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## Outcome of percutaneous locked plating of extra-articular distal tibial metaphyseal fractures

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### Abstract

**Introduction:** Management of fractures involving the distal tibial metaphysis is one of the most challenging and controversial issue due to poor soft tissue envelop. Multiple different fixation modalities are available with different outcome. Percutaneous plating of the distal tibia fracture is gaining more popularity due to minimal interruption of the fracture biology and favorable functional and radiological outcomes. **Purpose:** To evaluate the functional and radiological outcome of management of distal tibia extra articular metaphyseal fractures using locked plates with Minimally Invasive Plate Osteosynthesis (MIPO) technique. **Methods:** Twenty four patients with extra- articular distal tibia metaphyseal fractures were operated with locked compression plates using MIPO technique. They were followed up at regular intervals. Functional and radiological results were evaluated at the end of follow up. **Results:** All fractures united at average time of 12.21 weeks (range; 8-20 weeks). Postoperatively, two patients developed deep infection and two patients developed malunion. Mean AOFAS score was excellent 90.6 points (range: 52-100) at last follow up. **Conclusion:** MIPO technique using distal tibia locked plating is an effective procedure for fixation of distal tibia extra-articular metaphyseal fractures. It provides near anatomical fracture reduction with sufficient stability and preservation of the blood supply to the fracture fragments. It provides excellent functional results with acceptable rate of complications.

**Keywords:** Biological fixation, Distal tibia locked plates, MIPO, Extra-articular fractures.

### INTRODUCTION

Management of fractures involving the distal tibial metaphysis is one of the most challenging and controversial issue. The poor blood supply in this area due to its subcutaneous location and lack of muscle coverage increase its vulnerability for complications such as delayed union and soft tissue complications such as infection and wound gapping [1].

Most of these fractures are basically unstable and are frequently associated with serious soft tissue injuries. Also, many complications were reported with different lines of management of distal tibial fractures including mal-alignment, delayed union, nonunion, and wound related complications [2].

Different treatment modalities have been described for the management of these fractures including different types of external fixators [3], plating either open or percutaneous [4] and intramedullary nailing [5] with varying controversial results.

Although intramedullary nailing is considered the ideal treatment option for diaphyseal tibial fractures, their use in metaphyseal distal tibia fractures is still controversial. This is due to the technically challenging distal nailing as the discrepancy of the diameter of the intramedullary canal between the diaphysis and metaphysis of the tibia make it difficult to achieve stable acceptable closed reduction. Also, the risk of nail protrusion into the ankle joint as the distal tibial fragment is small [1].

Non-operative management of these fractures is rarely indicated in adults due to inherited instability of most of these fractures and the prolonged immobilization needed resulting in joint stiffness as well as shortening and rotational malunion [6]. Although Conventional plate fixation technique provide stable fixation, it is associated with extensive dissection and periosteal stripping which increase the risk of soft tissue complications. On the other hand, Percutaneous plating employ indirect reduction techniques and allow stabilization of distal tibia fractures with minimal violation of the vascularity of the soft tissue covering [7].

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The concept of minimally invasive plate osteosynthesis (MIPO) is to provide stable fixation with minimal iatrogenic soft tissue injury and minimal damage to bone vascularity with preservation of the fracture haematoma. This concept is of particular importance in the management of distal tibial fractures, due to poor extra-osseous blood supply in the distal metaphysis of the tibia and thin soft tissue coverage [8].

In this technique, osteosynthesis can be achieved using a variety of anatomical locked plates [9] or non-locking plates [10]. Using locking plates offer the advantages of more stability due fixed angle locking design of the screws and thin non-irritating profile [11, 12]. Successful results were reported by several studies using both types of plating systems [9, 10, 13, 14]. However, a higher rate of complications, loss of mechanical stability, and implant-related soft tissue irritation have been reported with the use of non-locking plates [7, 9, 11, 15, 16]. On the other hand, using locking plates have been associated with improved fracture mechanical stability, higher expenses, and the need for a longer fracture consolidation time [15]. Encouraging results for closed reduction and percutaneous plating of closed extra-articular distal tibial fractures have been reported using locked plate distal tibia [3].

In this study we evaluated the functional and radiological outcome of management of distal tibia extra articular metaphyseal fractures using locked plates with Minimally Invasive Plate Osteosynthesis (MIPO) technique.

## PATIENTS AND METHODS

Between January 2015 and December 2019, 24 adult patients with extra articular distal tibial fractures were operated at our university Emergency hospital using distal tibia locked plate with MIPO technique.

Only adult patients with recent closed fractures within 4cm to 12cm from tibial plafond with Follow up more than 6 months were included in this study. We excluded skeletally immature patients, cases with pathological fractures, cases with open fractures, cases with bad skin condition, fractures less than 4cm or more than 12cm from tibial plafond, neglected fractures that require open reduction, fractures with complex intra-articular extension and patients with follow up less than 6 months from this study. [Table 1]

**Table 1:** Pre and post-operative data of the 24 patients.

Patient	age	sex	Co-morbidity and special habits	AO classification	Tschrene classification	Fixation Fibula	Time Before surgery (days)	Operative time (minutes)	Exposure to radiation (seconds)	P W B (WEEKS)	Time to full union FWB (weeks)	Complications	Follow up (months)	AOFAS Final follow up
1	40	M	smoking	43A2	C0	yes	3	90	150	8	15	No	60	good
2	32	F	No	43A1	C0	yes	2	95	134	7	12	No	55	excellent
3	22	M	smoking	43A2	C0	yes	4	90	141	9	20	Deep infection	54	poor
4	30	F	No	43A2	C0	No	2	60	110	6	13	malalignment	45	good
5	35	M	smoking	43A2	C1	yes	7	90	164	8	17	No	42	excellent
6	28	F	No	43A2	C0	No	2	70	105	7	13	No	40	excellent
7	37	M	smoking	43A2	C0	No	4	65	131	8	15	malalignment	38	fair
8	35	M	No	43A2	C0	No	2	60	104	5	10	No	38	excellent
9	50	M	DM	43A1	C0	No	4	75	125	6	12	No	35	excellent
10	35	M	No	43A1	C0	No	3	60	109	7	14	No	30	excellent
11	27	M	No	43A1	C0	yes	4	90	153	7	12	No	30	good
12	42	M	No	43A1	C0	No	2	60	99	6	14	No	28	excellent
13	20	M	No	43A1	C0	No	1	55	90	5	10	No	26	excellent
14	53	M	smoking	43A2	C1	No	8	65	100	7	12	No	25	good
15	28	M	No	43A2	C0	No	1	45	100	6	10	No	24	excellent
16	60	F	DM	43A3	C1	yes	7	90	90	8	12	Deep infection	20	fair
17	24	M	smoking	43A2	C0	No	2	60	65	7	10	No	19	excellent
18	33	M	No	43A3	C1	yes	8	80	85	6	10	No	18	excellent
19	48	F	DM	43A1	C0	yes	6	70	80	8	13	No	16	good
20	56	M	Smoking DM	43A3	C1	yes	9	75	105	8	12	No	15	good
21	23	F	No	43A1	C0	No	3	45	45	6	8	No	12	excellent
22	35	M	No	43A2	C0	No	2	50	70	7	9	No	12	excellent
23	40	M	No	43A1	C0	No	1	40	55	6	10	No	9	excellent
24	48	M	smoking	43A2	C0	No	6	60	80	8	10	No	8	excellent
	36.7					9	3.9	68.3	103.8(1:44)	6.92	12.21		29.5	

Fracture pattern was classified according to the AO classification system [16]. Soft tissue injuries were classified using Tschrene classification [17]. Functional scoring at final follow up was done using AOFAS [18, 19]. The operation was postponed till oedema subsides guided by the appearance of skin wrinkle sign.

Under spinal anesthesia, the patient was placed in supine position on a radiolucent table, with a thigh tourniquet inflated after exsanguination. Routine preparation and draping was performed. Radiologically guided closed-indirect reduction had been achieved by manipulation and maintained manual traction. Care should be taken to maintain the

anatomical alignment of the limb by keep the patella facing the ceiling at all time. A locked plate was inserted subcutaneously, but extra-periosteally through a longitudinal or short oblique incision over the medial malleolus to avoid injury of saphenous vein and nerve. The subcutaneous tunnel can be created using the plate itself with the locking sleeve used as a handle to control the direction or by using a long periosteal elevator. The screws in the proximal fragments were inserted through separate skin stab incisions. The first screws proximal and distal to the fracture were non-locked to help in reduction of the fracture and positioning of the plate using the anatomically pre-contoured plate as a guide for reduction. Fluoroscopic control of the most acceptable reduction in both planes was confirmed before applying the locked screws. Care should be taken to avoid fracture recurvatum deformity by maintaining traction with the ankle in planter flexion position. (Figure 1)



**Figure 1:** Intra-operative photo for MIPO technique of distal tibia

Open reduction and plate internal fixation (ORIF) of the fracture of the fibula was done in nine cases where the tibial fracture was comminuted and at the same level of the fibular fracture. Plate fixation of the fibula before fixation of the tibia facilitated the reduction of the tibia by restoring the length and rotation of the fractured fragments.

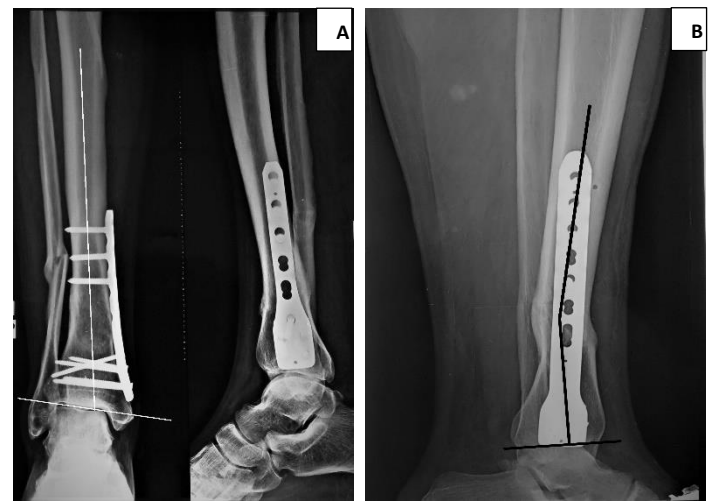
Wound was closed in layers and simple sutures to the skin. A removable below knee splint was applied to allow soft tissue healing and immobilize the fibular fracture is not surgically fixed. Active ankle joint motion was allowed as early as possible as tolerated. First follow up was 10-14 days post-op for wound inspection, removal of the splint and check radiographs. Then regular follow up every 6-8 weeks until full weight bearing is allowed when the fracture is both radiologically and clinically united. Malunion was defined as deformity greater than 5 degrees in the sagittal plane (ante-/ recurvation), greater than 5 degrees in the coronal plane (varus/valgus deformity), and as or greater than 15 degrees for rotational malunion [20].

## RESULTS

Between January 2015 and December 2019, 18 males and 6 females of mean age 36.7 years (range: 20-60 years) were treated for a distal tibial fracture with locked plate using MIPO technique. They Mean time between admission and definitive fracture fixation was 3.9 days (range: 1-9 days). Eight patients were smokers, and four patients were diabetic. Regarding tscherne classification, 19 patients (79.2%) were Tscherne C 0, and five patients (20.8%) were C 1. According to AO classification nine fractures were classified as 43A1, 12 (50%) fractures were 43A2 and 3 were 43A3. The fibula was fixed in nine (37.5%) cases to restore of the ankle mortise and help to restore the height of the tibia in comminuted unstable fractures.

Average operative time was 68.3 minutes (range; 40-95 minutes) while the average time of exposure to radiation was 103.8 seconds (range; 45-164 seconds). The average follow-up was 29.5 months (range; 8-60 months). All Fractures healed in average time 12.21 weeks (range; 8-20 weeks) where full weight bearing was allowed. Fracture healing was defined as radiological evidence of bridging mature callus combined with pain-free full weight bearing.

Four complications were reported (16.7%). Two patients (8.3%) developed deep infection, one of them was diabetic and the other was a smoker. Both were treated by debridement and implant removal after complete fracture healing. Two patients developed a malunion (8.3%). One patient had recurvatum and the other had valgus malalignment. None of these patients required corrective osteotomy. None of the patients had shortening more than 1cm compared to the uninjured side or rotational malalignment greater than 15 degrees. (Figure 2)



**Figure 2:** Malunion of distal tibia; A: Valgus malunion. B: Recurvatum malunion

The average AOFAS at final follow up was 90.6 points (range: 52-100) (Excellent). (Figure 3) The average time of union in cases in which the fibula was fixed was prolonged (13.7 weeks) than the cases in which the fibula was not fixed (11.3 weeks). However, it was statically insignificant. Also, the fixation of the fibula significantly affected malalignment, but it was statistically insignificant. The presence of malalignment significantly affected the final AOFAS score. ( $P < 0.05$ ) Smoking delayed the time of union in smoking patients and it with statistically significant. ( $P < 0.05$ ) The degree of soft tissue injury (Tscherne classification) significantly affected both the delay in the time before surgery and the rate of infection. However, it was statistically significant with the former only. ( $P < 0.05$ ) The severity of the fracture (AO classification) significantly affected the degree of soft tissue injury (Tscherne classification). This was statistically significant. ( $P < 0.05$ )

## DISCUSSION

Fractures involving distal tibia remain a challenging common injury. The subcutaneous location and poor vascularity increase the vulnerability of soft tissue insult, skin break down, infection and affection of bone healing. The difference in diameter of the intramedullary canal between the diaphyseal and metaphyseal segments of the bone can make maintenance of fracture reduction stability in this area difficult [21].

The aim of the operative treatment is to achieve ideal ankle joint alignment and at the same time provide sufficient stable reduction to withstand early movement. These mechanical goals should be fulfilled using surgical techniques that minimize bone and soft tissue devascularization to decrease the incidence of treatment related complications. The concept of the minimally invasive plate

Osteosynthesis (MIPO) provides both mechanical stability and minimal soft tissue devascularization [22].



**Figure 3:** Case 12: A, B: Preoperative X-ray. C, D: Early post-operative X-ray. E, F: Final follow up X-ray. G, H, I: Clinical outcome at final follow up.

However, the MIPO techniques depend on indirect fracture reduction through using intraoperative fluoroscopy to verify the sufficient fracture reduction and do not permit direct visualization of the fracture fragments resulting in prolonged operative time and excess radiation exposure which are the main drawbacks of this technique and difficulty to achieve perfect anatomical reduction [23].

In the current study, we evaluated the functional results and complication rate of (MIPO) biological plating for the treatment of extra-articular fractures of the distal tibia in adults using locked anatomical distal tibia plate.

The average age of patients in this study was 36.7 years (range: 20-60 years), and 17 patients (71%) were below the age of 40 years old which is comparable to similar studies [24, 25, 26]. In our study, the age of the patient had no impact on the time to achieve union. Of the 24 patients, 18 (75%) were males and 6 were females. Predominance of male gender in this study was due to more heavy work activities and more outdoor activities of males in our community. Male gender predominance of distal tibial fractures was reported by other similar studies [27, 28].

High energy trauma, either motor vehicle accidents or road traffic accidents or fall from height was the common mode of injury. The same was reported by Kumar *et al.*, [29] and Ram *et al.*, [30]. This reflects the high injury nature of the distal tibial fractures and its associated soft tissue insult that can jeopardize the final outcome.

The magnitude of the associated soft tissue injury of the distal tibial fractures affects the timing of operation and the choice of osteosynthesis method [31]. Careful preoperative evaluation of the degree of soft tissue injury is critical to decide the optimal timing of operative intervention to minimize the iatrogenic related soft tissue complications. In this study, we used Tscherne classification for closed fracture for preoperative evaluation of the condition of the soft tissue. [17] The degree of soft tissue injury (Tscherne classification) affected both the delay in the time before surgery and the rate of infection. However, it was statistically significant with the former only. The severity of the fracture (AO classification) significantly affected the degree of soft tissue injury (Tscherne classification). This was statistically significant ( $p < 0.05$ ). The energy needed to fracture the distal tibia would certainly affect the vitality of soft tissue envelop of the distal leg.

The value and the effect of fixing the fibular fracture associated with distal tibial fractures remains controversial [32, 33, 34, 35]. In the current study, the fibula was fixed in nine cases (37.5%) to restore of the ankle mortise and help to restore the height of the tibia in comminuted unstable fractures. The tibia union time and malalignment were affected by fixation of the fibula, but it was statistically insignificant. Fixation of the fibula prolonged the healing time of the tibia but reduced the incidence of malalignment. However, this is not enough to support routine fixation of the fibula in all cases of distal tibial fractures taking into consideration the effect of violation of soft tissue needed to fix the fibula.

In the current study, locked plates were used all patients due to relative increased stability of the fixed angle screw-plate configuration and its low profile limiting soft tissue irritation. No cases of implant failure or implant related irritation was reported in our study. Khalsa *et al.*, [36] in a review article of 27 studies including 764 cases comparing locked versus nonlocked plating for treatment of acute distal tibia fracture reported that using locked plates lowers the probabilities of reoperation and malalignment. Christian *et al.*, [37] reported the same finding and added that both plating systems have comparable outcomes as regard the time to union, the rate of infection, and functional scores. Although many studied reported favorable outcome using percutaneous locked plates in management of distal tibial fractures [7, 9, 11, 15, 20, 21, 22, 23, 24, 25, 27], the stability of the fracture fixation remains the main determinant of

successful fracture healing regardless the type of plating system used [30, 38].

In our study, the average operative time was 68.3 minutes (range; 40-95minutes) and the average time of exposure to radiation was 1.73 minutes (103.8 seconds) (range; 45-164seconds). The reported average operative time ranged from 51.40 min to 114.40 min [11, 26, 39, 40]. The reported average time of exposure to radiation was 0.72 min to 3.8 min [26, 30, 38, 39, 41]. Both operative time and time of radiation exposure depend on surgeon experience with this technique, complexity of the fracture pattern and the need for fixation of the fibula. One of the drawbacks of the current technique is indirect fracture reduction under radiological control, leading to increase both operative time and time of radiation exposure compared to using locked intramedullary nailing [26] or open plating techniques [29].

In this study, all Fractures healed in average time 12.2 weeks (range; 8-20 weeks) where full weight bearing was allowed. The average time to radiological bony union in similar studies was reported between 16-22 weeks [4, 7, 14, 23, 24, 26, 40, 42, 43]. Meidinger *et al.*, [44] reported that smoking have a significant effect on fracture healing. The same was observed in the current study where smoking significantly prolonged the union time in smoking patients. ( $P < 0.05$ )

In the current study, two patients developed a malunion (8.3%). One patient had recurvatum, and the other had valgus malalignment. Despite the presence of malalignment, the functional result was good in one of them and fair in the other and both were satisfied with the results. None of these patients required corrective osteotomy. Ronga *et al.*, [9] in their study of 19 cases reported that four patients had angular deformity less than 7 degrees. Helfet *et al.*, [45] in their series of 20 patients reported four cases of malunion; two with more than 5 degrees of varus and two with more than 10 degrees of recurvatum. Our study is comparable to these findings. Other studies reported a single case of malalignment [14, 24, 46]. Meticulous intra-operative radiological monitoring of the fracture reduction and increase experience with this technique can minimize the postoperative malunion.

In the current study, deep infection developed in two patients (8.3%) one was diabetic and the other was smoker and all of them were successfully treated by debridement and implant removal after complete fracture healing. Infection did not appear to have any long term negative effect on fracture healing or the rehabilitation of the patient. Ronga *et al.*, [9] reported rate of deep infection of 16% that required implant removal after complete union. Lau *et al.*, [41] reported a rate of late infection of 15% in MIPPO fixation of a locking plate in distal tibial fractures. Piątkowski *et al.*, [19] in their study of 45 patients observed late infection reaching the metal implant that required implant removal in five patients (11.1%). In the literature there is a controversy when comparing the rate of infection between minimal percutaneous fixation and conventional open reduction and internal fixation of distal tibial fractures. Some studies report infection rate up to 31.5% with conventional plating [47] others report no significant difference between the two techniques [48, 49]. The low rate of deep infection reported in the current study can be explained by the selection criteria of the patient where open fractures and cases of bad skin condition were excluded from the study. Also, the optimal timing of intervention where the tissue swelling had subsided enough to allow tissue manipulation without affecting its vascularity.

In the current study the functional results were evaluated using the AOFAS score. The average AOFAS in the final follow of average 29.5 months (range; 8-60 months) was 90.6 points (range: 52-100) (Excellent). Collinge and Protzman [14] reported a good to excellent result with a mean AOFAS score of 85. In the study undertaken by Redfern *et al.*, [24] all patients returned to their pre-injury occupation or level of activity. The mean AOFAS score in the MIPO group of the study by Guo

*et al.* [26] was 83.9. Bahari *et al.*, [23] reported mean AOFAS score of 90 at a mean of 19 months follow-up.

## CONCLUSION

MIPO technique using distal tibia locking plating is an effective procedure for fixation of distal tibia extra-articular metaphyseal fractures. It provides near anatomical reduction of the fracture with sufficient stability and preservation of the blood supply to the fracture fragments. It provides excellent functional results with acceptable rate of complications.

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## Conflict of interest

The authors declare that they have no conflict of interest.

## Informed consent

Informed consent was obtained from all individual participants included in the study.

## Ethical approval

This study was approved by our institution's IRB.

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