Distal tibial fractures: comparison between external locked plate and conventional open reduction and internal fixation

Bahaa A. Motawea

Department of Orthopedic and Trauma Surgery, Faculty of Medicine, El Hadra University Hospital, Alexandria University, Alexandria, Egypt

Correspondence to Bahaa A. Motawea, MD, Department of Orthopedic Surgery, Faculty of Medicine, Alexandria University, Alexandria, Egypt Tel: +20 3486 7047; fax: +20 3485 0028; e-mail: bahaamotawea@gmail.com

Received: 9 February 2018
Revised: 9 March 2018
Accepted: 24 March 2018
Published: 17 November 2021

The Egyptian Orthopaedic Journal 2021, 56:211–218

Background
Distal tibial fractures are notorious for being associated with skin complications such as wound dehiscence and infection. The use of angle-stable external locked plate has a dual advantage, acting as an external fixator, which avoids the complications associated with conventional open surgery, and avoiding the cumbersome bulky external frames traditionally used for lower limb fractures. Moreover, joint spanning is not necessary in this technique, leaving the ankle joint free, avoiding joint stiffness commonly associated with the conventional frames.
Patients and methods
A total of 56 patients with closed distal tibial fractures were randomly assigned in two equal groups. Group A comprised patients treated with the conventional open reduction and internal fixation, whereas group B comprised patients treated with external locked plate (supracutaneous plate). The patients were assessed according to the Klemn and Borner scoring system at the end of follow-up.
Results
Group B patients had significantly better clinical and radiological outcome than group A. The union in group B was more rapid (12.96±2.74 weeks) than in group A (18.68±12.12 weeks), with a statistically significant difference between them. The rate of complications was significantly less in the group B, with only three patients having superficial self-limiting infection in comparison with group A, with 11 patients having deep infection and skin dehiscence with exposure of the plate. None of the cases of group B developed implant failure, whereas seven cases in group A developed implant failure.
Conclusion
Treatment of closed distal tibial fractures by external locked plate could result in a better functional outcome than conventional open reduction and internal fixation, while avoiding the skin complications associated with the conventional plating.
Level of evidence
Level II: prospective randomized double-blinded study.

Keywords:
distal tibia, external locked plate, Klemm and Borner scoring system

Egypt Orthop J 56:211–218

1110-1148

Introduction

The management of distal tibial fractures has long been a challenge to orthopedic surgeons [1–4]. This type of fracture is notorious for being associated with hardware-related problems, causing skin complications, such as wound dehiscence and infection [5,6]. There is also a high incidence of nonunion among these fractures, as there is not enough soft tissue envelope around the bone in this area. Moreover, fractures in this area usually result from a high-velocity injury, which in turn is associated with significant soft tissue trauma and violation [7–9].

There are many options for the operative management of this type of fractures. Conventional open reduction and internal fixation (ORIF) is a treatment option; however, further compromise of the inherently deficient traumatized soft tissue envelope associated with the conventional open surgery is associated with a high risk of complications including skin breakdown and infection [10–12]. Conventional ORIF also has the potential disadvantage of extensive soft tissue dissection and periosteal stripping leading to high rates of complications, including infection delayed union and nonunions [13,14].

An alternative line of treatment is the use of joint spanning external fixators; however, most of the external frames available are bulky and inconvenient, and may interfere with the usual daily activities, leading to problems with sleeping and clothing and can cause an impediment to the contralateral extremity when walking. Moreover, being a joint spanning construct,

 DOI: 10.4103/eoj.eoj_101_21

it is associated with ankle joint stiffness and high incidence of nonunion [15–18].

The use of angle-stable external locked plate is an innovative treatment option [19,20]. It has a dual advantage, acting as an external fixator and avoiding the cumbersome bulky external frames traditionally used for lower limb fractures. Moreover, joint spanning is not necessary in this technique, leaving the ankle joint free, avoiding joint stiffness commonly associated with the conventional frames.

To our knowledge, and after review of the literature, this is the first study comparing the conventional ORIF as the standard traditional line of treatment and the use of external locked 'supracutaneous' plate for the management of closed distal tibial fractures.

We hypothesize that the use of external locked plates might result in a better functional outcome with a lower rate of complications, including infection, nonunion, and implant failure [21].

Patients and methods

Inclusion criteria

The following were the inclusion criteria:

(1) Adult patients having closed isolated distal tibial fracture AO type A or B.
(2) Presenting within 3 weeks after injury.

Exclusion criteria

The following were the inclusion criteria:

(1) Skeletally immature patients.
(2) Open fractures.
(3) Distal tibial fractures with intra-articular extension.
(4) AO type C fractures.

A total of 56 patients with closed distal tibial fractures were included in this study. They were randomly assigned to either one of the two treatment groups. Group A comprised patients who were treated by conventional ORIF, whereas group B comprised patients who were treated by external locked 'supracutaneous plate.'

An independent surgeon outside the surgical team did the randomization process to avoid bias in patient selection. This was done by random choice from 56 closed envelopes previously prepared and equally divided between the two treatment methods. A closed envelope was picked up by the independent surgeon and delivered to the surgical team shortly before surgery. Fully informed consent was taken from all the patients, clarifying the pros and cons of each procedure. The procedure followed the ethical outlines set by our institution.

After taking informed consent, all patients underwent detailed clinical and radiological examination along with all routine investigations. The initial radiographic evaluation included anteroposterior and lateral radiographs of the ankle. Fracture was classified with AO classification, and computed tomography was done if there is doubt of intra-articular extension.

The basic demographic and clinical characteristics of both groups are displayed in Table 1. There was no statistically significant difference between both the groups. There was predominance of young males in both groups and for road traffic accidents as the predominant mode of trauma. AO-typeA2 was the predominant pattern of fracture in both groups. Most of the patients did not have associated comorbidities, and they presented shortly after injury, on an average 7.25 days in group A and 5.82 days in group B.

Surgical technique for group A (ORIF) [22–24]

Under general or spinal anesthesia, a broad-spectrum antibiotic was administered 30–60 min preoperatively. Tourniquet was applied to mid-thigh after exsanguination of the limb. The affected leg was prepared and draped in the usual standard sterile fashion. The patient was positioned supine on a radiolucent operating table.

A skin incision was made down to the bone exposing the fracture site, with elevation of the soft tissue envelop as one layer. Curettage of the fracture site was done to ease the reduction. Application of 4.5 mm distal tibial locked plate and screws was done, followed by thorough wash, and then insertion of a surgical drain followed by wound closure and applying of a crepe bandage. No cast was applied, and the patient was encouraged for knee and ankle range-of-motion exercises. The patient stayed in the hospital for 2 days till removal of the drain and then discharged. The removal of the stitches occurred after 2 weeks. Absolute non-weight bearing was continued till fracture healing.

Surgical technique for group B (external locked plating) [25–27]

Under general or spinal anesthesia, a broad-spectrum antibiotic was administered 30–60 min preoperatively. No tourniquet was used. The affected leg was prepared and draped in the usual standard sterile fashion. The patient was positioned supine on a radiolucent operating table.

Fracture reduction was achieved by manipulation under image guidance. A percutaneous clamp may be used to maintain reduction.

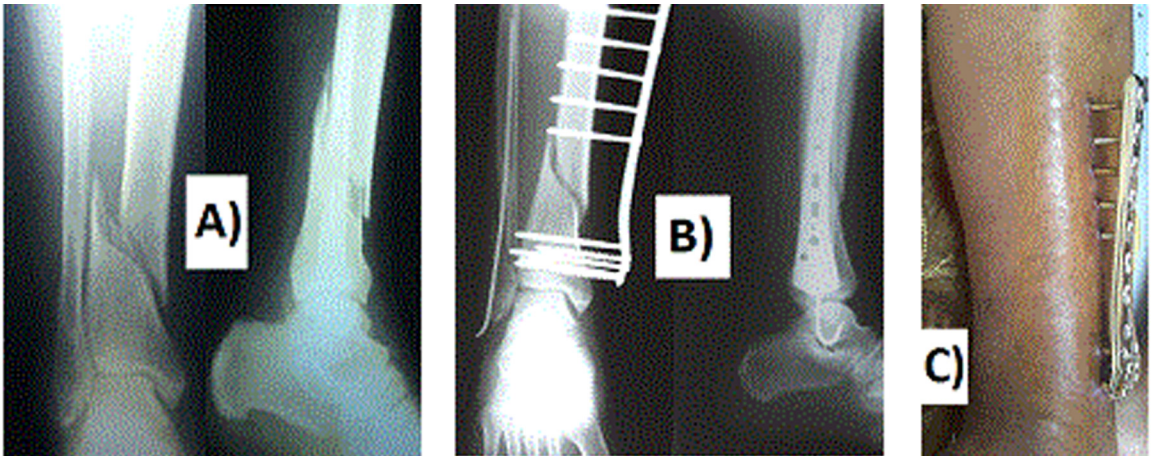
The angle-stable 4.5-mm distal femoral locked plate (Fig. 1) or 4.5 mm broad locked plate (Fig. 2) of sufficient length to span the fracture fragments is

Table 1 Basic characteristic feature of the studied groups

	Group A [*n* (%)]	Group B [*n* (%)]	*P*
Age			
Range	26.0–55.0	29.0–56.0	
Mean±SD	40.75±7.93	42.14±6.73	0.481
Sex			
Male	20 (71.4)	23 (82.1)	
Female	8 (28.6)	5 (17.9)	0.264
Smoking	16 (57.1)	13 (46.4)	0.297
Affected side			
Right	19 (67.9)	21 (75.0)	0.384
Left	9 (32.1)	7 (25.0)	
Mode of trauma			
Car accident	12 (42.9)	12 (42.9)	0.980
FFH (falling from height)	5 (17.9)	5 (17.9)	
Motorcycle Accident	5 (17.9)	6 (21.4)	
Sport-related injury	6 (21.4)	5 (17.9)	
Fracture pattern			
A1	9 (32.1)	9 (32.1)	
A2	12 (42.9)	10 (35.7)	
A3	3 (10.7)	2 (7.1)	
B2	4 (14.3)	7 (25.0)	0.753
Associated fibular #			
Associated comorbidities	18 (64.3)	23 (82.1)	0.113
Free	23 (82.1)	19 (67.9)	
DM	5 (17.9)	9 (32.1)	0.178
Time elapsed before surgery (days)			
Range	2.0–21.0	2.0–15.0	
Mean±SD	7.25±4.59	5.82±3.60	0.201
Union in weeks			
Range	8–40	10–20	
Mean±SD	18.68±12.12	12.96±2.74	0.013*

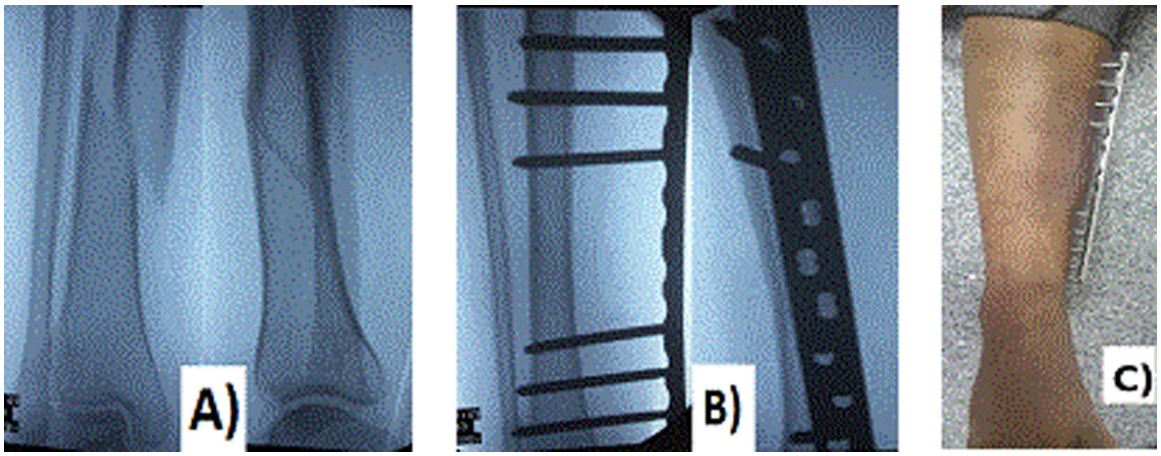
DM, diabetes mellitus.

Figure 1



(a) The preoperative plain radiography of a distal tibial fracture in anteroposterior and lateral views. (b) After operative fixation using distal femoral locked plate anteroposterior and lateral views. (c) A clinical postoperative photograph of the right leg showing the plate in situ.

Figure 2



(a) Intraoperative C-arm images in both anteroposterior and lateral views of a distal tibial fracture. (b) After perfect anatomical reduction and fixation using a broad locked plate. (c) A clinical postoperative photograph of the right leg showing the plate in situ.

chosen with the aim of engaging at least 8–10 cortices proximal and distal to the fracture, taking care to avoid implanting screws at the fracture site. The chosen plate is placed over the medial aspect of the tibia, separated from the skin surface by a distance 2–3 cm, not less than 2 cm to allow easy postoperative care later on and not more than 3 cm to increase the mechanical stability of fixation. The most proximal and distal holes intended for initial screw fixation were provisionally engaged by a 3-mm K-wire after fracture reduction under fluoroscopic guidance. Satisfactory plate placement was then confirmed by the image intensifier. Successive holes were drilled through locked drill-sleeves via stab wounds where the overlying soft tissue envelope is intact, and screws are placed after ensuring good reduction. The screws were applied with suitable length to hold the bone bicortically, and at the same time, the screws heads lock in the plate firmly. Lastly, the K-wires were withdrawn and replaced by screws in the same manner (Fig. 1).

Wash of the whole construct with normal saline was done, followed by disinfection with povidone iodine (betadine), drying any blood ooze around the screw holes, and then application of small pieces of vaselinized gauze around each screw. We used crepe bandage 15 cm to wrap the whole construct and leg as a one unit for protection from clothes and pollution (Fig. 2).

Antibiotics were given for 2 days postoperatively. Knee and ankle range-of-motion exercises and tip-toe touch were allowed immediately postoperatively. Four weeks later, partial weight bearing was allowed. After 8 weeks postoperatively, full weight bearing was allowed as tolerated.

Daily standard care consisted of wash with soap and water to remove and prevent crust formation followed by wash with a bottle 500 ml of normal saline, disinfection with betadine, drying then vaselinized gauze around each screw, and lastly, crepe bandage.

The patients were followed for at least 1 year postoperatively. Assessment was done both clinically and radiologically according to the Klemn and Borner scoring system. Union was defined as healing of at least three of four cortices on a biplanar plain radiograph (Table 2).

Results

External locked (supracutaneous) plating resulted in a statistically significant better functional outcome than the ORIF group (Table 3 and Fig. 3).

The ankle range-of-motion was significantly better among the supracutaneous group. The pain was also significantly better in this group; these two parameters explain the better functional outcome in this group (Table 4).

The radiological assessment revealed significantly earlier time to union in group B. Union was defined as healing of at least three of four cortices on biplane plain radiographs. The average time to union in group A was 18.68±12.12 weeks, ranging from 8 to 40 weeks, whereas in group B was 12.96±2.74 weeks, ranging from 10 to 20 (Table 1, Figs. 4 and 5).

Complications

Eleven cases among group A developed deep infection with skin breakdown, and exposure of the hardware

Table 2 Klemn and Borner scoring system [1]

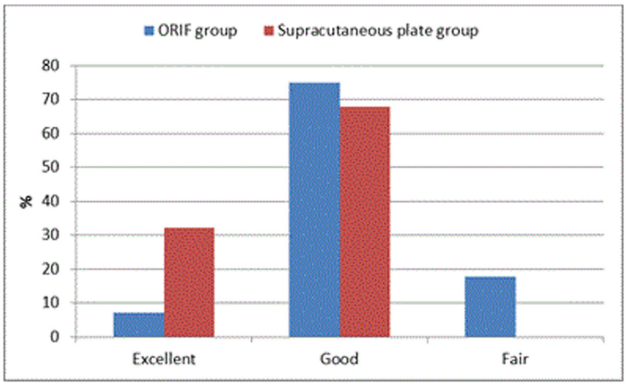
Final score	ROM	Muscle atrophy	Alignment	Pain	Union
Excellent	4	3	4	4	4
Good	3	2	3	3	3
Fair	2	1	2	2	2
Poor	1	0	1	1	1
Components of the scoring system				Rating	
ROM ankle (range-of-motion)					
No restriction				4	
<25%				3	
25–50%				2	
50–75%				1	
Muscle atrophy (calf)					
No atrophy				3	
<2 cm				2	
2–3				1	
>3 cm				0	
Alignment					
Normal				4	
Angular deformity				3	
5–10°				2	
>10°				1	
Pain (at the fracture site)					
Absent				4	
On prolonged				3	
On weight bearing				2	
At rest				1	
Union (weeks)					
<12				4	
13–24				3	
25–36				2	
>36				1	

Table 3 Comparison between the two studied groups regarding the final postoperative score

Final score	Group A [*n* (%)]	Group B [*n* (%)]	*P*
Excellent	2 (7.1)	9 (32.1)	
Good	21 (75.0)	19 (67.9)	0.008*
Fair	5 (17.9)	0 (0.0)	

(Figs. 6 and 7). They were managed by debridement and antibiotics according to the result of culture and sensitivity, and closed suction drainage (vacuum seal). In five cases, the infection subsided with late removal of the implant after fracture union. Six cases were associated with mechanical failure of the implant and removal of the implant was mandatory with temporary joint spanning external frame in three cases in which the infection happened soon after surgery. Seven cases developed mechanical failure of the implant; six of them were associated with deep infection. In group B, only three cases developed mild self-limiting superficial screw-track infection (Fig. 8). None of the cases developed implant failure (Table 5).

Figure 3



Comparison between the two studied groups regarding the final postoperative score.

Statistical analysis

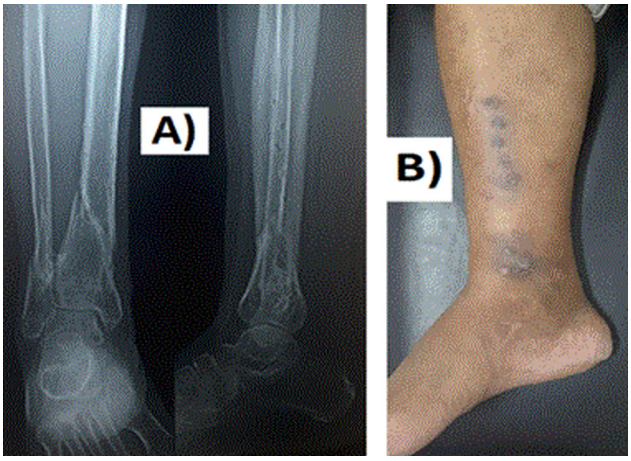
The data were collected and entered into the personal computer. Statistical analysis was done using Statistical Package for the Social Sciences (SPSS/version 20) software (IBM Corp. Released 2011. IBM SPSS Statistics for Windows, Version 20.0. Armonk, NY: IBM Corp.).

Table 4 Comparison between the two studied groups regarding postoperative score

Variables of the scoring system with significant differences between the groups	Group A	Group B	*P*
Ankle ROM			
Range	2.00–4.00	3.00–4.00	0.001*
Mean±SD	3.11±0.74	3.68±0.48	
Pain			
Range	2.00–4.00	3.00–4.00	0.001*
Mean±SD	3.00±0.77	3.89±0.31	
Union			
Range	1.00–4.00	3.00–4.00	0.006*
Mean±SD	3.00±1.25	3.71±0.46	
Total			
Range	11.00–19.00	16.00–19.00	0.0001*
Mean±SD	15.71±2.40	18.07±0.81	

There were no statistically significant differences between both groups regarding the alignment and calf muscle atrophy. ROM, range-of-motion.

Figure 4



(a) Radiography of 10 weeks postoperative and immediately after removal of the supracutaneous plate; anteroposterior and lateral view showing union of the fracture. (b) Skin condition after removal of the plate.

Arithmetic mean and SD were used for descriptive statistics. For categorized parameters, χ^2 test was used, whereas for numerical data, *t*-test was used to compare the two groups. For more than two groups, analysis of variance test was used. The level of significant was 0.05.

Discussion

The most important finding of this study is that external locked plate can be effectively used for closed isolated fractures of the distal tibia to avoid skin complications and infection associated with the conventional ORIF of this type of fracture. The use of this line of operative treatment resulted in faster union with better functional outcome with a lower incidence of mechanical failure of the implant [28].

Distal tibial fractures usually result from high-velocity injuries with significant violation of the inherently deficient soft tissue envelope in this area. Consequently, operative treatment of fractures in this area by conventional ORIF is expected to cause further compromise to the soft tissue envelope [29]. In this study, 11 cases developed deep infections with skin dehiscence and exposure of the hardware, and nine of them had preoperative diabetes mellitus.

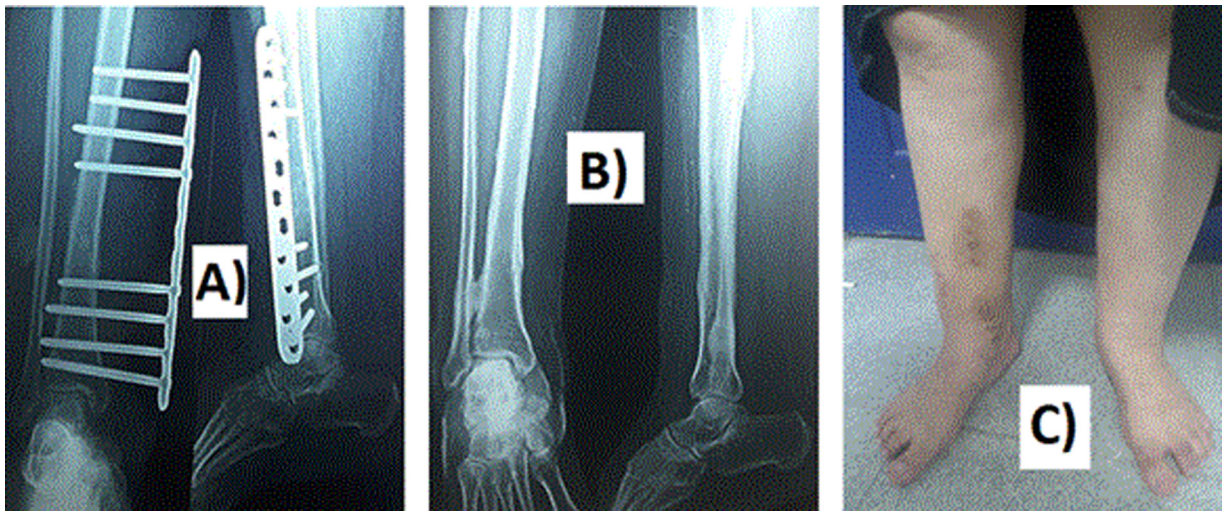
Actually, closed isolated distal tibial fractures constitute a big challenge to orthopedic trauma surgeons. The use of standard and circular external fixators for the distal tibia are often bulky and uncomfortable for the patient. Most patients also find them esthetically unacceptable interfering with the activities of daily living. Moreover, to create a stable construct, joint spanning is required. Consequently, the incidence of joint stiffness is higher with lower functional outcome [30].

The use of angle-stable locked plate as external fixator constitutes a viable option for this type of fracture. This low-profile external fixator is cosmetically more acceptable and does not interfere with the normal gait [31,32].

Despite its low profile, external fixation with the locked plate seems strong enough to withstand the forces acting on the distal tibia. As the shape of plate matches with anatomical shape of the bone, this would allow for better angular and axial stability. If this is coupled with the very low incidence of infection, it might explain the fact that none of the cases in this group developed mechanical failure of the implant [33].

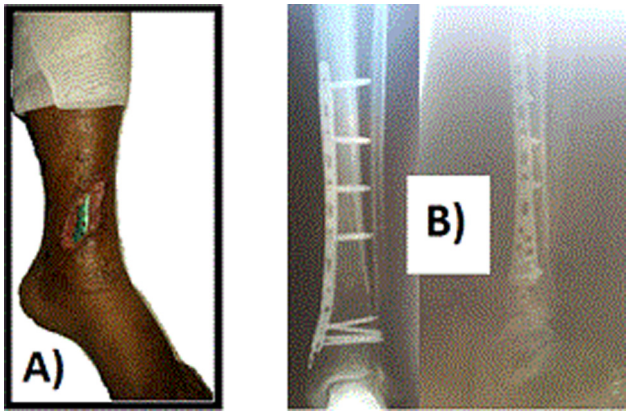
The use of supracutaneous locked plate combines the advantage of minimally invasive plate osteosynthesis along with avoiding the skin complications associated

Figure 5



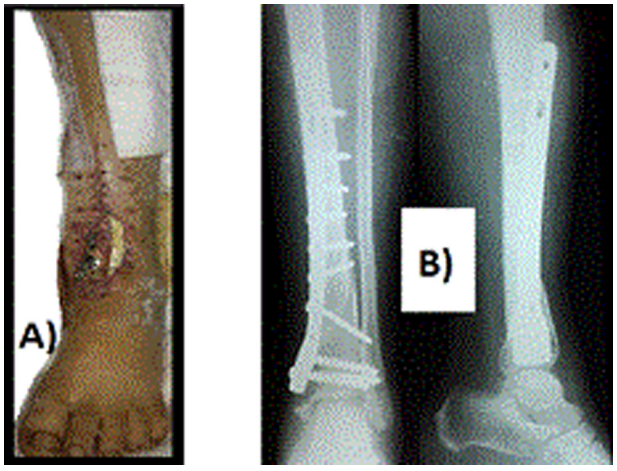
(a) Radiography of 12 weeks postoperative anteroposterior and lateral view showing union of the fracture. (b) Radiography of immediately after removal of the supracutaneous plate anteroposterior and lateral view. (c) Skin condition after removal of the plate.

Figure 6



(a) A 39-year-old male patient had fracture of his distal left tibia fixed by open reduction and internal fixation using titanium distal tibial locked plate with skin breakdown over the lower medial aspect of the left leg with exposure of the plate. (b) Anteroposterior and lateral radiography views of the same patient.

Figure 7



(a) A 23-year-old male patient had fracture of his distal left tibia fixed by open reduction and internal fixation using metal 4.5 mm distal tibial plate with skin breakdown over the lower medial aspect of the left leg with exposure of the plate. (b) Anteroposterior and lateral radiography views of the same patient.

with the conventional open surgery and the bulky inconvenient external frames. The lack of joint spanning sets the ankle joint free, avoiding stiffness and regional osteoporosis, with a better functional outcome [34].

To our knowledge, this is the first report in the literature comparing the results of conventional plating and the supracutaneous plate for the management of distal tibial fractures. The supracutaneous plate being a recent line of operative treatment is still not popular among orthopedic surgeons and is still not widely accepted by the patients who used to have plates internally fixed to their bones. Consequently, patients had to be properly counseled preoperatively. The other limitation of this study is the relatively low number of cases, not enough to reach a generalization or a solid proof justifying the use of external locked plate as a first line of operative treatment of distal tibial fractures. Powered prospective randomized clinical trials, preferably on a multicenter basis, should be conducted to reach to this solid conclusion. Finally, being a recent study, it was difficult to find a suitable scoring system that combines both radiological and clinical assessments. We used the Klemn and Borner scoring system, despite being not popular. It was used previously in a similar study. Its drawback is that it does not include the complications of the treatment, and the time to union is

Figure 8

The external locked supracutaneous plate in situ with mild screw-track infection.

Table 5 Comparison between the two studied groups regarding the postoperative outcome

Complications	Group A [*n* (%)]	Group B [*n* (%)]	*P*
Infection	11 (39.3)	3 (10.7)	0.014*
Implant failure	7 (25.0)	0	0.005*

expressed in grades not numbers, which increases the difficulty of direct assessment.

Conclusion

Treatment of closed isolated distal tibial fractures by external locked plate could potentially result in a better functional outcome than conventional ORIF, while avoiding the skin complications associated with the conventional plating.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1 Singh A, Kumar R, Ummat V, Pandey PK. Comparative study of minimally invasive plating versus nailing in distal tibia metaphyseal extraarticular fractures. J Dent Med Sci 2017; 16:5–9.

2 Tull F, Borrelli J. Soft-tissue injury associated with closed fractures: evaluation and management. J Am Acad Orthop Surg 2003; 11:431–438.

3 Joveniaux P, Ohl X, Harisboure A. Distal tibia fractures: management and complications of 101 cases. Int Orthop 2010; 34:583–588.

4 Vallier HA, Cureton BA, Patterson BM. Factors influencing functional outcomes after distal tibia shaft fractures. J Orthop Trauma 2012; 26:178–183.

5 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.

6 Natarajan GB, Srinivasan DK, Vijayaraghavan PV. Comparison of clinical, radiological, and functional outcome of closed fracture of distal third tibia treated with nailing and plate osteosynthesis. Afr J Trauma 2014; 3:68–72.

7 Zelle BA, Bhandari M, Espiritu M. Treatment of distal tibial fractures without articular involvement: a systematic review of 1125 fractures. J Orthop Trauma 2006; 20:76–79.

8 Bedi A, Le TT, Karunakar MA. Surgical treatment of nonarticular distal tibia fractures. J Am Acad Orthop Surg 2006; 14:406–416.

9 Vallier HA, Le TT, Bedi A. Radiographic and clinical comparisons of distal tibia shaft fractures (4 to 11 cm proximal to the plafond): plating versus intramedullary nailing. J Orthop Trauma 2008; 22:307–311.

10 Maffulli N, Toms AD, McMurtie A, Oliva F. Percutaneous plating of distal tibial fractures. Int Orthop 2004; 28:159–162.

11 Ronga M, Shanmugam C, Longo UG, Oliva F, Maffulli N. Minimally invasive osteosynthesis of distal tibial fractures using locking plates. Orthop Clin North Am 2009; 40:499–504.

12 Leonard M, Magill P, Khayyat G. Minimally-invasive treatment of high velocity intra-articular fractures of the distal tibia. Int Orthop 2009; 33:1149–1153.

13 Hazarika S, Chakravarthy J, Cooper J. Minimally invasive locking plate osteosynthesis for fractures of the distal tibia: results in 20 patients. Injury 2006; 37:877–887.

14 Cheng W, Li Y, Manyi W. Comparison study of two surgical options for distal tibia fracture: minimally invasive plate osteosynthesis vs. open reduction and internal fixation. Int Orthop 2011; 35:737–742.

15 Collinge C, Kuper M, Larson K, Protzman R. Minimally invasive plating of high-energy metaphyseal distal tibia fractures. J Orthop Trauma 2007; 21:355–361.

16 McCann PA, Jackson M, Mitchell ST, Atkins RM. Complications of definitive open reduction and internal fixation of pilon fractures of the distal tibia. Int Orthop 2011; 35:413–418.

17 Redfern DJ, Syed SU, Davies SJM. Fractures of the distal tibia: minimally invasive plate osteosynthesis. Injury 2004; 35:615–620.

18 Im GI, Tae SK. Distal 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.

19 Ma CH, Tu YK, Yeh JH. Using external and internal locking plates in a two stage protocol for treatment of segmental tibial fractures. J Trauma 2011; 71:614–619.

20 Ma CH, Yu SW, Tu YK, Yen CY, Yeh JJ, Wu CH. Staged external and internal locked plating for open distal tibial fractures. Acta Orthop 2010; 81:382–386.

21 Frigg R. Development of the locked compression plate. Injury 2003; 34:6–10.

22 Francois J, Vandeputte G, Verheyden F, Nelen G. Percutaneous plate fixation of fractures of the distal tibia. Acta Orthop Belg 2004; 70:148–154.

23 Janssen KW, Biert J, Kampen A. Treatment of distal tibial fractures: plate versus nail: a retrospective outcome analysis of matched pairs of patients. Int Orthop 2007; 31:709–714.

24 Toms AD, McMurtie A, Maffulli N. Percutaneous plating of the distal tibia. J Foot Ankle Surg 2004; 43:199–203.

25 Kerkhoffs GM, Kuipers MM, Marti RK, Van der Werken C. External fixation with standard AO-plates: technique, indications, and results in 31 cases. J Orthop Trauma 2003; 17:61–64.

26 Collinge C, Sanders R, DiPasquale T. Treatment of complex tibial periarticular fractures using percutaneous techniques. Clin Orthop Relat Res 2000; 375:69–77.

27 Frigg R. Locked compression plate (LCP). An osteosynthesis plate based on the Dynamic Compression Plate and the Point Contact Fixator (PC-Fix). Injury 2001; 32:63–66.

28 Kloen P. Supercutaneous plating: using a locked compression plate as an external fixator. J Orthop Trauma 2009; 23:72–75.

29 Stoffel K, Dieter U, Stachowiak G, Gachter A, Kuster MS. Biomechanical testing of the LCP-how can stability in locked internal fixators be controlled? Injury 2003; 34:11–19.

30 Kuhn S, Appelmann P, Pairon P, Mehler D, Hartmann F, Rommens PM. A new angle stable nailing concept for the treatment of distal tibia fractures. Int Orthop 2014; 38:1255–1260.

31 Kanchanomai C, Phiphobmongkol V. Biomechanical evaluation of fractured tibia externally fixed with an LCP. J Appl Biomech 2012; 28:587–592.

32 Woon CY, Wong MK, Howe TS. LCP external fixation-external application of an internal fixator: two cases and a review of the literature. J Orthop Surg Res 2010; 5:19.

33 Tulner SA, Strackee SD, Kloen P. Metaphyseal locking compression plate as an external fixator for the distal tibia. Int Orthop 2012; 36:1923–1927.

34 Hasenboehler E, Rikli D, Babst R. Locking compression plate with minimally invasive plate osteosynthesis in diaphyseal and distal tibial fracture: a retrospective study of 32 patients. Injury 2007; 38:365–370.