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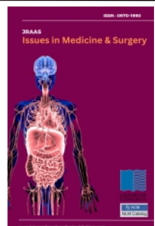

Research Article

Section: Orthopaedics

Functional & Radiological Outcomes of Suprapatellar Intramedullary Nailing in Proximal Tibial & Tibial Shaft Fractures: A Prospective Study

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HIGHLIGHTS

- Improved fracture alignment
- Good functional outcomes
- Early fracture union
- Minimal cartilage injury
- Low anterior knee pain

Key Words:
Suprapatellar nailing
Proximal Tibial fracture
Tibial shaft fracture
Intramedullary nail
Lysholm score
LEFS

ABSTRACT

Introduction: Proximal tibial and tibial shaft fractures are common injuries often caused by high-energy trauma. Conventional infrapatellar intramedullary nailing with the knee in flexion may lead to difficulty in maintaining alignment, whereas the suprapatellar semi-extended approach improves fracture reduction, alignment control, and surgical ergonomics. **Aim & Objectives:** To evaluate the effectiveness of suprapatellar intramedullary nailing in proximal tibial and tibial shaft fractures by assessing fracture reduction, alignment, functional and radiological outcomes, and postoperative complications associated with the suprapatellar approach. **Materials & Methods:** A prospective observational study was conducted on 30 patients with proximal tibial and tibial shaft fractures treated with suprapatellar intramedullary nailing at Kanti Devi Medical College Hospital & Research Centre. Patients were followed for six months with clinical and radiological evaluation. Functional outcomes were assessed using the Lysholm Knee Scoring Scale and LEFS, while arthroscopy was used to evaluate patellofemoral cartilage integrity before and after nail insertion. **Results:** The mean age of patients was 48.2 ± 18.6 years. Radiological union was achieved within 16 weeks in 86.6% of patients, with a mean union time of 13.8 ± 2.7 weeks. Knee flexion greater than 120° was achieved in 66.7% of patients. The mean Lysholm score was 82.6 ± 11.4 and the mean LEFS score was 69.2 ± 12.1. Anterior knee pain was observed in 6.6% of patients. Arthroscopic evaluation demonstrated minimal patellofemoral cartilage injury in most cases. **Conclusions:** Suprapatellar intramedullary nailing is a safe and effective technique for proximal tibial and tibial shaft fractures. The semi-extended position facilitates improved fracture alignment and provides satisfactory fracture union with good functional outcomes and minimal complications.

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INTRODUCTION

Fractures of the proximal tibia and tibial shaft are among the most common long-bone injuries encountered in orthopaedic trauma practice and are frequently associated with significant morbidity, particularly among young and economically product-ive individuals. These fractures commonly result from high-energy mechanisms such as road traffic accidents and falls from height. Due to the subcutaneous location of the tibia and limited soft tissue coverage, such injuries are associated with compli-cations including delayed union, malunion, infection, and impaired functional recovery [1–3].

Intramedullary nailing is currently considered the gold standard treatment for tibial shaft fractures because it provides stable fixation while preserving fracture biology and allowing early mobilization [4-6]. However, proximal third tibial fractures remain technically challenging when treated using conventional infrapatellar nailing performed with the knee in flexion. Deforming muscular forces acting on the proximal fragment often result in apex anterior angulation and valgus malalignment, making reduction difficult to maintain [7-10]. In addition, anterior knee pain remains a common postoperative complaint following infrapatellar tibial nailing and may adversely affect kneeling and activities of daily living [11,12]. Various techniques including modified entry points and the use of blocking screws have been described to improve fracture alignment in proximal tibial fractures [13-15]. Tornetta & Collins introduced the semi extended position for tibial nailing to facilitate improved control of fracture reduction [16]. This concept subsequently evolved into the suprapatellar approach, in which the intramedullary nail is inserted through the suprapatellar pouch with the knee maintained in a semi-extended position [17]. The suprapatellar approach offers several advantages including improved alignment control, easier fluoroscopic visualization, reduced deforming forces on the proximal fragment, and improved surgeon ergonomics, particularly in proximal tibial fractures, obese patients, and polytrauma cases [18–22]. Although early concerns existed regarding potential patellofemoral cartilage injury, cadaveric and clinical studies have demonstrated minimal intra-articular damage when protective instrumentation is used [23–26].

Recent studies have reported satisfactory fracture union, improved alignment, lower incidence of anterior knee pain, and favorable functional outcomes following suprapatellar tibial nailing [27]. Functional recovery after tibial fracture fixation can be objectively assessed using validated scoring systems such as the Lysholm Knee Scoring Scale and the Lower Extremity Functional Scale (LEFS), which evaluate pain, stability, mobility, and activities of daily living. **Figure 1** shows the illustrative representation of suprapatellar intramedullary nailing in proximal tibial and tibial shaft fractures, demonstrating the surgical technique, fracture fixation patterns, radiological outcomes, and functional recovery assessed by Lysholm Knee Score and Lower Extremity Functional Scale (LEFS).

Despite encouraging international and Indian reports, prospective data evaluating combined radiological, functional, and patellofemoral outcomes following suprapatellar intramedullary nailing remain limited. Therefore, the present study aimed to evaluate the clinical, radiological, and functional outcomes of suprapatellar intramedullary nailing in patients with proximal tibial and tibial shaft fractures.

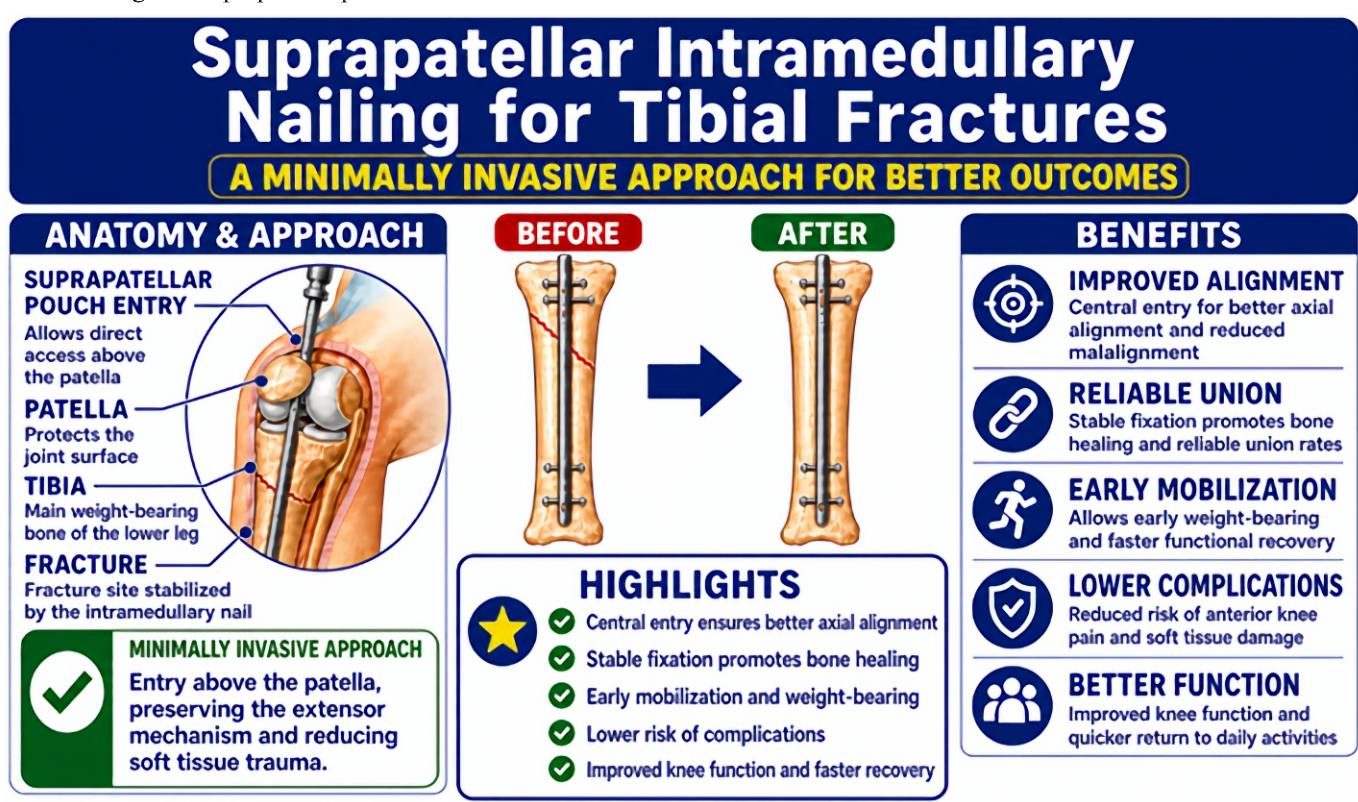

Figure 1: Overview of suprapatellar intramedullary nailing showing surgical technique, fracture fixation, radiological union, and functional outcomes.

MATERIALS & METHODS

Study design and setting

This prospective observational study was conducted in the Department of Orthopaedics, Kanti Devi Medical College Hospital & Research Centre, Mathura, Uttar Pradesh, over a period of 24 months from January 2024 to December 2025 after obtaining approval from the Institutional Ethics Committee.

Study population

A total of 30 patients with proximal tibial and tibial shaft fractures treated using suprapatellar intramedullary nailing were included in the study.

Inclusion criteria

1. Closed tibial shaft fractures
2. Closed proximal tibial fractures
3. Gustilo-Anderson grade I and II open tibial fractures
4. Skeletally mature patients
5. Patients medically fit for surgery
6. Patients willing to participate and provide informed consent

Exclusion criteria

1. Gustilo-Anderson grade III open fractures
2. Distal tibial fractures
3. Tibial plateau fractures
4. Pathological fractures
5. Old malunited tibial fractures
6. Skeletally immature patients
7. Patients medically unfit for surgery

***Patient evaluation*:** All patients underwent detailed history taking, clinical examination, and radiological assessment using anteroposterior and lateral radiographs of the affected leg. Fractures were classified according to the AO/OTA classification system. Routine laboratory investigations and pre-anesthetic evaluation were performed before surgery.

***Operative technique*:** All procedures were performed under appropriate anesthesia with the patient placed supine on a radiolucent operating table. The knee was maintained in a semi-extended position with approximately 20° of flexion using a bolster. A longitudinal skin incision approximately 5 cm in length was made proximal to the superior pole of the patella. The quadriceps tendon was split longitudinally to gain access to the suprapatellar pouch. Arthroscopic evaluation of the patellofemoral joint was performed before nail insertion, and cartilage status was assessed using the Outerbridge grading system. A protective cannula and trocar were inserted through the trochlear groove to the tibial entry point under fluoroscopic guidance. Sequential reaming of the intramedullary canal was performed, followed by insertion of an appropriately sized intramedullary nail. Proximal locking was performed using a jig, while distal locking was performed using a freehand technique under fluoroscopic guidance.

Following fixation, the knee joint was irrigated thoroughly and repeat arthroscopic evaluation of the patellofemoral joint was performed. The quadriceps tendon and skin were closed in layers and sterile dressing was applied.

***Postoperative protocol*:** Static quadriceps exercises were initiated on postoperative day 1, followed by knee flexion exercises on day 2 and passive range-of-motion exercises from day 3 onward. Ambulation with walker support and progressive weight-bearing were permitted depending on fracture stability and patient tolerance.

***Follow-up*:** Patients were followed clinically and radiologically at the 12th postoperative day, monthly for the first 3 months, and at 6 months postoperatively.

***Outcome assessment*:** Clinical evaluation included assessment of knee range of motion, limb length discrepancy, angular deformity, and anterior knee pain. Malalignment was defined as angulation greater than 5° in any plane. Radiological evaluation included assessment of fracture union, alignment, loss of reduction, and implant-related complications.

Functional outcomes: Functional outcomes were assessed using the Lysholm Knee Scoring Scale and Lower Extremity Functional Scale (LEFS). Arthroscopic evaluation of the patellofemoral joint was performed preoperatively and postoperatively using the Outerbridge grading system.

Statistical analysis: Data were entered into Microsoft Excel and analyzed using descriptive statistics. Continuous variables were expressed as mean ± standard deviation, while categorical variables were expressed as frequencies and percentages.

RESULTS

A total of 30 patients with proximal tibial and tibial shaft fractures treated with suprapatellar intramedullary nailing were included in the study. All patients completed clinical, radiological, and functional follow-up as per the study protocol.

Demographic profile

The age of patients ranged from 20 to 88 years, with a mean age of 48.2 ± 18.6 years. Most patients belonged to the young and middle-aged adult group. There were 16 males (53.3%) and 14 females (46.7%) **(Table 1)**.

Radiological union

Radiological union was achieved within 16 weeks in most patients. The mean union time was 13.8 ± 2.7 weeks. No cases of non-union were observed during the study period **(Table 2)**.

Knee range of motion

At final follow-up, knee flexion greater than 120° was achieved in 66.7% of patients **(Table 3)**. **Table 4** shows the functional outcome based on the Lysholm Knee Score among the study participants.

Functional outcome

The mean Lysholm score was 82.6 ± 11.4. Good to fair functional outcome was observed in the majority of patients. The mean LEFS score was 69.2 ± 12.1. Most patients regained satisfactory lower limb function and activities of daily living. **Table 5** shows the functional outcome based on the Lower Extremity Functional Scale (LEFS) among the study participants.

Complications

Superficial surgical site infection was observed in four patients and was managed conservatively. Anterior knee pain was observed in two patients (6.6%). Delayed union was observed in four patients. No cases of implant failure, significant malalignment, deep infection, or neurovascular injury were observed. **Table 6** shows the complications observed among the study participants during the study.

Arthroscopic findings

Arthroscopic evaluation of the patellofemoral joint demonstrated Outerbridge grade 0 cartilage in 25 patients, indicating no obvious iatrogenic cartilage injury attributable to the suprapatellar approach. Visualization was inconclusive in five patients due to blood contamination of the arthroscopic field. **Figure 2** shows the preoperative radiograph depicting a proximal tibial fracture with evident disruption of the proximal tibial anatomy and fracture alignment before surgical intervention. **Figure 3** shows the immediate postoperative radiograph following suprapatellar intramedullary nailing, demonstrating satisfactory placement of the intramedullary nail with adequate fracture reduction and alignment. **Figure 4** shows the follow-up radiograph demonstrating satisfactory fracture union with maintained alignment, progressive callus formation, and signs of successful healing at the fracture site.

Table 1: Demographic profile of patients

Variable	Number of patients	Percentage
Male	16	53.3%
Female	14	46.7%
Proximal tibial fractures	12	40%
Tibial shaft fractures	18	60%

Table 2: Time to radiological union

Time to union	Number of patients	Percentage
≤12 weeks	10	33.3%
13–16 weeks	16	53.3%
>16 weeks	4	13.3%

Table 3: Knee range of motion at final follow-up

Knee flexion	Number of patients	Percentage
>120°	20	66.7%
100°–120°	8	26.7%
<100°	2	6.6%

Table 4: Lysholm Knee Score outcome

Outcome	Number of patients	Percentage
Good	16	53.3%
Fair	10	33.3%
Poor	4	13.3%

Table 5: LEFS outcome

Outcome	Number of patients	Percentage
Good	14	46.7%
Fair	11	36.6%
Poor	5	16.7%

Table 6: Complications observed in the study

Complication	Number of patients
Superficial infection	4
Anterior knee pain	2
Delayed union	4

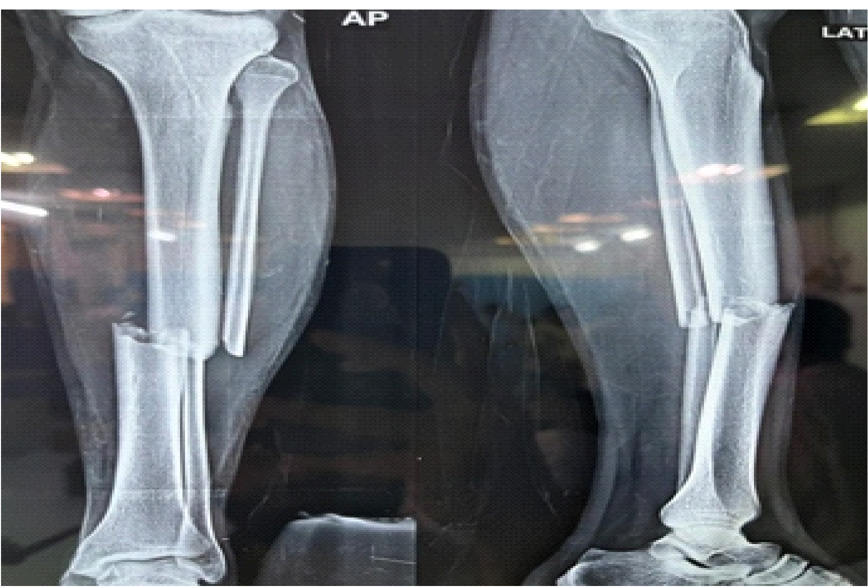

Figure 2: **Preoperative radiograph showing proximal tibial fracture.**

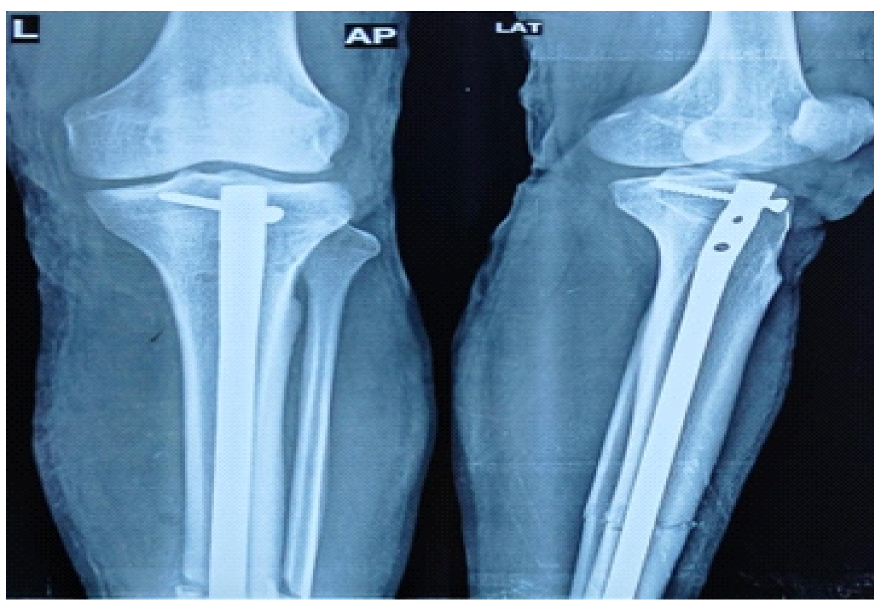

Figure 3: Immediate postoperative radiograph following suprapatellar intramedullary nailing.

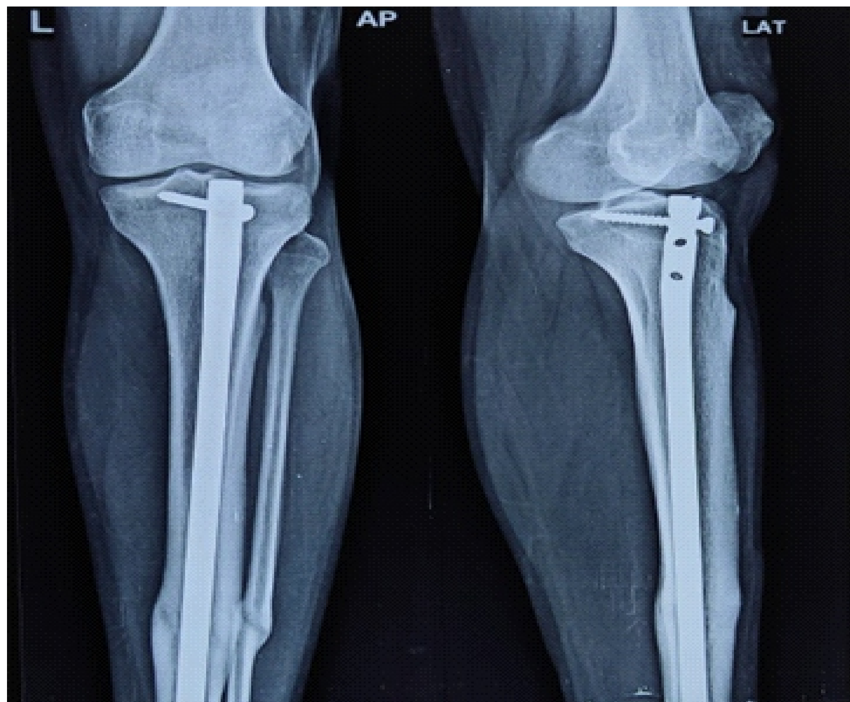

Figure 4: Follow-up radiograph showing satisfactory fracture union.

DISCUSSION

Fractures of the proximal tibia and tibial shaft remain challenging injuries because of their subcutaneous location, limited soft-tissue coverage, and tendency toward malalignment, particularly in proximal third fractures. Intramedullary nailing is considered the gold standard treatment for tibial shaft fractures; however, conventional infrapatellar nailing performed with the knee in flexion is associated with difficulty in maintaining fracture reduction and postoperative anterior knee pain [5,6]. The suprapatellar approach performed in a semi-extended position was introduced to overcome these limitations by improving fracture alignment and facilitating nail insertion [16,17].

In the present study, the mean age of patients was 48.2 years, with a slight male predominance. These findings are comparable with previous studies by Court-Brown et al. and Nandi et al., which demonstrated a similar demographic pattern in tibial fractures [3,22]. Proximal tibial fractures accounted for 40% of cases, while tibial shaft fractures constituted 60% of the study population. Proximal third tibial fractures are technically difficult because deforming muscular forces frequently result in apex anterior and valgus malalignment during conventional infrapatellar nailing [10]. Tornetta and Collins demonstrated that the semi-extended position improves fracture reduction and alignment control in proximal tibial fractures [16]. Similar findings have been reported by Sanders et al., Ryan et al., and Franke et al., who demonstrated improved alignment with the suprapatellar technique [15,17,18]. In the present study, satisfactory fracture alignment was achieved in all patients without the routine use of adjunctive reduction techniques or blocking screws. Radiological union was achieved within 16 weeks in most patients, with a mean union time of 13.8 ± 2.7 weeks. No cases of non-union were observed. These findings are comparable with studies by Sanders et al., Franke et al., & Nandi et al., which reported high union rates following suprapatellar tibial nailing [15,18,22]. The absence of non-union in the present study suggests that the suprapatellar approach provides adequate stability while preserving fracture biology.

At final follow-up, most patients achieved satisfactory knee range of motion, with 66.7% demonstrating knee flexion greater than 120°. Similar postoperative mobility outcomes have been reported by Eastman et al. & Ryan et al. [16,17]. Preservation of the extensor mechanism and avoidance of patellar tendon splitting in the suprapatellar approach may contribute to improved postoperative knee mobility. Functional outcomes assessed using the Lysholm Knee Scoring Scale and Lower Extremity Functional Scale (LEFS) were satisfactory in most patients. Good to fair Lysholm outcomes were observed in 86.6% of patients, while good to fair LEFS outcomes were observed in 83.4% of patients. Poor functional outcomes were predominantly observed in elderly patients above 60 years of age. Similar functional outcomes have been reported by Sharma et al., Singh et al., & Patel et al. [23–25].

Anterior knee pain remains one of the most frequently reported complications following infrapatellar tibial nailing. Keating et al. and Katsoulis et al. reported a relatively high incidence of postoperative anterior knee pain following conventional infrapatellar approaches [5,6]. In the present study, anterior knee pain was observed in only 6.6% of patients, supporting previous reports suggesting that the suprapatellar approach may reduce postoperative knee morbidity by avoiding violation of the patellar tendon. Arthroscopic evaluation of the patellofemoral joint demonstrated Outerbridge grade 0 cartilage in most patients, with no obvious iatrogenic cartilage injury attributable to the suprapatellar approach.

These findings are consistent with cadaveric and clinical studies by Gelbke et al. & Beltran et al., which demonstrated minimal intra-articular cartilage damage with the use of protective instrumentation [13,14]. The arthroscopic assessment performed in the present study further supports the safety of the suprapatellar approach with respect to patellofemoral cartilage integrity.

The present study has certain limitations, including a small sample size, relatively short follow-up duration, and absence of a comparative infrapatellar control group. Further multicentric studies with larger sample sizes and longer follow-up are recommended to evaluate long-term functional and patellofemoral outcomes better.

Overall, the findings of the present study suggest that suprapatellar intramedullary nailing is a safe and effective technique for the management of proximal tibial and tibial shaft fractures, providing satisfactory fracture union, favorable functional outcomes, and low complication rates [26,27].

CONCLUSION

Suprapatellar intramedullary nailing is a safe and effective technique for the management of proximal tibial and tibial shaft fractures. The semi-extended position facilitates improved fracture alignment and provides satisfactory radiological union and functional outcomes with minimal complications. The suprapatellar approach also demonstrated low incidence of anterior knee pain and minimal patellofemoral cartilage morbidity when appropriate protective instrumentation was used.

LIMITATIONS & FUTURE PERSPECTIVES

The study's limitations include a single-centre setting, a relatively small sample size, and a short study duration, which may limit the broader applicability of the results. Future studies should incorporate multicentre designs with larger populations to enhance validity, assess long-term outcomes, and investigate advanced diagnostic & management approaches. Such efforts will improve overall patient care and help minimize complications.

CLINICAL SIGNIFICANCE

The clinical significance of this study lies in its potential to bridge the gap between research findings and practical healthcare applications. It emphasizes the importance of trans-lating scientific observations into meaningful improve-ments in patient care, diagnosis, and treatment outcomes. By highlighting real-world relevance, the study contributes to evidence-based medical practice and supports informed clinical decision-making. Ultimately, the findings aim to enhance patient quality of life, optimize therapeutic strategies, and promote better disease management in clinical settings.

ABBREVIATIONS

LEFS: Lower Extremity Functional Scale
IMIL: Intramedullary Interlocking Nailing
RTA: Road Traffic Accident
ORIF: Open Reduction and Internal Fixation
SPN: Suprapatellar Nailing
IPN: Infrapatellar Nailing

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AUTHOR CONTRIBUTIONS

All authors significantly contributed to the study conception and design, data acquisition, or data analysis and interpretation. They participated in drafting the manuscript or critically revising it for important intellectual content, consented to its submission to the current journal, provided final approval for the version to be published, and accepted responsibility for all aspects of the work. Additionally, all authors meet the authorship criteria outlined by the International Committee of Medical Journal Editors (ICMJE) guidelines.

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CONFLICT OF INTEREST

Authors declared that there is no conflict of interest.

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All necessary consent & approval was obtained by authors.

CONSENT FOR PUBLICATION

All necessary consent for publication was obtained by authors.

DATA AVAILABILITY

All data generated and analyzed are included within this research article. The datasets utilized and/or analyzed in this study can be obtained from the corresponding author upon a reasonable request.

USE OF ARTIFICIAL INTELLIGENCE (AI) & LARGE LANGUAGE MODEL (LLM)

The authors confirm that no AI & LLM tools were used in thewriting or editing of the manuscript, and no images were altered or manipulated using AI & LLM.

AUTHOR'S NOTE

This article serves as an important educational tool for the scientific community, offering insights that may inspire future research

diretions. However, they should not be relied upon independently when making treatment decisions or developing public health policies.

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