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Metaphyseal locking plate as a definitive external fixator for treating open tibial fractures—Clinical outcome and a finite element study

Ching-Hou Ma [a], Chin-Hsien Wu [a], Yuan-Kun Tu [a,b], Ting-Sheng Lin [b,*]

[a] Department of Orthopedics, E-Da Hospital, Kaohsiung, Taiwan
[b] Department of Biomedical Engineering, I-Shou University, Kaohsiung, Taiwan

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ABSTRACT

We evaluated both the outcome of using a locking plate as a definitive external fixator for treating open tibial fractures and, using finite element analysis, the biomechanical performance of external and internal metaphyseal locked plates in treating proximal tibial fractures. Eight open tibial patients were treated using a metaphyseal locked plate as a low-profile definitive external fixator. Then, finite element models of internal (IPF) as well as two different external plate fixations (EPFs) for proximal tibial fractures were reconstructed. The offset distances from the bone surface to the EPFs were 6 cm and 10 cm. Both axial stiffness and angular stiffness were calculated to evaluate the biomechanical performance of these three models. The mean follow-up period was 31 months (range, 18–43 months). All the fractures united and the mean bone healing time was 37.5 weeks (range, 20–52 weeks). All patients had excellent or good functional results and were walking freely at the final follow-up. The finite element finding revealed that axial stiffness and angular stiffness decreased as the offset distance from the bone surface increased. Compared to the IPF models, in the two EPF models, axial stiffness decreased by 84–94%, whereas the angular stiffness decreased by 12–21%. The locking plate used as a definitive external fixator provided a high rate of union. While the locking plate is not totally rigid, it is clinically stable and may be advisable for stiffness reduction of plating constructs, thus promoting fracture healing by callus formation. Our patients experienced a comfortable clinical course, excellent knee and ankle joint motion, satisfactory functional results and an acceptable complication rate.

Introduction

Open tibial fractures pose treatment dilemmas for orthopedic surgeons. These injuries are associated with significant morbidity due to the increased risks of infection, nonunion, malunion, joint stiffness and possible amputation.[1,2] Recently, we designed a two-stage protocol for open tibial injury consisting of a first stage that used low-profile, locked plates for temporary external fixation after debridement and anatomic reduction, followed by soft-tissue reconstruction. The second stage then consisted of locked plates for definitive internal fixation, using minimally invasive percutaneous osteosynthesis.[3–5]

During our practice, eight open tibial fractures were healed without major complications by only the first-stage treatment due to patients' refusing the second-stage treatment. The possibility of one-stage locked plating was enlightening. However, we were concerned about the external locked plate not having sufficient stiffness. Descriptions in the literature of fixation stability using this new external locked plating technique are limited. Consequently, clinical recommendations on its practical use to reduce the risk of implant failure still remain to be determined.

The purpose of this study was to evaluate the outcome of using a metaphyseal locked plate as a definitive external fixator for treating open tibial fractures. The second goal was to compare the biomechanical stiffness of the external and internal metaphyseal locked plates for tibial fracture in the finite element (FE) model and evaluate whether the external metaphyseal plate alone has enough strength until bone union.

Materials and methods

Between January 2006 and December 2010, a total of 68 patients with open tibial fractures were treated at our institution using the described technique. Eight of the 68 patients (six men, two women), ranging in age from 21 to 64 years (average age, 44 years), received only the first-stage treatment and refused the second-stage procedure (Table 1) (Fig. 1). Of these patients, five were Gustilo and Anderson type III (A: 2, B: 3), two were type II and

* Corresponding author at: Department of Biomedical Engineering, I-Shou University, No. 8, Yida Rd., Yanchao District, Kaohsiung City 82445, Taiwan. Tel.: +886 7 6151100x7463; fax: +886 7 6155150.
E-mail addresses: tslin@isu.edu.tw, tslin.bme@gmail.com (T.-S. Lin).

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Table 1
Patient demographics.

Case	Age/gender	Mechanism	Gustilo grade	AO/OTA classification	Other fracture	Associated injury
1	28/Male	MCA	IIIA	42-C2		
2	44/Female	Fall	II	41-C3	Calcaneus	
3	64/Male	MVA	IIIB	42-C1/43-A3	ribs, clavicle	Hemopneumothorax
4	34/Male	MVA	IIIB	42-C2		
5	49/Male	Fall	II	43-C1	pelvis	
6	51/Female	MCA	IIIA	43-C2		
7	21/Male	MCA	–	41-A3	Radius	Intracranial hemorrhage
8	64/Male	MCA	III	41-C2		

MCA, motorcycle accident; MVA, motor vehicle accident.

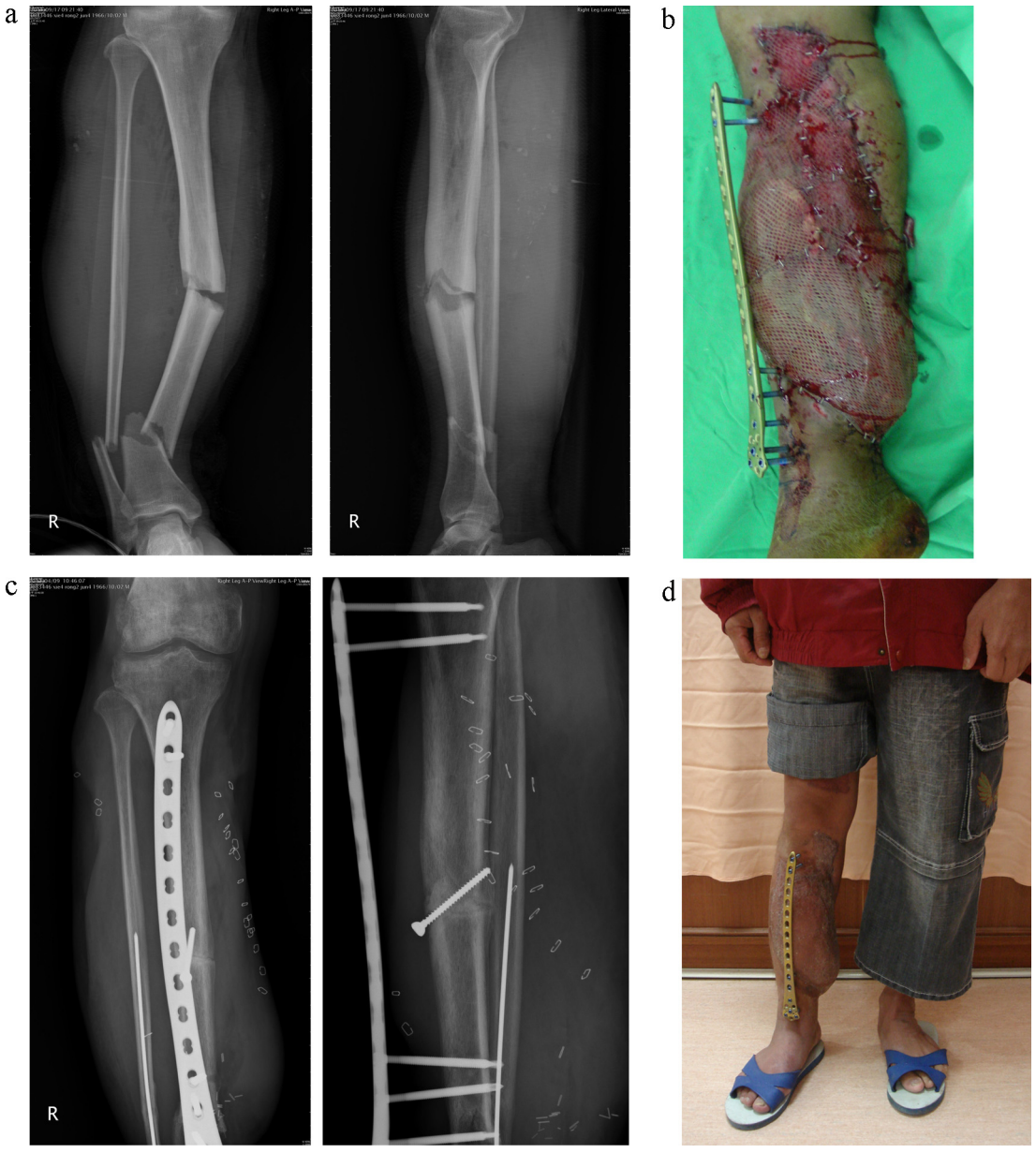

Fig. 1. (a) A 34-year-old male (case 4) sustained Gustilo type IIIB, AO/OTA 42-C2 fractures. (b) The fracture was stabilised with metaphyseal locked plate used as definitive external fixator, and then the soft tissue defect was treated with a latissimusdorsalis free flap. (c) Antero-posterior and lateral X-ray images after surgery and (d) the low-profile locked plate provided adequate stability with few limitations on dressing or walking.

one was a closed fracture at the initial injury.[6] The fractures were caused by falls from heights of >2 m ($n = 2$) and traffic accidents ($n = 6$).

All eight fractures were evaluated radiographically and clinically. The radiographic evaluation was done using antero-posterior and lateral postoperative radiographs as well as antero-posterior and lateral weight-bearing radiographs taken at the time of healing and at the most recent follow-up. Time to union, nonunion, malunion, leg shortening, range of motion for the knee and ankle, deep infection and reasons for no internal