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Original article

Distal tibial fracture: An ideal indication for external fixation using locking plate

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ABSTRACT

Objective: To evaluate the feasibility and efficiency of one-stage external fixation by using locking plate in distal tibial fractures.

Methods: In this non-control prospective study, 28 patients with distal tibial fractures were included and underwent one-stage external fixation by using locking plate. There were 21 males and 7 females, with a mean age of 43 years (19–63). According to AO/OTA fracture classification, there were 9 cases of Type A1, 9 of Type A2, 10 of Type A3 fractures. There were 21 close and 7 open fractures. The locking plate was placed on the anteromedial aspect of the tibia with 4–5 bicortical screws inserted in both distal metaphysis and diaphysis. The radiographic and clinic results were evaluated.

Results: All patients were followed up for the average of 16 months (ranging from 12 to 21 months). The average surgery duration was 38 (25–60) minutes. The mean time to fracture healing were 14.6 ± 2.67, 17.5 ± 3.66, and 18.4 ± 3.37 ($p < 0.05$) weeks in type A1, A2, and A3 fractures respectively. By the end of the follow-ups, the mean AOFAS score were 96.11 ± 2.32, 92.67 ± 1.80 and 92.00 ± 2.06 ($p > 0.05$) in type A1, A2, and A3 fractures respectively. None of nonunion, deep infection, or breakage of screw or plate were observed.

Conclusions: Distal tibial fracture was the ideal indication for external fixation using locking plate. The external plating is characterized by ease of performance, less invasive, fewer soft tissue impingement, improved cosmesis, and convenient for removal.

Introduction

Distal tibial fractures are difficult to manage due to its poor blood supply and limited soft tissue envelope.[1,2] The dynamic compressive plating technique requires a large exposure to allow reduction and plate fixation to be performed. Inherit with the large exposure is an increase in the risk of non-union and infection.[3,4] Minimally invasive percutaneous plate osteosynthesis (MIPPO) reduces these risks. Nevertheless, precontoured and angular stable plates may be prominent under the skin of the medial malleolus and may cause secondary skin necrosis.[5–7] Intramedullary nailing can provide rigid stability in diaphyseal fractures of the tibia. However, secondary to the hourglass shape of the medullary canal at the metaphysis of the distal tibial, antegrade intramedullary nailing is a technically challenging procedure, carrying with it the specific risk of primary and secondary malalignment. Additionally, anterior knee pain is a common complaint after antegrade tibial nailing.[8–11]

In our experience, the distal tibial fracture should be treated as a type of "open fracture" due to its poor soft tissue envelope which will have been contused from the injury, even without an open wound. The importance of minimizing secondary damage to the soft tissues by the surgical approach and implants is equal to the importance of fixation of fracture. Therefore, we evaluated an external fixation using femoral LISS (Less Invasive Stabilization System) plate for some selected patients with distal tibial fractures.

In this study, we present the technique of external fixation of a distal tibial fracture using a femoral LISS plate. The plate was positioned over the anteromedial aspect of the tibia as an external fixator intended for definitive fixation. The purpose of this study was to evaluate the clinical outcomes and complications.

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Methods

Twenty-eight adult patients with unilateral distal tibial fractures were included from August 2011 to October 2012. Inclusive criteria were: skeletal maturity, an isolated fracture involving the distal one third of tibia, with or without fibular fracture. Exclusive criteria included: pathological fractures, Gustilo types III B or C open fractures,[12] tibial fractures accompanied with skin defect on the anteromedial aspect of lower limbs, comminuted fractures with substantial articular displacement, multiple fractures with spinal injury, and lower limbs with pre-existing neurological deficit, autoimmune disease, or vascular disease.

There were 21 males and 7 female, with the average age of 43 (19–63) years old. Four patients were caused by falling, 6 by motor vehicle accident, 10 in an automobile-pedestrian accident, and 8 in a sports related injury. The fractures were classified according to the AO/OTA guidelines,[13] including 9 type 43-A1, 9 type 43-A2, and 10 type 43-A3. There were 7 open fractures: including 2 Gustilo type I, 3 Gustilo type II, and 2 Gustilo type IIIA. The closed fractures were evaluated for soft tissue injury according to Tscherne classification.[14] An associated fibular fracture was present in 25 patients, including 10 proximal, 6 middle and 9 distal ones. Six patients were smokers. Four patients had diabetes mellitus. All smokers and diabetics were well monitored during the whole duration of treatment.

Surgical technique

The surgery was not performed until the swollen soft tissue relieved. The skeletal traction and administration of medicine were prescribed to alleviate the swelling. The average pre-operation length was 3 days (2–5 days) for the closed fractures. For the open fractures, the fixation of fracture was achieved after debridement in an emergency setting. The associated distal fibular fractures were internally fixed to correct the length, and provide lateral stability. The proximal and middle fibular fractures were not fixed in this study.

For the tibial fractures with spiral and oblique morphology, an incision with a length of 3 cm–4 cm was at the anterolateral aspect of tibia to expose and clean the gap between the fracture end. Using manual traction at the ankle or through a single Steinmann pin inserted into the calcaneus, the fracture was anatomically reduced. A clamp or two K-wires were used to temporarily fix and maintain the anatomic reduction. A femoral LISS plate (9–11 holes) (Synthes, Oberdorf, Switzerland) was placed over the anteromedial aspect of tibia. The contralateral femoral LISS plate was used for fixation. i.e., a right femoral LISS plate was used to fix a left distal tibial fracture, and a left femoral LISS plate was used to fix a right distal tibial fracture. This peculiarity was incorporated into our surgical technique because we found that the contour of contralateral femoral LISS plate was matched to the anteromedial aspect of the lower leg. The broad end of the plate was placed close to ankle joint, which can provide more screws to stabilize the short distal segment. The plate was placed as close to the skin as possible to increase the stability of fixation. The folded gauge (1 cm–2 cm in thickness) was used to keep the plate apart from the skin, preventing abrasion or shear stress between the plate and skin. Successive holes were drilled over locking drill-guides through incisions where the overlying soft tissue is intact, and at this point, depth was confirmed by using a depth gauge. The locking screws of corresponding length were inserted. All screws achieved bicortical purchase. In both proximal and distal fragments, 4 to 5 bicortical locking screws were inserted respectively (Fig. 1). The position and orientation of screws were checked with X-ray. The skin was sutured and a drainage tube was placed which was pull out 24 h later.

Fig. 1. Intraoperative picture showing the position of femoral LISS plate.

For comminuted distal tibial fractures, we did not perform open reduction. Under live C-arm X-ray, the reduction of length and alignment was achieved by manual traction and percutaneous manipulation using Schanz pins. Two K-wires were used to percutaneously fix and maintain the reduction. The following steps for placement of screws and plate were the same as the steps mentioned above.

The patients were allowed to walk with partial weight bearing from post-operative Day 2. The pin sites were cleaned twice a day using a Betadine solution. Patients were examined in the outpatient clinics every 4 weeks for radiographical and functional evaluation. Once cortical bridging on biplanar radiographs was observed, the patients were allowed to walk with full weight bearing for one month before the plate was removed in the outpatient setting.

The X-ray images were evaluated by two senior physicians who concluded the final outcome. Fracture healing was defined as the resolution of pain at the fracture site and cortical bridging on biplanar radiographs. Complications were defined as the fixation failure, infection, and non-union. The functional recovery was evaluated by an independent, trained medical interviewer who was not involved in their treatment, according to AOFAS ankle scoring system at a minimum of one year after plate removal.[15]

A group *t* test and ANOVA test were used to assess associations between the variables and outcomes. The variables included age, gender, and type of fractures. A p value of <0.05 was considered with significant difference.

Results

All patients were followed up for an average of 16.2 (12–21) months. The mean surgery length was 38 (25–60) minutes. All wounds healed without complications. After four-week follow-ups, all the patients had full range of motion in adjacent joints (Fig. 2). All fractures healed at a mean of 16.7 (12–24) weeks, without evidence for non-union, deep infection, or broken screws or plates (Figs. 3–5). The Type A3 fracture demonstrated a prolonged healing time, comparing with Type A1 fracture ($p = 0.038$) (Table 1). Once cortical bridging on biplanar radiographs was observed, the patients were allowed to walk with full weight bearing. After one month of weight-bearing walking, the patients underwent plate removal in the clinics. During the procedure of removing plate, the mean VAS (visual analogue score) was 3.5 (1–7) points. All plates and screws were removed without difficulty within 3 min. At final follow-up, there were no recurrent fractures. The mean AOFAS score was 93 (88–100). There was no significant difference in AOFAS between the different groups related to age, gender, and type of fractures ($p > 0.05$) (Table 1).

Three patients had local superficial pin site effusion without compromise of the clinical outcome. Two of them presented pin site effusion at 4 weeks post the operation. The effusion was under

Fig. 2. At 4 weeks postoperation, ankle joint with full range of motion.

control after undergoing continual cleansing with Betadine for one week. For the third patient who presented with a pin site effusion after 12 weeks of operation, the involved screw was removed when the effusion was still present despite one week of cleaning with Betadine. All patients were satisfied with their outcome and all of them archived desirable quality of life comparing to those of pre-injury.

Discussion

The surgical treatment of distal tibia fractures is challenging because of the subcutaneous location of the bone, poor vascularity, and the limited soft tissue coverage.[16] The external fixation is an damage-control approach to treat open fractures, but are often bulky and many patients find them less than aesthetically pleasing. Besides the complication of anterior knee pain, intramedullary nailing of distal tibial fractures has not been proven to be stable. Additional devices are recommended to reinforce the stability of nailing, such as blocking screws and another locking plate, either of which will increase surgery length and medical cost. The clinical series using internal locking plate demonstrated favorable results, but several complications, including soft tissue necrosis and infection, are not rare.[17,18]

Our study has the limitations of: the lacking of the control group and the controversial medical management of the closed fractures with external fixation, which were traditionally treated with internal fixation.

We used femoral LISS plates other than tibial locking plates out of three considerations. First, the anteromedial aspect of tibia can be clearly palpated, which facilitates fast and accurate insertion of screws with less risk of neurovascular injuries. In our study, the average surgery length was 38 min which was obviously short for an operation involving in tibial fractures. Second, we found that the contour of femoral LISS plate was matched to the anteromedial aspect of contralateral lower limb. The plate can be placed very close to the skin and be well consealed under stockings, enabling patients to walk with normal trousers. Thirdly, the broad end of

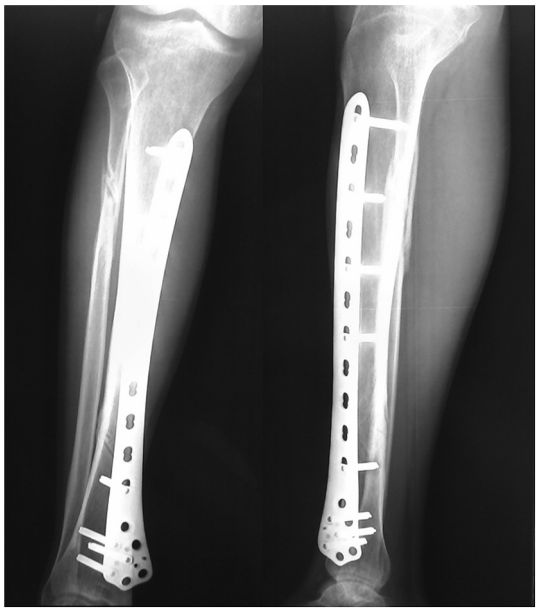

Fig. 4. Twelve weeks postoperative X-ray showing fracture healing.

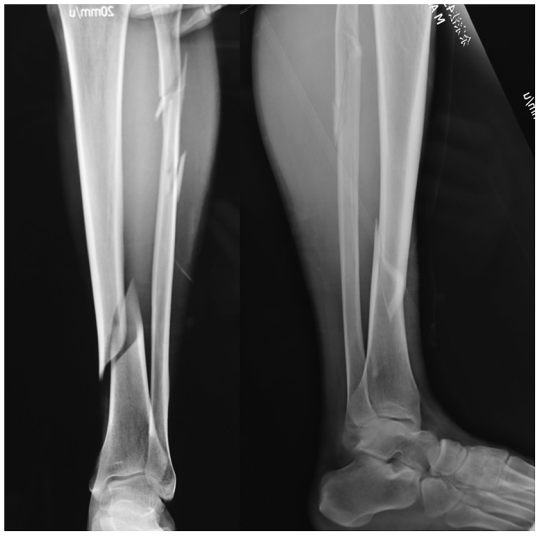

Fig. 3. Preoperative X-ray showing distal tibial fracture with proximal fibular fracture.

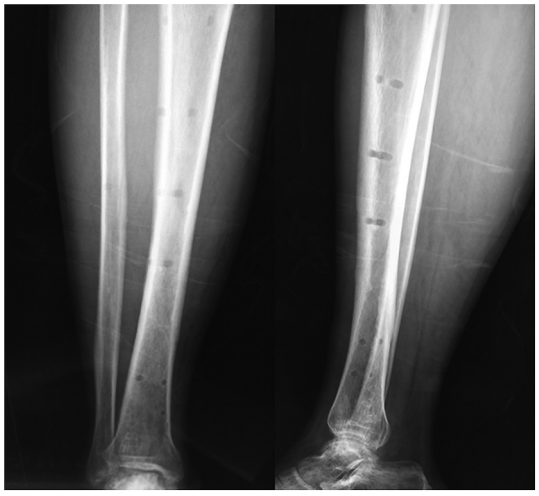

Fig. 5. Six months after plate removal, X-ray showing well fracture healing.

Table 1
Comparison of results between different groups.

	Time of fracture healing (weeks)	*p* Value	AOFAS score	*p* Value
Male	16.48 ± 3.46		93.57 ± 2.69	
Female	17.71 ± 3.90	0.434	93.43 ± 2.94	0.196
Closed fractures	16.86 ± 3.38		93.57 ± 2.56	
Open fractures	16.29 ± 4.39	0.722	91.57 ± 2.69	0.089
Age <50 years	17.05 ± 3.2		93.71 ± 3.64	
Age ≥50 years	16.00 ± 4.28	0.508	93.48 ± 2.42	0.562
Type A1	14.6 ± 2.67		96.11 ± 2.32	
Type A2	17.5 ± 3.66		92.67 ± 1.80	
Type A3*	18.4 ± 3.37	0.038	92.00 ± 2.06	0.053

*Comparing with type A1, $p = 0.038$.

femoral LISS plate has greater versatility to insert distal screws, with seven distal holes allowing more precise modulation to get the greatest bone purchase. The diameter of screws in femoral LISS plate is greater than that of the screws in the tibial plate. All screws used in this study were bicortical. Using a femoral LISS plate with 9–11 holes, there are 4–5 screws in both distal and proximal segment respectively. All these features mentioned above increase the stability of construct, which is beneficial for fracture healing.[19,20] In this study, all patients achieved fracture union with a mean time of 16.7 (12–24) weeks. At the final follow-up, there were no nonunions, no loosening nor breakage of screws and plates.

The medially placed screws have less influence on the activity of muscles. The patients were allowed to walk with partial weight bearing from the second day after the operation. None of the patients complained of discomfort with ankle motion. Their function was high, with an average AOFAS score 93. In other authors' reports,[21] the tibial LISS plates were placed on the lateral aspect of tibia and progressed to internal fixation in staged operations. The laterally placed plate had many disadvantages. The distance between plate and bone is large, resulting in increased offset. Additionally, the screws only achieved unicortical purchase. These factors decreased the stiffness of the fixation construct. At the same time, laterally placed screws passed through the muscles on the anterolateral aspect of tibia can compromise the activity of muscles and cause discomfort, pin site effusion, and even cause neurovascular injuries.

Once cortical bridging on biplanar radiographs was observed, the patients were instructed to walk with full weight bearing for one month to allow for adequate remodeling of the bone, which should theoretically decrease the risk of fracture after plate removal. In this study, all screws and plates were removed in clinic without difficulty within three minutes. During the procedure of plate removal, the mean VAS was 3.5 (1–7) points. We did not encounter any difficulty in removing these external screws and plates. No recurrent fracture presented after plate removal. In contrast, the operation to remove an intramedullary nail or internal locking plate can be troublesome in some cases. In Raja's report of plate removal, the rate of complication was as high as 47%.[22]

As for infection, it was reported that the rate is 1% in closed tibial fractures, 5% for Gustilo Type I, 10% for Type II, and >15% for Type III.[23–25] Using external plating, deep infection becomes less of a concern due to maintenance of the integrity of the soft tissue envelope. In this study, there were 7 open fractures that underwent external plating. None of these open fractures developed an infection. Three patients were observed with occurrence of effusion from one or two of the screw sites. However, these did not demonstrate loosening nor breakage of plates and screws, and none had a deep infection.

Using external plating, the knee pain and malalignment which were common with nailing can be avoided. The fractures were anatomically reduced by open reduction with a small incision without massive dissection. There were only stab incisions for screw insertion. The external plate makes digging and tunneling around the bone unnecessary. The femoral LISS plate was used for definitive fixation without transition to internal fixation, which assuredly decreases both medical expenses and surgical injuries.

In conclusion, external fixation of distal tibial fracture using locking plate is still controversial, particularly for the closed fractures. Because the internal fixation is the classical surgery for the closed fractures. Furthermore, it can be regarded as an expansion of application of femoral LISS plate, which is designed for the internal fixation of femoral fracture. In this study, we found that the external fixation using femoral LISS plate is a promising novel concept for the treatment of distal tibia fractures. This technique can shorten the surgical duration, decrease medical expenses, and is characterized as easy performance, minimally invasive, fewer complications, improved cosmesis, and proved convenient for removal. Longer follow-up and larger series of patients are needed for to confirm these findings.

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