Annals of Medical Research
DOI: 10.5455/annalsmedres.2019.06.361 2019;26(9):1846-51

Original Article

The evaluation of results in minimally invasive plate osteosynthesis for tibial shaft and 1/3 distal tibia fractures

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Abstract

Aim: Our study aims to retrospectively evaluate the clinical, radiological and functional results of MIPO (minimally invasive plate osteosynthesis) in the treatment of tibial shaft and tibia distal 1/3 fractures.

Material and Methods: Seventeen patients who underwent MIPO surgery due to tibial shaft and tibia distal 1/3 fractures between March 2011 – March 2015 were included in this study. Several parameters evaluated including radiological union, full-weight bearing, alignment problems, soft tissue complications, implant irritation, implant removal and AOFAS Score.

Results: The most common fractures were noted as 42-A1, 42-B1 and 43-A1 according to AO/OTA Classification. The average follow-up period was 29.5 months (5-47 months). The average time for union was 4.7 months (2.5-10 months). The average period for full weight-bearing was 5.2 months (1-12 months). One patient (5.8%) had malunion (6 degrees of anterior angulation). Ten (58.8%) patients had complaints about medial sided ankle pain with wearing long boots. Three patients (17.6%) underwent implant removal. Average AOFAS score was 85.7 (63-100).

Conclusion: MIPO is a safe and effective method for the tibial shaft and the tibia distal 1/3 region fractures regarding the high union rates, low complication incidence and good functional results.

Keywords: Distal tibia fracture; MIPO; minimally invasive; biological fracture fixation; bone union

INTRODUCTION

The fractures of the tibial shaft and 1/3 distal tibia are relatively common injuries that are usually caused by high-energy trauma. In addition to long-lasting recovery and rehabilitation periods, relatively high complication rates lead to increased treatment costs and prolonged labor losses.

The weak soft tissue coverage of the anteromedial tibia increases the likelihood of traumatic injury, compromises fracture healing and prepares ground for increased incidence of complications. Thus, the decision of treatment options becomes complicated in distal 1/3 tibial fractures (1). Surgical and non-surgical treatment methods were used both for the tibial shaft and the tibia distal 1/3 region fractures. Even though IMN (intramedullary nailing) is the preferred treatment alternative in the diaphyseal fractures of tibia, the method to be used in the surgical treatment of the tibia distal 1/3 region fractures is still controversial despite the variety of options (2–4).

Biological fracture fixation and minimally invasive surgical principles have been developed with a better understanding of biological factors affecting the fracture healing, developement of atraumatic surgical techniques and innovations in implant designs. Thus, the fracture line is bridged by using less invasive approaches without periosteal detachment and union is achieved with lesser complications (5). The determination of optimal treatment in tibial fractures, especially in distal 1/3 region, is important for reducing treatment costs and preventing socioeconomic losses.

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Received: 30.06.2019 **Accepted:** 08.08.2019 **Available online:** 30.09.2019
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periosteal detachment and union is achieved with lesser complications (5). The determination of optimal treatment in tibial fractures, especially in distal 1/3 region, is important for reducing treatment costs and preventing socioeconomic losses.

Our study aims to retrospectively evaluate the clinical and radiological results of MIPO (minimal invasive plate osteosynthesis), which is one of the methods used in the surgical treatment of tibial shaft and tibia distal 1/3 fractures. Our hypothesis is MIPO is a safe and effective treatment option with good functional results and low complication rates.

MATERIAL and METHODS

Following approval of the local ethic board, patients who underwent MIPO surgery with the diagnosis of tibial shaft and tibia distal 1/3 region fractures between March 2011 and March 2015 were included in this study. Patient data related to inpatient stay, outpatient visits as well as readmissions were extracted from hospital records and analyzed. One patient out of 18 patients could not be reached due to change of contact information. The data from other 17 patients were included for this study.

Preoperative Management

Standard tibia-fibula (AP (anterior-posterior) and lateral) and/or ankle (AP, lateral and mortise) X-rays were taken in the admission of each patient. Further imaging with CT (computerised tomography) was performed on fractures with ankle joint involvement. Fractures were classified regarding AO/OTA classification. Short or long leg splint was applied for all patients depending on the fracture localisation. Regression of soft tissue swelling (positive wrinkle sign) was waited before surgery.

Operative Technique

Broad spectrum intravenous antibiotics are given preoperatively. The patient is positioned supine on a radiolucent operating table under spinal or general anesthesia. The pneumatic tourniquet is used to minimize bleeding. Incision is made over the medial malleolus measuring about 3 cm with a gentle curve avoiding the saphenous vein and nerve (Figure. 1). A submuscular and extraperiostal tunnel is made by blunt dissection. A distal tibial anatomical locking plate (TST, Turkey) is passed through the tunnel by retrograde technique. Fracture reduction is achieved under image intensifier by assessing length, axial and rotational alignment. Fluoroscopy is also used to adjust the plate to meet the bone contours. A locking cortical or cancellous screw is inserted to the distal metaphyseal fragment. Fracture reduction was confirmed with image intensifier and a cortical screw is inserted to proximal diaphyseal fragment to maximize bone-plate contact. Remaining screws are inserted by stab incisions. Wound is irrigated with saline and closure done in layers. After sterile wound dressing is done and a well-padded posterior splint is applied with the ankle in neutral position.

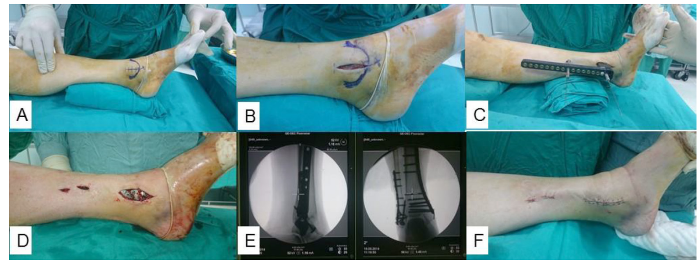

Figure 1. (A) Marking the skin incision, (B) Skin is incised over medial malleolus, (C) Retrograde placement of the locking plate using a radiolucent handle through the submuscular tunnel, (D) Fixation is completed with proximal locking screws which are inserted through the stab incisions, (E) Intraoperative image intensifier confirmation of the final fixation, (F) Skin closure

Postoperative Management

Postoperative wound cleansing was daily performed and the stitches were removed on the 2nd week. The patients were evaluated in follow-up controls at the 2nd and 6th weeks and in every 2 months afterwards. Callus bridge development on at least one cortex in each plane on AP and lateral x-rays, and pain-free full weight-bearing were accepted as a complete union. The lack of completion of these criteria 6 months after the surgery was accepted as a delayed union and no sign of callus development on the 9th month was accepted as nonunion. Limb length discrepancy (LLD) >1 cm, varus or valgus deformity >5 degrees, and flexion or extension deformity >5 degrees were accepted as malunion. The functional evaluation of the patients was performed regarding the ankle hind foot scoring scale of AOFAS (American Orthopaedic Foot and Ankle Society) (Figure. 2).

Figure 2. (A) Distal tibial fracture – preoperative x-rays, (B) Early postoperative x-rays, (C) X-rays after fracture union and implant removal (postoperative 26th months), (D) Final functional status

RESULTS

The mean age of the patients was 42.9 (range between 22 90). Eleven of the patients were men (64.7%) and other 6 were women (35.3%). Etiological factors causing fracture were fall-related in 13 patients (76.4%), sports injuries in

2 patients (%11.7), traffic accident in 1 patient (5.8%), and crush injury in one patient (5.8%), respectively. Twelve of the patients had right limb fracture (70.5%) while the other 5 of the patients had left limb fracture (29.5%). Anatomical localizations of the fractures showed that 12 patients had tibia distal 1/3 region fractures and 5 patients had tibial shaft fractures. Most common fractures were noted as 42-A1, 42-B1 and 43-A1 according to AO/OTA Classification (Figure 3).

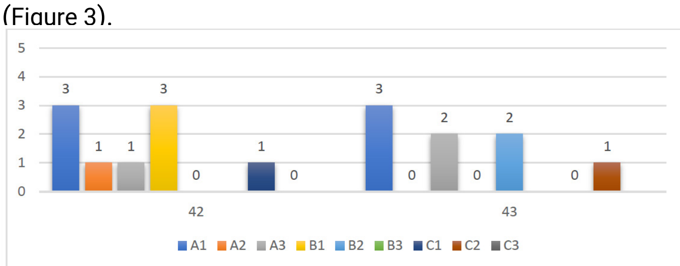

Figure 3. Fracture types regarding AO/ OTA Classification

All fractures included in this study were closed fractures. As 13 patients (76.4%) had coexisting fibula fractures at different levels, 4 patients (23.6%) had intact fibula. Within 13 fibula fractures 6 were localized in proximal third (46.1%), 6 were localized in distal third (46.1%), and 1 was localized both in proximal and distal third (7.6%). Fibular fixation was performed in 5 patients (38.4%) while no fibula fixation needed in the other 8 patients (61.5%). Among total 17 patients, 4 fractures (23.6%) had joint involvement where the other 13 fractures (76.4%) were extra-articular.

The average time between trauma and surgery was 10 days (range between 3-26 days). The average duration of stay in the hospital was 15.7 days (range between 9-30 days). The average follow-up period of the patients was 29.5 months (range between 5-47 months). No additional surgery was needed for any of the patients due to delayed union or nonunion. The average time for union was 4.7 months (range between 2.5-10 months). Two patients (11.7%) had delayed union, in which further surgery was not performed, had complete union at the end of first year. One patient (5.8%) within 17 patients had malunion (6 degrees of anterior angulation). LLD between 0.6-1 cm was noted in 2 patients (11.7%) and LLD was <0.6 cm on the rest of the patients.

Ten (58.8%) of 17 patients had complaints about medial sided ankle pain with wearing long boots. Two patients (11.7%) had wound site erosion and superficial infection. These 2 patients were treated with oral antibiotherapy and debridement under local anesthesia. Three of 17 patients (17.6%) underwent implant removal (1 patient - severe skin irritation, 2 patients - superficial infection). No additional surgery was performed for 1 patient who had a refracture due to simple fall in postoperative 5th month. The patient treated with bracing and complete fracture union was obtained in postoperative 10th month after the initial surgery. None of the patients had implant failure. The average period for full weight-bearing was 5.2 months (range between 1-12 months). Average AOFAS score was 85.7 (range between 63-100).

DISCUSSION

Surgical and non-surgical treatment options are available for both tibial shaft and distal 1/3 region fractures including circular cast or functional brace, IMN, E.F (external fixation), ORIF (open reduction and internal fixation). Even though IMN is considered as the gold standard in surgical treatment of tibial shaft fractures, the optional method for distal tibia fractures is still a subject of discussion. Also, the best treatment alternative to be chosen in conditions that IMN cannot be performed on tibial shaft fractures (including narrow or deformed intramedullary canal, some segmental fractures, existence of intramedullary implant and open growth plate) is not clear (6,7).

Different results and rates of union complications were reported for both conservative and surgical treatment of tibial shaft fractures. Sarmiento et al. (8) stated that the average time for union was 18 weeks, non-union rate was 1%, the rate of LLD >1 cm was 10%, and the rate of varus deformity >8 degrees was 5% on his extended case series. Nowadays, the use of conservative treatment for distal tibial fractures is very limited because of the higher complication rates. Nonoperative management may be chosen in patients that cannot tolerate surgery or in carefully selected co-operative patients under close clinical and radiological control.

The rate of non-union after surgical treatment of distal tibial fractures was reported as 2-17.6% for E.F and as 8.3-35% for ORIF, respectively (9). The delayed union rates following IMN of tibial fractures were reported as 0-11% for closed and 9-47% for open fractures, and non-union rates were reported as 0-8% for closed and 3-17% for open fractures, respectively (10). Yin et al. (1) reported that the average union time of patients with tibial shaft fractures after MIPO surgery was 12 weeks. The average union time in distal tibial fractures after MIPO surgery was reported as 17.6-22 weeks and the rate of delayed union was reported between 0-31.5% (11). In a study in which IMN and ORIF were compared for distal tibial shaft fractures, it was stated that late union, malunion and additional surgical interventions were found to be more frequent in patients that treated with IMN (12). According to a study by Li et al. (13), the treatment results of MIPO, IMN and E.F for the treatment of distal tibial fractures had no difference between three methods regarding the hospital stay, radiological union time or union frequency. Zou et al. (14) compared the results of MIPO and ORIF in distal tibial fractures and noted that both methods were similar regarding union time in AO type A1, A2 and B fractures. They found that MIPO was better than ORIF in AO Type C fractures as the already damaged periosteal integrity would further be compromised secondary to open surgery. They also found that ORIF resulted better in AO type A3 fractures as the union process might prolong secondary to periosteal entrapment between fragments in closed methods.

The average union time in our study was 4.7 months. The two patients who had delayed union had co-existing neurological problems in their ipsilateral extremity. Additionally, one of 2 patients had a refracture and reduction loss after another fall in postoperative 5th months. We applied a functional brace and complete union was obtained on the 5th month after refracture. We think that the union delay was related to these patients' poor adaptation to rehabilitation process, and limited weight-bearing and mobilization. The soft tissue envelope is preserved and additional damage to bone blood supply is avoided in MIPO surgery. It is a well-known fact that the micro-movement provided by axial loading after elastic fracture fixation enhances callus formation and healing of the fracture (3). This is particularly important in comminuted fractures because the vascular supply of the fragments is severely disrupted with the initial trauma. Although the vascularity of bone is relatively preserved in simple fracture configurations, the weak soft tissue coverage of distal tibia is prone to fracture healing complications. The stable fixation with locking plate screw systems allow early joint movement and result with high-quality functional healing.

The anatomical structure of the proximal and distal tibial metaphysis may lead to difficulties in restoration of alignment while using IMN or E.F in treatment of these regions' fractures. Malunion or malalignment is one of the most frequent complications of external fixators, and it was reported at a rate as high as 45% in distal tibial fractures (15). Iqbal et al. (16) reported that the rate of malunion in distal tibial fractures was 25.9% with IMN and 5,3% with plate osteosynthesis. Li et al. (10) found no statistical difference in malunion rates between IMN and plate osteosynthesis groups in treatment of distal tibial fractures. The authors claimed that the proximal and distal tibial fractures may be fixed with adequate axial and lateral stability by using new generation nails with multi-axial locking. The malunion rate of distal tibial fractures after MIPO surgery was reported between 0-36.8% in the literature (11,17).

In our study 1 patient had malalignment more than accepted limits. Additionally, 2 patients had LLD between 0.6-1 cm while the difference was <0.6 cm in other 15 patients. During the MIPO surgery, to avoid interfering with the natural bone healing, the fracture site is not exposed and the fragments are not directly seen. Thus, careful intraoperative examination of the contralateral extremity and effective use of fluoroscopic imaging are essential for prevention of malalignment at the stages of indirect fracture reduction, plate placement and final fixation. Fracture reduction must be obtained before plate fixation. The locking plate can be used as a reduction aid but this technique does not always guarantee a proper reduction. Posterior padding of ipsilateral cruris and ankle may be used to control posterior angulation of the fracture. Rotational malalignment is a potential complication in comminuted fractures which can be avoided with aligning the anterior superior iliac spine, patella, and second ray of the foot using the electrocautery cable (cable technique).

The rate of surgical site infection was reported as 0-50% for distal tibial fractures (13). After MIPO of distal tibial fractures, Paluvadi et al. (11) reported 5% superficial and 2% deep infections in their prospective study of 50 patients and Lau et al. (18) reported 2% acute and 15% late infections in their case series of 48 patients. The infection rates in MIPO surgery are lower than open plate osteosynthesis (19,20). The limited surgical incisions and less invasive surgical technique avoid additional soft tissue damage. Thus, the blood supply of bone fragments and soft tissue sheath is preserved. The fracture site is not exposed as wide dissections are not performed. Due to these reasons, it is considered that the frequency of infection in MIPO is lesser than conventional open plate osteosynthesis. However, repetitive implant manipulation during submuscular plate advancement may cause a potential dead space which may lead to complications such as infection and non-union.

Wound healing problems, discomfort or delayed wound complications secondary to plate irritation may be seen after MIPO (13,21). After the initial trauma, soft tissue contusion and edema have negative effect on the vascular supply of the soft tissue. Furthermore, fractures of distal tibia causes soft tissue damage and blister formation which may prolonge hospital stay, delay surgery and complicate with infection (22). Iatrogenic trauma due to surgery may cause additional injury on already damaged soft tissue. This condition may cause wound site complications especially in ankle and distal tibial fractures. The extremity should be elevated in a splint or temporary external fixator, and the surgery should be delayed until the wrinkle sign is positive. Short-term use of non-steroidal anti-inflammatory drugs preoperatively may also be helpful to decrease soft tissue swelling and edema (23).

Two (11.7%) of 17 patients in our study developed skin erosion and late superficial infection, but none of our patients had deep infection or osteomyelitis. These 2 patients were initially treated with oral antibiotics and wound debridement. Although these 2 patients were fully recovered, they later underwent implant removal due to complaints of implant irritation. Implant removal for any reason was reported as 5-92.7% in the literature (11). Ten patients included in our study had discomfort over medial malleolus while wearing long boots. Three of 17 patients underwent implant removal surgery.

Fibula fractures accompany 60-80% of tibial shaft fractures (24). Thirteen patients in our study had fibula fractures at different levels. Fibular fixation was performed in 5 of these patients while no fixation was needed for the rest. There are two different opinions on fixation of the fibular fractures: 1. Fixation of the fibular fracture, restores length and alignment of the limb, helps the reduction of tibial fracture, and supports ankle stability (2,17,19). 2. Fixation of fibula leads to decreased tension on tibial fracture, and might cause a delayed union or non-union

(25). We recommend that fibula distal 1/3 region fractures should fixed in order to obtain a more stable ankle joint.

The average time of full weight-bearing was 5.2 months in our study. Our results were similar with the other studies in literature (10,15). Average AOFAS score in our study was 84.7. Similar scores were obtained when compared to the other studies in the literature (11). Three patients with an AOFAS score <70 had previous history of neurological deficit. The average AOFAS score would have been 89 if these 3 patients were excluded.

Retrospective design, lack of comparison with other treatment options and relatively small number of patients are our limitations. Additionally, all the fractures included in this study were closed and relatively simple fractures. MIPO may be used as a second stage in treatment of open fractures after initial treatment with external fixators. Moreover, minimally invasive technique may also be combined with open reduction of complex intra-articular fractures.

CONCLUSION

As a conclusion, MIPO is a safe and effective method for the tibial shaft and the tibia distal 1/3 region fractures regarding the high union rates, low complication incidence and good functional results. Further prospective randomized controlled trials in larger groups are required in the future to show the superiority of MIPO over other treatment methods.

Competing interests: The authors declare that they have no competing interest.
Financial Disclosure: There are no financial supports.
Ethical approval: Ethics committee approval uploaded as an additional file in JPG format.

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