaches

Variable	Group A (Suprapatellar) n=44	Group B (Infrapatellar) n=43	p-value
	Frequency (%) / Mean \pm SD		
Operative time (minutes)	78.4 ± 11.2	92.6 ± 13.8	<0.001
Fluoroscopy time (seconds)	78.9 ± 16.5	104.3 ± 21.6	<0.001
Intraoperative blood loss (mL)	108.5 ± 28.7	126.4 ± 31.5	0.007
Need for open reduction	4 (9.1%)	10 (23.3%)	0.071
Hospital stay (days)	6.4 ± 1.8	7.5 ± 2.1	0.011

Patients treated using the suprapatellar approach demonstrated significantly improved radiological and functional outcomes compared with the infrapatellar group.

Mean fracture union time was significantly shorter in Group A (18.6 ± 3.1 weeks) compared to Group B (20.4 ± 3.8 weeks; $p=0.019$). Malalignment greater than 5 degrees was observed in only 4.5% of patients in the suprapatellar group versus 18.6% in the infrapatellar group, showing a statistically significant difference ($p=0.041$).

The mean knee flexion achieved at final follow-up was significantly greater in Group A than Group B ($128.6 \pm 8.4^\circ$ vs $121.2 \pm 10.6^\circ$; $p<0.001$).

Functional assessment using the Lysholm Knee Score also revealed significantly better outcomes in the suprapatellar group (91.8 ± 5.7 vs 84.6 ± 7.9 ; $p<0.001$). Furthermore, excellent-to-good functional outcomes were achieved in 88.6% of patients undergoing suprapatellar nailing compared with 72.1% in the infrapatellar group ($p=0.049$) (Table 4).

Table 4: Radiological and Functional Outcomes Following Tibial Intramedullary Nailing

Variable	Group A (Suprapatellar) n=44	Group B (Infrapatellar) n=43	p-value
	Frequency (%) / Mean \pm SD		
Union time (weeks)	18.6 \pm 3.1	20.4 \pm 3.8	0.019
Delayed union	3 (6.8%)	6 (14.0%)	0.286
Malalignment (>5°)	2 (4.5%)	8 (18.6%)	0.041
Knee flexion at final follow-up (degrees)	128.6 \pm 8.4	121.2 \pm 10.6	<0.001
Lysholm knee score	91.8 \pm 5.7	84.6 \pm 7.9	<0.001
Excellent/Good outcome	39 (88.6%)	31 (72.1%)	0.049

Functional outcome assessed using Lysholm Knee Scoring Scale. Malalignment defined as angular deformity >5°.

Postoperative complications were comparatively lower in the suprapatellar group. Anterior knee pain was significantly less frequent among patients treated using the suprapatellar approach than the infrapatellar approach (13.6% vs 37.2%; $p=0.011$). Superficial infection occurred in 4.5% of Group A and 7.0% of Group B patients, while deep infection was observed in one patient in each group. Knee stiffness was more commonly noted in the infrapatellar group (11.6%) compared with the

suprapatellar group (4.5%), although the difference was not statistically significant ($p=0.224$).

Nonunion, implant failure, and reoperation rates were also numerically higher in the infrapatellar group; however, these differences did not achieve statistical significance.

Overall, the suprapatellar approach demonstrated a lower complication profile with significantly reduced incidence of anterior knee pain (Table 5).

Table 5: Postoperative Complications Following Suprapatellar and Infrapatellar Tibial Nailing

Complication	Group A (Suprapatellar) n=44	Group B (Infrapatellar) n=43	p-value
	Frequency (%)		
Anterior knee pain	6 (13.6%)	16 (37.2%)	0.011
Superficial infection	2 (4.5%)	3 (7.0%)	0.624
Deep infection	1 (2.3%)	1 (2.3%)	0.987
Knee stiffness	2 (4.5%)	5 (11.6%)	0.224
Nonunion	1 (2.3%)	3 (7.0%)	0.309
Implant failure	1 (2.3%)	2 (4.7%)	0.562
Reoperation required	2 (4.5%)	5 (11.6%)	0.224

Discussion

Tibial shaft fractures remain one of the most frequently encountered long-bone injuries requiring operative fixation, and intramedullary interlocking nailing continues to be the standard treatment modality because of its biomechanical stability and favorable union rates.

However, the optimal surgical approach for nail insertion remains controversial. The present study compared suprapatellar and infrapatellar approaches for tibial intramedullary nailing and demonstrated that the suprapatellar approach was associated with superior operative efficiency, improved alignment, better functional outcomes, and reduced postoperative anterior knee pain.

In the present study, the majority of patients were young adult males, with mean ages of 38.6 \pm 12.4 years in the suprapatellar group and 40.1 \pm 11.7 years in the infrapatellar group. Road traffic accidents accounted for nearly 70% of injuries in both groups. These findings are consistent with previous Indian and international studies by Beaudoin et al., Hendrickx et al., and Karladani et

al., which reported a predominance of tibial shaft fractures among economically productive young males due to high-energy trauma mechanisms [11,12,13]. The high incidence among males may be explained by greater occupational exposure, increased outdoor activities, and higher rates of vehicular travel [13].

The present study demonstrated significantly shorter operative time in the suprapatellar group compared to the infrapatellar group (78.4 \pm 11.2 vs 92.6 \pm 13.8 minutes; $p<0.001$). Similar findings were reported by Sakale et al., and Panda et al., who observed that the semi-extended position used during suprapatellar nailing facilitates easier fracture reduction and simplifies guidewire placement, thereby reducing operative complexity [14,15]. In the infrapatellar approach, hyperflexion of the knee often causes displacement of fracture fragments due to quadriceps tension, especially in proximal-third tibial fractures, making reduction technically more demanding and time-consuming [16].

Fluoroscopy exposure was also significantly reduced in the suprapatellar group (78.9 ± 16.5 vs 104.3 ± 21.6 seconds; $p < 0.001$), which is comparable to findings reported in meta-analyses by MacDonald et al. and Chaubey et al., [17,18]. Reduced fluoroscopy time may be attributed to easier maintenance of reduction in the semi-extended position and improved intraoperative imaging alignment [19]. Decreased radiation exposure is clinically important for both the patient and operating room personnel, particularly in high-volume trauma centers [20].

The suprapatellar approach also showed significantly lower intraoperative blood loss and shorter hospital stay. These findings may be explained by less soft tissue manipulation, easier instrumentation, and reduced need for repeated fracture reduction maneuvers [21]. Although the difference in requirement for open reduction did not reach statistical significance (9.1% vs 23.3%; $p = 0.071$), the trend favored the suprapatellar technique, suggesting improved fracture control during nail insertion.

Radiological outcomes in the present study demonstrated significantly lower malalignment rates in the suprapatellar group (4.5% vs 18.6%; $p = 0.041$). Similar observations have been reported by Thompson et al., and Lee et al., particularly for proximal tibial fractures [22,23]. The semi-extended knee position minimizes the deforming pull of the quadriceps muscle, thereby maintaining alignment during reaming and nail insertion [24]. In contrast, excessive knee flexion during infrapatellar nailing tends to produce apex anterior deformity and malreduction, especially in proximal metaphyseal fractures.

Fracture union time was significantly shorter in the suprapatellar group (18.6 ± 3.1 weeks vs 20.4 ± 3.8 weeks; $p = 0.019$). This finding is consistent with studies by Lone et al., and Nimavat et al., who reported improved biological and mechanical conditions with suprapatellar nailing [25,26]. Better maintenance of alignment and reduced soft tissue trauma may contribute to enhanced fracture healing and earlier weight-bearing [26].

Functional outcomes assessed using the Lysholm Knee Score were significantly better in the suprapatellar group (91.8 ± 5.7 vs 84.6 ± 7.9 ; $p < 0.001$), with greater knee flexion achieved at final follow-up. These findings correlate with studies by Santhanam et al., and Chan et al., who observed improved postoperative knee function with suprapatellar nailing [27,28]. The reduced need for extreme knee flexion during surgery likely minimizes postoperative quadriceps irritation and peri-patellar soft tissue trauma, facilitating earlier mobilization and rehabilitation [27]. One of the most clinically relevant findings of the present

study was the significantly lower incidence of anterior knee pain in the suprapatellar group (13.6% vs 37.2%; $p = 0.011$). Anterior knee pain is one of the most common complications after tibial nailing and has been linked to patellar tendon injury, injury to the infrapatellar branch of the saphenous nerve, fat pad scarring, and chronic tendon irritation [27]. The infrapatellar approach requires splitting or retraction around the patellar tendon, which may explain the higher postoperative pain rates [28]. In contrast, the suprapatellar approach avoids direct injury to the patellar tendon and maintains the knee in a more physiologic position during surgery. Similar reductions in anterior knee pain with suprapatellar nailing have been reported in systematic reviews by Chen et al., and Gao et al [29,30].

Concerns regarding intra-articular cartilage injury and septic arthritis with suprapatellar nailing have been raised previously because instrumentation traverses the patellofemoral joint. However, in the present study, infection rates, implant failure, and reoperation rates were low and comparable between groups. No increased incidence of deep infection or clinically significant knee morbidity was observed in the suprapatellar group. These findings support previous studies by Valsamis et al., and Papotto et al., demonstrating that the use of protective sleeves effectively minimizes cartilage damage and intra-articular contamination [31,32].

Limitations

The present study was conducted at a single tertiary care center with a relatively limited sample size, which may restrict generalizability of the findings. The follow-up duration was limited to short- to mid-term assessment and may not reflect long-term functional outcomes or late complications such as patellofemoral degeneration. In addition, surgeon preference and variation in fracture morphology could have influenced operative and functional outcomes despite comparable baseline characteristics between groups.

Conclusion

The present study demonstrated that the suprapatellar approach for tibial intramedullary nailing provides superior operative and functional outcomes compared to the traditional infrapatellar approach.

Suprapatellar nailing was associated with significantly shorter operative time, reduced fluoroscopy exposure, lower blood loss, improved fracture alignment, faster union, better knee range of motion, and higher functional scores. Furthermore, the incidence of postoperative anterior knee pain was significantly lower in the suprapatellar group without an increase in infection, implant failure, or reoperation rates. The

semi-extended positioning during suprapatellar nailing facilitates easier fracture reduction and alignment maintenance, particularly in proximal and metaphyseal fractures. Therefore, the suprapatellar approach represents a safe, effective, and reliable alternative for the management of tibial shaft fractures.

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