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Research Article

# A Comparative Study between Minimally Invasive Plate Osteosynthesis versus Open Reduction and Internal Fixation for Distal Third Tibia Fractures

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## Abstract

**Background:** Despite the array of surgical and non-surgical approaches available for treating distal tibia fractures, managing unstable fractures continues to pose a challenge. This study compares the advantages and clinical outcomes of minimally invasive plate osteosynthesis (MIPO) and open reduction and internal fixation (ORIF) in managing distal third tibia fractures.
**Methods:** Our study focused on 60 cases selected based on age and fracture type. A comparative analysis was performed between two groups, examining factors such as age, gender, AO Foundation and Orthopedic Trauma Association (AO/OTA) fracture type, length of hospital stays, surgical duration, complication rates, time to return to daily routines, and adherence to the criteria set by the American Orthopedic Foot and Ankle Society (AOFAS).
**Results:** The blood loss during surgery was significantly more in the ORIF group (142 ± 56.83 ml versus 81.83 ± 37.63 ml) ($P < 0.05$). The rate of complications was significantly higher in the ORIF group compared to the MIPO group ($P < 0.05$). Time for back to routines was significantly shorter in the MIPO group (17.63 ± 7.86 weeks versus 22.36 ± 8.81 weeks) ($P < 0.05$). No significant differences were found in surgery duration, hospitalization time,, time of hospitalization, and AOFAS score between the MIPO and ORIF groups.
**Conclusion:** The optimal method for managing distal tibia fractures remains uncertain due to discrepancies between the outcomes of MIPO and ORIF. We favor MIPO due to its potential for early bone union, quicker return to normal activities, and reduced risk of wound complications.

*Keywords:* Tibia; Fractures; Minimally Invasive Surgical Procedures

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## Background

Tibia fractures are frequently encountered in long bones, representing a common occurrence. These fractures typically present as closed injuries, often occurring in conjunction with soft tissue damage resulting from high-energy traumas like accidents or falls from heights. In such cases, prompt emergent stabilization may be necessary. In 10 to 13% of cases, the fracture is in the distal third tibia (1, 2), and in about 80% of cases, it is associated with fibula fracture (3).

Challenges in managing tibia fractures stem from factors like inadequate soft tissue coverage, compromised blood supply, and the extensive subcutaneous area on the anterior surface of the tibia. Failure to employ the correct technique in a timely manner can lead to serious repercussions for the patient, including soft tissue damage, infections, malunion, non-union, neurovascular injuries, osteoarthritis, and disability (2, 3).

The management of distal third tibia fractures can vary significantly based on the fracture type and extent of soft tissue damage. Treatment options range from non-surgical approaches such as closed reduction and casting to surgical interventions like external fixators, intramedullary nails (IMN), open reduction and internal fixation (ORIF), and minimally invasive plate osteosynthesis (MIPO) (1, 4).

ORIF is the most common technique done using plates such as locking compression plate (LCP) and dynamic compression plate (DCP). This method requires large skin incisions to the depth of the periosteum (5); extensive dissection and periosteal stripping can have complications such as scars, full-thickness skin necrosis, adhesions, non-union, bleeding and hematoma, and neurovascular damage. Moreover, the duration of surgery, recovery time, and the risk of osteomyelitis increase (6, 7).

Approximately fifty years ago, the adoption of innovative minimally invasive techniques like MIPO and IMN was believed to reduce the likelihood of experiencing such complications (8, 9). Nevertheless, the use of the IMN technique for distal third tibia fractures is constrained by factors such as the potential for fracture extension into the distal tibia articular surface, expansion of the medullary cavity space, and the heightened risk of malunion (10).

In the MIPO technique, anatomical plates are strategically positioned for biological fixation following an indirect reduction guided by fluoroscopy. This technique utilizes smaller incisions placed at a specific distance from the fracture site, improving precision and effectiveness compared to traditional open methods (11). This technique has been used for long bone fractures such as the clavicle (12), radius, humerus (6), tibia, fibula (13), and femur (14). Numerous studies have consistently highlighted the lower incidence of complications associated with this method compared to alternative techniques, showcasing enhanced bone union rates, improved functional outcomes, and favorable aesthetic results (1, 12).

This control-matched study analyzed patients treated with MIPO and ORIF to assess and compare the benefits and clinical outcomes associated with these respective techniques.

## Methods

***Participants:*** Between December 2017 and December 2021, our center received 94 cases of distal third tibia fractures, with or without fibula fractures, which were surgically treated by a specific orthopedic surgeon. Of these cases, 42 underwent treatment with ORIF, while 52 were treated with MIPO. The study inclusion criteria encompassed patients over 18 years of age at admission, complete fractures in the distal third tibia, and closed or Gustilo-Anderson type I open fractures. The exclusion criteria included associated fractures in other areas, neurovascular injuries, and displaced intraarticular tibial fractures (> 2 mm). The participants included 30 patients per group who were selected based on gender, age, and fracture type. Radiographs were obtained in both anteroposterior and lateral views, and fractures were categorized according to the Orthopedic Trauma Association (OTA) classification. A total of thirty-four patients were excluded from the study for the following reasons: two patients had pathological fractures, six patients had not received follow-up care, eight patients were under 18 years old, ten patients had Gustilo-Anderson type II or III open fractures, five patients had fractures in other areas, and three patients had displaced intra-articular fractures of the tibia with displacements greater than 2 mm.

***Ethics:*** Ethical approval for this study protocol was granted by the institutional review board of our hospital, and all patients provided informed consent.

***Surgical Technique:*** All patients underwent prompt surgical intervention, with surgery being postponed only in cases of swelling or anesthesia-related considerations. Patients were positioned on a radiolucent table with a tourniquet in the supine position under either spinal or general anesthesia. The surgical procedures were performed by a designated surgeon and the same surgical team for all patients.

In the ORIF group, the conventional anteromedial approach was employed. After performing an open reduction, a locking compression plate (LCP) was positioned on the medial side of the tibia and secured with at least four screws on each side. For oblique or spiral fracture configurations, cortical lag screws were utilized. In the MIPO group, closed reduction was conducted under fluoroscopic guidance. The plate length was determined based on preoperative imaging. Precise plate placement and limb alignment were verified using fluoroscopy. Plate length is critical, with support for four holes at the proximal end of the fracture site being essential. To preserve the greater saphenous vein, anteromedial curved incisions (approximately 3 cm) were made at the proximal and distal ends of the anticipated plate position, and a submuscular tunnel was created between these incisions through blunt dissection. A Kelly clamp was used to pull the plate through the submuscular tunnel under radiographic monitoring. Subsequently, 4 locking screws were inserted in the distal tibia metaphysis, and 4 cortical screws in the proximal region through the pre-existing small incisions. Reduction and fixation were verified through radiographic assessment.

Fibula fixation may not always be required, except in cases of inferior tibiofibular syndesmosis instability or to restore tibial length in comminuted fractures.

***Postoperative Management:*** Postoperatively, antibiotic therapy was continued for 24 hours, and a short leg splint was applied for pain control for 2 weeks. After the initial 2-week period, sutures were removed. Patients were then encouraged to begin exercises for the knee and ankle joints. Progressive weight bearing was permitted upon the observation of callus formation in radiographic images. Plain radiographs were taken monthly until bridging callus formation was evident in 3 of the 4 cortices. Subsequently, routine radiographic follow-ups were scheduled every 3 months for all patients. The same postoperative management protocol was implemented for both groups, with all patients undergoing follow-up for a minimum of 12 months. Non-union was defined as a lack of tricortical continuity after 9 months, while malunion was characterized by an angulation exceeding 5° in any plane or a rotational deformity exceeding 10°. Delayed union was diagnosed if the bone union had not been achieved after 6 months.

***Tools and Outcomes:*** A comparative analysis was conducted between the two groups, considering factors such as age, gender, AO Foundation and Orthopedic Trauma Association (AO/OTA) fracture type, length of hospital stays, surgical duration, complication rates, adherence to the American Orthopedic Foot and Ankle Society (AOFAS) criteria, and the time required for return to normal activities.

The assumption of normality of the data was checked using the Kolmogorov-Smirnov test. To examine the relationship between qualitative variables in two surgical methods, Pearson's chi-square test was utilized. The difference in the mean of quantitative variables in the two surgical methods was investigated using the independent t-test. A box plot was used to visually check the difference of a number of variables in the study. All analyses in this study were conducted using RStudio software (version 2023.06.1; Posit PBC, Boston, MA, USA). The box plot was drawn using the tidyverse, hrbrthemes, viridis, and ggplot2 packages. The Stats package was used to perform independent t-tests and Pearson chi-square tests, and the dgof package was used to perform the Kolmogorov-Smirnov test.

## Results

The Kolmogorov-Smirnov test results revealed that all quantitative variables in the study followed a normal distribution (P > 0.05). Demographic information of the patients are summarized in table 1.

Figure 1 illustrates the box plot for hospitalization time, surgery time, blood loss, bone union time, AOFAS, and time of back to work, and comparison of the MIPO and ORIF. The box plot analysis showed that the MIPO method had significantly lower blood loss, bone union time, and time of back to work compared to the ORIF method.

Table 1 presents the clinical characteristics of the participants based on the type of surgery. In the MIPO group, the average blood loss was 81.83 ± 37.63 ml, while in the ORIF group, it was 142 ± 56.83 ml. This difference was statistically significant (P < 0.001), indicating that the MIPO method resulted in less bleeding.

**Table 1.** The general data of the patients in the ORIF and MIPO groups

| Patient | ORIF | | | MIPO | | |
|---|---|---|---|---|---|---|
| | Age (years)/gender | Fracture pattern | Follow-up time (months) | Age (years)/gender | Fracture pattern | Follow-up time (months) |
| **1** | 18/M | Type A | 6 | 18/M | Type A | 6 |
| **2** | 21/M | Type B | 9 | 22/F | Type B | 9 |
| **3** | 21/M | Type A | 9 | 24/M | Type A | 12 |
| **4** | 22/M | Type A | 9 | 26/F | Type A | 9 |
| **5** | 23/F | Type A | 9 | 26/M | Type B | 8 |
| **6** | 25/F | Type B | 12 | 27/M | Type B | 9 |
| **7** | 25/F | Type B | 12 | 29/M | Type B | 9 |
| **8** | 29/F | Type A | 24 | 30/M | Type A | 9 |
| **9** | 31/M | Type B | 9 | 32/M | Type C | 12 |
| **10** | 32/F | Type A | 9 | 35/F | Type B | 12 |
| **11** | 33/F | Type A | 6 | 35/M | Type A | 6 |
| **12** | 33/F | Type B | 9 | 38/M | Type B | 12 |
| **13** | 35/F | Type B | 9 | 39/M | Type A | 9 |
| **14** | 36/M | Type A | 9 | 41/F | Type A | 12 |
| **15** | 38/M | Type B | 15 | 42/M | Type A | 12 |
| **16** | 40/M | Type C | 12 | 44/F | Type A | 6 |
| **17** | 42/M | Type B | 12 | 48/F | Type B | 18 |
| **18** | 43/M | Type A | 9 | 49/M | Type B | 15 |
| **19** | 43/M | Type B | 12 | 50/M | Type A | 9 |
| **20** | 44/M | Type A | 9 | 51/M | Type A | 12 |
| **21** | 45/M | Type C | 42 | 52/M | Type C | 24 |
| **22** | 47/F | Type A | 12 | 60/F | Type A | 18 |
| **23** | 48/F | Type A | 9 | 61/F | Type B | 12 |
| **24** | 49/M | Type C | 12 | 63/M | Type A | 18 |
| **25** | 53/M | Type A | 9 | 66/M | Type B | 18 |
| **26** | 54/F | Type C | 12 | 67/F | Type C | 12 |
| **27** | 58/M | Type B | 12 | 68/M | Type A | 9 |
| **28** | 65/M | Type A | 12 | 68/F | Type A | 9 |
| **29** | 67/M | Type A | 15 | 75/M | Type A | 18 |
| **30** | 72/M | Type B | 12 | 77/M | Type B | 18 |
| **Total** | Age: 39.73 ± 14.38 years<br>M: 63.3%, F: 36.7% | Type A: 50%<br>Type B: 36.7%<br>Type C: 13.3% | 11.9 ± 6.56 months<br>Range: 6-42 | Age: 45.43 ± 17.16 years<br>M: 66.7%, F: 33.3% | Type A: 53.3%<br>Type B: 36.7%<br>Type C: 10% | 12.06 ± 4.44 months<br>Range: 6-24 |

ORIF: Open reduction and internal fixation; MIPO: Minimally invasive plate osteosynthesis; M: Male; F: Female

The average time to return to work was 17.63 ± 7.86 weeks for MIPO and 22.36 ± 8.81 weeks for ORIF, with a statistically significant difference (P = 0.033), showing faster recovery for MIPO patients. Hospitalization time, surgery time, and bone union time averages were lower in the MIPO group, although this difference was not statistically significant (P > 0.05). The AOFAS score was higher in the MIPO group, but this was not statistically significant. Pearson's chi-square test results indicated no significant relationship between gender and AO fracture in the MIPO and ORIF groups (P > 0.05).

## Discussion

Despite the availability of various surgical and non-surgical interventions for treating distal tibia fractures, managing unstable fractures remains a significant challenge in orthopedics. Every method used to manage this type of fracture has its own advantages and disadvantages. For instance, casting is not ideal for long-term fixation due to the risk of bone displacement, malunion, or non-union (1, 4). External fixators are associated with pin tract infections, pins loosening, and malunion (15).

While IMN is often the preferred treatment for diaphyseal fractures of the tibia, its effectiveness in treating distal tibia fractures is limited (16). A prevalent complication associated with this technique is chronic anterior knee pain, with reported incidence rates as high as 73.2% (17).

The ORIF technique relies on achieving anatomical stability at the fracture site, which can lead to increased operating time and a higher risk of infection (18). In our study, the average surgical duration for the MIPO group was 136.83 ± 53.55 minutes, while for the ORIF group, it was 150.83 ± 43.66 minutes.

Soft tissue dissections, wound dehiscence, infection, delayed union, and non-union are some potential complications associated with ORIF (19). In our current study, a 45-year-old male participant from the ORIF group with an AO type C fracture experienced delayed union at 32 weeks. His 12-year history of diabetes and a 30 pack-year of cigarette consumption were notable factors in his case.

Extensive dissection involved in the ORIF can lead to an increased incidence of wound complications, including dehiscence, full-thickness necrosis, and infection. In addition to the aesthetic concerns important to patients, the necessity for prolonged intravenous antibiotic use, frequent debridement in the operating room, and, in severe cases, even amputation underscore the focus of orthopedic specialists on addressing these complications (7). In our study, 4/30 cases in the ORIF group experienced surgical site infections, with one requiring drainage and a full course of antibiotics. Additionally, wound dehiscence occurred in 5/30 cases in the ORIF group.

In recent years, numerous studies have affirmed the efficacy of the MIPO in managing distal tibia fractures and yielding favorable outcomes. Onta et al. highlighted MIPO as a promising treatment option for such fractures due to its ability to minimize tissue dissection, preserve hematoma, and maintain the periosteum at the fracture site (10). All reduction procedures are typically conducted under fluoroscopy guidance, and the technique's ability to bridge the fracture site eliminates the need for direct contact with the fracture side (18). While ORIF is more suitable for types A and B fractures, MIPO is preferred for comminuted fractures (18). Studies have indicated a 5-17% rate of delayed union or non-union with the MIPO (20, 21). Hasenboehler et al. noted that using MIPO for simple fracture patterns can cause prolonged healing time (21). In this study, 16/30 patients in the MIPO group had AO type A, with specific patients experiencing bone union at around 12.12 ± 5.34 weeks compared to 13.46 ± 4.24 weeks in the ORIF group. No instances of delayed or non-union were observed in the MIPO group.

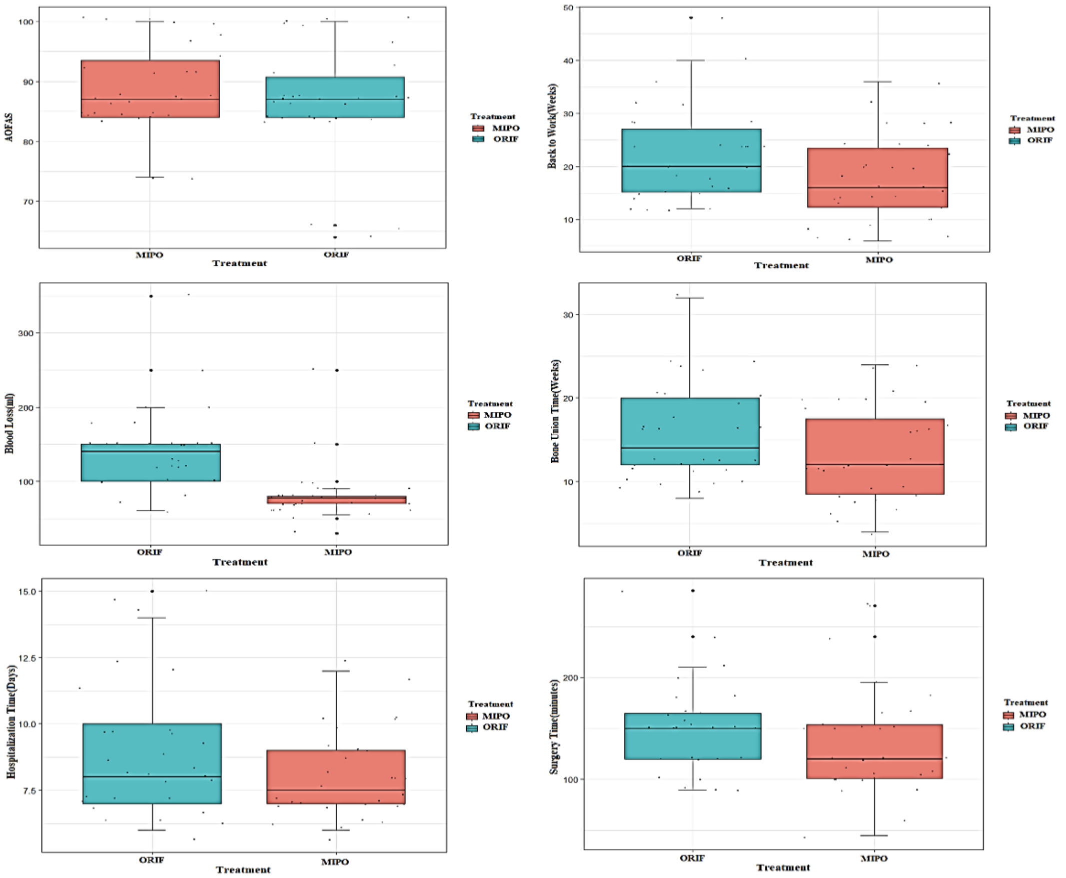


**Figure 1.** The box plot for hospitalization time, surgery time, blood loss, bone union time, AOFAS, and time of back to work variables, and comparison of the minimally invasive plate osteosynthesis (MIPO) and open reduction and internal fixation (ORIF) surgical methods

**Table 2.** The clinical characteristics of the study participants by type of surgery

| Variables | MIPO (n = 30) | ORIF (n = 30) | P-value |
|---|---|---|---|
| Age | 45.43 ± 17.16 | 39.73 ± 14.28 | 0.169 |
| Hospitalization time | 8.00 ± 1.68 | 9.00 ± 2.55 | 0.079 |
| Surgery time | 136.83 ± 53.55 | 150.83 ± 43.66 | 0.272 |
| Follow-up (months) | 12.06 ± 4.44 | 11.90 ± 6.56 | 0.909 |
| Blood loss | 81.83 ± 37.63 | 142 ± 56.83 | < 0.001 |
| Bone union time | 13.33 ± 5.56 | 15.73 ± 6.77 | 0.107 |
| AOFAS | 88.96 ± 7.18 | 86.86 ± 9.24 | 0.330 |
| Back to work | 17.63 ± 7.86 | 22.36 ± 8.81 | 0.033 |
| Complications | | | 0.007 |
| None | 30 (100) | 20 (66.70) | |
| Malunion | 0 | 1 (3.30) | |
| Infection | 0 | 4 (13.30) | |
| Surgical scar | 0 | 5 (16.70) | |
| Gender | | | 0.787 |
| Male | 20 (66.70) | 19 (63.30) | |
| Female | 10 (33.30) | 11 (36.70) | |
| AO Fracture | | | 0.916 |
| Type A | 16 (53.50) | 15 (50) | |
| Type B | 11 (36.70) | 11 (36.70) | |
| Type C | 3 (10) | 4 (13.30) | |

MIPO: Minimally invasive plate osteosynthesis; ORIF: Open reduction and internal fixation; AOFAS: American Orthopedic Foot and Ankle Society; AO Fracture: AO Foundation and Orthopedic Trauma Association (AO/OTA) fracture

The average time for radiological union was 15.73 ± 5.77 weeks in the ORIF group and 13.33 ± 5.56 weeks in the MIPO group. Similar findings were reported by Guo et al. (22) and Li et al. (23), reported similar findings, expressing satisfaction with the MIPO technique and noting no cases of delayed or non-union among their patients.

A study conducted by Ozsoy et al. reported that the MIPO may be complicated by saphenous nerve or greater saphenous vein injury (24). Cheng et al. evaluated 30 patients with distal tibia fractures to compare MIPO and ORIF. In their study, one patient in the MIPO group (1/15) had nerve palsy postoperatively (19). Notably, none of these complications, such as injury to the saphenous nerve and greater saphenous vein, occurred in our study as we meticulously explored and protected these structures during surgery.

Previous research has suggested a lower risk of infection with the MIPO, as evidenced by the absence of infections in the MIPO group in our study. However, it is important to note that repetitive plate insertion can create dead space, potentially increasing the risk of infection and delayed union (25).

Although statistical analysis did not show significant differences in surgery duration, bone union time, and AOFAS scores between the MIPO and ORIF groups, we observed more favorable outcomes in patients treated with MIPO. These included shorter hospitalization times (MIPO: 8.00 ± 1.68 days and ORIF: 9.00 ± 2.55 days), reduced surgical duration (136.83 ± 53.55 versus 150.83 ± 43.66 minutes), decreased blood loss (81.83 ± 37.63 ml versus 142.00 ± 56.83 ml), quicker return to routines (17.63 ± 7.86 versus 22.36 ± 8.81 weeks), and a lower incidence of complications with the MIPO. These findings support the superiority of the MIPO over ORIF in managing distal tibia fractures.

### *Conclusion*

The optimal method for managing distal tibia fractures remains uncertain due to discrepancies between the outcomes of MIPO and ORIF. We favor MIPO due to its potential for early bone union, quicker return to normal activities, and reduced risk of wound complications.

## Conflict of Interest

The authors declare no conflict of interest in this study.

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