Distal Tibial Fracture Fixation with Locking Compression Plate (LCP) Using the Minimally Invasive Percutaneous Osteosynthesis (MIPO) Technique

Abid Mushtaq[1], Rizwan Shahid[2], Muhammad Asif[3], Mohammad Maqsood[1]

Abstract

Background: Treatment of distal tibial fractures has always been a challenge. Distal tibia is more superficial, with less soft tissue coverage and blood supply. Therefore, operative treatment can lead to complications. We aim to see the results of the distal tibial fracture fixation with LCP using MIPO.

Patients and Methods: Twenty-one consecutive patients were prospectively reviewed. AO types 43A, 43B and 43C were included. Fourteen male and seven female patients with a mean age of 51 years were included.

Results: Mean time to union was 5.5 months (range 3–13 months). Seventeen fractures healed with good functional outcome. One patient had delayed union. One patient had nonunion and underwent revision; the fracture ultimately healed with good functional outcome. Two patients developed superficial wound infections but the fractures united completely.

Discussion: The MIPO technique for distal tibia has shown good results with many additional advantages over the conventional methods. Early mobilization without risk of secondary displacement helps to prevent stiffness and contracture.

Key Words

Locking compression plate (LCP) · Minimally invasive plate osteosynthesis (MIPO)

Eur J Trauma Emerg Surg 2009;35:159–64

DOI 10.1007/s00068-008-8049-1

Introduction

Unstable fractures of the distal tibia with or without intra-articular fracture extension can present a management challenge. High rates of associated complications have been reported with conventional methods of fixation [1–6]. Intramedullary nailing is generally not considered suitable for distal periarticular tibial fractures. Conventional open reduction and internal fixation of such injuries results in extensive soft tissue dissection and periosteal injury, compromising the blood supply, and may be associated with high rates of infection, delayed union, and nonunion [1–6]. Similarly, external fixation of distal tibial fractures may also be associated with a high incidence of pin site infection and loosening in up to 50% of cases and malunion rates of up to 45% [7].

Minimally invasive plate osteosynthesis (MIPO) may offer biological advantages. Reduced soft tissue dissection and exposition results in low surgical trauma and thus preservation of the blood supply is one of the main advantages of MIPO. Biological fixation is achieved with lesser evacuation of osteogenic fracture hematoma [8]. Locking compression plates provide a stable construct. They function as an internal–external fixator in a bridging fashion [7, 9–18]. Minimally invasive plate osteosynthesis (MIPO) was recently introduced with many claimed benefits, and has now become more popular with the development of the distal tibial LCP [18–21]. This plate is side-specific and precontoured to match the shape of the medial aspect of the tibia, which helps to achieve indirect reduction of the fracture. The plate is tunneled subcutaneously, but extraperiosteally, through a small skin incision (2 cm) and along the medial aspect of the tibia and then fixed with locking screws. The device allows the screws to lock to the plate, thus creating a stable fixed-angle device [6, 22].

[1] Lincoln County Hospital, Lincoln, UK,
[2] Countess of Chester Hospital NHS Trust, Chester, UK,
[3] Blackpool Victoria Hospital, Blackpool, UK.

Received: April 2, 2008; revision accepted: August 5, 2008;
Published Online: October 18, 2008

Table 1. Summary of results.

Pt. no.	M/F	Age	MOI	AO classification	Open/closed	Delay in fixation (days)	Op. time (min)	Fibula fixation	Union (months)	FWB (weeks)	Complications
1	M	67	RTA	43B2	Closed	15 (blisters)	70	No	6	6	No
2	F	42	Fall	43A3	Closed	2	90	Yes	13	13	D-union
3	M	34	Fall	43A3	Type I	2	50	Yes	9	9	No
4	M	92	Fall	43A2	Closed	6	55	No	6	6	No
5	M	47	RTA	43A2	Closed	8	65	No	6	6	No
6	M	45	RTA (polytrauma)	43A1	Closed	1	70	No	4	4	No
7	M	48	Fall	43C2	Closed	2	110	Yes	5	5	No
8	M	33	Fall	43A2	Closed	9	100	No	5	5	No
9	F	38	Fall	43A2	Type I	1	65	Yes	6	6	No
10	F	40	RTA	43A2	Closed	1	90	Yes	12	12	W inf
11	M	58	RTA (polytrauma)	43B3	Closed	1	120	Yes	5	5	No
12	M	36	RTA (polytrauma)	43B2	Type II	4		Yes	6	12	W inf
13	M	79	Fall	43A2	Type I	1	60	No	6	6	No
14	F	94	Fall	43A1	Closed	1	75	Yes	3	3	No
15	F	75	RTA	43C3	Type II	7	90	Yes		24	N-union
16	M	51	Fall (skiing)	43A2	Closed	4	90	Yes	3	6	No
17	F	39	Fall	43B1	Closed	2	95	No	6	6	No
18	M	31	RTA	43A2	Closed	3		No	3	12	No
19	F	26	RTA (polytrauma)	43C1	Closed	1	200	Yes	6	6	No
20	M	46	Fall	43A2	Closed	3	80	Yes	4	4	No
21	M	57	Fall	43A1	Closed	14	105	No	4	4	No

Indications for minimally invasive plate osteosynthesis of distal tibial fractures include displaced distal tibial fractures (43A, 43B and 43C), unstable metaphyseal fractures that are too distal for safe stabilization with intramedullary nails [2], and fractures with intra-articular extensions.

We reviewed our experience in treating distal tibia fractures using the new LCP plate with the MIPO technique in 21 patients in order to assess clinical and functional outcome.

Patients and Methods

We prospectively followed the patients who underwent distal tibial fracture fixation consecutively with LCP using the MIPO technique between March 2003 and December 2005 at Lincoln County Hospital, UK. A total of 21 patients (7 female, 14 male) with a mean age of 51 years (range 24–92 years) were included. There were 16 closed and five open fractures.

Our series included high-energy open and closed fractures of distal tibia. The fractures included both intra and extrarticular injuries. We kept the medical records and radiographs for each case under review. Fractures were classified according to the AO comprehensive classification system [23] (Table 1). There were fourteen 43A, four 43B and three 43C fractures. Open fractures were classified according to the Gustilo and Anderson classification system [24]. Nine patients were involved in road traffic accidents and 12 had a fall from height. Out of nine RTA patients, four had multiple injuries. There were five open fractures (three type I and two type II, Gustilo and Anderson). All of the patients had an associated fibular fracture. Wounds associated with open fractures were managed initially by standard debridement and irrigation and primary fixation, with subsequent plastic surgical involvement used where appropriate (Figures 1, 2).

Patients were allowed to mobilize nonweight-bearing with crutches on the first postoperative day with active and passive foot and ankle exercises. Enoxaparin and TEDS were used as thromboprophylaxis postoperatively. The patients started partial weight-bearing at six weeks which could then gradually be increased to full weight-bearing depending on the radiological and clinical assessment.

Patients were followed up in the outpatient department at two weeks post-op for wound inspection and to check radiographs. They were then reviewed at intervals of six weeks and three, six and twelve months

Figure 1. Figure showing small incisions with good healing.

after surgery with a clinical and radiological examination. The patients were discharged when the fracture was completely united and any postoperative complications had been identified and treated appropriately.

Surgical Technique

One senior consultant trauma surgeon performed all of the operations. Intravenous antibiotics were given at induction. The patient was positioned supine on a table, with a thigh tourniquet. Percutaneous plating was performed after satisfactory closed indirect reduction was achieved and the plate was temporarily fixed using K-wires through the plate. This plate has specially designed holes on the distal and proximal tip of the plate for this purpose. A kidney dish rolled in a towel was placed under the leg to prevent posterior sagging of the tibia at the fracture site during the fixation. For 43C fractures, shortening, axis deviation and quality of reduction was achieved using the following techniques: (1) by anatomical reduction and fixation of the fibula; (2) manual traction and temporary fixation of the bone using K-wires; (3) intraarticular fractures which were displaced or rotated were anatomically reduced using thick (2 mm) K-wires or Steinmann pins as a joystick. Preliminary reduction was checked under image intensifier. Femoral distractor was not used as a reduction tool. A distal tibial LCP (Synthes) was tunneled subcutaneously but extraperiosteally through a short longitudinal incision (2 cm) over the medial malleolus, avoiding injury to the saphenous nerve and vein. Interfragmentary compression was accomplished in selected cases with a plate-independent lag screw (PILS) or through the plate (Figure 1).

The fibular fracture was fixed in 12 cases using a one-third tubular plate, which helped to bring the tibia out to length and reduce the fracture. In the other nine patients, the fibula fracture involved the proximal third and so did not require fixation. An image intensifier was used intraoperatively to assess fracture reduction and fixation. Wound closure was achieved with absorbable braided suture material for the deep layers and a monofilament subcuticular suture to the skin. A wool and crepe bandage was applied. A removable ankle splint was used at night in six patients who were elderly and less active in order to prevent equinus deformity.

Results

We followed these 21 patients for clinical and radiological outcome (Figures 2, 3).

The median number of days between admission and definitive fracture fixation was two days (range 0–15 days). Mean operation time was 88 min (range 50–200). The fibula was fixed in 12 cases (Table 1). Bone grafting from the iliac crest was performed at the time of definitive fixation in two cases (15 and 21). Minimum follow-up was 12 months.

Fracture healing was defined as radiological evidence of bridging mature callus combined with pain-free full weight-bearing. Mean union time was 5.5 months (range 3–13 months). In the closed fracture group, 14 fractures united within six months, one fracture took between six and twelve months, and one fracture united twelve months after surgery. In the open fracture group of five patients, three fractures healed within six months, one in nine months, and one case developed aseptic nonunion.

Two patients developed wound infections (cases 10 and 12). One patient had a delayed union (case 2) and the other developed nonunion (case 15).

Case 10 (who developed a wound infection) was a 40-year-old lady. She was a diabetic with poor control and HbA1C 11.8. The skin over the fracture site was noted to be ischemic at the time of operation. The skin broke down at the level of ischemia postoperatively. Plastic surgeons were involved and a skin flap was transferred. The fracture healed and the plate was removed after 12 months.

Case 12 had a type II open 43B2 fracture. This gentleman was involved in a RTA and had multiple

Figures 2a to 2d. a-b) Preoperative fracture of distal tibia AP and lateral radiographs. c-d) Postoperative AP and lateral radiographs.

injuries, including ipsilateral femoral shaft fracture, diaphragm rupture, and liver and splenic injuries. He had a deep laceration on the anterolateral aspect of the leg away from the fracture site which showed the signs of superficial infection. The patient recovered well after a course of antibiotics and the fractures healed completely at six months.

Case 2 had delayed union. This patient was known to have multiple sclerosis and hypothyroidism. She underwent revision with exchange plating and bone grafting, and the fracture eventually healed at 13 months.

Case 15 (who developed nonunion) was a 75-year-old female. This lady was on long-term steroids for asthma. The patient had a type II open 43C3 fracture. The fracture was temporarily fixed with an external fixator for initial soft tissue management. LCP fixation was performed after seven days and the external fixator was removed at the same time. She developed nonunion, for which revision surgery with exchange plating (LCP) and bone grafting was performed at 18 months. The fracture subsequently healed after six months.

Discussion

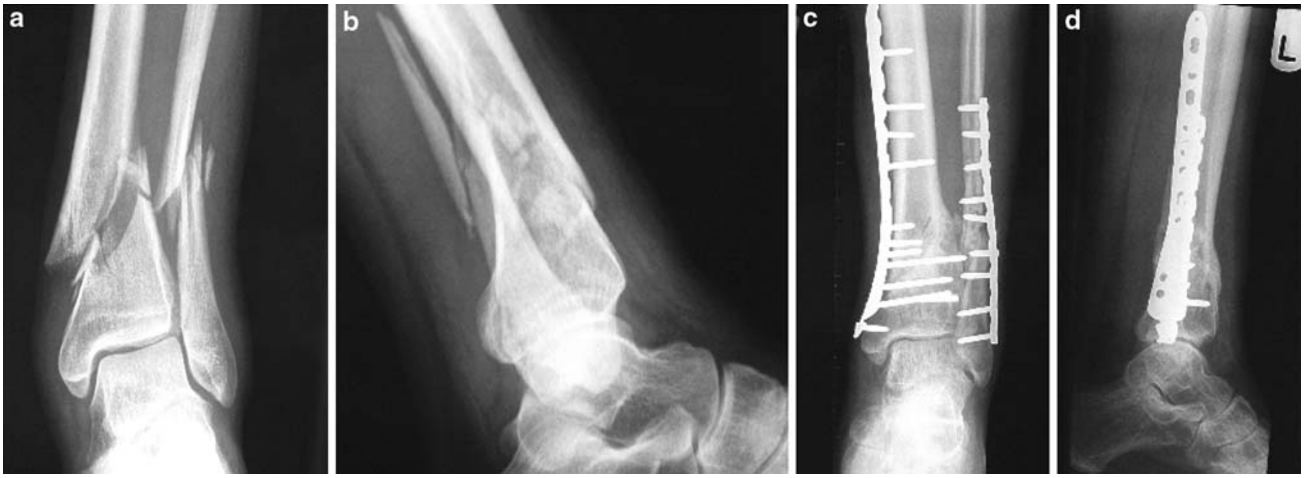
Traditional methods of distal tibial fracture fixation have been associated with high rates of complications, such as wound infection, malunion, nonunion and implant failure. Open reduction in the distal tibia causes an increased risk of disrupting the blood supply, as shown by Borelli et al. [25].

LCP plating using MIPO causes minimal soft tissue damage. Therefore, it has a biological advantage over ORIF in that it preserves the periosteal blood supply and as a result increases the chance of healing [19]. Collinge and Sanders [20] have described indirect fracture reduction and percutaneous plating techniques as evolutionary steps in biological plating. Redfern et al. [30] and Borg et al. [19] reported good results for MIPO using closed, indirect reduction and contoured dynamic compression plates for distal tibial fractures.

Our experience supports recent studies of LCP fixation using MIPO in this respect as an alternative for the treatment of fractures that are not suitable for intramedullary nailing, such as fractures with intra- or periarticular extensions as well as complex extra-articular distal tibial fractures.

Favorable results have been described using minimally invasive plate osteosynthesis techniques for the fixation of distal femoral fractures [26–29]. Recently, Borrelli et al. [25] demonstrated that the distal metaphyseal region of the tibia has a relatively rich extra-osseous blood supply, provided primarily by branches of the anterior tibial and posterior tibial arteries. The ''internal fixator'' design of locking plates has the advantage that screw insertion does not draw the bony fragments to the plate, and hence the precise contouring of the plate is less important for achieving accurate fracture reduction [10]. For the same reason, the footprint of the locking plate should also be significantly smaller than traditional nonlocking plates, hence preserving periosteal blood supply to the fracture [10].

In the majority of cases, we have found it possible to safely mobilize partial weight-bearing of patients from the first postoperative day without external



Figures 3a to 3d. a-b) AP and lateral views of fractures of the distal tibia and fibula. c-d) Six-month postoperative AP and lateral radiographs showing union.

splintage of the limb. This also allows early mobilization of the knee, ankle and subtalar joints.

In simple noncomminuted fractures we used the plate to either compress the fracture site using dynamic holes in the plate, or simply as a neutralization plate after lagging the fracture with cortical screws. In complex fractures with comminution, the plate was used as a bridging device. In our study, healing took 20 weeks on average. We did not notice any significant difference between the fracture healing of simple and multifragmentory fractures when using this plate with the MIPO technique.

We believe that the judicious use of distal tibial LCP to fix a spectrum of distal tibial fractures results in early healing of these injuries with minimal complications.

Although our study includes only a small number of cases, the clinical and radiological results are very encouraging. This technique allows for soft tissue recovery and has gained popularity, as complication rates with this strategy appear to be significantly improved [2, 5].

Conclusion

The MIPO technique using LCP plates is a reliable approach for metaphyseal and distal tibia shaft fractures that are not suited to intramedullary nailing. The distal tibial LCP is a side-specific, precontoured, low-profile plate. The soft tissue complications, malalignment and knee irritation problems that are encountered with fixation techniques more commonly used in such injuries are minimized.

We believe that the fracture anatomy largely determines the mode of application of these plates in order to achieve early union in these injuries. The plate should be used as a neutralizing device in simple noncomminuted fractures after achieving compression at the fracture site. However, in complex comminuted fractures these plates should be used as a bridging device to stabilize the fractures. Judicious use of these plates with the MIPO technique helps to achiev early fracture union with minimal complications.

Due to the small number of patients involved in our study, we cannot draw any definitive conclusions from our preliminary results, but we view them as a valuable basis for future studies.

References

1. Fisher WD, Hambledon DL. Problems and pitfalls of compression fixation of long bone fractures: a review of results and complications. Injury 1978;10:99–107.
2. Olerud S, Karlstrom G. Tibial fractures treated by AO compression osteosynthesis. Acta Orthop Scand Suppl 1972;1:1–104.
3. Ruëdi T, Allgöwer M. Fractures of the lower end of the tibia into the ankle joint. Injury 1969;1:92–9.
4. Ruëdi T, Allgöwer M. The operative treatment of intraarticular fractures of the lower end of the tibia. Clin Orthop 1979;138:105–10.
5. Russell TA. Fractures of the tibia and fibula. In: Rockwood CA, Green DP, Buckolz RW, Heckman JD, eds. Fractures in adults, 4th edn. Philadelphia: Lippincott, 1996:2139–57.
6. Wagner M. General principles for the clinical use of the LCP. Injury 2003;34:B31–42.
7. Siebenrock KA, Schillig B, Jakob RP. Treatment of complex tibial shaft fractures. Arguments for early secondary intramedullary nailing. Clin Orthop Relat Res 1993;290:269–74.

8. Farouk O, Krettek C, Miclau T, Schandelmaier P, Guy P, Tscherne H. Minimally invasive plate osteosynthesis and vascularity: preliminary results of a cadaver injection study. Injury 1997;28:SA7–12.
9. Bhandari M, Guyatt GH, Swiontkowski MF, Schemitsch EH. Treatment of open fractures of the shaft of the tibia. J Bone Joint Surg Br 2001;83:62–8.
10. Egol KA, Kubiak EN, Fulkerson E, Kummer FJ, Koval KJ. Biomechanics of locked plates and screws. J Orthop Trauma 2004;18:488–93.
11. Hochstein P, Aymar M, Winkler H, Wentzensen A. Surgical treatment of diaphyseal tibial fractures. Choice of procedure and results of treatment of 187 fractures. Unfallchirurgie 1994;20:259–75.
12. Kai H, Yokoyama K, Shindo M, Itoman M. Problems of various fixation methods for open tibia fractures: experience in a Japanese level I trauma center. Am J Orthop 1998;27:631–6.
13. Ryf C, Götsch U, Perren T, Rillmann P. Neue Stabilisierungsverfahren bei distalen Tibiafrakturen (LCP, MIPO). Ther Umschau Band 2003;60:768–75.
14. Skoog A, Soderqvist A, Tornkvist H, Ponzer S. One-year outcome after tibial shaft fractures: results of a prospective fracture registry. J Orthop Trauma 2001;15:210–5.
15. Sommer C, Gautier E. Stellenwert und Vorteil neuer winkelstabiler Implantate bei Schaftfrakturen (LCP vs. Nagel). Ther Umschau 2003;60:751–6.
16. Sommer C, Gautier E, Müller M, Helfet DL, Wagner M. First clinical results of the locking compression plate (LCP). Injury 2003;34:B43–54.
17. Toms AD, McMurtie A, Maffulli N. Percutaneous plating of the distal tibia. J Foot Ankle Surg 2004;43:199–203.
18. Tornetta P III, Weiner L, Bergman M, Watnik N, Steuer J, Kelly M, Yang E. Pilon fractures: treatment with combined internal and external fixation. J Orthop Trauma 1993;7:489–96.
19. Borg T, Larsson S, Lindsjo U. Percutaneous plating of distal tibia fractures: preliminary results in 21 patients. Injury 2004; 35:608–14.
20. Collinge CA, Sanders RW. Percutaneous plating in the lower extremity. J Am Acad Orthop Surg 2000;8:211–6.
21. Khoury A, Liebergall M, London E, Mosheiff R. Percutaneous plating of distal tibial fractures. Foot Ankle Int 2002;23:818–24.
22. Frigg R. Development of the locking compression plate. Injury 2003;34:B6–10.
23. Muller ME, Nazarian S, Koch P, Schatzker J. The AO classification of fractures of long bones. Berlin: Springer, 1990.
24. Gustilo B, Anderson JT. Prevention of infection in the treatment of one thousand and twenty-five open fractures of long bones. J Bone Joint Surg 1976;58-A:453–8.
25. Borrelli J, Prickett W, Song E, Becker D, Ricci W. Extraosseous blood supply of the tibia and the effects of different plating techniques: a human cadaveric study. J Orthop Trauma 2002;16:691–5.
26. Krettek C, Schandelmaier P, Miclau T, Tscherne H. Minimally invasive percutaneous plate osteosynthesis (MIPPO) using the DCS in proximal and distal femoral fractures. Injury 1997;28:SA20–30.
27. Krettek C, Schandelmaier P, Miclau T, Bertram R, Holmes W, Tscherne H. Transarticular joint reconstruction and indirect plate osteosynthesis for complex distal supracondylar femoral fractures. Injury 1997;28:SA31–41.
28. McFerran MA, Smith SW, Boulas HJ, Schwartz HS. Complications encountered in the treatment of pilon fractures. J Orthop Trauma 1992;6:273–85.
29. Wenda K, Runkel M, Degreif J, Rudig L. Minimally invasive plate fixation in femoral shaft fractures. Injury 1997;28:SA13–9.
30. Redfern DJ, Syed SU, Davies SJM. Fractures of the distal tibia. Injury 2004;35:615–20.

Address for Correspondence
Abid Mushtaq
31 Kingswood Road
Wollaton
Nottingham
NG8 1LD, UK
Phone (+44) 7882217794
e-mail: drabidmushtaq@hotmail.com