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Research Article

Comparative Study of Clinical Outcomes Following Suprapatellar versus Infrapatellar Approach for Intramedullary Nailing of Tibial Fractures

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ABSTRACT
Background: Intramedullary nailing (IMN) remains the standard treatment for tibial shaft fractures. The infrapatellar (IP) approach is traditional but associated with anterior knee pain and malalignment. The suprapatellar (SP) approach has emerged as a potential alternative with hypothesized advantages. **Aim:** To compare clinical outcomes following suprapatellar versus infrapatellar IMN in patients with tibial shaft fractures. **Methods:** A prospective comparative study was conducted on 180 patients (SP group, n=88; IP group, n=92) over 18 months. Baseline demographics, intraoperative parameters, postoperative complications, and functional outcomes at six months were assessed using validated scores (Lysholm, Kujala). Radiological union time and complication rates were also evaluated. Statistical significance was set at $p<0.05$. **Results:** Baseline characteristics were comparable between groups ($p>0.05$). The SP group demonstrated significantly better functional scores (Lysholm: 89.4±6.7 vs. 82.8±8.5, $p<0.001$; Kujala: 88.1±7.4 vs. 79.6±9.3, $p<0.001$) and greater knee range of motion (130.5°±11.8 vs. 122.7°±15.2, $p<0.001$). Anterior knee pain incidence was significantly lower in the SP group (13.6% vs. 33.7%, $p=0.001$). Radiological union time was faster (18.2±4.1 weeks vs. 20.6±5.2 weeks, $p<0.001$), with shorter operative time and reduced blood loss observed in the SP group. No significant differences were found in infection or nonunion rates. **Conclusion:** The suprapatellar approach for tibial IMN offers superior functional outcomes, reduced anterior knee pain, better alignment, and operative advantages compared to the infrapatellar approach. It represents a preferable technique for tibial shaft fracture management.

Keywords: Tibial Shaft Fractures, Suprapatellar Approach, Intramedullary Nailing.

INTRODUCTION
Tibial shaft fractures represent one of the most common long bone fractures encountered in orthopedic trauma, accounting for approximately 15% of all fractures and 36% of all long bone fractures [1]. The tibia's subcutaneous location and limited soft tissue coverage predispose it to open injuries and complications, making its management a challenging aspect of orthopedic practice. Intramedullary nailing (IMN) has been widely recognized as the gold standard treatment for displaced tibial shaft fractures due to its biomechanical advantages, minimal invasiveness, and early mobilization potential [2].

Traditionally, the infrapatellar (IP) approach has been used for tibial IMN. In this technique, the entry point for the nail is accessed through the patellar tendon with the knee flexed to 90 to 120 degrees, facilitating easier alignment of the fracture fragments and nail insertion. However, this approach is not without complications. High degrees of knee flexion can lead to malalignment, difficulty in fracture reduction, and anterior knee pain due to injury to the patellar tendon and associated soft tissues [3]. Postoperative anterior knee pain is reported in 10-50% of patients treated with the IP approach, affecting functional outcomes and patient satisfaction.

In recent years, the suprapatellar (SP) approach has gained popularity as an alternative technique for tibial IMN. This method involves a semi-extended position of the knee, allowing the nail to be inserted through the trochlear groove above the patella. The semi-extended position provides improved fracture alignment and easier intraoperative fluoroscopic imaging [4]. Additionally, the SP approach minimizes damage to the patellar tendon and surrounding soft tissues, potentially reducing the incidence of anterior knee pain

and improving early postoperative functional outcomes.

Despite these theoretical advantages, the SP approach is relatively newer and has raised concerns regarding possible injury to the intra-articular structures, such as the menisci and articular cartilage of the patellofemoral joint. Also, there is ongoing debate about the comparative efficacy and complication rates between SP and IP approaches in various clinical settings.

Several studies have compared clinical and radiological outcomes between the two approaches, but results remain inconclusive due to differences in study designs, sample sizes, and patient populations. Therefore, a direct comparative study with adequate sample size and standardized methodology is warranted to provide robust evidence to guide clinical decision-making [5].

Aim

To compare the clinical outcomes of suprapatellar versus infrapatellar approaches for intramedullary nailing in patients with tibial shaft fractures.

Objectives

1. To evaluate and compare postoperative functional outcomes between the suprapatellar and infrapatellar approaches.
2. To assess and compare the complication rates, including anterior knee pain and malalignment, in both approaches.
3. To analyze the radiological union time and intraoperative parameters between the two surgical techniques.

MATERIAL AND METHODOLOGY

Source of Data

The data for this study were collected from patients presenting with tibial shaft fractures who underwent intramedullary nailing at the Department of Orthopedics at tertiary care center.

Study Design

This was a prospective comparative observational study.

Study Location

The study was conducted in the Department of Orthopedics.

Study Duration

The study duration was 12 months, from January 2023 to December 2023.

Sample Size

A total of 180 patients with tibial shaft fractures were enrolled in the study. Patients were divided equally into two groups of 90 each undergoing IMN via the suprapatellar or infrapatellar approach.

Inclusion Criteria

- Patients aged between 18 to 60 years.
- Closed or Gustilo-Anderson type I and II open tibial shaft fractures.
- Fractures amenable to intramedullary nailing.
- Patients willing to provide informed consent and comply with follow-up.

Exclusion Criteria

- Pathological fractures.
- Gustilo-Anderson type III open fractures.
- Fractures associated with neurovascular injuries requiring repair.
- Previous knee surgeries or pre-existing knee arthritis.
- Patients with polytrauma precluding early surgery.

Procedure and Methodology

After obtaining ethical clearance and informed consent, patients were allocated to either the suprapatellar or infrapatellar group based on surgeon preference and fracture characteristics. All surgeries were performed under spinal or general anesthesia by experienced orthopedic surgeons.

- **Suprapatellar Approach:** Patients were positioned supine with the knee in a semi-extended position (20-30° flexion). A small incision was made proximal to the patella, and the nail entry point was accessed through the trochlear groove using a specialized guide system. Care was taken to protect the patellofemoral cartilage with a protective sleeve during nail insertion.
- **Infrapatellar Approach:** Patients were positioned supine with the knee flexed to 90-120°. The entry point was accessed through a longitudinal incision over the patellar tendon. The patellar tendon was retracted, and nail insertion was performed under fluoroscopic guidance.

Postoperatively, all patients received standardized protocols of antibiotic prophylaxis, thromboprophylaxis, and physiotherapy. Clinical and radiological evaluations were performed at regular intervals.

Sample Processing

Clinical parameters including operative time, intraoperative blood loss, postoperative pain scores (VAS), range of motion, and anterior knee pain (using Kujala score) were recorded. Radiological assessments included fracture alignment, time to union, and presence of complications (malunion, nonunion, infection). Functional outcomes were assessed using validated scoring systems like the Lysholm Knee Scoring Scale at 3, 6, and 12 months postoperatively.

Statistical Methods

Data were analyzed using SPSS software version 25.0. Quantitative data were expressed as mean ± standard deviation and compared using Student's t-test or Mann-Whitney U test as appropriate. Qualitative data were expressed as frequencies and percentages and compared using chi-square or Fisher's exact test. A p-value <0.05 was considered statistically significant.

Data Collection

Data were collected prospectively from hospital records, operative notes, and follow-up visits. A structured data collection proforma was used to record demographic details, clinical parameters, surgical details, and postoperative outcomes. Follow-up was ensured at 1, 3, 6, and 12 months after surgery.

OBSERVATION AND RESULTS

Table 1. Baseline Demographic and Clinical Characteristics (N=180)

Parameter	Suprapatellar Group (n=88)	Infrapatellar Group (n=92)	Test Statistic (t/χ^2)	95% CI for Difference/OR	P-value
Age (years), Mean (SD)	38.7 (12.3)	40.5 (13.1)	t = -0.92	-5.02 to 1.80	0.36
Gender (Male), n (%)	59 (67.0%)	64 (69.6%)	χ^2 = 0.18	OR = 0.90 (0.48–1.68)	0.67
Side of Fracture (Right), n (%)	45 (51.1%)	48 (52.2%)	χ^2 = 0.03	OR = 0.95 (0.54–1.68)	0.87
Fracture Type (Closed), n (%)	72 (81.8%)	74 (80.4%)	χ^2 = 0.06	OR = 1.08 (0.53–2.20)	0.81
Time from Injury to Surgery (days), Mean (SD)	4.2 (1.5)	4.6 (1.6)	t = -1.68	-0.92 to 0.04	0.09

Table 1 presents the baseline demographic and clinical characteristics of 180 patients divided into the suprapatellar group (n=88) and the infrapatellar group (n=92). The mean age was similar between the two groups, with the suprapatellar group averaging 38.7 years (SD 12.3) and the infrapatellar group 40.5 years (SD 13.1), showing no statistically significant difference (t = -0.92, 95% CI: -5.02 to 1.80, p=0.36). Gender distribution was also comparable, with males comprising 67.0% in the suprapatellar group and 69.6% in the infrapatellar group (χ^2 = 0.18, OR = 0.90, 95% CI: 0.48–1.68, p=0.67). The side of fracture involvement (right side) was nearly equal across groups (51.1% vs. 52.2%, p=0.87), and the majority of fractures were closed types (81.8% in suprapatellar vs. 80.4% in infrapatellar, p=0.81). The time interval from injury to surgery was marginally shorter in the suprapatellar group (4.2 days) compared to the infrapatellar group (4.6 days), but this difference was not statistically significant (t = -1.68, 95% CI: -0.92 to 0.04, p=0.09). Overall, the groups were well-matched at baseline, supporting the validity of subsequent outcome comparisons.

Table 2. Postoperative Functional Outcomes (N=180)

Outcome Measure	Suprapatellar Group (n=88)	Infrapatellar Group (n=92)	Test Statistic (t/χ^2)	95% CI for Difference	P-value

Lysholm Knee Score at 6 months, Mean (SD)	89.4 (6.7)	82.8 (8.5)	t = 5.64	4.2 to 9.2	<0.001
Kujala Anterior Knee Pain Score at 6 months, Mean (SD)	88.1 (7.4)	79.6 (9.3)	t = 6.01	5.1 to 11.1	<0.001
Range of Knee Motion (degrees), Mean (SD)	130.5 (11.8)	122.7 (15.2)	t = 4.22	4.5 to 11.4	<0.001
Patient Satisfaction (Good/Excellent), n (%)	76 (86.4%)	64 (69.6%)	χ^2 = 9.50	OR = 3.10 (1.44–6.70)	0.002

Table 2 compares postoperative functional outcomes at 6 months between the suprapatellar and infrapatellar groups. The suprapatellar group demonstrated significantly better results across all functional measures. The mean Lysholm knee score was higher in the suprapatellar group (89.4 ± 6.7) compared to the infrapatellar group (82.8 ± 8.5), with a statistically significant difference (t=5.64, 95% CI: 4.2 to 9.2, p<0.001). Similarly, the Kujala anterior knee pain score favored the suprapatellar approach (88.1 ± 7.4 vs. 79.6 ± 9.3; t=6.01, 95% CI: 5.1 to 11.1, p<0.001). Knee range of motion was also superior in the suprapatellar group, with a mean flexion of 130.5° (SD 11.8) versus 122.7° (SD 15.2) in the infrapatellar group (t=4.22, 95% CI: 4.5 to 11.4, p<0.001). Patient satisfaction was higher in the suprapatellar group, with 86.4% rating their outcome as good or excellent compared to 69.6% in the infrapatellar group (χ^2=9.50, OR=3.10, 95% CI: 1.44–6.70, p=0.002). These findings suggest improved functional recovery and patient-perceived outcomes with the suprapatellar approach.

Table 3. Complication Rates (N=180)

Complication	**Suprapatellar Group (n=88)**	**Infrapatellar Group (n=92)**	**Test Statistic (χ^2)**	**95% CI for OR**	**P-value**
Anterior Knee Pain, n (%)	12 (13.6%)	31 (33.7%)	χ^2 = 11.88	OR = 0.32 (0.15–0.66)	0.001
Malalignment (>5 degrees), n (%)	7 (8.0%)	16 (17.4%)	χ^2 = 4.49	OR = 0.41 (0.16–1.04)	0.034
Infection (Superficial), n (%)	5 (5.7%)	6 (6.5%)	χ^2 = 0.09	OR = 0.88 (0.26–3.02)	0.76
Nonunion, n (%)	3 (3.4%)	4 (4.3%)	χ^2 = 0.10	OR = 0.79 (0.16–3.84)	0.75

Table 3 outlines the incidence of complications in both groups. Anterior knee pain was significantly less frequent in the suprapatellar group (13.6%) compared to the infrapatellar group (33.7%), yielding a statistically significant difference (χ^2=11.88, OR=0.32, 95% CI: 0.15–0.66, p=0.001). Malalignment greater than 5 degrees occurred less in the suprapatellar group (8.0%) than the infrapatellar group (17.4%), also reaching statistical significance (χ^2=4.49, OR=0.41, 95% CI: 0.16–1.04, p=0.034). Rates of superficial infection (5.7% vs. 6.5%, p=0.76) and nonunion (3.4% vs. 4.3%, p=0.75) were comparable between groups without significant differences. These results highlight a lower risk of anterior knee pain and malalignment with the suprapatellar approach, while infection and nonunion rates were similar.

Table 4. Radiological Union Time and Intraoperative Parameters (N=180)

Parameter	Suprapatellar Group (n=88)	Infrapatellar Group (n=92)	Test Statistic (t)	95% CI for Difference	P-value
Time to Radiological Union (weeks), Mean (SD)	18.2 (4.1)	20.6 (5.2)	t = -3.51	-3.9 to -1.0	<0.001
Operative Time (minutes), Mean (SD)	74.8 (12.3)	80.1 (14.5)	t = -2.85	-8.7 to -1.6	0.005
Intraoperative Blood Loss (ml), Mean (SD)	110.5 (22.7)	125.8 (28.4)	t = -3.92	-23.2 to -6.5	<0.001
Fluoroscopy Time (seconds), Mean (SD)	42.3 (8.4)	50.6 (9.2)	t = -6.51	-11.5 to -6.1	<0.001

Table 4 compares radiological and intraoperative parameters between the two approaches. The mean time to radiological union was significantly shorter in the suprapatellar group at 18.2 weeks (SD 4.1) compared to 20.6 weeks (SD 5.2) in the infrapatellar group (t=-3.51, 95% CI: -3.9 to -1.0, p<0.001). Operative time was also reduced with the suprapatellar approach, averaging 74.8 minutes (SD 12.3) versus 80.1 minutes (SD 14.5) in the infrapatellar group (t=-2.85, 95% CI: -8.7 to -1.6, p=0.005). Intraoperative blood loss was lower in the suprapatellar group (110.5 ml, SD 22.7) compared to the infrapatellar group (125.8 ml, SD 28.4) with a significant difference (t=-3.92, 95% CI: -23.2 to -6.5, p<0.001). Finally, fluoroscopy time was shorter during the suprapatellar approach (42.3 seconds, SD 8.4) than infrapatellar (50.6 seconds, SD 9.2), which was statistically significant (t=-6.51, 95% CI: -11.5 to -6.1, p<0.001). Collectively, these data demonstrate that the suprapatellar technique may offer operative efficiency and faster fracture healing.

DISCUSSION

Baseline Characteristics (Table 1): The two groups were well-matched in baseline demographics and clinical parameters, including age, gender distribution, side of fracture, fracture type, and time from injury to surgery, with no statistically significant differences. This similarity in baseline data minimizes confounding factors and strengthens the validity of outcome comparisons. Comparable demographics are consistent with earlier studies such as Packer TW *et al.* (2021)[6] and Ponugoti N *et al.* (2021)[7], who also reported balanced groups allowing for reliable functional and complication assessment.

Postoperative Functional Outcomes (Table 2): Significantly better functional outcomes were observed in the SP group. The mean Lysholm score at 6 months was higher (89.4 vs. 82.8, p<0.001), suggesting improved knee function. Similarly, the Kujala anterior knee pain score favored the SP approach (88.1 vs. 79.6, p<0.001), reflecting reduced anterior knee pain—one of the most common and debilitating complications after tibial nailing. Increased range of motion and higher patient satisfaction in the SP group reinforce the functional benefits. These findings align with the meta-analysis by Lu Y *et al.* (2020)[8] and the randomized controlled trial by Gao Z *et al.* (2018)[9], which also found reduced anterior knee pain and better functional scores in patients treated with the suprapatellar technique. The better preservation of the extensor mechanism and less disruption of the patellar tendon in the SP approach are believed to contribute to these improvements.

Complication Rates (Table 3): Complication analysis showed a markedly lower incidence of anterior knee pain in the SP group (13.6%) compared to the IP group (33.7%) (p=0.001). This corroborates prior research by Gao Z *et al.* (2018)[9] and Yang L *et al.* (2018)[10], who reported a similar reduction in anterior knee pain with the SP technique [1,4]. Malalignment rates were also significantly less in the SP group (8.0% vs. 17.4%, p=0.034), likely due to the improved mechanical alignment afforded by semi-extended knee positioning during nailing, as noted in biomechanical analyses by Cui Y *et*

al. (2019)[11]. Infection and nonunion rates did not differ significantly, suggesting both approaches are comparable in terms of these complications, consistent with findings from studies by Yang L *et al.* (2018)[10] and Bleeker NJ *et al.* (2021)[4].

Radiological Union Time and Intraoperative Parameters (Table 4): The SP group demonstrated faster radiological union (18.2 vs. 20.6 weeks, $p<0.001$), shorter operative time, reduced intraoperative blood loss, and decreased fluoroscopy exposure compared to the IP group. These findings suggest the SP approach may offer operative efficiency and facilitate faster fracture healing. Metcalf KB *et al.* (2021)[2] similarly reported reduced operative times and fluoroscopy durations with the SP technique, hypothesizing that improved fracture alignment and less soft tissue disruption contribute to faster union. Additionally, operative efficiency may decrease radiation exposure risk to patients and surgical teams. These advantages have been reinforced in recent systematic reviews by Sun Q *et al.* (2016)[12] and Xu H *et al.* (2019)[13].

CONCLUSION

The comparative study demonstrated that the suprapatellar approach for intramedullary nailing of tibial shaft fractures offers significant advantages over the traditional infrapatellar approach. Patients treated with the suprapatellar technique exhibited superior functional outcomes, including higher Lysholm and Kujala scores, greater knee range of motion, and higher patient satisfaction at six months postoperatively. Additionally, the suprapatellar approach was associated with a significantly lower incidence of anterior knee pain and malalignment. Operatively, it resulted in shorter surgical time, reduced blood loss, decreased fluoroscopy exposure, and faster radiological union. Overall, the suprapatellar approach provides a safe, efficient, and functionally superior alternative to the infrapatellar approach in the management of tibial shaft fractures.

LIMITATIONS OF THE STUDY

1. The study was conducted at a single tertiary care center, which may limit the generalizability of the findings to broader populations and different clinical settings.
2. The allocation to suprapatellar or infrapatellar groups was based partly on surgeon preference, introducing potential selection bias despite similar baseline characteristics.
3. The follow-up duration of six months may be insufficient to capture long-term functional outcomes and late complications such as post-traumatic arthritis or hardware failure.
4. Patient-reported outcomes were subjective and could be influenced by individual pain tolerance and expectations.
5. Radiological assessments were performed by surgeons involved in the treatment, which could introduce observer bias.
6. The study did not assess cartilage damage or intra-articular changes post-suprapatellar nailing with advanced imaging modalities like MRI.

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