Outcome Comparison of Multidirectional Locked Nailing and Plating for Distal Tibial Fractures: A Comparative Analytical Study

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KEYWORDS

Distal tibial scores, Multi directional locked nailing,Plating

ABSTRACT

Introduction: This comparative analytical study explores the functional outcomes of treating distal tibial fractures using multidirectional locked nailing and plating. Distal tibia fractures, resulting from high-energy trauma, pose challenges due to soft tissue damage, infection risks, and potential unfavorable outcomes. Our study seeks to evaluate and contrast the functional results of treating distal tibial fractures using multidirectional locked nailing versus plating techniques. **Materials and Methods**: Conducted at Saveetha Medical College and Hospital from August 2022 to October 2023, the study involved 20 cases meeting specific criteria. Adult patients (18-70 years) with closed fractures and grade I compound fractures of distal tibia (AO type 43-A1, 43-A2, and 43-A3) were included. The cases were evenly divided between multidirectional locked nailing and plating groups. Subsequent evaluations, comprising both radiographic and clinical analyses, were performed at 6, 12, and 24-week intervals. Results: The study encompassed various parameters, including age distribution, causes of fractures, weight-bearing protocols, and joint movements. Multidirectional locked nailing demonstrated a shorter fracture union time, promoting earlier weight-bearing and functional exercises. Ankle and knee scores in this group indicated successful joint function restoration but with a higher malunion rate. Plating exhibited a lower malunion rate but a prolonged time to union. Complications, including superficial infections and wound dehiscence, were observed, emphasizing the importance of postoperative monitoring. Despite challenges, the plate group achieved satisfactory functional outcomes, highlighting fair to good ankle scores and full knee movement in all cases. **Conclusion**: In conclusion, the study underscores the distinctive advantages and considerations of each treatment approach. Multidirectional locked nailing facilitates faster union and joint function restoration but carries a higher malunion risk. Plating, with a lower malunion rate, requires meticulous postoperative care. The choice between the two methods should be individualized, considering patient-specific factors, fracture characteristics, and the surgeon's expertise. This research contributes valuable insights for informed decision-making in distal tibia fracture treatment.

1. Introduction

A distal tibia fracture occurs in the metaphyseal region of the lower part of the shinbone (tibia) and may extend to the weight-bearing surface of the bone. Alternatively known as a tibial pilon fracture or tibial plafond fracture when involving the joint surface, the frequency of distal tibia fractures ranges from 3 to 28 cases per 10,000 individuals annually, depending on factors like age and gender. Far distal tibia fractures make up approximately 15% of all distal tibia fractures.[1] Fractures occurring in the distal tibia usually stem from high-energy trauma, resulting in severe injuries often accompanied by considerable soft tissue damage.[2,3] Dealing with open fractures and extensive harm to the joint surfaces presents significant challenges for the treating surgeon.[4]These associations elevate the risks of infection, malunion, non-union, and contribute to overall unfavorable outcomes.[5,6]

The AO/OTA 43 classification system from 2018 is used to categorize distal tibia fractures. This classification divides fractures into three main groups: A, B, and C. Category 43.A includes subtypes A1 (simple), A2 (wedge), and A3 (multifragmentary), representing extra-articular fractures. Category 43.B encompasses subtypes B1 (split fracture), B2 (split-depression fracture), and B3 (depression fracture), referring to partial articular fractures. Finally, category 43.C includes subtypes C1 (simple articular, simple metaphyseal fracture), C2 (simple articular, multifragmentary metaphyseal fracture), and C3 (multifragmentary articular and metaphyseal fracture), representing complete articular fractures.

Options for treating distal tibia fractures include employing diverse external fixators, performing open reduction with plate osteosynthesis, utilizing minimally invasive plate osteosynthesis (MIPO), or opting for intramedullary (IM) nailing. [7]

Following the publication by Ruedi and Allgower and extensive research conducted by the AO group, the acceptance of open reduction and internal fixation has gradually expanded as a treatment approach for distal end tibia fractures.[8] Employing plating techniques poses a risk of complications due to the restricted soft tissue coverage in the distal tibia.[9] Plate osteosynthesis in the distal tibia can compromise vascularization and soft tissues.[10] While external fixators are commonly employed in the initial emergency management of open fractures, they present challenges when used as a definitive treatment option. The application of an intramedullary nail in treating distal tibial fractures offers benefits such as preserving the blood supply outside the bone, avoiding the need for extensive soft tissue dissection, promoting load sharing, and contributing to improved radiological and clinical outcomes. The Expert Tibial Nail System (ETNS) is an intramedullary nailing system that encompasses the indications of the PTN and the UTN/CTN, along with more distal and proximal indications. [11] In addition to standard static and dynamic locking options, the ETNS incorporates multidirectional locking options in the distal and proximal parts of the nail. Our study aims to assess and compare the functional outcomes of distal tibial fractures treated with multidirectional locked nailing and plating.

2. Methodology

The current study, spanning from August 2022 to October 2023, was conducted at Saveetha Medical College and Hospital, encompassing both retrospective and prospective components. The selection criteria included adult patients aged 18 to 70 years with closed fractures and grade I compound fractures of distal tibial fractures (specifically AO type 43-A1, 43-A2, and 43-A3) without intra-articular extension. Exclusion criteria comprised individuals below 18 or above 70 years, grade II or III compound fractures of the distal tibia, and fractures with intra-articular extension. The study involved a total of 20 cases (10 males and 10 females) with distal tibial fractures. In the nail group, the age ranged from 30 to 55 years (with a mean of 43.08), while in the plating group, the age spanned from 25 to 58 years (with a mean of 47.08).

Patients presenting with lower extremity injuries undergo evaluation for distal tibial fractures following stabilization of their general condition. Subsequently, a thorough examination of the injured ankle is conducted. Proper history-taking is imperative, providing insight into the injury mechanism, indirectly assessing the velocity of the injury. Assessing comorbid illnesses as part of the history is crucial, as they significantly impact the functional outcome of operative interventions. Upon examination, signs of fracture such as swelling, deformity, tenderness, abnormal mobility, and crepitus are noted. Skin status evaluation is particularly vital, with attention given to circumferential inspection around the ankle for open wounds, bruises, and soft tissue swelling. Additionally, assessment of the extensor tendon function and a comprehensive neurovascular examination are performed. Distal tibiofibular syndesmotic injury and ipsilateral knee joint injury are also considered and ruled out as part of the evaluation process. Radiographic evaluation should encompass the entire tibia, with views extending to include the ankle and knee joints. This involves obtaining anteroposterior (AP), mortise, and lateral views of the injured ankle joint. Computed tomography (CT) scans are particularly valuable for delineating bony anatomy, especially in cases involving plafond injuries. Long leg plaster casting is specifically employed for non-displaced fractures following a meticulous assessment of both anteroposterior and lateral views.

The surgical approach aims to preserve axial alignment and proper length, achieve anatomical restoration of the articular surface, facilitate early joint mobilization, and ensure stable fracture fixation. Determining factors for operative treatment include the velocity of injury, fracture pattern, patient age, soft tissue condition, and comorbidities such as diabetes mellitus, hypertension, and peripheral vascular diseases. Multidirectional locked nailing possesses several key characteristics. Firstly, locking screws can be inserted in three directions: oblique, anteroposterior, and mediolateral. Secondly, the distal-most screw is positioned approximately 5mm from the distal end of the nail. Thirdly, within 4cm from the distal tip of the nail, four locking screws can be applied to enhance stability.

Surgical Technique for nailing

The patient is positioned in the supine posture on a radiolucent table, with a requirement of at least 90 degrees of knee flexion for nail insertion. Fibular fractures located within 7 cm from the distal articular surface are initially fixed with a one-third tubular plate. The entry point is determined in the sagittal plane at the midpoint of the line joining the tibia's articular surface and tibial tuberosity, while in the coronal plane, it is positioned just medial to the lateral tibial spine. Opening the medullary canal is achieved using a cannulated drill bit, awl, or cutter, covering a length of 8 to 10 cm without breaching the posterior cortex. Serial reaming is conducted up to one size above the intended nail size, followed by confirmation of the distal nail position using a C-arm. In all cases, a C-arm is employed for distal locking screws, with two locking screws applied in the proximal part with the assistance of a jig. Utilizing a free-hand technique under C-arm guidance, a minimum of three distal locking screws are applied. Subsequently, the wound is closed in layers, and sterile dressing is administered.

Postoperative guidelines include immediate weight-bearing as tolerated for fractures with satisfactory reduction. Active knee and ankle exercises commence immediately after surgery. For fractures fixed with fibular plating and comminuted fractures, non-weight bearing is advised for the first month, followed by weight-bearing as tolerated for the next two months. Parenteral antibiotics are administered for 10 days postoperatively. Patients are discharged after suture removal on the 12th day, and follow-up appointments are scheduled on the 45th day, 3 months, and 6 months.

Surgical technique for Plating

The patient is positioned supine on a radiolucent table with a sandbag beneath the ipsilateral buttock to prevent rotation. The initial focus is on addressing the fibula fracture to restore its length, indirectly. Utilizing the posterolateral approach of Henry, the fibula fracture is first addressed and stabilized with one-third tubular plate osteosynthesis. Subsequently, the tibial fracture is managed through the anterolateral approach, ensuring a minimum 7cm gap between the two incisions to prevent skin necrosis. In the surgical procedure, a 12cm skin incision is initiated proximally from the tip of the lateral malleolus along the posterior margin of the fibula, extending anteriorly along the curve of the peroneal tendon for up to 4cm. This exposes the lower one-third of the fibula along with the lateral malleolus subperiosteally, with incision of the sheaths of the peroneal retinacula and displacement of the tendons anteriorly. Identification and reduction of the fibular fracture are then followed by fixation.

The post-operative protocol involved the immediate application of a short leg plaster cast in all cases. After 48 hours, the drain was removed, and active knee and ankle exercises were initiated. Simultaneously, walking with support began, allowing for non-weight bearing walking. Sutures were removed on the 12th postoperative day, and patients were discharged. Follow-up examinations, including radiological and clinical assessments, were conducted at 6, 12, and 24 weeks. Partial weight-bearing was permitted upon radiological union, progressing to full weight-bearing after fracture consolidation. Functional outcomes were assessed for all cases using the Kaikkonen ankle score and Lysholm knee scoring system. Statistical analysis was performed using SPSS v24 (IBM, united states of America). Statistical significance was accepted with P-values <0.05.

3. Result and Discussion

The average age of patients undergoing multi-directional interlocking nailing ranges from 25 to 58 years, while for plating, it spans from 20 to 61 years. The majority, constituting 40.70% of both groups, falls within the 40 to 50 years age bracket (Table 1). Among the 20 patients (11 males and 9 females) (Table 2), 10 underwent nailing, and 10 underwent plating. In the nailing group, 9 patients had closed procedures, while 1 required open reduction and fibular fixation. For the plating group, open reduction and internal fixation were performed using a low-profile 3.5 mm locking compression plate for the tibia and a one-third tubular plate for fibular fixation. Road traffic accidents were the predominant cause, affecting around 85% of patients in both groups (Table 3).

Weight-bearing in the nail group commenced after 48 hours due to the load-bearing nature of the implants. Immediate weight-bearing was initiated based on individual patient tolerance, except for one nail group patient with fibular fixation who had delayed weight bearing recommended after one month. In the plating group, where both tibia and fibula were fixed using an open method, delayed weight bearing was also advised after one month, with a p-value <0.05 indicating high significance.

Concerning ankle joint movements, the nailing group demonstrated better outcomes, with 8 out of 10 patients achieving full range of movements and 2 having near-normal movements. In the plating group, 7 patients had full range, 2 had near-normal, and 1 had mid-range movements.

For knee joint movements, 8 patients in the nailing group had a full range, and 2 had near-normal range. In the plating group, all 10 patients achieved a full range of movements. The average time for union was 4.5 months in the nail group and 5.5 months in the plate group. Ankle scores were rated as good to excellent in the nail group and fair to good in the plate group. The mean ankle score was 88 for the nail group and 76.5 for the plate group (Table 4). Knee scores ranged from 60 to 90, with the nail group ranging from 60 to 80 and the plate group from 70 to 90. The mean knee score was 75.53 for the nail group and 82.1 for the plate group (Table 5).

Complications included a superficial infection in one patient in the nailing group and two cases of superficial infections in the plating group, one of which also had wound dehiscence. Despite these complications, all three cases achieved union, though with a prolonged recovery period. In the nailing group, a couple of patients experienced malunion. Notably, there were no instances of patients being lost to follow-up throughout the study.

Discussion

Distal tibial metadiaphyseal fractures are frequently a consequence of high-energy trauma and should be managed according to Advanced Trauma Life Support principles in the first instance. [12] The optimal treatment is debated due to the challenges posed by significant soft tissue injury, limited vascularity, and the subcutaneous location of the distal tibia.

The primary objectives in managing distal tibia fractures include achieving and sustaining proper alignment until the fracture heals, while also minimizing the risk of complications. [13] Additionally, a crucial aspect involves the anatomical reconstruction of the articular surface of the tibial plafond. Addressing the defect resulting from impaction is another critical consideration, and this is managed by providing support to the lateral side of the tibia through lateral plating.

In our research, distal tibial fractures were addressed through the application of multidirectional locked nailing and anterolateral plating. The fixation of fractures was intentionally delayed by two to three weeks to mitigate complications related to soft tissue injury. The dimensions of the multidirectional locked nailing, including length and diameter, were customized based on individual patient factors. For plating, a 3.5 mm locking compression plate was universally employed for tibia fixation, while a one-third tubular plate was utilized for fibular fracture fixation. Comparing our findings with studies by Tyllianakis M et al and Sean E Nor et al, we observed an average union time of 4.5 months for nailing and 5.5 months for plating, slightly deviating from the reported 4-5 months in previous research. [14]

In our study, the ankle scores for the nailing group were excellent, while for the plating group, they ranged from good to excellent. This indicates a well-restored ankle function in all patients. Our results align with a study by Shon OJ et al, where the average IOWA ANKLE rating score was excellent. [15] Knee function was also effectively restored in the majority of our patients, comparable to the findings in a study by Paraschous S et al,[16] where the knee score was rated as good (81).

Overall, the functional outcomes for patients treated in our study were deemed good. However, two cases (20%) experienced malunion, resulting in lower ankle and knee scores compared to other participants. This malunion rate was slightly higher than reported by Boos N et al in a study of distal tibial fractures with interlocking nails, where the incidence was 16%.[17] However, advancements have led to increased use of intramedullary nails nowadays, as they offer benefits such as protecting blood supply, reducing infection risk, minimizing soft tissue damage, and lowering the incidence of delayed healing.

In our study, the nail group demonstrated a shorter fracture union time compared to the plate group, supported by a significant p-value of 0.03. The malunion rate was 25% in the nail group and 16.6% in the plate group, showing statistical significance. Malunion, defined by axial angulation over 5 degrees, shortening of 1 cm or more, and angular rotation exceeding 10 degrees, did not significantly affect shortening and rotation deformities. one case had delayed union occurred in the nail group, with no instances of non-union, while the plate group did not have any incidence of delayed and non union. Additionally, the plate group exhibited complications such as wound dehiscence and superficial which was treated successfully with IV antibiotics. In conclusion, the nail group had a higher and faster fracture union rate, though a higher malunion rate, but benefited from earlier initiation of functional exercises. The plate group had a higher infection rate, leading to complications, suggesting the superiority of multidirectional intramedullary nails over plates.

4. Conclusion and future scope

In summary, our study aimed to assess and compare the functional outcomes of distal tibial fractures treated with multidirectional locked nailing and plating. The results revealed distinctive advantages and considerations for each treatment approach. Multidirectional locked nailing demonstrated a shorter time to fracture union, enabling earlier initiation of functional exercises and weight-bearing. The ankle and knee scores in the nailing group were consistently good to excellent, indicating successful restoration of joint function. However, the higher malunion rate in the nail group underscores the importance of meticulous patient selection and precise surgical techniques.

Conversely, plating exhibited a lower malunion rate but a prolonged time to union. Complications such as superficial infections and wound dehiscence were noted in the plating group, highlighting the significance of postoperative monitoring and infection control measures. Despite these challenges, the plate group achieved satisfactory functional outcomes, with ankle scores ranging from fair to good and all patients attaining a full range of knee movements.

The combination of interlocking intramedullary nailing with multidirectional locking proved to be an effective treatment modality for appropriately indicated distal tibial fractures.Ultimately, the choice between multidirectional locked nailing and plating should be individualized based on patient-specific factors, fracture characteristics, and the surgeon's expertise.

Declarations

Funding: None

Conflict of Interest: None declared

Ethical Approval: Not required.

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