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Original Research Article

SUPRAPATELLAR VERSUS INFRAPATELLAR NAILING FOR TIBIAL SHAFT FRACTURES: A COMPARISON OF SURGICAL AND CLINICAL OUTCOMES BETWEEN TWO APPROACHES

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ABSTRACT

Background: Intramedullary nailing is the standard treatment for tibial shaft fractures. While the infrapatellar (IP) approach has been traditionally used, the suprapatellar (SP) approach has gained popularity due to potential advantages in alignment and functional outcomes. However, comparative evidence between the two approaches remains limited and heterogeneous. The objective is to compare suprapatellar and infrapatellar intramedullary nailing in terms of surgical and clinical outcomes in patients with tibial shaft fractures.

Materials and Methods: A prospective, interventional, randomized study was conducted over 18 months including 40 adult patients with tibial shaft fractures. Patients were randomly allocated into two groups: SPN (n=20) and IPN (n=20). Baseline demographic and fracture characteristics were comparable between groups. Intraoperative parameters (operative time, blood loss), clinical outcomes (time to union, range of motion), and functional outcomes (Lysholm knee score and Lower Extremity Functional Scale [LEFS]) were assessed. Statistical analysis was performed using unpaired t-test, Chi-square test, and Fisher's exact test, with $p<0.05$ considered significant.

Results: The mean operative time was significantly lower in the SPN group compared to the IPN group (109.55±15.26 vs. 145.15±28.28 minutes; $p<0.05$). Mean blood loss was also significantly reduced in the SPN group (42.45±7.07 ml vs. 63.45±8.02 ml; $p<0.05$). Duration of hospital stay and time to clinical union were comparable between the groups ($p>0.05$). Functional outcomes were significantly better in the SPN group, with 100% patients achieving excellent LEFS scores compared to 65% in the IPN group ($p<0.05$). The mean Lysholm knee score was higher in the SPN group (91.05±4.62 vs. 74.90±7.92), though not statistically significant. The incidence of malalignment was significantly lower in the SPN group (5% vs. 20%; $p<0.05$).

Conclusion: Suprapatellar intramedullary nailing offers superior intraoperative efficiency and improved functional outcomes compared to the infrapatellar approach, while maintaining comparable fracture healing. It may be considered a preferred technique for the management of tibial shaft fractures.

Keywords: Tibial shaft fracture; Suprapatellar nailing; Infrapatellar nailing; Intramedullary nailing; Functional outcome; Lysholm knee score; Lower extremity functional scale; Malalignment.

INTRODUCTION

Tibial shaft fractures are among the most common long bone injuries encountered in orthopedic practice, accounting for a substantial proportion of lower extremity trauma worldwide.[1] Owing to the subcutaneous location of the tibia and its limited soft tissue envelope, these fractures are frequently associated with soft tissue compromise, increasing the risk of complications such as infection, delayed union, and malalignment.[2,3] The incidence is particularly high in young, active individuals exposed to high-energy trauma such as road traffic accidents, while low-energy mechanisms predominate in the elderly population.[4]

Intramedullary nailing (IMN) is widely regarded as the gold standard for the management of tibial shaft fractures due to its biomechanical stability, preservation of periosteal blood supply, and favorable functional outcomes.[5] However, the success of this technique is highly dependent on accurate fracture reduction and optimal entry point selection, as malalignment remains a recognized complication, particularly in proximal and distal third fractures.[6,7]

Traditionally, tibial IMN has been performed using the infrapatellar (IP) approach, which requires flexion of the knee joint to approximately 90° to facilitate access to the entry point.[8] Although widely practiced, this approach is associated with several technical challenges. Hyperflexion may lead to difficulty in maintaining fracture alignment due to the deforming forces of the quadriceps mechanism, particularly resulting in apex anterior angulation.[9] Furthermore, obtaining optimal intraoperative fluoroscopic images can be technically demanding, often increasing operative time and radiation exposure.[10] Anterior knee pain is another well-documented complication of the infrapatellar approach, with reported incidence ranging from 10% to 86%, significantly impacting postoperative functional outcomes and patient satisfaction.[11]

To address these limitations, the suprapatellar (SP) approach has emerged as a viable alternative. This technique involves nail insertion through the patellofemoral joint in a semi-extended knee position, which facilitates improved fracture alignment by neutralizing quadriceps tension and enabling easier intraoperative imaging.[12] Additionally, the use of specialized instrumentation and protective sleeves minimizes iatrogenic soft tissue injury and may reduce postoperative morbidity.[13]

Recent studies have suggested that the suprapatellar approach may offer several advantages, including reduced operative time, decreased blood loss, improved alignment, and lower rates of anterior knee pain.[14,15] A systematic review and meta-analysis by Xu et al. demonstrated superior functional outcomes and reduced malalignment rates with the suprapatellar technique compared to the infrapatellar approach.[16] Similarly, MacDonald et al. reported significantly lower anterior knee pain and improved patient-reported outcomes with suprapatellar nailing.[17]

Despite these encouraging findings, concerns persist regarding potential intra-articular damage to the patellofemoral joint and long-term cartilage degeneration associated with the suprapatellar approach.[18] Moreover, existing literature presents variability in reported outcomes, and high-quality comparative studies remain limited.

In this context, the present prospective randomized study was undertaken to compare suprapatellar and infrapatellar intramedullary nailing techniques in the management of tibial shaft fractures. The study aims to evaluate differences in surgical parameters and clinical outcomes, including range of motion, functional scores, and complication rates, thereby contributing to the growing body of evidence guiding optimal surgical approach selection.

MATERIALS AND METHODS

This hospital-based prospective, interventional, randomized study was conducted over a period of 18 months in the Department of Orthopedics at Government Medical College, Nandurbar, to compare the surgical and clinical outcomes of suprapatellar nailing (SPN) and infrapatellar nailing (IPN) in patients with tibial shaft fractures. A total of 40 adult patients meeting the eligibility criteria were enrolled and randomly allocated into two equal groups, with 20 patients undergoing SPN and 20 patients undergoing IPN.

The sample size was determined based on previously published data comparing operative time between the two techniques, considering a power of 80% and a significance level of 5%. The minimum required sample size was calculated to be 17 patients per group; however, to enhance statistical validity and account for potential loss to follow-up, 20 patients were included in each group.

Patients aged more than 18 years with closed, displaced, extra-articular tibial shaft fractures undergoing intramedullary nailing were included in the study. Both male and female patients were eligible, and associated fibular fractures were not considered an exclusion criterion. Patients with polytrauma requiring multidisciplinary management, pediatric fractures, infected fractures, refractures with implants in situ, and fractures involving the articular surface or segmental tibial fractures were excluded from the study.

After obtaining approval from the Institutional Ethics Committee, all eligible patients were enrolled following written informed consent. A detailed clinical evaluation, including history, general and local examination, and baseline functional assessment, was performed using a predesigned proforma. Demographic data, mechanism of injury, fracture characteristics, and comorbidities were

recorded. Fractures were classified according to the AO/OTA classification system based on radiographic findings.

Randomization was carried out using a computerized random number generation method, wherein patients were assigned to either the SPN or IPN group based on randomly generated values. All surgical procedures were performed by experienced senior orthopedic surgeons following standardized operative protocols. Prophylactic antibiotics were administered at the time of induction in all cases.

Intraoperative parameters, including duration of surgery (from positioning to wound closure), blood loss, and radiation exposure, were recorded. Radiation exposure was quantified using Dose Area Product (DAP), expressed in Gy•cm². The accuracy of the nail entry point was assessed using intraoperative and immediate postoperative radiographs in both anteroposterior and lateral views, with the optimal entry point defined as approximately 2 mm medial to the lateral tibial spine on the anteroposterior view.

Postoperative evaluation included both clinical and radiological assessments. Patients were followed up at 2 weeks, 4 weeks, 12 weeks, and 24 weeks. At each visit, clinical parameters such as wound healing, complications, range of motion of the knee joint, and return to functional activity were evaluated. Radiological assessment using standard anteroposterior and lateral radiographs of the knee and leg was performed postoperatively and at 3 months, with additional imaging as required.

Functional outcomes were assessed using validated scoring systems, including the Lysholm Knee Score and the Lower Extremity Functional Scale (LEFS). LEFS scores were categorized as excellent (70–80), good (60–70), fair (40–60), and poor (<40). Primary outcome measures included range of motion, Lysholm knee score, and LEFS, while secondary outcomes included duration of hospital stay and intraoperative parameters.

Statistical analysis was performed using appropriate software, including SPSS version 20 and Microsoft Excel. Quantitative variables were expressed as mean ± standard deviation, while qualitative variables were presented as frequencies and percentages. Comparisons between groups were performed using the unpaired Student's t-test for continuous variables and Chi-square or Fisher's exact test for categorical variables. A p-value of less than 0.05 was considered statistically significant.

The study was conducted in accordance with ethical principles outlined in the Declaration of Helsinki and guidelines for biomedical research on human subjects. Participation was voluntary, and confidentiality of patient data was maintained throughout the study. Patients were informed about both surgical techniques and retained the right to withdraw from the study at any point without affecting their standard of care.

RESULTS

A total of 40 patients were included in the study, with 20 patients each in the suprapatellar nailing (SPN) and infrapatellar nailing (IPN) groups. The baseline demographic and clinical characteristics of the study population are presented in [Table 1]. The majority of patients in both groups belonged to the 18–30 years age group (45% in SPN vs. 40% in IPN), with comparable mean ages (38.05 ± 17.29 vs. 37.65 ± 17.29 years; p>0.05). Both groups were predominantly male (70% vs. 80%), with right-sided fractures being more common. Most patients were classified as ASA Grade I in both groups, and no statistically significant differences were observed between the groups for baseline characteristics.

Table 1: Baseline Demographic and Clinical Characteristics

Variable	Category	SPN (n=20)	%	IPN (n=20)	%	p-value
Age (years)	18–30	9	45	8	40	>0.05
	31–40	3	15	4	20	
	41–50	4	20	3	15	
	51–60	1	5	2	10	
	61–70	2	10	2	10	
	71–80	1	5	1	5	
	Mean ± SD	38.05 ± 17.29		37.65 ± 17.29		
Sex	Male	14	70	16	80	>0.05
	Female	6	30	4	20	
Laterality	Right	13	65	16	80	>0.05
	Left	7	35	4	20	
ASA Grade	Grade I	19	95	18	90	>0.05
	Grade II	1	5	2	10	

Fracture characteristics and mechanism of injury are summarized in [Table 2]. Complex fracture patterns were more frequent in the SPN group (50%), whereas simple fractures predominated in the IPN group (55%), though this difference was not statistically significant (p>0.05). Road traffic accidents were the most common mechanism of injury in both groups (45% vs. 55%), followed by falls from height and sports injuries, with no significant intergroup difference.

Table 2: Fracture Characteristics and Mode of Injury

Variable	Category	SPN (n=20)	%	IPN (n=20)	%	p-value
Fracture Pattern	Simple	7	35	11	55	>0.05
	Wedge	3	15	4	20	
	Complex	10	50	5	25	
Mode of Injury	RTA	9	45	11	55	>0.05
	Fall from height	6	30	5	25	
	Sports injury	5	25	4	20	

Intraoperative and perioperative parameters are detailed in [Table 3]. The mean duration of surgery was significantly shorter in the SPN group compared to the IPN group (109.55 ± 15.26 minutes vs. 145.15 ± 28.28 minutes; $p<0.05$). Similarly, mean intraoperative blood loss was significantly lower in the SPN group (42.45 ± 7.07 ml vs. 63.45 ± 8.02 ml; $p<0.05$). However, the duration of hospital stay was comparable between the two groups ($p>0.05$).

Table 3: Intraoperative and Perioperative Parameters

Parameter	SPN (Mean ± SD)	IPN (Mean ± SD)	p-value
Duration of surgery (min)	109.55 ± 15.26	145.15 ± 28.28	<0.05
Blood loss (ml)	42.45 ± 7.07	63.45 ± 8.02	<0.05
Hospital stay (days)	6.15 ± 1.53	7.25 ± 2.05	>0.05

Clinical outcomes are presented in [Table 4]. The time to clinical union was similar between the two groups, with mean union times of 13.25 ± 4.34 weeks in the SPN group and 14.85 ± 4.45 weeks in the IPN group ($p>0.05$). Postoperative knee range of motion was also comparable. Functional outcomes, however, were significantly better in the SPN group, with all patients (100%) achieving excellent outcomes on the Lower Extremity Functional Scale compared to 65% in the IPN group ($p<0.05$). The mean LEFS score was higher in the SPN group. Similarly, the Lysholm knee score was higher in the SPN group, although the difference was not statistically significant.

Table 4: Clinical Outcomes

Parameter	Category	SPN (n=20)	%	IPN (n=20)	%	p-value
Clinical Union	<7 weeks	2	10	1	5	>0.05
	7–14 weeks	10	50	7	35	
	14–21 weeks	8	40	12	60	
	Mean ± SD	13.25 ± 4.34		14.85 ± 4.45		
Knee ROM (°)	Mean ± SD	115.35 ± 10.44		113.25 ± 9.68		>0.05
LEFS Score	Excellent	20	100	13	65	<0.05
	Good	0	0	7	35	
	Mean ± SD	75.55 ± 3.22		70.65 ± 4.33		
Lysholm Score	Mean ± SD	91.05 ± 4.62		74.90 ± 7.92		>0.05

Complications are summarized in [Table 5]. The incidence of malalignment was significantly lower in the SPN group (5% vs. 20%; $p<0.05$). One case of superficial infection was noted in the SPN group, while no such cases were observed in the IPN group, with no statistically significant difference.

Table 5: Complications

Complication	SPN (n=20)	%	IPN (n=20)	%	p-value
Malalignment	1	5	4	20	<0.05
Superficial infection	1	5	0	-	>0.05

DISCUSSION

The present prospective randomized study was conducted to compare suprapatellar nailing (SPN) and infrapatellar nailing (IPN) in the management of tibial shaft fractures, focusing on both surgical parameters and functional outcomes. The findings of this study suggest that while both techniques provide satisfactory fracture healing and comparable radiological outcomes, the suprapatellar approach demonstrates superior intraoperative efficiency and improved functional results.

The baseline demographic characteristics of the study population were comparable between the two groups, thereby minimizing selection bias. The majority of patients in both groups belonged to the younger age group (18–30 years), with a predominance of male patients, reflecting the typical epidemiological pattern of tibial shaft fractures associated with high-energy trauma. Similar demographic distributions have been reported by Al-Azzawi et al., Sahni et al., and Vishnu et al., where young male patients constituted the majority of cases.[19–21] The absence of statistically significant differences in baseline characteristics in the present study strengthens the validity of subsequent outcome comparisons.

In terms of fracture characteristics and mechanism of injury, road traffic accidents were the most common cause in both groups, followed by falls and sports injuries, consistent with previously published literature.[20,21] Although a higher proportion of complex fractures was observed in the SPN group, this difference was not statistically significant. Comparable findings have been reported by Al-Azzawi et al., who also noted a trend toward more complex fracture patterns in the suprapatellar group without significant intergroup differences.[19]

One of the most notable findings of this study was the significantly shorter operative time associated with the suprapatellar approach. The mean duration of surgery in the SPN group was significantly lower compared to the IPN group, which can be attributed to the semi-extended position facilitating easier fracture reduction and improved intraoperative visualization. These findings are consistent with those reported by Al-Azzawi et al., who demonstrated reduced operative time and radiation exposure with the suprapatellar technique.[19] Similarly, studies by Sahni et al. and Vishnu et al. have reported shorter surgical duration with SPN compared to IPN.[20,21] The reduced need for repeated manipulation and improved fluoroscopic access likely contribute to enhanced operative efficiency in the suprapatellar approach.

Intraoperative blood loss was also significantly lower in the SPN group in the present study. This may be related to reduced surgical manipulation and shorter operative duration. Comparable findings have been reported by Sahni et al., who observed significantly lower blood loss in patients undergoing suprapatellar nailing.[20] Minimization of intraoperative blood loss is clinically relevant, as it may facilitate faster recovery and reduce perioperative morbidity.

The duration of hospital stay was comparable between the two groups, indicating that both techniques allow similar early postoperative recovery. This observation is consistent with prior studies, including those by Vishnu et al. and Umur et al., which also demonstrated no significant difference in hospital stay between the two approaches.[21,22]

Fracture healing outcomes, as assessed by time to clinical union, were comparable between the two groups in the present study. Both SPN and IPN techniques achieved satisfactory union rates, with no statistically significant difference in mean healing time. Similar findings have been reported in multiple studies, including those by Vishnu et al. and Sahni et al., suggesting that the choice of approach does not significantly influence fracture healing kinetics.[20,21]

Postoperative knee range of motion was also comparable between the two groups, indicating that both techniques allow adequate restoration of joint mobility. These findings are consistent with those of Vishnu et al., who reported similar postoperative knee range of motion in both groups.[21]

However, functional outcomes showed a clear advantage for the suprapatellar approach. In the present study, all patients in the SPN group achieved excellent functional outcomes based on the Lower Extremity Functional Scale, compared to a lower proportion in the IPN group. The mean functional scores were also significantly higher in the SPN group. This can be attributed to reduced anterior knee pain and improved biomechanics associated with the semi-extended approach. Similar findings have been reported by van de Pol et al., who demonstrated improved patellofemoral function and reduced anterior knee pain in patients treated with suprapatellar nailing.[23] Sahni et al. also reported superior functional scores in the suprapatellar group.[20]

The Lysholm knee score was higher in the SPN group, although the difference was not statistically significant in the present study. Nevertheless, the trend toward better functional outcomes aligns with findings from previous studies. Al-Azzawi et al. reported significantly higher Lysholm scores in the SPN group compared to the IPN group.[19] Similarly, studies by Umur et al. and Vishnu et al. have demonstrated improved knee function with the suprapatellar approach.[21,22]

Complication analysis revealed a significantly lower incidence of malalignment in the SPN group compared to the IPN group. This finding highlights one of the key advantages of the suprapatellar approach, as the semi-extended position reduces deforming forces and facilitates better alignment during nail insertion. Similar observations have been reported by Vishnu et al. and Metcalf et al., who demonstrated reduced rates of malalignment and malunion with the suprapatellar technique.[21,24]

Although one case of superficial infection was observed in the SPN group, the difference was not statistically significant. Importantly, concerns regarding intra-articular damage associated with the suprapatellar approach were not evident in the present study, supporting the safety of the technique when performed with appropriate instrumentation and precautions.

Overall, the findings of the present study suggest that while both suprapatellar and infrapatellar approaches are effective for tibial shaft fracture fixation, the suprapatellar approach offers several advantages, including reduced operative time, lower blood loss, improved functional outcomes, and decreased risk of malalignment. These advantages make the suprapatellar approach a preferable alternative, particularly in complex fracture patterns where maintaining alignment is challenging.

CONCLUSION

The present study demonstrates that both suprapatellar and infrapatellar intramedullary nailing are effective techniques for the management of tibial shaft fractures, achieving comparable

fracture union rates and satisfactory restoration of knee range of motion. However, the suprapatellar approach offers distinct advantages in terms of intraoperative efficiency and functional outcomes.

Suprapatellar nailing was associated with significantly reduced operative time and intraoperative blood loss, along with a lower incidence of malalignment. Additionally, patients treated with the suprapatellar approach exhibited superior functional outcomes, as reflected by higher lower extremity functional scores and improved Lysholm knee scores, likely attributable to reduced anterior knee pain and better biomechanical alignment during fixation.

Although both techniques are safe and reliable, the findings of this study suggest that the suprapatellar approach may be considered a preferable alternative to the traditional infrapatellar technique, particularly in cases where optimal alignment and early functional recovery are critical. Further large-scale, multicentric studies with longer follow-up are recommended to validate these findings and assess long-term outcomes, including patellofemoral joint health.

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