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Research Article

A Comparative Prospective Study Evaluating Functional and Radiological Outcomes of Suprapatellar Versus Infrapatellar Approaches for Intramedullary Nailing in Patients with Distal Tibial Shaft Fractures

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ABSTRACT

Background: Distal tibial shaft fractures are common injuries associated with high-energy trauma and functional disability. Intramedullary nailing is the standard treatment; however, the optimal surgical approach, suprapatellar or infrapatellar, remains debated, particularly in resource-limited settings like Bihar, where early mobilization and functional recovery are essential.

Aim: To compare the functional and radiological outcomes of suprapatellar versus infrapatellar approaches for intramedullary nailing in patients with distal tibial shaft fractures.

Methodology: This prospective comparative study was conducted at a tertiary care center in Patna over one year, including 40 patients with distal tibial shaft fractures. Patients were equally divided into suprapatellar (n=20) and infrapatellar (n=20) groups. Outcomes assessed included fracture union time, malalignment, anterior knee pain (VAS), functional outcome using Lysholm knee score, and postoperative complications. Statistical analysis was performed using SPSS version 20.0, with $p < 0.05$ considered significant.

Results: The suprapatellar group demonstrated significantly shorter mean time to union (17.2 *vs* 19.6 weeks, $p = 0.02$), lower malalignment rates (10 vs 30%, $p = 0.04$), and better functional outcomes with higher Lysholm scores (91.6 vs 85.3, $p = 0.01$). Anterior knee pain was significantly lower in the suprapatellar group (VAS 1.8 vs 3.6, $p = 0.003$). Complication rates were lower in the suprapatellar group, with no significant increase in infection or implant failure.

Conclusion: Suprapatellar intramedullary nailing offers superior radiological alignment, faster fracture union, improved functional recovery, and reduced anterior knee pain compared to the infrapatellar approach, making it a preferable technique for distal tibial shaft fractures in the Bihar population.

Keywords: Tibial fractures, Intramedullary nailing, Suprapatellar approach, Infrapatellar approach, Fracture healing

INTRODUCTION

Fractures of the tibial shaft represent one of the most common long-bone injuries encountered in orthopedic practice, accounting for a significant proportion of trauma admissions worldwide. These fractures frequently occur following high-energy trauma such as road traffic accidents and falls from height, particularly affecting the economically productive young adult population [1]. Distal third tibial shaft fractures present unique challenges due to limited soft tissue coverage, metaphyseal widening, and biomechanical instability, which increase the risk of malalignment, delayed union, and functional impairment [2]. Intramedullary nailing (IMN) has become the gold standard for managing tibial shaft fractures because it provides stable fixation, allows early mobilization, and preserves the periosteal blood supply [3].

Traditionally, IMN of the tibia has been performed using the infrapatellar (IP) approach with the knee in flexion. Although widely practiced, this approach is associated with several technical and clinical limitations, including difficulty in maintaining reduction in distal fractures, increased fluoroscopy time, and a higher incidence of postoperative anterior knee pain [4]. The flexed knee position during IP nailing may also contribute to apex anterior deformity and malalignment, especially in distal tibial fractures where maintaining the mechanical axis is critical [5]. Studies have reported postoperative anterior knee pain in a considerable proportion of patients undergoing infrapatellar nailing, adversely affecting kneeling, squatting, and overall functional recovery [6].

The suprapatellar (SP) approach has emerged as an alternative technique that allows nail insertion through a semi-extended knee position. This approach provides improved alignment control, facilitates reduction, and reduces deformity, particularly in distal metaphyseal fractures [3]. Several comparative studies have demonstrated that SP nailing is associated with lower rates

of malalignment and postoperative knee pain compared with the IP approach, without compromising union rates or increasing complications [7]. A large retrospective comparative analysis reported significantly lower risk of malunion and postoperative knee pain with suprapatellar nailing compared to infrapatellar nailing, although functional outcomes were similar between groups [8]. Furthermore, systematic reviews and meta-analyses have suggested that the SP approach may offer superior functional scores, shorter operative time, and improved ankle and knee function in patients with distal tibial fractures [4].

Despite these promising results, the superiority of the suprapatellar approach remains a subject of ongoing debate. Recent randomized controlled trials have shown that although suprapatellar nailing may reduce early postoperative knee pain and improve kneeling ability, the differences in long-term functional outcomes between the two approaches may not be clinically significant [9]. Thus, the current literature reflects heterogeneity in results, and there is no universal consensus regarding the optimal approach for distal tibial shaft fractures. Moreover, most available evidence originates from high-income countries and tertiary trauma centers, which may not reflect the clinical realities of resource-limited settings.

In the context of India, particularly in Bihar, the burden of road traffic accidents and high-energy trauma has been steadily increasing, leading to a rising incidence of tibial shaft fractures. Bihar, being a densely populated state with a developing healthcare infrastructure, receives a large number of trauma referrals at tertiary care centers. Patients often present late, with complex fracture patterns, associated soft tissue injuries, and limited access to rehabilitation services. In such a setting, achieving early union, proper alignment, and optimal functional recovery is critical for reducing disability, economic burden, and loss of productivity among patients. However, there is a paucity of region-specific prospective data comparing suprapatellar and infrapatellar approaches for intramedullary nailing of distal tibial fractures in this population.

Additionally, socioeconomic factors, occupational demands (such as squatting and kneeling in daily life), and variations in postoperative rehabilitation compliance may influence functional outcomes differently in the Bihar population compared to Western cohorts. Anterior knee pain, malalignment, and delayed union can significantly affect the ability of patients to return to work, especially in labor-intensive occupations common in this region. Therefore, evaluating the most appropriate surgical approach for IMN in distal tibial fractures within this specific demographic context is of paramount importance.

Although multiple international studies have compared suprapatellar and infrapatellar approaches, there remains limited prospective evidence from Indian populations, particularly from Bihar. Differences in injury patterns, healthcare access, cultural practices, and functional expectations necessitate region-specific evaluation of these surgical techniques. A prospective comparative study conducted in a tertiary care center in Bihar would help determine the approach that offers better alignment, lower complication rates, reduced knee pain, and improved functional recovery in this population. Such evidence would guide surgeons in selecting the most effective and context-appropriate surgical technique, ultimately improving patient outcomes and reducing long-term disability.

The aim of this study is to prospectively compare the functional and radiological outcomes of suprapatellar versus infrapatellar approaches for intramedullary nailing in patients with distal tibial shaft fractures treated at a tertiary care center in Bihar, with specific evaluation of fracture union, alignment, anterior knee pain, complications, and functional recovery.

MATERIALS AND METHODS

This prospective comparative study was conducted in the Department of Orthopedics at MGM Medical College, Kishanganj, Bihar, India. The institution caters to a large population from both urban and rural areas and serves as a major trauma referral center for high-energy injuries such as road traffic accidents and falls from height. The study was carried out over a one-year duration, from January 2025 to December 2025, after obtaining approval from the Institutional Ethics Committee. Written informed consent was obtained from all participants prior to enrolment in the study. Confidentiality of patient data was strictly maintained, and participants were free to withdraw from the study at any stage without affecting their treatment.

This investigation was designed as a prospective, comparative, interventional study evaluating functional and radiological outcomes of suprapatellar versus infrapatellar approaches for intramedullary nailing in distal tibial shaft fractures. Patients presenting to the outpatient department and emergency services who fulfilled the inclusion criteria were enrolled consecutively and allocated into two groups based on the surgical approach used:

Group A (n = 20): Patients treated with suprapatellar intramedullary nailing (SP group)

Group B (n = 20): Patients treated with infrapatellar intramedullary nailing (IP group)

Allocation to surgical technique was performed using alternate assignment to maintain equal group sizes and minimize selection bias.

A total of 40 subjects were included in the study. The sample size was determined based on feasibility within the one-year study duration and expected patient load at the tertiary care center. The sample was considered adequate to detect clinically meaningful differences in functional and radiological outcomes between the two groups in a prospective observational setting.

Inclusion Criteria

Patients aged 18 to 65 years. Closed or Gustilo-Anderson Grade I and II open fractures of the distal third tibial shaft. Fractures amenable to treatment with intramedullary nailing. Patients presenting within two weeks of injury. Patients willing to provide informed consent and comply with follow-up.

Exclusion Criteria

Gustilo-Anderson Grade III open fractures. Pathological fractures. Associated ipsilateral femur fractures (floating knee injuries). Previous surgery or deformity of the affected tibia. Polytrauma patients medically unfit for surgery. Patients were lost to follow-up before completion of a minimum of 6 months.

METHODOLOGY

All patients underwent detailed clinical evaluation, including history of injury, comorbidities, and functional status. Radiological evaluation included 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 investigations and anesthetic fitness were obtained prior to surgery.

Surgical Technique

All surgeries were performed under spinal or general anesthesia on a radiolucent operating table with image intensifier guidance.

Suprapatellar Approach (Group A)

The knee was maintained in a semi-extended position (approximately 15–20° flexion). A small longitudinal incision was made proximal to the patella, and the entry point was established through the quadriceps tendon into the tibial canal using a protective sleeve to minimize intra-articular damage. Guidewire insertion, reaming, and nail placement were performed under fluoroscopic control. Locking was done proximally and distally as per fracture configuration.

Infrapatellar Approach (Group B)

The knee was flexed to approximately 90–110°. A longitudinal incision was made along the patellar tendon (either trans-patellar or parapatellar). The entry point was created below the patella, followed by guidewire insertion, canal reaming, nail insertion, and locking as per standard technique.

In both groups, fracture reduction was achieved using manual traction and adjunct techniques such as poller screws where required. All patients received prophylactic antibiotics and standard postoperative care.

Postoperative Protocol and Follow-Up

Early mobilization was encouraged in both groups. Passive and active range-of-motion exercises for the knee and ankle were initiated within 48 hours. Partial weight-bearing was allowed based on fracture stability and radiological signs of healing, progressing to full weight-bearing as tolerated.

Patients were followed up at 6 weeks, 3 months, 6 months, and 12 months postoperatively. At each visit, clinical and radiological evaluations were performed.

Outcome Measures

Radiological outcomes

Time to fracture union (defined as bridging callus in at least three cortices). Malalignment (angulation >5° in any plane). Delayed union and non-union rates

Functional outcomes

Knee function and pain were assessed using standardized scoring systems such as the Lysholm Knee Score. Ankle function was assessed using a range of motion and functional scales. Anterior knee pain was assessed using the Visual Analog Scale (VAS). Time to return to pre-injury activity/work

Complications

Infection (superficial/deep). Implant failure. Anterior knee pain. Reoperation rates.

Data were recorded in a structured case record form and entered into Microsoft Excel and analyzed using Statistical Package for the Social Sciences (SPSS) version 20.0. Descriptive statistics were expressed as mean, standard deviation, frequency, and percentage. Continuous variables (e.g., time to union, functional scores) were compared using Student's t-test. Categorical variables (e.g., malalignment, complications) were analyzed using the chi-square test. A *p-value* < 0.05 was considered statistically significant.

RESULTS

A total of 40 patients with distal tibial shaft fractures were included in the study and followed for a minimum period of 12 months. Patients were equally distributed into Group A (Suprapatellar approach, n = 20) and Group B (Infrapatellar approach, n = 20). The results were analyzed with respect to demographic profile, radiological union, functional outcome, and complications.

Table 1 shows the baseline demographic and injury characteristics of patients in both groups. The mean age in the suprapatellar group was 38.4 ± 10.2 years and in the infrapatellar group was 36.7 ± 11.5 years, with no statistically significant difference ($p > 0.05$). Both groups were comparable in terms of gender distribution, mechanism of injury, side of involvement, and proportion of open fractures, indicating a homogeneous baseline profile for comparison.

Table 2 demonstrates the radiological outcomes in both groups. The mean time to fracture union was significantly shorter in the suprapatellar group (17.2 weeks) compared to the infrapatellar group (19.6 weeks) (p = 0.02). Malalignment was also significantly lower in the suprapatellar group (10%) than in the infrapatellar group (30%) (p = 0.04). Although delayed union and non-union were more frequent in the infrapatellar group, the difference was not statistically significant.

Table 3 shows the comparison of functional outcomes between the two groups at the final follow-up. Patients treated with the suprapatellar approach demonstrated significantly better functional outcomes, including higher Lysholm knee scores (91.6 vs 85.3), lower anterior knee pain scores (VAS 1.8 vs 3.6), higher rates of full knee

Table 1: Baseline demographic and injury characteristics of study population

Variables	*Group A (Suprapatellar) (n=20)*	*Group B (Infrapatellar) (n=20)*	*p-value*
Mean age (years)	38.4 ± 10.2	36.7 ± 11.5	0.62
Male : Female	15 : 5	14 : 6	0.72
Mode of Injury (RTA/Fall)	14 / 6	13 / 7	0.74
Side (Right/Left)	12 / 8	11 / 9	0.75
Open fractures (Grade I–II)	5 (25%)	6 (30%)	0.72

Table 2: Radiological outcomes

Radiological outcome	*Group A (SP) (n=20)*	*Group B (IP) (n=20)*	*p-value*
Mean Time to Union (weeks)	17.2 ± 2.8	19.6 ± 3.4	0.02*
Malalignment (>5°)	2 (10%)	6 (30%)	0.04*
Delayed Union	1 (5%)	3 (15%)	0.29
Non-union	0 (0%)	1 (5%)	0.31

*Statistically significant

Table 3: Functional Outcomes at Final Follow-up (12 Months).

Functional outcome	*Group A (SP) (n=20)*	*Group B (IP) (n=20)*	*p-value*
Mean Lysholm Knee Score	91.6 ± 5.4	85.3 ± 7.2	0.01*
Anterior Knee Pain (VAS score)	1.8 ± 1.1	3.6 ± 1.5	0.003*
Full Knee Range of Motion (%)	18 (90%)	14 (70%)	0.04*
Time to Full Weight Bearing (weeks)	8.4 ± 1.6	9.8 ± 2.1	0.03*

*Statistically significant

Table 4: Postoperative Complications.

Complications	*Group A (SP) (n=20)*	*Group B (IP) (n=20)*	*p-value*
Superficial Infection	1 (5%)	2 (10%)	0.55
Deep Infection	0 (0%)	1 (5%)	0.31
Anterior Knee Pain (Persistent)	2 (10%)	7 (35%)	0.04*
Implant Failure	0 (0%)	1 (5%)	0.31
Reoperation	0 (0%)	1 (5%)	0.31

*Statistically significant

range of motion, and earlier return to full weight-bearing ($p < 0.05$ for all). These findings suggest superior functional recovery with the suprapatellar technique.

Table 4 illustrates the complication profile of both techniques. Persistent anterior knee pain was significantly higher in the infrapatellar group (35%) compared to the suprapatellar group (10%) ($p = 0.04$). Other complications such as infection, implant failure, and reoperation, were slightly more common in the infrapatellar group but did not reach statistical significance. Overall, the suprapatellar approach demonstrated a lower complication rate and improved patient comfort.

The findings of this prospective comparative study indicate that the suprapatellar approach for intramedullary nailing of distal tibial shaft fractures provides better radiological alignment, faster fracture union, improved functional outcomes, and reduced anterior knee pain compared to the infrapatellar approach. The baseline characteristics of both groups were comparable, ensuring the validity of comparisons. The suprapatellar technique showed clear advantages in terms of early mobilization, knee function, and complication profile, making it a more favorable approach for distal tibial fractures in the studied population.

DISCUSSION

The present prospective comparative study evaluated the functional and radiological outcomes of suprapatellar (SP) versus infrapatellar (IP) approaches for intramedullary nailing in distal tibial shaft fractures in a Bihar population treated at a tertiary care center. The findings of this study demonstrate that the suprapatellar approach offers superior radiological alignment, faster fracture union, improved functional outcomes, and lower incidence of anterior knee pain compared to the infrapatellar approach. These findings are consistent with previously published literature and reinforce the growing body of evidence supporting the SP technique as a preferred approach for distal tibial fractures [1-3].

In the present study, both groups were comparable with respect to age, sex distribution, mode of injury, and fracture characteristics, ensuring a fair comparison of outcomes. Similar baseline comparability has been reported in earlier studies evaluating SP versus IP approaches [4,5]. The predominance of young male patients and road traffic accidents as the leading cause of injury in our cohort reflects the demographic and epidemiological pattern commonly reported in developing regions, including India [3,6].

A key finding of the present study was the significantly shorter mean time to union in the suprapatellar group (17.2 weeks) compared to the infrapatellar group (19.6 weeks). This observation aligns with previous studies reporting faster union with the SP approach due to improved fracture reduction and stability achieved in the semi-extended position [7-8]. Better maintenance of alignment and reduced soft tissue disruption may contribute to enhanced biological healing in SP nailing [4]. Although some studies have reported comparable union times between the two approaches, the trend towards earlier union in SP nailing has been consistently observed [1,9].

Malalignment remains one of the major concerns in distal tibial fractures due to the metaphyseal flare and limited cortical contact. In our study, malalignment (>5°) was significantly lower in the SP group (10%) compared to the IP group (30%). This finding is supported by multiple studies demonstrating improved alignment control with the SP approach, attributed to easier reduction and better maintenance of the mechanical axis during nail insertion [2,10]. The semi-extended position in SP nailing reduces deforming forces and allows better fluoroscopic visualization, thereby decreasing the risk of angular deformities [4]. In contrast, the flexed knee position in the IP technique may predispose to apex anterior angulation, especially in distal fractures [11,12].

Functional outcomes in our study were significantly better in the SP group, as evidenced by higher Lysholm knee scores, earlier weight-bearing, and improved knee range of motion. These results are

consistent with findings from randomized controlled trials and meta-analyses demonstrating superior or equivalent functional outcomes with SP nailing [13,14]. The reduced soft tissue handling and improved alignment associated with SP nailing may facilitate earlier rehabilitation and functional recovery.

One of the most clinically relevant findings of this study was the significantly lower incidence of anterior knee pain in the SP group (10%) compared to the IP group (35%). Anterior knee pain is a well-recognized complication of infrapatellar nailing and has been reported in up to 50% of patients in some series. The etiology is multifactorial, including injury to the patellar tendon, infrapatellar branch of the saphenous nerve, and intra-articular irritation. The SP approach avoids violation of the patellar tendon and reduces mechanical irritation at the entry point, thereby reducing postoperative knee pain. Our findings are consistent with several meta-analyses reporting significantly lower rates of anterior knee pain with the SP technique [15,16].

Complication rates in the present study were low in both groups, with slightly higher rates observed in the IP group, although most differences were not statistically significant. The absence of deep infection and implant failure in the SP group further supports the safety of this technique. Concerns have been raised regarding potential intra-articular damage with the SP approach; however, studies have demonstrated that the use of protective sleeves and careful technique minimizes cartilage injury and does not result in long-term knee dysfunction.

The findings of this study have particular relevance in the context of Bihar, where patients often belong to labor-intensive occupations requiring frequent squatting, kneeling, and climbing. In such a population, anterior knee pain and malalignment can significantly impair functional capacity and delay return to work. The superior functional outcomes and reduced knee pain observed with the SP approach in this study suggest that it may be more suitable for the socioeconomic and occupational demands of this region.

CONCLUSION

Suprapatellar intramedullary nailing provides superior alignment, faster union, improved functional recovery, and significantly less anterior knee pain compared to the infrapatellar approach for distal tibial shaft fractures, making it a safer, more effective, and functionally advantageous technique for patients in resource-limited settings.

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