



Comparative Study of Suprapatellar versus Infrapatellar Approach for Intramedullary Nailing in Proximal Tibial Fractures.

¹Dr. Kore Girish Digambar

¹Assistant Professor, Department of Orthopaedic, MIMSR Medical College and YCR Hospital, Ambejogaoi Road, Vishwanath Puram, Latur, Maharashtra, INDIA.



Correspondence:

Dr. Kore Girish Digambar.

Assistant Professor, Department of Orthopaedic, MIMSR Medical College and YCR Hospital, Ambejogaoi Road, Vishwanath Puram, Latur, Maharashtra, INDIA.

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Abstract

Background: Intramedullary nailing of proximal tibial fractures presents challenges in maintaining alignment and preserving knee function. The suprapatellar approach permits nail insertion with the knee semi-extended and may offer advantages over the conventional infrapatellar approach. **Aim:** To compare clinical, functional and radiological outcomes following suprapatellar and infrapatellar intramedullary nailing in proximal tibial fractures. **Materials and Methods:** This illustrative analysis used simulated summary data for 160 patients, with 80 patients in each group, under an assumed prospective comparative observational design with 12-month follow-up. Outcomes included postoperative alignment, fracture union, anterior knee pain, knee range of motion, Lysholm scores, operative duration, fluoroscopy time and complications. Between-group comparisons used Welch's t-test, Pearson's chi-square test or Fisher's exact test. Effect estimates were reported with 95% confidence intervals, and $p < 0.05$ was considered statistically significant. **Results:** Postoperative malalignment was less frequent in the suprapatellar group (5.0% versus 16.3%; $p = 0.021$). At 12 months, anterior knee pain occurred in 13.8% versus 33.8% (risk difference -20.00 percentage points; 95% CI -32.39 to -6.83; $p = 0.003$). Knee range of motion was greater ($132.4 \pm 7.8^\circ$ versus $126.8 \pm 9.5^\circ$), and Lysholm scores were higher (93.2 ± 5.1 versus 87.6 ± 7.4), both $p < 0.001$. Mean operative duration was shorter by 11.30 minutes (95% CI -15.66 to -6.94), and fluoroscopy time was shorter by 27.70 seconds (95% CI -35.79 to -19.61), both $p < 0.001$. Among united fractures, mean union time was 18.6 ± 3.2 versus 20.1 ± 4.1 weeks ($p = 0.013$). Twelve-month union rates were 97.5% versus 93.8% ($p = 0.443$). Differences in infection, implant failure and reoperation were not statistically significant. **Conclusion:** The simulated comparison favoured suprapatellar nailing for alignment, knee pain, functional outcomes and operative efficiency, without demonstrating a significant difference in final union or complications. These illustrative findings require validation using actual clinical data.

Keywords: Proximal tibial fractures; Intramedullary nailing; Suprapatellar approach.



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INTRODUCTION

Proximal tibial fractures present considerable challenges because of the short proximal fragment, wide metaphyseal canal and deforming muscular forces, which can compromise reduction during intramedullary nailing. Restoration of alignment, stable fixation and preservation of knee function are essential treatment objectives. Krettek and Edwards (2023) [1] highlighted the susceptibility of proximal tibial fractures to valgus and apex-anterior deformity and emphasised appropriate entry-point selection, reduction techniques and supplementary reduction aids. The choice of surgical approach is therefore particularly relevant in these injuries. The conventional infrapatellar approach involves nail insertion with the knee flexed, whereas the suprapatellar approach permits insertion with the knee in a semi-extended position. This positioning may facilitate maintenance of reduction and fluoroscopic assessment; however, passage through the patellofemoral joint raises concerns about cartilage injury. Chan et al. (2016) [2], in a prospective randomised pilot study, found no significant between-group differences in visual analogue pain scores, Lysholm scores or knee range of motion at follow-up, although the small sample and incomplete follow-up limited definitive conclusions. Avilucea et al. (2016) [3] reported a lower rate of malalignment with suprapatellar nailing in distal tibial fractures, supporting interest in the approach for fractures where alignment is difficult to maintain; nevertheless, those findings cannot be directly extrapolated to proximal fractures. MacDonald et al. (2019) [4], in a multicentre randomised trial involving 95 patients, reported less postoperative anterior knee pain with the suprapatellar approach, demonstrating the importance of assessing patient-centred outcomes alongside fracture healing. Similarly, van de Pol et al. (2024) [5] demonstrated better patellofemoral function and less anterior knee pain at 12 months following suprapatellar nailing in a randomised trial of tibial fractures.

AIM

To compare the clinical, functional and radiological outcomes of suprapatellar and infrapatellar approaches for intramedullary nailing in patients with proximal tibial fractures.

OBJECTIVES

1. To compare postoperative alignment, time to fracture union and union rates between the two approaches.
2. To compare anterior knee pain, knee range of motion and functional outcomes between the two groups.
3. To compare operative duration, fluoroscopy exposure time and postoperative complications between the two approaches.

MATERIALS AND METHODS

Source of Data

The study population comprised patients with proximal tibial fractures who presented to the emergency department or orthopaedic outpatient department and were admitted for intramedullary nailing at MIMSR Medical College, Latur. Data were obtained from clinical examinations, hospital records, operative notes, radiographic investigations and scheduled postoperative follow-up assessments. Eligible patients were recruited consecutively after written informed consent had been obtained.

Study Design

The study was conducted as a hospital-based, prospective, comparative observational study. Patients were categorized according to the surgical approach used: the suprapatellar group and the infrapatellar group. Selection of the approach was based on the treating surgeon's clinical decision, fracture characteristics and availability of the required instrumentation. No random allocation was assumed. Potential differences in baseline fracture severity and patient characteristics were considered during analysis.

Institutional Ethics Committee approval was obtained before recruitment. Patient confidentiality was maintained throughout the study.

Study Location

The study was conducted in the Department of Orthopaedics at MIMSR Medical College, Latur, a tertiary care hospital with emergency trauma services, fluoroscopy-assisted operating facilities and postoperative rehabilitation services.

Study Duration

The study was conducted for 12 months, and each patient was scheduled for follow-up for 12 months after surgery. The overall study period included recruitment and follow-up of the last enrolled participant.

Sample Size

The total sample size was 160 patients. For this draft, the comparative groups comprised:

- **Group A:** 80 patients treated with suprapatellar intramedullary nailing.
- **Group B:** 80 patients treated with infrapatellar intramedullary nailing.

The sample size of 160 was specified for the study. A power-based justification was not inferred because the anticipated primary-outcome difference, variability or event rates were not provided. The final manuscript should state the actual basis used to determine this sample size and confirm the observed group distribution.

Inclusion Criteria

Patients were included when they met the following criteria:

1. Age of 18 years or above, with skeletal maturity.
2. An acute, unilateral, extra-articular proximal tibial fracture involving the metaphysis or proximal third of the shaft.
3. A fracture configuration and proximal fragment length suitable for stable fixation with an intramedullary nail.
4. A closed fracture or Gustilo–Anderson type I or II open fracture.
5. Medical fitness for operative treatment.
6. Provision of written informed consent and willingness to attend follow-up assessments.

The anatomical definition of a proximal fracture was applied consistently using preoperative radiographs, and the corresponding AO/OTA classification was recorded.

Exclusion Criteria

Patients were excluded when they had:

1. Intra-articular extension involving the tibial plateau.
2. Gustilo–Anderson type III open fractures.
3. Pathological fractures, established nonunion, malunion or previous fixation of the index fracture.

4. Vascular injury requiring repair or soft-tissue damage that precluded definitive intramedullary nailing.
5. Active infection around the operative site or knee joint.
6. Previous ipsilateral knee arthroplasty, substantial knee deformity or pre-existing symptomatic knee disease that could interfere with functional assessment.
7. Associated ipsilateral femoral, patellar or major ligamentous injuries, or contralateral lower-limb injuries that substantially affected rehabilitation.
8. Medical contraindications to surgery or inability to provide informed consent.

Patients who missed follow-up after enrolment were recorded as lost to follow-up rather than retrospectively excluded from the study.

Procedure and Methodology

Preoperative assessment

Following initial stabilisation, each patient underwent a detailed history and clinical examination. Age, sex, body mass index, mechanism of injury, affected side, smoking status, diabetes mellitus, associated injuries and time from injury to surgery were recorded. The limb was examined for swelling, skin condition, open wounds, compartment status and distal neurovascular function.

Anteroposterior and lateral radiographs of the entire tibia, including the knee and ankle, were obtained. Fractures were classified using the AO/OTA system, and open injuries were graded using the Gustilo–Anderson classification. Computed tomography was obtained when articular extension was suspected. Routine preanaesthetic investigations were performed according to institutional practice.

Operative treatment

All procedures were performed under appropriate anaesthesia with fluoroscopic guidance. Antibiotic prophylaxis and perioperative care followed institutional protocols. Nail design, nail dimensions, locking configuration, surgeon experience and use of additional reduction techniques were documented.

In the **suprapatellar group**, patients were positioned supine with the knee in a semi-extended position, approximately 15–30° of flexion. A longitudinal incision was made proximal to the superior pole of the patella, and the quadriceps tendon was split longitudinally. A dedicated protective sleeve was introduced through the patellofemoral interval. The tibial entry point and guidewire position were confirmed fluoroscopically. Reduction, canal preparation and nail insertion were completed while maintaining protection of the patellofemoral cartilage. Proximal and distal locking were performed, and final alignment was assessed before irrigation and wound closure.

In the **infrapatellar group**, patients were positioned supine with the knee flexed to approximately 90°. The guidewire and entry point were confirmed fluoroscopically, followed by fracture reduction, canal preparation, nail insertion and proximal and distal locking.

In both groups, additional reduction aids, including percutaneous clamps, blocking screws or temporary reduction plates, were used when required and were recorded. Operative duration was measured from skin incision to completion of closure. Fluoroscopy exposure time was obtained from the fluoroscopy unit; it was treated as exposure time rather than a direct measurement of radiation dose.

Postoperative care and follow-up

Postoperative care included analgesia, wound assessment, neurovascular monitoring and thromboprophylaxis according to individual risk and institutional protocols. Quadriceps exercises and knee and ankle mobilisation were initiated as tolerated. Progression of weight-bearing was based on fixation stability, fracture configuration, soft-tissue condition and radiological healing. Rehabilitation instructions and deviations from the planned programme were documented.

Patients were assessed at approximately 2 weeks, 6 weeks, 3 months, 6 months and 12 months after surgery. Each assessment included examination of the wound, fracture-site tenderness, walking ability, knee pain, knee movement and complications. Follow-up radiographs were obtained at the designated fracture-healing assessments.

Outcome assessment

The primary outcome was postoperative coronal or sagittal malalignment, defined for this draft as angulation exceeding 5° in either plane on standardised radiographs. Coronal and sagittal angulation were also recorded as continuous measurements. Immediate postoperative alignment and subsequent loss of alignment were assessed separately.

Secondary outcomes included anterior knee pain, measured using a 0–10 visual analogue scale; knee function, measured using the Lysholm knee score; and knee range of motion, measured with a goniometer. Pain assessments used a consistent activity condition, such as walking or kneeling, across both groups.

Fracture union was assessed using clinical and radiological findings. Clinical union was characterised by absence of fracture-site tenderness and painless weight-bearing. Radiological union was defined as bridging callus across at least three of four cortices on anteroposterior and lateral radiographs. Time to union was recorded from the date of surgery to the first assessment satisfying the specified criteria.

Other outcomes included operative duration, fluoroscopy time, hospital stay, infection, implant failure, secondary procedures and nonunion. Nonunion was defined as failure of healing by nine months with no radiological progression during the preceding three months. Routine clinical follow-up was not considered sufficient to exclude asymptomatic patellofemoral cartilage damage.

Sample Processing

No biological specimen was collected specifically for the research comparison. Blood samples obtained for routine preoperative or clinically indicated postoperative investigations were processed by the hospital laboratory according to its standard operating procedures.

For study-data processing, each participant was assigned a unique identification number. Clinical forms, operative records and radiographs were linked using this identifier. Radiographic angulation and union assessments were entered into a structured database. Data were checked for completeness, duplication, inconsistent dates and implausible values before analysis. Original records were reviewed to resolve discrepancies, and missing observations were retained as missing rather than replaced with assumed values.

Statistical Methods

Data were analysed using SPSS 28.0 version. Continuous variables were summarised as mean and standard deviation when approximately normally distributed and as median and interquartile range when skewed. Categorical variables were presented as frequencies and percentages.

Independent-group comparisons of continuous outcomes were performed using an independent-samples t-test, with Welch's correction where appropriate, or the Mann-Whitney U test for markedly skewed data. Categorical outcomes were compared using Pearson's chi-square test or Fisher's exact test when expected cell counts were small.

Between-group effects were reported using mean differences, risk differences or risk ratios, with 95% confidence intervals. Serial pain and functional scores were analysed using a mixed-effects model incorporating group, follow-up time and their interaction. Time to union was analysed using survival methods when follow-up was incomplete, with patients censored at their last assessment if union had not been documented.

Because treatment allocation was non-randomised, adjusted analyses considered clinically relevant confounders, including age, smoking, diabetes, open-fracture status, fracture pattern and surgeon-related factors. The number of covariates was restricted according to the available outcome events.

All statistical tests were two-sided, and $p < 0.05$ was considered statistically significant. The number of patients contributing data at each follow-up was reported, and secondary-outcome analyses were interpreted as exploratory. Only analyses actually performed should remain in the completed manuscript.

Data Collection

Data were collected using a structured case-record form at enrolment, during surgery, at discharge and at each follow-up visit. Baseline information included demographic characteristics, comorbidities, injury mechanism, fracture classification, soft-tissue status and pre-injury functional limitations. Operative information included the surgical approach, implant characteristics, reduction aids, operative duration, fluoroscopy exposure time and intraoperative complications.

Postoperative information included wound condition, pain scores, knee movement, functional scores, weight-bearing status, radiographic alignment, progression of union and complications. Reoperations, reasons for missed visits and losses to follow-up were documented. Identifiable information was stored separately from the analysis dataset, and access was restricted to authorised study personnel.

RESULTS

Table 1. Overall comparison of clinical, functional and radiological outcomes between the two approaches (N=160)

Outcome	Suprapatellar (n=80)	Infrapatellar (n=80)	Effect (95% CI)	Test statistic	p value
Hospital stay, days	6.4 (2.1)	7.6 (2.8)	MD -1.20 (-1.97 to -0.43)	$t = -3.07$	0.003
Anterior knee pain at 12 months, n (%)	11 (13.8)	27 (33.8)	RD -20.00 (-32.39 to -6.83)	$\chi^2 = 8.84$	0.003
Knee range of motion at 12 months, degrees	132.4 (7.8)	126.8 (9.5)	MD 5.60 (2.88 to 8.32)	$t = 4.07$	<0.001
Lysholm knee score at 12 months	93.2 (5.1)	87.6 (7.4)	MD 5.60 (3.61 to 7.59)	$t = 5.57$	<0.001
Postoperative malalignment >5° in either plane, n (%)	4 (5.0)	13 (16.3)	RD -11.25 (-21.31 to -1.58)	$\chi^2 = 5.33$	0.021

Fracture union by 12 months, n (%)	78 (97.5)	75 (93.8)	RD 3.75 (−3.36 to 11.52)	Fisher's exact*	0.443
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Among 160 patients, with 80 in each group, the suprapatellar group had a significantly shorter mean hospital stay than the infrapatellar group (6.4 ± 2.1 versus 7.6 ± 2.8 days; mean difference [MD] -1.20 days, 95% CI -1.97 to -0.43 ; $p=0.003$). Anterior knee pain at 12 months was reported in 13.8% and 33.8%, respectively, representing a risk difference of -20.00 percentage points (95% CI -32.39 to -6.83 ; $p=0.003$). The suprapatellar group also had greater knee range of motion ($132.4 \pm 7.8^\circ$ versus $126.8 \pm 9.5^\circ$) and higher Lysholm scores (93.2 ± 5.1 versus 87.6 ± 7.4), with both differences statistically significant ($p<0.001$). Postoperative malalignment occurred less frequently in the suprapatellar group (5.0% versus 16.3%; $p=0.021$). However, the difference in fracture union by 12 months was not statistically significant (97.5% versus 93.8%; $p=0.443$).

Table 2. Comparison of postoperative alignment, time to fracture union and union rates between the two approaches (N=160)

Radiological outcome	Suprapatellar (n=80)	Infrapatellar (n=80)	Effect (95 % CI)	Test statistic	p value
Absolute postoperative coronal angulation, degrees	2.1 (1.3)	3.4 (1.9)	MD -1.30 (-1.81 to -0.79)	$t = -5.05$	<0.001
Absolute postoperative sagittal angulation, degrees	2.4 (1.5)	4.1 (2.3)	MD -1.70 (-2.31 to -1.09)	$t = -5.54$	<0.001
Malalignment $>5^\circ$ in either plane, n (%)	4 (5.0)	13 (16.3)	RD -11.25 (-21.31 to -1.58)	$\chi^2 = 5.33$	0.021
Time to union among united fractures, weeks†	18.6 (3.2)	20.1 (4.1)	MD -1.50 (-2.68 to -0.32)	$t = -2.52$	0.013
Fracture union by 6 months, n (%)	73 (91.3)	64 (80.0)	RD 11.25 (0.25 to 22.24)	$\chi^2 = 4.11$	0.043
Fracture union by 12 months, n (%)	78 (97.5)	75 (93.8)	RD 3.75 (−3.36 to 11.52)	Fisher's exact*	0.443
Nonunion at final assessment, n (%)	2 (2.5)	5 (6.3)	RD -3.75 (-11.52 to 3.36)	Fisher's exact*	0.443

The suprapatellar group demonstrated significantly lower mean absolute coronal angulation ($2.1 \pm 1.3^\circ$ versus $3.4 \pm 1.9^\circ$; MD -1.30° , 95% CI -1.81 to -0.79) and sagittal angulation ($2.4 \pm 1.5^\circ$ versus $4.1 \pm 2.3^\circ$; MD -1.70° , 95% CI -2.31 to -1.09), with $p<0.001$ for both comparisons. Malalignment exceeding 5° occurred in 4 patients (5.0%) in the suprapatellar group and 13 patients (16.3%) in the infrapatellar group ($p=0.021$). Among fractures that united, mean time to union was shorter with the suprapatellar approach (18.6 ± 3.2 versus 20.1 ± 4.1 weeks; MD -1.50 weeks, 95% CI -2.68 to -0.32 ; $p=0.013$). Union by six months was more frequent in the suprapatellar group (91.3% versus 80.0%; $p=0.043$). At 12 months, however, neither union rates (97.5% versus 93.8%) nor nonunion rates (2.5% versus 6.3%) differed significantly ($p=0.443$). The time-to-union comparison included only the 78 and 75 united fractures, respectively, and therefore excluded nonunions.

Table 3. Comparison of anterior knee pain, knee range of motion and functional outcomes between the two approaches (N=160)

Functional outcome	Suprapatellar (n=80)	Infrapatellar (n=80)	Effect (95 % CI)	Test statistic	p value
Anterior knee pain VAS at 6 weeks, 0–10	3.2 (1.3)	4.1 (1.5)	MD -0.90 (-1.34 to -0.46)	$t = -4.06$	<0.001
Anterior knee pain VAS at 6 months, 0–10	1.4 (0.9)	2.3 (1.2)	MD -0.90 (-1.23 to -0.57)	$t = -5.37$	<0.001
Anterior knee pain VAS at 12 months, 0–10	0.8 (0.7)	1.6 (1.1)	MD -0.80 (-1.09 to -0.51)	$t = -5.49$	<0.001
Patients reporting anterior knee pain at 12 months, n (%)‡	11 (13.8)	27 (33.8)	RD -20.00 (-32.39 to -6.83)	$\chi^2 = 8.84$	0.003
Knee range of motion at 6 months, degrees	125.8 (9.6)	119.4 (11.2)	MD 6.40 (3.14 to 9.66)	$t = 3.88$	<0.001
Knee range of motion at 12 months, degrees	132.4 (7.8)	126.8 (9.5)	MD 5.60 (2.88 to 8.32)	$t = 4.07$	<0.001
Lysholm knee score at 6 months, 0–100	86.4 (7.2)	80.8 (8.6)	MD 5.60 (3.12 to 8.08)	$t = 4.47$	<0.001
Lysholm knee score at 12 months, 0–100	93.2 (5.1)	87.6 (7.4)	MD 5.60 (3.61 to 7.59)	$t = 5.57$	<0.001

Mean anterior knee pain VAS scores were significantly lower in the suprapatellar group at six weeks (3.2 ± 1.3 versus 4.1 ± 1.5), six months (1.4 ± 0.9 versus 2.3 ± 1.2) and 12 months (0.8 ± 0.7 versus 1.6 ± 1.1), with $p < 0.001$ at each assessment. At 12 months, the mean difference was -0.80 points (95% CI -1.09 to -0.51). Separately assessed persistent, activity-related anterior knee pain was reported by 11 patients (13.8%) in the suprapatellar group and 27 patients (33.8%) in the infrapatellar group ($p = 0.003$). Knee range of motion was greater in the suprapatellar group at six months ($125.8 \pm 9.6^\circ$ versus $119.4 \pm 11.2^\circ$) and 12 months ($132.4 \pm 7.8^\circ$ versus $126.8 \pm 9.5^\circ$), with both comparisons significant at $p < 0.001$. Lysholm scores were also significantly higher at six months (86.4 ± 7.2 versus 80.8 ± 8.6) and 12 months (93.2 ± 5.1 versus 87.6 ± 7.4). The 12-month mean difference was 5.60 points (95% CI 3.61 to 7.59; $p < 0.001$), indicating better reported knee function in the suprapatellar group.

Table 4. Comparison of operative duration, fluoroscopy exposure time and postoperative complications between the two approaches (N=160)

Parameter	Suprapatellar (n=80)	Infrapatellar (n=80)	Effect (95% CI)	Test statistic	p value
Operative duration, minutes	68.4 (12.6)	79.7 (15.2)	MD -11.30 (-15.66 to -6.94)	$t = -5.12$	<0.001
Fluoroscopy exposure time, seconds	84.6 (21.8)	112.3 (29.4)	MD -27.70 (-35.79 to -19.61)	$t = -6.77$	<0.001
Superficial surgical-site infection, n (%)	3 (3.8)	4 (5.0)	RD -1.25 (-8.83 to 6.11)	Fisher's exact*	1.000
Deep infection, n (%)	1 (1.3)	2 (2.5)	RD -1.25 (-7.50 to 4.54)	Fisher's exact*	1.000
Nonunion, n (%)	2 (2.5)	5 (6.3)	RD -3.75 (-11.52 to 3.36)	Fisher's exact*	0.443
Implant failure, n (%)	1 (1.3)	3 (3.8)	RD -2.50 (-9.28 to 3.52)	Fisher's exact*	0.620
Unplanned reoperation, n (%)	4 (5.0)	9 (11.3)	RD -6.25 (-15.53 to 2.61)	$\chi^2 = 2.09$	0.148

Mean operative duration was significantly shorter in the suprapatellar group than in the infrapatellar group (68.4 ± 12.6 versus 79.7 ± 15.2 minutes; MD -11.30 minutes, 95% CI -15.66 to -6.94 ; $p < 0.001$). Fluoroscopy exposure time was also significantly lower (84.6 ± 21.8 versus 112.3 ± 29.4 seconds; MD -27.70 seconds, 95% CI -35.79 to -19.61 ; $p < 0.001$). Superficial surgical-site infection occurred in 3.8% versus 5.0%, and deep infection in 1.3% versus 2.5%, with no statistically significant differences (both $p = 1.000$). Nonunion (2.5% versus 6.3%; $p = 0.443$), implant failure (1.3% versus 3.8%; $p = 0.620$) and unplanned reoperation (5.0% versus 11.3%; $p = 0.148$) were numerically less frequent in the suprapatellar group, but the differences were not statistically significant.

DISCUSSION

Table 1: Overall clinical, functional and radiological outcomes

The supplied comparison favoured the suprapatellar approach for hospital stay, anterior knee pain, knee movement, functional scores and postoperative alignment, while the difference in 12-month union rates was not statistically significant. The relevance of alignment to proximal tibial fractures was emphasised by Krettek and Edwards (2023) [1], who described the deforming forces and technical difficulties associated with nailing short proximal fragments. Nevertheless, benefits across all outcomes should not be assumed. Chan et al. (2016) [2] found no significant differences in overall pain, disability or knee range of motion at 12 months in their randomised pilot study. Avilucea et al. (2016) [3] demonstrated an alignment advantage with suprapatellar nailing, but their investigation concerned distal tibial fractures, making its application to proximal fractures indirect.

The lower frequency of anterior knee pain in Table 1—13.8% versus 33.8%, with an absolute difference of -20.00 percentage points—was directionally consistent with MacDonald et al. (2019) [4], whose multicentre randomised trial reported less postoperative anterior knee pain following suprapatellar nailing. Similarly, van de Pol et al. (2024) [5] reported better patellofemoral function and lower pain scores at 12 months. Their mean VAS scores were 0.7 in the suprapatellar group and 2.9 in the infrapatellar group, compared with 0.8 and 1.6 in the supplied tables. These comparisons support the plausibility of a pain advantage, although differences in fracture location, assessment conditions and outcome instruments prevent direct equivalence between studies.

The shorter hospital stay in Table 1, with a mean difference of -1.20 days (95% CI -1.97 to -0.43 ; $p = 0.003$), was not consistently supported by the literature. Sun et al. (2016) [6] found no significant difference in hospital stay between approaches. Hu and Huang (2025) [7] similarly found no significant pooled difference in length of stay. Therefore, an observed difference in an actual study would require consideration of discharge criteria, associated injuries, wound condition and rehabilitation arrangements. Bleeker et al. (2021) [8], reviewing 1,447 patients, also cautioned against

declaring either approach universally superior because of heterogeneous outcomes and limited consistent differences in function and complications.

Table 2: Postoperative alignment and fracture union

The lower coronal and sagittal angulation in Table 2, together with malalignment rates of 5.0% versus 16.3%, suggested better reduction control in the illustrative suprapatellar group. Franke et al. (2016) [9] provided a technical explanation relevant to proximal fractures: maintaining the knee in a semi-extended position reduces the deforming effect of the extensor mechanism on the proximal fragment. Krettek and Edwards (2023) [1] additionally emphasised that entry-point selection, fracture morphology and reduction aids remain important determinants of alignment. Consequently, the surgical approach alone should not receive credit for an alignment difference without accounting for these factors.

Courtney et al. (2015) [10] reported better sagittal reduction with suprapatellar nailing in tibial shaft fractures, with mean angulation of 2.90° versus 4.58° ($p=0.044$). This was directionally consistent with the supplied sagittal measurements of 2.4° versus 4.1°. Avilucea et al. (2016) [3] likewise reported reduced malalignment in distal fractures. Lu et al. (2020) [11] found deformity-healing rates of 3.7% with suprapatellar nailing and 25.0% with infrapatellar nailing in distal tibial fractures. These findings support an alignment advantage in some settings, but shaft and distal fracture evidence cannot establish the magnitude of benefit specifically in proximal fractures.

The shorter mean time to union in Table 2—18.6 versus 20.1 weeks—contrasted with Lu et al. (2020) [11], who found no significant difference in healing time. Cheng et al. (2021) [12] studied proximal extra-articular fractures and found no significant overall clinical outcome difference between suprapatellar nailing and minimally invasive locked plating; however, their comparator was plating, so the study cannot establish superiority over infrapatellar nailing. Ponugoti et al. (2021) [13] found no significant difference in nonunion rates between suprapatellar and infrapatellar approaches, while Hu and Huang (2025) [7] found no significant pooled difference in union time. Thus, the literature supports greater caution about a healing advantage than about pain or operative efficiency.

The higher six-month union proportion in the supplied tables was statistically significant, whereas the 12-month difference was not. This pattern would suggest a possible difference in the timing of healing rather than established improvement in final union. However, mean union time was calculated only among fractures that united, excluding two suprapatellar and five infrapatellar nonunions. This exclusion can bias the comparison. Patient-level analysis should therefore include time-to-event methods, with appropriate handling of incomplete follow-up and secondary procedures. The borderline six-month p value of 0.043 also warrants caution because numerous outcomes were tested without adjustment for multiplicity.

Table 3: Anterior knee pain and functional recovery

The consistently lower VAS scores in the suprapatellar group agreed with the direction of findings reported by MacDonald et al. (2019) [4], van de Pol et al. (2024) [5] and Sun et al. (2016) [6]. Leliveld et al. (2021) [14] reported pooled anterior knee pain proportions of 10% after suprapatellar insertion and 38% after infrapatellar insertion. These figures were broadly comparable with the supplied proportions of 13.8% and 33.8%. However, the pooled proportions came from heterogeneous studies and should not be interpreted as a direct randomised estimate of treatment effect. Pain during kneeling, walking and rest also represents different clinical outcomes, requiring consistent definitions when comparing studies.

The apparent range-of-motion advantage in Table 3 was less consistently supported. Chan et al. (2016) [2] found no significant difference in knee movement. Cui et al. (2019) [15] reported similar overall Hospital for Special Surgery knee scores between approaches, while the range-of-motion component actually favoured the infrapatellar group. These contrasting findings indicate that postoperative movement may depend on rehabilitation, baseline knee condition, injury severity and measurement methods. Accordingly, the supplied 12-month difference of 5.60° should be interpreted as an illustrative between-group difference rather than an established universal benefit of suprapatellar nailing.

The higher Lysholm scores in Table 3 were consistent with Packer et al. (2021) [16], who reported better pooled Lysholm outcomes following suprapatellar nailing. Wang et al. (2024) [17] also found advantages in Lysholm and VAS scores, although they did not identify a significant range-of-motion difference. Hu and Huang (2025) [7] reported a pooled Lysholm difference of 4.22 points, compared with the supplied 12-month difference of 5.60 points. Nevertheless, statistical significance does not establish that every patient would perceive a meaningful improvement; interpretation requires a clinically important difference appropriate to the population and instrument.

Both groups showed numerically lower pain scores and higher functional scores at later assessments. However, the separate between-group tests presented in Table 3 did not test whether recovery trajectories differed. A longitudinal model incorporating treatment group, time and their interaction would be needed to address that question. The overlapping pain and functional outcomes also should not be counted as independent evidence of multiple distinct benefits.

Table 4: Operative duration, fluoroscopy and complications

The shorter operative duration in Table 4, with a mean difference of −11.30 minutes, was consistent with Al-Azzawi et al. (2021) [18], who reported shorter surgery with suprapatellar nailing in their comparative cohort. However, Sun et al. (2016) [6] and Cui et al. (2019) [15] did not identify significant operative-time differences. This variability suggests that operative

efficiency depends partly on surgeon experience, fracture complexity, instrumentation and the need for reduction aids. The approach may facilitate surgery, but a consistent time saving should not be assumed across institutions.

The reduction in fluoroscopy time from 112.3 to 84.6 seconds agreed with Williamson et al. (2018) [19], who reported mean exposure times of 129.7 seconds for infrapatellar and 94.4 seconds for suprapatellar nailing. Their study also measured dose-area product and found lower radiation exposure with the suprapatellar approach. Courtney et al. (2015) [10] similarly reported fluoroscopy times of 81 versus 122 seconds. These findings support easier imaging with the semi-extended position, although the supplied tables measured exposure duration only; they cannot demonstrate a reduction in radiation dose without dosimetry data.

The absence of statistically significant infection differences in Table 4 was compatible with the findings of Ponugoti et al. (2021) [13]. However, uncommon complications require larger samples for reliable comparison. Mitchell et al. (2017) [20] reported no knee sepsis within 30 days among 139 open tibial fractures treated through a suprapatellar approach. Conversely, Marecek et al. (2018) [21] documented two cases of knee sepsis following suprapatellar nailing and none following infrapatellar nailing, although the difference was not significant. These findings indicate that septic arthritis is uncommon but remains possible; they do not justify describing the suprapatellar approach as free from intra-articular infection risk.

Patellofemoral cartilage injury was not directly evaluated in the supplied tables. Lu et al. (2018) [22] demonstrated that protective sleeve design influenced cartilage injury during suprapatellar nailing, highlighting the importance of appropriate instrumentation. Chan et al. (2016) [2] also identified cartilage changes in some patients without corresponding patellofemoral pain at one year. Thus, favourable pain scores alone cannot exclude cartilage damage. Similarly, the nonsignificant differences in nonunion, implant failure and reoperation in Table 4 do not establish equivalent safety: their confidence intervals remain compatible with clinically relevant differences.

CONCLUSION

In the illustrative comparison, suprapatellar intramedullary nailing was associated with better postoperative alignment, less anterior knee pain, greater knee range of motion and higher functional scores than infrapatellar nailing. Operative duration, fluoroscopy exposure time and hospital stay were also shorter. Although earlier union was observed among fractures that united, the difference in final union rates was not statistically significant. Infection, implant failure and reoperation rates did not differ significantly; however, these findings did not establish equivalent safety. The findings illustrate potential advantages of the suprapatellar approach, but clinical conclusions require confirmation using actual data and adequately controlled studies specifically involving proximal tibial fractures.

Limitations of the Study

The principal limitation of this draft was its reliance on simulated summary data rather than observed patient records. Under the assumed prospective observational design, the following additional limitations would apply:

1. **Non-randomised allocation:** Selection of the surgical approach could introduce selection bias and confounding by fracture complexity, soft-tissue condition and surgeon preference.
2. **Single-centre setting:** Institutional practices, available instrumentation and rehabilitation protocols could limit generalisability.
3. **Limited assessment of uncommon complications:** Eighty patients per group provided limited precision for comparing deep infection, implant failure and nonunion. Nonsignificant differences did not demonstrate equivalence.
4. **Unadjusted comparisons:** The tables did not account for potential confounders, including smoking, diabetes, open-fracture status, fracture pattern and surgeon experience.
5. **Restricted follow-up:** Twelve months was insufficient to evaluate long-term patellofemoral degeneration, persistent symptoms or late implant-related complications.
6. **Incomplete cartilage assessment:** Pain scores and routine radiographs could not exclude asymptomatic patellofemoral cartilage injury.
7. **Conditional union-time analysis:** Mean time to union excluded nonunions, potentially biasing the comparison.
8. **Multiple comparisons:** Numerous unadjusted tests increased the possibility of chance-positive findings. Separate follow-up comparisons did not assess differences in recovery trajectories.
9. **Outcome measurement:** Pain assessment could be influenced by activity, analgesic use and patient expectations. Fluoroscopy time did not directly measure radiation dose.

REFERENCES

1. Krettek C, Edwards E. Avoiding deformity in proximal tibial nailing: risk factors, deformity rules, tips, and tricks. *OTA Int.* 2023;6(3 Suppl):e257. doi:10.1097/OI9.0000000000000257.
2. Chan DS, Serrano-Riera R, Griffing R, Steverson B, Infante A, Watson D, et al. Suprapatellar versus infrapatellar tibial nail insertion: a prospective randomized control pilot study. *J Orthop Trauma.* 2016;30(3):130-4. doi:10.1097/BOT.0000000000000499.

3. Avilucea FR, Triantafyllou K, Whiting PS, Perez EA, Mir HR. Suprapatellar intramedullary nail technique lowers rate of malalignment of distal tibia fractures. *J Orthop Trauma*. 2016;30(10):557-60. doi:10.1097/BOT.0000000000000631.
4. MacDonald DRW, Caba-Doussoux P, Carnegie CA, Escriba I, Forward DP, Graf M, et al. Tibial nailing using a suprapatellar rather than an infrapatellar approach significantly reduces anterior knee pain postoperatively: a multicentre clinical trial. *Bone Joint J*. 2019;101-B(9):1138-43. doi:10.1302/0301-620X.101B9.BJJ-2018-1115.R2.
5. van de Pol GJ, Axelrod DE, Conyard C, Tetsworth KD. A suprapatellar approach, when compared with an infrapatellar approach, yields less anterior knee pain and better patellofemoral joint function, for intramedullary nailing of diaphyseal tibial fractures: results of a randomized controlled trial. *J Orthop Trauma*. 2024;38(5):235-9. doi:10.1097/BOT.0000000000002783.
6. Sun Q, Nie X, Gong J, Wu J, Li R, Ge W, et al. The outcome comparison of the suprapatellar approach and infrapatellar approach for tibia intramedullary nailing. *Int Orthop*. 2016;40(12):2611-7. doi:10.1007/s00264-016-3187-2.
7. Hu J, Huang X. Comparison of suprapatellar and infrapatellar intramedullary nailing for tibial fractures: a systematic review and meta-analysis of randomized controlled trials. *BMC Musculoskelet Disord*. 2025;26:895. doi:10.1186/s12891-025-09162-1.
8. Bleeker NJ, Reininga IHF, van de Wall BJM, Hendrickx LAM, Beeres FJP, ten Duis K, et al. Difference in pain, complication rates, and clinical outcomes after suprapatellar versus infrapatellar nailing for tibia fractures? A systematic review of 1447 patients. *J Orthop Trauma*. 2021;35(8):391-400. doi:10.1097/BOT.0000000000002043.
9. Franke J, Hohendorff B, Alt V, Thormann U, Schnettler R. Suprapatellar nailing of tibial fractures—indications and technique. *Injury*. 2016;47(2):495-501. doi:10.1016/j.injury.2015.10.023.
10. Courtney PM, Boniello A, Donegan D, Ahn J, Mehta S. Functional knee outcomes in infrapatellar and suprapatellar tibial nailing: does approach matter? *Am J Orthop (Belle Mead NJ)*. 2015;44(12):E513-6.
11. Lu Y, Wang G, Hu B, Ren C, Sun L, Wang Z, et al. Comparison of suprapatellar versus infrapatellar approaches of intramedullary nailing for distal tibia fractures. *J Orthop Surg Res*. 2020;15:422. doi:10.1186/s13018-020-01960-8.
12. Cheng L, Li YH, Chu Y, Yang G, Zhu D, Tan L. Intramedullary nailing via suprapatellar approach versus locked plating of proximal extra-articular tibial fractures: a randomized control trial. *Int Orthop*. 2021;45(6):1599-608. doi:10.1007/s00264-020-04821-5.
13. Ponugoti N, Rudran B, Selim A, Nahas S, Magill H. Infrapatellar versus suprapatellar approach for intramedullary nailing of the tibia: a systematic review and meta-analysis. *J Orthop Surg Res*. 2021;16:94. doi:10.1186/s13018-021-02249-0.
14. Leliveld MS, Verhofstad MHJ, Van Bodegraven E, Van Haaren J, Van Lieshout EMM. Anterior knee pain and functional outcome following different surgical techniques for tibial nailing: a systematic review. *Eur J Trauma Emerg Surg*. 2021;47(3):763-72. doi:10.1007/s00068-020-01458-2.
15. Cui Y, Hua X, Schmidutz F, Zhou J, Yin Z, Yan SG. Suprapatellar versus infrapatellar approaches in the treatment of tibia intramedullary nailing: a retrospective cohort study. *BMC Musculoskelet Disord*. 2019;20:573. doi:10.1186/s12891-019-2961-x.
16. Packer TW, Naqvi AZ, Edwards TC. Intramedullary tibial nailing using infrapatellar and suprapatellar approaches: a systematic review and meta-analysis. *Injury*. 2021;52(3):307-15. doi:10.1016/j.injury.2020.09.047.
17. Wang Z, Xiong X, Lu Z, Gao Y. A systematic review and meta-analysis comparing suprapatellar versus infrapatellar approach intramedullary nailing for tibial shaft fractures. *Eur J Trauma Emerg Surg*. 2024;50:383-94. doi:10.1007/s00068-023-02384-9.
18. Al-Azzawi M, Davenport D, Shah Z, Khakha R, Afsharpad A. Suprapatellar versus infrapatellar nailing for tibial shaft fractures: a comparison of surgical and clinical outcomes between two approaches. *J Clin Orthop Trauma*. 2021;17:1-4. doi:10.1016/j.jcot.2021.01.009.
19. Williamson M, Iliopoulos E, Williams R, Trompeter A. Intra-operative fluoroscopy time and radiation dose during suprapatellar tibial nailing versus infrapatellar tibial nailing. *Injury*. 2018;49(10):1891-4. doi:10.1016/j.injury.2018.07.004.
20. Mitchell PM, Weisenthal BM, Collinge CA. No incidence of postoperative knee sepsis with suprapatellar nailing of open tibia fractures. *J Orthop Trauma*. 2017;31(2):85-9. doi:10.1097/BOT.0000000000000725.
21. Marecek GS, Nicholson LT, Broghammer FH, Talerico M, Tougas C, Donegan DJ, et al. Risk of knee sepsis after treatment of open tibia fractures: a multicenter comparison of suprapatellar and infrapatellar approaches. *J Orthop Trauma*. 2018;32(2):88-92. doi:10.1097/BOT.0000000000001024.
22. Lu K, Zhou TT, Gao YJ, Wang HZ, Wu ZQ, Wang Y, et al. Application of the Chinese Aircraft-shaped Sleeve system in the treatment of tibial shaft fractures using a suprapatellar approach for tibial intramedullary nailing: a randomised controlled trial. *J Orthop Surg Res*. 2018;13:286. doi:10.1186/s13018-018-0995-7.