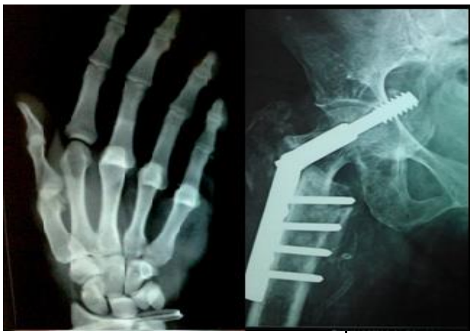

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Analysis of functional outcome following expert tibial nail fixation for distal tibial fractures

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Abstract
Background: Various treatment options exist for distal tibia fractures, such as external fixators, intramedullary nails, and internal plate fixation. Recently, there has been a growing inclination towards minimally invasive approaches with the expectation of better results. The objective of this study was to evaluate the efficacy of intramedullary nails, specifically elastic titanium nails (ETN), in the treatment of distal tibial metaphyseal fractures.
Methods: A total of 30 patients with extra-articular distal tibial fractures, who sought treatment between March 2021 and March 2023, underwent intervention with ETN and were subsequently monitored for a minimum duration of 2 years. The functional outcomes were evaluated using the AOFAS score.
Results: The patients had an average age of 46.6 years, with 18 males and 12 females. The right side was more commonly affected. Road traffic accidents (RTA) were the most frequent cause of injury. The average time for bone union was 19 weeks, ranging from 15 to 28 weeks. Two patients experienced complications related to malunion, while three cases had infections. However, despite these complications, all patients eventually achieved bone union.
Conclusion: In conclusion, for distal tibial metaphyseal fractures without involvement of the articular surface, the utilization of intramedullary nailing with expert tibia nails provides satisfactory stability at the fracture site and contributes to expedited healing and earlier return to work.

Keywords: Tibial fracture, Intramedullary nail, expert tibia nail, AOFAS Score

Introduction

A distal tibia fracture refers to a fracture occurring in the metaphyseal region of the lower part of the shinbone (tibia), which can extend to the weight-bearing surface of the bone. This type of fracture is alternatively called a tibial pilon fracture or tibial plafond fracture when it involves the joint surface.

The frequency of distal tibia fractures varies between 3 to 28 cases per 10,000 individuals annually, depending on factors such as age and gender. They account for 1% of all lower limb fractures, 3% to 10% of all fractures of the tibia1 and approximately 20% to 40% are open fractures.

Typically resulting from high-energy trauma like falls from heights or motor vehicle accidents, these fractures are commonly accompanied by significant soft tissue damage and are frequently classified as open fractures [1]. These associations increase the risk of infection, malunion, non-union, and ultimately lead to unfavorable overall outcomes [2].

The distal tibia fracture is categorized using the AO/OTA 43 classification system from 2018. This classification divides the fractures into three main groups: A, B, and C.

Under category 43.A, there are subtypes A1 (simple), A2 (wedge), and A3 (Multi fragmentary), which represent extra-articular fractures.

Category 43.B includes subtypes B1 (split fracture), B2 (split-depression fracture), and B3 (depression fracture) and refers to partial articular fractures.

Lastly, category 43.C encompasses subtypes C1 (simple articular, simple metaphyseal fracture), C2 (simple articular, multifragmentary metaphyseal fracture), and C3 (Multifragmentary articular and metaphyseal fracture) and represents complete articular fractures.

A variety of treatment methods are available for distal tibia fractures, including the use of different types of external fixators, intramedullary nailing, and internal plate fixation. In recent times, there has been a preference for minimally invasive techniques in the hopes of achieving improved outcomes.

In the past, distal end tibia fractures were typically managed through conservative methods involving traction, followed by early range of motion. This treatment approach was grounded in the idea of ligamentotaxis. Complications like unacceptable deformity and loss of range of movements in ankle were seen when patient is treated conservatively [3, 4].

Following the publication by Ruedi and Allgower and extensive research conducted by the AO group, open reduction and internal fixation gradually gained broader acceptance as a treatment approach for distal end tibia fractures [5].

While external fixators are commonly utilized in the initial emergency management of open fractures, they pose challenges when employed as a definitive treatment option.

The utilization of an intramedullary nail in the treatment of distal tibial fractures offers advantages 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 which covers the indications of the PTN and of the UTN/CTN, plus more distal and more proximal indications [6]. Additional to the standard static and dynamic locking options, the ETNS features multi directional locking options in the distal and proximal part of the nail.

This study aimed to assess the effectiveness of intramedullary nails (ETN) in the management of distal tibial metaphyseal fractures.

Materials and Methods

This was a prospective study conducted at our hospital between March 2021 and March 2023, involving 30 patients with extra-articular distal tibial fractures. The study aimed to assess the outcomes of these patients who underwent treatment with an expert tibial nail. The ethical committee of our institution approved this study. All patients with extra-articular distal tibial fractures located within 5cm from the ankle joint, who were willing to undergo surgery and follow-up, were included in our study. Patients with intra-articular fractures, distal tibial fractures greater than 5cm from the ankle joint, severe comminuted fractures, grade 3 compound injuries, and patients deemed medically unfit for surgery were excluded from the study. Upon admission, a comprehensive history regarding the mechanism of injury was obtained from all patients, followed by a thorough clinical and radiological evaluation. Closed fractures were immobilized using a splint or slab, while open fractures underwent meticulous wound debridement and primary closure before immobilization. The neurovascular status of the limb was assessed and recorded in the patients' case records. Additionally, any associated fractures were evaluated and documented. Standard anteroposterior and lateral radiographs were performed to capture images of the leg, enabling the identification and classification of the fracture type and pattern. The fractures were categorized according to the AO/OTA classification system, with type A representing extra-articular fractures, type B indicating partial articular fractures, and type C indicating complete articular fractures. The Tscherne system was utilized to assess soft tissue injury, while open fractures were classified using the Gustilo-Anderson classification. Routine blood investigations, serology, ECG, and chest X-rays were conducted to evaluate the patients' suitability for surgery. Any existing co morbid conditions were carefully noted and recorded in the patients' case records. Preoperatively, the length of the nail was approximately measured from the medial joint line to the medial malleolus of the contralateral limb. Once informed and written consent for the surgery was obtained, the patients were scheduled for the procedure. The surgery was performed with the patient under spinal anaesthesia and intravenous antibiotics cover. Cefaperazone sulbactam (1.5 gm) was administered intravenously during the anaesthesia induction and continued for at least 3 days in the postoperative period to ensure effective antibiotic therapy. The patient was positioned supine on the operating table, with their legs hanging over the edge of the table. Alternatively, the patient was positioned supine with the knee flexed at 90 degrees, and a bolster or pillow was placed under the knee for support. Fracture reduction was primarily performed using closed methods, which involved manual traction, manipulation, or the application of reduction clamps under fluoroscopy guidance. Using patellar tendon splitting approach, a vertical skin incision is made along the medullary canal, extending from the inferior pole of the patella to the tibial tuberosity. Awl is used to create a bone entry point, aligning with the medullary canal and the lateral tubercle of the intercondylar eminence in the anteroposterior (AP) view, and at the anterior edge of the tibial plateau in the lateral view. Under fluoroscopy guidance, a ball-tipped guide wire is inserted in line with the medullary canal in the AP view and at a 10-degree angle to the tibial shaft in the lateral view. Once the fracture is reduced, the guide wire is advanced to the distal fragment, ensuring its position is centered within the distal segment and its tip lies at the distal physeal scar. Serial reaming of the medullary canal is performed using a flexible reamer, gradually increasing the size by 0.5mm increments. The selected nail, typically 1 to 1.5mm smaller in diameter than the last reamer used, is mounted on an insertion handle. With the knee hyperflexed to facilitate insertion, the nail is inserted into the medullary canal with slight rotational movements under C-arm control. Close monitoring is maintained during nail passage across the fracture site using the C-arm. The distal tip of the nail is positioned approximately 0.5 to 1cm from the subchondral bone of the ankle joint or at the physeal scar. Distal locking of the nail is performed using a free-hand technique under C-arm control, with the C-arm repositioned for anteroposterior and mediolateral screw placement. The specific orientation and number of distal locking screws are determined by the surgeon's preference based on the fracture pattern. Biplanar screw fixation offers enhanced stability in distal tibial fractures. Proximal locking is accomplished using a jig, typically with two proximal locks performed from lateral to medial. Prior to proximal locking, fracture reduction is checked, and if there is any distraction at the fracture site, reverse jamming is applied. Once hemostasis is ensured, the wound is closed in layers, and a sterile dressing is applied. Postoperatively, all patients were provided with a crepe bandage or limb elevation for a period of 2-3 days. Ankle and knee mobilization exercises were initiated on the day of surgery, considering the patient's pain tolerance and compliance. Early mobilization began on the first postoperative day, involving non-weight-bearing walking. Complete weight bearing was avoided for a period of 4-6 weeks. Intravenous antibiotics were administered to all patients for 3 days, followed by oral antibiotics for an additional 4-7 days. Postoperative X-rays, including anteroposterior (AP) and lateral views, were taken to assess fracture reduction, screw orientation, and nail position. Wound inspection was conducted on the second and fifth postoperative day, with suture removal occurring on day 12. Patients were scheduled for follow-up at 1, 3, and 6-month intervals after the surgery, and subsequently on a yearly basis. During these follow-up visits, radiological evaluations were performed to assess fracture union and alignment. Clinical assessments were conducted to evaluate the range of motion at the knee and ankle, time required for fracture healing, return to work, presence of knee pain, limb length, and any deformities. Functional assessment was carried out using the AOFAS score. All follow-up data, including scoring results, were carefully documented in the patients' case records. All the follow up data and the scoring were documented in the patient case records.The data collected was analyzed using IBM SPSS Version 22.0. Armonk, NY: IBM Corp. Continuous variables were expressed as mean± SD and categorical variables were expressed as number and percentages. Chi square test was used in the comparison of categorical variables. A P value of less than 0.05 was considered to be statistically significant.

Results

A group of 30 patients with Distal Tibial fractures, who sought medical attention between May 2021 to May 2022, underwent fixation with Expert tibial nail for management and were followed up for a minimum of 2 years. The average age of the patients was 46.6 years, with a range of 25 to 60 years (Table 1). Out of the total group, 18 patients were males, while 12 patients were females(Figure 1). The right side was more frequently affected, observed in 17 of the patients (Table 2). The most common mode of injury observed among the patients was road traffic accidents (RTA), which occurred in 26 individuals. Accidental falls accounted for the mode of injury in 4 patients (Figure 2). In accordance with the AO fracture classification, the most frequently encountered type of fracture was 43A1, followed by types 43A3 and 43A2 (Table 4). For all cases, closed reduction of the tibia was performed, followed by internal fixation using an intramedullary nail, utilizing the patellar tendon splitting approach. The study revealed that closed fractures were more prevalent, observed in 24 patients, compared to open fractures, which were identified in 6 patients (Table 3). In our study, 16 patients had accompanying fibular fractures, and among them, fixation was performed in 7 cases. It is noteworthy that in all instances, the fibula was fixed before proceeding with tibia nailing. For 17 patients, three locking bolts were utilized in the distal fragment, while for the remaining 13 patients, two locking bolts were employed (Figure 3).

The average duration of follow-up for the patients was 12 months, with a range of 8 to 24 months. The average distance between the tibial plafond and the distal extent of the fracture was measured to be 4.2 cm, ranging from 3.1 to 5 cm. Radiological evidence of fracture union was successfully achieved, with an average union time of 19 weeks, ranging from 15 to 28 weeks. Functional assessment was conducted using the AOFAS score, which indicated good outcomes with an average score of 90, ranging from 76 to 98 at 3 months. There was no change in the score after the 1 year period. Two patients experienced complications related to malunion, with one case involving loosening of the proximal locking bolt, leading to implant removal. Infections occurred in three cases, including one case of superficial infection that resolved with intravenous antibiotics and dressing, and two cases of deep infection that required implant removal for resolution. Despite the complications, all three cases eventually achieved union, although it took longer compared to other patients. Additionally, three patients reported anterior knee pain, while two patients had restricted ankle movements, both of which were managed conservatively. None of the patients were lost to follow up. (Table 5)

Discussion

Fractures in the metaphyseal region of the distal tibia occur due to both axial and rotational forces. Surgeons face significant challenges when treating these fractures, including their location within the anatomy, associated soft tissue damage, extensive fragmentation, and the presence of abundant blood vessels in this area. The approach to treating distal metaphyseal extra-articular fractures differs from that of intra-articular pilon and diaphyseal fractures. The main objective of surgical management for these fractures is to ensure the fracture remains properly aligned within an acceptable range and to achieve sufficient stability at the fracture site, promoting successful union and enabling early mobilization. Internal fixation with plates is a commonly used method for treating distal tibial fractures. However, this approach carries the risk of complications such as skin necrosis, deep infections, delayed union, and refractures [7]. On the other hand, intramedullary nailing offers a superior option for treating these fractures. It provides load sharing capabilities and preserves the fracture hematoma, which promotes faster union and facilitates early mobilization. Conventional intramedullary tibia nails, while a preferable option for metaphyseal fractures, have limitations such as difficulty in manipulating metaphyseal fractures, single-plane locking screws, lower Herzog bend, and absence of distal locking screw holes at the nail tip. The challenges mentioned earlier can be effectively addressed by using an intramedullary tibia nail known as an ETN (Expert Tibial Nail). The ETN offers several advantages, including multiplanar interlocking options, locking holes positioned near the nail tip for enhanced angular stability despite a short distal segment, provision for compression, and an optimal Herzog's bend. These features collectively make the ETN an ideal choice of implant for metaphyseal fractures, particularly in the distal tibia. The average age in our study was 46.6 years, with the highest proportion of patients (40%) being in their fourth decade of life. In a study conducted by Gregory and Sanders [8], the mean age was reported as 30 years, while in another series by Duwelius *et al*., the mean age was 40.5 years [9]. Fractures of this type are predominantly caused by high-energy trauma, which accounts for approximately 85% of cases. These findings are consistent with studies conducted by Gregory and Sanders (85.10%) [8] and Krettak *et al*. [10]. (71%). In our study, the rate of malunion was found to be 10%. The acceptable range for malalignment, as per Trafton's criteria, included valgus-varus angulation less than 5 degrees, anteroposterior angulation less than 10 degrees, and rotation less than 10 degrees. Egol *et al*. reported a malalignment rate of 10% in their study population [11], while Rene Attal *et al*. found a malalignment rate of 5.4% in their study [12]. In our study, the average time for radiological union was 19 weeks, ranging from 15 to 28 weeks. This timeframe aligns with other studies in the literature, which reported radiological union ranging from 17 to 22.6 weeks following intramedullary nailing for tibia fractures. We performed additional procedures, such as dynamization, in one patient (5%) to address delayed union, resulting in successful fracture union. None of the cases required bone grafting. In the study conducted by Rene Attal *et al*., a screw breakage rate of approximately 3.2% was reported [12]. On the other hand, Markmiller *et al*. reported a screw breakage rate of around 14% in their study [13]. In our study, however, none of the cases experienced any screw breakage. Among the patients, 10% experienced superficial skin infections, 5% had delayed union, and there were no cases of implant failure. Our study's primary limitation is the lack of a comparative analysis between the outcomes of ETN and other surgical options for this type of fractures. Additionally, the study is constrained by a small sample size and the use of non-standardized radiographic assessment methods.

Table 1: Age Group

Age in years	No of patients	Percentage
20-30	4	13%
31-40	7	24%
41-50	10	33%
51-60	9	30%
Total	30	100%

Table 2: Side Involved

Side	No of patients	Percentage
Right	17	57
Left	13	43

Table 3: Type of Injury

Type of injury	No of cases	Percentage
Open	6	20
Type I	4	13
Type II	2	7
Closed	24	80
Grade 0	5	17
Grade I	8	27
Grade II	8	26
Grade III	3	10

Table 4: Fracture Pattern

AO OTA type	No of patients	Percentage
43A1	12	40
43A2	8	27
43A3	10	33

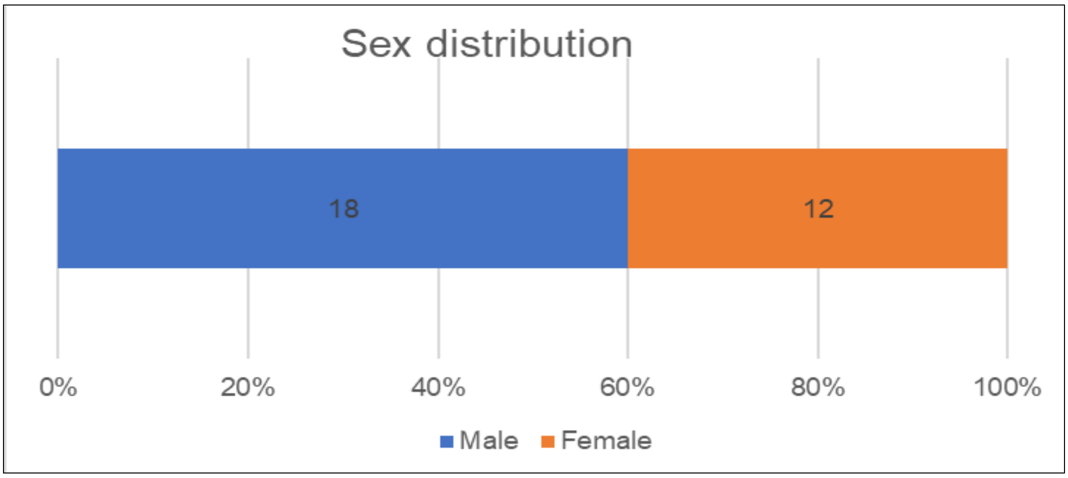

Fig 1: Sex Distribution

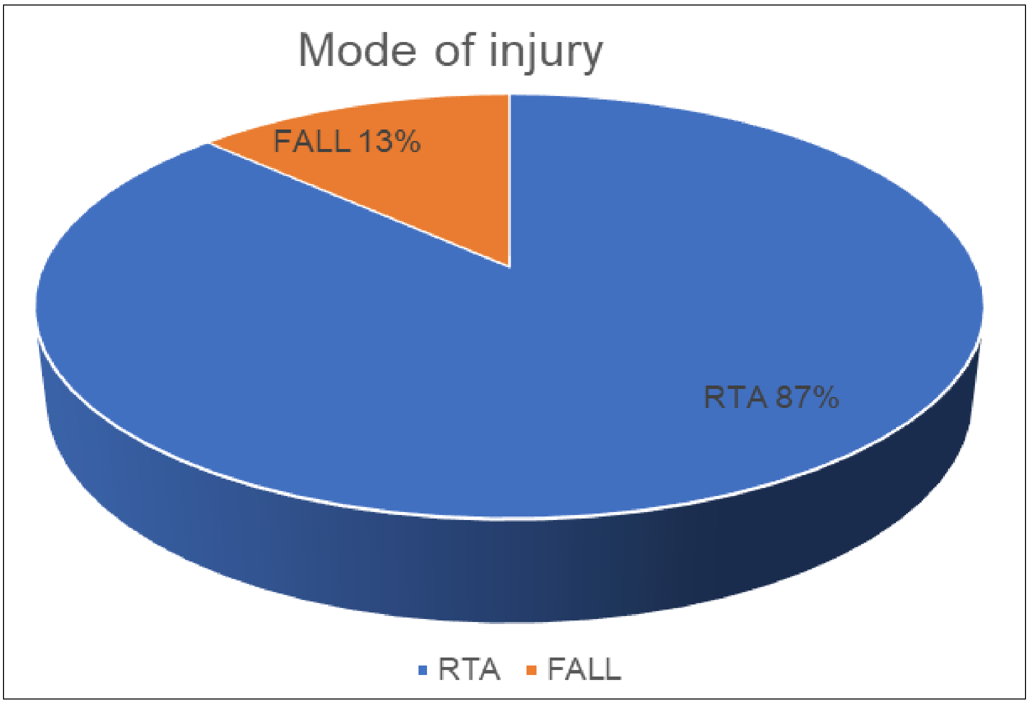

Fig 2: Mode of Injury

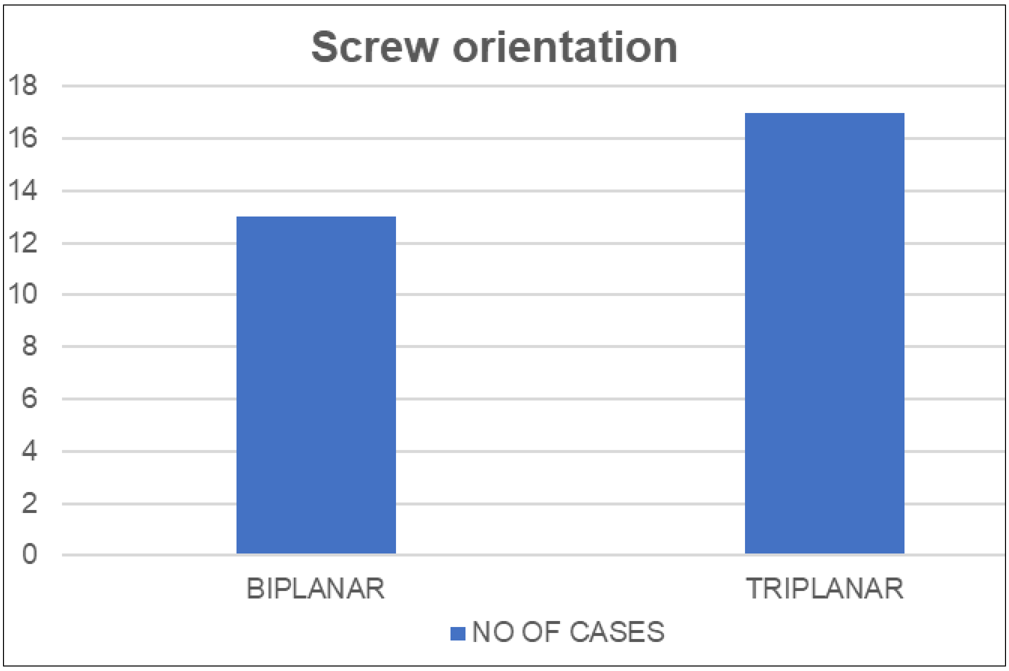

Fig 3: Screw Orientation

Table 5: Patients Demographics and Data

S. No	Age	Sex	Side	Mode of Injury	AO OTA Type	Type of Injury	Fibula Fracture	Screw Orientation	AOFAS Score 3 month	AOFAS Score 1 year
1	38	M	R	RTA	43A1	Open Type 1	Present	BIPLANAR	98	98
2	33	M	L	RTA	43A3	Closed Grade 0	Absent	TRIPLANAR	96	94
3	46	F	R	RTA	43A1	Open Type 2	Present	BIPLANAR	96	96
4	53	M	L	RTA	43A3	Closed Grade 1	Present	BIPLANAR	76	76
5	58	F	R	RTA	43A1	Closed Grade 2	Absent	TRIPLANAR	90	90
6	55	M	R	SAF	43A2	Closed Grade 0	Absent	TRIPLANAR	93	92
7	44	F	L	RTA	43A3	Closed Grade 2	Present	BIPLANAR	80	80
8	39	M	R	RTA	43A1	Open Type 1	Absent	TRIPLANAR	78	78
9	41	M	R	RTA	43A2	Closed Grade 1	Present	BIPLANAR	82	82
10	48	F	L	SAF	43A3	Closed Grade 2	Present	TRIPLANAR	90	90
11	60	M	R	RTA	43A1	Closed Grade 1	Absent	TRIPLANAR	96	96
12	25	F	L	RTA	43A2	Open Type 2	Present	BIPLANAR	93	93
13	36	F	R	RTA	43A3	Closed Grade 2	Absent	TRIPLANAR	95	95
14	49	M	L	RTA	43A1	Closed Grade 1	Present	BIPLANAR	98	98
15	51	M	L	SAF	43A3	Open Type 1	Present	TRIPLANAR	84	83
16	57	M	R	RTA	43A1	Closed Grade 2	Absent	TRIPLANAR	88	88
17	31	F	L	RTA	43A3	Closed Grade 0	Present	BIPLANAR	95	95
18	43	M	R	RTA	43A3	Closed Grade 3	Present	TRIPLANAR	90	90
19	42	F	L	RTA	43A1	Closed Grade 1	Absent	BIPLANAR	93	93
20	46	M	R	RTA	43A2	Closed Grade 3	Present	TRIPLANAR	95	95
21	27	M	R	RTA	43A1	Closed Grade 1	Absent	TRIPLANAR	76	76
22	29	F	R	RTA	43A1	Closed Grade 2	Absent	TRIPLANAR	86	86
23	30	M	R	RTA	43A1	Closed Grade 2	Absent	TRIPLANAR	80	78
24	32	M	R	SAF	43A2	Closed Grade 0	Absent	TRIPLANAR	91	91
25	37	M	L	RTA	43A2	Closed Grade 1	Absent	BIPLANAR	78	78
26	47	M	L	RTA	43A3	Open Type 1	Present	TRIPLANAR	96	96
27	50	M	L	RTA	43A1	Closed Grade 1	Absent	BIPLANAR	98	94
28	52	F	L	RTA	43A3	Closed Grade 2	Present	TRIPLANAR	92	92
29	59	F	R	RTA	43A2	Closed Grade 0	Present	BIPLANAR	84	84
30	56	F	R	RTA	43A2	Closed Grade 3	Present	BIPLANAR	86	82

Conclusion

We have determined that maintaining a properly aligned short distal segment during fracture fixation is crucial for achieving favorable functional outcomes. Consequently, our conclusion is that in cases of distal tibial metaphyseal fractures that do not involve the articular surface, IM nailing with an ETN offers sufficient stability at the fracture site and facilitates faster healing and earlier resumption of work activities.

Declarations

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Conflict of Interest: None declared

Ethical Approval: Not required

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