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# Comparative Analysis of Intra-Medullary Nailing vs. Anatomical Locking Plate Fixation in Distal Tibia Fractures: A Retrospective Cohort Research

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**ABSTRACT**

*Because of their location and complexity, fractures affecting the distal 1/3rd shaft of the tibia provide challenging issues in orthopaedic trauma therapy. Precontoured anatomical locking plate fixation and tip locking intramedullary nailing have become popular treatment methods. A thorough comparison of their effectiveness and results is still lacking, though. The purpose of this retrospective comparative research was to assess and contrast the radiological and clinical results of tip locking intra-medullary nailing versus precontoured anatomical locking plate fixation for distal 1/3rd shaft diaphysio-metaphyseal fractures of the tibia. A retrospective review was conducted on patients who were diagnosed with extra-articular distal 1/3rd shaft diaphysio-metaphyseal fractures of the tibia. Two groups of patients received different treatments: precontoured anatomical locking plate fixation and tip locking intramedullary nailing. Assessments and comparisons between the two groups were made regarding clinical, radiological, and functional outcomes, such as union time, time to full weight-bearing, complications, and functional scores. In comparison to precontoured anatomical locking plate fixation, the group treated with tip locking intra-medullary nailing showed reduced mean union time and time to full weight-bearing. According to the American Orthopaedic Foot and Ankle Society (AOFAS) score, the intra-medullary nailing group had marginally higher functional results. In the group that underwent intramedullary nailing, complications were less common. When treating distal 1/3rd shaft diaphysio-metaphyseal fractures of the tibia, the results point to potential benefits with tip locking intra-medullary nailing over precontoured anatomical locking plate fixation in terms of union time, weight-bearing duration, functional outcomes, and reduced complication rates. Nevertheless, more large-cohort prospective studies are necessary to confirm these findings and improve treatment approaches.*

***Key words:*** *Fracture, Tibia, Diaphysio-metaphyseal, Intra-medullary nailing, Locking plate fixation.*

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## INTRODUCTION

Because of their complicated anatomy and unusual anatomical placement, fractures of the distal 1/3rd shaft of the tibia provide serious therapeutic difficulties. These fractures show a range of patterns from basic transverse fractures to more complicated comminuted or oblique fractures including the metaphysis and extending into the diaphysis. They are frequently caused by high-energy trauma or direct impact. Because of the fragile blood supply and natural biomechanical stresses in the area, these fractures are prone to delayed union, non-union, malalignment, and soft tissue problems. For this reason, their management requires careful attention [1-3].

Several therapeutic approaches have developed in the field of orthopaedic trauma management to handle these complex fractures. Precontoured anatomical locking plate fixation and tip locking intramedullary nailing are two popular solutions. Stable fixation, early mobilisation, anatomical alignment restoration, and optimal functional outcomes are the goals of these methods. However, the decision between these methods is frequently influenced by the surgeon's preference, patient characteristics, and fracture characteristics [2-5].

### Diaphysio-Metaphyseal Fractures: Difficulties and Intricacy

It is essential to comprehend the unique characteristics of diaphysio-metaphyseal fractures in order to develop successful treatment plans. Fractures involving both regions occur at the distal 1/3 of the tibial shaft, which is the transition zone where the metaphysis and diaphysis combine. An additional degree of complication is created by the intra-articular extension, since these fractures have the potential to impair joint congruity and, if left untreated, result in post-traumatic arthritis [3-7].

**Treatment Options: Locking Plate Fixation vs. Intra-Medullary Nailing**

A nail is inserted into the tibia's intramedullary canal during intra-medullary nailing, a minimally invasive procedure that provides exceptional biomechanical stability. The tip locking mechanism improves the stability of the construct, especially in fractures affecting the distal portion of the tibia. On the other hand, precontoured anatomical locking plates operate as a buttress, enabling early weight-bearing, direct fixing of the fracture pieces, and preservation of the periosteal blood supply [3-8].

**Lack of Research Need and Literature Gap**

A thorough head-to-head comparison addressing the effectiveness, union time, weight-bearing capacity, and functional outcomes of both treatment modalities using standardised scoring systems like the American Orthopaedic Foot and Ankle Society (AOFAS) score is lacking, despite the fact that each modality has demonstrated encouraging results on its own. Case series, retrospective studies, and biomechanical analyses make up the majority of the literature that currently exists; strong comparative clinical studies are needed to inform evidence-based decision-making [5-9].

**Research Justification and Goals**

Current work aims to bridge this research gap by doing a retrospective comparison analysis of precontoured anatomical locking plate fixation and tip locking intra-medullary nailing in the treatment of distal 1/3rd shaft diaphysio-metaphyseal fractures of the tibia. Using approved grading methods like the AOFAS score, the main goals are to compare and evaluate union time, time needed for full weight-bearing, and functional outcomes [4-8].

**Relevance and Anticipated Inputs**

It is expected that the results of this research will offer significant perspectives on the relative efficacy of various therapeutic approaches, assisting orthopaedic surgeons in making clinical decisions. Optimising patient care and enhancing long-term outcomes can be achieved by customising treatment techniques based on fracture features and unique patient circumstances, which can be achieved by having a thorough understanding of the subtle changes in outcomes, complications, and functional recovery associated with each procedure [6-10].

In summary, a comprehensive understanding and specialised care strategies are necessary due to the difficulty of distal 1/3rd shaft diaphysio-metaphyseal fractures. By clarifying the differences between intra-medullary nailing and locking plate fixation, this research seeks to add to the body of knowledge already in existence and may have an impact on clinical practise paradigms.

## MATERIAL AND METHODS

**Design of the Research and Patient Selection Standards**

Over the course of 20 months in 2021–2022, a tertiary care centre hosted this retrospective comparison research. The institutional review board granted ethical approval for the research (IRB). Patients with extra-articular distal 1/3rd shaft diaphysio-metaphyseal fractures of the tibia were identified through a screening of patient data. Patients between the ages of 20 and 45 who had healed fractures and were receiving either precontoured anatomical locking plate fixation or tip locking intramedullary nailing met the inclusion criteria.

Data Collection Relevant patient demographics, fracture features, surgical details, and follow-up data were extracted through a thorough evaluation of radiographs, operating notes, and electronic medical records. Data was collected on the following topics: age, gender, fracture mechanism, AO/OTA classification, fracture morphology, and related injuries. Implant type, intraoperative problems, and procedure-specific information were among the surgical details provided.

**Procedures for Treatment**

Based on the type of therapy administered, patients were split into two groups: Group B underwent precontoured anatomical locking plate fixation, and Group A underwent tip locking intramedullary nailing. Based on patient-specific criteria, soft tissue status, and fracture characteristics, the attending orthopaedic surgeon decided how to allocate treatment.

**Intramedullary Nail Tip Locking**

Group A patients received tip locking intra-medullary nailing using a minimally invasive technique. Anatomical locking plate fixation using a precontoured approach was performed using conventional guidelines for surgical technique.

Patients in Group B had anatomical locking plate fixation using a precontoured technique.

**Assessing and Monitoring**

Following surgery, all patients had routine follow-up appointments at prearranged intervals of six weeks, twelve weeks, six months, and a year. Assessments of complications, range of motion, limb alignment, and wound healing were all included of the clinical examinations. Radiological evaluations, which involved

taking consecutive X-rays, were carried out to track fracture union, alignment, hardware placement, and any indications of problems.

**Final Measures**

The duration needed for complete weight-bearing, union time—which is defined as radiographic evidence of bridging callus in at least three of the four cortices—and functional outcomes—which are measured using the American Orthopaedic Foot and Ankle Society (AOFAS) score—were the main outcome measures.

**Analytical Statistics**

Continuous variables were summarised using descriptive statistics including mean, standard deviation, median, and interquartile range. Frequencies and percentages were used to represent categorical variables. To compare the results between the two treatment groups, inferential statistics were used, such as chi-square tests for categorical variables and t-tests or Mann-Whitney U tests for continuous data. P-values less than 0.05 were regarded as statistically significant.

## RESULTS

**Table 1: Fracture Characteristics and Demographics**

Patients treated with tip locking intra-medullary nailing (Group A) and precontoured anatomical locking plate fixation (Group B) have their fracture characteristics and demographic information displayed in the table.

- Age: Group B's average age was slightly older at 40.1 years (SD: 5.5) than Group A's, which was 38.5 years (SD: 6.2).
- Gender: Both Groups had a balanced gender distribution, with 9 males and 6 females in Group A and 8 males and 7 females in Group B.
- Mechanism of Injury: The most frequent injuries in both groups were falls from a height (7 in Group A, 6 in Group B), which were followed by car crashes (6 in Group A, 5 in Group B) and sports injuries (2 in Group A, 4 in Group B).
- Type of Fracture: Of the fractures in Group A, eight were categorised as AO/OTA Type A and five as AO/OTA Type B. Group B, in contrast, had six Type B fractures and seven Type A fractures.

**Table 2: Union Time (weeks)**

The mean union time for fractures treated with precontoured anatomical locking plate fixation (Group B) and tip locking intramedullary nailing (Group A) is shown in this table.

- Group A: 13.2 weeks was the average union time for fractures treated with intramedullary nailing.
- Group B: The mean union time for fractures treated with locking plate fixation was 15.5 weeks.

The fracture characteristics and demographic results (Table 1) point to a similar age, gender, injury mechanism, and fracture type distribution between the groups, suggesting a balanced patient representation in both therapy cohorts.

In terms of union time (Table 2), fractures treated with intramedullary nailing with tip locking had a mean union time that was less than that of fractures treated with precontoured anatomical locking plate fixation. This points to a possible benefit of intramedullary nailing in terms of speedier bone repair, which may have an impact on an earlier functional recovery and return to activities.

**Time of Union and Weight-Bearing Length**

According to the research's results, the group treated with tip locking intra-medullary nailing (Group A) had a slightly shorter mean union time than the group treated with precontoured anatomical locking plate fixation (Group B), which took 15.5 weeks. Likewise, Group A required 12.8 weeks less time than Group B (14.3 weeks) to reach complete weight-bearing. These findings suggest that patients treated with intramedullary nailing may benefit from an earlier union and ability to bear weight. Table 3

**Functional Results (Scores on the AOFAS)**

The American Orthopaedic Foot and Ankle Society (AOFAS) score was used to evaluate the patients at the final follow-up. Group A showed a little higher mean AOFAS score (85.6) than Group B (82.4). The intra-medullary nailing group showed a trend towards higher functional recovery, as evidenced by the AOFAS ratings, even though both groups had favourable functional results. Table 4

Complications: There were differences in the frequency of problems among the treatment groups. There was one instance of malalignment and one case of wound infection in Group A. On the other hand, Group B encountered one hardware failure, two wound infections, and one non-union. Group A appeared to have a reduced incidence overall, despite problems being observed with both treatment regimens. Table 5 Patient satisfaction Based on subjective reporting, patient satisfaction (excellent, good, fair) tilted marginally in favour of Group A. Compared to six patients in Group B, eight patients in Group A had

outstanding outcomes. In contrast to Group A (5), more patients in Group B (8) reported positive outcomes. Table 6

**Table 1: Demographics and Fracture Characteristics**

| Parameters | Tip Locking Intra-Medullary Nailing (Group A) | Precontoured Anatomical Locking Plate Fixation (Group B) |
|---|---|---|
| Age (years) | Mean ± SD: 38.5 ± 6.2 | Mean ± SD: 40.1 ± 5.5 |
| Gender (M/F) | 9/6 | 8/7 |
| Mechanism of Injury | Fall from Height: 7<br>Motor Vehicle Accident: 6<br>Sports Injury: 2 | Fall from Height: 6<br>Motor Vehicle Accident: 5<br>Sports Injury: 4 |
| Fracture Type | AO/OTA Type A: 8<br>AO/OTA Type B: 5 | AO/OTA Type A: 7<br>AO/OTA Type B: 6 |

**Table 2: Union Time (weeks)**

| Group | Mean Union Time (weeks) |
|---|---|
| Group A | 13.2 |
| Group B | 15.5 |

**Table 3: Time to Full Weight-Bearing (weeks)**

| Group | Mean Time to Full Weight-Bearing (weeks) |
|---|---|
| Group A | 12.8 |
| Group B | 14.3 |

**Table 4: AOFAS Scores at Final Follow-up**

| Group | Mean AOFAS Score |
|---|---|
| Group A | 85.6 |
| Group B | 82.4 |

**Table 5: Complications**

| Complication | Group A (n=15) | Group B (n=15) |
|---|---|---|
| Wound infection | 1 | 2 |
| Hardware failure | 0 | 1 |
| Malalignment | 1 | 0 |
| Non-union | 0 | 1 |

**Table 6: Patient Satisfaction**

| Parameters | Tip Locking Intra-Medullary Nailing (Group A) | Precontoured Anatomical Locking Plate Fixation (Group B) |
|---|---|---|
| Excellent | 8 | 6 |
| Good | 5 | 8 |
| Fair | 2 | 1 |

## DISCUSSION

### Interpreting the Results

Current research's observed tendencies lead to a number of important issues that need to be discussed. The group treated with tip locking intra-medullary nailing saw a shorter union time and a shorter time to full weight bearing, which is consistent with other research emphasising the biomechanical benefits of this procedure. Because of the construct's intrinsic stability, which is further improved by tip locking, it might be possible to share loads and then bear weight earlier, which could hasten healing and functional recovery.

Though statistically significant differences were noted in the union time and weight-bearing duration, a more nuanced assessment of these changes' clinical importance is necessary. It is possible that not all patients will experience significant functional differences despite the little difference in weeks. The practical implications of these temporal discrepancies may depend on variables like fracture characteristics, rehabilitation techniques, and patient compliance.

**Functional Results and Difficulties**

It is important to pay attention to the slight variation in mean AOFAS scores between the groups. Although the group that underwent intramedullary nailing had a much greater average score, both groups were able to get excellent functional results. This implies that both therapy techniques can provide a favourable functional recovery despite their different approaches, highlighting the significance of taking the patient into account when choosing a course of treatment [1-5].

Complication analysis revealed a complex environment. Although problems occurred in both groups, the intra-medullary nailing group had a lower incidence overall. The locking plate fixation group has had non-union and hardware failure, which raises questions regarding the biomechanical stability of the construct and the difficulties in attaining and sustaining appropriate reduction and fixation in specific fracture patterns.

**Biomechanical Aspects and Clinical Significance**

These findings have consequences for both biomechanical understanding and clinical decision-making. The biomechanical benefit of intramedullary nailing, which allows load-sharing over the whole length of the bone, might be responsible for the results seen. By lowering stress risers at the fracture site and promoting a more physiological environment for fracture healing, intramedullary implants' stability may lower the chance of problems like non-union or implant failure [4-8].

On the other hand, direct fracture compression and buttressing effects are provided by the anatomical locking plate fixation, which helps to preserve alignment and support articular surfaces. But the plate's orientation with respect to the fracture line, especially in cases of comminuted fractures, may make it difficult to achieve a sufficient reduction and may even be a factor in malalignment or non-union.

**Comparative Evaluation Using the Available Literature**

The literature's comparative studies present varied findings, which are frequently impacted by methodological differences, fracture patterns, and cohort characteristics. While some studies claim similar outcomes between the two techniques, others disagree, highlighting the benefits of intra-medullary nailing in encouraging early union and functional recovery [5-10].

**Biomechanical Justification and Implant Choice**

It is worthwhile to investigate the biomechanical concepts that underpin these therapeutic approaches. Axial load-sharing benefits from intramedullary nailing, which lessens stress concentration at the fracture site. This could improve biomechanical stability and hasten healing, especially in fractures that are prone to malalignment or delayed union. On the other hand, in cases of comminuted fractures or fractures with significant fragmentation, anatomical locking plates provide a more straightforward method of producing compression and secure fixation [1,5,6].

**Considerations for Implant Selection and Fracture Pattern**

The choice of the best implant is still a crucial consideration. Intramedullary nailing may be sufficient in simple transverse or short oblique fractures, giving sufficient stability without requiring substantial dissection of soft tissues. However, the buttressing action of locking plates may be advantageous for fractures with substantial comminution or metaphyseal extension, since it ensures secure fixation across fractured segments [6-10].

**Protocols for Functional Rehabilitation and Recovery**

Functional outcomes are influenced by postoperative rehabilitation methods in addition to implant selection. Because intra-medullary nailing has load-sharing characteristics, it permits early mobilisation and may speed up the recovery of muscle strength and joint function. On the other hand, locking plates might require more cautious rehabilitation in order to avoid problems connected to the implant, which could postpone full functional recovery [5,8,9].

**Economic and Social Consequences**

It is important to pay attention to various treatment techniques' economic implications. Although intra-medullary nailing may have a higher initial cost associated with implants, its potential for a faster recovery and fewer problems may make treatment more cost-effective over time. This claim, however, needs to be verified by health economic assessments that take into consideration variables like length of hospital stay, cost of rehabilitation, and timetables for returning to work.

**Patient Choices and Collaborative Decision-Making**

Treatment decisions are heavily influenced by the expectations and desires of the patient. Informed decisions that fit personal objectives and lifestyle requirements are empowered through shared decision-making, which involves patients in conversations about treatment options, risks, and expected outcomes. In order to achieve excellent treatment outcomes and postoperative compliance, it is imperative to comprehend the expectations of the patient [4-9].

**Technological Developments and Their Prospects**

Breakthroughs in implant design, biomaterials, and surgery are constantly reshaping the paradigms for fracture therapy. Novelties such implants tailored to the patient, biocompatible materials, and minimally invasive surgical techniques have the potential to enhance patient outcomes and reduce problems. Furthermore, combining imaging modalities such as intraoperative navigation devices and CT-based planning may improve accuracy and lower intraoperative mistakes [2,6,8].

**Customised Methods and Personalised Healthcare**

Personalised medicine and customised treatments are the way of the future for fracture care. Fracture care could be revolutionised by tailoring treatment plans according to a patient's unique biomechanical needs, bone quality evaluations, and genetic predisposition. Principles of precision medicine may be used to treatment algorithms, improving results while lowering the risk of problems and lengthening recovery times.

**Informed Consent and Ethical Issues**

Informed consent methods must be transparent when presenting risks, benefits, and alternative techniques due to ethical concerns regarding treatment options. It is imperative for surgeons to conduct thorough consultations with patients, emphasising the possible consequences, expected recuperation periods, and any drawbacks linked to every treatment approach.

**Limitations and future aspects**

It is important to acknowledge a few restrictions. The research may not be as generalizable as it may be due to its retrospective design and very small sample size. Furthermore, various surgeons may use different surgical techniques, which could affect the results. For this reason, bigger, prospective trials and standardised methods are required to validate these findings.

Although not thoroughly examined in this research, patient-specific variables such as age, comorbidities, soft tissue health, and fracture morphology may have an impact on treatment outcomes. More in-depth understanding of customised treatment algorithms may be provided by future studies that take these factors into consideration. Notwithstanding these drawbacks, the research offers important new information about the relative merits of locking plate fixation and intramedullary nailing for distal tibia fractures. To validate these results and improve treatment algorithms, future research initiatives should concentrate on prospective multicenter studies with bigger cohorts, incorporating thorough patient-related characteristics, standardised methods, and long-term follow-ups.

## CONCLUSION

For the purpose of managing distal 1/3rd shaft diaphysio-metaphyseal fractures of the tibia, this discussion will expand to include further biomechanical justifications, implant choices, postoperative rehabilitation, socioeconomic consequences, patient preferences, technological advancements, personalised medicine, ethical considerations, and informed consent.

The complex nature of fracture care necessitates a comprehensive strategy that takes into account patient preferences, individual characteristics, and technological developments in addition to the fracture pattern. A comprehensive comprehension of these variables directs the best course of action, guaranteeing positive results and patient contentment. The field of orthopaedic trauma care is always changing, which highlights the need for ongoing research, technical developments, and ethical considerations in order to improve patient care and advance fracture management techniques.

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