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Original Research Article

Functional and radiological outcome of intramedullary nailing in proximal tibial fractures through supra patellar approach

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ABSTRACT

Background: Proximal third tibial fractures pose complex challenges in orthopaedic trauma care. The choice of surgical approach plays a pivotal role in achieving successful outcomes. This study was conducted to address the significant gap in research regarding the functional and radiological outcomes of the supra patellar approach in intramedullary nailing for proximal tibial fractures.
Methods: This prospective cohort study was conducted on a total of 100 patients presenting with proximal tibial fractures. All patients underwent intramedullary nailing using the supra patellar approach. Functional Outcome was assessed using the lower extremity functional scale (LEFS) at 3 weeks, 3 months, and 6months and 1-year post-surgery. Union status, alignment, and hardware-related complications were assessed through X-rays at each follow-up point to study the radiological outcome.
Results: At the end of1-year follow-up, 88% of patients had an excellent LEFS score,10% had a good LEFS score, and 2% had a fair LEFS score. All patients had a radiological union at 1 year follow up with an average radiological union time being 5.6 (±1.8) months.
Conclusions: We advocate for the utilization of suprapatellar nailing as the preferred approach for managing proximal third tibial fractures. This method consistently yields excellent clinical and radiological outcomes while maintaining a minimal complication rate in comparison to other management modalities.

Keywords: Intramedullary nailing, Suprapatellar approach, Proximal tibia fractures

INTRODUCTION

Fractures of the tibia are among the most frequently occurring long bone fractures, accounting for approximately 2% of adult fractures.[1] Proximal tibial fractures present a unique set of challenges in orthopaedic surgery, characterized by their intricate anatomy and complex biomechanics and exhibit an increased likelihood of significant soft tissue damage and bone comminution with higher complication rates. Historically, proximal third tibial fractures have posed significant challenges in achieving and sustaining correct alignment, often resulting in early failure as indicated in the reported case series.[2-6]

Fixation options for proximal tibia fractures typically include intramedullary nailing (IMN), locking plates and external fixation, utilizing pins and an external frame. The choice of fixation method depends on factors such as the fracture type, severity, and the patient's overall health and mobility. While IMN has established itself as the preferred surgical approach for tibial shaft fractures, there remains a contentious aspect when it comes to determining the definitive management strategy for proximal third tibial fractures.[7] The treatment of these fractures has evolved over the years, with closed IMN emerging as a promising surgical option. A commonly preferred and traditional method for accessing the proximal tibia involves utilizing an infrapatellar (IP) portal, achieved through either a

transpatellar tendon split or by gently moving the tendon in a medial or lateral direction. Managing proximal third diaphyseal tibial fractures using this method can pose challenges because it necessitates hyperflexion of the knee to establish a suitable entry point, potentially causing additional displacement of the fracture.[8] Moreover, it is worth noting that anterior knee pain is a documented complication of this procedure, impacting anywhere from 10% to 40% of patients.[9] Furthermore, the use of fluoroscopic imaging presents challenges, as it necessitates significant tilting of the C-arm to align with the flexed knee. Lastly, the surgeon must operate from stepstools or with their arms extended above shoulder level when reaming in a superior-to-inferior direction.

The development of the suprapatellar (SP) approach was aimed to address these challenges. Positioning the limb semi-extended offers sufficient support without requiring continuous manual reduction maintenance. This approach also simplifies the positioning and use of the image intensifier, ultimately resulting in a more streamlined surgical procedure without compromising the final outcome.[10]

This study addresses the significant gap in research regarding the functional and radiological outcomes of the supra patellar approach in intramedullary nailing for proximal tibial fractures. Despite the potential advantages of this approach, there is a notable scarcity of comprehensive studies assessing its efficacy and safety.

Moreover, the limited representation of research from the Indian subcontinent on this topic highlights the need for data that are specific to this geographical context, considering the diverse patient demographics and healthcare practices in the region. This study aims to contribute valuable insights to orthopaedic trauma management and aid clinicians in making evidence- based decisions, particularly in a region where such data are scarce.

METHODS

This is a prospective cohort study conducted in the Department of Orthopaedics, Sarojini Naidu Medical College, Agra over a period of 2 years (2021-2023). A total of 100 patients presenting with proximal tibial fractures were enrolled for the study.

Patients aged above 18 years with closed or compound grade 1 and 2 proximal tibial fractures amenable to IMN, willingness to participate, and signed informed consent were included, whereas patients below the age of 18 years, those with compound grade 3 fractures, pathological fractures, intra- articular fractures, associated vascular injuries, previous knee or hip joint pathology, inability to follow- up or patients unfit for surgery were excluded from the study. All patients underwent IMN using the supra patellar approach.

Surgical technique

Patient positioning

The patient is placed in a supine position on the operating table with the affected knee flexed at approximately 20 degrees, facilitating access and alignment during the procedure (Figure 1a).

Incision

A midline incision is made at the superior pole of the patella, ensuring a precise entry point for the surgical approach (Figure 1b).

Quadriceps tendon split

A longitudinal split is carefully created in the quadriceps tendon, allowing access to the knee joint from the supra patellar region (Figure 1c).

Figure 1: (a) Patient positioning, (b) surface marking and incision, and (c) quadriceps tendon splitting.

Knee joint entry

The knee joint is entered from the supra patellar region, providing direct access to the tibia.

Custom trocar and protective sleeve

A custom-made trocar, accompanied by a protective sleeve, is inserted into the knee joint. This trocar serves as a guiding instrument for the subsequent steps (Figure 2a).

Entry points

The entry points for the trocar are positioned just medial to the lateral tibial spine, ensuring accurate placement and reducing the risk of damage to surrounding structures, and a guide pin is inserted (Figure 2b and c).

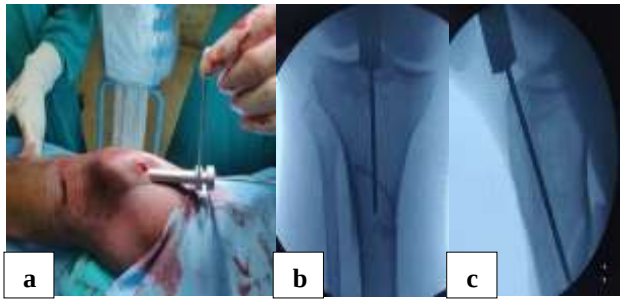

Figure 2: (a) Insertion of custom trocar and sleeve, (b) and (c) intra-op radiographs showing insertion of guide pin.

Fracture reduction

Fracture reduction is meticulously performed, aligning the fractured segments to restore anatomical positioning.

Guide wire insertion

The guide pin is replaced with a guide wire, which is carefully inserted through the trocar and advanced into the tibial canal, providing a precise path for the nail placement (Figure 3a and b).

Serial reaming

Serial reaming is performed to prepare the intramedullary canal for nail insertion, ensuring a proper fit and alignment (Figure 3c-e).

Fluoroscopy confirmation

The entire process is closely monitored and confirmed using fluoroscopy imaging to verify accurate reduction, guide wire placement, and reaming.

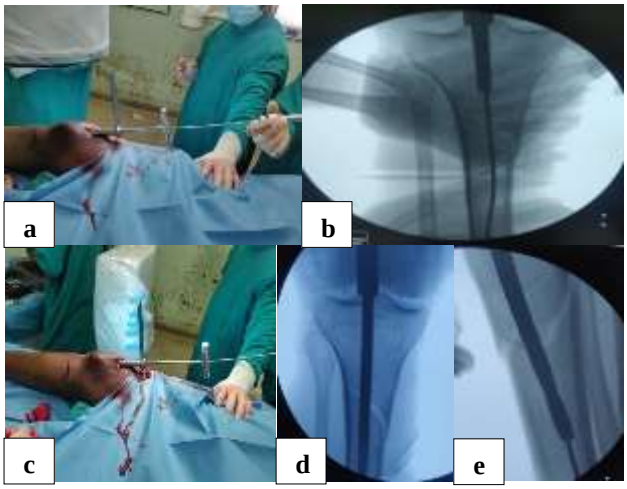

Figure 3: (a) Guide pin replaced with a guide wire, (b) intra-op radiograph showing insertion of the guide wire in the tibial canal, (c) insertion of reamer over the guide wire, (d) and (e) radiographs showing the passage of reamer.

Nail placement

An appropriately sized intramedullary nail is inserted into the prepared canal, providing stable fixation of the fracture (Figure 4a and b).

Proximal screw insertion

A custom-made proximal jig is employed to facilitate the precise insertion of the proximal screw, securing the nail's position (Figure 4c and d).

Distal screw insertion

The distal screw is inserted using a freehand technique under fluoroscopy guidance to ensure proper fixation and alignment (Figure 4e).

Suturing and closure

Following successful nail placement and screw fixation, the surgical site is thoroughly washed, and sutures are meticulously applied to close the incision, ensuring a secure and clean wound closure.

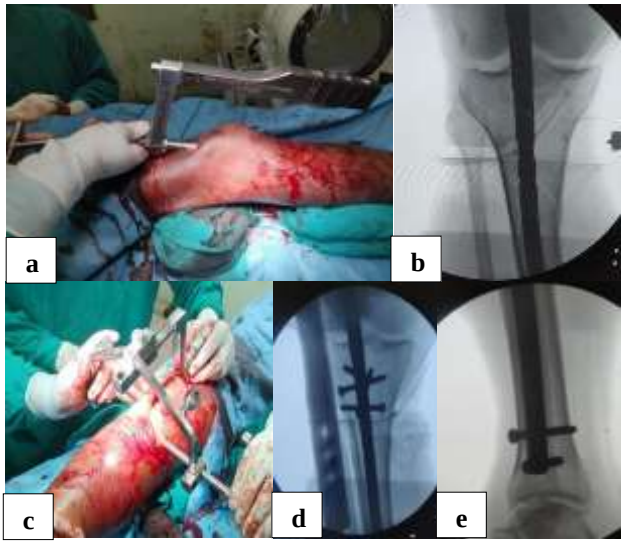

Figure 4: (a) and (b) Insertion of the nail, (c) Jig application for proximal locking, (d) and (e) radiographs showing proximal and distal locking screws.

Post-operative protocol

Knee and ankle range of motion initiated as soon as possible. Partial weight bearing was started at 4 weeks, and full weight bearing at 6-8 weeks.

For highly comminated fractures, partial weight bearing was initiated from 6-8 weeks while full weight bearing was allowed from 10-12 weeks or after the radiological union, whichever was earlier.

Outcome measures

Functional outcome

Functional outcome was assessed using the LEFS at 3 weeks, 3 months, and 6 months and 1-year post-surgery. The LEFS is a comprehensive assessment tool consisting of 20 self-reported questions that gauge a patient's ability to perform various lower extremity activities. Each question is rated on a scale from 0 (indicating extreme difficulty) to 4 (indicating no difficulty), with a total score range of 0 to 80, where higher scores indicate better lower extremity function. A score of 70-80 was graded as excellent, 60-70 as good, 40-60 as fair and less than 40 as poor.

Radiological outcome

During each follow-up, true anteroposterior (AP) and true lateral radiographs of the leg, including the knee and ankle joint, were obtained. Union status, alignment, and hardware- related complications were assessed through X-rays at each follow-up point to study the radiological outcome.

Statistical analysis

The data was collected on a Microsoft excel sheet. Statistical package for the social sciences (SPSS) was used for statistical analysis. Descriptive statistics, paired t-tests, and analysis of variance (ANOVA) were employed to assess functional and radiological outcomes. P values <0.05 were considered statistically significant.

RESULTS

A total of 100 patients above the age of 18 years were enrolled on the study (Table 1). The age mean age of the participants in the study was 42.5±12.8 years, with a range of 19 to 75 years.

Table 1: Age distribution.

Age interval (years)	No. of participants
18-25	20
25-40	36
40-60	34
>60	10
Total	100

Out of the 100 participants, 66 were male while 34 were female. 73 out of the 100 participants sustained trauma as a result of road traffic accidents (RTA), 16 sustained fractures as a result of falls, 6 were injured during sport-related activities while the rest 5 had miscellaneous causes (e.g. assault, and industrial accident). 54 of the 100 patients had a simple proximal tibia fracture, 32 had a grade 1 compound fracture while the rest 14 had a grade 2 compound fracture. The mean duration between the traumatic event and the surgical intervention was 4.2 days, with a range of 1 to 10 days. The mean operative time for the surgical procedure was 75±12 minutes while the mean blood loss during the surgery was 120±30 ml (Table 2).

Table 2: Baseline characteristics.

Variables	Frequency
Mean age (years)	42.5±12.8
Male	66
Female	34
Trauma mechanism	
Road traffic accidents (RTA)	73
Fall	16
Sporting activity	6
Others	5
Fracture type	
Simple	54
Compound grade 1	32
Compound grade 2	14
Time to surgery (days)	4.2
Operative time (min)	75±12
Blood loss (ml)	120±30

Functional outcome

At 3-weeks post-surgery, the mean LEFS score was 55, indicating moderate functional limitation. At 3 months' post-surgery, the mean LEFS score improved to 64, indicating mild to moderate functional limitation. At 6 months' post-surgery, the mean LEFS score further improved to 72, indicating minimal functional limitation, while the mean LEFS at the end of 1-year follow-up was 78 (Table 3 and Figure 5).

Table 3: Mean LEFS score.

Follow up duration	Mean LEFS score
3 weeks	55
3 months	64
6 months	72
1 year	78

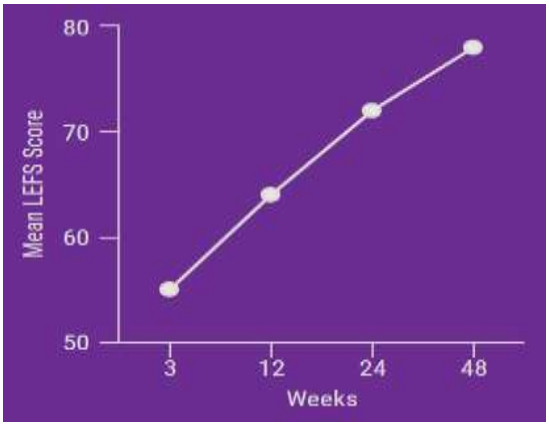

Figure 5: Mean LEFS score at each follow-up.

At the end of 1-year follow-up, 88 % of patients had an excellent LEFS score (70-80), 10% had a good LEFS score (60-70), and 2 had a fair LEFS score (40-60).

Radiological outcome

At 3 weeks' post-surgery, radiological assessments showed alignment maintenance and early signs of fracture healing in 78% of participants. At 3 months' post-surgery, radiological assessments indicated stable fracture union in 84% of participants and in 95 % at 6 months' post-surgery. At 1-year follow-up, all participants demonstrated complete fracture union and maintenance of alignment. The average time for the radiological union was 5.6 (±1.8) months.

These results demonstrate favorable functional and radiological outcomes for participants undergoing intramedullary nailing through the supra-patellar approach for proximal tibial fractures. The functional recovery improved over time, and radiological assessments indicated successful fracture union and alignment maintenance, affirming the efficacy and safety of this surgical technique for managing these fractures.

Figure 6: (a) Pre-operative X-ray of a 25-year-old male with proximal tibia fracture, (b) immediate post-op x-ray, (c) X-ray at 3-months follow-up, and (d) X-ray at 1-year follow-up.

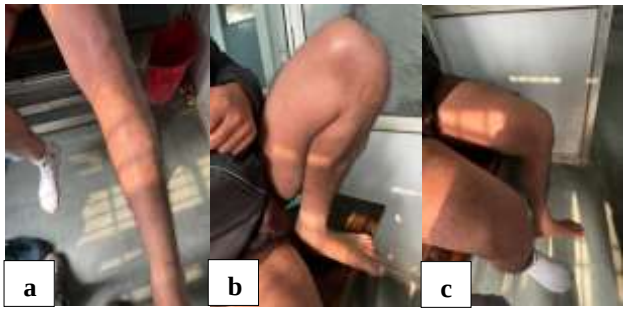

Figure 7 (a-c): Functional outcome.

DISCUSSION

Fractures of the proximal third of the tibia represent approximately 8-10% of all tibial fractures. These injuries, characterized by their high-energy nature, often entail severe damage to soft tissues. Given the proximity to the joint, it becomes imperative to restore anatomical alignment in order to regain functional capabilities. While open reduction with plate osteosynthesis is capable of achieving the desired anatomical alignment, its effectiveness in achieving satisfactory functional restoration is hindered by the high incidence of complications associated with this method.[11] The use of an intramedullary nail to stabilize these fractures appears to be a secure approach, building upon the positive outcomes observed in tibial shaft fractures managed through nailing procedures. Preservation of the soft tissue envelope, utilization of load-sharing intramedullary devices, a minimally invasive surgical approach, decreased blood loss, and the potential for partial weight-bearing post-procedure are the benefits associated with nailing.[12] Post-operative knee pain can be attributed to factors such as the division of the patellar tendon, potential protrusion of the proximal nail, structural damage within the joint, and the involvement of the infrapatellar nerve. The utilization of the suprapatellar approach is specifically designed to mitigate these concerns, aiming to minimize post-operative pain and complications.[13]

Tornetta et al proposed nailing in the semi-extended position via a para-patellar approach.[14] Concerns associated with this approach included enduring anterior knee discomfort, damage to intra- articular structures, as well as potential deviations in patellar tracking due to the release of the retinaculum. In their cadaveric study, Eastman et al assessed the viability of the retro-patellar technique for intramedullary nailing through a suprapatellar incision and subsequently endorsed its use for tibial fracture fixation.[15]

Sanders et al illustrated exceptional results using the suprapatellar approach in a diverse series of tibial fracture cases. Post-nail insertion arthroscopic assessments and one-year magnetic resonance imaging (MRI) follow-ups disclosed no substantial cartilage damage, reaffirming the approach's favourable outcomes.[16] In their randomized controlled trial investigating the management of tibial shaft fractures, Chan et al. observed no notable difference in outcomes between the suprapatellar and infrapatellar approaches.[17]

Kulkarni et al in their study on 43 subjects with proximal tibia fractures described average LEFS at the end of 1-year follow-up of 89.4%, which is similar to that of our study.[18] Our study demonstrates a progressive improvement in functional status over time. At 3 weeks, the mean LEFS score indicated moderate functional limitation, which is expected immediately after surgery. This is often due to the postoperative challenges patients face during early rehabilitation. At the 3-month follow-up, the mean LEFS

score improved to indicate mild to moderate functional limitation. This significant improvement suggests that patients are successfully transitioning to a more functional state during the early postoperative period. By the 6-month follow-up, the mean LEFS score reached minimal functional limitation, indicating that patients were regaining near-normal or normal functional status. These results are encouraging and highlight the potential for an excellent functional recovery following intramedullary nailing through the suprapatellar approach.

CONCLUSION

We advocate for the utilization of suprapatellar nailing as the preferred approach for managing proximal third tibial fractures. This method consistently yields excellent clinical and radiological outcomes while maintaining a minimal complication rate in comparison to other management modalities. The inherent advantages of suprapatellar nailing, including precise positioning and optimal nail entry render it a highly viable option for addressing proximal third tibial fractures. The suprapatellar approach exhibited several advantages including superior knee functional scores, a reduced incidence of malalignment, decreased surgical duration, and reduced requirement for open reduction.

Notably, the significant reduction in the occurrence of anterior knee pain, a common issue associated with the conventional infrapatellar approach, underscores its applicability in the nailing of various tibial fracture types. It is important to highlight that in cases involving revisions and infections, we still employ the infrapatellar nailing technique. Consequently, we recommend that orthopaedic surgeons acquire proficiency in both approaches to ensure versatility in their surgical toolkit.

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Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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