RESEARCH ARTICLE

Functional Outcome of Management by Intramedullary Interlocking Nailing for Extra-Articular Distal Tibial Fractures in Adults

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Abstract

Objectives: Extra-articular distal tibial fractures (EADTFs) are commonly associated with fibular fractures in approximately 85% of cases and present unique challenges due to their unstable nature and propensity for complications such as malunion, delayed union, non-union, and soft tissue compromise. This study aimed to evaluate the functional and radiological outcomes of intramedullary interlocking nailing (IMN) in the management of EADTFs.

Methods: This prospective observational study was conducted on 30 patients diagnosed with extra-articular distal tibial fractures, who underwent intramedullary nailing at a tertiary care center. Radiographic assessments included time to union, loss of reduction, and angular malalignment. Diagnostic criteria for consistent bony union, non-union, delayed union, and malunion were applied. Functional outcomes were measured using the American Orthopaedic Foot and Ankle Society (AOFAS) scoring system during follow-up evaluations.

Results: Of the 30 patients included, the mean age was 41.6 ± 15.6 years, with a male predominance (73.3%). Based on the AOFAS score, 26.7% of patients achieved an excellent outcome, 56.7% had good outcomes, and 16.6% had fair outcomes. No patient recorded a poor outcome. Radiologically, the mean time to union was 18.5 ± 2.2 weeks. Malunion occurred in 6.7% of cases, while there were no instances of delayed union, non-union, or infection reported.

Conclusion: Intramedullary interlocking nailing is a reliable and effective treatment modality for extra-articular distal tibial fractures, offering favorable functional outcomes and a low complication rate. The technique demonstrates consistent union rates and minimal risk of infection or non-union, reinforcing its role as a preferred management strategy in appropriately selected cases.

Level of evidence: IV

Keywords: AOFAS score, Extra-articular distal tibial fractures, Functional outcome, Intramedullary nailing, Malunion

Introduction

Distal tibial fractures constitute approximately 7–10% of all lower extremity fractures and are commonly associated with concomitant fibular fractures in nearly 85% of cases.[1-4] The tibia is the most frequently fractured long bone due to its subcutaneous location and limited soft tissue coverage, especially in the distal third.[3,4] Extra-articular distal tibial fractures (EADTFs) are inherently unstable and are frequently complicated by malunion, delayed union, non-union, wound breakdown, and infection.[5-8]

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Closed fractures of the distal third of the tibia are typically managed through closed reduction and internal fixation techniques such as intramedullary nailing, plating (either open or minimally invasive), or external fixation systems like the Ilizarov apparatus. Although plating is often preferred for EADTFs, especially when associated with fibular fractures, it is linked to a higher risk of soft tissue complications, including superficial infection, delayed wound healing, and implant exposure. These issues are largely attributed to the anatomical characteristics of the distal tibia, including a minimal soft tissue envelope and susceptibility to swelling and blister formation following trauma.[9]

Intramedullary nailing (IMN), widely accepted as the gold standard for tibial shaft fractures, offers a minimally invasive and biologically favourable option. Evidence supports its use in distal tibial fractures, even with associated fibular involvement. However, IMN is not without limitations, with angular malalignment in the coronal plane being a notable concern.[10-13] Few studies have comprehensively assessed the functional and radiological outcomes following IMN in the management of EADTFs. Therefore, the objective of the present study is to evaluate the efficacy, outcomes, and complication profile of intramedullary nailing in the treatment of extra-articular distal tibial fractures.

Materials and Methods

Study Design and Setting

This prospective observational study was conducted over a period of 18 months in the Department of Orthopaedics at GIMSR Institute of Medical Sciences, Visakhapatnam, Andhra Pradesh, India. The aim was to evaluate the functional and radiological outcomes of intramedullary nailing (IMN) in patients with extra-articular distal tibial fractures (EADTFs). Ethical approval for the study was obtained from the Institutional Ethics Committee of GIMSR (Approval No. IEC 112/2022), and all procedures conformed to the ethical standards outlined in the 1964 Declaration of Helsinki and its later amendments.

Patient Population and Demographics

A total of 30 patients with EADTFs were enrolled. All patients underwent surgical fixation with intramedullary interlocking nailing. Demographic data, including age, sex, injury mechanism, type of fracture (open or closed), and time to surgery, were recorded. The mean age of the cohort was 41.6 ± 15.57years (range: 31-40 years), and all patients were followed until radiological and functional outcomes could be assessed.

Inclusion and Exclusion Criteria

Inclusion criteria included:

- Patients aged ≥18 years.
- Extra-articular fractures of the distal third of the tibia.
- Both closed fractures and open fractures are classified as Gustilo-Anderson type I or II.

Exclusion criteria included:

- Gustilo-Anderson type III open fractures.
- Pathological fractures.
- Metabolic bone disorders.
- Patients unwilling or unable to provide informed consent.

Treatment and Surgical Procedure

All patients underwent closed reduction and internal fixation using standard intramedullary interlocking nails. Nail entry point is just medial to the lateral tibial spine in AP and anterior to the tibial articular surface in lateral view under fluoroscopy control. The type of nail (conventional or zero-lock) and the use of poller screws were noted. Some cases accommodate two distal locking screws, and some cases three distal locking screws, depending on the size of the distal fragment. Fibular fixation was performed when deemed necessary. The surgical technique was standardized among all operating surgeons.

Follow-Up (duration 1 year) and Outcome Measures

Patients were evaluated clinically and radiologically during follow-up visits. Radiographs of the affected limb were taken in anteroposterior and lateral views, including the knee and ankle. Parameters assessed included:

- Time to radiological union.
- Loss of fracture reduction.
- Angular malalignment.
- Evidence of non-union, delayed union, or malunion.

Criteria for Consistent Bony Union

Consistent union was defined according to Sarmiento's criteria:

1. Painless full weight-bearing.
2. Radiographic evidence of bridging callus formation across at least three of the four cortices on AP and lateral views.

Functional Assessment

Functional outcomes were evaluated using two scoring systems after 30 weeks of surgery:

- American Orthopaedic Foot and Ankle Society (AOFAS) score.
- Olerud and Molander score.

Standardized questionnaires were administered during follow-up visits by two independent examiners blinded to the surgical details.

Statistical Analysis

Data were entered in Microsoft Excel and analyzed using SPSS version 25.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were used to summarize demographic and clinical characteristics. Continuous variables were expressed as mean ± standard deviation (SD), and categorical variables as frequencies and percentages. Statistical significance was set at $p \leq 0.05$.

Patient Confidentiality

No identifying data or images were used. Written informed consent was obtained from all participants prior to inclusion in the study.

Results

The mean age of the study population was 42 ± 16 years. Most patients (27%) belonged to the age group of 31–40 years, followed by 23% in the 41–50-year group [Table 1].

Male predominance was observed, with 73% of patients being male. High-energy trauma was the primary mode of injury in 83% of cases.

Table 1. Distribution of patients according to time to surgery

Time to surgery (days)	n	%
1 – 5	24	80.0
6 – 10	6	20.0
Total	30	100.0
Mean ± SD	3.3 ± 2.6 days	
Range	1 – 10 days	

Among the patients, 60% sustained closed fractures and 40% had open fractures. According to the Gustilo-Anderson classification, 67% of open fractures were type I and 33% were type II [Figure 1]. Based on the Tscherne classification of soft tissue injury, 63% had grade 0 injury, 13% had grade 1, and 23% had grade 2 injuries [Figure 2]. According to the AO classification, 33% of patients had type A1, 40% had type A2, and 27% had type A3 fractures.

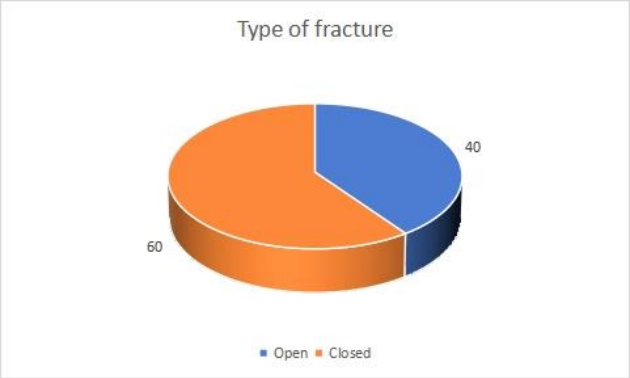

Figure 1. Pie chart showing distribution of patients according to type of fracture

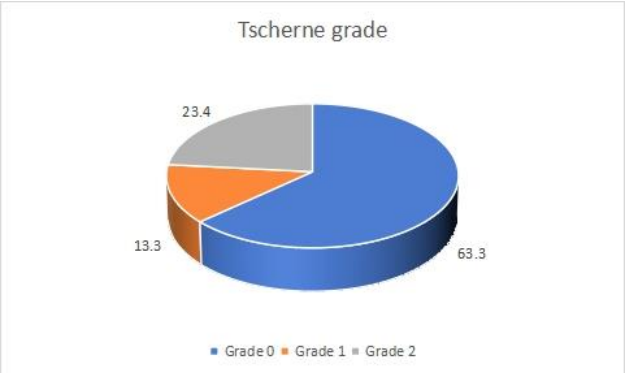

Figure 2. Pie chart showing distribution of patients according to soft tissue injury grading

Fibular fractures were present in 83% of patients, and fibular fixation was performed in 33% of cases. Conventional nails were used in 47% of patients, and zero-lock nails in 53%. Poller screws were utilized in 53% of the cases. The duration from injury to surgery was 1–5 days in 80% and 6–10 days in 20% of patients, with a mean of 3.3 ± 2.6 days [Table 1].

The mean time for partial weight bearing was 10.0 ± 4.4 days, and full weight bearing was achieved in 16 ± 3.5 weeks. The average time to return to work was 30.0 ± 11 weeks [Figure 3].

Figure 3. Bar chart showing distribution of patients according to time required for weight bearing

Radiological union was achieved in all patients, with a mean time of 19 ± 2.2 weeks. Only 6.7% experienced malunion of about 5^0 varus/valgus (coronal deformity) only, and no cases of delayed union, non-union, or infection were reported [Table 2].

Table 2. Distribution of patients according to distance of fracture site from tibial plafond

Parameter	Mean	SD	Range
Distance of fracture site from tibial plafond (cm)	8.3	1.9	4 – 11
Time of radiological union (weeks)	19	2.2	12 – 26

Functional outcomes assessed by AOFAS score revealed that 27% had excellent results, 57% good, and 17% fair. No patient reported a poor outcome [Table 3]. According to Olerud and Molander scoring, 40% had excellent, 47% good, 10% fair, and 3.3% poor outcomes [Figure 4].

Table 3. Distribution of patients according to American orthopedic foot and ankle society score outcomes

AOFAS	N	%
Excellent (95 – 100)	8	27
Good (75 – 94)	17	57
Fair (51 – 74)	5	17
Poor (0-50)	0	0.0
Total	30	100

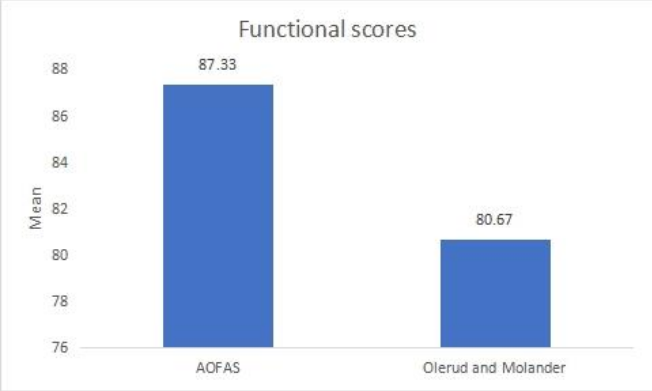

Figure 4. Bar chart showing distribution of patients according to functional scores

Discussion

Extra-articular distal tibial fractures (EADTFs) pose a distinct surgical challenge due to their anatomical location, subcutaneous nature, and limited vascular supply. Anatomical location of the distal tibial fracture indicates the centre of the fracture line from distal to proximal corresponds to 4-5 cm from the tibial plafond. These characteristics make them vulnerable to complications such as delayed union, non-union, wound complications, and malalignment. The primary goal of this study was to assess the functional and radiological outcomes of intramedullary nailing (IMN) in treating EADTFs—a topic that remains underexplored despite its clinical relevance. Technical challenges in fixation of this fracture pattern include soft tissue complications (infection, wound breakdown), implant failure, non-union/delayed union, intraoperative fracture propagation, and poor screw hold in osteoporotic bone.[14]

Adequate fixation with an intramedullary nail requires careful preoperative planning and use of additional techniques like a poller screw.[15] A major finding of this study was the high rate of satisfactory functional outcomes achieved using IMN, with 83% of patients reporting excellent or good results on the AOFAS score. This supports the hypothesis that IMN is a safe and effective treatment for EADTFs, despite its limitations, including difficulty in controlling short distal fragments, the risk of malalignment, and limited distal locking options in older nail designs. Comparable results have been reported by previous research that observed 80% good-to-excellent outcomes with IMN fixation.[16,17] Likewise, others documented excellent-to-good outcomes in the range of 88–93%.[18-22]

The mean time to radiological union in the present study was 19 weeks, which aligns with previously reported timelines by research ranging from 16 to 20 weeks.[18,19] Importantly, no cases of delayed union or non-union were observed, which may be attributed to early surgical intervention (mean 3.3 days) and stable fixation techniques. Similar trends in early operative timing were noted in the study by Mahajan *et al.,* which also emphasized favourable union outcomes.[16]

In terms of early mobilization and return to function, the current study revealed a mean full weight-bearing time of 16 weeks and a return-to-work time of 30.0 weeks. This is consistent with the findings by Patil *et al*., who noted immediate or early weight-bearing in over 60% of their patients.[20] Early weight-bearing is critical in optimizing rehabilitation and minimizing socioeconomic burden, and IMN appears to facilitate this when compared to more invasive options like ORIF.[20,21]

Functional evaluation using the Olerud and Molander scoring system further substantiated the clinical success of IMN, with 87% of patients achieving good to excellent results. Similar outcomes were described by researchers, reinforcing the validity of IMN in this fracture subset.[23,24]

Despite the positive outcomes, malunion was observed in 6.7% of patients because of the fracture pattern and the difficulty in reduction in obese patients. While no severe complications such as infection or non-union were reported, this finding underscores the technical demand of IMN, particularly in distal metaphyseal regions where maintaining alignment is challenging. The use of poller screws in more than half the cases may have contributed to alignment preservation. New methods of fixation, like custom-made 3D titanium cages, are also in use as reported by Otoukesh B *et al* in their case report.[25]

This study is limited by its relatively small sample size and single-center design, which may affect the generalizability of the results. Additionally, there was no comparative arm with alternative fixation modalities such as plating or external fixation, restricting direct treatment comparisons. Larger multicentric randomized controlled trials are necessary to further evaluate the superiority of IMN over other methods in the treatment of EADTFs. The role of adjuncts like poller screws and fibular fixation also merits further exploration to establish standardized surgical protocols.

Conclusion

This prospective observational study demonstrates that intramedullary nailing is a safe, effective, and minimally invasive method for managing extra-articular distal tibial fractures. The technique yielded high union rates, early return to function, and favorable functional scores, with minimal complication rates. The findings support IMN as a reliable option in carefully selected patients. However, further research with larger cohorts and comparative trials is needed to validate its superiority over other fixation strategies and to refine patient selection criteria for optimal outcomes.

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References

1. Court-Brown CM, McBirnie J, Wilson G. Adult ankle fractures--an increasing problem? Acta Orthop Scand. 1998;69(1):43-47. doi:10.3109/17453679809002355.
2. Koval KJ, Lurie J, Zhou W, et al. Ankle fractures in the elderly: what you get depends on where you live and who you see. J Orthop Trauma. 2005;19(9):635-639. doi: 10.1097/01.bot.0000177105. 53708.a9.
3. Kannus P, Palvanen M, Niemi S, Parkkari J, Järvinen M. Increasing number and incidence of low-trauma ankle fractures in elderly people: Finnish statistics during 1970-2000 and projections for the future. Bone. 2002;31(3):430-433. doi:10.1016/s8756-3282(02)00832-3.
4. Canale ST, Beaty JH. Campbell Operative Orthopedics. 12th ed. Maryland Heights, Missouri: Mosby; 2013.
5. Whittle AP, Russell TA, Taylor JC, Lavelle DG. Treatment of open fractures of the tibial shaft with the use of interlocking nailing without reaming. J Bone Joint Surg Am. 1992;74(8):1162-1171.
6. Hutson JJ, Zych GA, Cole JD, et al. Mechanical failures of intramedullary tibial nails applied without reaming. Clin Orthop Relat Res. 1995;(315):129-137.
7. Zelle BA, Bhandari M, Espiritu M, Koval KJ, Zlowodzki M, Evidence-Based Orthopaedic Trauma Working Group. Treatment of distal tibia fractures without articular involvement: a systematic review of 1125 fractures. J Orthop Trauma. 2006;20(1):76-79. doi: 10.1097/01.bot.0000202997. 45274.a1.
8. Newman SD, Mauffrey CP, Krikler S. Distal metadiaphyseal tibial fractures. Injury. 2011;42(10):975-984. doi: 10.1016/j.injury.2010.02.019.
9. Gupta A, Anjum R, Singh N, Hackla S. Outcome of Distal Both Bone Leg Fractures Fixed by Intramedulary Nail for Fibula & MIPPO in Tibia. Arch Bone Jt Surg. 2015;3(2):119-123.
10. Krettek C, Schandelmaier P, Tscherne H. Nonreamed interlocking nailing of closed tibial fractures with severe soft tissue injury. Clin Orthop Relat Res. 1995;(315):34-47.
11. Angliss RD, Tran TA, Edwards ER, Doig SG. Unreamed nailing of tibial shaft fractures in multiply injured patients. Injury. 1996;27(4):255-260. doi:10.1016/0020-1383(96)00059-9.
12. Bedi A, Le TT, Karunakar MA. Surgical treatment of nonarticular distal tibia fractures. J Am Acad Orthop Surg. 2006;14(7):406-416. doi:10.5435/00124635-200607000-00003.
13. Hardy JRW, Richardson JB. Diaphyseal fractures of the tibia: defining the place of external fixation. In: De Bastiani G, Apley AG, Goldberg A, eds. Orthofix External Fixation in Trauma and Orthopaedics. London: Springer; 2000:275–285.
14. Beshr M, Dixon J, Stevenson I. Distal Fibula Pro-Tibial Screws in Salvage Fixation of Bimalleolar Ankle Fractures in Osteoporotic Bone–A Novel Technique. Arch Bone Jt Surg. 2024;12(5):361-364. doi: 10.22038/ABJS.2024.76119.3515.
15. Ahmed A, Ali M, Farooq MO, Sulaiman MA, Rashid H, Ahmad T. Benefits of Poller Screw in Improving Radiological Outcomes after Intra-Medullary Nailing for Distal Tibia Fractures; A Retrospective Cohort Study. Arch Bone Jt Surg. 2024;12(10):701-705. doi: 10.22038/ABJS.2024.79504.3639.
16. Mahajan NP, Pawar ED, Supe AC, Managukiya HJ. Role of tibia interlocking nail in treating distal tibial metadiaphyseal fractures: study of 46 cases. International Journal of Research in Orthopedics. 2018 Jan; 4:65-71.
17. Bajaj S, Dhawale R, Garg RN. Evaluation of the clinical, functional and radiological outcomes in patients with distal tibia fractures with simple intra-articular extension treated with intramedullary multidirectional locking nail: A prospective study. Int. J. Res. Orthop. s. 2024;10:138-47.
18. Adhikari V, Sitaula P, Thapa O, et al. Functional Outcome of Solid Interlocking Nail in Open Tibial Fracture at a Tertiary Care Center: A Descriptive Cross-sectional Study. JNMA J Nepal Med Assoc. 2024;62(273):297-300.doi:10.31729/jnma.8571.
19. Sagar B V S, Nandi SS, Kulkarni SR, Bagewadi R. Functional Outcomes of Tibia Fractures Treated With Intramedullary Interlocking Nails by Suprapatellar Approach: A Prospective Study. Cureus. 2023;15(6):e40485. doi:10.7759/cureus.40485.
20. Patil R, Gowaikar A, Shirke A, Lokapur A, Ghelani G, Mehta S. A comparative study of extra-articular distal tibia fractures managed b y intramedullary nailing vs locking plate. Int J Orthop Sci. 2020;6:224-8.

21. Sagar B V S, Nandi SS, Kulkarni SR, Bagewadi R. Functional Outcomes of Tibia Fractures Treated With Intramedullary Interlocking Nails by Suprapatellar Approach: A Prospective Study. Cureus. 2023;15(6):e40485. doi:10.7759/cureus.40485.
22. Rahul PA, Mahesh V, Nagaraja BN, Narayanaswamy HD, Ranganath L, Srinivasamurthy KM. Studies on elastic stable intramedullary nailing (ESIN) for the treatment of diaphyseal fracture of femur in skeletally immature dogs using titanium elastic nails. Indian Journal of Veterinary Surgery. 2022;43(1):24-7.
23. Arora KK, Kapila R, Chaudhary P, Singla R, Sanan L. Functional and radiological outcome of distal tibia fractures managed with expert tibia nail: a prospective clinical study. International Surgery Journal. 2023;10(8):1366.
24. Kruppa CG, Hoffmann MF, Sietsema DL, Mulder MB, Jones CB. Outcomes After Intramedullary Nailing of Distal Tibial Fractures. J Orthop Trauma. 2015;29(9):e309-e315. doi:10.1097/BOT.0000000000000323.
25. Otoukesh B, Parvandi A, Niroomand M, Karimpour M, Rahmanizadeh M, Amiri S. Managing Distal Tibia Fracture Nonunion by Using Custom-Made Three-Dimensional Titanium Cage; A Rare Case Report. Arch Bone Jt Surg. 2025.