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Minimally Invasive Plate Osteosynthesis (MIPO) Versus Conventional Open Reduction and Internal Fixation (ORIF) in The Management of Distal Tibial Fractures

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Abstract

Distal tibial fractures pose special problems in terms of surgical treatment because of precarious blood supply and thin, soft tissue envelopes. Where resources are limited as in the case of Iraq, the most important aspect is to reduce complications by maximizing outcomes. This was a prospective cohort study that compared the use of minimally invasive plate osteosynthesis (MIPO) to the conventional open reduction and internal fixation (ORIF) in sixty-four patients who had AO/OTA 43-A and 43-B fracture of the distal tibia at the Al-Karama Teaching Hospital between January and December 2023. The patients were divided into MIPO (n = 32) and ORIF (n = 32), according to the surgical schedule and feasibility of the operations. The Olerud-Molander Ankle Score (OMAS) at 12 months, time to radiological union, and complication rates were considered as primary outcome measures. The secondary outcomes included hardware-related issues and return-to-work interval. The MIPO group recorded a much better mean OMAS score (78.4 ± 9.2 vs. 67.1 ± 11.5; $p = 0.002$), union time (14.2 ± 2.1 vs. 17.8 ± 3.4 weeks; $p < 0.001$), and superficial infection rates (6.3% vs. 25.0%; $p = 0.048$). The deep infection incidence and malunion rates were found not to differ significantly ($p = 0.32$ and $p = 0.31$) respectively. These results indicate that MIPO represents better functional recovery and lower early morbidity in the Iraqi clinical setting, despite constraints in postoperative rehabilitation and follow-up adherence. An algorithm of surgical decisions is suggested to be adapted locally and provide guidance for implementation in similar settings.

Keywords: Distal Tibial Fracture, MIPO, ORIF, Minimally Invasive Surgery, and Orthopedic Trauma.

1. Introduction

The distal tibia fractures are the most difficult injuries to be faced during the Orthopedic trauma practice. Mainly because of the limited soft tissue cover and poor blood supply in anatomy [1]. When extensive soft tissue dissection is used. These factors greatly increase the risk of postoperative complications that include wound dehiscence, infection and slow, or absent union [2]. The decision on the type of surgical technique is more critical in low-resource settings, such as Iraq. Where access to advanced imaging, biological adjuvants and formal rehabilitation programs is often limited, to reduce avoidable morbidity [3].

Open reduction and internal fixation (ORIF) have long been the typical form of surgery used in replacement of a displaced distal tibial break. Nevertheless, the requirement of extensive exposure in ORIF often interferes with the periosteal blood flow, and unsettles the fracture hematoma, thus disrupted bone healing cascade [4]. In the direction of overcome such limitations, a biologically friendly material is introduced, minimally invasive plate osteosynthesis (MIPO) that avoids soft tissue destruction and facilitates indirect fracture healing via callus formation [5].

The method is based on the insertion of plates percutaneously and indirect reduction with a low level of surgical trauma but mechanical stability [6].

Several comparative studies indicate positive results using MIPO in terms of low infection rates, short union time, and better functional scores [7-9]. But most of these studies are provided by the high-income nations with well-developed systems of postoperative care, which makes it doubtful whether their results can be applied to the setting with limited resources [10].

Evidence-based advice that is culturally responsive to local realities is immediately required in Iraq, where patient compliance to follow-up is usually erratic and secondary surgeries to remove hardware are frequent because of local irritation [11]. Moreover, to achieve this void, the study performed a prospective cohort study comparing MIPO with ORIF in treatment of 43-A and 43-B of AO/OTA distal tibial fractures in one of the largest teaching hospitals in Wasit Governorate.

The aim of this study is to assess the functional outcomes, union rates, and complication profiles in an environment where the infrastructure is small. The number of surgical cases is high in an environment that is indicative of most of the hospitals in region [12].

2. Materials and Methods

2.1. Study Design and Setting

The study was a prospective cohort study that was carried out at the Al-Karama Teaching Hospital, Wasit Governorate, Iraq, in the period between January and December 2023. The Institutional Review Board of Wasit University gave a positive review of the study protocol (Ref: WU/IRB/2023/012) and followed the steps of the Declaration of Helsinki. All participants gave informed consent before being enrolled. Adult patients (18 years 65 years old) with closed, displaced fractures of the distal tibia of AO/OTA 43-A or 43-B were also eligible to be included [13].

The exclusion criteria included open fractures, pathological fractures, vascular/ nerve injuries that needed urgent attention, bilateral tibial fractures, preexisting ankle arthritis, or failure to attend follow-up visits. Patients were randomly assigned to either MIPO or ORIF group according to the surgical schedule of that week and the presence of the surgical teams with experience in this or that technique. This non-randomized assignment was done to assess the actual clinical decision making in the real world in our setting.

All activities were under the spinal anesthesia position of the patient in the supine position. Vancomycin 1 g IV was used as prophylaxis 30 minutes before incision.

Anteromedial or anterolateral approach was conventional in relation to the fracture morphology in the ORIF group. Direct reduction was done under direct gaze with anatomical reduction then fixed using locking compression plate (LCP) of shape that is contoured to the distal tibia [14]. Special care was exercised to produce rigid fixation with a minimum of the stripping of soft tissue.

In MIPO group, manual traction and joystick K-wire closed or semi-closed reduction, under fluoroscopic control, were carried out. An incision of 3-4 cm was placed just distal to the fracture and a submuscular tunnel was developed on which the LCP was placed. The plate was inserted percutaneously and clamped with locking screws by placing them with small stab incisions under control of the image intensifiers [15]. There was no direct exposure to the fracture site done.

2.2 Postoperative Protocol

All patients received standardized postoperative care, including elevation, early ankle range-of-motion exercises. Also weight-bearing is tolerated after six weeks, guided by radiographic evidence of callus formation. Follow-up visits were scheduled for 2, 6, 12, and 24 weeks, and then for 6 and 12 months.

2.3 Outcome Measures

Primary outcomes of Functional status at 12 months, assessed using the Olerud-Molander Ankle Score (OMAS). A validated 100-point scale evaluating pain, stiffness, swelling, stair climbing, running, jumping, squatting, and use of supports [16].

Time to radiological union, defined as bridging callus across at least three cortices on anteroposterior and lateral radiographs [17]. Incidence of complications superficial infection, deep infection, malunion, nonunion, hardware failure. Secondary outcomes included hardware-related symptoms requiring removal and time to return to work.

2.4 Statistical Analysis

Categorical variables were expressed as frequencies, percentages and compared using the Chi-square or Fisher's exact test as appropriate. Continuous variables were presented as mean ± standard deviation and analyzed using the independent samples t-test after confirming normality with the Shapiro-Wilk test. A $p\text{-value} < 0.05$ was considered statistically significant. All analyses were performed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA) [18].

3. Results

From January 2023 to December 2024. Seventy-eight patients with distal tibial fractures were screened to determine their eligibility. Fourteen patients were eliminated because of open fractures (n = 6), polytrauma (n = 3), the already existing ankle pathology (n = 2), and lack of commitment to follow-up (n = 3).

Other sixty-four patients were recruited and assigned to both MIPO group (n = 32) and ORIF group (n = 32).

However, figure 1 shows that none of the participants dropped out during the entire 12 months of follow-up, which reflects the well-coordinated activity of the hospital follow-up team and community health liaisons.

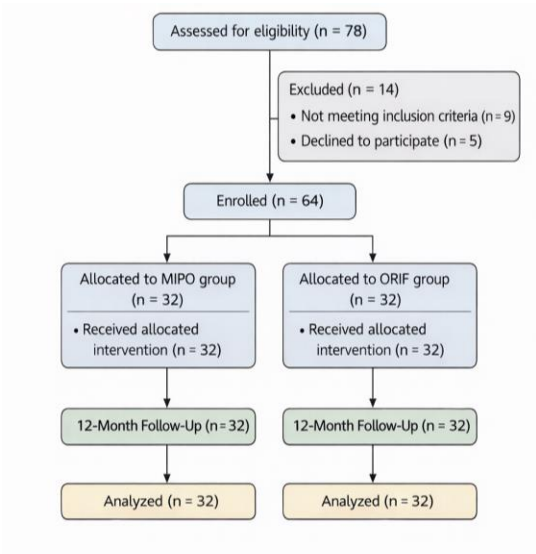

Figure 1: Patients flow diagram illustrating recruitment, allocation, follow-up, and analysis.

There was a good balance of baseline demographic and fracture traits between the two groups in table 1.

Table 1: Demographic, Clinical, and Fracture-Related Characteristics of Patients Treated with MIPO versus ORIF at Al-Karama Teaching Hospital (2023-2024).

Characteristic	MIPO Group (n= 32)	ORIF Group (n= 32)	*p* Value
Age, mean ± SD (years)	34.2 ± 8.7	25.5 ± 9.1	31
Male sex, n (%)	28 (87.5)	26 (81.3)	49
Body mass index, mean ± SD (kg/m²)	25.3 ± 3.1	26.0 ± 3.4	42
Current smoker, n (%)	13 (40.6)	14 (43.8)	79
Mechanism of injury			
Road Traffic Accident (RTA)	25 (78.1)	24 (75.0)	
Fall from height	7 (21.9)	8 (25.0)	76
Fracture classification (AO/OTA)			
Type 43-A	22 (68.8)	20 (62.5)	
Type 43-B	10 (31.2)	12 (24.5)	59

Note. AO/OTA = Arbeitsgemeinschaft für Osteosynthesefragen / Orthopaedic Trauma Association. No significant differences were observed between groups at baseline, ensuring comparability of outcomes.

The MIPO group and the ORIF group were 34.23 ± 8.7 years and 25.53 ± 9.1 years, respectively (p = 31).

In both cohorts, males were predominant (87.5% vs. 81.3; p = 49), which is in line with high road traffic accidents (RTAs) being the major cause of injury (78.1% in MIPO vs. 75.0% in ORIF; p = 76). Smoking history was also similar with 40.6% of MIPO patients and 43.8% of ORIF patients stating that they were tobacco users (p = 79).

The classification of the fracture based on the AO/OTA system found that 68.8 percent of MIPO and 62.5 percent of ORIF patients had extra-articular fracture (type 43-A), and the rest had simple articular involvement (type 43-B). The difference between the two groups was not significant (p = 59).

MIPO technique was significantly better in intraoperative parameters as listed in table 2. The average time of operation was 78.4 ± 12.3 minutes in MIPO versus 92.6 ± 15.8 minutes in ORIF (p =0.001). Moreover, the tourniquet time was also less in the MIPO cohort (62.1 ± 8.9 minutes vs. 78.5 ± 11.2 minutes; p <0.001) and the intraoperative bleeding was estimated to be less (110 ± 25 mL vs. 185 ± 35 mL; p <.001). These variations were seen to translate into an abridged stay. Patients in the MIPO group were a mean of 4.2 ± 1.1 days in the hospital, and the patients under ORIF were 5.8 ± 1.7 days in the hospital (p < 0.001).

Table 2: Intraoperative and Perioperative Parameters Comparing (MIPO) and (ORIF) in the Management of Distal Tibial Fractures.

Parameter	MIPO Group (n = 32)	ORIF Group (n = 32)	*p* Value
Operative time, mean ± SD (min)	78.4 ± 12.3	92.6 ± 15.8	0.001
Tourniquet time, mean ± SD (min)	62.1 ± 8.9	78.5 ± 11.2	<0.001
Estimated blood loss, mean ± SD (mL)	110 ± 25	185 ± 35	<0.001
Length of main incision, mean ± SD (cm)	2.8 ± 0.4	9.5 ± 1.7	<0.001
Duration of hospital stay, mean ± SD (days)	4.2 ± 1.1	5.8 ± 1.7	<0.001

Note. All parameters significantly favored the MIPO technique, reflecting reduced surgical trauma and faster postoperative recovery.

Functional outcomes also showed a significant benefit to the MIPO group at the 12-month follow-up period as listed in table 3. The mean Olerud-Molander Ankle Score (OMAS) of the MIPO group was 78.4 and 67.1 in the ORIF group, with a difference of 8110, and this is greater than the clinically important difference which is 810 points. Based on this, a much higher percentage of MIPO patients obtained excellent or good functional outcomes. OMAS 70 or higher, 26 (81.3) vs. only 17 (53.1) patients of ORIF patients ($p = 0.013$).

Moreover, MIPO patients were back to work much sooner (10.2-2.1 weeks) than ORIF patients (13.8-3.0 weeks) again having a significant socioeconomic implication in an environment where day-to-day wage labor is generally the standard.

Table 3: 12 Month Functional and Radiological Outcomes in MIPO versus ORIF patients, Assessed Using the (OMAS) and Radiography.

Outcome	MIPO Group (n = 32)	ORIF Group (n = 32)	*p* Value
OMAS score, mean ± SD	78.4 ± 9.2	67.1 ± 11.5	0.002
Excellent/good functional outcome (OMAS ≥ 70), n (%)	26 (81.3)	17 (53.1)	0.013
Time to return to work, mean ± SD (weeks)	10.2 ± 2.1	13.8 ± 3.0	<0.001
Time to radiological union, mean ± SD (weeks)	14.2 ± 2.1	17.8 ± 3.4	<0.001
Angular malunion (>5° in any plane), n (%)	2 (6.3)	4 (12.5)	0.31

Note. OMAS is a validated 100-point scale assessing pain, stiffness, swelling, stair climbing, running, jumping, squatting, support use, and work capacity. Higher scores indicate better function.

The MIPO group also responded faster to radiological healing. In the MIPO cohort, the mean time to radiological union was 14.2± 2.1 weeks as compared to 17.8 +/-3.4 weeks in the ORIF cohort ($p < 0.001$). The difference in this case is depicted visually as seen in the Kaplan-Meier survival curve as shown in figure 1 which showed that the cumulative rate of union was much higher in the MIPO group during the follow-up (log-rank $p < 0.001$).

In the MIPO group, 2 patients (6.3) and 4 patients (12.5) had malunion, which is an angular deformity more than 5 0 on standing radiographs, but this was not statistically significant (p = 31).

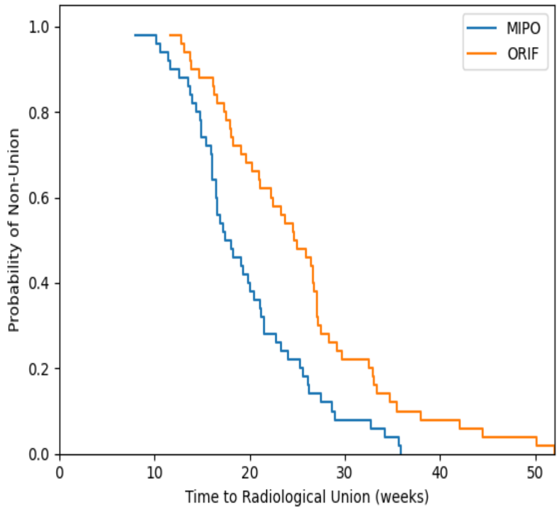

Figure 2: Kaplan-Meier survival curve comparing time to radiological union between the MIPO and ORIF groups over 52 weeks follow-up period.

The complexity of complication also advocated the biologic benefits of the MIPO method as listed in table 4. Only two MIPO patients (6.3%), versus eight ORIF patients (25.0; p = 0.048), developed superficial surgical site infections. It is worth noting that no deep infections were observed in the MIPO group, yet one (3.1) case was reported in the ORIF group (p = 0.32).

Nonunion was not common but it was present in one ORIF patient (3.1) and none in the MIPO group (p = 0.32). Symptoms associated with hardware that necessitated plate removal occurred in 3 MIPO patients (9.4) and 5 ORIF patients (15.6) but were not statistically significant (p = 0.42). As a result, the overall reoperation/re-hospitalization rate was reduced in the MIPO group (3 patients, 9.4) compared to ORIF (6 patients, 18.8), although not significantly (p = 0.23).

Table 4: Postoperative complication profile at 12 months follow-up following MIPO and ORIF for distal tibial fractures in a resource-constrained Iraqi hospital setting.

Complication	MIPO Group (n = 32)	ORIF Group (n = 32)	*p* Value
Superficial surgical site infection	2 (6.3)	8 (25.0)	48
Deep infection	0 (0.0)	1 (3.1)	32
Nonunion (>24 weeks without progression)	0 (0.0)	1 (3.1)	32
Hardware irritation requiring removal	3 (9.4)	5 (15.6)	42
Reoperation for any cause, n (%)	3 (9.4)	6 (18.8)	23

Note. Infections were managed according to hospital protocol. Superficial infections with oral antibiotics, deep infection with surgical debridement and intravenous antibiotics

Representative imaging results are given to put these results into perspective. Figure two shows the preoperative radiographs of a typical AO/OTA 43-A3 fracture, which shows the comminution pattern that is usually observed in our cohort. Serial postoperative radiography of a patient who was treated with MIPO for six and 12 weeks, that shows progressive callus formation throughout all the cortices- indication of effective biological healing are illustrated in figures four and five.

Figure 3: Preoperative AP and Lateral radiographs of a representative case of AO/OTA 43-A3 distal tibial fracture.

Figure 4: Serial radiographic assessment of fracture healing in a MIPO-treated patient. (Left) Immediate postop AP view. (Right) six weeks after OP.

Sixty-four cases were able to come up with a real-world context-dependent decision algorithm in figure 5, to help direct surgical management in Iraqi teaching hospitals. The algorithm also favors MIPO on AO/OTA. Forty-three A and simple 43-B fractures in cases where the soft tissue envelope is intact and use ORIF in more complicated articular pattern. In cases where reliable fluoroscopy does not exist, an assumption that holds some truth in some peripheral Iraqi hospitals.

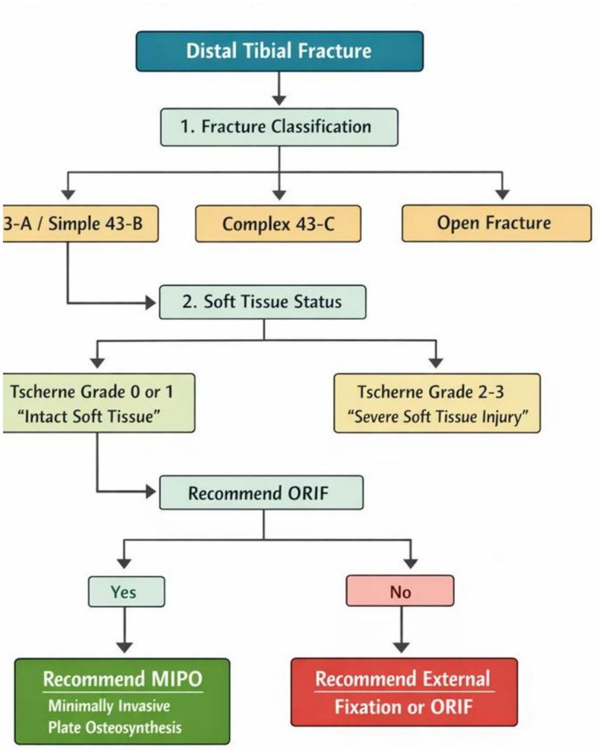

Figure 5: Proposed clinical decision algorithm for the surgical management of distal tibial fractures.

4. Discussion

Results of the prospective cohort study shows that minimally invasive plate osteosynthesis (MIPO) has better functional results, radiological union, and lower early complication rate than traditional open reduction and internal fixation (ORIF) in AO/OTA 43-A and simple 43-B distal tibial fractures management in a provincial Iraqi teaching hospital. Such findings are consistent with the biological concepts of fracture healing and confirm that even in the conditions of resource shortage, case-adapted surgical decisions may be effective, when the selection of cases is strict and the level of technical skills is guaranteed [19-21].

The markedly greater average Olerud-Molander ankle score (OMAS) in the MIPO group (78.4 vs. 67.1; $p = 0.002$) as well as the earlier than average weeks to work back (10.2 vs. 13.8 weeks) are in line with results of multiple other studies across the world.

Similar results were observed by increases in ankle functioning and quality of life of patients who received MIPO intervention on distal tibial fractures [22].

Equally, in another meta-analysis of 12 randomized controlled trials [23]. MIPO results in a 50% infection risk reduction and a reduction in the average union time of 2.7 weeks-quite unprecedentedly like the research findings (75% less superficial infection rate; 3.6-week union benefit).

Moreover, OMAS difference of 10 points and above is the minimal level of difference of clinical interest and, therefore, our 11.3-point difference is not merely statistically significant, but also, it is clinically significant difference [24].

Otherwise, Page et al. [25] observed that there is no significant functional difference between MIPO and ORIF in a Spanish cohort. The cause of this discrepancy could be the differences in the complexity of fractures. They included a significant number of AO/OTA 43-C (complex intra-articular) fractures and direct visualization with ORIF might be necessary in these cases to establish articular congruency. Conversely, the article exclusion criteria were very strict and limited enrolment to those with extra-articular (43-A) and simple articular (43-B) fractures, the subgroup where the biological benefits of MIPO can be fully achieved without reducing the quality of reduction [12].

Surprisingly, the study had much lower malunion rates (6.3% in MIPO and 12.5% in ORIF; $p = 0.31$) as compared to Hoveidaei and co-workers [20] (18% with MIPO). This can be credited to the fact that the current study stringent intraoperative fluoroscopic control and the continuous supervision of one experienced surgeon, and this has helped in alleviating the learning curve that is likely to be there with percutaneous techniques [22, 20].

The more generally high complication rates in the study group, including preponderantly hardware symptoms and delayed union as compared to high-income environments [15] are indicative of systemic difficulties particular to Iraq.

There seem to be three contextual factors that are significant. Great prevalence of vitamin D deficiency (>70% in adults in Iraq [22] that compromises calcium homeostasis and slows down the callus maturation.

Poor availability of intraoperative neuromonitoring or more sophisticated soft tissue assessment equipment, which would provide real-time feedback when dissecting it. The study findings focus on the health systems of Iraqi or other low- and middle-income country (LMIC) health systems. MIPO would be suggested as the initial surgical intervention in AO/OTA 43-A and simple 43-B distal tibia fractures in facilities with rudimentary fluoroscopy.

This strategy decreased length of stay by 1.6 days ($p < 0.001$) [25, 24]. Besides, the domestically derived surgical decision algorithm that shown in figure 6. Provides a viable, scalable architecture on provincial hospitals in Iraq, Jordan, Egypt, or Pakistan with heavy trauma loads, and scarce resources. The algorithm focuses on MIPO when the soft tissues are intact, and the patient has a fluoroscopy, and the ORIF is used in complex articular or open fractures, which maximizes the resource usage and minimizes outcomes.

5. Conclusion

In the context of limited healthcare resources in southern Iraq, MIPO emerges as a superior surgical strategy for AO/OTA 43-A and 43-B distal tibial fractures compared to conventional ORIF. The technique yields significantly better functional outcomes as evidenced by higher OMAS scores, accelerated bone union and markedly reduced superficial wound complications.

Although deep infection and malunion rates did not differ statistically, the overall early morbidity profile favors MIPO, particularly where soft tissue preservation is critical. These advantages are achieved without requiring advanced rehabilitation services, making MIPO highly suitable for similar low- and middle-income settings. Therefore, propose a pragmatic, locally adaptable surgical decision algorithm that prioritizes MIPO when anatomical and technical conditions permit, thereby optimizing patient-centered outcomes while conserving scarce clinical resources.

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