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The results of minimally invasive percutaneous plate osteosynthesis (MIPPO) in distal and diaphyseal tibial fractures

Mehmet Atıf Erol AKSEKİLİ[1], İsmail ÇELİK[2], Arslan Kağan ARSLAN[3], Tuğhan KALKAN[4], Mahmut UĞURLU[4]

[1]Department of Orthopedics, Ankara Training and Research Hospital, Turkey;
[2]Department of Orthopedics, Afşin State Hospital, Kahramanmaraş, Turkey;
[3]Department of Orthopedics, Gölbaşı Hasvak State Hospital, Ankara, Turkey;
[4]Department of Orthopedics, Faculty of Medicine, Yıldırım Beyazıt Univesity, Ankara, Turkey

Objective: The aim of this study was to evaluate the time to union and complications in cases of tibial diaphysis and distal tibial fractures fixed with a minimally invasive percutaneous plate.

Methods: Thirty-five patients (23 males, 12 females) were operated on using minimally invasive percutaneous plate osteosynthesis (MIPPO) principles for tibial diaphysis and distal tibial fractures. Twenty-eight were closed and seven were open fractures. After direct or indirect fracture reduction, the plate was advanced through a submuscular extraperiosteal tunnel through the distal incision without opening the fracture line. The plate was fixed with screws through the proximal and distal incisions. Clinical and radiological evaluations were made at four to six week intervals after surgery. Full weight-bearing was allowed after an average of 14.43 (range: 12 to 20) weeks and 15.39 (range: 8 to 32) weeks in open and closed fractures, respectively. Duration of the union and complications were analyzed.

Results: The mean duration of the union was 20.7 (range: 16 to 28) weeks and 17.96 (range: 10 to 36) weeks in open and closed fractures, respectively. All cases showed union except one who had an implant failure. Necrosis at the wound developed in one case and infection in another.

Conclusion: MIPPO is an effective alternative treatment for tibial diaphysis and distal tibia fractures with low complication and high union rates.

Key words: Distal and diaphyseal tibial fracture; locking compression plate (LCP); minimally invasive percutaneous plate osteosynthesis (MIPPO).

The choice of treatment method in unstable tibia distal end fractures with or without joint involvement remains controversial.[1] A variety of treatment modalities have been defined and a high rate of complications reported. Conservative treatment can be applied to stable extra-articular fractures with minimal shortening; however, malunion, shortening, motion restriction and osteoarthritis have been reported in these fractures, especially in pilon fractures.[2-4] External fixation can be used in open fractures with soft tissue damage that pre-

Correspondence: Mehmet Atıf Erol Aksekili, MD. 1597 Cadde Küme Evleri, Üniversiteler Mh, Çamlık Sitesi, E6-39 Bilkent-1, Çankaya, Ankara, Turkey.
Tel: +90 364 - 611 68 77 e-mail: atifaksekili@yahoo.com

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cludes plate fixation and intramedullary nailing (IMN); however, malalignment (1-4%), malunion (5-25%),[5,6] nonunion (2-17.6%)[6] and pin tract infection (10-100%)[6,7] have been reported.

For conventional open anatomical reduction, where open reduction and internal fixation (ORIF) is performed, large soft tissue dissection and periosteal elevation are needed. High rates of complications, such as infection (8.3-23%),[8,9] delayed union and nonunion (8.3-35%),[8-12] have been reported with this technique.

In the last decade, minimally invasive percutaneous plate osteosynthesis (MIPPO), performed by indirect reduction, has become a successful treatment modality in complex fractures of the lower extremity.[13-15] The aim of MIPPO is to preserve the osteogenic hematoma of the fracture and the nutritional arteries of the bone while preventing iatrogenic soft tissue damage.[16] Vascular injection studies have compared cases treated by MIPPO with classic open techniques and MIPPO was found to result in higher preservation of periosteal circulation.[16-18]

Locked compression plates are commonly used for fracture fixation. Locking compression plating (LCP) provides an angular stability for fixation.[15,19] Locked screws prevent the plate from pressing the bone, preserving periosteal blood supply.[13,20-22] This system stimulates callus formation due to flexible elastic fixation. The anatomic shape of the plate prevents malalignment of the fracture and provides a better axial and angular weight distribution.[16,21] Fractures extending to the distal end joint of the tibia can be treated with the MIPPO method through a small incision at the metaphysis region following prior anatomic reduction of the inter-joint fracture.[7]

The aim of this retrospective study was to analyze the results of the MIPPO technique, using the LCP system in tibia diaphysis and distal end fractures.

Patients and methods

Thirty-five cases (23 males, 12 females; average age: 41.9 years; range: 20 to 80 years) of unstable tibia distal end fractures treated with MIPPO between 2005 and 2009 were retrospectively analyzed. Medical records, print-outs and radiology reports were recorded. The series included open and closed tibia distal end fractures with or without joint involvement.

Patients were first stabilized with plaster casts before undergoing surgery. Temporary external stabilization was performed in cases with additional dislocation and/or severe soft tissue damage. Fixation was performed after soft tissue healing.

Fractures were classified according to the AO classification and fractures with joint involvement according to the Ruedi and Allgower fracture classification. Open and closed fractures were classified according to Gustilo and Anderson, and Tscherne classifications, respectively. Standard irrigation and debridement was applied to open fractures. Cases with skin defects were consulted with a plastic surgeon. Antibiotic prophylaxis was performed with cefazolin during anesthesia induction; gentamicin was added in patients with Gustilo and Anderson Grade 1 and 2 open fractures, and a combination of cefazolin+gentamicin+metronidazole was given for three days in Type 3 fractures. Cases were operated on standard operating tables, in the supine position with air tourniquet application following elevation of the extremity.

Percutaneous plate placement was performed after sufficient closed, indirect reduction or percutaneous direct reduction. The LCP was placed submuscularly and extraperiosteally through a small incision on the medial malleolus. If the space between the plate and the bone was large, the plate was compressed towards the bone using a puller screw with special attention given that the plate not damage vessels compressed between it and the bone. The LCP plate was used as a bridging plate. Joint faces were rigidly fixed through a separate incision after placement in the correct positions. The fibula was fixed in cases in which ankle anatomy and stability had to be restored. Initial fibula fixation provides lengthening and helps place the tibia in the correct position.[23] The tibia was placed with the guidance of the fibula after placement and fixation of the fibula in some selected cases.

Intraoperative C-arm fluoroscopy was used to evaluate the correct placement and fixation of the fractures. Deep tissues were brought together using braided suture materials while the skin was closed with monofilament sutures. Patients were evaluated postoperatively at the outpatient clinic; 10 to 15 days after the operation for wound problems, and 30 days after for radiological and clinical improvement. Follow-up continued for approximately for 4 to 6 weeks until clinical and radiological union was observed.

Radiological union was defined as the appearance of a mature callus on 3 or 4 planes and clinical union as no pain inducement after full weight-bearing. Additionally, soft tissue was evaluated and wound infections, necrosis, tenderness due to the plate and plate removal were recorded.

Table 1. Details of open fractures.

Case	Injury	AO class	Gustilo type	Time to FWB (weeks)	Time to fracture union	Complications
2	RTA (inside the vehicle)	43A1	1	13	16	
33	FFH	42A1	1	16	19	
3	OA	42A2	2	14	20	
10	GSW	42B2	2	14	16	No radiological healing in lateral plane
23	OA	43A3	2	12	22	
25	RTA (outside the vehicle)	42A2	2	20	24	
26	FFH	43C1	3	12	28	Superficial infection

FWB: full weight-bearing; RTA: road traffic accident; FFH: fall from height; OA: occupational accident; GSW: gunshot wound.

Results

According to the AO classification; 5 patients (14.3%) were 42A1, 15 patients (42.9%) 42A2, one patient (2.9%) 42B2, one patient (2.9%) 43A1, 4 patients (11.4%) 43A2, one patient (2.9%) 43A3, 2 patients (5.7%) 43C1, and 6 patients (17.1%) 43C2 type. According to the Gustilo and Anderson fracture classification; 2 patients (5.7%) were defined as Class 1, 4 (11.4%) as Class 2, and one (2.9%) as Class 3. According to the Ruedi and Allgower fracture classification; 3 cases (8.6%) were Class 1, 6 patients (17.1%) Class 2, and one patient (2.9%) was Class 3. Fractures were caused by road accidents involving non-motorized individuals in 3 cases (8.6%), road traffic accident in the motor vehicle in 4 cases (11.4%), gunshot in one case (2.9%), assault in one case (2.9%), occupational accident in 6 cases (17.1%), and a fall from a height in 20 cases (57.1%) (Table 1).

Open fractures were found in 7 cases (20%). The causes of open fractures were occupational accidents in 2 cases, fall from a height in 2 cases, road traffic accident in motor vehicle in one and outside motor vehicle in one, and gunshot in one case. Cases were classified as 42A1 in one, 43A1 in one, 42A2 in 2, 43C1 in one, 43A3 in one, and 42B2 in one patient according to the AO classification. Full weight-bearing was allowed after a mean of 14.43 (range: 12 to 20) weeks. Mean fracture healing period was 20.7 (range: 16 to 28) weeks. Radiological nonunion was detected in one case and another developed a superficial infection. One patient (Case 10) had a radiological nonunion 11 months following surgery. The cause of the open fracture in this case was gunshot injury. The patient was treated conservatively for 45 days in another center before admission to our hospital. The same patient had been treated for acute lymphocytic leukemia 5 years before the fracture. A distal anatomical plate was applied using the MIPPO technique in this case. Full weight-bearing was permitted after 14 weeks and union was obtained at the 16th week (Fig. 1).

Closed fractures were present in 28 cases (80%). Follow-up continued for a mean of 15.93 (range: 6 to 28) months. Full weight-bearing was allowed at an average of 15.39 (range: 8 to 32) weeks postoperatively and union was detected after mean of 17.96 (range: 10 to 36) weeks. Fractures were caused by traffic accident outside the motor vehicle in 2 cases, traffic accident in

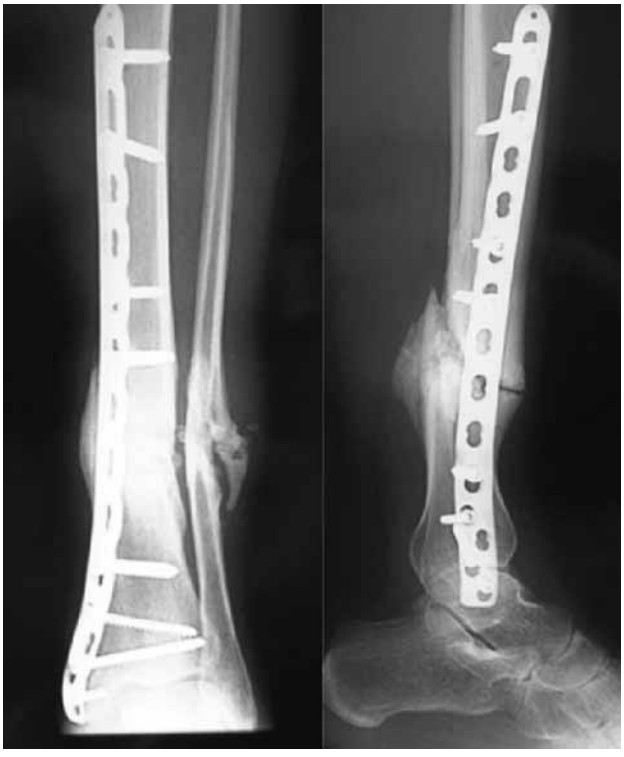

Fig. 1. Radiological appearance of Case 10 at postoperative Month 11. Despite presence of radiological pseudarthrosis, full weight-bearing was achieved for the last 30 weeks.

the motor vehicle in 3, assault in one, occupational accident in 4 and fall from a height in 18 cases. The fractures were classified according to the AO classification as 42A1 in 4, 42A2 in 13, 43A2 in 4, 43C1 in one, and 43C2 in 6 cases. According to the Tscherne fracture classification, 13 fractures were Grade 0, 11 were Grade 1, 3 were Grade 2 and one was Grade 1.

Temporary fixation was performed in 11.4% (4 cases) of all patients using unilateral external fixators (Fig. 2). No pin tract infection was seen. The cases were followed-up for a mean of 14.37 (range: 6 to 28) months. Implant extraction was performed in 11.4% of the cases. Debridement was performed in 8.6% (3 patients).

Discussion

Distal end fractures of the tibia are usually seen along with serious soft tissue problems caused by both the high energy generated at injury and the corrupted circulation. Borrelli et al.[17] demonstrated that the distal metaphyseal region of the tibia has a relatively rich blood flow through the anterior and posterior tibial arteries. They also showed that open plate techniques performed in this region interfere seriously with blood flow when compared to the MIPPO technique. Management and severity of the soft tissue injury is one of the most important determinants of the prognosis distal end fractures of the tibia. Complications such as wound dehiscence, infection, and nonunion can be seen when soft tissue status is ignored. Helfet et al.,[9] in a study comprising 20 pilon fractures treated with MIPPO technique, suggested routine external fixation application. The permanent treatment was performed after the edema in the soft tissues had subsided. In our series, external fixation was applied on four pilon fractures with serious soft tissue injury, and no postoperative problems were encountered. In a case

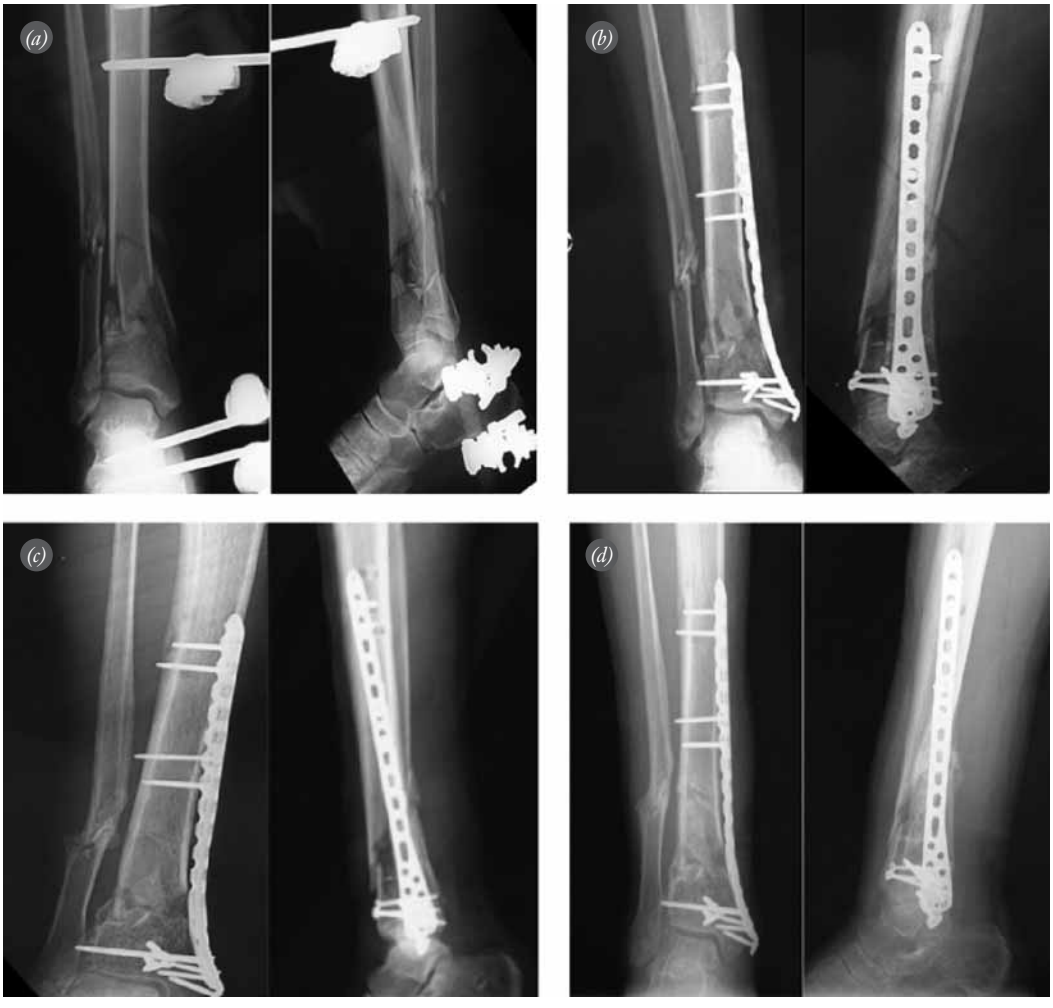

Fig. 2. **(a)** Radiological appearance of Case 26 after temporary external stabilization. **(b)** First month and **(c)** fourth month view after definitive fixation. **(d)** Mature callus tissue formation seen in postoperative 6th month.

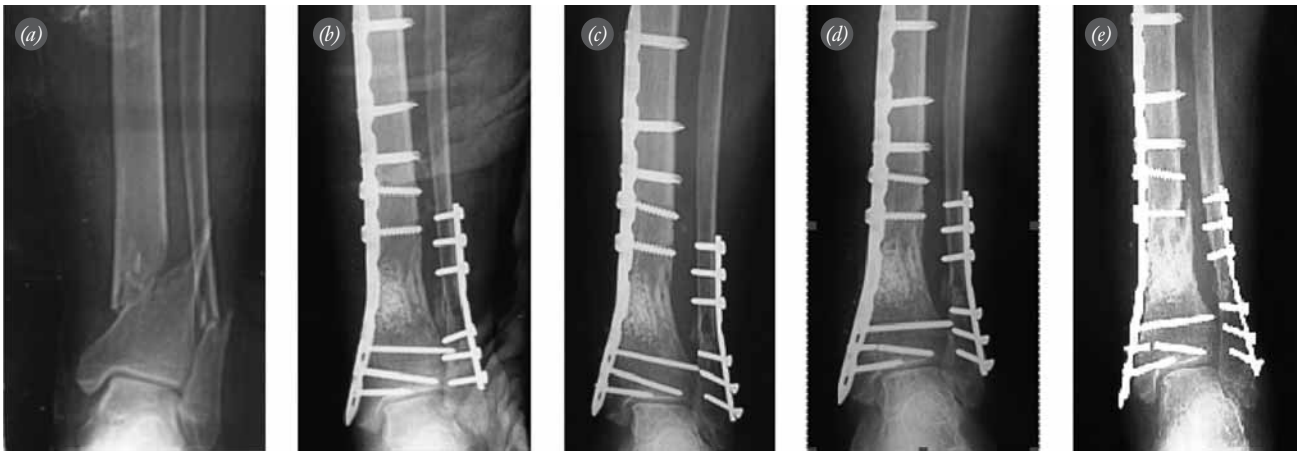

Fig. 3. **(a)** Preoperative, **(b)** postoperative first day, **(c)** 2nd month, **(d)** 3rd month and **(e)** 6th month views of Case 18. Implant failure occurred at postoperative third month.

who had a pilon fracture and external fixation was not applied, wound dehiscence occurred and the patient was treated with a free vascularized muscle flap.

Infection rates vary between 0 and 50% following the surgical treatment of tibia distal end fractures.[8,19,24-26] The highest rate of infection is seen in cases with ORIF application.[27] A serious decrease in the infection rates has been seen in patients treated with external fixation.[23,28] The rate of infection with MIPPO technique is lower than the ORIF, and similar to external fixation.[9,19,26,29-32] Results from this current study are in line with these reports. Superficial infections occurred in 2 of our patients and deep infection in one patient. One case with superficial infection responded to oral antibiotics. The implant was removed in the case with deep infection and full union was obtained 36 weeks after the surgery (Case 34).

Osteopenia is a frequently seen problem in the elderly population and complicates the treatment and healing of fractures. Stable internal fixation and early mobilization is one of the current concepts in fracture treatment.[33] However, it is difficult to obtain a stable internal fixation in an osteopenic bone. The screw is weakly held to the bone and pull-out is probable which may cause implant failure.[34,35] We encountered implant failure in a patient with osteoporosis (Case 18). The remaining defect after fracture reduction was grafted using a spongious allograft. Partial weight-bearing was instructed in the second month and implant failure occurred in the third. The case was operated in another center in the 7th postoperative month (Fig. 3).

Open fractures were fixed following irrigation, debridement and appropriated antibiotic treatment when no signs of infection was found. A superficial infection responding to oral antibiotics (Case 26), and a complication resulting in radiological nonunion without a clinical problem (Case 10) occurred.

Intramedullary nailing may be impossible in cases with previous long bone fractures, especially those with a disturbance in alignment. Other options may be exter-

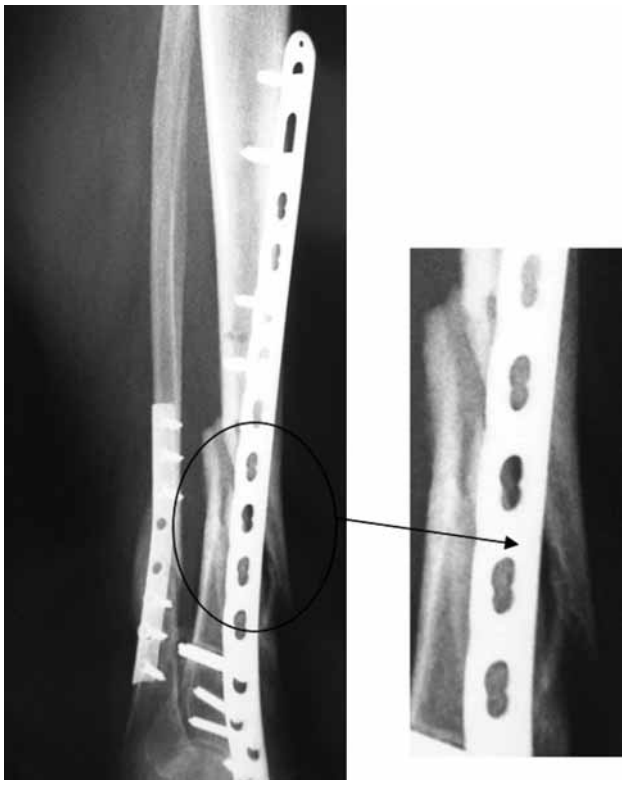

Fig. 4. Radiological appearance of secondary healing seen in Case 32.

nal fixation, classical plating, and MIPPO. Case 7 had previous tibia and femur fractures on the same side and MIPPO was applied. Postoperative alignment disturbance was present. Mobilization with partial weight-bearing was begun 6 weeks postoperatively and union obtained in the 18th week.

Redfern et al. instructed full weight-bearing following clinical evaluation and the radiological appearance of callus formation.[1] A similar method was used in this study. However, no weight-bearing was instructed in some patients until 6 to 7 weeks after the operation due to complicated fractures located in the joint. Case 18, a patient with osteoporosis, experienced implant failure in the postoperative 3rd month after full weight-bearing was started. Bone loss may accompany osteoporotic fractures. In this situation, the close reduction of the fracture fragments is essential. Fixation using plates should be performed in such a manner that the weight is distributed to a large area in order to prevent bone failure.[28] In this case, implant failure occurred despite these precautions and the graft was used to repair the bone defect that occurred after the reduction of the fracture. Weight-bearing was following the observance of signs of union and the absence of clinical signs of pain or tenderness, without the need for observation of full radiological healing. We believe that full weight-bearing improves the secondary healing of the fracture. These findings were supported in most of our cases. Case 32 in our study is an informative example on the safety of full weight-bearing in such cases (Fig. 4).

In conclusion, MIPPO aims to reduce surgical trauma and protect the vascular integrity and osteogenic hematoma of the fracture, and is an effective alternative treatment for tibial diaphysis and distal tibia fractures with low complication and high union rates.

Conflicts of Interest: No conflicts declared.

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