A Comparative Study between Results of Extraarticular Distal Tibia Fractures Fixed by Minimally Invasive Locked Plate versus Expert Nail

Mohamed Said Abouelela*, Moustafa Hussein Hegazy,
Ali Mahmoud Emran, Mohamed Roshdy El-Tabbakh
Orthopedic Surgery Department, Faculty of Medicine, Tanta University, Tanta, Egypt
***Corresponding author,** Mohamed Said Abouelela**, Mobile:** (+20) 01226192906, **Email:** dr.mohamed.aboelela93@gmail.com

ABSTRACT

Background: Expert Tibial Nail is useful for all extra-articular tibia fractures since it offers several proximal and distal locking options.

Objective: This study compared the outcomes of adult extra-articular distal tibial fractures treated with expert nail versus minimally invasive locked plate.

Patients and methods: Forty patients, both sexes, over the age of eighteen, with extra-articular distal tibia fractures, open fractures grade I, recent fractures that manifested within two weeks of injury, and with or without fibular fractures were included in this prospective investigation. There were two equal groups of patients: Group A patients who were fixed by locked plate utilising the minimally invasive plate osteosynthesis (MIPO) technique, whereas group B patients were treated by expert Nail.

Results: In both groups, the operational time varied considerably (P<0.01). Intra operative blood loss, fracture union time and post-operative weight bearing were significantly different between both groups. Age, sex and complication were insignificantly different between scores from the American Orthopaedic Foot and Ankle Society (AOFAS). Smoking status also did not seem to affect AOFAS scores in group A, but there was a trend towards lower scores in smokers versus non-smokers in group B that neared significance.

Conclusions: Both MIPO and Expert intramedullary interlocking nailing (ILN) techniques can achieve favorable outcomes for extra-articular distal tibial fractures in adults. Patient preferences, surgeon experience, soft tissue state, and fracture pattern may all influence the decision between MIPO and intramedullary nailing.

Keywords: Expert Nail, Intramedullary interlocking nailing, Minimally invasive plate osteosynthesis, Extrarticular distal tibia fractures.

INTRODUCTION

Fracture occurs because of mechanical overload to different bones in the body with different consequences. The key to choosing the best treatment technique for a particular fracture is having a thorough grasp of the mechanical and biological elements of fracture healing [1, 2].

Tibia hold the highest incidence of broken long bones in the body with rate about 20 per 100,000 patient\year with increased incidence among males. Most injuries require hospital admissions with prolonged periods of treatment away from social life and work. The most frequent site for tibial fractures is diaphysis, and fibular fractures are present in roughly 80% of these events [3, 4].

Fractures of the distal tibia shaft affect people of all ages and make up around 40% of all tibial injuries. Because of the anatomical characteristics of the fracture, such as its subcutaneous location with inadequate blood supply and close proximity to the ankle joint, distal tibial fractures in skeletally mature patients without articular extension are challenging to treat [5].

(Part omitted) Distal tibia fractures have usually been treated with internal fixation using standard plates. However, alternative strategies have been proposed, such as intramedullary nailing (IMN) and minimally invasive plate osteosynthesis (MIPO), both of which have become common fixation methods to address this injury pattern, in light of new research and the high rate of complications associated with this procedure [5].

Since locking plates and biological fixation have been developed to treat fractures of the extremities, the usage of MIPO has increased since it has a far better reported prognosis and a lower rate of complications than the standard procedure. The MIPO approach has been widely utilised to treat distal tibia fractures in a safe and effective manner, with positive results [6].

Because it may lock in both proximal and distal directions, Expert Tibial Nail is useful for all extraarticular tibia fractures. Four locking choices are located distally in different planes, while five locking options are located proximally. This implant design aids in most extraarticular tibial fractures in obtaining enhanced locking and stable fixation [6].

Received: 11/10/2024
Accepted: 10/12/2024

Therefore, this study aimed to compare the effects of minimally invasive locked plate vs expert nail treatment for adult extra-articular distal tibial fractures.

PATIENTS AND METHODS

This study involved 40 distal tibia extra-articular fracture patients. The study was conducted in January 2023 to January 2024.

Inclusion criteria: Patients aged >18 years with extra-articular tibial fracture, mixed sexes, open grade I, recent (two weeks post-injury), and with/without fibular fractures.

Exclusion criteria: Patients under 18 years old, with grade II and grade III open fractures, comminuted fractures, intra-articular fractures, medically unfit for surgery and pathological fractures, or peripheral neuropathies/peripheral vascular disorders.

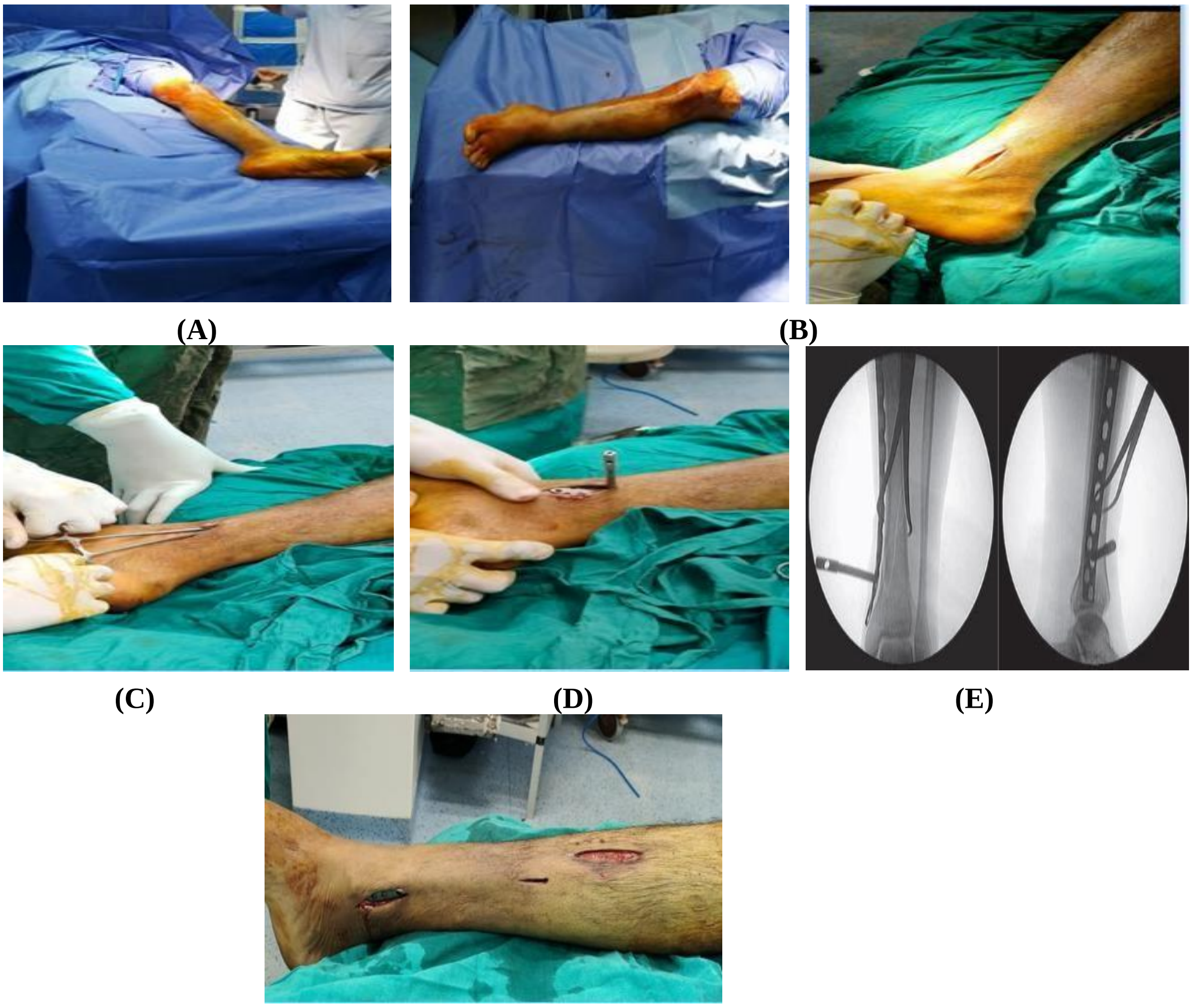
Patients were randomly assigned to either a locked plate with MIPO technique (Group A) or an Expert Nail (Group B). All patients underwent comprehensive assessment, including full history, clinical examination, lab tests (CBC, PT, PC, INR, RBS, urea, creatinine), and imaging (X-rays, CT scan).

Preoperative management included systemic analgesics for appropriate pain control, temporary stabilisation of all patients with an above-knee slab, proper management of blood glucose in diabetic patients, optimisation of co-morbidities, randomisation, and the administration of a prophylactic antibiotic, specifically the third-generation Cephalosporin (Ceftriaxone), to all patients 30 minutes prior to surgery. Time passed since the injury was ranging from 2 to 7 days due to optimising patients' general conditions and skin condition before surgery.

Group A, Distal tibial locked plate with MIPO technique: On a radiolucent table, patients were placed supine with their contralateral iliac crest raised. Better exposure and access to the operated medial side are made possible by the rotation. On the thigh, a tourniquet was applied and tightened to 300 mmHg. The surgeon may decide to repair the fibula if it is fractured within 7 cm of the lateral malleolus tip or if it facilitates tibia reduction. For the initial stage of open reduction and internal fixation of the fibular fracture, a traditional third tubular plate was utilised. An incision of 3 cm was made across the tibia's antero-medial aspect, beginning at the medial malleolus' tip [7].

Using a Cobb dissector, a subcutaneous extra periosteal tunnel was made. A plate was then inserted through the tunnel, being careful not to harm the periosteum. The right plate size was chosen, and the level of the plate was determined with the help of the image intensifier [8].

Manual manipulation and the use of a fixator or percutaneous clamps helped to reduce the fracture. One screw was placed across the medial malleolus, while the other was placed just beneath the fracture site; the latter helped reduce bone by making use of the plate's anatomical contour.(Sentence omitted). In order to prevent undue strain on the skin, the subcutaneous tissue should be tightly closed over the plate (Figure 1).



(A) (B) (C) (D) (E) (F)

Figure (1): (A) Positioning and draping of distal tibial locked plate, (B) Incision over medial malleolus, (C) Introduction and adjustment of plate, (D) Choosing an appropriate plate size and determine the level of the plate with the aid of the image intensifier, (E) The plate correctly positioned so that the plate itself acts as a reduction mould [8], (F) MIPO technique requires only small incisions.

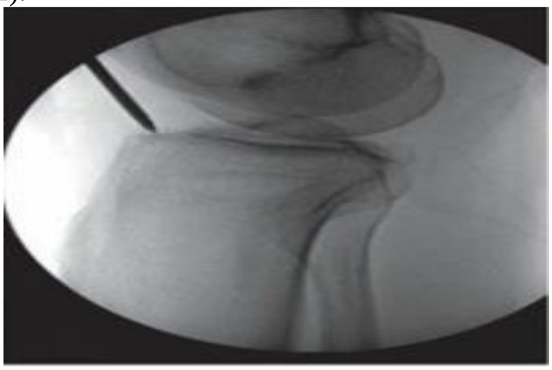
Group B, Expert Nail:

The surgeon may make a deep incision transpatellar, medial, or lateral parapatellar, extending from the patella's inferior pole to the tibial tuberosity [8], depending on the patella's anatomy. Make the cut along the medullary canal's central axis. The deep incision may extend from the inferior pole of the patella to the tibial tuberosity, with options including a transpatellar, medial, or lateral parapatellar approach, based on the patient's anatomy and the surgeon's preference [9].

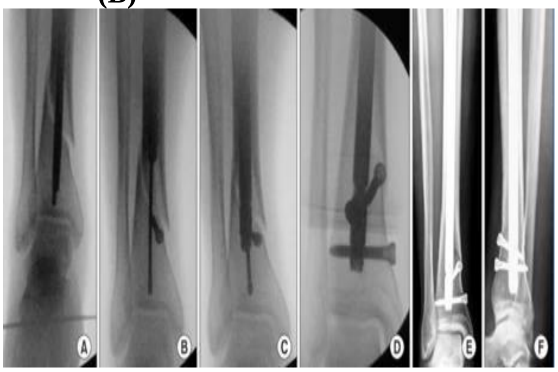
Properly aligning the nail required careful adjustment of the entry point. The A.P. entered the intramedullary canal and aligned with the lateral tubercle of the intercondylar eminence. The entry point was on the lateral side of the tibial plateau's ventral edge [10].

A solid awl was used. The image intensifier verified proper placement before the aperture was fully opened. The reduction was essential for IMN's effective functioning. Meticulous consideration of length, angulation, and rotation during fracture reduction, guide-wire placement, reaming, and nail insertion is essential for successful reduction.

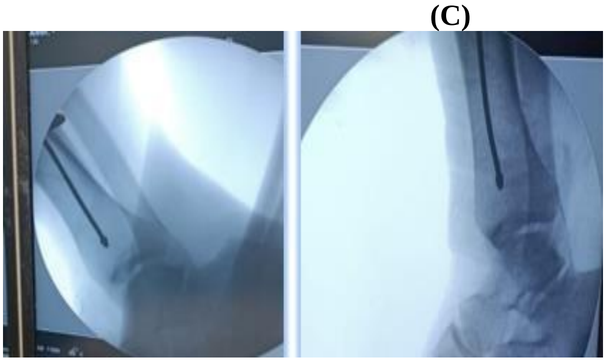
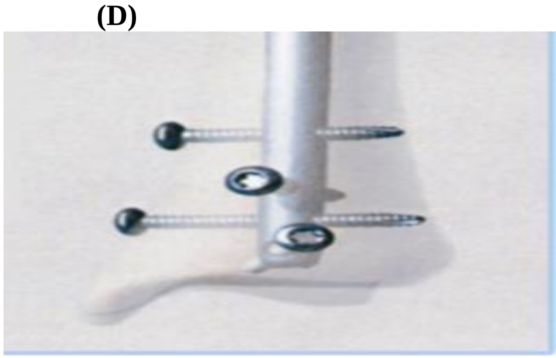
After guide-wire insertion, further adjustments were essential to prevent displacement. The methods range from simple adjustments, like mild traction and rotation, to advanced techniques, such as percutaneous reduction forceps and blocking screws. We start with the least invasive and progress towards more invasive ones. [11]. Under fluoroscopic guidance, the guidewire was advanced from the entry portal into the tibial canal, across the fracture site, and into the tibia. Centre the guide rod within the distal fragment, 1.0 cm to 0.5 cm proximal to the ankle joint on anteroposterior and lateral views [10]. Small core diameter, deep fluted sharp reamers were employed for reaming. The diameter of the reamer increased steadily by half a millimeter at a time until cortical sound was detected. The nail was fitted with the insertion device and locking screw guide. Direct the proximal bend of the nail posteriorly and keep the knee flexed to avoid patellar impingement during insertion. The positioning of the iliac crest, patella, and second foot ray was evaluated in terms of their rotational alignment. 0.5 to 1.0 cm below the cortical opening is the ideal location for the proximal end of the nail during gentle back-and-forth twisting for successful insertion with moderate pressure. The lateral fluoroscopic view showed this position to be optimal. 0.5 to 2.0 cm separated the distal nail tip from the ankle joint's subchondral bone. For very distal fractures, the nail must be inserted closer to the distal end [10]. These nail systems employ oblique locking screws that travel anteromedialy and anterolateraly to posteromedialy and posterolateraly respectively. Expert nail features multidirectional interlocking screws. The design features 4 distal screw openings, enabling the use of 2-3 screws for enhanced fixation and rotation prevention. The surgical wounds were closed with absorbable sutures. If the paratenon of the patellar tendon sheath was opened during the approach, it was repaired (Figure 2).

(A) **(B)**

(C) **(D)**

(E) **(F)**

Figure (2): Lateral (A) and AP (B) Views of the proximal tibia demonstrate the ideal starting point for a tibial nail. With either an awl or with a guide pin that can be enlarged with a cannulated drill or awl [12], (C) Reduction of spiral fracture by reduction clamp, (D) Reduction by pollar screw [11], (E) Guide wire must be in the central portion of the distal fragment in both the AP and lateral views to avoid a translational or angular deformity [13], (F) Expert nail has multidirectional interlocking screws [9].

Postoperative X-rays were taken immediately, neurovascular assessment was performed, patients received Ceftriaxone antibiotics intravenously twice daily, low molecular weight heparin was given every 24 hours until mobilization to prevent DVT/PE, and patients were sent home on the third day with a one-week course of oral Ceftriaxone, analgesics, anti-edematous drugs, and instructions for ROM and quadriceps exercises, but without weight-bearing.

Follow-up program: Two weeks post-surgery, stitches were taken out. The crutches were used on both sides, limiting weight bearing to the injured side. Six-week check-ups involved screening for infections and taking follow-up AP and lateral whole leg X-rays. 10% of MIPO group patients had superficial infection, while 5% had deep infection. The muscles' range of motion and strength were evaluated. Patients were permitted to bear limited weight on their toes. Starting at 5 weeks for the expert nail group and 8 weeks for the MIPO group. A 12-week check-up included X-rays to assess union or fixation progress. 25% of patients are instructed to start full weight bearing if full union is achieved. If the fracture indicated incomplete union with callus formation in 67% of cases, the patient was advised for partial weight bearing. 24-week mark: X-ray follow-up. Once full union is achieved, which occurs in roughly 92% of cases, patients are advised to resume full weight bearing and return to work. American orthopedic. The AOFAS scoring system for the foot and ankle was documented.

Ethical approval: This study was approved by Tanta University Hospitals' Ethical Committee. Following receipt of all information, signed consent was provided by each participant. The study adhered to the Helsinki Declaration throughout its execution.

Statistical analysis

IBM Inc., Chicago, implemented statistical analysis using SPSS version 26. ANOVA with post hoc Tukey test was applied for comparing quantitative variables among the three groups. The variables were represented by their mean values and standard deviations. The Chi-square test determined the frequency and percentage distribution of qualitative variables. A P value ≤ 0.05 in a two-tailed test signifies a statistically significant result.

RESULTS

Demographic data and medical history were insignificantly different both groups, while onset of trauma was significantly different (Table 1**)**.

Table (1): Demographic data, time passed since injury and medical history of the studied groups

		Group A (n = 20)	Group B (n = 20)	Test	P
Age (years)		42.85±12.35	34.95±12.56	t=2.006	0.052
≤40		10(50.0%)	14(70.0%)	χ^2=1.667	0.197
>40		10(50.0%)	6(30.0%)		
Sex	**Male**	12(60.0%)	13(65.0%)	0.107	1.000
	Female	8(40.0%)	7(35.0%)		
BMI		25.69±1.86	27.22±2.99	1.942	0.060
Smoking		6(30.0%)	8(40.0%)	0.440	0.507
Onset of trauma		4.80±1.74	2.80±1.06	72.00*	**>0.001***
Medical history	**Diabetes**	5(25.0%)	4(20.0%)	0.143	1.000
	HTN	3(15.0%)	4(20.0%)	0.173	1.000

Data are presented as mean ± SD or frequency (%). * Significant p value <0.05. BMI: Body Mass Index, χ2: Chi square test, t: Student t-test, HTN: hypertension.

Complications were insignificantly different, while AOFAS score, and operative time were significantly different in both groups (P<0.01) (Table 2).

Table (2): Comparison between the two studied groups according to complications, AOFAS score and operative time

		Group A (n = 20)	Group B (n = 20)	χ2	P
Complications	**Malunion**	1(5.0%)	2(10.0%)	0.360	1.000
	Delayed union	1(5.0%)	1(5.0%)	0.000	1.000
	Nonunion	0(0.0%)	1(5.0%)	1.026	1.000
	Superficial infection	2(10.0%)	0(0.0%)	2.105	0.487
	Deep infection	1(5.0%)	0(0.0%)	1.026	1.000
AOFAS score	**Considered fair (50 to 74)**	1(5.0%)	1(5.0%)	5.518*	**0.048***
	75 to 89 Considered good	11(55.0%)	4(20.0%)		
	>90 (Excellent result)	8(40.0%)	15(75.0%)	t=1.548	0.130
	---	87.10 6.80 ±	90.75±8.06		
Operative time		101.3 ±7.06	83.45 ±10.88	6.137*	**>0.001***

Data are presented as mean ± SD or frequency (%). * Significant p value <0.05. AOFAS: American Orthopedic Foot and Ankle Society, χ2: Chi square test, t: Student t-test.

Intra-operative blood loss, fracture union time and post-operative weight bearing were significantly different between both groups (P < 0.05) (Table 3**)**.

Table (3): Comparison between the two studied groups according to intra operative blood loss, fracture union time and post-operative weight bearing

	Group A (n = 20)	**Group B (n = 20)**	**T**	**P**
Intra operative blood loss	89.50±11.83	51.45±9.10	11.399*	**>0.001***
Fracture union time	14.35±4.16	8.95±1.28	5.552*	**>0.001***
Post-operative weight bearing	10.65± 1.60	7.62±1.34	6.494*	**>0.001***

Data are presented as mean ± SD. * Significant p value <0.05.

Age, sex and complication were insignificantly different between AOFAS scores in this study population. Smoking status also did not seem to affect AOFAS scores in group A, but there was a trend towards lower scores in smokers versus non-smokers in group B that neared significance **(**Table 4).

Table (4): Relation between AOFAS score and demographic data, smoking and complications in total sample

		AOFAS score			**□2**	**P**
		Considered fair (50 to 74) (n = 2)	**75 to 89 considered good (n = 15)**	**>90 (excellent result) (n = 23)**		
Age (years)	**≤40**	1(50.0%)	9(60.0%)	14(60.9%)	0.409	1.000
	>40	1(50.0%)	6(40.0%)	9(39.1%)		
Sex	**Male**	1(50.0%)	9(60.0%)	15(65.2%)	0.585	1.000
	Female	1(50.0%)	6(40.0%)	8(34.8%)		
Smoking		1(50.0%)	4(26.7%)	9(39.1%)	1.122	0.549
Complications	**Malunion**	0(0.0%)	2(13.3%)	1(4.3%)	1.631	0.619
	Delayed union	0(0.0%)	0(0.0%)	2(8.7%)	1.822	0.557
	Nonunion	0(0.0%)	1(6.7%)	0(0.0%)	2.866	0.421
	Superficial infection	0(0.0%)	1(6.7%)	1(4.3%)	1.202	1.000
	Deep infection	0(0.0%)	1(6.7%)	0(0.0%)	2.866	0.421

Data are presented as frequency (%). AOFAS: American Orthopedic Foot and Ankle Society.

DISCUSSION

Although there was a difference in the number of patients who experienced superficial wound infections between the MIPO group and the Expert nail group (10%), the difference was not statistically significant. One patient (2.5% of total cases) in the MIPO group had a deep surgical site infection requiring surgical debridement and IV antibiotics (Ceftriaxone). These deep infection rates were within the expected range for these procedures. **Mani Kc *et al.*** [14] reported that there was no significant difference between MIPO and IMIL groups in delayed union (12% vs. 14%) and deep infection (2% vs. 2%). The average degrees of malunion in the MIPPO group were significantly lower (5 [3–7] ± 1.41) than in the IMIL group (10.22 [8–14] ± 2.04). The MIPO group had a higher rate of superficial infection (8%) compared to the IMIL group (4%). The difference in non-union rates (2% vs 6%) between the first and second groups was statistically significant. **Mohamed *et al.*** [15] reported that, among patients in the MIPO group, one exhibited rotational deformity (25-degree external rotation), while two patients displayed coronal plane malalignment (Although insignificant). Additionally, one patient in the MIPO group experienced delayed union, and another encountered non-union, both of which were insignificant compared to the expert nail group.

In agreement with our results about AOFAS score, **Singla *et al.*** [16] showed that 80% of expert tibial nailing patients and 55% of distal tibial plating patients recorded superior outcomes based on AOFAS scores in their respective groups but the difference between both groups was insignificant, as indicated by **Mani Kc *et al.*** [14] in their study, with AOFAS scores of 84.16 (60-98) ± 8.80 for the former and 83.84 (61-98) ± 8.87 for the latter.

In this study, age and gender did not appear to significantly impact AOFAS scores. In agreement,

Hap and Kwek [17] showed that functional outcomes were similar for younger and older patients. **Rademakers *et al.*** [18] reported excellent functional results in patients of all ages with no correlation to age. Age did not impact significantly our study's functional outcome results.

In this study, smoking status also did not seem to affect AOFAS scores in group A, but there was a trend towards lower scores in smokers versus non-smokers in group B that neared significance. Several prior studies have linked smoking to higher non-union rates and poorer functional recovery after tibial fractures [19, 20].

In this trial, there was a substantial difference in the mean amount of time before surgery—5.0 days for the MIPPO group and 2.0 days for the ILN group. This implies that because of improving skin health, the fractures in the MIPPO group were comparatively older at the time of surgery than those in the ILN group. In this investigation, group B's mean operational time was notably less than in group A (101.3 minutes), at 83.45 minutes. There was a statistically significant difference ($p < 0.001$), indicating that the ILN technique generally required less time to perform than the MIPPO technique.

In accordance, **Singla *et al.*** [21] showed that the expert tibial nailing patients had a mean operative time of 83.15 minutes, which was significantly less than the 101.2 minutes for the distal tibial plating patients. This finding is inconsistent with several other studies that have reported shorter operative times with MIPPO technique [22, 23] .

In this study, group B (ILN) had significantly less intraoperative blood loss compared to group A (MIPO). The mean blood loss for group B was 51.45 ml, while for group A it was 89.50 ml. This difference was statistically significant, suggesting that the ILN technique was associated with less blood loss during surgery. In accordance, **Singla *et al.*** [16] showed that the intraoperative blood loss was compared between expert tibial nailing and distal tibial plating procedures. The expert tibial nailing group had a significantly lower mean intraoperative blood loss (51.6 ml) compared to the distal tibial plating group (89.1 ml). This finding disagrees with **Li *et al.*** [24] who demonstrated reduced blood loss with the MIPO technique due to the smaller incisions.

In this study, group B (ILN) had a shorter mean fracture union time (8.95 weeks) compared to group A (MIPO), which had a mean of 14.35 weeks. The difference was statistically significant, indicating that fractures treated with ILN may heal faster than those treated with the MIPPO technique. In agreement, **Singla *et al.*** [16] revealed that the average fracture union time for patients in the expert tibial nailing group was 18.6 weeks, which showed a considerable decrease from the distal tibial plating group's patients' mean fracture union time of 25.84 weeks. This finding is inconsistent with **Li *et al.*** [24] who reported faster union rates with MIPPO technique. The rigid fixation provided by the locked plate in the MIPPO technique may contribute to the faster union rates observed in this study.

Limitations: One of the study's limitations was the very small sample size.(Part omitted). Lack of long-term follow-up data beyond fracture union limits assessment of outcomes like post-traumatic arthritis. Difference in timing of surgery between groups may have influenced some outcome measures. Lack of patient-reported outcome measures and return to work/activity status. Lack of detailed radiographic assessment and classification of fracture patterns.

CONCLUSION

In adults, both MIPO and ILN methods led to successful results for extra-articular distal tibial fractures. Based on AOFAS ratings, the Expert Nail group had a slightly larger percentage of excellent functional outcomes. Nevertheless, the complication rates for malunion, delayed union, and non-union were minimal for both fixation techniques. While, both MIPO and Expert Nail may result in a successful fracture union and a satisfactory functional recovery, the decision between the two procedures may be influenced by the patient's preferences, the soft tissue condition, the surgeon's experience, and the fracture pattern.

Conflict of interest: None.
Financial disclosures: None.

REFERENCES

1. **Ronga M, Longo U, Maffulli N (2010):** Minimally invasive locked plating of distal tibia fractures is safe and effective. Clin Orthop Relat Res., 468: 975-82.
2. **Zelle B, Bhandari M, Espiritu M *et al.* (2006):** Treatment of distal tibia fractures without articular involvement: a systematic review of 1125 fractures. J Orthop Trauma, 20: 76-9.
3. **Achten J, Parsons N, Mcguinness K *et al.* (2015):** Uk fixation of distal tibia fractures (uk fixdt): Protocol for a randomised controlled trial of 'locking' plate fixation versus intramedullary nail fixation in the treatment of adult patients with a displaced fracture of the distal tibia. BMJ Open, 50: 300-30.
4. **Tornetta P, court-Brown C, Heckman J *et al.* (2014):** Rockwood, green, and wilkins fractures in adults and children: Eighth edition. 2nd ed., Pp: 307-52. https://search.worldcat.org/title/Rockwood-and-Green's-fractures-in-adults/oclc/300348277
5. **Kneifel T, Buckley R (1996):** A comparison of one versus two distal locking screws in tibial fractures treated with unreamed tibial nails: a prospective randomized clinical trial. Injury, 27: 271-3.
6. **Redfern D, Syed S, Davies S (2004):** Fractures of the distal tibia: minimally invasive plate osteosynthesis. Injury, 35: 615-20.
7. **Hodgson S (2009):** AO principles of fracture management. Ann R Coll Surg Engl., 9(5): 448-49.

8. **Apivatthakakul T (2017):** Tibial shaft - special considerations. Ao foundation. J Clin Orthop Trauma, 20: 600-30.
9. **Kuhn S, Hansen M, Rommens P (2008):** Extending the indications of intramedullary nailing with the expert tibial nail. Acta Chir Orthop Traumatol Cech., 75: 77-87.
10. **Heckman J (2008):** Campbell's operative orthopaedics. JBJS., 90: 500-30.
11. **Guo J, Tang N, Yang H *et al.* (2010):** A prospective, randomised trial comparing closed intramedullary nailing with percutaneous plating in the treatment of distal metaphyseal fractures of the tibia. J Bone Joint Surg Br., 92: 984-8.
12. **Gross S, Galos D, Taormina D *et al.* (2016):** Can tibial shaft fractures bear weight after intramedullary nailing? A randomized controlled trial. J Orthop Trauma, 30: 370-5.
13. **Cöster M, Rosengren B, Bremander A *et al.* (2014):** Comparison of the self-reported foot and ankle score (SEFAS) and the american orthopedic foot and ankle society score (AOFAS). Foot Ankle Int., 35: 1031-36
14. **Mani Kc K, Pangeni B, Marahatta S *et al.* (2022):** Comparative study between intramedullary interlocking nailing and minimally invasive percutaneous plate osteosynthesis for distal tibia extra-articular fractures. Chin J Traumatol., 25: 90-4.
15. **Mohamed M, E Al-Ashhab M, Kandil W (2022):** Comparative study between expert nail tibia and minimally invasive plate osteosynthesis (mipo) fixation in lower fourth tibial fracture. BJAS., 7: 27-33.
16. **Singla A, Goyal D, Sandhu K *et al.* (2021):** Comparison of the results of expert tibial nailing with results of distal tibial plating in patients with distal 1/3rd extraarticular tibial fractures. Int J Orthop Sci., 7:737-42.
17. **Hap D, Kwek E (2020):** Functional outcomes after surgical treatment of tibial plateau fractures. J Clin Orthop Trauma, 11: 11-5.
18. **Rademakers M, Kerkhoffs G, Sierevelt I *et al.* (2007):** Operative treatment of 109 tibial plateau fractures: five- to 27-year follow-up results. J Orthop Trauma, 21: 5-10.
19. **Scolaro J, Schenker M, Yannascoli S *et al.* (2014):** Cigarette smoking increases complications following fracture: a systematic review. J Bone Joint Surg Am., 96: 674-81.
20. **Xu B, Anderson D, Park E *et al.* (2021):** The influence of smoking and alcohol on bone healing: Systematic review and meta-analysis of non-pathological fractures. E Clini Med., 42: 101-79.
21. **Singla A, Goyal D, Sandhu K *et al.* (2021):** Comparison of the results of expert tibial nailing with results of distal tibial plating in patients with distal 1/3rd extraarticular tibial fractures. Int J Orthop Sci., 7: 737-42.
22. **Lin Z, Zhang H, Luo G *et al.* (2019):** Comparison of 3 treatment methods for distal tibial fractures: A network meta-analysis. Med Sci Monit., 25: 7480-7.
23. **Marazzi C, Wittauer M, Hirschmann M *et al.* (2020):** Minimally invasive plate osteosynthesis (MIPO) versus open reduction and internal fixation (ORIF) in the treatment of distal fibula Danis-Weber types B and C fractures. J Orthop Surg Res., 15: 1-9.
24. **Li F, Liu X, Wang F *et al.* (2019):** Comparison between minimally invasive plate osteosynthesis and open reduction-internal fixation for proximal humeral fractures: a meta-analysis based on 1050 individuals. BMC Musculoskelet Disord., 20: 1-11.