Treatment of open tibial fractures using unreamed interlocking nails

Saied K. Abdelhamid[a], Abdelhamid A. Attalla[a], Mohamed A. Abdel-Aal[b]

[a]Department of Orthopedic Surgery, Faculty of Medicine for Girls, Al-Azhar University, Cairo, Egypt, [b]Department of Orthopedic Surgery, El-Bakry General Hospital, Cairo, Egypt

Correspondence to Mohamed A. Abdel-aal, MD, Consultant of Orthopedic Surgery El-Bakry General Hospital, Department of Orthopedic Surgery, El-Bakry General Hospital, Cairo, Egypt; Tel: 01020995024; fax: 23930054; e-mail: mohamed_abdelaal1983@hotmail.com

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Background
Internal splintage of open tibial fractures have gained acceptance as a preferred method of early stabilization of such injuries.
Patients and methods
Fifty-five patients were operated upon. They were followed from July 2008 to March 2012 (44 months), with an average follow-up time of 23 months. The final results were evaluated through a scheme including seven parameters: pain, union, malunion, infection, range motions of nearby joints, implant and technical failure, and activity and return to the same work.
Results
According to previous parameters, union was achieved in 52 (94.5%) cases at an average time of 20 weeks (16–52 weeks), with 5.5% incidence of nonunion. Excellent and good range of knee and ankle motions were achieved at the final follow-up visit in 49 (89.09%) cases. The incidence of complication was acceptable; mainly, malunion was found in 7.3%, deep infection in 12.7%, implant and technical failure in 9.1%, and full activity and return to the same work in 89.1% cases. The overall results of our series are as follows: excellent in 19 (34.5%) cases, good in 27 (49.1%) cases, fair in six (10.9%) cases, and poor in three (5.5%) cases.
Conclusion
Utilizing unreamed interlocking nail for open tibial fractures is a good method of treatment, particularly those of grades II and IIIA. The high proportions of excellent and good results confirm that this technique is superior to all other known methods of fracture fixation.

Keywords:
fracture tibia, interlocking nail, undreamed

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Introduction

Open tibial fractures are more frequent than any other long bone fractures. Because of high prevalence of complications associated with these fractures, the optimum method of treatment remains a subject of controversy [1]. The prognosis of these fractures is determined primarily by the amount of devitalized soft tissues caused by the injury and by the level and type of bacterial contamination. Moreover, the extent of soft tissue damage is determined by energy absorbed by the affected area at time of injury. The goals of treating these fractures are preventing infection, restoring soft tissue vitality, achieving bony union, and instituting early joint motion and muscle rehabilitation. Various techniques have been utilized, including the following: plaster cast immobilization [2], functional cast brace as utilized by Sarmiento and Latta [3], and external fixators either uniplanar or multiplanar fixators [4,5]. In addition, circular fixators utilized for fractures of the periarticuler region, either proximal or distal, proved to be effective in providing good stability [6].

Internal fixation utilizing plates and screws provide rigid fixation for unstable fractures, and thus reducing the problem of nonunion [6,7]. However, stripping of soft tissues to apply the plate was shown to increase the rate of infection [8].

Intramedullary fixation using Lottes and Ender's nails [9] had been used successfully, though they were not preferred in comminuted fractures as they might lead to shortening or redisplacement [10,11].

Interlocking nailing without reaming resulted in lower incidence of malunion, nonunion, and rate of infection, and allows early patient rehabilitation especially for unstable fractures [12].

Patients and methods

Fifty-Five patients with open tibial fractures were treated and followed from July 2008 to March 2012 (44 months). This study approved by the Ethical committee of Faculty

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of Medicine for Girls, Al-Azhar University, Cairo, Egypt. There were 44 (80%) men and 11 (20%) women. The age ranged between 25 and 65 years with a mean age 33.2 years. The right side was affected in 31 (56.4%) cases and the left side in 24 (43.6%) cases. The fractures were simple in 34 (61.8%) cases and comminuted in 21 (38.2%) cases. The upper-third part was affected in 11 (20%) cases, middle-third in 35 (63.6%) cases, and the lower-third in nine (16.4%) cases. The causative trauma was motor car accident in 25 (45.5%) cases, fall from a height in 19 (34.5%) cases, direct trauma with heavy object in nine (16.4%) cases, and gunshot injury in two (3.6%) cases. Eight (14.5%) cases had associated muscle–skeletal injuries (five with fracture femur, one case with stable pelvic fracture, and two cases with Colles' fracture), 17 cases had grade II fracture, 14 cases grade IIIA, and seven cases grade IIIB (Tables 1 and 2).

Resuscitationof the patient was achieved thorough irrigation utilizing 3–7 l saline solution. All contaminated, devitalized soft tissues and bone fragments were excised and gunshots extracted. Broad spectrum antibiotic was given (third-generation cephalosporin, 1 g intravenous/12 h).

Nailing was done at the time of debridement in 32 cases, less than 12 h in 12 cases, delayed for 72 h due to other medical problems in six cases, and delayed between 7 and 15 days with average 6 days in five cases. Unreamed tibial nail of 8 mm diameter was used in 16 (29.1%) cases, of 9 mm in 33(60%) cases, and of 10 mm diameter in six (10.9%) cases. The length ranged between 35 and 39 mm (Table 3).

Surgical technique

Length and width of the nail was provisionally determined preoperatively. The nail of proper width and length was assembled to the distal locking target device to adjust the position of the distal locking screws. Through longitudinal paramedian incision about 4 cm parallel to the patellar tendon, the entry point of the nail was detected and opened using a curved Awl. A guide wire was passed through the medullary canal down to the level of the fracture site under direct vision (in cases of grades II and III fractures) while utilizing the image intensifier (in cases of grade I fractures). The guide wire was directed toward the distal fragment and its position was checked again radiographically for further confirmation. The chosen nail was attached to the insertion jig and driven over the guide wire through the medullary canal. The distal locking target device was assembled to the jig and distal locking screws were inserted first then the proximal ones.

Wounds were dressed every other day and weight bearing was encouraged for those who had no other associated injuries prohibiting walking (five cases) and as soon as the patient's tolerability to pain permitted.

Dynamization by removal of either proximal or distal locking screws was carried out for 38 (69.1%) cases, fibular osteotomy in addition to dynamization in two (3.6%) cases, autogenous bone grafting in four (7.3%) cases, bone marrow injection in three (5.5%) cases, and both dynamization and bone grafting in two (3.6%) cases (Figs 1 and 2).

Results

The patients of this series were followed for 18–44 months, with an average follow-up of 23 months. They were evaluated both clinically and radiologically. Evaluation was based on a scheme including seven items: (i) pain; (ii) union and nonunion; (iii) malunion; (iv) infection; (v) range of nearby joints' motions; (vi) implant and technical failure; and (vii) full activity and return to the same work.

According to this scheme, results were classified into four categories: excellent, good, fair, and poor. The criteria of each item are explained in Table 4.

Table 1 Distribution of patients

	Right side	Left side	Simple	Comminuted	Upper-third	Middle-third	Lower-third
Male	27	17	28	16	10	27	7
Female	4	7	6	5	1	8	2
Total	31	24	34	21	11	35	9

Table 2 Classification of fractures

	Grade I	Grade II	Grade IIIA	Grade IIIB
Male	11	14	12	7
Female	6	3	2	–
Total	17	17	14	7

Table 3 Timing of nailing

	Immediate	Within 12 h	Within 72 h	7–15 days
Male	27	9	5	3
Female	5	3	1	2
Total	32	12	6	5

A patient was rated 'excellent' if all his parameters were rated excellent, but if one parameter was rated good, then his rate would decrease to 'good' instead.

Pain

Nineteen (34.5%) cases had no pain (excellent), 28 (50.9%) cases had pain with strenuous activity (good), six (10.9%) cases had pain elicited with normal activities (fair), and in two (3.7%) cases pain developed even at rest (Table 5).

Union

Union was evaluated clinically by the capability of the patient to bear weight fully on the affected side without pain, absence of movement at fracture site, and radiologically by the presence of bridging callus and/or the disappearance of the fracture line on two radiographic views.

Fifty-two (94.5%) cases were fully united and the time of union ranged between 4 and 17 months, with an average of 9 months. Nineteen (34.5%) cases united before 6 months and were rated excellent, 28 (50.9%) cases united between 6 months and 1 year and were rated good, five (9.1%) cases united after 1 year and were rated fair, whereas three (5.5%) cases failed to unite and were rated poor (Table 6).

Malunion

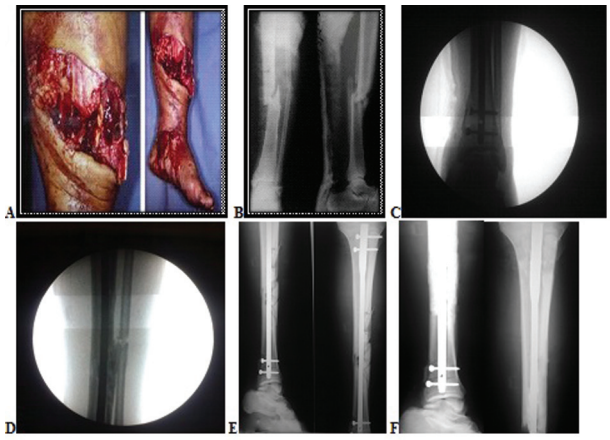
Malunion was defined as angular deformity (either varus or valgus) of more than 5°, anteroposterior angulations more than 10°, or shortening more than 1 cm [13].

Cases with neither malunion nor shortening were rated excellent and 36 (65.5%) cases were of this category. Cases with less than 15° angular deformity or less than 3 cm shortening were rated good and 16 (29.1%) cases were of this category. Cases with less than 20° angular deformity or less than 4 cm shortening were rated fair. We had two (3.6%) cases with varus angulations (15–19°). Cases with more than 20° angular

Figure 1

(a) Open fracture of both bones of right leg grade II. (b) Radiography showing short oblique diaphyseal fracture. (c) Intramedullary fixation with an interlocking tibial nail. (d) Four months postoperative showing complete union of fracture. (e) Full knee flexion with proper squatting of the patient.

Figure 2



(a) Open fracture of both bones left leg grade IIIA. (b) Radiography showing diaphyseal fracture of both bones of leg. (c and d) Intraoperative radiography during nail applying. (e) Immediate postoperative with good reduction and proper alignment. (f) Three months postoperative following dynamization.

Table 4 Full activity and return to same work

Characters	Excellent	Good	Fair	Poor
Pain	No pain	Pain with vigorous activity	Pain with normal activity	Pain at rest
Union	Before 6 months	6–12 months	After 1 year	Persistent nonunion
Malunion	No	0–20°	20–40°	>40°
Infection	Neither superficial nor deep	Superficial	Deep and controlled	Deep uncontrolled
Range of motions	Full range	0–30° restriction	30–60° restriction	>60° restriction
Implant and technical failure	Neither implant nor technical failure	Technical failure	Implant failure	Both implant and technical failure
Full activity and return to same work	Full activity and return same work	Same work with invalidity <20%	Same work with >20% invalidity	Inability to return back same work

deformity or more than 4 cm shortening were rated poor and there were two (3.6%) cases related to this category with valgus angulations of 25 and 30° (Table 7).

Infection

Cases with neither superficial nor deep infection [21 (38.2%) cases] were rated excellent. Patients with superficial infections [27 (49.1%) cases] were rated good. Patients with properly controlled deep infection [five (9.1%) cases] were rated fair. Cases with uncontrolled deep infection [two (3.6%) cases] were rated poor (Table 8).

Range of motions

Range of motion of the knee and ankle joints were evaluated and compared with contralateral side. There were 21 (38.2%) cases with full range of motions of both knee and ankle joints and were rated excellent, 23 (41.8%) cases lost less than 30° of full range and were rated good, nine (16.4%) cases showed loss from 30 to 60° of full range and were rated fair, and two (3.6%) cases lost more than 60° of full range and were rated poor (Table 9).

Table 5 Distribution of pain

	Grade I	Grade II	Grade IIIA	Grade IIIB	Total
No pain (excellent)	12	6	1	–	19
Pain with vigorous activity (good)	5	10	10	3	28
Pain with normal activity (fair)	–	1	2	3	6
Pain at rest (poor)	–	–	1	1	2

Table 6 Distribution of union rate

Rates of union	Grade I	Grade II	Grade IIIA	Grade IIIB
Before 6 months (excellent)	13	4	2	–
Between 6 and 12 months (good)	12	8	6	2
After 1 year (fair)	–	1	2	2
Persistent nonunion (poor)	–	–	1	2

Table 7 Distribution of malunion

Rates of malunion	Grade I	Grade II	Grade IIIA	Grade IIIB
No malunion or shortening (excellent)	13	15	5	2
<15° angular deformity or <3 cm shortening (good)	4	2	8	2
<20° angular deformity or <4 cm shortening (fair)	–	–	1	1
>20° angular deformity or >4 cm shortening (poor)	–	–	–	2

Implant and technical failure

Patients with neither implant nor technical failure [50 (90%) cases] were rated excellent. Patients with technical failure [three (5.5%) cases] were rated good; in these cases one of the distal locking screws was outside its corresponding hole in the nail. Those with implant failure (one case) were rated fair; in this case one locking screw was broken. Patients with both technical and implant failure were rated poor and there was one case where one locking screw was broken and the nail was slightly low distally.

Full activity and return to same work

Full activity of the patient and return to previous work was considered as an excellent result. It was achieved in 37 (67.3%) cases. Return to the same work with invalidity less than 20% was considered good and was achieved in 12 (21.8%) cases. Return to same work with more than 20% invalidity was rated fair and was achieved in four (7.3%) cases. In two (3.6%) cases, patients were unable to return back to previous work and were rated poor (Table 10).

Table 8 Distribution of infection rate

Infections	Grade I	Grade II	Grade IIIA	Grade IIIB	Total
No infection (excellent)	12	7	2	–	21
Superficial (good)	5	9	9	4	27
Controlled deep (fair)	–	1	2	2	5
Uncontrolled deep (poor)	–	–	1	1	2

Table 9 Distribution of range of motions

Range of motions	Grade I	Grade II	Grade IIIA	Grade IIIB	Total
Full range of motion (excellent)	10	8	2	1	21
<30° loss of motion (good)	7	9	5	2	23
31–60° loss (fair)	–	–	6	3	9
>60° loss of motion (poor)	–	–	1	1	2

Table 10 Summary of overall results

Results	Excellent	Good	Fair	Poor
Pain	19	28	6	2
Union	19	28	5	3
Malunion	35	16	2	2
Infection	21	27	5	2
Range of motions	21	23	9	2
Implant and technical failure	50	3	1	1
Full activity and return same work	37	12	4	2

Discussion

Open tibial fractures represent a challenge to most of the orthopedic surgeons. They are considered an indication for operative fixation. Several techniques have been used to treat these fractures.

Plaster cast is described by many authors but its shortcomings of infection, malunion, and shortening hinder its usage [2].

External fixation is universally accepted as a technique of choice, particularly for grades II and III fractures [14]. However, pin track infection, malunion, and surgical demanding as a technique are major shortcomings [15].

Unreamed interlocking tibial nail is of utmost importance for treating open fractures in which periosteal blood supply is already compromised by the original trauma. In addition, it allows control of rotation, axial alignment, and length [16,17].

We compared our results with those of other series utilizing the same technique of fixation [16,18–20].

Our series had 47 patients with no pain or occurring with vigorous activity. This may be explained by the fact that early rehabilitation of the patient would improve the psychological status of the patient. Moreover, lower incidence of infection with its effect on development of cicatrization may lessen the incidence of pain [21].

Delayed union was reported in 11 (20%) cases. Seven cases were grade III, three cases related to grade II, and only one case was grade I. These results emphasized the fact that the more the soft tissue injury, the slower the rate of bone healing. It was counteracted by bone grafting in four cases, bone marrow injection in three cases, fibular osteotomy in addition to dynamization of the fracture in two cases, and in two cases both dynamization and bone grafting were carried out. All cases of delayed union showed complete union by 12 months.

The nonunion rate in our series was 5.5% (three cases). All of them related to grade III. These results are more or less in agreement with the results of other studies [16,18–20]. In addition, the results emphasize that the more the devitalization of soft tissues, the higher the incidence of nonunion [22].

Malunion was reported in four (7.3%) cases. In two cases the distal locking screws were removed (dynamization of the fracture) early on to counteract the development of delayed union. The other two cases showed sever infection and at the same time the patients started bearing weight early without casting protection as recommended by many authors [23].

Seven (12.7%) cases of deep infection had been reported, which is comparably high. This might be attributed to the increased number of grade III (21 cases) with marked soft tissue devitalization. Furthermore, delay interference in some cases might be a predisposing factor [24]. There was no deep infection in grade I cases and this may be attributed to the preservation of soft tissue envelop around the fracture ends.

Regarding range of motions of knee and ankle joints as a key for evaluating efficiency of the technique, 21 (38.2%) cases regained full range of motions for both knee and ankle joints; this can be attributed to the early rehabilitation of the patient's joints and the proper control of infection preventing its spread to nearby joints. In 11 (20%) cases, the range of motions of the knee joint was markedly affected. All of them related to grade III, which explains that the more the soft tissues damage, the more the delay of patient recovery, which in turn affects the range of motions of the nearby joints [25].

There was a high incidence of cases with neither implant nor technical failure, accounting for 50 (90.9%) cases. This may be due to perfection and mastering the technical issue. One more advantage of the technique is the use of distal targeting device for applying the distal locking screws. This device minimizes the operative time and lessens the hazards proposed by exposure to radiation during nail application [26,27].

The overall results of our series are as follows:

Excellent: 19 (34.5%) case.

Good: 27 (49.1%) cases

Fair: six (10.9%) cases

Poor: three (5.5%) cases

Conclusion

Unreamed tibial nailing is considered a good method for the management of open fracture tibia. The results of our series emphasize that strict adherence to technical prerequisites, proper wound management,

and frequent use of bone grafting or bone marrow injection may support the fact that this technique is safe, efficacious, and could be the treatment of choice for grades I and II open tibial fractures.

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Conflicts of interest
There are no conflicts of interest.

References

1 Nicoll EA. Fractures of the tibial shaft, a survey of 705 cases. J Bone Joint Surg Br 1964; 46:373–387.

2 Brown PW, Urban JG. Early weight bearing treatment of open fractures of the tibia. An end-result study of 63 cases. J Bone Joint Surg Am 1969; 51:59–75.

3 Sarmiento A, Latta LL. Functional fracture bracing. J Am Acad Orthop Surg 1999; 7:66–75.

4 Edwards CC. Staged reconstruction of complex open tibial fractures using Hoffmann external fixation. Clinical decisions and dilemmas. Clin Orthop 1983; 178:130–161.

5 Watson JT, Ripple S, Hoshaw SJ. Hybrid external fixation for tibial plateau fractures: clinical and biomechanical correlation. Orthop Clin North Am 2002; 33:199–209.

6 Patzakis MJ, Wilkins J. Factors influencing rate in open fracture wounds. Clin Orthop Relat Res 1989; 243:36–40.

7 Chapman MW. The use of immediate internal fixation in open fractures. Orthop Clin North Am 1980; 11:579–591.

8 Farouk O, Krettek C, Miclau T. Minimally invasive plate osteosynthesis and vascularity: preliminary results of a cadaver injection study. Injury 1997; 28 (Suppl 1):7–12.

9 Lottes JO. Medullary nailing of the tibia with the triflange nail. Clin Orthop 1974; 105:253–266.

10 Chapman MW. The role of intramedullary fixation in open fractures. Clin Orthop 1986; 212:26–34.

11 Bhandari M, Guyatt G, Tornetta P. Randomized trial of reamed and undreamed intramedullary nailing of tibial shaft fractures. J Bone joint Surg Am 2008; 90:2567–2578.

12 Bonatus LB, Kassman S, Stegemann P, France J. Prospective study of union rate of open tibial fractures treated with locked unreamed intramedullary nails. J Orthop Trauma 1994; 8:45–49.

13 Andrew H, Schmeling GJ, Finkemeied MB. Treatment of tibial fractures. Instructional course lecture. J Bone Joint Surg 2003; 85-A:352–368.

14 Thakur AJ, Patankar J. Open tibial fractures. Treatment by uniplanar external fixation and early bone grafting. J Bone Joint Surg Br 1991; 73B:448–451.

15 Chao EY, Hein TJ. Mechanical performance of the standard orthofix external fixator. Orthopedics 1988; 11:1057–1069.

16 Whittle AP, Russell TA, Taylor JC. Treatment of open fractures of the tibial shaft with the use of interlocking nailing without reaming. J Bone Joint Surg 1992; 74A:1162–1171.

17 Ziran BH, Darwish M, Klatt BA. Intramedullary nailing in open tibia fractures: a comparison of two techniques. Int Orthop 2004; 28:235–238.

18 Helfet DL, Howey T, Dipasquale T. The treatment of open and/or unstable tibia fractures with an unreamed double locked tibial nail. Orthop Rev 1994; Suppl:9–17.

19 Sanders R, Jersinovich I, Anglen J. The treatment of open tibial shaft fracture using an interlocking intramedullary nail without reaming. J Orthop Trauma 1994; 8:504–510.

20 Tornetta P III, Bergman M, Watnik N. Treatment of grade IIIB open tibial fractures: a prospective randomized comparison of external fixation to non-reamed locked nailing. J Bone Joint Surg Br 1994; 76:13–19.

21 Salem KH. Critical analysis of tibial fracture healing following unreamed nailing. Int Orthop 2012; 36:1471–1477.

22 Kakar S, Tornetta P. Open fractures of the tibia treated by immediate intramedullary tibial nail insertion without reaming. J Orthop Trauma 2007; 21:153–157.

23 Penn-Barwell JG, Bennett PM, Fries CA, Kendrew JM. Severe open tibial fractures in combat trauma: management and preliminary outcomes. J Bone Joint Surg 2013; 95B:101–105.

24 Khatod M, Botte MJ, Hoyt DB. Outcomes in open tibia fractures: relationship between delay in treatment and infection. J Trauma 2003; 55:949–954.

25 Mouit B, Gordon GH, Marc SF. Treatment of open fractures of the shaft of the tibia. A systemic overview and meta-analysis. J Bone Joint Surg 2001; 83-B:62–68.

26 Gordon JE, O'Donnell JC. Tibia fractures: what should be fixed? J Pediatr Orthop 2012; 32(Suppl 1):52–61.

27 Parrett BM, Matros E, Pribaz JJ, Orgill DP. Lower extremity trauma: trends in the management of soft tissue reconstruction of open tibia-fibula fractures. Plast Reconstr Surg 2006; 117:1315–1322.