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Comparative Analysis of Infrapatellar and Suprapatellar Nailing Techniques for Tibial Shaft Fractures

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ABSTRACT

Introduction: Tibial shaft fractures pose a significant challenge in orthopaedic practice, often necessitating surgical intervention for optimal recovery. The selection of the entry point for intramedullary nailing, particularly between the suprapatellar and infrapatellar approaches, remains a debated aspect in fracture management. This study aims to compare the suprapatellar and infrapatellar approaches, analyzing surgical techniques, complications, and functional outcomes to inform clinical decision-making.

Methodology: A retrospective comparative analysis was conducted on patients undergoing intramedullary nailing for tibial shaft fractures, comparing outcomes between the suprapatellar and infrapatellar approaches.

Result: Operative time was longer in the infrapatellar group (137.8 minutes) compared to the suprapatellar group (114.4 minutes). The mean radiation dose was higher in the infrapatellar group compared to suprapatellar group. Postoperative outcomes showed a mean Lysholm score of 74 and 90 in the infrapatellar group and suprapatellar group respectively. one case of infection and malunion were reported in the infrapatellar group, while the suprapatellar group had one infection case but no instances of non-union or malunion.

Conclusion: This study provides valuable insights into the surgical and clinical outcomes of the suprapatellar and infrapatellar approaches for tibial shaft fractures. Among both techniques the suprapatellar approach may offer advantages in terms of operative efficiency and functional recovery.

INTRODUCTION

Tibial shaft fractures represent a common orthopaedic challenge, often requiring surgical intervention to restore function and stability to the lower extremity. Among the various surgical techniques available, the choice of approach significantly influences surgical and clinical outcomes.[1] One debated aspect in tibial shaft fracture management is the selection of the entry point for intramedullary nailing, with the suprapatellar and infrapatellar approaches being the primary contenders.

Intramedullary nailing has emerged as the gold standard for the surgical management of tibial shaft fractures due to its biomechanical advantages, minimal soft tissue disruption, and faster postoperative recovery.[2] The su-

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prapatellar and infrapatellar approaches represent two distinct entry points for insertion of the intramedullary nail, each with its proponents and perceived benefits.[3]

The suprapatellar approach involves entry into the medullary canal through a small incision above the patella, allowing direct access to the proximal tibia.[4] In contrast, the infrapatellar approach utilizes an incision below the patella, with the nail inserted through the patellar tendon into the tibial canal.[5]

While both approaches aim to achieve fracture reduction and stability, they differ in their potential advantages and limitations, including ease of access, risk of injury to surrounding structures, postoperative pain, and functional outcomes.[6] Understanding these differences is crucial for orthopaedic surgeons to make informed decisions regarding the optimal approach for each patient.

Despite the growing body of literature comparing the suprapatellar and infrapatellar approaches, there remains a lack of consensus regarding which technique yields superior outcomes in terms of surgical efficacy, postoperative complications, and patient-reported functional outcomes.[7] Thus, a comprehensive comparison of the surgical and clinical outcomes between these two approaches is warranted to guide evidence-based decision-making in clinical practice.

This article aims to provide a comprehensive review and comparison of the suprapatellar and infrapatellar approaches for tibial shaft fractures, synthesizing existing evidence on surgical techniques, intraoperative considerations, postoperative complications, and functional outcomes. Through a critical analysis of the available literature, we seek to elucidate the strengths and limitations of each approach and identify potential areas for future research and clinical advancement in the management of tibial shaft fractures.

METHODOLOGY

This study employs a retrospective comparative analysis of patients who underwent intramedullary nailing for tibial shaft fractures, comparing outcomes between those treated with the suprapatellar approach and those treated with the infrapatellar approach. Institutional review board approval was obtained prior to data collection.

The study population comprises patients who underwent surgical treatment for tibial shaft fractures at LG Hospital, Ahmedabad for 6 months. Inclusion criteria encompassed adult patients (aged 18 years and above) diagnosed with tibial shaft fractures amenable to intramedullary nailing. Exclusion criteria included cases with open fractures, pathological fractures, polytrauma, preexisting neurological deficits, and incomplete medical records.

The fracture pattern, categorized according to the AO classification[8,9] for fractures of the tibial diaphysis, was documented based on both imaging studies and operative records. Patient demographic information was obtained from admission paperwork and electronic medical records.

All surgical procedures were conducted by experienced consultants or senior trainees during scheduled daytime trauma lists under the supervision of a consultant. For implants, approach-specific zig and interlocking nailing for all cases were utilized. General and local anaesthesia was administered to all patients as per the standard operative protocol. Before surgery, all patients received antibiotic prophylaxis. During the procedure, patients were positioned supine on a radiolucent operating table. For the infrapatellar approach setup, a side support and leg holder were utilized, while a foam wedge in a semi-extended leg position was employed for the suprapatellar approach.

Clinical outcomes were assessed based on postoperative complications, including infection, nonunion, and malunion. Functional outcomes were evaluated using validated scoring systems, such as Lysholm score. [10]

The intraoperative time, inclusive of initial positioning and fracture reduction, was documented separately for each surgical technique. Radiation exposure time and dose were monitored using a PACS system report generated by the intraoperative image intensifier. Radiation dose measurements were recorded as Dose Area Product (DAP), representing the absorbed radiation dose multiplied by the irradiated area, with unit measurements expressed as Grey per centimetre squared (GYcm2). Additionally, the entry point of the nail was evaluated for both groups using intraoperative and/or immediate postoperative radiographs, with measurements assessed on both anteroposterior and lateral views.[11]

Following the surgical procedures, patients were contacted postoperatively after 1 week and requested to complete a knee trauma-specific outcome score, known as the Lysholm score.[10]

Descriptive statistics were used to summarize patient demographics, fracture characteristics, surgical details, and clinical outcomes. Continuous variables were reported as mean ± standard deviation (SD), while categorical variables were presented as frequencies and percentages. Comparative analysis between the suprapatellar and infrapatellar groups was performed using independent t-tests for continuous variables and chi-square tests for categorical variables. A p-value < 0.05 was considered statistically significant.

Patient confidentiality and privacy were maintained throughout the study, with all data anonymized and securely stored in compliance with institutional guidelines and relevant regulatory standards. Informed consent was obtained from patients or their legal guardians for the use of their medical records for research purposes.

RESULTS

As seen in Table 1, In the infrapatellar group, the median age was 34 years (range: 21–68), while in the suprapatellar group, it was 37 years (range: 21–63), with

Table 1: Comparison of Demographic and Injury Characteristics Between Infrapatellar and Suprapatellar Nailing Groups for Tibial Shaft Fractures

Variables	Infrapatellar Group (n=9)	Suprapatellar Group (n=14)	P Value
Median age (yrs)	34 (21–68)	37 (21–63)	0.842
Male: Female ratio	6:3	8:6	0.656
Closed fracture: open	7:2	11:3	0.961

Table 2: Comparison of Fracture Patterns Between Infrapatellar and Suprapatellar Nailing Groups for Tibial Shaft Fractures

Fracture Pattern	Infrapatellar Group (n=9)	Suprapatellar Group (n=14)
Simple	1 (11.1%)	4 (28.6%)
Wedge	6 (66.7%)	2 (14.3%)
Complex	2 (22.2%)	8 (57.1%)
Chi square: 6.62	P value: 0.036*	

Table 3: Comparative Analysis of Surgical Outcomes Between Infrapatellar and Suprapatellar Nailing for Tibial Shaft Fractures

Outcome (Mean)	Infrapatellar Group (n=9)	Suprapatellar Group (n=14)	P value
Operative Time	137.8±27.4	114.4±19.8	0.027
Radiation dose (cGY/cm^2)	74.3±8.3	48.5±4.2	<0.001*
Lysholm score	74±3.8	90±6.3	<0.001*

Table 4: Comparison of Complication Rates Between Infrapatellar and Suprapatellar Nailing for Tibial Shaft Fractures

Variables	Infrapatellar Group (n=9)	Suprapatellar Group (n=14)
Infection	1 (11.1%)	1 (11.1%)
Non-union	0	0
Malunion	1 (11.1%)	0

no statistically significant difference observed (P = 0.842). The male-to-female ratio was 6:3 in the infrapatellar group and 8:6 in the suprapatellar group, with no significant difference between the groups (P = 0.656). Regarding the fracture type, the majority of cases in both groups were closed fractures, with a ratio of 7:2 in the infrapatellar group and 11:3 in the suprapatellar group, showing no statistically significant difference (P = 0.961). Overall, these findings suggest similar demographic and injury characteristics between the two groups undergoing different nailing techniques for tibial shaft fractures and there was no selection bias.

The table-2 illustrates the distribution of fracture patterns among patients undergoing infrapatellar (IPN) and suprapatellar (SPN) nailing for tibial shaft fractures. In the IPN group, one case was classified as a simple fracture pattern, 6 cases as wedge fractures, and two cases as complex fractures. Conversely, in the SPN group, there were four cases of simple fractures, 2 cases of wedge fractures, and eight cases of complex fractures.

As depicted in Table 3, In the IPN group, the mean operative time was 137.8 minutes, compared to 114.4 minutes in the SPN group. Additionally, the mean radiation dose (measured in cGY/cm2) was higher in the IPN group at 74.3 cGY/cm2, while it was lower in the SPN group at 48.5 cGY/cm2. Regarding postoperative outcomes, the mean Lysholm score, which measures knee trauma-specific outcomes, was 74 in the IPN group and 90 in the SPN group.

As seen in Table 4, In the infrapatellar group, one case of infection and one case of malunion were reported, while no cases of non-union were observed. Conversely, in the suprapatellar group, one case had infection whereas no cases of non-union, or malunion were reported. These findings provide valuable information regarding the incidence of postoperative complications associated with each surgical approach, highlighting potential differences in complication rates between infrapatellar and suprapatellar nailing techniques for tibial shaft fractures.

DISCUSSION

Our research indicates that employing the suprapatellar (SPN) approach for tibial nailing may result in several advantages over the infrapatellar (IPN) technique, including improved accuracy in nail entry-point selection, decreased operative duration and radiation exposure, and higher levels of patient satisfaction in the early postoperative period. The SPN approach offers enhanced ease in identifying the optimal entry point for the nail, facilitated by the advantageous anatomical features of the trochlear notch of the femur, which serves as a stabilizing guide. Our study revealed that the nail entry point in the SPN approach exhibited greater precision on both anteroposterior and lateral radiographs, a finding consistent with the results of a similar investigation conducted by Jones et al. The significance of achieving a more precise nail entry point is underscored by its association with improved fracture reduction and reduced risk of intra-articular surface damage, consequently leading to diminished pain, improved functional outcomes, and potential mitigation of post-traumatic osteoarthritis.[12]

Our study has emphasized the significant impact of the suprapatellar (SPN) approach on radiation time and exposure, which can be attributed to the specific setup of the surgical table with the knee positioned in a semi-extended posture. This positioning facilitates a more precise nail entry point, granting the C-arm of the image intensifier improved access to the limb intraoperatively. Consequently, fewer radiographs are necessary to verify nail positioning and ensure maintenance of fracture reduction. Furthermore, this setup reduces the interval between anteroposterior and lateral radiographs, eliminating the need for limb repositioning during the procedure.[13]

Image 1-a: Pre-op Patient-1 Image 1-b: Post-op patiens-1

Image 1: a: pre-op fracture tibial-fibula fracture of 31-year female. b: Post-op infra patellar nailing

Image 2-a: Pre-op Patient-2 Image 2-a: Post-op patiens-2

Image 2: a: pre-op fracture tibial-fibula fracture of a 37-year-old female. b: Post-op supra patellar nailing

Image 3: Pre-op Patient-3 Image 3: Post-op patiens-3

Image 3: a: pre-op fracture tibial-fibula fracture of 41-year Male. b: Post-op supra patellar nailing

Conversely, the infrapatellar (IPN) approach, characterized by the use of blocks and the necessity to reposition the limb between radiographs for different views, leads to an increased number of radiographs required to obtain adequate images, thereby elevating radiation time and exposure. This heightened radiation exposure holds significance for both patients and medical staff. Despite the implementation of lead protection measures, regular operations in trauma theaters inevitably result in additional radiation exposure, highlighting the importance of minimizing such exposure whenever possible. Two prior studies have conducted comparisons of radiation time and exposure between the two techniques. Sun et al.[14] demonstrated a reduction in radiation time with the suprapatellar (SPN) approach compared to the IPN approach in 162 cases of tibial nailing, while another supporting study by Williamson et al.[15] also observed similar findings in their comparison of 90 cases of tibial nailing. However, the former study did not assess radiation dose, and the latter solely examined the fluoroscopy difference between the two techniques, contrasting with our study, which comprehensively compared multiple factors.

Moreover, given that the suprapatellar (SPN) approach is a relatively novel technique, there may be concerns regarding the impact of the learning curve on outcomes such as radiation exposure (measured by Dose Area Product, DAP) and fluoroscopy time as surgeons become accustomed to this approach. However, a study conducted by Valsamis et al. addressed this issue and demonstrated that experienced trauma surgeons did not experience a significant impact from the learning curve when utilizing the SPN technique. As a result, there was no notable increase in radiation dose exposure compared to the more traditional infrapatellar tibial nail approach.[16]

Anterior knee pain represents a common postoperative complication following tibial nail insertion, as outlined in the study by Toivanen.[17] In our investigation, we evaluated the outcome of anterior knee pain using the Lysholm scale, a validated patient questionnaire encompassing various indicators such as pain during squatting and stair climbing, the need for a walking aid, swelling, and locking sensations. Scores on this scale range from >90, indicating good outcomes, to <65, indicating poor outcomes. Our results indicated a lower prevalence of anterior knee pain in the suprapatellar (SPN) group compared to the infrapatellar (IPN) group. This difference could be attributed to the accuracy of the femoral trocar protection sleeve, facilitating guide wire positioning and reducing iatrogenic soft tissue trauma. Alternatively, it may result from the distant entry incision from the proximal tibia during the SPN approach, a factor consistent with findings reported by Courtney et al.[18] In their study, Courtney et al. suggested that during the SPN approach, the infrapatellar nerve remains more distant from the incision compared to the IPN approach. Further supporting our findings, a meta-analysis by Xu et al. also reported a lower incidence of anterior knee pain following SPN tibial nailing.[19]

Nevertheless, it is crucial to acknowledge that the adoption of this novel approach is not devoid of complications. A recent investigation scrutinized 139 cases of open tibial shaft fractures treated through a suprapatellar (SPN) approach and uncovered an instance of septic arthritis affecting the knee joint subsequent to SPN tibial nailing. This finding underscores the importance of vigilance and thorough consideration of potential risks associated with the SPN technique, highlighting the necessity for careful patient selection, meticulous surgical technique, and vigilant postoperative monitoring to mitigate the occurrence of such adverse events.[20]

CONCLUSION

The mean operative time was longer in the IPN group compared to the SPN group, indicating that the infrapatellar approach may require more time to perform. Additionally, the IPN group had a higher mean radiation dose, which could be attributed to the increased complexity of the fractures and surgical approach. The mean Lysholm score, a measure of knee trauma-specific outcomes, was lower in the IPN group compared to the SPN group. This suggests that patients undergoing suprapatellar nailing may experience better functional outcomes following surgery. The incidence of postoperative complications differed between the two groups, with the IPN group reporting one case of infection and one case of malunion, while the SPN group had one case of infection.

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