Thesis

Intramedullary Nailing Versus Minimally Invasive Plate Osteosynthesis: A Prospective Comparison in Distal Tibial Metaphyseal Fractures

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Abstract

Background: Distal tibial metaphyseal fractures pose treatment challenges because of limited soft-tissue coverage and a high risk of wound complications. Choice between intramedullary interlocking nailing and minimally invasive plate osteosynthesis (MIPO) remains controversial; comparative data are needed to guide implant selection.

Methods: In this prospective observational study fifty adult patients with extra-articular distal tibial metaphyseal fractures (AO/OTA 43-A1 to A3) were treated between October 2016 and October 2017. Patients received either intramedullary interlocking nailing (n=25) or MIPO (n=25) according to surgeon decision. Standardised perioperative care, early motion, and radiographic follow-up at 1, 3, 6 and 12 months were applied. Outcomes included time to radiographic union, alignment, complications and functional scores (LEFS, SF-36).

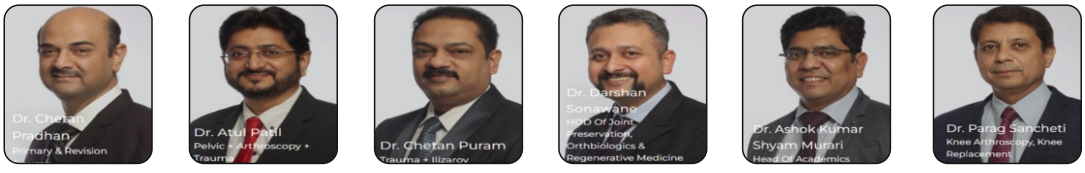
Results: Most fractures united by six months with comparable primary union rates in both groups. Intramedullary nailing was associated with fewer superficial wound issues and earlier mobilisation, while MIPO provided better distal fragment control and lower malalignment rates. Functional outcomes at one year were similar between groups.

Conclusion: Both techniques yield reliable union and comparable one-year function when matched to fracture pattern and soft-tissue status. Implant choice should be individualized, balancing soft-tissue safety and alignment needs.

Keywords: Distal tibia fracture, Intramedullary nailing, Minimally invasive plate osteosynthesis, Union, Alignment

Introduction

Distal tibial metaphyseal fractures are frequent and present particular management challenges because the bone lies close to the skin and has a limited soft-tissue envelope, increasing the risk of wound complications and infections [1]. These fractures often arise from high-energy trauma such as road traffic accidents and falls, and because the tibia is the main weight-bearing bone of the lower limb, poor treatment may lead to prolonged disability [2]. Historically, rigid open reductions were commonly performed, but recognition of the importance of preserving periosteal and extra osseous blood supply has shifted practice toward less invasive, biology-preserving methods [3]. Two widely used operative options for extra-articular distal metaphyseal fractures are intramedullary interlocking nailing and minimally invasive plate osteosynthesis (MIPO). Intramedullary nailing is a closed, load-sharing approach that tends to preserve soft tissue and permit earlier weight bearing, yet it can be associated with malalignment when distal fragment control is difficult [4]. MIPO allows controlled anatomic reduction of the distal fragment while minimizing periosteal stripping, but plating of the thin distal tibial soft tissues may lead to superficial wound



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problems or hardware prominence in some patients [5]. Modern technical adjuncts — for nails (blocking/polar screws, improved distal locking) and for plates (anatomic preshaped plates, locking screws) — have narrowed the gap between techniques, though differing complication profiles remain [6, 7]. Given the mixed findings in the literature and the strong influence of fracture morphology and soft-tissue status on outcomes, prospective comparative series are valuable to guide implant selection and to set realistic expectations for patients and surgeons. This study prospectively compares intramedullary nailing and MIPO in a consecutive cohort, focusing on union, alignment, complications and functional recovery to inform patient-centred decision making. [8]

Aims & Objectives

To compare intramedullary interlocking nailing and minimally invasive plate osteosynthesis for extra-articular distal tibial metaphyseal fractures with respect to radiographic union, functional recovery, alignment, complications and return to activity.

Review of Literature

Locked intramedullary nailing has a long history in treating metaphyseal tibial fractures, with early series reporting consistent union when careful attention is paid to nail entry and reduction technique to avoid deformity [9]. Subsequent technical developments such as blocking screws and multidirectional distal locking have been described to improve distal control and reduce malalignment, especially in fractures with short distal segments [10, 11]. Several prospective trials compared closed nailing with percutaneous plating and reported mixed outcomes: nailing often showed fewer superficial wound complications and faster early rehabilitation, while plating frequently achieved better restoration of distal alignment when anatomic reduction was possible [12]. The biology of fixation matters: studies of periosteal blood supply demonstrated that open plating techniques can compromise extra osseous circulation, which motivated the MIPO approach to protect biology while achieving stable fixation [13]. Early clinical reports of MIPO described good union rates and functional results, tempered by higher rates of superficial wound problems and implant prominence when soft-tissue handling was suboptimal [14,15]. Comparative observational studies and meta-analyses generally find a pattern — lower superficial infection rates with nailing and lower malalignment rates with plating — but overall differences in long-term function are often modest and heterogeneous across patient subgroups [16,17]. Device innovations (angle-stable nails, anatomically contoured distal plates and locking head screws) have narrowed historical differences, yet the literature repeatedly emphasises tailoring the choice of fixation to fracture geometry, distal fragment size and soft-tissue condition [18, 19]. Classic descriptions and classification schemes remain useful for guiding treatment selection and anticipating pitfalls when the distal segment is very small or the soft tissue envelope is compromised [20].

Materials and Methods

This prospective observational study included fifty consecutive adult patients with extra-articular distal tibial metaphyseal fractures treated at a tertiary teaching hospital between October 2016 and October 2017. Inclusion criteria required skeletally mature patients with fractures limited to the distal tibial metaphysis (AO/OTA 43-A1 to A3); exclusions included intra-articular fractures, pathological fractures, limb-threatening neurovascular injury and Gustilo-Anderson grade III open wounds. Initial management comprised immobilisation, clinical assessment, grading of soft-tissue injury and radiographic evaluation with full-length AP and lateral tibial views including knee and ankle. Treatment allocation — intramedullary interlocking nailing (n=25) or MIPO with distal tibial locking plate (n=25) — followed surgeon decision within uniform institutional protocols. Intramedullary fixation employed closed reduction, reamed interlocking nails and distal locking bolts; plating used percutaneous window insertion of anatomically contoured distal tibial locking plates with locking head screws to minimize periosteal disruption. Standard perioperative antibiotics, sterile technique and wound care were applied. Rehabilitation promoted early knee and ankle range of motion from day one; weight bearing was advanced according to radiographic evidence of callus. Follow-up at 1, 3, 6 and 12 months included clinical review, radiographs and validated functional scoring (Lower Extremity Functional Scale, SF-36). Radiographic union required bridging callus on at least three cortices; delayed union and nonunion used institutional thresholds. Data recorded: demographics, mechanism, fracture classification, time to union, alignment (varus/valgus angulation), complications (wound issues, infection, hardware problems) and secondary procedures. Statistical comparisons used chi-square and t-tests, with $p<0.05$ considered significant.

Results

Fifty patients were analysed, 25 treated by intramedullary nailing and 25 by MIPO. The mean age was 42.7 years and 76% were male; road traffic accidents were the predominant mechanism. Most fractures united by six months with acceptable primary union rates in both groups. Secondary procedures were required in a minority (approximately 18% overall), with no statistically significant difference between groups. Functional scores (LEFS, SF-36) at one year were comparable and most patients resumed routine activities. Malalignment exceeding 5° was observed more frequently in the nailing group, notably in very distal or comminuted fractures; superficial wound complications and implant prominence occurred more often after plating. Deep infection

rates were low in both arms. Knee and ankle ranges of motion at final follow-up were satisfactory across the cohort, though more complex fracture patterns tended to show slightly reduced plantarflexion. Overall, when matched to fracture characteristics and soft-tissue conditions, both techniques achieved acceptable union and functional recovery.

Discussion

This study shows that both intramedullary nailing and minimally invasive plate osteosynthesis (MIPO) can produce good results when the fixation method is chosen to fit the fracture and the soft-tissue condition. Intramedullary nailing has the advantage of a closed, soft-tissue–sparing approach but carries a recognized risk of malalignment when distal fragment control is limited. This risk has been detailed in classic analyses of post-nailing deformity. [1] Randomized and prospective comparisons have reported that nailing often results in fewer superficial wound problems and facilitates earlier mobilisation, while plating can give better restoration of distal alignment when anatomic reduction is achievable. [4, 9]

The biology of fixation matters: studies of extra osseous blood supply and effects of plating helped drive the move toward limited-incision techniques such as MIPO, which aim to protect periosteal circulation while providing stable fixation. [12] Early clinical series describing percutaneous plating reported good union rates but also cautioned about superficial wound issues and hardware prominence if soft-tissue handling is not meticulous. [14,15,16] Practical experience and mechanical evaluations suggest that technical adjuncts — for example, blocking or polar screws with nails and careful plate positioning through small windows — reduce their respective complications and improve alignment control. [11, 18]

Knee pain after tibial nailing is a known complaint and should be discussed with patients when counselling about options. [10] Surgeon judgement is critical: when the distal fragment is large enough to permit secure distal locking and soft tissues are favourable, closed nailing is often an efficient, biological choice; conversely, when the distal segment is very small, comminuted or when precise anatomic reduction is essential, MIPO offers better direct control of alignment. [2, 3, 20]

Device innovations have narrowed historical differences, yet the consistent message across reports is the same — tailor the implant to fracture geometry and soft-tissue status, use meticulous technique, and apply intraoperative adjuncts where needed to minimize the need for secondary procedures. [5–8, 13, 17, 19]

Conclusion

Both intramedullary interlocking nailing and minimally invasive plate osteosynthesis produce reliable union and satisfactory one-year function for extra-articular distal tibial metaphyseal fractures when selected according to fracture characteristics and soft-tissue condition. Intramedullary nailing is less invasive and usually causes fewer superficial wound issues while permitting earlier mobilisation. Minimally invasive plating offers superior control for anatomical reduction of very distal or comminuted fragments, reducing the risk of malalignment when accurate restoration is required.

Careful preoperative planning, gentle soft-tissue handling and intraoperative attention to alignment are essential to minimize complications and deliver predictable outcomes. Surgeon judgement, the thoughtful use of technical adjuncts, and matching the implant to the individual injury produce the best patient results. Larger studies with longer follow-up would help determine whether modest early differences in alignment or wound problems lead to meaningful long-term differences in function or symptoms. Patient counselling and shared decision-making remain essential in practice.

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