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Functional and Radiological Outcome of Proximal Tibia Fracture Treated with Suprapatellar Nailing

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Abstract

Background:
Proximal third tibial fractures, often resulting from high-energy trauma, present a challenge due to the difficulty in achieving optimal alignment and maintaining fixation. Traditional intramedullary nailing via the infrapatellar route is associated with complications such as anterior knee pain and malalignment. The suprapatellar (SP) approach, performed with the knee in a semi-extended position, has gained popularity due to improved reduction and ease of instrumentation.

Objective:
To evaluate the functional and radiological outcomes of proximal third tibia fractures treated with suprapatellar intramedullary interlocking (IMIL) nailing.

Materials and Methods:
A prospective interventional study was conducted on 15 skeletally mature patients (aged 18–65 years) with extra-articular proximal third tibia fractures. Patients underwent suprapatellar IMIL nailing and were followed up at 2 weeks, 6 weeks, and 24 weeks. Functional outcome was assessed using the Lower Extremity Functional Scale (LEFS), and radiological union was monitored through serial radiographs.

Results:
The mean age was 34.6 years, with 60% being male. Left-sided fractures were more common (60%). The average time to union was 14 weeks. Functional outcomes were excellent in 54%, good in 33%, and fair in 13% of patients. Only 2 patients (13%) experienced delayed union; no cases of infection or significant malalignment were reported. The suprapatellar approach was associated with minimal anterior knee pain and satisfactory alignment.

Conclusion:
Suprapatellar IMIL nailing for proximal third tibial fractures provides a favorable alternative to conventional approaches. It offers improved alignment, fewer complications, and excellent early functional outcomes. This approach is particularly beneficial in proximal fractures where anatomical reduction is difficult with traditional infrapatellar techniques.

Keywords: Proximal third tibia fracture, Suprapatellar nailing, Intramedullary interlocking nail, Functional outcome, Radiological union

INTRODUCTION

Proximal tibial fractures represent approximately 5–11% of all tibial shaft fractures and frequently result from high-energy trauma, such as road traffic accidents or falls from height [1]. These fractures are commonly extra-articular and pose significant surgical challenges due to the anatomical geometry of the proximal tibia, muscle forces, and difficulty in maintaining fracture reduction [2].

Traditionally, intramedullary nailing has been a mainstay for treating diaphyseal and metaphyseal fractures of the tibia. However, in proximal third fractures, the standard infrapatellar technique—performed with the knee in hyperflexion—often leads to complications such as anterior knee pain, valgus or procurvatum deformities, and difficulty with entry point alignment [3,4]. These issues are primarily due to the quadriceps force causing anterior angulation when the knee is flexed, which hinders reduction [5].

The suprapatellar nailing approach, introduced as an alternative, involves a semi extended knee position, which aligns the intramedullary canal more accurately with the nail trajectory. This method improves fluoroscopic visualization, facilitates reduction, and potentially reduces surgical time and intraoperative radiation exposure [6]. Moreover, SP nailing offers better control in proximal fractures and has been associated with lower rates of malalignment and postoperative complications [7,8].

While several studies have established the biomechanical and radiological advantages of suprapatellar over infrapatellar nailing, clinical outcomes, and complication profiles—particularly in proximal third tibia fractures—remain an area of active investigation [9]. A growing body of literature supports SP nailing in improving alignment and functional outcomes without increasing risks to intra-articular structures when performed with appropriate instrumentation [10].
This study aims to evaluate the functional and radiological outcomes of suprapatellar IMIL nailing in extra-articular proximal third tibial fractures. By assessing union rates, complications, and lower limb functionality, this study seeks to validate the efficacy of the SP approach in a prospective cohort from a tertiary care centre.

Materials and Methods

Study Design and Setting

A prospective interventional study was conducted in the Department of Orthopaedics at Dhanalakshmi Srinivasan Medical College and Hospital, Tamil Nadu, over an 18-month period from March 2023 to August 2024. All patients were followed up for a minimum of six months, with assessments at 2 weeks, 6 weeks, and 24 weeks postoperatively.

Study Population

A total of 15 patients presenting with extra-articular proximal third tibial fractures were enrolled in the study. Eligible patients were between 18 and 65 years of age, skeletally mature, and met the inclusion and exclusion criteria as outlined below.

Inclusion Criteria

- Patients with extra-articular proximal third tibial fractures (with or without associated fibular fractures)
- Both genders
- Closed fractures or Gustilo-Anderson Grade I/II open fractures
- Fractures less than 3 weeks old
- Patients who consented to surgery and postoperative follow-up

Exclusion Criteria

- Intra-articular tibial plateau fractures
- Age below 18 or above 65 years
- Pathological fractures
- Gustilo-Anderson Grade III open fractures
- Neurovascular injuries or neurological disorders
- Patients unfit for surgery due to medical contraindications
- Patients not willing to participate in follow-up

Preoperative Evaluation

All patients underwent clinical evaluation, including history, physical examination, and preoperative imaging. Fractures were classified using the AO/OTA and Gustilo-Anderson systems. Standard preoperative work-up, including blood investigations and anaesthetic clearance, was completed. Informed consent was obtained in the patient's native language.

Surgical Technique

All procedures were performed under spinal anaesthesia with the patient in the supine position. The knee was flexed approximately 20–30° with a bolster placed under the knee joint.

A 2-cm longitudinal incision was made approximately 1 cm above the superior pole of the patella. After splitting the quadriceps tendon, a protective sleeve and trocar were inserted into the knee joint. The entry point was established under

fluoroscopic guidance, located just lateral to the tibial tuberosity on the anteroposterior view and anterior to the articular margin in the lateral view.

A guidewire was introduced into the medullary canal under fluoroscopy, followed by sequential reaming of the canal 1–1.5 mm beyond the intended nail diameter. The selected titanium intramedullary nail was inserted over a ball-tipped guidewire and locked proximally using the insertion jig and distally using a freehand technique.

Intraoperative alignment was verified in both planes using C-arm fluoroscopy. Wounds were closed in layers and a sterile dressing was applied. Postoperative antibiotics and analgesics were administered as per institutional protocol.

Postoperative Protocol

Patients were mobilized on the first postoperative day with non-weight-bearing ambulation. Partial weight-bearing was initiated at 6 weeks, progressing to full weight-bearing by 12–14 weeks based on clinical and radiological signs of healing.

Patients were followed up at 2, 6, and 24 weeks postoperatively. Radiographs were obtained at each visit to assess fracture union, alignment, and implant position. Union was defined radiographically by the presence of bridging callus in at least three cortices and clinically by the absence of pain or tenderness at the fracture site.

Outcome Measures

- Functional Outcome: Evaluated using the Lower Extremity Functional Scale (LEFS), a validated 20-item questionnaire assessing daily physical activity.
- Radiological Outcome: Time to fracture union, alignment (coronal and sagittal planes), and complications such as delayed union, non-union, infection, or implant failure were recorded.

Data Collection and Statistical Analysis

Data were collected using a pre-designed template and analysed using SPSS version 22. Descriptive statistics (mean, standard deviation, and percentages) were used to summarize baseline characteristics and outcomes. Inferential statistics, including the Student's t-test and Chi-square test, were used to assess associations where applicable. A p-value <0.05 was considered statistically significant.

Results

Demographics and Baseline Characteristics

A total of 15 patients were enrolled, with a male predominance (60%, n=9). The mean age of patients was 34.6 years, ranging from 21 to 60 years. Left-sided fractures were more frequent (60%), and the majority of fractures were closed (60%). Two patients had associated comorbidities: one with diabetes and another with a concomitant femoral shaft fracture.

Table 1: Demographic and Baseline Data

Variable	Value
Total patients	15
Age group (most common)	31–40 years (40%)
Gender	Male: 9 (60%), Female: 6 (40%)
Side of fracture	Left: 9 (60%), Right: 6 (40%)
Type of fracture	Closed: 9 (60%), Open: 6 (40%)
Grade of open fracture	Grade I: 4, Grade II: 2
Associated comorbidities	Present in 2 (13%) patients

Functional Outcome (LEFS Scores)

The Lower Extremity Functional Scale (LEFS) was used to evaluate postoperative functionality at final follow-up. Eight patients (54%) achieved excellent scores, five (33%) had good scores, and two (13%) had fair scores. No patient reported poor functional outcomes.

Table 2: Functional Outcome (LEFS Score)

LEFS Score Category	Number of Patients	Percentage (%)
Excellent	8	54
Good	5	33
Fair	2	13
Poor	0	0

Fracture Union and Complications

Union was achieved in all patients, with most fractures uniting within 14 weeks. Two patients (13%) experienced delayed union; however, no cases of non-union, implant failure, or infection were observed.

Table 3: Union Time and Complications

Time to Union	Number of Patients	Percentage (%)
12 weeks	4	27
14 weeks	7	46
16 weeks	4	27

Complication	Number of Patients	Percentage (%)
Delayed union	2	13
No complications	13	87

Summary of Outcomes

The suprapatellar nailing technique demonstrated satisfactory functional and radiological outcomes in the majority of cases. Alignment was maintained in all cases as confirmed through serial imaging. Minimal anterior knee pain was reported and did not affect functional outcomes.

Table 4: Summary of Outcomes

Parameter	Observation
Union achieved	100% of cases
Functional outcome (Good/Excellent)	87% of patients
Delayed union	13% of patients
Infections	None
Postoperative knee pain (significant)	None observed

Discussion

Proximal third tibial fractures are biomechanically challenging due to their location, the deforming forces of the quadriceps and hamstring muscles, and the tendency for malalignment during surgical fixation [1]. The advent of suprapatellar intramedullary nailing (SP-IMN) has introduced a valuable technique that offers enhanced alignment and surgical ergonomics for these fractures. The present prospective study demonstrated promising functional and radiological outcomes in patients with extra-articular proximal tibial fractures managed with SP nailing.

Demographics and Fracture Profile

The majority of patients in this study were young to middle-aged males (mean age: 34.6 years), consistent with the literature, where high-energy trauma is the predominant etiology in this demographic [2,3]. Males are typically more prone to these injuries due to greater involvement in high-risk activities. Similar demographic trends were noted by Sagar et al. [4] and Fu et al. [5], supporting the external validity of our findings.

Functional Outcomes

In our study, the functional outcome was excellent or good in 87% of the patients as per LEFS scoring. This aligns with studies by Kulkarni et al. [6] and Wang et al. [7], both of whom reported high satisfaction scores and early return to function with SP nailing. The semiextended position of the knee during SP nailing offers better control during reduction, especially for proximal fractures, thereby reducing malreduction risks and improving functional outcomes [8].

Radiological Union and Complications

Union was achieved in all patients, with a mean union time of approximately 14 weeks. Delayed union occurred in only two cases (13%), and no patient developed non-union, infection, or significant malalignment. These findings are in line with Zelle et al. [9], who also demonstrated high union rates with minimal complications using the SP technique.

One of the primary concerns with SP nailing is potential intra-articular damage, particularly to the patellofemoral cartilage. However, multiple cadaveric and clinical studies have demonstrated that with proper technique and instrumentation, damage to intra-articular structures is minimal and clinically insignificant [10,11]. No patients in our study reported significant anterior knee pain—a commonly cited postoperative complaint in infrapatellar nailing [12].

Comparison with Infrapatellar Approach

The infrapatellar (IP) approach, although widely used, has several limitations in managing proximal third tibial fractures. Due to the required hyperflexion of the knee, there is increased risk of apex anterior angulation and difficulty in maintaining reduction during nail insertion [13]. In contrast, SP nailing permits a more anatomically aligned starting point and improved fluoroscopic control without hyperflexion, thereby reducing technical errors and fluoroscopy time [14].

Yang et al. [15], in a meta-analysis comparing SP and IP approaches, concluded that SP nailing significantly reduces blood loss, operative time, and malalignment, while improving LEFS and Lysholm scores. Our study's findings resonate with these conclusions, particularly in terms of reduced complications and improved functionality.

Radiation Exposure and Surgical Efficiency

A secondary benefit of SP nailing is reduced intraoperative radiation exposure. Williamson et al. [16] demonstrated that surgeons performing SP nailing used significantly less fluoroscopy time compared to IP techniques. This was attributed to the more straightforward visualization of the entry point and fracture alignment in the semi extended position.

Anterior Knee Pain

Anterior knee pain has long been associated with IM nailing, especially via the infrapatellar approach due to patellar tendon splitting or irritation. Several studies, including those by Jones et al. [17] and Fontalis et al. [18], have indicated that SP nailing does not significantly increase anterior knee pain. Our results corroborate these findings, with no patient reporting debilitating pain at the final follow-up.

Limitations

This study has several limitations. The sample size was small (n=15), and while sufficient to draw preliminary conclusions, larger multicentre trials would strengthen the evidence. Moreover, a longer follow-up period would be necessary to assess late complications such as chronic knee pain or osteoarthritis. Objective assessment tools such as MRI or second-look arthroscopy could provide further insights into intra-articular cartilage status post-SP nailing.

Strengths and Clinical Relevance

Despite its limitations, the study's prospective design, standardized surgical technique, and structured follow-up protocol enhance its validity. Our findings provide clinical support for adopting SP nailing, especially in proximal tibial fractures, where the benefits of improved alignment and reduced operative complexity are particularly advantageous.

Conclusion

The management of proximal third tibial fractures continues to pose technical challenges due to the propensity for malalignment and the complex biomechanical forces acting at the fracture site. The suprapatellar intramedullary interlocking nailing (SP-IMN) technique, as explored in this study, has proven to be a safe, effective, and reproducible option for treating these fractures.

In our prospective analysis of 15 patients, the SP approach demonstrated excellent to good functional outcomes in 87% of patients and successful fracture union in all cases. The technique facilitated improved alignment during nail insertion by eliminating the need for knee hyperflexion and enabled superior intraoperative imaging due to the semi-extended positioning. These technical advantages translated to reduced malalignment rates and optimal implant placement.

Furthermore, postoperative complications were minimal, with only two instances of delayed union and no infections or malunions. Notably, none of the patients in our cohort reported significant anterior knee pain, supporting previous studies that suggest the SP approach does not compromise patellofemoral joint integrity when performed correctly.

Given these findings and corroborative literature, suprapatellar nailing should be considered a preferred method, particularly for proximal tibial fractures. It not only simplifies the surgical technique but also improves radiographic and functional outcomes. Future research with larger cohorts, longer follow-up, and comparative trials with the infrapatellar technique will further define the role of SP nailing in tibial fracture management.

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