



 Research Article

Functional and Radiological Outcome Analysis of Tibial Nailing Approaches for Distal Shaft Fracture Management

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ABSTRACT

Distal tibial shaft fractures represent a challenging category of lower-extremity injuries due to their complex anatomical characteristics, limited soft-tissue coverage, and susceptibility to complications affecting functional recovery. Intramedullary nailing remains a widely accepted treatment modality; however, the optimal entry approach continues to be debated, particularly between suprapatellar and infrapatellar techniques. This research article presents a comparative analytical evaluation of functional and radiological outcomes associated with different tibial nailing approaches for distal shaft fracture management. The study framework integrates clinical outcome assessment, radiographic evaluation, complication analysis, and interpretation of biomechanical considerations derived from contemporary evidence. Previous investigations have demonstrated variations in alignment accuracy, postoperative pain, knee-related morbidity, and early functional recovery between suprapatellar and infrapatellar approaches. Comparative studies and meta-analyses indicate that the suprapatellar approach may provide technical advantages through semi-extended positioning and improved fracture reduction control, whereas concerns regarding intra-articular instrumentation remain an important consideration. The present analysis highlights the relationship between surgical approach selection and patient-centered outcomes, emphasizing the importance of balancing procedural advantages with potential risks. Findings from existing comparative evidence suggest that approach-specific decision-making should consider fracture characteristics, surgeon expertise, and functional expectations. The study contributes to the evolving

understanding of tibial intramedullary fixation strategies by providing an integrated framework for evaluating radiological restoration and functional performance in distal tibial shaft fracture management.

KEYWORDS

Distal tibial shaft fracture; Intramedullary nailing; Suprapatellar approach; Infrapatellar approach; Functional outcome; Radiological assessment; Fracture fixation; Orthopedic trauma; Surgical technique.

INTRODUCTION

Background

Distal tibial shaft fractures constitute a significant proportion of lower-limb injuries encountered in orthopedic trauma practice. The tibia is particularly vulnerable because of its subcutaneous anatomical position, limited soft-tissue envelope, and biomechanical role in weight transmission. Epidemiological investigations have demonstrated that tibial shaft fractures occur frequently among adult fracture populations, with variations related to trauma mechanisms, age distribution, and injury severity (Court-Brown and Caesar, 2006; Larsen et al., 2015). Management of these fractures requires careful consideration of fracture stability, alignment restoration, biological preservation, and early functional rehabilitation.

Intramedullary nailing has become a preferred fixation method for many tibial shaft fractures because it provides load-sharing stabilization, allows early mobilization, and minimizes extensive soft-tissue disruption compared with traditional plating approaches. However, technical factors associated with nail insertion, particularly the choice of entry approach, significantly influence surgical accuracy and

postoperative outcomes. The conventional infrapatellar approach requires knee flexion during nail insertion, which may complicate fracture reduction in distal fractures because deforming forces can contribute to malalignment. In contrast, the suprapatellar approach enables nail insertion through a semi-extended knee position, potentially improving control of the proximal and distal fracture segments.

The evolution of suprapatellar tibial nailing has generated substantial clinical interest because distal tibial fractures often present challenges related to sagittal and coronal plane alignment. Sanders et al. (2014) demonstrated that the semi-extended suprapatellar technique could achieve reliable radiographic outcomes and favorable clinical results, supporting its application in complex tibial fracture patterns. Similarly, technical assessments have explored the anatomical safety and feasibility of retropatellar approaches for intramedullary instrumentation (Eastman et al., 2010).

Despite these developments, controversy remains regarding the comparative superiority of suprapatellar versus infrapatellar approaches. Concerns regarding intra-articular entry,



cartilage injury, infection risk, and long-term knee symptoms continue to influence clinical decision-making. Conversely, proponents of suprapatellar nailing emphasize improved alignment control, reduced deforming forces, and simplified instrumentation in difficult distal fractures. Recent comparative studies have attempted to clarify these differences through retrospective analyses, prospective investigations, and systematic reviews (Cui et al., 2019; Lu et al., 2020; Yang et al., 2023).

Problem Statement

Although intramedullary nailing represents an established treatment strategy for tibial shaft fractures, the optimal surgical approach remains unresolved. Distal tibial fractures are particularly challenging because traditional infrapatellar techniques may increase difficulty in maintaining fracture reduction, while suprapatellar techniques introduce concerns related to intra-articular access. Existing literature provides heterogeneous findings regarding functional outcomes, radiological alignment, complication rates, and patient recovery.

Furthermore, differences in study methodologies, fracture classifications, follow-up durations, and outcome measurement systems make direct comparison difficult. Some investigations report improved alignment and reduced operative difficulty with suprapatellar nailing, whereas others demonstrate comparable outcomes between approaches. Therefore, a comprehensive analytical evaluation is required

to understand how approach selection influences functional restoration and radiological success.

Research Relevance

The selection of an appropriate tibial nailing approach has direct implications for surgical efficiency, fracture healing, rehabilitation potential, and long-term patient satisfaction. A better understanding of approach-related outcomes may assist orthopedic surgeons in selecting procedures tailored to fracture morphology and patient-specific requirements.

Recent evidence has expanded beyond simple fixation success toward evaluating functional recovery, postoperative complications, and quality-of-life-related outcomes. The comparative analysis of suprapatellar and infrapatellar techniques therefore represents an important area of orthopedic trauma research. The investigation is also relevant because modern fracture management increasingly emphasizes minimally invasive approaches while maintaining anatomical restoration.

The importance of evaluating surgical approaches from multiple perspectives is further supported by emerging orthopedic research involving innovative biological and regenerative interventions. Chen et al. (2024) demonstrated the importance of systematic evaluation of safety, tolerability, and clinical outcomes when introducing new therapeutic approaches in musculoskeletal conditions. Although their research focused on mesenchymal stem cell therapy for knee osteoarthritis rather than fracture fixation, it reinforces the broader



principle that orthopedic interventions require rigorous assessment of both functional benefits and potential risks.

Objectives

The primary objective of this research is to analyze functional and radiological outcomes associated with suprapatellar and infrapatellar intramedullary nailing approaches for distal tibial shaft fractures.

The specific objectives are:

1. To evaluate differences in postoperative functional recovery between suprapatellar and infrapatellar tibial nailing approaches.
2. To analyze radiological outcomes including fracture alignment, healing progression, and maintenance of fixation stability.
3. To examine approach-related complications and limitations associated with each surgical technique.
4. To identify clinical factors influencing the selection of optimal tibial nailing approaches.
5. To establish an evidence-based framework for improving decision-making in distal tibial shaft fracture management.

Scope and Significance

This research focuses on comparative evaluation of surgical approaches used for intramedullary fixation of distal tibial shaft fractures. The analysis integrates clinical outcomes, radiological

parameters, and biomechanical considerations based exclusively on the provided literature.

The significance of this study lies in its contribution toward refining surgical strategies for tibial fractures. By synthesizing evidence from comparative trials, observational studies, and meta-analyses, the research provides insight into the practical advantages and limitations of each approach. The findings may support improved surgical planning, patient counseling, and outcome optimization.

LITERATURE REVIEW

Evolution of Tibial Intramedullary Nailing Approaches

Intramedullary nailing has undergone significant technical evolution since its introduction as a stabilization method for tibial fractures. Early approaches primarily utilized infrapatellar entry because of familiarity and avoidance of intra-articular instrumentation. However, limitations associated with knee flexion positioning and fracture reduction challenges stimulated the development of alternative techniques.

The suprapatellar approach was introduced to overcome mechanical disadvantages associated with infrapatellar insertion. By maintaining the knee in a semi-extended position, the technique reduces anterior translation forces and improves control during nail advancement. Sanders et al. (2014) reported favorable radiographic and clinical outcomes using the semi-extended



suprapatellar technique, suggesting improved procedural stability in selected fracture patterns.

Eastman et al. (2010) examined the retropatellar technique through anatomical assessment and provided early evidence regarding the feasibility of alternative nail insertion pathways. Their findings contributed to the growing acceptance of suprapatellar approaches while highlighting the importance of anatomical precision.

Comparative Clinical and Radiological Evidence

Comparative research has increasingly focused on whether suprapatellar nailing provides measurable advantages over conventional intrapatellar methods. Cui et al. (2019) conducted a retrospective cohort study comparing both approaches and identified differences in treatment outcomes, emphasizing that approach selection may influence postoperative recovery and fracture management efficiency.

Lu et al. (2020) performed a comparative evaluation of suprapatellar and intrapatellar approaches specifically for distal tibia fractures. Their findings contributed evidence regarding alignment control and clinical outcomes, demonstrating the relevance of approach-specific factors in distal fracture management.

Metcalf et al. (2021) compared intrapatellar and suprapatellar approaches for tibial fracture fixation and emphasized that both techniques can achieve successful fixation, although technical considerations may influence outcome differences. Their study reinforced the need for

individualized approach selection rather than universal preference for one technique.

Meta-analytical evidence has further attempted to consolidate comparative findings. Gao et al. (2018) evaluated randomized controlled trials and identified potential advantages of suprapatellar nailing in certain clinical outcomes. Similarly, Yang et al. (2023) conducted a systematic review and meta-analysis focusing on distal tibial fractures, highlighting differences between approaches while acknowledging variability among included studies.

Putu Bihan Surya Kinanta et al. (2025) further examined comparative outcomes through meta-analysis, contributing recent evidence regarding the effectiveness of suprapatellar and intrapatellar techniques. Their analysis supports continued investigation into approach-specific differences.

METHODOLOGY

1 Research Design and Analytical Framework

This study adopts a comparative analytical research framework to evaluate functional and radiological outcomes associated with suprapatellar and intrapatellar intramedullary nailing approaches for distal tibial shaft fractures. The methodological design is structured around a clinical outcome comparison model that integrates surgical technique variables, postoperative functional parameters, radiological indicators, and complication profiles.



The framework is developed based on the principle that successful fracture management is not determined solely by union rates but by the interaction between anatomical restoration, mechanical stability, functional recovery, and patient safety. Tibial fracture fixation requires a balance between achieving stable alignment and minimizing procedure-related complications. Therefore, the analytical model evaluates the surgical approaches through four interconnected domains:

1. Surgical approach characteristics – assessment of suprapatellar and infrapatellar entry techniques, positioning requirements, and technical considerations.
2. Functional outcome evaluation – analysis of postoperative mobility, pain-related limitations, rehabilitation progression, and return to daily activities.
3. Radiological outcome assessment – evaluation of fracture alignment, maintenance of reduction, healing progression, and implant stability.
4. Safety and complication analysis – assessment of approach-related adverse outcomes including malalignment, knee-related symptoms, and postoperative complications.

This multidimensional approach allows evaluation beyond isolated radiographic success and provides a comprehensive understanding of how surgical technique influences patient recovery.

2 Study Conceptual Model

The conceptual foundation of this research is based on the relationship between surgical approach selection and postoperative clinical outcomes. The independent variable is defined as the tibial intramedullary nailing approach:

- Suprapatellar approach
- Infrapatellar approach

The dependent variables include:

- Functional recovery indicators
- Radiological healing parameters
- Complication occurrence
- Long-term clinical performance

The model assumes that the surgical approach affects outcomes through several intermediate mechanisms. The suprapatellar approach may influence alignment accuracy by allowing semi-extension positioning and reducing deforming forces during nail insertion. Conversely, the infrapatellar approach may provide familiarity and avoidance of intra-articular access but may present technical challenges in distal fracture patterns.

The analytical relationship can be represented as:

Surgical Approach → Mechanical Control During Fixation → Fracture Alignment → Healing Quality → Functional Recovery

This model emphasizes that radiological restoration and functional improvement are

interconnected rather than independent outcomes.

3 Patient and Fracture Evaluation Framework

The evaluation framework focuses on adult patients presenting with distal tibial shaft fractures requiring intramedullary fixation. Tibial shaft fractures represent a clinically diverse group because injury mechanisms, fracture patterns, and soft tissue conditions influence treatment outcomes.

Court-Brown and Caesar (2006) highlighted the epidemiological significance of adult fractures and emphasized the importance of understanding injury characteristics when evaluating treatment strategies. Similarly, Larsen et al. (2015) demonstrated variations in tibial shaft fracture incidence and epidemiological patterns, supporting the need for individualized fracture assessment.

The methodological assessment considers:

- Fracture location and distal extension
- Fracture pattern and stability
- Soft tissue condition
- Alignment requirements
- Postoperative rehabilitation potential

These factors are essential because distal tibial fractures frequently create challenges related to maintaining reduction due to the anatomical transition between the wider metaphyseal region and narrower diaphyseal canal.

4 Evaluation of Surgical Techniques

4.1 Suprapatellar Intramedullary Nailing Approach

The suprapatellar technique involves nail insertion through a controlled pathway above the patella while maintaining the knee in a semi-extended position. The theoretical advantage of this method is improved mechanical alignment during nail insertion.

A semi-extended position minimizes anterior knee flexion forces and provides improved visualization of the tibial entry point. Sanders et al. (2014) demonstrated that this positioning strategy can facilitate accurate nail placement and favorable radiological outcomes.

The functional advantages proposed for the suprapatellar technique include:

- Improved control of distal fracture alignment
- Reduced difficulty during nail advancement
- Enhanced ability to manage fractures with metaphyseal extension
- Potential reduction in operative manipulation

However, the approach requires careful attention to intra-articular safety. Concerns regarding cartilage injury and infection risk remain important limitations requiring evaluation.



Honkonen et al. (2024) investigated clinical outcomes associated with suprapatellar tibial fracture nailing and reported associations between approach selection and postoperative complication patterns, including compartment-related outcomes. These findings demonstrate the importance of evaluating both technical advantages and safety considerations.

4.2 Infrapatellar Intramedullary Nailing Approach

The infrapatellar approach represents the conventional method for tibial intramedullary nail insertion. It typically requires knee flexion to access the proximal tibial entry point.

The primary advantages of this approach include:

- Long-term surgical familiarity
- Avoidance of intra-articular instrumentation
- Established procedural workflow

However, knee flexion during insertion may create challenges in distal tibial fractures. Increased anterior forces can contribute to difficulties maintaining alignment, particularly in fractures with metaphyseal involvement.

Metcalf et al. (2021) compared infrapatellar and suprapatellar techniques and demonstrated that both approaches remain effective fixation strategies, although technical differences influence clinical decision-making.

5 Functional Outcome Assessment Framework

Functional evaluation represents a major component of postoperative fracture management because anatomical healing alone does not guarantee satisfactory patient recovery.

The functional assessment framework evaluates:

Pain and Knee Function

Pain levels and knee-related symptoms are important indicators because tibial nailing procedures involve structures around the knee joint. The presence of postoperative anterior knee pain has historically influenced evaluation of tibial nailing outcomes.

The assessment considers:

- Pain during weight bearing
- Range of motion limitations
- Knee discomfort during activities
- Functional restrictions

The importance of evaluating functional safety is supported by broader orthopedic outcome research. Chen et al. (2024) emphasized the importance of systematic monitoring of treatment tolerability and functional responses when evaluating musculoskeletal interventions. Although their study focused on regenerative therapy for knee osteoarthritis, the methodological principle of structured functional assessment remains applicable.



Mobility and Rehabilitation Progression

Early mobilization is a major objective after tibial fracture fixation. Intramedullary nails provide load-sharing stability, allowing progressive rehabilitation when fracture stability permits.

John and Mir (2022) discussed extreme nailing concepts and immediate weight-bearing constructs in distal tibial fractures, highlighting the relationship between fixation stability and functional recovery potential.

Functional evaluation therefore considers:

- Time to partial weight bearing
- Time to full weight bearing
- Return to normal activities
- Patient-reported recovery status

6 Radiological Outcome Assessment Framework

Radiological evaluation is essential for determining fixation success and fracture healing progression.

The radiological assessment model includes:

Alignment Evaluation

Correct alignment following tibial nailing is critical because malalignment may affect biomechanics and long-term limb function.

Assessment parameters include:

- Coronal plane alignment

- Sagittal plane alignment
- Angular deformity
- Rotational positioning

The suprapatellar technique has received attention because semi-extension positioning may improve control of alignment during nail insertion. Comparative investigations by Gao et al. (2018) and Yang et al. (2023) evaluated differences between approaches and highlighted alignment considerations as an important outcome variable.

Fracture Healing Assessment

Radiological healing evaluation includes:

- Evidence of callus formation
- Progressive fracture consolidation
- Maintenance of implant position
- Absence of fixation failure

The relationship between mechanical stability and biological healing remains central to fracture treatment analysis.

7 Comparative Evidence Integration Strategy

The study integrates evidence from comparative observational studies, randomized controlled trials, and meta-analytical investigations.

The evidence synthesis incorporates:

- Cui et al. (2019): retrospective cohort comparison

- Lu et al. (2020): distal tibia fracture approach comparison
- Metcalf et al. (2021): tibial fracture fixation approach analysis
- Gao et al. (2018): randomized trial meta-analysis
- Yang et al. (2023): systematic review and meta-analysis
- Cinats et al. (2025): multicenter randomized controlled evaluation

Cinats et al. (2025) provides important contemporary evidence through a multicenter randomized controlled framework, strengthening understanding of comparative outcomes between approaches.

The methodological interpretation emphasizes that no single approach universally dominates; instead, outcomes depend on fracture characteristics, surgical expertise, and patient-specific factors.

RESULTS

The comparative analysis of suprapatellar and infrapatellar intramedullary nailing approaches demonstrates that both techniques provide reliable fixation for distal tibial shaft fractures; however, differences exist in technical performance, radiological restoration, and functional recovery patterns. The findings indicate that approach selection influences fracture management primarily through

differences in surgical positioning, reduction control, and postoperative rehabilitation characteristics.

1 Functional Outcome Findings

The evaluation of functional outcomes indicates that patients treated with the suprapatellar approach frequently demonstrate favorable early functional recovery, particularly in fractures involving the distal tibial segment. The semi-extended positioning associated with suprapatellar nailing appears to facilitate controlled nail insertion and reduce the difficulty of maintaining fracture alignment during fixation. This technical advantage may contribute to improved postoperative mobility and reduced limitations during rehabilitation.

Comparative investigations have reported that suprapatellar nailing can provide improved surgical ergonomics and may reduce challenges associated with knee flexion during conventional infrapatellar insertion. Lu et al. (2020) observed differences in clinical outcomes between approaches for distal tibial fractures, suggesting that the choice of entry technique can influence postoperative recovery characteristics.

The infrapatellar approach remains an effective method with established clinical reliability. However, distal fractures may present additional technical challenges because knee flexion during nail insertion can increase deforming forces, potentially affecting reduction quality. Metcalf et al. (2021) demonstrated that although both approaches achieve successful fixation,

procedural differences influence clinical outcomes and surgical decision-making.

Functional recovery is also associated with weight-bearing progression. John and Mir (2022) emphasized that stable intramedullary constructs can support earlier mobilization strategies in distal tibial fractures. The present analysis suggests that suprapatellar techniques may offer practical advantages in selected cases by improving fixation control and facilitating rehabilitation progression.

Chen et al. (2024) highlighted the importance of structured evaluation of treatment safety and functional response in orthopedic interventions. Although their investigation focused on intra-articular regenerative therapy rather than fracture fixation, the methodological relevance supports the necessity of assessing both functional improvement and potential adverse outcomes when comparing surgical techniques.

2 Radiological Outcome Findings

Radiological evaluation demonstrates that alignment restoration represents one of the most important differences between tibial nailing approaches. Distal tibial fractures are particularly susceptible to malalignment because of the transition between the metaphyseal and diaphyseal regions. Maintaining reduction during nail insertion is therefore a critical determinant of long-term biomechanical performance.

The available evidence indicates that the suprapatellar approach may provide improved control of fracture alignment due to the semi-

extended knee position. Sanders et al. (2014) reported favorable radiographic outcomes using the suprapatellar technique, supporting its application in complex fracture patterns.

Meta-analytical evidence has further evaluated these radiological differences. Gao et al. (2018) reported potential benefits associated with suprapatellar nailing in specific outcome measures, while Yang et al. (2023) demonstrated that approach-related differences should be interpreted considering fracture location, study methodology, and clinical variability.

The findings also indicate that successful radiological outcomes depend on factors beyond entry approach alone. Fracture morphology, implant selection, surgical accuracy, and postoperative management significantly influence healing progression. Cui et al. (2019) emphasized that comparative outcomes are affected by patient characteristics and procedural factors, indicating that approach selection should be integrated into a broader treatment strategy.

3 Complication and Safety Findings

Complication analysis reveals a complex relationship between technical advantages and potential risks. The suprapatellar approach reduces some mechanical challenges associated with infrapatellar insertion but introduces concerns regarding intra-articular access.

Recent evidence has examined whether suprapatellar nailing increases knee-related complications. Honkonen et al. (2024) investigated complication patterns and reported

findings suggesting that suprapatellar tibial nailing may be associated with differences in acute compartment syndrome-related outcomes compared with infrapatellar techniques.

The concern regarding cartilage injury remains an important consideration. However, improvements in instrumentation design and surgical technique have contributed to increasing acceptance of suprapatellar approaches. Eastman et al. (2010) provided anatomical evidence supporting the feasibility of retroapatellar techniques when appropriate precautions are applied.

The INSURT multicenter randomized controlled trial by Cinats et al. (2025) represents significant recent evidence evaluating infrapatellar versus suprapatellar approaches. Its findings contribute to the understanding that both techniques require careful clinical application rather than assuming universal superiority of one method.

4 Overall Analytical Findings

The overall findings indicate that suprapatellar nailing demonstrates potential advantages in distal tibial shaft fractures where alignment control and reduction maintenance are critical. The infrapatellar approach remains valuable due to its established clinical history and avoidance of intra-articular instrumentation.

The evidence suggests that optimal outcomes depend on matching the surgical technique to fracture characteristics rather than selecting an approach based solely on procedural preference. Distal fractures with metaphyseal extension may

particularly benefit from suprapatellar techniques, whereas simpler fracture patterns may achieve comparable results through infrapatellar methods.

DISCUSSION

The comparative evaluation of tibial nailing approaches highlights that surgical technique selection represents a multifactorial decision involving biomechanics, fracture anatomy, rehabilitation objectives, and risk management. The findings demonstrate that suprapatellar and infrapatellar approaches should not be considered competing techniques with a universally superior option; rather, they represent complementary strategies applicable under different clinical circumstances.

One of the central findings is the potential advantage of the suprapatellar approach in maintaining fracture alignment. The semi-extended position modifies the mechanical environment during nail insertion by reducing anterior displacement forces and improving control of the proximal tibial entry trajectory. This advantage is particularly relevant for distal tibial shaft fractures, where maintaining alignment is technically demanding.

The results correspond with previous comparative studies. Cui et al. (2019) demonstrated that differences between approaches may influence treatment outcomes, while Lu et al. (2020) emphasized the relevance of approach selection in distal tibial fractures. Similarly, Yang et al. (2023) concluded through

systematic analysis that suprapatellar and infrapatellar techniques show differences in certain outcomes, although variations among studies limit definitive conclusions.

The functional implications of approach selection extend beyond fracture union. Modern orthopedic trauma management increasingly emphasizes early mobilization, pain reduction, and restoration of daily activities. The ability of intramedullary fixation to provide stable load-sharing constructs is central to this objective. John and Mir (2022) highlighted the importance of fixation stability in supporting early weight-bearing strategies, reinforcing the relationship between mechanical performance and functional recovery.

However, the potential advantages of suprapatellar nailing must be balanced against concerns regarding intra-articular exposure. The introduction of instrumentation through the patellofemoral region requires careful technique to minimize cartilage-related complications. Eastman et al. (2010) contributed anatomical evidence supporting the feasibility of retropatellar approaches, but continued monitoring of long-term knee outcomes remains necessary.

The broader principle of evaluating orthopedic interventions through structured safety and efficacy assessment is also reflected in Chen et al. (2024). Their investigation of intra-articular mesenchymal stem cell therapy emphasized the importance of systematic evaluation of musculoskeletal interventions. Although

unrelated to fracture fixation, the study reinforces the need for balanced assessment of therapeutic advantages and possible complications.

Recent evidence from randomized and multicenter investigations provides further context. Cinats et al. (2025) contributed high-level comparative evidence through evaluation of suprapatellar and infrapatellar nailing for tibial fractures. Such studies are important because previous evidence has often been limited by retrospective designs and methodological differences.

Despite increasing evidence supporting suprapatellar techniques, several limitations remain. Differences in fracture classification, surgeon experience, implant systems, follow-up periods, and outcome measurement methods create challenges in comparing studies directly. Furthermore, patient-specific factors such as age, bone quality, injury mechanism, and associated soft-tissue damage may influence outcomes independently of surgical approach.

The findings suggest that future research should focus on standardized multicenter trials evaluating long-term functional outcomes, patient-reported measures, and cost-effectiveness. Integration of advanced imaging, biomechanical modeling, and personalized surgical planning may further improve approach selection.

Overall, the evidence supports a selective approach strategy. Suprapatellar nailing offers meaningful technical advantages for complex

distal tibial fractures, while infrapatellar nailing remains an effective and established technique. The optimal surgical decision should be based on fracture characteristics, clinical expertise, and individualized patient requirements.

CONCLUSION

The comparative evaluation of suprapatellar and infrapatellar intramedullary nailing approaches demonstrates that both techniques represent effective treatment options for distal tibial shaft fractures, but their clinical performance differs according to fracture characteristics, technical requirements, and patient-specific considerations. The analysis indicates that the suprapatellar approach provides important biomechanical and procedural advantages, particularly in maintaining fracture alignment, improving reduction control, and facilitating nail insertion in challenging distal fracture patterns.

The semi-extended positioning associated with suprapatellar nailing reduces deforming forces during fixation and may contribute to improved radiological outcomes. Evidence from comparative studies and meta-analyses suggests that this approach can achieve favorable alignment and functional recovery outcomes, especially when managing fractures with metaphyseal extension or increased risk of malalignment. However, careful attention must be given to intra-articular safety, surgical technique, and appropriate instrumentation to minimize potential complications.

The infrapatellar approach continues to maintain clinical relevance because of its long-established use, procedural familiarity, and avoidance of intra-articular entry. Although technical challenges may occur during distal tibial fracture fixation, experienced surgeons can achieve satisfactory outcomes through appropriate reduction strategies and implant selection.

The findings emphasize that surgical approach selection should not be based on a single universal preference. Instead, decision-making should incorporate fracture anatomy, soft-tissue condition, alignment requirements, surgeon expertise, and anticipated functional demands. A personalized treatment strategy provides the greatest opportunity for achieving optimal fracture healing and functional restoration.

This research contributes to the existing orthopedic trauma literature by presenting an integrated analytical framework linking surgical approach, biomechanical behavior, radiological restoration, and functional outcomes. Future investigations should focus on large-scale multicenter randomized studies with standardized outcome measures, long-term patient-reported evaluations, and advanced biomechanical analysis to further define the role of each technique.

Ultimately, successful distal tibial fracture management depends on achieving a balance between mechanical stability, biological preservation, functional recovery, and patient safety. Both suprapatellar and infrapatellar approaches remain valuable components of

modern tibial fracture fixation, with approach selection guided by evidence-based clinical judgment.

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