Minimally invasive percutaneous plate osteosynthesis for lateral malleolus fractures

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Background
Lateral malleolus fracture is one of the most common fractures that may occur as a part of ankle joint trauma. Open reduction and internal fixation is considered as the state of the art for displaced lateral malleolar fractures in order to obtain congruent ankle mortise. But in certain conditions, soft-tissue status together with patient comorbidities may impede this technique. Minimally invasive percutaneous plate osteosynthesis (MIPPO) for lateral malleolus may be a suitable solution for ankle fractures with soft-tissue problems.
Patients and methods
Through the period between May 2012 and May 2016 in Ain Shams University hospitals, a prospective study on 51 patients with displaced lateral malleolus fractures as a part of ankle trauma with bad soft-tissue condition has been managed through the MIPPO approach. All patients have been evaluated as regards the grade of soft-tissue injury, timing of surgery from trauma, duration of the procedure, time to union, postoperative ankle function, and reported superficial peroneal nerve injury. Open fractures, associated pilon fractures, and established Charcot neuropathic joints had been excluded from the study.
Results
The minimum follow-up for all the patients was 12 months and maximum was 25 months with a mean of 13.7 months postoperatively. Thirty patients (58.8%) were grade III according to Tscherne classification of closed soft-tissue injury. Mean time of surgery from trauma was 45.9 h (12 h to 6 days). The average procedure time was 56 min (20–80 min). The average time to union was within 7 weeks (5–10 weeks), all patients had good-to-excellent ankle function with a mean of 89.9 according to the American Orthopedic Foot and Ankle Score, and no superficial peroneal nerve injury was documented.
Conclusion
MIPPO for lateral malleolus is an effective and safe technique, provided that ankle mortise congruity is obtained.

Keywords:
ankle trauma, lateral malleolus, minimally invasive percutaneous plate osteosynthesis, superficial peroneal nerve

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Introduction

Lateral malleolus fracture is one of the most common fractures in orthopedic trauma, it occurs mostly as a part of ankle joint injury [1,2].

Soft-tissue status is one of the determining factors that may alter the pathway of fracture management in the ankle region because of paucity of the covering soft-tissue envelope and blood supply [3].

Pott's ankle fractures have been classified either anatomically (AO/OTA classification) or Weber classification, also they are classified according to the position of the foot and the violating force in the most commonly used Lauge Hansen classification [4,5].

The level of lateral malleolus involvement in Danis and Weber classification predicts the involvement of syndesmotic ligaments in the injury necessitating the insertion of syndesmotic screws [5,6].

Open reduction and internal fixation (ORIF) that allows absolute stability is the state of the art in management of such fractures according to the AO principles [3].

Indirect reduction of lateral malleolus fractures could be achieved by traction and reversing the trauma mechanism. Fixation could be done using lag screw (for simple transverse Weber type A fractures), intramedullary nailing (not popular and technically

demanding), or through minimally invasive percutaneous plate osteosynthesis (MIPPO) that allows preservation of the soft-tissue envelope. All these are alternatives to the ORIF technique [7–10].

In this prospective study, we hypothesized that MIPPO of lateral malleolus fracture technique might be an effective and safe method in cases of Pott's ankle fractures associated with soft-tissue comorbidities.

Patients and methods

Through the period between May 2012 and May 2016 in Ain Shams University hospitals, 86 patients with Pott's ankle fracture had been admitted, from which 51 patients had been involved in a prospective study with MIPPO technique for lateral malleolus fractures as a part of ankle joint trauma management. The study was approved by the institutional ethics committee in the Orthopedic Department of Orthopaedic Surgery, Ain Shams University, Cairo, Egypt.

Open fractures, associated pilon fractures, and established Charcot neuropathic joints had been excluded from the study.

Cases in which congruent ankle mortise was not achieved by indirect closed methods, a shift to open direct reduction was done and was also excluded from the study (four patients).

Only Weber type B (32 patients, 22 of them associated with medial malleolus fracture) and type C (19 patients, seven of them associated with medial malleolus fracture) were included. Patients were assessed according to Tscherne classification of closed soft-tissue injury [11]. Thirty patients were classified as grade III (58.8%) (Fig. 1). Eighteen patients had skin bullae and nine patients had been known to be diabetic with uncontrolled blood sugar level in the last 3 months. Mean age was 38 (21–65 years). Thirty-nine patients were females and 13 were males. Indication of surgical management was displacement greater than 2 mm, shortening greater than 2 mm, and the associated medial injury either ligamentous or bony.

No preoperative superficial peroneal nerve (SPN) injury was detected in all cases.

All patients had spinal anesthesia, seated in supine position with a pillow under the affected hip in order to produce internal rotation of the affected leg exposing the approach area more easily and facilitating mortise

Figure 1

Patient with severe soft-tissue injury Tscherne III and skin bullae.

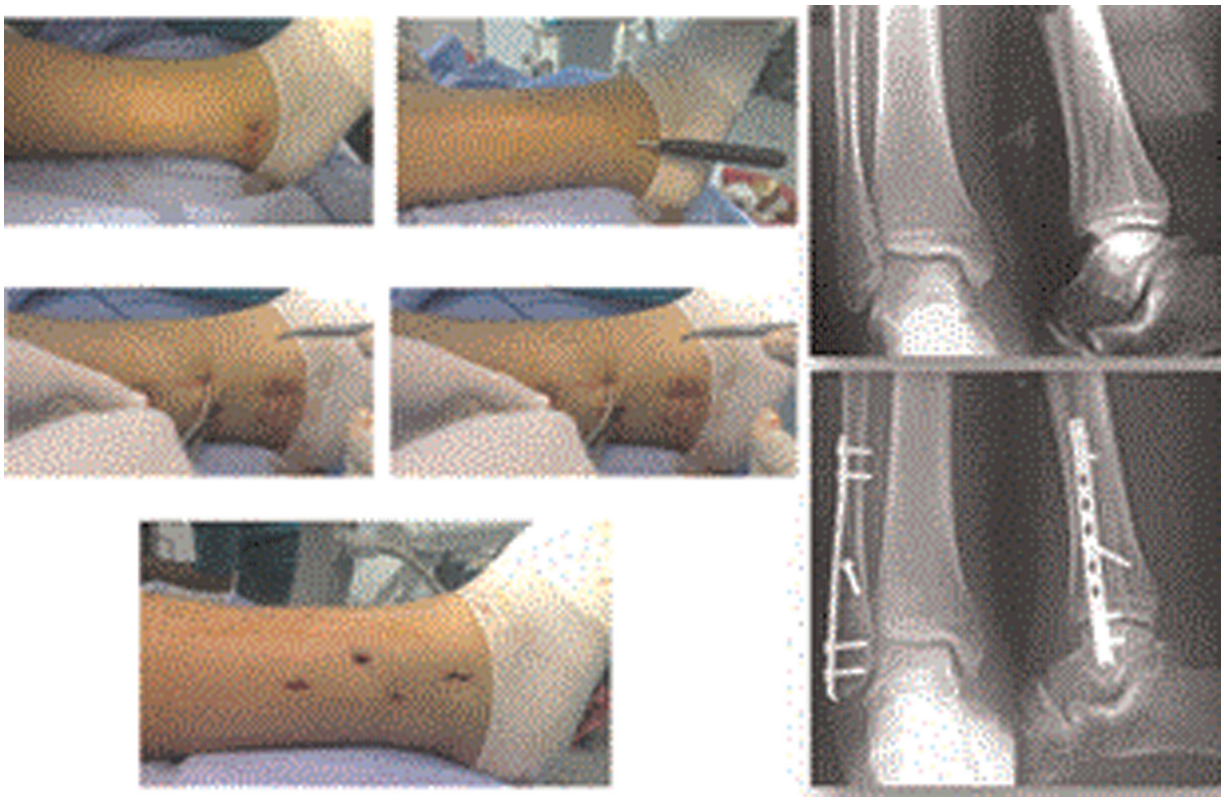
view. After sterilization and draping, elevation of the affected ankle was performed using towel drape beneath to facilitate reduction in the sagittal plane. Reduction was done indirectly before skin incisions with traction and reversal of the mechanism of injury and checked with image intensifier as regards the angulation, rotation, and fibular length.

In cases of comminuted fractures, rotation and angulation were checked and the length was adjusted after distal plate fixation using traction of the plate-bone construct with a hook.

In cases of Weber type B (supination external rotation), stabilization of fracture through small snip incisions at the anterior and posterior edges of the fibula using towel forceps was done followed by application of a lag screw if possible (five cases).

A small skin incision (2 cm) was done over the tip of the lateral malleolus, followed by periosteal stripper to open a subcutaneous tunnel. Then the plate with proper length was used, one-third tubular plate was used for simple ankle fracture pattern as it is working as a neutralization plate (Fig. 2). Locked plates were used for comminuted fracture patterns to avoid shortening (six patients).

Figure 2



Steps, preoperative and postoperative radiographies of Weber B fracture lateral malleolus managed by minimally invasive percutaneous plate osteosynthesis technique.

At the proximal part of the plate, another small skin incision was done down to the bone through the subcutaneous tissue with careful dissection of peroneal muscles. The plate was centralized over the bone adding indirect reduction in cases of comminuted fractures (Fig. 3). After rechecking of reduction by image intensifier, augmentation of the fixation was done by adding at least another screw on either side of the fracture.

Closure of wounds was done and further injuries were dealt with according to their pathology (deltoid ligament repair or medial malleolus fixation).

All patients have been evaluated for the duration of the procedure, time of union, ankle joint function according to American Orthopedic Foot and Ankle Score (AOFAS), and postoperative SPN injury. Data were collected and statistical analysis was done.

Follow-up

The patients were followed up every 2 weeks till union and then every 3 months up to 1 year postoperatively. The minimum follow-up was 12 months and maximum was 25 months with a mean of 13.7 months.

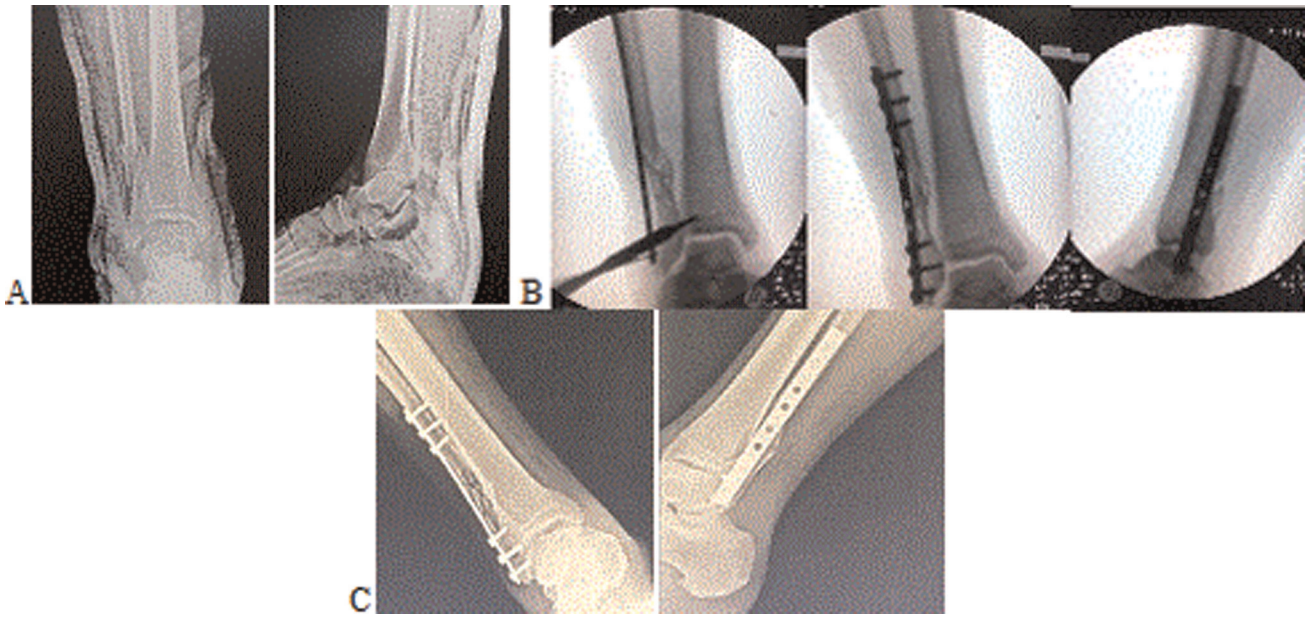
Statistical analysis

The analysis was done using the Statistical Package for the Social Sciences (SPSS software version 19) (IBM Corp. Released 2010, IBM SPSS Statistics for Windows, Version 19.0, Armonk, NY: IBM Corp.). Data are expressed as mean±SD. The incidence of superficial infection was correlated with the grades using the nonparametric Kruskal–Wallis (χ^2) test. For the above comparisons, P less than 0.05 was considered statistically significant and P less than 0.01 was considered statistically highly significant.

Results

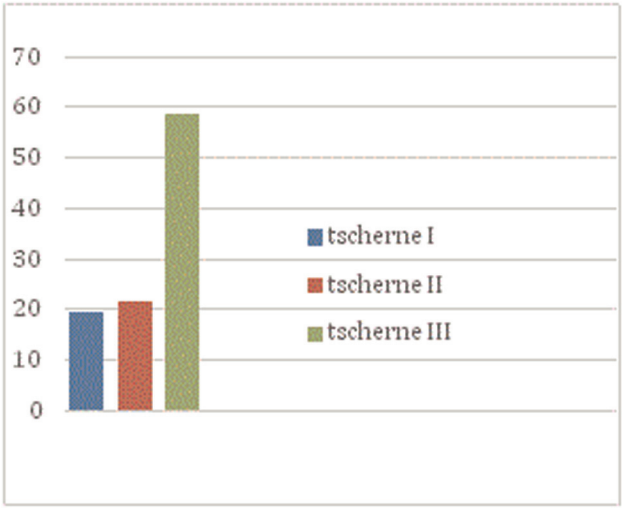
In the present study, patients with lateral malleolus fracture with severe soft-tissue injuries were managed through the MIPPO technique. All patients have been evaluated as regards the grade of soft-tissue injury, timing of surgery from trauma, duration of the procedure, time to union, postoperative ankle function, and reported SPN injury.

Figure 3



Comminuted Weber C fracture lateral malleolus (Tscherne III). (a) Preoperative radiography. (b) Intraoperative fluoroscopy. (c) One-month postoperative radiography.

Figure 4



Percentage of patients according to Tscherne classification.

Thirty patients (58.8%) were grade III, 11 patients (21.5%) were grade II, and 10 patients (19.6%) were grade I (Fig. 3).

Eighteen patients had skin bullae and nine patients had been known to be diabetic with uncontrolled blood sugar level in the last 3 months (mean HbA1C was 10.6) (Fig. 4).

The mean time of surgery from trauma was 45.9 h (12 h to 6 days). The average procedure time was 56 min (20–80 min). The average union rate was within 7 weeks (5–10 weeks); all patients had good-to-excellent ankle function ranging from 82 to 98 with a mean of 89.9 according to the AOFAS.

Table 1 Evaluation of patients' results as regarding their range and mean

Evaluation items	Range	Mean
Time of surgery from trauma	12 h to 6 days	45.9 h
Procedure time	20–80 min	56 min
Time to union	5–10 weeks	7 weeks
AOFAS	82–98	89.9
Time of exposure to radiation	0.5–3.5 min	1.26 min
Superficial skin infection	4 patients	
Postoperative SPN injury	No injury	

AOFAS, American Orthopedic Foot and Ankle Score; SPN, superficial peroneal nerve.

No SPN injury was documented.

Four patients developed superficial wound infection with delayed wound healing. Antibiotics were continued for 2 weeks with daily dressing and the condition improved (Table 1).

In the present study, it was found that there was no statistical significant difference between the three grades of closed soft-tissue injury regarding the duration of surgery, time of union, and ankle scores (Table 2). Also, it was found that the incidence of superficial infection was statistically significant in grade III injuries ($P<0.001$) (Table 3).

Table 2 Results of MIPPO technique as regards Tscherne grades

	Grades (mean±SD)			
Parameters	Grade I (*n*=10)	Grade II (*n*=11)	Grade III (*n*=30)	*P* value
Time till operation	42.00±28.77	44.82±33.60	47.67±34.13	0.889
Duration of surgery	52.5±17.68	55.45±16.04	58.00±14.12	0.602
Time of union	6.7±0.82	7.36±1.36	6.77±1.30	0.353
Ankle function score	91.70±3.97	90.18±3.19	89.27±4.22	0.250

MIPPO, minimally invasive percutaneous plate osteosynthesis. *$P<0.05$ is significant.

Table 3 Incidence of superficial infection according to the grade of soft-tissue injury

	Grades [*n* (%)]			
Parameters	Grade I (*n*=10)	Grade II (*n*=11)	Grade III (*n*=30)	*P* value
Superficial infection				
Present	–	1 (9.1)	3 (10)	χ^2=36.26
Absent	10 (100)	10 (90.9)	27 (90)	$P<$**0.001****

**$P<0.01$ is highly significant.

Discussion

Lateral malleolus fractures are one of the most common fractures in orthopedic surgery [1]. ORIF is considered as the state of the art for managing such type of fractures. Because of paucity of the covering soft-tissue envelope and blood supply, wound complications like infection and skin dehiscence are as high as 20%. Patients with severe soft-tissue injury, especially if accompanied by uncontrolled diabetes mellitus or peripheral vascular disease, are at high risk for developing such complications [12].

Many authors have applied minimal invasive surgeries for lateral malleolus fractures aiming in preservation of fracture hematoma and decreasing the incidence of skin complications, especially in fractures with soft-tissue injury. These techniques include lag screws (for simple transverse Weber type A fractures), intramedullary nailing, or through MIPPO [7–10].

All patients had good-to-excellent ankle function ranging from 82 to 98 with a mean of 89.9 according to the AOFAS. The average procedure time was 56 min (20–80 min). This wide range in ankle function scores and operative time is explained by the associated medial malleolus fracture that was fixed by malleolar screws or tension band technique decreasing the scores and increasing the operative time.

Four patients were excluded from the study as congruent ankle mortise was not achieved by the indirect methods and classic open procedure was done. After surgical dissection, it was noticed that two of these patients had soft-tissue interposition obscuring the reduction. The time till operation was about 8 days in the other two patients. So we recommend not to apply this technique in patients with delayed operative intervention of more than 1 week.

In a retrospective study done by Krenk and colleagues demonstrating the MIPPO technique for lateral malleolus fractures, they analyzed 19 patients with lateral malleolar fractures (mean age 54.8 years, mean follow-up 107.5 weeks). In almost 50% of patients, the authors used a lateral plate without screws through the distal fragment, and reduction loss was absent [10]. Pires *et al.* [13] also applied the same approach in one patient of their series.

In the present study, lateral plate was used in all the patients with at least two proximal and two distal locking screws. All fractures, whether Weber type B or type C, are considered unstable fractures, especially if they are comminuted. We excluded type A fractures from this study as they are too distal for biological fixation. Distal incision, which is ~2 cm, will interfere with the fracture hematoma losing one of the benefits of biological fixation.

Hess and colleagues fixed 20 patients with lateral fibular fracture using locked plates. Three of them developed aseptic nonunion, while 17 fractures healed with no signs of infection or nonunion at an average of 9 weeks. This technique was recommended by the authors, especially in complex fractures with poor soft-tissue condition [14]. In this study, we used locked plates (six patients) in comminuted fractures aiming to maintain length and avoid shortening and collapse of the fracture.

Thirty-one patients were evaluated by Siegel and Tornetta treated by extraperiosteal plating for pronation–abduction injuries. The local blood supply was preserved as the plate was applied laterally over the

"periosteal sleeve". All the patients healed within 10 weeks [15].

In a study done by Pires and colleagues, 20 patients were evaluated with lateral malleolus fractures managed by MIPPO technique. Only Weber type B was included in their study. The mean patient follow-up was 16.5 months (12–20). Time from injury to surgery averaged 4.4 days, ranging from 1 to 11 days. The duration of surgery averaged 32.8 min (15–73) from skin incision to closure. The total duration of fluoroscopy exposure averaged 61 s (20–120). The average time to healed fracture was 8 weeks. The AOFAS score ranged from 72 to 100 with an average of 88.3 points (SD of 6.8 points). Two of their patients presented surgical complications. One skin necrosis required implant removal 6 months postsurgery, and one developed malunion due to malreduction. It was not possible to assess the association between functional outcomes and complications due to the small sample size [13].

In the present study, the average union rate was 7 weeks for all the patients; regardless, their grade of soft-tissue injury with no signs of nonunion was noticed.

Unlike the aforementioned studies, four patients developed superficial skin infection. Three of these patients had uncontrolled diabetes mellitus and were of the category grade III soft-tissue injury. One was grade II. It was found that the incidence of superficial infection was statistically significant in grade III injuries ($P<0.001$).

The mean AOFAS after 1 year post surgery was 88.9. This was comparable to the scores of previous studies reported by Pires and colleagues.

In a study done by Chiang and colleagues, they retrospectively studied 71 patients. ORIF was done to 34 patients and MIS to 37 patients (13 were managed by MIPPO and 24 managed by the minimally invasive transfracture procedure). They concluded that the total complication rate was significantly higher in the ORIF group, while a longer operative time and greater exposure to fluoroscopy were reported in the MIS group [16].

In this study, it was obvious that intraoperative fluoroscopic exposure was increased (mean was 1.3 min). This is one of the drawbacks of the MIPPO technique as indirect reduction maneuvers require more image-intensifier pictures to ensure congruent ankle mortis.

It is necessary to determine further benefits of MIPPO for lateral malleolar fractures, so a randomized prospective trial should be done comparing this technique to the classic ORIF.

Conclusion

Lateral malleolus fractures are one of the most common fractures in orthopedic surgery. Minimal invasive percutaneous plate osteosynthesis is considered the ideal technique for managing such fractures, especially in diabetic patients with critical soft-tissue injuries, provided that ankle mortise congruity is obtained.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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