Treatment of distal tibial fractures using locked plates: low contact dynamic compression plate

Mohamed Y. Ali

Department of Orthopedic Surgery, Cairo University, Cairo, Egypt

Correspondence to Mohamed Y. Ali, MD, MRCS, Department of Orthopedic Surgery, Cairo University Hospital, Elzohor Building, ElMaadi, Cairo, Egypt. Tel: 01227620862; fax: +20 225 170 541; e-mail: myouness@kasralainy.edu.eg

Received: 10 July 2017
Revised: 11 August 2017
Accepted: 1 September 2017
Published: 6 August 2021

The Egyptian Orthopaedic Journal 2020, 55:172–177

Background
Distal tibial fracture accounts for approximately three per 10 000 women/year plus 28 per 10 000 men/year. Conservative treatment often results in malunion, nonunion, and ankle stiffness. Moreover, surgery faces challenge of difficult rigid fixation of the relatively short distal fragment, plus poor soft tissues and blood supply at the distal tibia. New modalities for overcoming these problems have recently been developed, including locked plates technology, which allows buttressing of the distal fragment by multiple locked screws, which are introduced by fixed different angles creating fixed-angle stability.
Aim
To evaluate the outcome of using distal tibial locked plate in fixation of closed extraarticular distal tibial fractures through minimally invasive plate osteosynthesis (MIPO) technique.
Patients and methods
A prospective study was conducted on 30 patients with distal tibial fracture fixed by distal tibial locked plate in Cairo University Hospital from January 2013 to September 2015. The mean age in the study was 39.7 years. Overall, 40% were females, whereas 60% were males. This study included 18 (60%) cases of type AO 43-A1, with mean healing time of 3.2 months; seven (23%) cases of AO 43-A2, with mean healing time of 6.75 months (one of them revised by another locked plate and grafting, so healed after 11 months); and five (17%) cases AO 43-A3, with mean healing time 3.6 months. One case was not united, and seven cases showed delayed union after 4–6 months. Two cases showed superficial infection, which resolved with antibiotics; one case developed deep infection, which necessitated serial surgical debridement for four times, with removal of plate in the last one and rotational flab coverage; and five cases showed angulations (four of them showed 5° angulation in anteroposterior plane, where one of the them showed in addition 10° posterior angulation, which was considered unacceptable, but the patient refused revision, whereas the fifth case had pure posterior angulation of 5°).
Results
Ankle range of motion (ROM) evaluation according to Ovadia score was as follows: 67% of cases were excellent, 13% of them were good, and 20% were fair; with mean ankle ROM being restored 70% of the normal side.
Conclusion
Locked plate is a comparable modality for distal tibial fractures to the new nailing systems and is superior to the convention ones in the rates of union and good alignment. Although concurrent fibular fixation did not prevent lateral angulations in some cases, fixation of the distal tibia alone with locked plate prevented angulation in others.

Keywords:
fracture distal tibia, locked plate osteosynthesis, MIPO locked plate, osteosynthesis MIPO

Egypt Orthop J 55:172–177

1110-1148

Introduction

Distal tibial metadiaphyseal fractures are a common consequence of road traffic accidents, falling injuries, and other high-energy trauma and usually involve a severe soft-tissue injury. These fractures generally require surgical management, such as reduction and internal or external fixation. Surgical treatment for distal tibial metadiaphyseal fractures is still a challenge because extensive soft-tissue injuries often disrupt the vascular supply to the fracture site and increase the risk of infection and delayed union or nonunion [1].

Moreover, this relatively short distal fragment makes rigid fixation technically difficult, and complications are not uncommon [2].

Few data exist on the epidemiology of distal tibia fractures of the metaphysis. It was reported that

incidence rates of metaphyseal ankle fractures varied considerably by age and sex. Its incidence ranged from a low of three per 10 000 per year among 30–34 years old women to a high of 28 per 10 000 per year among 15–19 years old men [3].

Conservative treatment of these fractures quite often results in a number of complications including malunion, nonunion, and ankle stiffness [4,5].

However, if complications occurred, subsequent operations are inevitable with prolonged hospital stay, which may even lead to disastrous complications [6].

The introduction of a plate design like point contact fixation, low contact dynamic compression plate, and locking compression plate minimizes the trauma to the injured zone, preserves the circulation around the fracture site, and also provides better fixation in the osteoporotic bone [7].

The locking compression plate provides enhanced stability in these situations with a minimum number of screws [7].

This device allows the screws to lock to the plate, thereby creating a stable, fixed-angle device, and also compared with a conventional plate, a locking plate imparts a higher degree of stability and provides better protection against primary and secondary losses of reduction and minimization of bone contact [8,9].

Patients and methods

A total of 30 patients with distal tibial fracture of varying patterns were included in a prospective study during the time period from January 2013 to May 2015.

Inclusion criteria were cases of distal tibial fractures having closed fracture; extraarticular fracture; AO types 43-A1, 43-A2, and 43-A3; simple fractures; and comminuted fractures.

Exclusion criteria were patients were excluded if they had local infection, open fracture, skin complications especially on the medial side, intraarticular extension (Pilon fracture), and vascular complications.

Patient data

A detailed clinical history was taken in all patients particularly regarding the history of the trauma: mechanism of trauma, time of injury, side affected, and time elapsed till operation. Personal history included name, sex, address, age, occupation, medical history, and previous surgeries. Clinical examination included general examination and local examination, such as inspection of skin for its condition, edema, and deformity; palpation for tenderness and functional disability; and neurological and vascular assessment of affected limb.

Management

Frist aid

In patients with polytrauma, resuscitation was done according to assisted trauma life support guidelines. Secondary to the previous survey, the traumatized leg was splinted. Frist aid measures for any other orthopedic insult were accomplished. The patients took analgesia and antiedematous drugs, unless there was a contraindication. Preoperative measures were done, including consent for operation.

Surgical management

Early surgery was preferred to avoid tissue edema and skin bullae, so as to have better incision site and its closure without tension. Marking of the operated limb was done. Anesthesia may be general or spinal. Prophylactic antibiotic was given at the time of induction of anesthesia. A tourniquet was applied at the mid-thigh. The patient was kept in supine position, with elevation of the ipsilateral buttocks with a sand bag. Short proximal and distal incisions were fashioned according to the fracture pattern. A plate was slided beneath the soft tissue. Reduction was done indirectly by maintaining traction and with the aid of a reduction towel till accepted reduction was seen by imaging. Screws are applied through proximal and distal incisions or through separate small incisions, and then closure of the skin and subcutaneous tissue was done.

Postoperative care

Immediate ankle mobilization was done but strictly nonweightbearing till evidence of callus formation appeared. Prophylactic antibiotic (cefotaxime) was given for 3 days, along with antiedematous and analgesics. Follow-up radiograph were done immediate postoperatively and 3, 6, and 12 weeks postoperatively. The patients were permitted to partially weight bear when evidence of callus appears in radiograph. Partial weight bearing was continued for 2 weeks with the aid of crutches, and then full weight bearing with the aid of crutches for another 2 weeks. Then full weight bearing was initiated without crutches.

Patients were evaluated by Ovadia ankle score system [4], both subjectively and objectively (Tables 1 and 2).

Results

Regarding age, the mean age was 39.7 years; the youngest patient was 18 years old, whereas the

Table 1 Subjective criteria of Ovadia ankle score system

Excellent	The patient reported no pain, had returned to the same job, pursued normal recreational activities, did not have to limit walking, did not take medication for pain, and did not limp
Good	The patient had mild pain after strenuous activity, had returned to the same job, undertook mild modification of recreational activities, did not limit walking, took no medication for pain, and did not limp
Fair	The patient had moderate pain with regular work, the patient worked but had changed jobs, significant modification in recreational activities was required, walking was limited, and the patient took analgesics for pain and limped occasionally
Poor	The patient had pain with each step, was unable to work, pursued no recreational activities, was severely limited with respect to walking, took analgesics for pain, and limped

Table 2 Objective criteria of Ovadia ankle score system

Excellent	Motion of the ankle joint was more than 75% of that on the normal side, tibiotalar alignment was normal, there was no tibial shortening or chronic swelling, and there was no equinus or calcaneus deformity
Good	Motion of the ankle joint was between 50 and 75% of that on the normal side, tibiotalar alignment was normal, without tibial shortening; there was minimum chronic swelling, and there was no equinus or calcaneus deformity
Fair	Motion of the ankle joint was between 25 and 50% of normal, there was varus or valgus angulation (up to 5°) or recurvatum of the fracture and <1.0 cm of tibial shortening, swelling was moderate, and no equinus or calcaneus deformity was present
Poor	Motion of the ankle joint was between 0 and 25% of normal; there was more than 5° of varus, valgus, or recurvatum deformity; >1.0 cm of tibial shortening was present; swelling was severe, and an equinus or calcaneus deformity of the ankle was present

oldest was 60 years old. Regarding sex, the study included 12 (40%) females and 18 (60%) males. Regarding side, 10 (33.3%) patient had left-side fracture and 20 (66.7%) patients had right-side fracture. Regarding pattern of fracture, 12 (40%) patients had simple oblique fracture, five (16.67%) patients had simple transverse fracture, two (6.67%) patients had simple spiral fractures, six (20%) patients had wedged fracture, and five (16.67%) patients had comminuted fractures. Regarding the mechanism of trauma, fall on twisted ankle was seen in seven (23.33%) patients, road traffic accident in 12 (40%) patients, motor bike accident in five (16.67%) patients, motor car accident in two (6.67%) patients, fall from more than 3 m high in two (6.67%) patients, and direct trauma in two (6.67%) patients.

Classification according to orthopeadic trauma association (OTA) system with mean time of healing to each group

A total of 18 (60%) patients were classified as 43-A1 and healed in a mean time of 3.2 months, seven (23.33%) patients were 43-A2, with mean healing time of 6.75 months, and five (16.67%) were 43-A3, with mean time of healing of 3.6 months.

Associated injuries

A total of 24 (80%) patients showed ipsilateral fracture distal fibula: 21 (70%) cases had distal 1/3 fracture fibula, and 12 (40%) of them were fixed; one (3.33%) patient had contralateral talus and sacrum fracture; one (3.33%) patient had contralateral humeral fracture; one (3.33%) patient had contralateral tibia fracture; and one patient had splenic tear and was operated on admission by splenectomy.

Time to return to full preinjury activities

Mean time to return to previous activities was 4.5 months; earliest to return was after 2.5 months and latest was after 8 months. However, there was one nonunion patient who was revised after 7 months and united after 4 months, and then he returned to previous activities within 1 month (totally 1 year).

Time elapsed till operation

Mean time till operation was 4 days; the least was 1 day, whereas the maximum stay for operation was 8 days (Fig. 1).

Regarding associated medical diseases, three (10%) patients were diabetic, six (20%) were hypertensive, one (3.33%) was hepatic, and the rest of the patients had no medical diseases.

Regarding the duration of follow-up and weight bearing, mean time till full weight bearing was 3.6 months; the earliest was after 2 months and the latest primary healing was within 7 months, whereas one nonunion case was excluded from this calculation, who did not unite till 7 months, after which was revised by another locked plate fixation and healed after 4 months.

Complications in this study

Infection

Three (10%) patients developed wound infection: two (6.67%) of them had superficial wound infection and culture and sensitivity tests was done, both resolved with antibiotic treatment, whereas one (3.33%) patient developed deep infection who was admitted for surgical debridement which was advised to be repeated every 2 weeks. Subsidence of infection was attained by the fourth time debridement at which

there was union and the plate was removed and coverage of exposed area by rotational musculocutaneous flap was done by plastic surgeon, and the then patient leg was put in posterior slab immobilizer for 1 month. Then, it was removed, and the patient was allowed to only partial weight bear for 4 weeks (Fig. 2).

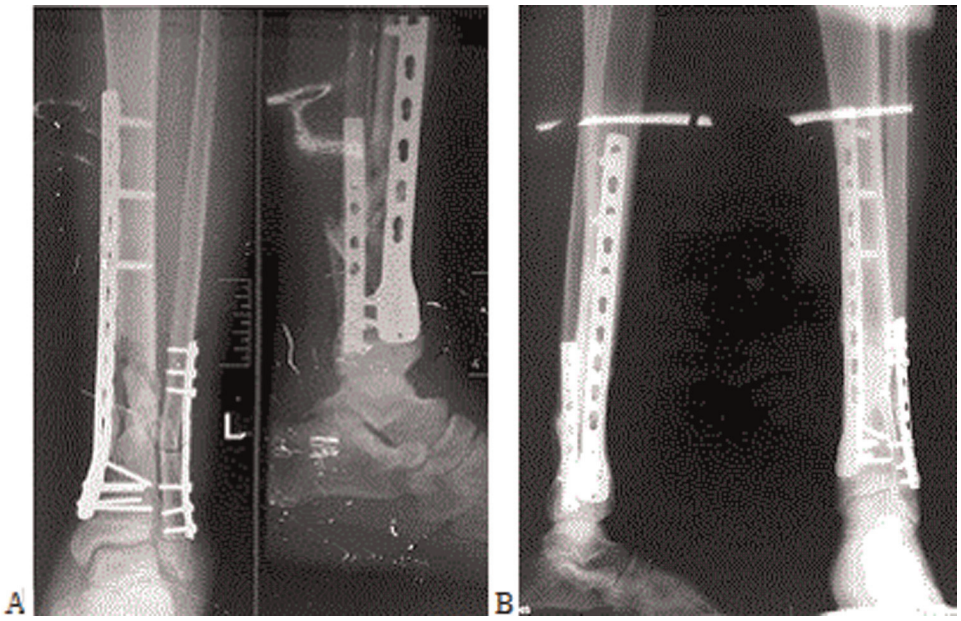
Malalignment

Five (16.67%) patients had malalignment of ankle: two (6.67%) patients had varus malalignment, two (6.67%) cases had valgus deformity (Fig. 3), two (6.67%) patients had recurvatum deformity one of them is associated with varus deformity. All deformities did not exceed 5°, except recurvatum deformity, which was associated with varus deformity. It exceeded 10° and needed to be corrected, but the patient refused and accepted the deformity after explaining it and its drawbacks later on.

Nonunion

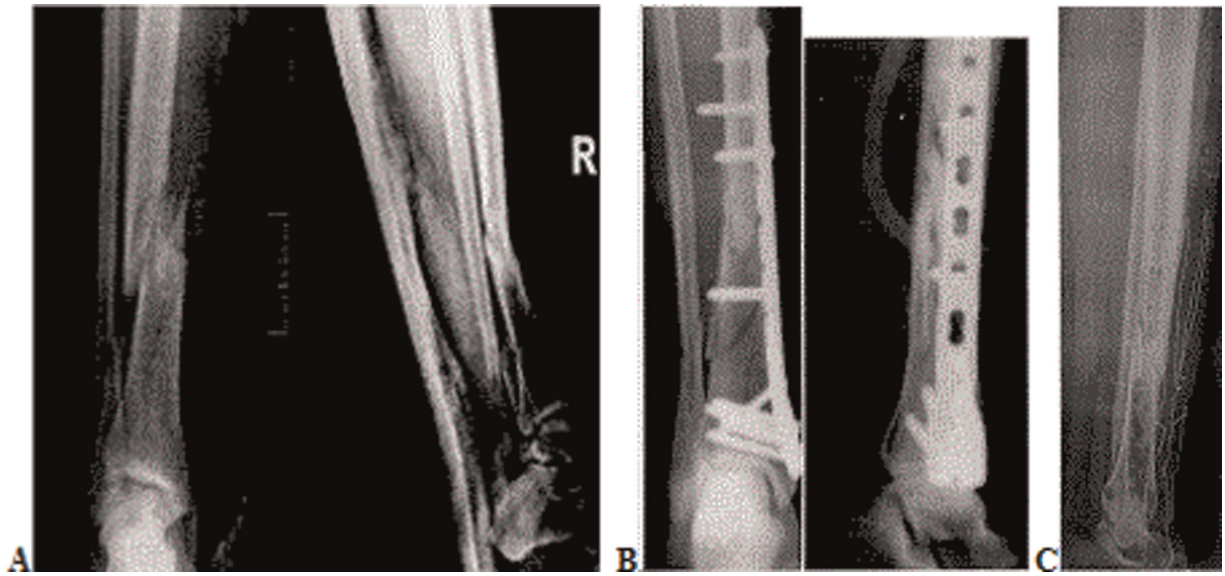
One (3.33%) case showed nonunion, with no evidence of callus till seventh month. He was a 55-year-old male, heavy smoker, and hypertensive. The plate was removed after 9 months with refreshing fracture ends and removing soft tissues in between. Then, iliac crest

Figure 1



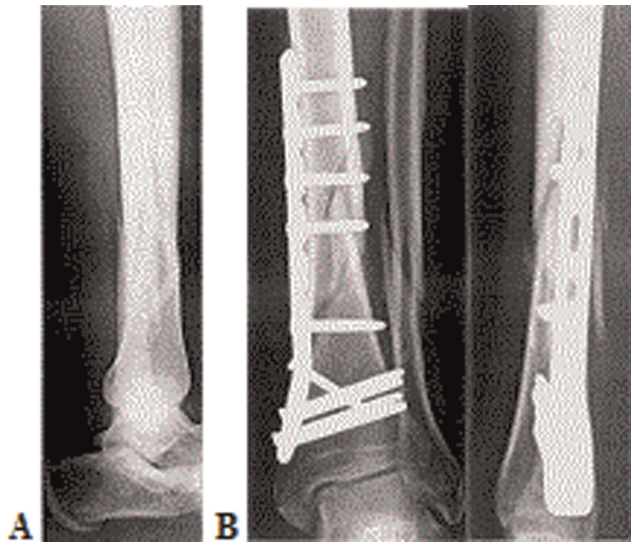
Distal tibial locked plate: (a) immediate postoperatively, (b) 4-month follow-up.

Figure 2



(a) Preoperative, (b) postoperative radiograph, (c) and after plate removal.

Figure 3



(a) Preoperative, (b) postoperative radiograph of fracture tibia with acceptable valgus deformity.

graft was used and another locked plate was applied. The patient was rehabilitated and followed up with the same regimen till union had occurred 4 months later.

Delayed union

Seven (23.33%) patients showed delayed healing time of fracture beyond 6 months. They were instructed to partially weight bear when callus started to appear within 4 months, and then full weight bearing was done after full union.

Final score: according to Ovadia subjective criteria table

A total of 11 (36.67%) patients were evaluated as excellent, 12 (40%) were evaluated as good, five (16.67%) patients were evaluated as fair, and two (6.67%) patients were evaluated as poor. Two patients were given poor score owing to pain, which appeared with each step. Regular analgesic administration, limited walking, and limping led to improvement in one patient after revision. According to Ovadia objective criteria table, 19 (63.33%) patients were evaluated as excellent, three (10%) patients were evaluated as good, seven (23.33%) patients were evaluated as fair and one (3.33%) was evaluated as poor. One patient was given poor objective score as she had recurvatum deformity of 10°, 5° varus deformity, 1 cm shortening, and only 40% of ankle range of motion (ROM) was present.

Discussion

Distal tibial fracture accounting for about three per 10 000 women/year plus 28 per 10 000 men/year. Conservative treatment often results in malunion, nonunion, and ankle stiffness. Moreover, surgery faces challenge of difficult rigid fixation of the relatively short distal fragment, plus poor soft tissues and blood supply at distal tibia. In this study, 30 patients were operated for fracture distal tibia by locked plate. Cases fixed with locked plate showed good to excellent ankle ROM scores as immediate postoperative mobility is allowable using locked plate, and also early weight bearing without disturbance of reduction can be observed.

No case was complicated by metal failure or even showed loss of primary reduction, indicating stability and rigid fixation properties of locked plate.

Mean healing time was 20 and 21 weeks using locked plate in two different studies including about 1/3 of cases having open fractures, whereas it was 15 weeks in this study where open fractures were excluded.

Patients of AO 43-Al fracture showed 3.2-month mean time of healing, whereas those of AO 43-A3 showed 3.6-month mean time of healing, indicating slight difference in the rate of healing in relation to its energy of causative trauma, so it is noticed that injuries characterized by high-energy trauma can be a predictor of healing time.

A total of 24 cases had concomitant distal 1/3 fracture fibular; nine (30%) of them were fixed. Malalignment rate was 16.67% (five cases): two (6.67%) of them showed 5° valgus deformity; two (6.67%) cases showed 5° varus deformity, where one of them showed in addition 10° posterior angulation; and the last one (3.33%) case showed 5° posterior angulation. Mean union time was 15 weeks. One (3.33%) case showed nonunion till 7 months and was revised by another locked plate with grafting and united after 4 months later. He was a 55-year-old male, heavy smoker and hypertensive with low energy trauma that resulted in AO 43-A2 fracture. Infection developed in three (10%) cases; two (6.67%) of them had superficial infection which resolved after antibiotic treatment, whereas one (3.33%) case developed deep infection that ended by removal of plate and coverage of exposed area by musculocutaneous flap. Excellent ankle ROM scores were encountered in 20 (66.67%) cases, good in four (13.33%) cases, and six (20%) cases were fair according to Ovadia score.

Cory Collinge and Robert Protzman [10] studied 43 patients of extraarticular distal tibial fracture, but five cases were lost to follow-up. So, of 38 patients, 16 cases (eight open and eight closed fractures) were treated first by external fixator for an average of 12 days followed by locked plate with or without fibular fixation, whereas other 22 cases were treated acutely by locked plate, all by minimally invasive plate osteosynthesis (MIPO)

technique. In 31 of 33 (94%) cases with associated fibula fracture, the fibula was repaired in the same setting. The study included eight open fractures that were classified as one case of Gustilo I, six cases of Gustilo II, and one case of Gustilo III. It also included 20 cases of 43-A2 AO fracture type, six cases of type 43-A3, seven cases of 43-C1 type, and six cases of 43-C2. They found one (3%) case of malunion in the form of valgus deformity of 6°. Union rate was 92% (35 cases) in the period from 4 to 5 months, whereas three (8%) cases were not united till 4–5 months. Ankle ROM showed good to excellent scores. No infection was reported in this study. A retrospective study by Li *et al.* [11] compared fixation of extraarticular distal tibial fracture by low multidirectional (expert) nail versus MIPO locked plating, with 23 cases in each group, during a period of 2 years. It included 34 cases of concomitant fibular fracture, and 30 of them were fixed by plate and screws. Each group included five females and 18 males. There were eight patients of 43-A1 AO fracture type, 11 patients of 43-A2 fracture type, four patients of 43-A3 fracture type, and six closed fractures. A total of 11 cases were Gustilo I open fractures and eleven were Gustilo II open fractures. In locked plate group, they noticed 100% union rate as all cases were united without need for any other operation, in average healing time 23.1±3.6 weeks. Malalignment more than 5° was noticed in only one (4.3%) case in plane of varus/valgus deformity. Infection rate was 13%, as three cases developed superficial infection with no deep infection cases. Ankle ROM was evaluated as excellent in 15 cases, rating 65%, and good in eight cases, rating 35%. Plate was removed in 19 cases after 1 year as a routine procedure. Another study by Im and Tae [12] compared fixation of distal tibia fractures by open nonlocked anatomic plating versus closed intramedullary nailing. It was a prospective follow-up study on 64 cases for 2 years, where 30 cases of them were fixed by anatomic plate and screws and 34 cases by nailing. Displaced articular fractures, Gustilo II and III fractures, were excluded. A previous study of Im and Tae prospectively followed up 30 patients of distal metaphyseal tibial fracture after operating them as open plating by anatomic nonlocked plate (applied to lateral surface), Closed and Gustilo I fractures only were included in the study; five cases were Gustilo I, while twenty cases were closed fractures, seven of them Tscheme 0, 15 of them Tscheme 1, and three were Tscheme 2. Only extraarticular and nondisplaced articular fractures only were included in the study; comprising 11 Al, 10 A2, four A3, and five Cl fracture cases. Fibular fracture fixation was needed only in five cases of 15 cases owing to syndesmotic instability. Age ranged from 17 to 60 years. There were 20 men and six women and 15 of cases were smokers. They notice that mean union time was 20 weeks in 28 (93.3%) cases, whereas two (6.67%) cases were not united: one was revised by grafting, whereas the other was due to deep infection, which needed revision by external fixator and serial debridement, and then reapplication of anatomic plate. Infection was reported in seven (23.3%) cases, and one of them was deep infection. Malunion mean angulation degree was 0.9° (range, 0–3°) and none developed angulation of more than 5°. Mean ankle ROM was 88.2% of the normal side.

Conclusion

Locked plate is a dependable modality for distal tibial fractures fixation when compared with other nailing systems. Even newer versions that can overcome the problem of small distal fragment such as expert nail and low multidirectional nail have comparable results in rates of union and good alignment.

Locked plate offered improved mechanical stability and perfect alignment when compared with locked nails in cases of concomitant distal third fibular fracture in where the fibula was not stabilized.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

References

1 Blick SS, Brumback RJ, Lakatos R, Poka A, Burgess AR. Early bone grafting of high-energy tibial fractures. Clin Orthop Relat Res 1989; 240:21–41.
2 Lau TW, Leung F, Chan CF, Chow SP. Wound complication of minimally invasive plate osteosynthesis in distal tibia fractures. Int Orthop 2008; 32:697–703.
3 Singer BR, McLauchlan GJ, Robinson CM, Christie J. Epidemiology of fractures in 15,000 adults: the influence of age and gender. J Bone Joint Surg Br 1998; 80:243–248.
4 Ovadia DN, Beals RK. Fractures of the tibial plafond. J Bone Joint Surg Am 1986; 68:543–551.
5 Riiedi TP, Allgower M. The operative treatment of intraarticular fractures of the lower end of the tibia. Clin Orthop Relat Res 1979; 138:105–110.
6 Pugh KJ, Wolinsky PR, McAndrew MP, Johnson KD. Tibial pilon fractures: a comparison of treatment methods. J Trauma 1999; 47:937–941.
7 Nork SE, Schwartz AK, Agel J, Holt SK, Schrick JL, Winquist RA. Intramedullary nailing of distal metaphyseal tibial fractures. J Bone Joint Surg Am 2005; 87:1213–1221.
8 Krackhardt T, Dilger J, Flesch I, Hontzsch D, Eingartner C, Weise K. Fractures of the distal tibia treated with closed reduction and minimally invasive plating. Arch Orthop Trauma Surg 2005; 125:87–94.
9 Ryf C, Gotsch U, Perren T, Rillmann P. New surgical treatment procedures in fractures of the distal tibia (LCP, MIPO). Ther Umsch 2003; 60:768–775.
10 Cory Collinge and Robert Protzman. Outcomes of minimally invasive plate osteosynthesis for metaphyseal distal tibia fractures. J Orthop Trauma 2010; 24:24–29.
11 Li Y, Liu L, Tang X, Pei F, Wang G, Fang Y, *et al.* Comparison of low, multidirectional locked nailing and plating in the treatment of distal tibial metadiaphyseal fractures. Int Orthop 2012; 36:1457–1462.
12 Im GI, Tae SK. Distal metaphyseal fractures of tibia: a prospective, randomized trial of closed reduction and intramedullary nail versus open reduction and plate and screws fixation. J Trauma 2005; 59:1219–1223.