One-Stage External Fixation Using a Locking Plate: Experience in 116 Tibial Fractures

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Abstract: The authors report the results of 1-stage external fixation using a locking plate in 116 tibial fractures (85 closed and 31 open). The patients were followed for an average of 22 months. The mean duration of surgery was 42 minutes. The mean fracture healing time was 12 weeks for proximal, 20 weeks for shaft, 14 weeks for distal, and 24 weeks for multisegmental tibial fractures. Nonunion, deep infection, and breakage of screws did not occur. External plate fixation is effective for tibial fractures and especially for metaphyseal fractures. It has the advantages of being easy to perform and less invasive, and the plate is conveniently located for removal. [Orthopedics. 2015; 38(8):494-497.]

The early design of the external plate was part of the Zespol system. It involved multiple nuts and washers, which may have dissuaded surgeons receptive to this technique. Since the advent of the locking plate with fewer moving parts, there has been a resurgence of interest in this technique.

However, most of the published studies on this topic have involved small numbers of patients. Furthermore, external plate fixation has often been described in staged surgeries for open fractures. Therefore, the use of external plate fixation remains controversial.

The current authors describe their early experience with 1-stage external fixation using a locking plate in 116 tibial fractures including both closed and open fractures.

Materials and Methods

To be included in this study, patients had to be skeletally mature and have a fracture involving the tibia with or without a fibular fracture. Patients were excluded if they had pathological fractures, Gustilo type IIIb or IIIC open fractures, comminuted fractures with substantial articular displacement, lower limbs with preexisting neurological deficit, or vascular disease.

Between July 2011 and January 2013, 116 successive patients with tibial fractures, including 85 closed and 31 open fractures (18 Gustilo type I and 13 Gustilo type II), underwent external plate fixation. There were 91 men and 25 women, with a mean age of 43 years (range, 19-63 years). There were 20 proximal, 39 shaft, 52 distal, and 5 multisegmental tibial fractures. Fractures were due to a fall (n=16), a motor vehicle accident (n=42), and a motor vehicle accident when the patient was a pedestrian (n=58).

Surgical Technique

Femoral LISS (Less Invasive Stabilization System; Synthes, West Chester, Pennsylvania) plates were positioned over the anteromedial aspect of the tibia as an external fixator intended for definitive fixation of tibial fractures. For proximal tibial fractures, ipsilateral femoral LISS plates were used (ie, the left proximal tibial fracture was fixed with the left femoral LISS plate). For distal tibial fractures, contralateral femoral LISS plates were used (ie, the left distal tibial fracture was fixed with the right femoral LISS plate). For tibial shaft and multisegmental fractures, the type of plate depended on whether the fracture line was...
close to the proximal or distal tibia. After that, it was fixed as a proximal or distal tibial fracture. This peculiarity was incorporated into the authors’ surgical technique because they found that the plate could be placed close to the anteromedial aspect of the tibia in this way.

All procedures were performed by 3 physicians (J.Z., M.L., X.H.). Each of them had 15 years of orthopedic surgery experience. The mean time between trauma and surgery was 3 days (range, 2-5 days) for closed fractures. For open fractures, fracture fixation was achieved after debridement in the emergency setting.

The associated distal fibular fractures were internally plated first to restore the correct length. The proximal and middle fibular fractures were not fixed.

For tibial fractures with spiral and oblique morphology, a small incision was made to expose and anatomically reduce the fracture. A clamp or 2 K-wires were used to temporarily fix and maintain the anatomic reduction. The broad end of the plate was placed close to the joint; this can provide more screws to stabilize the short metaphyseal segment. A stack of evenly folded towels (1 to 2 cm thick) was provisionally used to keep the plate apart from the skin. Successive holes were drilled over locking drill-guides through stab incisions, where the overlying soft tissue envelope was intact. Once the depth had been determined, 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. The position and the orientation of the screws were checked with fluoroscopy. The skin was sutured and a drainage tube, which was discontinued after 24 hours, was embedded.

For comminuted tibial fractures, reduction of length and alignment were achieved via manual traction and percutaneous manipulation using Schanz pins under live C-arm fluoroscopy. The K-wires were used to percutaneously fix and maintain the reduction. The subsequent steps for placement of the screws and plate were the same as those mentioned above.

Patients were allowed to walk with partial weight bearing starting on postoperative day 2. The screw sites were cleaned twice a day with a Betadine solution (Aidplus Medical Appliance Co, Ltd, Shenzhen, China). Patients were seen in the clinic every 4 weeks for radiographic and functional evaluation.

**Results**

The patients were followed for a mean of 22 months (range, 18-30 months). The mean duration of surgery was 42 minutes (range, 30-71 minutes). All traumatic wounds healed without further problems.

The mean fracture healing time was 12 weeks (range, 10-20 weeks) for proximal tibial, 20 weeks (range, 12-28 weeks) for tibial shaft, 14 weeks (range, 12-20 weeks) for distal tibial, and 24 weeks (range, 16-36 weeks) for tibial multisegmental fractures.

Once cortical bridging was observed on biplanar radiographs, patients were allowed to walk with full weight bearing for 1 month before the plate was removed in an outpatient setting. All plates and screws were removed without difficulty within 3 minutes.

Eight patients had transient pin site infections without compromise of clinical outcome. Five infections occurred 4 weeks postoperatively and were controlled after continual cleansing with Betadine solution for 1 week. Three infections occurred 12 weeks postoperatively and were resolved by removing the involved screws.

All of the patients were satisfied with their outcomes and returned to their previous activity levels. Nonunion, deep infection, and breakage of screws and plates did not occur.

Representative cases of proximal tibial (Figures 1-2), tibial shaft (Figures 3-4), distal tibial (Figures 5-6), and tibial multisegmental (Figures 7-8) fractures are presented in this article.

**Discussion**

Compared with traditional external fixators, which are of-
Ten bulky, locking plates have a low profile and thus are less likely to strike the contralateral lower leg in the swing-through phase of either leg during amputation.\(^7\)

The current authors used femoral LISS plates instead of tibial locking plates for 3 reasons. First, they have found that the contour of the femoral LISS plate matches the anteromedial aspect of the tibia. The plate can be placed very close to the skin and can be well concealed under stockings, enabling patients to walk while wearing trousers. Second, the anteromedial aspect of the tibia can be clearly palpated, facilitating fast and accurate insertion of screws with less risk of neurovascular injuries. Third, the broad end of the femoral LISS plate has 7 holes, allowing more precise modulation to obtain the greatest bone purchase. The diameter of the screws in the femoral LISS plate is greater than that of the screws in the tibial plate. Bicortical screws were used in this study. All of these features increase the stability of the construct.

All of the patients eventually achieved fracture healing. The fracture healing time was shorter for tibial metaphyseal than for tibial shaft and multisegmental fractures.

Conventional treatment for tibial fractures includes plating or nailing.\(^8\) Internal plating with large exposure increases the risks of nonunion and infection. Percutaneous plating reduces these risks. Nevertheless, the submuscle or subcutaneous plates may be prominent under the skin or muscles and may cause soft tissue problems.\(^9-11\) Intramedullary nailing can provide rigid stability in tibial shaft fractures. However, for tibial metaphyseal fractures that have an hourglass-shaped medullary canal, nailing is a technically challenging procedure with risk of malalignment. Complementary devices such as blocking screws and an additional locking plate, both of which will increase surgical duration and costs, are recommended to augment the stabil-

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Figure 3: Anteroposterior radiographs showing a tibial shaft fracture preoperatively (A), postoperatively (B), and after plate removal (C).

Figure 4: Postoperative medial side photograph showing a tibial shaft fracture with an external plate in situ.

Figure 5: Anteroposterior radiographs showing a distal tibial fracture preoperatively (A), postoperatively (B), and after plate removal (C).

Figure 6: Postoperative medial side photograph showing a distal tibial fracture with an external plate in situ.
ity of nailing. Additionally, anterior knee pain is commonly reported after antegrade tibial nailing.12-14

One-stage external plate fixation decreases both costs and surgical injuries. Fractures are anatomically reduced via a small incision without massive dissection. The medially placed screws and plate have less influence on muscle activity. Because stab incisions were used for screw insertion, and therefore digging and tunneling around the bone was not necessary, the risk of infection could be decreased. With external plat-ing, deep infection is less of a concern due to maintenance of the integrity of the soft tissue envelope.

In this study, 31 open fractures underwent external plat-ing and none developed an infection. All of the screws and plates were removed within 3 minutes in an outpatient setting. The authors did not encounter difficulty removing these external screws and plates. No recurrent fracture occurred after plate removal. In contrast, surgery to remove an intramedullary nail or an internal locking plate can lead to complications in some cases. Raja et al15 reported a complication rate as high as 47% for plate removal.

CONCLUSION

The authors found that external plate fixation is effective for tibial fractures and especially for metaphyseal fractures. The femoral LISS plate is effective as an external fixator for tibial fractures because the contour of the plate matches the anterome-dial aspect of the tibia. This technique has the advantages of being easy to perform and less invasive, and the plate is conveniently located for removal. Additional studies are needed to confirm these find-ings.

REFERENCES