Early Results of Minimally Invasive Percutaneous Plate Osteosynthesis for Fractures of the Distal Tibia: A Retrospective Case Series and Review of the Literature

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**ABSTRACT:** Minimally invasive percutaneous plate osteosynthesis was developed on the concept that preservation of the soft tissue envelope during surgical management of distal tibial fractures is of paramount importance. We report on our early experience using this technique over a 1-year period with 14 such injuries that were treated by a locking compression plate via minimally invasive surgery. The surgical reduction was excellent in most of the cases and all fractures healed uneventfully. One superficial infection and a wound slough were the only complications recorded. The mean follow-up was at 15 months, and all patients were satisfied with a mean ankle-hindfoot score of 84. Early results of such management are very encouraging.

**KEYWORDS:** Minimally invasive osteosynthesis, distal tibial fractures

**Introduction**

Distal tibial fractures are usually high-energy injuries, often associated with extensive soft tissue damage. To describe the potential complexity of these fractures, Ruoff and Snider in 1971 coined the term ‘explosion fracture’. Around 10% to 30% of these fractures are open.¹⁻³

Prevention of further soft tissue compromise at the course of their treatment is of paramount importance to achieve a good clinical result⁴ and to minimize the complications that might be devastating.⁵,⁶

Minimally invasive percutaneous plate osteosynthesis (MIPO) is a relatively new technique but has been used for more than a decade. It minimizes the surgical trauma to the zone of injury, thus preserving the soft tissue envelope and the blood supply to the fracture site.⁷⁻⁹

The aim of this study was to evaluate the outcome of this technique during the early days of our attempt to use this to move away from the old and established methods of open and extensive surgery of distal tibial injuries.

**Patients and Methods**

Between 2002 and 2003, we treated 14 patients with fractures of the distal tibia, by MIPO.

We conducted a retrospective review of these patients to determine the union rate associated with the MIPO technique as well as the complication rate. This was done by retrieving the medical notes and radiological images for data collation.

Nine patients were men and 5 were women, with a male to female ratio of 2:1. The mean age was 41.2 years (range: 21-72 years) and both sides were equally affected. There were 3 type A, 4 type B, and 7 type C fractures, according to the AO classification.¹⁰ Three fractures were open: 2 were grade I and 1 was grade II, according to the Gustilo classification¹¹ (Figure 1).

Road traffic accident was the cause in 6 of the fractures, fall from a height in 3, twisting injury in 4, and crush injury from a heavy object in 1 (Table 1).

A locking compression plate (LCP) was the fixation device used in all the cases, and minimally invasive percutaneous osteosynthesis (MIPO) was the technique implemented. All the surgeries were performed by A.M.N. and S.L., with the assistance of G.A. Associated fibular fractures were plated first to establish the correct length (in cases with epiphyseal and/or metaphyseal comminution of the tibia), using similar technique (Figure 2). Fixation of the fibula, however, was not deemed necessary in all cases (as in extra-articular, meta-diaphyseal simple tibial fractures). Intra-articular tibial fractures were fixed with screws, wherever applicable, through mini-arthrotomies via separate small incisions, and metaphyseal voids were filled with autologous cancellous bone graft from the iliac crest (Figure 3).

Ten patients underwent fracture fixation within 24 hours of injury, 1 patient within 48 hours, and the remaining 3 had undergone surgery 5 and 6 days later following immobilization in a long leg cast until the extensive swelling subsided (Table 1). All patients received intravenous antibiotics (the antibiotic used was cefuroxime which is a second-generation cephalosporin) for 24 hours peri-operatively; those with an open fracture received antibiotics for 48 to 72 hours.

A short leg cast was applied for 24 to 48 hours post-operatively, for soft tissue treatment, followed by passive and active ankle mobilization, as soon as the pain allowed.
stockings for 6 weeks following surgery were the only anti-thrombotic measure in these patient series. The patients were reviewed clinically and radiologically at 3, 6, and 12 weeks following discharge from hospital and every 4 weeks afterward, unless specific reasons dictated otherwise.

The patients remained non–weight bearing (NWB) until callus formation was evident on the radiographs and subsequently progressed to partial weight bearing (PWB) until fracture union was achieved; they were then allowed to full weight bearing, even if the fracture was not consolidated fully (Table 1).

We were able to review all our patients in a special clinic, which was organized for that purpose. The follow-up reviews were done by A.M.N., S.L., and G.A. Demographic and clinical data were retrieved from the case notes. The quality of surgical reduction was scored from the post-operative radiographs by implementing the radiological score introduced by Burwell and Charnley.12 These scorings and extraction of other data were performed by S.L.

The functional outcome was evaluated using the American Foot and Ankle Society Score.13 The current patient employment status was recorded and patients were also asked about their satisfaction from the treatment they received.

The Ethical Committee approved our project for us to be able to review the medical records and radiological images for the purpose of publication.

The mean follow-up was 15 months (range: 13–20 months).

**Results**

In all, 12 of 14 patients (85.70%) had an excellent radiographic score of surgical reduction, whereas the remaining 2 (14.30%) ended up with an intra-articular step of 2 mm. There was no leg length discrepancy of more than 1 cm or any angular deformity of more than 5°. One patient (7.00%) developed superficial infection that was successfully treated with oral antibiotics; there was also a wound slough in 1 patient (7.00%); however, no bacteria were isolated from the cultures and local wound care, which included wound cleaning with sterile water and application of non-adhesive Vaseline gauze to the wound with an overlay of sterile dressing, which was adequate for healing. There were no deep infections. The mean hospital stay following surgery was 7 days (range: 3–12 days). Patients remained NWB for a mean of 4.7 weeks (range: 3–7 weeks) and PWB for a mean of 9.2 weeks (range: 7–11 weeks). All fractures (100%) united with a mean time to union of 13.8 weeks (range: 12–17 weeks) (Table 2).

Loss of reduction or failure of the implants was not recorded during the course of fracture healing; all implants were still implanted at the time of follow-up.

The mean ankle-hindfoot score at the time of follow-up was 84 (range: 76–97). All the patients were satisfied with the results (10 patients [71.00%] quoted the result ‘excellent’ and 4 patients [29.00%] ‘good’) and were all mobilizing well without significant pain.

Most of the patients were able to demonstrate near-normal ankle range of movements, whereas 3 of them (21.00%) had restriction of ankle motion, which, however, did not affect their daily activities. The pre-injury job status was affected in 3 patients (21.00%) who were previously heavy manual workers and had to be redeployed to lighter duties (Table 2).

**Discussion**

Distal tibial fractures represent a significant treatment challenge to orthopaedic surgeons.14 Early results using non-operative treatment of displaced high-energy intra-articular fractures of the distal tibia have been disappointing.14,15 Several authors have reported an unacceptably high incidence of complications, such as wound slough, deep wound infection, malunion, non-union, and even amputation following traditional techniques of open reduction and internal fixation (ORIF) of severe ankle injuries.5,6,16,17 Ovadia and Beals16 reported a 10% incidence of superficial wound infection and a 6% incidence of osteomyelitis in patients with closed fractures treated with ORIF. In the same patient series, the incidence of infection increased to 31% when the fracture was open. McFerran et al17 reported that major complications occurred in 40% of fractures treated with ORIF. Using minimal surgical intervention, in our patient series, the rate of both superficial and deep infection was significantly reduced compared with...
traditional ORIF, and there was no loss of reduction or implant failure with the use of LCPs.

Fixation with the use of a spanning unilateral external fixator offers advantages in the treatment of the soft tissue injury associated with tibial plafond fractures; however, concerns regarding this treatment method have also been reported in the literature. Pugh et al., comparing external fixation with ORIF for pilon fractures, found that fractures in the external fixator group showed significant tendency to lose their initial adequate reduction, independent of bone grafting or fibula fixation. Renzi Brivio et al. reported that in 25 patients treated with external fixation for pilon fractures, 9 patients (36%) developed post-operative complications ranging from pin tract infection, malunion, or pseudarthrosis to below-knee amputation due to osteomyelitis. Ankle and subtalar joint stiffness is another concern with this treatment modality compared with ring fixators that do not cross these joints.

Fixation of tibial plafond fractures by circular (Ilizarov) or hybrid frames constitutes an attractive method of treating these injuries as it disturbs minimally the soft tissues while providing adequate fracture stability to allow early loading and mobilization promoting fracture union. Leung et al. using limited open reduction and Ilizarov frame fixation reported comparable results with previous studies using ORIF; however, 29% of the patients developed pin tract infection. Hutson and Zych reported a 35% complication rate for juxtaarticular fracture management. On a series of 37 tibial plafond fractures treated with hybrid external fixation by Barbieri et al., a 35% complication rate was recorded, including 3 deep infections, 3 non-unions, and 3 loss of reduction, whereas in another patient series, the early outcomes of hybrid external fixation for distal tibial fractures were inferior to internal fixation.

Minimally invasive percutaneous plate osteosynthesis derives from the principle of 'biological' methods of fracture treatment with emphasis on preservation of blood supply to the bone, minimal surgical dissection, and maintenance of soft tissue envelope at the zone of injury to minimize the complications that are attributed to surgery. Various types of internal fixation devices could be used with this technique. Khoury et al. reported that the selection of soft or hard plates (AO 3.5-mm reconstruction plate or AO 4.5-mm dynamic compression plate) should depend on the fracture anatomy and configuration. Francois et al. reported the use of a prebent reconstruction plate via minimally invasive surgery for treating these injuries, with good results.

We prefer the use of an LCP with the MIPPO technique due to the added advantages of such a device, which include the following: locking of the screws onto the plate ensures angular as well as axial stability; eliminating the possibility of the screws to toggle, slide, or be dislodged, thus

| SERIAL NO. | AGE/SEX | SIDE | MECHANISM OF INJURY | CLASSIFICATION (AO) | DAYS TO SURGERY | NWB, WK | PWB, WK |
|------------|---------|------|---------------------|---------------------|----------------|--------|--------|
| 1          | 28/M    | R    | RTA                 | A2                  | 1              | 3/52   | 9/52   |
| 2          | 41/F    | R    | RTA                 | C2, open (Gustilo I)| 1              | 4/52   | 9/52   |
| 3          | 40/F    | R    | Fall from height    | C2                  | 6              | 6/52   | 10/52  |
| 4          | 29/M    | L    | RTA                 | B1                  | 2              | 4/52   | 9/52   |
| 5          | 45/M    | L    | Heavy object        | B1, open (Gustilo I)| 1              | 4/52   | 8/52   |
| 6          | 65/F    | L    | Twisting injury     | B2                  | 6              | 5/52   | 9/52   |
| 7          | 72/F    | L    | Twisting injury     | C2                  | 1              | 6/52   | 10/52  |
| 8          | 21/M    | R    | Fall from height    | C3                  | 1              | 7/52   | 7/52   |
| 9          | 49/M    | L    | Twisting injury     | A2                  | 1              | 4/52   | 9/52   |
| 10         | 35/M    | R    | RTA                 | C1                  | 1              | 4/52   | 11/52  |
| 11         | 29/M    | R    | RTA                 | B2                  | 1              | 3/52   | 9/52   |
| 12         | 44/F    | L    | Twisting injury     | A2                  | 1              | 4/52   | 9/52   |
| 13         | 56/M    | R    | Fall from height    | C1, open (Gustilo II)| 1              | 5/52   | 10/52  |
| 14         | 22/M    | L    | RTA                 | C3                  | 5              | 7/52   | 10/52  |

Abbreviations: NWB, non–weight bearing; PWB, partial weight bearing; RTA, road traffic accident.

The time elapse till surgery and the post-operative weight-bearing progression are included.
greatly reducing the risk of post-operative secondary loss of reduction; lack of compression of the plate against the bone suppresses the risk of primary loss of reduction and preserves the blood supply to the fracture site; ability to use screws in a compression mode if required to achieve best reduction of the fracture fragments; and no or less need of primary bone graft. As the LCP is based on external fixation biomechanical principles, we did not deem fixation of the fibula necessary in all cases.

Timing of surgery is important in the management of high-energy tibial plafond fractures. Mast et al. advocated surgery (ORIF) within 8 to 12 hours of injury or delaying surgery until soft tissue oedema is decreased. Following that principle, most of our patients underwent surgery within 24 hours of their injury, and wound-healing complications were minimal. For tibial plafond fractures that are associated with extensive soft tissue swelling, good results have been reported by a 2-stage procedure involving initial spanning external fixation followed by delayed minimal internal fixation to restore the joint congruency. In our patient series, severe injuries with excessive soft tissue compromise were still treated by a single-stage procedure (mini-arthrotomies and minimally invasive LCP fixation), following initial immobilization on a back slab and elevation until subsidence of the extensive oedema; our results are comparable with the ones above, avoiding, however, a second operation.

In the case of an open tibial plafond fracture, Francois et al. advocated a 2-stage procedure, which includes stabilization of the fracture by plating of the distal fibula and bridging external fixation, followed by removal of the fixator and application of a percutaneous plate, a week later. We treated all 3 of our patients with open fractures by irrigation, thorough surgical debridement of the wound, and primary fixation using percutaneous plating via the same or a separate wound. Although we had no deep infections with this method, in an open fracture beyond type 2 (according to the Gustilo classification), we would agree with a 2-stage procedure.

It is worth mentioning that other authors have described their experience with dealing with similar high-energy fractures, using different surgical techniques with variable results. Beytemür et al. in their paper titled ‘Is intramedullary nailing applicable for distal tibial fractures with ankle joint extension?’ noted that intramedullary nailing is not contraindicated in the management of simple intra-articular distal tibial fractures. In their retrospective case series, they achieved union in all their patients, similar to our case series. However, our mean union time was 13.8 weeks, whereas it was 16.5 weeks in their patients. Whether this difference is important or significant is not clear. They also noted varus or valgus deformities in 3 of their patients as well as rotational deformity in 1 patient. We did not record any angular deformity of significance. Such angular or rotational deformities may affect the cosmetic, if not the functional, outcome of treating these injuries. This needs to be taken into account.
consideration when making a choice of treatment method, and the patients need to be well informed about these complications. In an attempt to elucidate this concern, the same author reported his comparative findings in another paper where they used MIPO in one group of patients and intramedullary nailing in another but similar group of patients. They conceded that MIPO is the first preference according to the literature.

Recently, another group of authors reported their experience with a similarly small number of patients with similar fractures. However, they reported 1 case of delayed union. Similar to our case series, they reported 2 cases of superficial wound infection. Unfortunately, they had 1 case of deep wound infection which required repeated wound debridement and extended period of intravenous antibiotics. We did not experience such severe complications in our similarly small patient population.

**Limitations of the study**

The number of patients in our series is no doubt small. This in itself is a confounding factor in drawing conclusions. We therefore advise caution in the interpretation. However, it was during the early days of our use of this technique which should be
an encouragement for any surgeon who is starting to or will be using the technique in the future. Applying the principles correctly is what matters, rather than the numbers. In the future, we might be able to hold this same view or one that differs, if significantly larger numbers are associated with results that are completely different. We look forward to such times with great anticipation.

This report is retrospective, and we have not made a claim of superiority to other techniques, but to emphasize one of the repertoires for good results. Perhaps in the future, we or other surgeons might be able to conduct head-to-head studies comparing the different techniques to determine superiority.

We did not record the smoking status of our patients. Unfortunately, we do not know for sure how this would have influenced the outcome of this fracture surgery.

Conclusions
Management of distal tibial fractures with MIPPO using an LCP is a technically demanding procedure; however, if performed according to proper principles, it minimizes the risks of complications that are commonly associated with these injuries. We retrospectively analysed the early results of this treatment modality over a 1-year period in our institution and found them to be very encouraging with less risk of angular or rotational deformities.

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Author Contributions
SL and GA designed the study collated the data, wrote the text together, and contributed to the literature search. GA wrote the abstract and conclusions. AN was the lead surgeon and supervised most of the surgeries. All the authors reviewed and approved the final manuscript.

Disclosures and Ethics
As a requirement of publication, author(s) have provided to the publisher signed confirmation of compliance with legal and ethical obligations including, but not limited to, the following: authorship and contributorship, conflicts of interest, privacy and confidentiality, and (where applicable) protection of human and animal research subjects. The authors have read and confirmed their agreement with the ICMJE authorship and conflict of interest criteria. The authors have also confirmed that this article is unique and not under consideration or published in any other publication, and that they have permission from rights holders to reproduce any copyrighted material. Any disclosures are made in this section. The external blind peer reviewers report no conflicts of interest.

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