RESEARCH PAPER

Clinical and Functional Outcomes of Distal Tibial Metaphyseal Fractures Treated with Expert Tibial Nail Fixation: A Prospective Study

Dr. Rupesh kanna[1], Dr. Harish[2], Dr. Mageshwer CS[3], Dr. Nikshai K [4]*, Dr. T. Sundararajan[5], Dr. F. Abdul Khader[6] and Dr. Sathyanarayanan L Y[7]

[1]*Assistant Professor, Department of Orthopaedics, Shri Sathya Sai Medical College & Research Institute, Sri Balaji Vidyapeeth deemed to be university, Puducherry, India*
[2]*Assistant Professor, Department of Orthopaedics, Shri Sathya Sai Medical College & Research Institute, Sri Balaji Vidyapeeth deemed to be university, Puducherry, India*
[3]*Senior Residents, Shri Sathya Sai Medical College & Research Institute, Sri Balaji Vidyapeeth deemed to be university, Puducherry, India*
[4*]*3rd Year Post Graduate, Shri Sathya Sai Medical College & Research Institute, Sri Balaji Vidyapeeth deemed to be university, Puducherry , India*
[5]*Professor, Head of the department,Department of Orthopaedics, Shri Sathya Sai Medical College & Research Institute, Sri Balaji Vidyapeeth deemed to be university, Puducherry, India*
[6]*Professor, Department of Orthopaedics, Shri Sathya Sai Medical College & Research Institute, Sri Balaji Vidyapeeth deemed to be university, Puducherry, India*
[7]*Professor, Department of Orthopaedics, Shri Sathya Sai Medical College & Research Institute, Sri Balaji Vidyapeeth deemed to be university, Puducherry, India*
[*]***Corresponding Author:** *Dr. Nikshai K [4]*, 3rd Year Post Graduate, Department of Orthopaedics, Shri Sathya Sai Medical College & Research Institute, Sri Balaji Vidyapeeth deemed to be university, Puducherry , India*
Email: Nikshai.k@gmail.com

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ABSTRACT

Introduction: Distal tibial metaphyseal fractures represent a challenging subset of lower limb injuries because of limited soft tissue coverage, compromised vascularity, and proximity to the ankle joint. These factors increase the risk of complications such as delayed union, malalignment, and infection. Traditional treatment methods, including conservative management and open reduction with plating, may be associated with prolonged immobilization or soft tissue complications. Intramedullary fixation has emerged as an effective alternative as it preserves fracture biology and allows early mobilization. The Expert Tibial Nail (ETN) system provides improved distal locking options and enhanced biomechanical stability for metaphyseal fractures.

Aim and Objectives: The present study aimed to evaluate the functional and radiological outcomes of distal tibial metaphyseal fractures treated with Expert Tibial Nail fixation. The objectives were to assess postoperative pain reduction, improvement in range of motion of the ankle and knee joints, progression of weight-bearing, fracture alignment, and overall functional outcome using the Olerud–Molander Ankle Score.

Methods: This prospective observational study was conducted in the Department of Orthopaedics at Shri Sathya Sai Medical College and Research Institute between June 2024 and November 2025. A total of 31 patients with distal tibial metaphysiodiaphyseal fractures (AO/OTA types 43A1–A3) were included. All patients underwent ETN fixation under fluoroscopic guidance. Patients were followed for 24 weeks, and outcomes were assessed using Visual Analog Scale (VAS) for pain, ankle and knee range of motion, weight-bearing progression, radiological alignment, and functional outcome using OMAS.

Results: Postoperative pain progressively decreased during follow-up, with all patients reporting complete pain relief by 24 weeks. Ankle and knee range of motion improved steadily, with most patients achieving near-normal mobility at final follow-up. Weight-bearing advanced gradually, with the majority of patients attaining full weight bearing by 24 weeks. Radiological evaluation demonstrated satisfactory alignment in most cases. Based on OMAS scoring, 74.2% of patients achieved good to excellent functional outcomes, with minimal complications.

Conclusion: Expert Tibial Nail fixation is a reliable and effective treatment modality for distal tibial metaphyseal fractures, providing stable fixation, early mobilization, satisfactory fracture alignment, and favorable functional outcomes.

Keyword: Distal Tibial Metaphyseal Fracturesm, Lower Limb, Soft Tissue, Plating

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**Author for Correspondence: Nikshai.k@gmail.com*

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INTRODUCTION

With the increasing pace of industrialization, urbanization, and high-speed vehicular traffic, fractures of the lower limb have become a significant public health concern. Among these, fractures of the tibia are particularly important because of the bone's crucial role in weight bearing and locomotion. Distal tibial fractures occur in the metaphyseal region of the tibia and may extend to the weight-bearing articular surface, commonly referred to as tibial pilon or plafond fractures. The term "pilon," introduced by Etienne Destot, describes the pestle-like shape of the distal tibial metaphysis near the ankle joint.

The tibia is the most frequently fractured long bone in the human body and is associated with relatively high rates of malunion and nonunion. Due to its subcutaneous location, open fractures occur frequently, particularly following high-energy trauma such as road traffic accidents and sports injuries. Distal metaphyseal fractures present unique challenges because of the limited soft tissue envelope, compromised blood supply, and proximity to the ankle joint, which increase the risk of infection, delayed union, and malalignment.

Historically, these fractures were managed conservatively or with open reduction and internal fixation. However, these approaches may result in prolonged immobilization or soft tissue complications. Intramedullary nailing has emerged as an effective alternative because it preserves fracture biology, minimizes soft tissue dissection, and provides stable fixation. The Expert Tibial Nail (ETN) system offers improved distal locking options and enhanced biomechanical stability. The present study aims to evaluate the functional and radiological outcomes of distal tibial fractures treated with ETN fixation.

MATERIALS AND METHODS

- **Study Design**

This study was designed as a prospective observational clinical study aimed at evaluating the functional and radiological outcomes of distal tibial metaphyseal fractures treated with Expert Tibial Nail (ETN). The prospective design enabled systematic data collection and regular follow-up assessments to evaluate fracture healing, postoperative complications, and functional recovery.

- **Study Area**

The study was conducted in the Department of Orthopaedics at Shri Sathya Sai Medical College and Research Institute, a tertiary care teaching hospital providing specialized trauma and orthopaedic services.

- **Study Population**

The study population consisted of patients presenting with distal tibial metaphysiodiaphyseal fractures involving the extra-articular region located 4–9 cm proximal to the distal articular surface of the tibia. A total of 31 patients meeting the inclusion criteria were enrolled. The study cohort included 24 male and 7 female patients, with ages ranging from 24 to 60 years. According to the AO/OTA classification, 25 fractures were classified as Type 43A1, four as Type 43A2, and two as Type 43A3.

- **Duration of the Study**

The study was conducted over a period of 18 months from June 2024 to November 2025. Each patient was followed clinically and radiologically for a minimum period of 24 weeks postoperatively.

- **Sample Size Calculation**

The sample size was determined based on the number of eligible patients presenting with distal tibial metaphyseal fractures during the study period. A total of 31 consecutive patients fulfilling the inclusion criteria were included in the study using a convenience sampling method.

- **Inclusion Criteria**

Skeletally mature patients aged more than 18 years

Distal tibial metaphysiodiaphyseal fractures located 4–9 cm above the distal articular surface

AO/OTA Type 43A1, 43A2, and 43A3 extra-articular fractures

Recent fractures occurring within 14 days of injury

Closed fractures and Gustilo–Anderson Grade I open fractures

- **Exclusion Criteria**

Fractures located within 4 cm or more than 9 cm from the distal articular surface

AO/OTA Type 43B or 43C intra-articular fractures

Skeletally immature patients (<18 years)

Pathological fractures

Polytrauma patients

Associated major injuries to the ipsilateral or contralateral limb

Pre-existing tibial deformities

Significant medical comorbid conditions

- **Ethical Consideration**

Ethical approval for the study was obtained from the Institutional Ethics Committee of Shri Sathya Sai Medical College and Research Institute. Written informed consent was obtained from all patients prior to enrollment. All procedures were conducted in accordance with the ethical principles outlined in the Declaration of Helsinki.

- **Procedure Involved**

All patients underwent Expert Tibial Nail fixation under spinal anesthesia. Patients were positioned supine on a radiolucent operating table. Closed reduction was achieved using axial traction under fluoroscopic guidance. The entry point was created through a patellar tendon splitting approach, followed by insertion of a guide wire and sequential reaming of the medullary canal. The appropriately sized ETN was inserted and stabilized using proximal and distal locking screws placed under image intensifier guidance. In cases of metaphyseal instability or malalignment, poller screws were used to maintain alignment. After fixation, wound closure was performed and sterile dressing applied.

- **Data Collection**

Preoperative investigations included complete blood count (CBC), erythrocyte sedimentation rate (ESR), C-reactive protein (CRP), and radiographic evaluation. Postoperatively, patients were assessed clinically and radiologically at 2 weeks, 6 weeks, and monthly up to 6 months. Outcome measures included pain assessment using the Visual Analog Scale (VAS), range of motion of the ankle and knee joints, fracture union, alignment, and postoperative complications.

- **Data Analysis**

Collected data were entered into a structured database and analyzed using appropriate statistical methods. Descriptive statistics were used to summarize demographic characteristics and clinical outcomes. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. Statistical analysis was performed to assess postoperative improvement and functional outcomes following ETN fixation.

RESULTS

Postoperative Outcome Evaluation Tables

Table 1: Postoperative Pain Assessment Using Visual Analog Scale (VAS) at Various Follow-up Intervals (N = 31)

VAS Category	Immediate	24 hrs	4 wks	8 wks	12 wks	16 wks	20 wks	24 wks
No pain (1)	0	0	4	13	16	20	30	31
Mild pain (1–3)	18	23	26	18	15	11	1	0
Moderate pain (4–6)	13	8	1	0	0	0	0	0
Severe pain (7–10)	0	0	0	0	0	0	0	0

Table 2: Distribution of Patients According to Range of Motion of Ankle and Knee at Follow-up Intervals (N = 31)

ROM Category	4 wks	8 wks	12 wks	16 wks	20 wks	24 wks
Ankle 50–60°	1	0	0	0	0	0
Ankle 61–70°	18	4	8	2	0	0
Ankle 71–80°	10	15	7	4	1	0
Ankle 81–90°	2	12	10	15	18	3
Ankle 91–100°	0	0	6	10	12	28
Knee 61–70°	16	5	0	0	0	0
Knee 71–80°	15	18	3	0	0	0
Knee 81–90°	0	8	18	3	1	0
Knee 91–100°	0	0	10	28	30	31

Table 3: Functional Recovery, Alignment, and Final Functional Outcome After ETN Fixation (N = 31)

Parameter	Category	4 wks	8 wks	12 wks	16 wks	20 wks	24 wks
Weight bearing	No weight bearing	19	16	6	4	2	1
Weight bearing	Partial weight bearing	12	15	25	26	14	3
Weight bearing	Full weight bearing	0	0	0	1	15	27
Alignment (Coronal)	None					28 (90.3%)	
Alignment (Coronal)	2–5°					2 (6.45%)	
Alignment (Coronal)	6–10°					1 (3.2%)	
Alignment (Sagittal)	0–5°					26 (83.9%)	
Alignment (Sagittal)	6–11°					5 (16.1%)	
OMAS Outcome	Excellent						10 (32.3%)
OMAS Outcome	Good						13

							(41.9%)
OMAS Outcome	Fair						8 (25.8%)
OMAS Outcome	Poor						0

DISCUSSION

Distal tibial metaphyseal fractures present considerable management challenges due to limited soft tissue coverage, poor vascularity, and proximity to the ankle joint. Court-Brown et al. reported that approximately 37.8% of tibial fractures occur in the distal third, highlighting the clinical significance of these injuries. Conventional intramedullary nails often provide limited distal fixation because of single-plane locking and inadequate distal screw positioning, which can compromise stability. To address these limitations, the Expert Tibial Nail System (ETNS) was developed with multiple proximal and distal locking options and improved biomechanical stability.

In the present study, the mean patient age was 40.68 years, which is comparable to the findings of Bhaskar et al. and Gupta et al., indicating that distal tibial fractures commonly affect middle-aged individuals. A higher prevalence among males was also observed, consistent with previous reports by Gawatre et al., Yadav et al., and Kachhap et al., likely due to increased occupational and outdoor activities.

Postoperative pain scores demonstrated a progressive decline during follow-up, similar to the findings of Arora et al., reflecting stable fixation and early mobilization following ETN. The mean time to full weight bearing was approximately 10 weeks, which is comparable to results reported by Yadav et al. and Li et al. Functional recovery was satisfactory, with most patients achieving near-normal ankle and knee range of motion. Radiological union occurred at a mean of 17 weeks, with minimal complications. Overall, approximately three-fourths of patients achieved good to excellent functional outcomes based on the Olerud–Molander Ankle Score, supporting the effectiveness of ETN in managing distal tibial fractures.

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