

Review

Plate versus intramedullary nail fixation in the treatment of distal tibial fractures: Clinical and functional impacts on the ankle

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Abstract

Objective: To compare the effectiveness of plate and intramedullary nail fixation in the treatment of distal tibial fractures and evaluate the impact of each technique on ankle function.

Methods: An integrative literature review was conducted, including articles published between 2010 and 2025 in the PubMed, Scopus, Web of Science, LILACS, and SciELO databases, which compared the two surgical methods and presented relevant clinical and functional data. Initially, 512 studies were identified through a systematic search. After applying the inclusion and exclusion criteria, 20 articles were included in the final sample for analysis.

Results: The analysis revealed that both techniques have high consolidation rates, ranging from 92% to 97%, with plate fixation associated with greater anatomical precision in complex intra-articular fractures and intramedullary nail fixation associated with shorter surgical time, less soft-tissue trauma, and earlier rehabilitation. Postoperative complications differ by method: plate fixation is most often associated with surgical site infection and delayed soft-tissue healing, while intramedullary nail fixation is at higher risk of mechanical malalignment and anterior knee pain. Regarding ankle function, evaluated mainly by standardized clinical scores such as the American Orthopaedic Foot and Ankle Society, quality of life indexes (SF-36), and range of motion measurements, the results showed equivalence between the techniques in extra-articular fractures. However, a slight functional superiority of plate fixation in complex joint fractures was observed, attributed to its greater capacity to anatomically restore the distal tibial articular surface.

Conclusion: The research demonstrates that there is no absolute superiority of one method over the other, and the choice depends on the fracture pattern and the patient's clinical profile. The findings reinforce the importance of individualizing treatment, preventing complications, and optimizing joint function, and highlight the need for prospective studies with prolonged follow-up and standardized assessment instruments.

Level of Evidence I; Systematic Review.

Keywords: Tibial fractures; Fracture fixation, internal; Bone nails; Bone plate; Ankle joint; Range of motion, articular.

Introduction

Tibial fractures are among the most frequent injuries of the appendicular skeleton, representing a clinical challenge due to their high incidence, variability of patterns, and risk of complications. Distal tibial fractures, comprising both the metaphyseal region and the metaphyseal-diaphyseal transition and articular tibial plafond fractures, have anatomical and biomechanical characteristics that make it

difficult to achieve adequate stability and preserve ankle function. These injuries often occur after high-energy trauma, such as automobile accidents, but may also result from low-energy trauma in older patients with bone fragility, due to the lower structural strength of the region and the limited coverage of soft tissue⁽¹⁾.

The surgical approach to these injuries has evolved over the last decades, with emphasis on two main fixation techniques:

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plate osteosynthesis and intramedullary nail fixation. The choice between methods should be based primarily on the characteristics of the fracture (extra-articular, metaphyseal, or intra-articular) and the conditions of the soft tissue, factors that predominate over any other variable in the therapeutic decision. Plate fixation, especially blocked ones, allows anatomical restoration and angular stability, but may be associated with greater soft-tissue trauma and a greater risk of infection^(2,3).

The intramedullary nail, considered a minimally invasive technique, favors the preservation of periosteal vascularization. However, it is important to highlight that, in the literature, its indication was mainly restricted to diaphyseal tibial fractures, historically being less indicated for distal metaphyseal fractures (distal plafond), due to greater difficulty in controlling axial alignment and maintaining joint congruence. This aspect explains the higher incidence of complications related to alignment and, in some cases, to involvement of the ankle joint^(2,3).

The literature shows differences regarding the clinical and functional outcomes of each technique. While some studies report lower complication rates with intramedullary fixation, others show better functional recovery with plates. These controversies highlight the need for comparative analyses that consider not only bone consolidation but also the impacts on joint function and patient's quality of life⁽⁴⁾.

Given this context, the following research question emerges: Which fixation method—plate or intramedullary nail—is more effective in the treatment of distal tibial fractures, based on bone consolidation and ankle function preservation?

Therefore, the objective of the study is to compare the effectiveness of plate and intramedullary nail fixation in the treatment of distal tibial fractures and to evaluate the impact of each technique on ankle function. The relevance of this investigation lies in the potential to provide scientific support for clinical practice, standardize therapeutic practice, and improve functional outcomes in patients affected by this condition.

Methods

This is an integrative literature review, a method that enables the synthesis and critical analysis of previous scientific studies on a given theme, and favors the identification of gaps for future investigations. This type of review involves gathering and synthesizing primary research results, providing a broad view of the phenomenon under study.

The process followed the following steps: (1) identification of the theme and formulation of the research question; (2) establishment of inclusion and exclusion criteria; (3) definition of information sources and search strategy; (4) selection of studies; (5) categorization of data; (6) critical analysis and interpretation of results; and (7) synthesis of knowledge.

The guiding question defined was: "What is the effectiveness of plate fixation compared to the intramedullary nail in the treatment of distal tibial fractures, considering the clinical

and functional outcomes, with emphasis on the impact on ankle function?"

Original studies were included if available in full text and published in Portuguese, English, or Spanish between 2010 and 2025, and that addressed a comparative analysis of plate and intramedullary nail fixation in the treatment of distal tibial fractures. Editorials, letters to the editor, literature reviews, isolated case reports, and studies that did not report ankle function as an outcome were excluded.

The search was conducted in the PubMed/MEDLINE, Scopus, Web of Science, LILACS, and SciELO databases. For the search strategy, controlled and uncontrolled terms were used, combined by Boolean operators: "tibial fractures", "distal tibia", "plating", "intramedullary nail", "ankle function", and "treatment outcome". In Portuguese, the terms used were: "fraturas da tíbia distal", "fixação com placa", "fixação com haste intramedular", and "função do tornozelo".

The selection was conducted in three stages: (1) reading the titles and abstracts for initial screening; (2) reading the full text to verify if they met the inclusion criteria; and (3) critical evaluation to define the final sample. The screening was performed by two independent reviewers, and any disagreements were resolved by consensus.

Data extracted from the selected studies included: year of publication, country, methodological design, sample size, surgical technique employed (plate or nail), outcomes evaluated, complications reported, and outcomes related to ankle function. Data were organized in Microsoft Excel® spreadsheets to facilitate analysis.

Data analysis was descriptive and comparative, enabling the identification of similarities and differences among studies and highlighting trends and gaps in scientific knowledge. The results were discussed in light of the current literature, considering their clinical relevance and practical applicability.

Results and Discussion

The database search identified 512 studies. After applying the inclusion and exclusion criteria, 20 articles were selected for full analysis. Altogether, these studies included approximately 687 patients, of whom 11 directly compared plate and intramedullary nail fixation in the treatment of distal tibial fractures, while nine addressed complications, ankle function, or recovery time (Table 1).

Clinical outcomes and consolidation rate

The bone consolidation rate was high in both methods, ranging from 92% to 97%, confirming the effectiveness of both techniques in the treatment of distal tibial fractures. Plate fixation stood out for its greater precision in restoring anatomical alignment, especially in metaphyseal and intra-articular fractures, a factor that helps reduce the risk of post-traumatic arthrosis and preserve ankle joint function^(5,6).

On the other hand, the intramedullary nail demonstrated intraoperative advantages, including shorter surgical time,

Table 1. Comparison of plate and intramedullary nail fixation in the treatment of distal tibial fractures

Outcome	Plate fixation	Intramedullary nail
Consolidation rate	92%–97%, with better accuracy in anatomical alignment, especially in metaphyseal fractures	92%–96%, with similar consolidation but greater risk of misalignment in fractures near the joint
Surgical time	Higher, due to ample fracture exposure	Lower, associated with less intraoperative bleeding and early recovery
Most frequent complications	Surgical site infection (8%–14%) and soft tissue complications	Misalignment (up to 12%) and anterior knee pain
Ankle function	Improved functional recovery in intra-articular and complex fractures	Similar functional outcomes at mid-term follow-up
Advantages	Accurate anatomical restoration; greater control in complex fractures	Minimally invasive technique; less aggression to soft tissues; early mobilization
Limitations	Increased risk of soft-tissue complications	Increased risk of misalignment and anterior knee pain

reduced bleeding, and less soft-tissue involvement. These benefits favor early mobilization and shorten hospitalization time, particularly in polytrauma patients⁽⁷⁾.

However, specific complications have been reported in each technique. Intramedullary nail was more associated with varus, valgus, or rotational misalignments, particularly in distal fractures close to the joint, in addition to anterior knee pain in up to 12% of patients. In plate fixation, the main adverse events involved surgical site infection and soft-tissue complications, with rates ranging between 8% and 14%, attributed to more extensive dissection required for the material implantation^(4,5).

These percentages confirm trends already described in the literature: while the plate provides better anatomical restoration, it pays the cost of greater soft-tissue trauma and infectious risk; the intramedullary nail, on the other hand, preserves periosteal vascularization, but presents biomechanical limitations in axial control in distal metaphyseal fractures, justifying the higher rates of misalignment and residual knee pain. Therefore, the findings of this review not only corroborate previous studies but also reinforce the importance of carefully selecting the surgical method, in which the fracture pattern and the condition of the soft tissues should predominate in decision-making^(4,5).

Overall, both techniques presented similar bone consolidation rates (92%–97%), but differed in terms of complications and functional impact on the ankle. Plate fixation was associated with a higher risk of soft-tissue complications and surgical site infection (8%–14%), although it was superior in anatomical restoration in complex intra-articular fractures, which favored the preservation of joint function. On the other hand, the intramedullary nail presented advantages such as shorter surgical time, less bleeding, and preservation of periosteal vascularization, but was more often associated with varus, valgus, or rotational misalignments and anterior knee pain (up to 12%), especially in distal metaphyseal fractures⁽⁸⁾.

Postoperative complications

Postoperative complications are a critical aspect in evaluating the effectiveness of fixation techniques used in the

treatment of distal tibial fractures, as they directly impact clinical outcomes, rehabilitation time, and the patient's quality of life. In this review, consistent differences were observed in complications associated with plate and intramedullary nail fixation⁽⁹⁾.

In plate fixation, the analyzed studies reported a higher incidence of soft-tissue complications, including superficial or deep infection and delayed wound healing, with rates ranging from 8% to 14%. This finding is attributed to the more invasive nature of the procedure, which requires extensive dissection and manipulation of the periosteum, compromising local vascularization and increasing susceptibility to infection. However, it is important to note that the higher incidence of complications with plate fixation cannot be attributed solely to the technique, but also to the intrinsic characteristics of the fractures. In many cases, plates are indicated for more severe, comminuted, or exposed fractures, situations that in themselves present a greater risk of infectious complications and healing⁽¹⁰⁾.

Thus, part of the observed association between plates and complications reflects the profile of the treated fractures rather than the fixation method alone. This consideration is fundamental to avoid an interpretive bias that unfairly disfavors the use of plates and to understand that the choice of implant must be guided by the fracture's complexity and the soft-tissue condition. In complex joint fractures, for example, the plate continues to offer irreplaceable advantages in terms of anatomical restoration, even with a higher risk of complications⁽¹¹⁾.

Intramedullary nail fixation, on the other hand, presented a distinct profile of complications, highlighting varus, valgus, or rotational alignment deviations, often related to the difficulty of axial control in distal fractures. In addition, functional complications, such as anterior knee pain due to the access route, were reported in up to 12% of patients. Although generally self-limited, this pain can compromise the return to sports and work activities^(12,13).

It is important to note that serious complications, such as pseudoarthrosis and implant failure, were infrequent in both techniques, occurring in less than 5% of cases, with no statistically significant difference between the methods⁽¹⁴⁾.

Overall, the comparative analysis shows that while plate fixation is more closely associated with infectious and soft-tissue complications, intramedullary nail fixation is associated with a greater risk of mechanical alignment deviations and persistent knee pain. It is important to emphasize that, historically, intramedullary nails have never been considered the best choice for the treatment of distal tibial fractures, precisely due to the anatomical particularities of this narrower medullary canal, shorter length to obtain adequate stability, and direct proximity to the ankle joint, factors that hinder axial and rotational control.

These findings reinforce the need for judicious selection of the technique, prioritizing fracture pattern characteristics and the state of the soft tissues. Thus, although the intramedullary nail offers advantages in diaphyseal fractures, in distal metaphyseal fractures, the plate continues to play a central role, especially in complex intra-articular cases.

Ankle function

Preservation of ankle function is one of the main clinical outcomes in the evaluation of distal tibial fractures, since the integrity of this joint is decisive for returning to daily and work activities. However, the studies included in this review reported heterogeneous results and varied methodologies for joint function measurement, using different clinical scores and follow-up times, which prevented a consistent comparison between plate and intramedullary nail fixation^(15,16).

Overall, some studies reported more favorable functional outcomes with the plate in intra-articular fractures, attributed to more accurate anatomical restoration, whereas others demonstrated similar results between techniques in extra-articular fractures. However, these observations reflect methodological variability and do not constitute sufficient evidence to conclude that one technique is superior to the other in the functional aspect^(17,18).

Thus, this study was not able to establish a definitive relationship between the type of osteosynthesis and ankle function. This limitation reinforces the need for prospective clinical trials with standardized functional assessment instruments and longer follow-up, so that more robust comparisons can be performed in the future^(9,20).

Comparative analysis and synthesis

The comparative analysis between plate and intramedullary nail fixation in the treatment of distal tibial fractures shows relevant technical differences and their respective clinical, functional, and prognostic impacts. Studies show that the choice of fixation method directly influences parameters such as consolidation time, joint function preservation, complications, and the quality of patient rehabilitation^(7,15,18).

Overall, plate fixation is associated with greater accuracy in anatomical restoration, especially in complex intra-articular and metaphyseal fractures, although it carries a higher risk of soft tissue complications, such as infection, dehiscence, and the need for reoperation. On the other hand, the intramedullary nail offers biomechanical advantages, such as efficient axial

support and preservation of periosteal vascularization, which favors bone consolidation and allows early mobilization. However, it may be related to specific complications, such as anterior knee pain, residual misalignments, and difficulty in reducing distal fractures^(4,6,10).

The synthesis of the findings suggests that there is no absolute superiority of one method over the other. The therapeutic decision should consider the fracture pattern, the patient's clinical condition, and the surgical team's experience^(15,17). Both methods can achieve satisfactory functional outcomes when applied judiciously, although they have different risk profiles that should be considered in surgical planning⁽²⁰⁾.

Comparison with the literature

The interpretation of the results of this study requires a critical appraisal of previously published evidence on the fixation of distal tibial fractures. Several studies have compared the effectiveness of plate osteosynthesis and intramedullary nail, demonstrating variations in clinical and functional outcomes depending on the profile of the studied population, the surgical technique employed, and the postoperative follow-up time^(6,8,17).


Authors report similar consolidation rates between the methods but highlight a higher incidence of surgical site-related complications with plate fixation, attributed to extensive tissue dissection. On the other hand, other studies indicate that the intramedullary nail may be associated with an increased risk of residual knee pain and rotational misalignment, especially in distal metaphyseal fractures with poor cortical support⁽¹⁰⁻¹³⁾.

In addition, systematic and recent meta-analyses reinforce the lack of consensus on the superiority of one method over the other, with the clinical context and individual patient characteristics determining the therapeutic choice⁽²⁰⁾. This confrontation highlights the importance of integrating the findings into the current guidelines, but also of recognizing gaps in the literature that justify the need for new prospective, multicenter studies with longer follow-up to consolidate more robust recommendations⁽¹⁶⁾.

Conclusion

Both plate and intramedullary nail fixation demonstrated satisfactory effectiveness in the treatment of distal tibial fractures, with high bone consolidation rates in both methods. Plate fixation showed greater accuracy in anatomical restoration in complex intra-articular fractures, while the intramedullary nail showed advantages in axial support and early mobilization. Postoperative complications differed between techniques: the plate was more often associated with infections and soft-tissue problems, and the intramedullary nail was more often associated with alignment deviations and anterior knee pain.

Absolute superiority of one method over the other was not identified; rather, specific indications were determined by the fracture pattern.

Authors' contributions: Each author contributed individually and significantly to the development of this article: HCC *(<https://orcid.org/0009-0000-6104-4064>) Conceived the study, conducted the literature review, and participated in the critical analysis of data; ACBN *(<https://orcid.org/0009-0009-7484-3557>) Conducted the literature review and participated in the critical analysis of data; DSYC *(<https://orcid.org/0000-0003-2876-1007>) Contributed to data extraction and synthesis, participated in the writing and critical revision of the manuscript; GAP *(<https://orcid.org/0009-0005-4803-698X>) Contributed to data extraction and synthesis, participated in the writing and critical revision of the manuscript. All authors read and approved the final manuscript. *ORCID (Open Researcher and Contributor ID) .

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