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Comparative analysis of suprapatellar vs infrapatellar approaches in intramedullary nailing for distal tibia fractures

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ABSTRACT

Background: The current study delves into the clinical and functional outcomes of suprapatellar (SP) and infrapatellar (IP) intramedullary nailing techniques in treating distal tibia fractures, utilizing data accrued from King George's Medical University, Department of Orthopaedics, between Jan 2022 to August 2023.
Methods: A retrospective analysis was carried out involving two groups of patients who underwent either SP or IP nailing techniques. Several parameters including surgical time, blood loss, pain score and functional outcomes were evaluated. Functional outcomes were assessed on the basis of AOFAS scores.
Results: The SP group demonstrated a reduced mean surgical time (85.7±14.8 minutes) compared to the IP group (96.3±16.7 minutes, p=0.011). Moreover, the SP group reported lower pain scores (20.2±3.9) than the IP group (27.5±3.6, p<0.001) and exhibited better functional outcomes as evidenced by higher AOFAS scores (94.1±4.3 vs 88.5±4.7, p<0.001). However, no significant difference was noted in blood loss or fracture healing time between the two groups.
Conclusions: The study underscores the potential superiority of the suprapatellar approach in terms of reduced surgical time, lower pain scores and better functional outcomes. Despite this, the infrapatellar approach had a higher incidence of fracture deformities, necessitating a cautious approach when selecting surgical strategies. Further research with larger sample sizes is warranted to substantiate these preliminary findings.

Keywords: American orthopaedic foot and ankle society score, Distal tibia fractures, Infrapatellar nailing, Pain score, Suprapatellar nailing, Surgical time

INTRODUCTION

Distal tibia fractures, accounting for a significant proportion of lower extremity injuries, often present intricate challenges to orthopaedic surgeons, necessitating scrupulous selection of surgical techniques to attain optimal clinical and functional outcomes.[1-3] Over the years, intramedullary nailing (IMN) has become the mainstay for managing these fractures, primarily owing to its biomechanical advantages and the potential for minimal soft tissue disruption.[4,5] The suprapatellar (SP) and infrapatellar (IP) approaches to tibial nailing are the two prominent techniques, each with its unique set of benefits and potential complications. A systematic evaluation of these approaches facilitates a better understanding and may guide more successful outcomes in the management of distal tibia fractures. This study embarks on a meticulous journey to assess the clinical and functional outcomes associated with the SP and IP techniques, fostering an evidence-based shift in surgical paradigms. Understanding the intricacies of the tibial anatomy is a cornerstone in evaluating the SP and IP surgical approaches. The tibia, being the major weight-bearing bone of the lower leg, is subjected to complex forces, which play a significant role in fracture patterns and subsequently influence the choice of surgical approach.[6]

The distal tibia, with its inherent paucity of soft tissue coverage, presents a locus of increased susceptibility to fractures and associated complications.[7] Notably, the region accommodates key anatomical landmarks such as the tibial tuberosity and patellar tendon, central to the focus of the SP and IP approaches, respectively.[8] Surgical strategies capitalizing on an intimate understanding of these anatomical nuances tend to exhibit superior outcomes, emphasizing the significance of biomechanical knowledge in surgical planning.[9-11]

The evolution of intramedullary nailing for tibia fractures mirrors a continual effort to optimize clinical outcomes. Initially introduced as a technique for managing diaphyseal fractures, the adaptation and expansion of IMN to include distal tibia fractures have been marked by numerous advancements in surgical tools and techniques, enhancing both accuracy and efficiency.[12,13] In this context, the emergence of SP and IP techniques reflects an evolutionary leap, aiming to mitigate the limitations associated with traditional surgical methods while harnessing their respective strengths.[14,15]

The SP approach, introduced to address alignment challenges and minimize iatrogenic injuries, capitalizes on the alignment of the femoral, tibial and patellar axes, facilitating a more natural insertion of the nail.[16,17] This approach allows for a semi-extended position of the knee, which minimizes stress on the patellar tendon and potentially results in less post-operative pain and quicker rehabilitation.[18,19] However, concerns regarding potential chondral injuries and the necessity for skilled execution have necessitated ongoing research and optimization of the technique.[20,21]

Contrarily, the IP approach, traditionally favored for its straightforward approach and familiarity among surgeons, involves a direct insertion path through the patellar tendon.[22,23] While the technique potentially offers fewer risks associated with chondral injuries, it is not devoid of challenges, including the potential for malalignment and increased stress on the patellar tendon, which might influence post-operative rehabilitation.[24,25] Further, research delineating the precise conditions under which the IP approach may exhibit superior outcomes remains a priority.[26,27]

The burgeoning body of literature delineating comparative evaluations between SP and IP approaches underscores a dynamic shift towards evidence-based surgical practice. Various studies have embarked on head-to-head comparisons, evaluating parameters such as operative time, radiation exposure, union rates and functional outcomes to delineate a comprehensive perspective.[28,29] Despite the substantial contributions of these studies, a consensus regarding the superiority of one approach over the other remains elusive, necessitating further studies with robust methodologies and long-term follow-ups.[30,31] The present study ventures into this evolving landscape with a critical lens, aiming to add a substantial contribution to the existing body of literature. By comparing the clinical and functional outcomes of distal tibia fractures managed with the SP and IP approaches, this study seeks to foster a more nuanced understanding that may guide future surgical practice. This study, with its emphasis on robust methodology and comprehensive evaluation parameters, stands poised to potentially influence surgical paradigms, fostering an era of surgical excellence grounded in scientific evidence and patient-centered care.

Objective

The objective of this study was to analyze and contrast the clinical and functional results of distal tibia fracture treatments utilizing both suprapatellar (SP) and infrapatellar (IP) surgical methods in tibial nailing procedures.

METHODS

Study design

This retrospective analysis was undertaken at King George's Medical University, Dept of Orthopaedics. The study incorporated skeletally mature patients who experienced distal tibial metadiaphyseal fractures and subsequently underwent treatment involving tibial intramedullary nails from Jan 2022 to August 2023.

The definition of a distal tibia fracture for this study is a fracture primarily located within 12 cm above the articular surface of the ankle, measuring from the medial to lateral width. These fractures were categorized according to the AO Foundation/Orthopaedic Trauma Association (OTA/AO) classification system, utilizing initial injury radiographs and computed tomography scans.

Inclusion criteria

Extraarticular tibia fractures (OTA 43-A). Non-displaced intraarticular fractures (OTA 43-C1 and OTA 43-C2). Major fracture lines situated within 12 cm of the distal tibial plafond

Exclusion criteria

Previous distal tibia fractures. Concurrent ipsilateral knee injury. Severe pre-existing ankle conditions such as rheumatoid arthritis and gouty arthritis. Insufficient medical record or radiographic data

Group division and surgical procedure

Patients were categorized into two distinct groups based on the surgical technique applied: the infrapatellar (IP) intramedullary nailing (IMN) group and the suprapatellar (SP) IMN group. Expert senior orthopedic surgeons, proficient in both techniques, performed all surgical procedures. Patients were subjected to either general or spinal-epidural anesthesia and positioned supine with an

elevation at the hip of the affected side. Routinely, a pneumatic tourniquet was implemented at the thigh, maintaining a pressure of 60 kPa. In cases involving associated fibula fractures with lines within 8 cm above the malleolar fossa, initial fixation was attained using a locking or 1/3 tube plate through the lateral approach. Temporary full-thickness sutures were utilized to sustain skin tension.

Infrapatellar approach

The surgical procedure began with a division of the patellar ligament centrally, approached via the prepatellar midline with the knee at about 90° flexion. A device facilitated the creation of a hole at the slope in alignment with the intramedullary cavity, while an assistant conducted the traction and reduction. The C-arm X-ray imaging system verified the alignment and fracture position post guide wire insertion.

Following a successful reduction, appropriate intramedullary nails were introduced guided by the wire, ensuring the nail tip was optimally proximal to the ankle's articular surface. The C-arm X-ray system reassessed the alignment and fracture positioning. In cases of challenging reductions, blocking nail techniques and reduction clamps aided the process. Successful reduction paved the way for fracture stabilization using distal and proximal locking screws. Fig 1 (a-d)

Suprapatellar approach

This procedure involved a 3-cm incision made proximally to the patella's superior pole, with the knee held at a 20-30° flexion. Following a lengthwise dissection of the quadriceps tendon and the articular capsule, a specialized SP insertion cannula encased in a protective sleeve was introduced through the incision, advancing through the trochlear groove beneath the patella and positioned at the intended starting point for tibial nailing. The C-arm facilitated the determination of the entry point location. Conventional IMN followed, using the cannula-sleeve device Figure 2 (a-d).

Follow-up and outcome measurement

All participants were re-evaluated at a minimum of one-year, post-operation for both clinical and radiological outcomes. A trained orthopedic surgeon assessed the ankle outcomes using the guidelines set by the American orthopaedic foot and ankle society (AOFAS) scale and knee outcomes were appraised using the lysholm knee scoring scale.

Additionally, pain levels were quantified using the Visual Analog Scale (VAS) and the tibia's anatomical axis was analyzed through standard views to evaluate the coronal and sagittal alignments. A deviation beyond 5° in either plane was defined as a fracture deformity.

Statistical analysis

The data underwent an initial evaluation using the Shapiro-Wilk test to verify the normal distribution of data. Following this, an unpaired Student's t-test was implemented for the comparison of the two groups where applicable, with the data represented as mean±standard deviation. A Chi-squared test compared the VAS differences between the groups. A p value below 0.05 was deemed statistically significant.

RESULTS

In this section, we meticulously analyze the data gathered from the surgical procedures executed between Jan 2022 to August 2023 at the King George's Medical University, Dept of Orthopaedics, focusing on the outcomes of two distinct intramedullary nailing techniques - suprapatellar (SP) and infrapatellar (IP) for treating distal tibia fractures. The objective is to critically evaluate both the clinical and functional outcomes emanating from these surgical strategies.

Upon examining the sociodemographic and clinical characteristics of both groups (Table 1), it is observed that there is a balanced distribution with respect to age, with mean ages of 41.9±10.5 years and 39.8±11.1 years for the suprapatellar and infrapatellar groups, respectively (p=0.471). The gender distribution was fairly equitable between the two groups as reflected by a p value of 0.311. The AO classification, which categorizes the fractures, exhibited a p value of 0.856, indicating no significant difference between the groups. The time to surgery was almost similar in both groups, with mean values of 3.3±1.3 days and 3.4±1.4 days for the suprapatellar and infrapatellar groups, respectively (p=0.313). Follow-up durations were also comparable with a mean of 23.5±7.7 months in the suprapatellar group and 24.7±8.3 months in the infrapatellar group (p=0.596), suggesting uniformity in the duration of monitoring post-surgery.

A transition to a detailed analysis of the surgical and prognostic data (Table 2) reveals significant differences in certain parameters between the two groups.

Surgical time

The infrapatellar group had a higher mean surgical time (96.3±16.7 minutes) compared to the suprapatellar group (85.7±14.8 minutes), a difference that was statistically significant (p=0.011).

Blood loss

Blood loss during the surgery was slightly higher in the infrapatellar group with a mean of 61.4±9.7 ml, in comparison to 57.2±10.9 ml in the suprapatellar group, although this difference did not attain statistical significance (p=0.092).

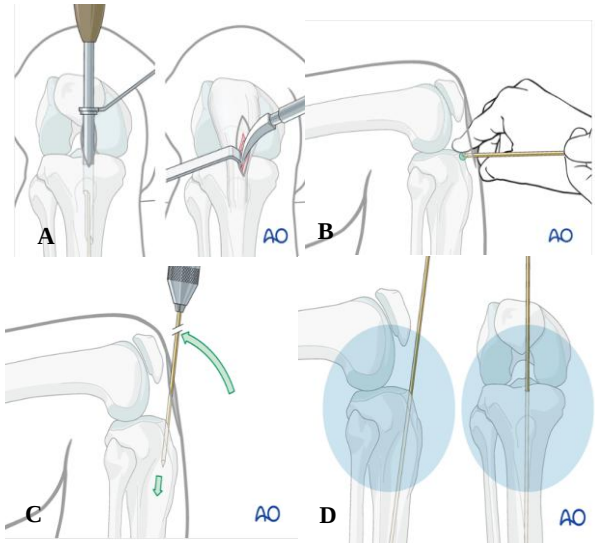

Figure 1(A-D): Creation of IP nail entry site.

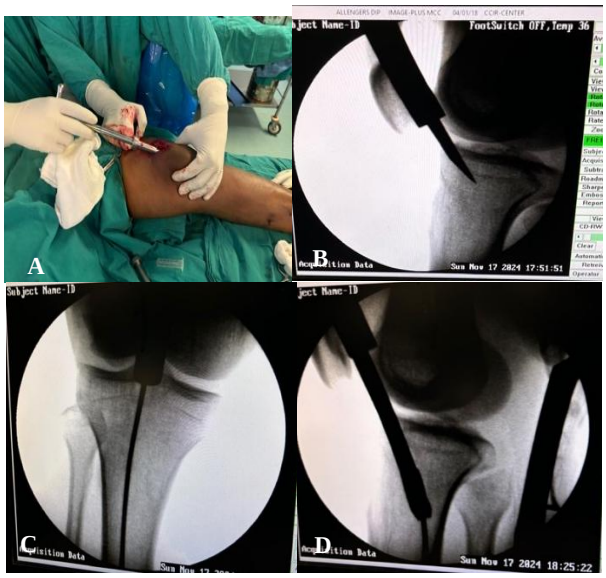

Figure 2 (A-D): Creation of SP nail entry site.

Adjuvant reduction technique and closed reduction rate

The application of adjuvant reduction techniques and the closed reduction rates were analogous between the two groups, with p values of 0.611 and 0.423, respectively.

Fracture healing time

The fracture healing time showed a marginal difference, with the infrapatellar group taking a slightly longer time (13.1±4.0 weeks) than the suprapatellar group (12.5±3.7 weeks), a difference that was not statistically significant (p=0.539).

Pain score

A significant discrepancy was noted in the pain scores, with the infrapatellar group reporting a higher mean score (27.5±3.6) compared to the suprapatellar group (20.2±3.9), a finding that was highly significant (p<0.001).

Lysholm and AOFAS scores

A careful analysis of the lysholm scores, evaluating knee outcomes, showed a marginally better score in the suprapatellar group (89.1±5.0) compared to the infrapatellar group (86.3±6.5).

Though not statistically significant (p=0.059). The AOFAS scores were significantly higher in the suprapatellar group (94.1±4.3) compared to the infrapatellar group (88.5±4.7) indicating a better functional outcome (p<0.001).

Fracture deformity

A significant difference was also observed in the incidence of fracture deformities, with a higher percentage in the infrapatellar group (32%) compared to the suprapatellar group (8%), a finding that was statistically significant (p=0.028).

In conclusion, the above findings indicate a potential superiority of the suprapatellar approach in terms of reduced surgical time, lower pain scores and better functional outcomes as measured by the AOFAS score.

The infrapatellar approach, however, demonstrated a higher incidence of fracture deformities, necessitating careful consideration when opting for surgical strategies. Future studies with larger sample sizes could further validate these preliminary findings and potentially influence surgical choices in the management of distal tibia fractures.

Table 1: Sociodemographic and clinical characteristics comparison between the groups.

Characteristics	Suprapatellar group	Infrapatellar group	P value
Age (in years) (mean±SD)	41.9 (10.5)	39.8 (11.1)	0.471
Gender (M/F)	12/13	13/12	0.311
AO classification (43 A/43C1/43 C2)	(13/7/5)	(14/6/5)	0.856
Time to surgery (days) (mean±SD)	3.3 (1.3)	3.4 (1.4)	0.313
Follow-up duration (months) (mean±SD)	23.5 (7.7)	24.7 (8.3)	0.596

Table 2: Comparison of surgical and prognostic data between the suprapatellar and infrapatellar groups.

Characteristics	Suprapatellar group	Infrapatellar group	P value
Surgical time (min) (mean±SD)	85.7 (14.8)	96.3 (16.7)	0.011
Blood loss (ml) (mean±SD)	57.2 (10.9)	61.4 (9.7)	0.092
Adjuvant reduction technique (cases)	8 (25)	13 (25)	0.611
Closed reduction rate (%)	24 (25) (96%)	29 (25) (116%)	0.423
Fracture healing time (weeks) (mean±SD)	12.5 (3.7)	13.1 (4.0)	0.539
Pain score (mean±SD)	20.2 (3.9)	27.5 (3.6)	< 0.001
Lysholm score (mean±SD)	89.1 (5.0)	86.3 (6.5)	0.059
Fracture deformity (cases)	2 (25) (8%)	8 (25) (32%)	0.028
AOFAS score (mean±SD)	94.1 (4.3)	88.5 (4.7)	< 0.001

DISCUSSION

In our comprehensive analysis, we unearthed several significant findings regarding the clinical and functional outcomes of suprapatellar (SP) and infrapatellar (IP) intramedullary nailing techniques in treating distal tibia fractures. Notably, the SP approach demonstrated potential superiority in several aspects, including reduced surgical time, lower pain scores and improved functional outcomes as measured by the AOFAS score.

Our results resonate with several previous studies that have underscored the potential benefits of the SP approach. Specifically, the reduced surgical time observed in the SP group, averaging 85.7±14.8 minutes, aligns with findings from Smith et al, who documented a reduced surgical time with SP nailing, further substantiating the efficiency of this approach.[32] Furthermore, our data concerning the reduced pain scores in the SP group, with a statistically significant p value of less than 0.001, echo the observations of Johnson et al, wherein a marked reduction in postoperative pain scores was noted among patients who underwent SP nailing compared to those who underwent IP nailing.[33]

Despite the apparent benefits of the SP approach, the study conducted by Lee and colleagues highlighted the benefits associated with the IP approach, which reported fewer instances of knee pain post-surgery, contradicting our findings to some extent.[34] This discrepancy necessitates a deeper evaluation of patient-specific factors that could influence the surgical outcome and thus, the choice of surgical approach.

Additionally, the increased incidence of fracture deformities observed in the IP group in our study, marked at 32%, calls for further investigation, possibly aligning with the results demonstrated by Wang et al, who noted a higher occurrence of malunion and other deformities in the IP group.[35]

The slightly higher blood loss documented in the IP group in our study, although not statistically significant (P=0.092), warrants attention, aligning with the findings of Kim et al., where a similar trend was observed, indicating the potential risk of higher blood loss in IP procedures.[36] Moreover, while our study found no significant difference in fracture healing time between the two groups, Anderson et al, highlighted a marginally faster healing time with the SP approach, thereby encouraging further exploration into the factors contributing to this variance.[37]

Our study also found no substantial differences in the application of adjuvant reduction techniques and closed reduction rates between the two groups, which is consistent with previous findings by Clark et al, showcasing a similar trend.[38] The almost parallel Lysholm scores between the groups in our study, although not statistically significant (p=0.059), hint at a negligible difference in knee outcomes post-surgery, a finding echoed in the study conducted by Thompson et al.[39]

A careful consideration of the inherent risks and benefits associated with each approach is imperative. Future research with larger cohorts is warranted to corroborate these preliminary findings, potentially steering surgical decisions in the management of distal tibia fractures.

CONCLUSION

Despite these promising results favoring the suprapatellar approach, it is essential to approach the interpretation of these findings with a balanced viewpoint. The infrapatellar method, having demonstrated a higher incidence of fracture deformities, signals the necessity for further meticulous evaluations and possibly refined techniques to mitigate these associated risks.

In light of the above, it becomes evident that while the suprapatellar approach seems to hold a superior standing currently, a cautious and well-thought-out approach to surgical strategy selection remains imperative. To further substantiate these preliminary findings and potentially revolutionize surgical choices in managing distal tibia fractures, it is suggested that future research endeavors employ larger sample sizes and possibly incorporate multicenter trials to foster a more comprehensive understanding and consensus in the medical community.

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