



Original Research Article

CLINICAL OUTCOMES OF EXTRA-ARTICULAR PROXIMAL AND DISTAL THIRD TIBIAL FRACTURES IN ADULTS TREATED WITH MULTIDIRECTIONAL TIBIAL NAILING

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ABSTRACT

Background: Extra-articular proximal and distal-third tibial fractures are difficult to treat with conventional intramedullary nailing because the short metaphyseal segment makes it hard to maintain alignment. Multidirectional tibial nails provide several interlocking options intended to improve control of these fragments. **Objective:** To describe the functional and radiological outcomes and recorded complications of adults with extra-articular proximal or distal-third tibial fractures treated with a multidirectional tibial nail (MTN). **Place and Duration of Study:** This study was conducted at Sheikh Khelifa Bin Zayed Hospital Quetta from May 2025 to May 2026.

Methods: This prospective observational cohort included 50 consecutive adults aged 18–60 years treated with an MTN. Functional outcome was graded with the Johner–Wruhs criteria and radiographic healing with the Radiographic Union Scale for Tibial fractures (RUST). Time to union and complications (infection, delayed union, shortening, dynamization, and primary or secondary malalignment) were recorded. Data were analysed descriptively using SPSS.

Results: Mean time to union was 20.99 ± 4.02 weeks and mean final RUST score was 10.8 ± 1.21 . Johner–Wruhs outcomes were excellent in 38 patients (76%), good in 8 (16%) and fair in 4 (8%); none was poor. Superficial infection occurred in 5 patients (10%), delayed union in 8 (16%), shortening in 3 (6%) and dynamization was required in 7 (14%). Primary malalignment was recorded in 7 patients (14%) and secondary malalignment in 3 (6%). No nonunion was observed.

Conclusion: In this uncontrolled series, MTN fixation of extra-articular proximal and distal-third tibial fractures was followed by predominantly excellent or good functional outcomes (92%) and union in all patients. Because of the single-arm design and modest sample, these findings are descriptive and do not establish superiority over conventional nails or plating. Comparative studies with longer follow-up are needed.

Keywords: Multidirectional tibial nail; extra-articular tibial fractures; intramedullary nailing; tibial fractures; Johner–Wruhs criteria; RUST score.

INTRODUCTION

Tibial fractures are among the most common long-bone fractures and account for a substantial proportion of lower-limb fractures. Their clinical characteristics and treatment requirements vary according to the fracture location and pattern, degree of displacement, associated soft-tissue injury, and presence of concomitant fibular fractures. Intramedullary nailing (IMN) is widely accepted as the standard treatment for displaced tibial shaft fractures because it provides stable fixation while preserving the fracture biology and allowing relatively early mobilisation and weight bearing.^[1,2] Randomised studies and meta-analyses have demonstrated satisfactory rates of fracture union and functional recovery following tibial IMN, with both reamed and unreamed techniques having specific indications depending on fracture characteristics.^[3-5] Although conventional IMN is particularly effective for fractures involving the middle third of the tibial shaft, fractures located near the proximal and distal metaphyses remain technically challenging. In these regions, the medullary canal is wider and the metaphyseal fracture fragment has less cortical contact with the nail. The resulting loss of endosteal fit can make control of the short metaphyseal fragment difficult and increase the risk of angular and rotational malalignment.^[6,7] In proximal-third tibial fractures, the anatomical configuration of the proximal tibia, muscle attachments, and tendency of the nail to assume an eccentric position within the widened metaphyseal canal may predispose to valgus and procurvatum deformities.^[8,9] Ricci et al. demonstrated that the use of adjunctive screws during IMN can facilitate fracture reduction and improve control of proximal-third tibial fractures.^[10] Similarly, distal-third tibial fractures present challenges for conventional IMN because of the short distal segment and relatively wide metaphyseal canal. The limited contact between the nail and surrounding cortex may permit translation and angular displacement during and after nail insertion. Valgus and recurvatum deformities are recognised complications of IMN in distal tibial fractures and typically occur in the coronal and sagittal planes, respectively.^[11,12] Vallier et al. reported a higher incidence of primary angular malalignment following IMN compared with plating in a prospective randomised comparison of extra-articular distal tibial fractures.^[13] These findings highlight the importance of achieving and maintaining adequate alignment when treating fractures in the distal third of the tibia. Several modifications and adjunctive techniques have therefore been developed to improve the stability of IMN in metaphyseal tibial fractures. Blocking, or “Poller,” screws can effectively narrow the metaphyseal canal, guide nail insertion, prevent nail translation, and increase the stiffness of the bone-implant construct.^[14,15] These screws have

demonstrated particular utility in fractures involving short proximal or distal segments, although their effectiveness depends on appropriate positioning and technical expertise.^[14,15]

Advances in nail design have provided an alternative approach to improving fixation in these challenging fracture patterns. Multidirectional tibial nails incorporate strategically positioned interlocking options that permit fixation in multiple planes and improve control of short metaphyseal fragments. This multiplanar fixation may increase resistance to angular and rotational forces while retaining the biological advantages associated with intramedullary fixation. Recent evidence also suggests that multiplanar distal interlocking screw fixation may reduce the risk of postoperative malalignment in distal tibial fractures treated with IMN.^[16] In addition, accurate positioning of the nail within the distal tibia is important, as placement close to the mechanical axis has been associated with improved coronal alignment.^[17]

Alternative fixation methods, particularly minimally invasive plate osteosynthesis (MIPO), remain important options for extra-articular proximal and distal tibial fractures. However, plate fixation may require greater soft-tissue manipulation and can be associated with wound complications and infection, particularly in fractures with compromised soft-tissue coverage.^[18] Comparative studies have demonstrated that both plating and IMN can achieve satisfactory clinical and radiological outcomes, although the relative risks of malalignment, infection, nonunion, and secondary procedures may vary according to fracture location, fracture characteristics, and treatment technique.^[18,19] Therefore, improving the ability of IMN to maintain alignment in metaphyseal tibial fractures could allow the biological and mechanical advantages of intramedullary fixation to be extended to fracture patterns that have traditionally been considered less suitable for conventional nailing.

Reliable assessment of fracture healing and functional recovery is essential when evaluating these treatment strategies. The Johner-Wruhs criteria are widely used to assess functional outcomes following tibial fractures and incorporate parameters including deformity, range of motion, pain, gait, and other functional limitations.^[20] Radiological assessment can be complemented by the Radiographic Union Scale for Tibial fractures (RUST), which was developed to provide a standardised method for evaluating cortical healing following tibial fracture fixation.^[21,22] The RUST score has demonstrated good reliability and clinical utility in assessing the radiographic progression of tibial fracture healing.^[22]

Despite advances in nail design and interlocking configurations, evidence regarding the use of multidirectional tibial nails for extra-articular proximal- and distal-third tibial fractures remains relatively limited. In particular, there is a need for further clinical data regarding fracture union,

maintenance of alignment, functional recovery, and postoperative complications in this specific fracture population. Therefore, the present study was conducted to evaluate the functional and radiological outcomes of extra-articular proximal- and distal-third tibial fractures treated with a multidirectional tibial nail (MTN). The study specifically assessed time to fracture union, RUST score, Johner-Wruhs functional outcome, restoration of knee and ankle range of motion, and postoperative complications including infection, delayed union, shortening, need for dynamization, and primary or secondary malalignment.

MATERIALS AND METHODS

Methods

Study design and setting

This prospective observational cohort study was conducted at Sheikh Khalifa Bin Zayed Hospital, Quetta, Pakistan, from May 2025 to May 2026. Fifty consecutive patients treated with an MTN were enrolled. The study received institutional ethics approval and written informed consent was obtained from all participants.

Participants

Adults aged 18–60 years with extra-articular proximal- or distal-third tibial fractures considered suitable for MTN fixation were eligible. Closed fractures and Gustilo–Anderson type I or II open fractures were included. Exclusion criteria were intra-articular fracture, Gustilo–Anderson type III open fracture, pathological fracture, medical instability precluding surgery, and inadequate clinical or radiological follow-up.

Initial Assessment and Preoperative Management

Patients were initially managed with a plaster-of-Paris slab, analgesia, limb elevation and intravenous fluids as indicated. Intravenous antibiotics were given to patients with open fractures according to institutional protocol, and urgent wound assessment and debridement were performed when indicated. Associated injuries were identified and treated. Clinical examination covered soft-tissue condition, distal neurovascular status, limb deformity and associated injuries.

Anteroposterior and lateral radiographs of the whole tibia, including the knee and ankle, were obtained for all patients. Fracture location, pattern, displacement, associated fibular fracture and soft-tissue condition were recorded. Fractures were classified using the AO/OTA system and open fractures using the Gustilo–Anderson classification. Routine preoperative investigations and anaesthetic assessment were completed before surgery.

Surgical Technique

All patients underwent MTN fixation under anaesthesia. Patients were positioned supine and the limb was prepared and draped under sterile

conditions. The entry point was identified under fluoroscopy and closed reduction was attempted; additional percutaneous reduction manoeuvres were used when needed to obtain and hold satisfactory alignment. A guidewire was passed across the fracture into the distal fragment under fluoroscopic control. Poller (blocking) screws were used when necessary to assist reduction and maintain alignment.

The MTN was then inserted over the guidewire across the fracture while maintaining reduction and the mechanical axis, with particular attention to preventing coronal and sagittal malalignment. Proximal and distal interlocking used the multidirectional locking options of the nail. Fluoroscopy in anteroposterior and lateral views confirmed reduction, nail position, screw placement and overall alignment. Associated fibular fractures were assessed intraoperatively and fixed when judged necessary on the basis of fracture pattern, tibial construct stability and limb alignment.

Postoperative Management and Follow-up

Patients were monitored for wound complications, neurovascular status, pain and other early complications. Active and assisted range-of-motion exercises of the hip, knee, ankle and toes, and quadriceps strengthening, were started as tolerated from the first postoperative day. Initial mobilisation was protected or non-weight-bearing as clinically indicated. Partial weight bearing began once there was satisfactory clinical and radiological evidence of healing and progressed to full weight bearing as union advanced; timing was individualised according to fracture pattern, reduction quality, bone quality and stability of fixation. Patients were followed clinically and radiographically at regular intervals until fracture union, with particular attention to delayed union, nonunion, infection, shortening and malalignment.

Dynamization, by removal of selected interlocking screws, was performed in patients in whom healing was judged unsatisfactory.

Outcome measures

The primary outcomes were time to union, RUST score and Johner–Wruhs functional outcome. Radiographic healing was assessed on anteroposterior and lateral radiographs using the RUST score. Knee and ankle range of motion were recorded descriptively. Secondary outcomes were superficial infection, delayed union, nonunion, shortening, primary and secondary malalignment, dynamization and other secondary procedures. Malalignment was defined as angular deviation greater than 5° in any plane. Primary malalignment was unsatisfactory alignment on immediate postoperative radiographs, and secondary malalignment was loss of initially satisfactory alignment during follow-up.

Statistical analysis

Data were entered and analysed in SPSS. Categorical variables are presented as counts and percentages and continuous variables as means with

standard deviations. The analysis was descriptive; no hypothesis-testing or adjusted analyses were planned, and no claims are made about statistical significance or independent predictors.

RESULTS

Union and radiographic outcome

The mean time to union was 20.99 ± 4.02 weeks and the mean final RUST score was 10.8 ± 1.21 . All fractures united, and no nonunion was observed.

Functional outcome

By the Johner–Wruhs criteria, 38 patients (76%) had an excellent outcome, 8 (16%) good and 4 (8%) fair, so 46 patients (92%) had an excellent or good result (Table 1). No patient had a poor outcome. Most patients had full knee and ankle range of motion at four months.

Table 1: Functional outcomes according to Johner–Wruhs criteria

Johner–Wruhs outcome	Number of patients	Percentage
Excellent	38	76%
Good	8	16%
Fair	4	8%
Poor	0	0%
Total	50	100%

Complications and secondary procedures

Delayed union occurred in 8 patients (16%), superficial infection in 5 (10%) and shortening in 3 (6%). Dynamization was required in 7 patients (14%). Primary malalignment was recorded in 7 patients (14%) and secondary malalignment in 3 (6%) (Table 2). These two categories were recorded separately and are not summed here, because patient-level overlap between them was not determined.

Table 2: Postoperative complications and secondary procedures

Complication/procedure	Number of patients	Percentage
Superficial infection	5	10%
Delayed union	8	16%
Shortening	3	6%
Dynamization required	7	14%
Primary malalignment	7	14%
Secondary malalignment	3	6%

Observations by fracture subgroup

Union appeared to take longer in open fractures, distal-third fractures and AO/OTA type C fractures. Subgroup numbers were small, and these observations are exploratory and were not tested statistically.

DISCUSSION

In this prospective series of 50 adults with extra-articular proximal- or distal-third tibial fractures treated with an MTN, all fractures united, with a mean union time of about 21 weeks and a mean RUST score of 10.8. Ninety-two percent of patients had an excellent or good Johner–Wruhs outcome. Delayed union (16%), superficial infection (10%), shortening (6%) and dynamization (14%) were the main recorded complications, and malalignment exceeding 5° was recorded immediately after surgery in 14% and during follow-up in 6%.

Kachhap et al. treated 30 patients with proximal- and distal-third tibial fractures using an expert tibial nail [23]. Our cohort likewise showed a high

proportion of excellent or good functional outcomes. Direct comparison is limited by differences in population, fracture distribution, implant, methods and follow-up, and neither study can show that multiplanar locking itself produced the results.

Mohammed et al. found that the configuration of distal locking was relevant to nonunion in distal-third tibial fractures nailed intramedullary [24], underscoring the importance of distal fixation of short segments. We observed no nonunion, although delayed union occurred in 16%. With no comparator group, this cannot be taken to show a lower nonunion risk attributable to multidirectional locking, and a cohort of 50 cannot exclude a small underlying risk.

Malalignment remains the principal concern in metaphyseal nailing. Obremskey and Medina described variation in alignment results with surgeon experience in distal-third tibial fractures [25], and Chaudhry et al. identified risk factors for malalignment when distal tibial fractures with fibular fractures were nailed [26]. Our primary and secondary malalignment rates (14% and 6%) are of

the same clinical order as concerns raised in these reports, but differences in case mix, reduction technique, definitions and follow-up preclude numerical comparison. Careful reduction, accurate nail positioning, adjunctive blocking screws and appropriate interlocking remain important technical considerations, although their independent effects were not tested here.

For proximal fractures, Meena et al. compared nailing with plating in closed extra-articular proximal tibial fractures [27], and Kc et al. compared nailing with MIPO in distal extra-articular fractures [28]. These comparative studies provide context but cannot be extrapolated directly to a single-arm cohort, and our complication rates should not be compared directly with theirs without equivalent definitions, case mix and follow-up. Our results do not show that MTN is superior to plating or to conventional nailing.

The tendency toward longer union in open, distal-third and AO/OTA type C fractures is clinically plausible, since these fractures typically involve greater soft-tissue injury or comminution, but it should be regarded as hypothesis-generating.

Limitations

This study has several limitations. It was a single-centre, single-arm series of modest size without a comparison group or sample-size calculation, so it cannot establish comparative effectiveness or control confounding. Baseline demographic and fracture-subgroup characteristics, and details of implant dimensions, number of interlocking screws, use of blocking screws and fibular fixation, were not analysed, which limits generalisability and the ability to attribute outcomes to nail design. Follow-up was scheduled until union and its completeness was not formally reported, so late complications may have been missed. Radiographic assessments were not documented as independent or blinded, and measurement methods for malalignment, as well as definitions of delayed union, shortening and infection, were not standardised in the protocol. Primary and secondary malalignment were recorded separately, and their overlap could not be determined. Range-of-motion findings were descriptive and subgroup comparisons were not formally tested.

Implications

These findings suggest that MTN fixation is a feasible option for selected extra-articular proximal- and distal-third tibial fractures in a resource-constrained setting, with favourable functional results and union in all patients. Prospective comparative studies, preferably randomised, with predefined outcome definitions, blinded radiographic assessment, complete follow-up and longer observation, are needed to compare MTN with conventional intramedullary nails and plate fixation.

CONCLUSION

In this uncontrolled cohort of 50 adults with selected extra-articular proximal- or distal-third tibial fractures, MTN fixation was associated with union in all patients, a mean union time of 20.99 ± 4.02 weeks, a mean RUST score of 10.8 ± 1.21 , and excellent or good Johner–Wruhs outcomes in 92%. Delayed union, superficial infection, shortening, dynamization and malalignment were recorded in a minority of patients. These descriptive findings apply to this cohort only and do not establish comparative effectiveness or a causal benefit of multidirectional locking.

Declarations

Ethics approval and consent: study was approved by hospital ethical committee. Written informed consent was obtained from all participants.

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Conflicts of interest: The authors declare no conflicts of interest.

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