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# Short-term results for the management of distal tibial fractures by minimally invasive locked plating

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**Background**

Fractures of the distal tibia can be challenging to treat because of the limited soft tissue, the subcutaneous location, and poor vascularity. Minimally invasive locked plate aims to reduce surgical soft-tissue trauma and to help preserve periosteal blood supply and fracture hematoma and is useful in treating these challenging fractures.

**Patients and methods**

This study included 26 patients between 20 and 53 years of age (mean 34 years), with both open and closed distal tibial pilon fractures that were intra-articular or extra-articular. All fractures were fixed using minimally invasive plate osteosynthesis under image control using a precontoured locking compression plate–distal tibial plate.

**Results**

There were 11 AO 43 A, seven AO 43 B, and eight AO 43 C fractures including 18 closed and eight open fractures. Fracture union was achieved in 23 patients (88%), whereas three cases (12%) showed delayed union. Four cases suffered from late infection, and plate removal was necessary, whereas six cases had minor wound problems and responded to conservative treatment. Twenty-two patients (85%) returned to their work within 1 year of operation; however, 17 patients (65%) had not returned to their preinjury sporting or leisure activities. Seven patients (27%) had angular deformities, all less than 7°. The final ankle–hindfoot score was 84.8 points.

**Conclusion**

Short-term results for treating distal tibial pilon fractures using minimally invasive locked plate (locking compression plate–distal tibial plate) to reduce surgical soft-tissue trauma and to help preserve periosteal blood supply and fracture hematoma appears encouraging, with union rates similar to that of open reduction internal fixation (ORIF) techniques, but avoiding the usual associated drawbacks.

**Keywords:**
ankle, locked plate, minimally invasive, pilon

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## Introduction

Fractures of the distal tibia can be challenging to treat because of the limited soft tissue, the subcutaneous location, and poor vascularity. The best treatment remains controversial [1]. Open reduction and internal fixation require extensive soft-tissue dissection with consequent periosteal injury even in expert hands [2]. External fixation has an established place in the treatment of distal tibial fractures, particularly when associated with significant soft-tissue injury [3]. Ilizarov frames, ankle-spanning, and hybrid constructs have been proposed either as a sole treatment or, more frequently, in conjunction with limited internal fixation [4]. Complications of external fixation include the development of pin-track infections, malunions or nonunions [3], and inaccurate reduction [5], especially of intra-articular fractures.

Classic open reduction and internal plate fixation is associated with high rates of complications, including infection (range 8.3–23%) [6,7] and delayed union and nonunions (range 8.3–35%) [6–9].

Newer surgical techniques that involve smaller incisions, less soft-tissue dissection, less periosteal stripping, and the use of intraoperative imaging or navigation are believed by many to improve healing rates and reduce complications [10]. Minimally invasive plate osteosynthesis (MIPO) is a technique that aims to reduce iatrogenic soft-tissue injury and damage to bone vascularity and preserve the osteogenic fracture hematoma [11]. This philosophy is especially applicable in the management of distal tibial fractures, owing to the vulnerable extraosseous–metaphyseal blood supply in the distal region of the tibia [12]. Encouraging results for closed reduction and percutaneous plating of closed intra-articular and extra-articular distal tibial fractures have been reported using contoured dynamic compression plates [13,14].

There has been an increasing trend towards the use of the locking compression plate (Synthes, USA) for fracture fixation. The device allows the screws to lock to the plate, therefore creating a stable, fixed-angle device [15,16]. The locking screw-plate interface allows

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fracture fixation without plate–bone adherence, thus preserving the fracture hematoma, and reduces the risk of nonunion by maintaining microvascular circulation within the cortex and its investing tissues [17,18]. The system also works as a flexible elastic fixation that stimulates callus formation.

The aim of this study was to assess short-term results of treating distal tibial pilon fractures with the MIPO technique using locked compression distal tibial plates including clinical and radiological results, fracture union, the infection rate, and other complications.

## Patients and methods

This was a prospective study that was carried out between May 2009 and November 2011 in the Orthopedic and Trauma Departments in Kasr Al Aini Hospitals in Cairo University and Al-Emadi Hospital and Doha Clinic Hospital in Qatar. This study was approved by the ethical committee at the hospitals where it was carried out. All patients provided consent for participation in the study. This study initially included 28 patients with distal tibial pilon fractures, but two patients were lost during follow-up; thus, only 26 patients were included in the final evaluation. This study included open and closed injuries that were intra-articular or extra-articular fractures. Patients with pathological fractures and lower limbs with pre-existing neurological deficits or vascular diseases were excluded. The study included 17 male and nine female participants in the age group between 20 and 53 years, with a mean age of 34 years. Twelve patients were injured in road traffic accidents, six patients suffered fractures due to fall from a height, six patients suffered fractures during sports activities, and two patients suffered fractures from falling while getting down the stairs. All patients had plain radiographs of the distal tibia and the ankle. A computed tomography scan of the distal tibia and the ankle was obtained in 12 patients with extension of the fracture to the joint as the minimally invasive technique limits the exposure, and the identification of the various articular fragments is vital for reconstruction.

Fractures were classified according to the AO comprehensive classification system [19], whereas open injuries were classified according to the Gustilo and Anderson method and closed injuries through the Tscherne classification [20].

All cases were treated initially with immediate reduction with temporary plaster stabilization. Elevation of the fractured limb with generous use of ice to reduce the swelling was utilized in the initial management. Soft-tissue assessment was performed before surgery. Open injuries were treated with intravenous antibiotics, adequate wound debridement, and lavage before any definitive fixation. Where possible, closure or coverage of any opening into the joint was achieved. Preliminary bridging external fixation was performed for temporary skeletal and soft-tissue stabilization in 11 cases of open fractures (Gustilo II and III) and when there was doubt about the viability of the soft tissue (Tscherne classification, closed fracture grade 2 or 3).

The duration between the initial trauma and the surgery was 7.5±4 days (range 5–15 days), depending on the skin condition. Surgery was planned when the ankle swelling subsided, and the 'wrinkle sign' was present.

The key concept of the MIPO approach was to preserve the soft tissues and the blood supply in the metaphyseal fracture area by not exposing them surgically. An entry site is developed over the distal tibia, and the plate is then inserted from the distal to the proximal, through a tunnel between the periosteum and the intact overlying tissue. The patient was placed supine on a radiolucent table, antibiotic prophylaxis was administered, and standard intraoperative fluoroscopy was used throughout the procedure. Using manual traction at the ankle or through a single Steinmann pin inserted into the calcaneus, the fracture was reduced gently, restoring the limb length, alignment, and rotation. Usually, internal fixation of the tibial fracture was performed first in cases with associated fibular fractures. However, in eight cases, when normal length, axis, and rotation of the tibial fracture could not be achieved, the fibular fracture was plated first using a one-third tubular plate to provide lateral stability, restore the correct length, and avoid overdistraction at the tibial fracture site. The main fracture fragments of the distal tibia were aligned and reduced percutaneously by indirect maneuvers using ligamentotaxis or through separate stab incisions using a periosteal elevator, clamps, or K-wires as joysticks, and then fixed with individual percutaneously inserted lag screws. A 3–5-cm-long straight or slightly curved skin incision was then made on the medial aspect of the distal tibia, which stopped distally at the tip of the medial malleolus. The incision was then carried straight across the subcutaneous fat, preserving the greater saphenous vein and the saphenous nerve. The dissection then extended down onto the periosteum, which was completely preserved. In this anatomical space (epiperiosteal), a subcutaneous tunnel was produced using forceps or a periosteum elevator. A precontoured locking compression plate–distal tibial plate (LCP–DTP) was used for the fixation of the tibial fracture. The plate was then inserted after proximal tunneling with a blunt instrument. Depending on the fracture situation, the plate was usually positioned on the anteromedial aspect of the tibia. Temporary plate fixation was performed with K-wires through the screw holes (or inserted drill sleeves) to approximate the final plate position before screw insertion. At this stage, limb alignment was assessed by comparison with the other limb. The correct rotation was established by evaluating the alignment of the proximal and the distal cortices of the distal tibia and comparing the axis between the tibial tuberosity and the intermetatarsal spaces at 90° of knee flexion. If the plate position was satisfactory, screws were then inserted percutaneously through stab wounds as necessary. At least three bicortical screws were inserted proximal to the fracture, whereas bicortical or unicortical screws were inserted distal to the metaphyseal fracture using as many of the distal plate holes as possible (maximum nine holes in the locked plate). The stab incisions were irrigated and closed with routine skin sutures, and then the wound was dressed. Finally, the restoration of the length, the alignment, and rotation of the reduced fracture were checked radiologically through intraoperative image intensification.

Parenteral antibiotics were continued for 3 days postoperatively, and then oral antibiotics were given for an additional week. Active range of motion with non-weight-bearing crutch walking while still in the hospital was allowed, and weight bearing as tolerated was allowed over time depending of the fracture pattern, fracture healing, and the stability of fracture fixation, but most patients could bear weight at least partially at 6 weeks. If the fracture was intra-articular, we kept the patients non-weight-bearing for the first 2 weeks, and asked them to start toe-touch weight bearing starting from the fourth postoperative week, and outpatient physiotherapy to maximize the range of motion of the foot and the ankle was carried out under supervision. The mean postoperative hospital stay was 12.6 days (range 7–23 days).

Patients were evaluated clinically, functionally, and radiologically (plain anteroposterior and lateral radiographs) at 2, 4, 6, 9, and 12 months from surgery, and then yearly. The follow-up duration ranged between 12 and 19 years (average 15 months). Clinical and functional outcomes were assessed using the Clinical Rating Systems for the ankle–hindfoot developed by the American Orthopedic Foot and Ankle Society [21].Three radiographic parameters were evaluated: union (bridging of at least three of four cortices on two orthogonal views), deformity (<7°), and leg-length discrepancy (<2.5 cm in the tibia) on standard long-leg radiographs. We considered a healing time less than 6 months as normal and between 6 and 9 months as a delayed union. Also, skin infection that occurred at least 2 months after complete wound healing was considered as late skin infection.

## Results

According to the AO classification, there were 11 (42%) AO 43 A fractures, seven (27%) AO 43 B fractures, and eight (31%) AO 43 C fractures. There were 18 (69%) closed fractures and eight (31%) open fractures (three cases Gustilo I, three cases Gustilo II, and two cases Gustilo III).

Preliminary external fixators were applied in 11 cases (42%) including six open fractures and five closed fractures. There was associated fibular fractures in 21 cases, of which eight cases were fixed by one-third tubular plates to restore the length and the alignment of the ankle joint before the fixation of the distal tibial fractures.

The time for full weight bearing in patients with closed fractures ranged between 12 and 28 weeks (average 19 weeks), whereas for patients with open fractures, it ranged between 15 and 48 weeks (average 23 weeks).

Regarding fracture union, it was achieved in 23 patients (88%) between 14 and 42 weeks (average 25 weeks), whereas three patients (12%) showed delayed union. These three patients had sustained high-energy trauma (Gustilo II and III). Two cases with were managed by autogenous iliac crest bone graft to achieve union, which was eventually achieved at 11 and 12 months postoperatively, whereas the third patient refused to undergo additional surgery and received bone marrow injection at the fracture site, which was performed twice, with union achieved eventually at 14 months (Figs. 1 and 2).

At the last follow-up, the range of motion of the ankle was reduced more than 20° compared with the contralateral side in seven patients (27%). Twelve of the 26 patients (46%) had a limp, but none of them used walking aids. Twenty-two patients (85%) returned to their work within 1 year of operation; however, 17 patients (65%) had not returned to their preinjury sporting or leisure activities. Seven patients (27%) had angular deformities, all less than 7°: three of these cases had valgus deformity, whereas four cases showed varus deformity. No patient had a leg-length discrepancy greater than 1.5 cm.

Clinical and functional results are shown in Table 1.

### Complications

In eight patients (31%), the plate was palpable in the subcutaneous tissues at the last follow-up, but this did not interfere with daily activities and did not necessitate plate removal. Four patients (15%) developed late infection around proximal or distal screws 3–6 months

**Figure 1**


(a) Preoperative radiograph of an AO 43 C pilon fracture. (b) The postoperative radiograph after 1 year showing the fracture united, with no limb shortening.

**Figure 2**


(a) Preoperative radiograph showing an AO 43 C1 Gustilo 1 fracture. (b) The postoperative radiograph after 6 weeks showing evidence of callus formation. (c) The postoperative radiograph after 3 month show progressive signs of healing.

postoperatively, which did not respond to local wound care and antibiotics, and these cases necessitated plate and screw removal together with an antibiotic course, and eventually, these wounds healed. Three of these four cases had preliminary external fixation before definitive fixation. Six patients (23%) suffered from minor wound dehiscence or superficial cellulites within the first 2 months postoperatively and were managed by local wound care, wound debridement, and oral or parenteral antibiotics, and these problems were finally resolved. Also, one patient suffered from screw breakage at 16 weeks, wherein the screws broke between the bone and the plate before complete union was achieved due to early full weight bearing, but callus formation was evident on radiographs; the case was managed by implant removal, opening the fracture site, and fixation by broad dynamic compression plate (DCP), and the fracture united at 42 weeks.

**Table 1 The ankle–hindfoot scale for clinical rating [21]**

| Items | Average score | Mean score |
|---|---|---|
| Pain (40 points) | 20–40 | 34.4 |
| Function (50 points) including | | |
| Activity limitations, support requirement (10) | 4–10 | 7.5 |
| Maximum walking distance, blocks (5) | 2–5 | 4.4 |
| Walking surfaces (5) | 0–5 | 3.9 |
| Gait abnormality (8) | 4–8 | 6.3 |
| Sagittal motion (flexion+extension) (8) | 4–8 | 6.9 |
| Hindfoot motion (inversion+eversion) (6) | 3–6 | 4.7 |
| Ankle–hindfoot stability (anteroposterior, varus–valgus) (8) | 8 | 8 |
| Alignment (10 points) | 5–10 | 8.7 |
| Total (100 points) | | 84.8 |

## Discussion

Reports in the literature on ORIF of distal tibia or pilon fractures are plagued by wound infection [22]. The high-energy trauma sustained during the initial injury causes massive soft-tissue injury and often devitalizes the soft tissue around the fracture site. The anteromedial aspect of the distal tibia is the most at risk of wound infection and dehiscence [23]. Collinge and Sanders [24] have described indirect fracture reduction and percutaneous plating techniques for the lower extremity, as an evolutionary step in biological plating. Minimally invasive plating techniques involving smaller incisions, less soft-tissue dissection, less periosteal stripping, and the use of intraoperative imaging or navigation reduce iatrogenic soft-tissue injury and damage to bone vascularity, and preserve the osteogenic fracture hematoma [11]. They are believed by many to improve healing rates and reduce complications.

Initial clinical series using these methods demonstrated favorable results with low rates of infection and nonunion [25–27], but several complications such as angular deformities greater than 7° and hardware failure have been reported [26,28].

It has been proposed that the reduced plate-to-bone compression afforded by locking plates serves to protect the viability of the bone by maintaining microvascular circulation within the cortex and its investing tissues [18]. Screw locking minimizes the compressive forces exerted by the plate on the bone because the plate does not need to be tightly pressed against the bone to stabilize the fracture [17,18]. The distal end of the LCP–DTP is anatomically contoured to the distal medial tibia, thus preventing primary displacement of the fracture caused by inexact contouring of a normal plate; it allows a better distribution of the angular and axial loading around the plate, and also, the distal end allows placement of up to nine locking screws that provide stability where satisfactory bone purchase is difficult [15].

The clinical importance of these advantages, however, is still debatable.

Several studies had investigated the differences between fractures fixed by locking plates and those fixed by nonlocking plates and found that there were no statistically significant differences between locking plates and nonlocking plates for patient-oriented outcomes, adverse events, or complications [29,30].

Previously published infection rates in the management of distal tibial injuries range from 0 to 50%. Deep infection and wound dehiscence are the major soft-tissue complications. Wound debridement, antibiotics, skin grafting, myocutaneous flap, and even arthrodesis have a role to play in management [3,4,6,13,14,22,23,27,31–34]. Studies using external fixation techniques reported significant reduction in infection rates [3,32,34]. Infection rates in the MIPO technique are better than those in previously reported ORIF studies and are comparable to the external fixation technique [4,13,14].

The AO distal tibia locking plate applied with minimally invasive techniques allows fracture reduction and alignment without the associated wound complications in ORIF. This was reflected in our results where only six cases (23%) had minor wound problems that resolved completely with only local wound care, wound debridement, and oral or parenteral antibiotics, whereas only four cases (15%) developed late infections that necessitated plate removal together with an antibiotic course, and wounds eventually healed and the fracture united.

Studies involving external fixation techniques showed complications such as loosening, malunion, imperfect articular reductions, and pin-tract infections [3,34,35].

Our study showed that seven patients (27%) had angular deformities, all of them less than 7°, where three cases had valgus deformity and four cases showed varus deformity. No patient had a leg-length discrepancy greater than 1.5 cm. These results are comparable to other published studies of Ronga *et al.* [1], Collinge *et al.* [25], Hazarika *et al.* [36], and Hasenboehler *et al.* [37].

In the current study, fracture union was achieved in 23 patients (88%) between 14 and 42 weeks (average 25 weeks), whereas three cases (12%) showed delayed union. These results are comparable to similar studies such as Bahari *el al.* [38] who had a mean fracture healing at 22.4 weeks postoperatively, and Ronga *et al.* [1] showed 95% union in 22.3 weeks, whereas Hasenboehler *et al.* [37] showed 90% union in 27.7 weeks and Hazarika *et al.* [36] had 90% union in 28.5 weeks. Our results are better in comparison with ORIF and external fixation [4,13,14,,22,27,31,32,34].

In eight patients (31%), the plate was palpable in the subcutaneous tissues at the last follow-up, but this did not interfere with daily activities and did not necessitate plate removal. These results are comparable to those of Bahari *et al.* [38] who found superficial tenderness or impingement over the medial aspect of the medial malleolus in five cases (of 42) and Ronga *et al.* [1] who found that the plate was palpable in the subcutaneous tissues in six patients (of 19).

Regarding the functional outcome in the current study, the range of motion of the ankle was reduced by more than 20° compared with the contralateral side in seven patients (27%), and 12 of the 26 patients (46%) had a limp, but none of them used walking aids. Twenty-two patients (85%) returned to their work within 8 months of operation; however, 17 patients (65%) had not returned to their preinjury sporting or leisure activities. These results are comparable to those of Bahari *et al.* [38] wherein 89% of the patients felt that they were back to their preinjury status and 95% were back to work within 6 months of injury, and those of Ronga *et al.* [1] where out of 19 patients, eight had a limp, but without using walking aids, and 16 cases did not return to their preinjury sporting or leisure activities, while the range of motion of the ankle was reduced by more than 20° compared with the contralateral side in five patients.

### Limitations of the study

The most important limitations are the relatively short-term follow-up duration, the relatively small number of cases, and the absence of control groups.

## Conclusion

Short-term results for treating distal tibial pilon fractures using minimally invasive locked plate (LCP–DTP) to reduce surgical soft-tissue trauma and to help preserve periosteal blood supply and fracture hematoma appear encouraging, with union rates similar to that of ORIF techniques, but avoiding the drawbacks of high infection rates and skin complications that are usually associated with ORIF techniques. However, long-term follow-up studies on a larger number of cases are recommended to evaluate whether this surgical technique provides a safe and effective management option for distal tibial fractures in the long term or not.

## Acknowledgements

### Conflicts of interest

There are no conflicts of interest.

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