ORIGINAL ARTICLE

Fixator-assisted Percutaneous Plate Fixation of Complex Diaphyseal Tibial Fractures

Abdullah A Nada[1], Mohamed Romeih[2], Mahmoud El-Rosasy[3]

Abstract

Aim: The purpose of this study is to evaluate the results of indirect reduction and fixation of comminuted diaphyseal tibial fractures using temporary simplified external fixator and plate osteosynthesis through a limited incision approach with special consideration of the duration of surgery and rate of complications.

Materials and methods: In this prospective case series study, 41 cases of comminuted diaphyseal tibial fractures were included. Twenty-two were closed fractures, 15 grade I open fractures, and four were grade II open fractures. Patients were evaluated clinically according to the lower extremity functional scale (LEFS).

Results: Of the 41 cases, 38 were followed up for at least 1 year. Using the LEFS, final scores ranged from 67–80 (mean 75). Union was achieved in all cases except one which united after bone grafting. The mean time to radiological healing was 12 weeks. Operative time from skin incision to closure ranged between 65 minutes and 100 minutes (mean of 80 minutes). There were four cases of superficial infection.

Conclusion: Treatment of comminuted tibial fractures through use the of a simplified external fixator to aid and maintain the reduction of comminuted tibial fractures whilst limited incisions are then used for minimally-invasive plate osteosynthesis in an effective and time-saving method with a low complication rate.

Keywords: Comminuted fracture, External fixator, Minimally invasive plate osteosynthesis, Tibia.

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Introduction

Comminuted fractures of tibia are challenging injuries. The choice of the fixation depends on multiple factors including the fracture pattern, proximity to the joints, bone quality, concomitant soft-tissue injury, the general condition of the patient and the available equipment.

The usual methods of treatment for such fractures include conventional plate fixation, biological plate fixation, intramedullary nailing and external fixation. Intramedullary nailing for tibial shaft fractures is considered the standard of care with satisfactory results in most cases.[1]

External fixation offers some benefits in terms of soft-tissue management and for severe comminution. However, concerns remain over the risks of pin tract infection, joint stiffness and the inconvenience from the bulky device.

Biological fixation by minimally-invasive locking plate osteosynthesis has become an attractive option for treating comminuted tibial fractures. The basic principles of this technique include indirect closed reduction, extraperiosteal dissection, plate osteosynthesis through limited approaches, functional alignment and relative stability with controlled motion at the fracture site for secondary bone healing through callus formation.[2,3]

Materials and Methods

This is a retrospective review of 41 patients with comminuted tibial shaft fractures. Patients were referred to the emergency department of Tanta University Hospital between March 2012 and March 2016. On admission, a detailed history and clinical examination with the necessary laboratory investigations were performed. At least two X-ray views were taken of the affected leg. In case where fracture extension into a joint was identified, additional CT scans were obtained (Table 1).

Surgery was performed within 10 days of injury. A broad spectrum antibiotic was given with the induction of anesthesia. The procedure was carried out with the patient supine on a standard radiolucent orthopedic table. No tourniquet was used.

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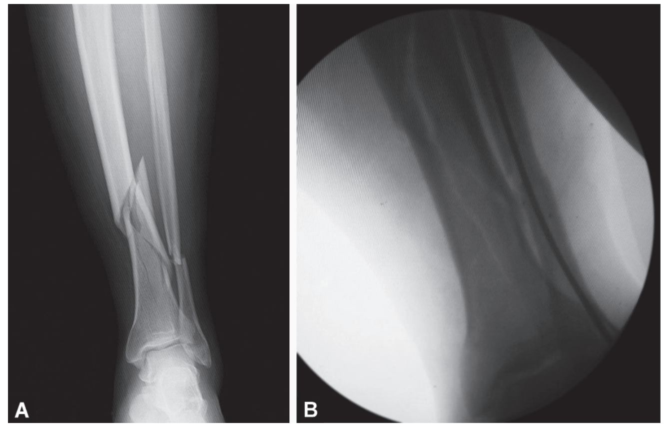
Table 1: Type of the fractures in the study according to AO classification system

Fracture type	*Number*
B1	7
B2	4
B3	10
C1	6
C2	5
C3	9
Total	41

Fig. 1: Temporary monolateral external fixator application



Figs 2A and B: Fracture configuration before (A) and after distraction (B) by the external fixator

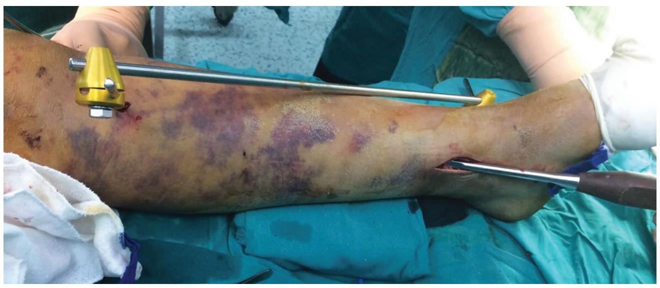


Fig. 3: Subcutaneous tunneling using long periosteal elevator

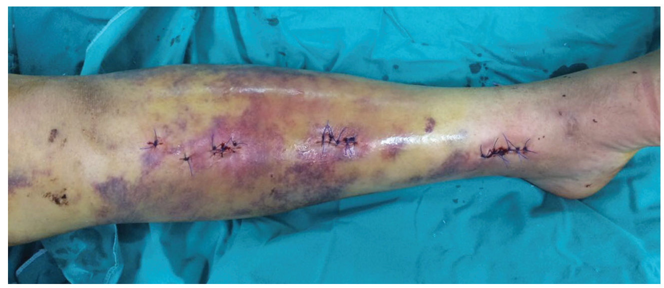


Fig. 4: Surgical skin incisions at the end of the surgery

Provisional reduction was obtained using a temporary monolateral external fixator. One Schanz pin (6 mm) was inserted in the proximal part of tibia parallel to the knee joint line and from medial to lateral. Another was inserted in the calcaneus or distal tibia (according to fracture level) from lateral to medial and parallel to the ankle joint line. A side bar was attached using clamps to the proximal and distal half pins in a crossed fashion (Fig. 1) but not locked until reduction was achieved manually by axial traction and manipulation. The crossed configuration of the fixator allows axial distraction across the fractures site without applying a varus or valgus moment. In some cases, the fibula was reduced and fixed first by an intramedullary wire or flexible nail to facilitate tibial fracture reduction and aid the correction of valgus or varus angulation at the fracture site. Reduction was confirmed using an image intensifier (Fig. 2).

The plate was inserted on the medial surface of the tibia (Fig. 1) unless a contraindication, e.g., unfavorable skin conditions or a thin patient were identified. For proximal and midshaft fractures, antegrade plating was performed using locking proximal tibial plates. Two small incisions were made proximal and distal to the fracture site; a small medial or lateral oblique incision was used on the upper part of the tibia and another small distal incision corresponding to the distal end of the plate. For distal tibia fractures, we used a curved anteromedial incision centered over the medial malleolus (Fig. 3).

A long periosteal elevator or a long plate is inserted through the incision and manipulated in the subcutaneous, extraperiosteal tissues to create a tunnel. An image intensifier was used to check the position and length of the plate before insertion and fixation (Fig. 3). The appropriate positioning of such anatomical pre-contoured plates assured a good reduction.

Two non-locked screws were inserted first, with one on each side of the fracture to drag the main bone fragments to the plate. Subsequently locking screws were inserted, with at least a total of four screws on each side and using the near–near, far–far configuration for stability—as is the case when using external fixators—for the plate functions as an internal fixator. The aim was to preserve a total of less than or equal to half of the plate holes filled with screws. The fixator was then removed and the wounds irrigated and repaired in layers (Fig. 4). No drains were inserted.

In the open fractures, 13 of 15 patients had wound debridement, irrigation, primary wound closure and application of a splint on the first day. Definitive fixation was performed within 1 week after the first operation. The remaining two open fractures, both grade I using the Gustilo and Anderson classification, had debridement and definitive fixation done at the same sitting within 24 hours of injury. This difference was related to the availability of the operating surgeon at the time of trauma, not due to patient-related reasons.

Active range of motion exercises were started for the knee and ankle joints once postoperative pain had subsided. Non-weight-bearing ambulation was initiated in the first week. The wound was inspected on the second postoperative day and sutures were removed 12–14 days postoperatively. Partial weight-bearing ambulation was then started for 6 weeks and full weight-bearing after 12 weeks or when at least 3 out of 4 cortices showed signs of bridging callus or bony continuity.

Results

Of the 41 patients included in this study, 38 of them were followed up for at least 1 year. The period of follow-up ranged from 1 year to 4 years with an average of 15 months.

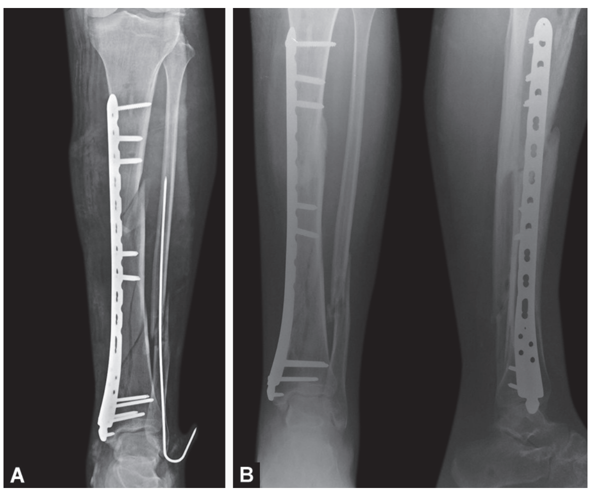
The delay to surgery ranged from 1 day to 10 days with a mean 5 days. The mean age of the patients was 36.8 years (range 19–61); males (85.4%) were more affected than females (14.6%). The mechanisms of injury were from motor vehicle accident (MVA) (51.2%), falls from heights (26.8%) and direct trauma (22%). The left side (57.1%) was affected more than the right side (43.8%).

There were 22 patients with closed fractures, 15 patients with open grade I fracture (Gustilo and Anderson classification) and four with grade II injuries. The fracture was classified according to the Arbeitsgemeinschaft für Osteosynthesefragen (AO) system: there were 7 42-B1 fractures, 4 42-B2, 10 42-B2, 6 42-C1, 5 42-C2 and 9 42-C3 patterns.

The average operative time was 80 minutes with a range of 65–100 minutes. Intraoperative blood loss was recorded by measuring the amount of blood in the suction machine and an estimation from the degree of blood saturation of gauze swabs;[4] this ranged from 20 mL to 120 mL with an average of 53.6 mL.

The results of treatment were analyzed clinically and radiologically. Clinical assessment was performed using the LEFS. The LEFS is a questionnaire containing 20 questions about the individual's ability to perform everyday tasks. The higher the score, the better the function.[5] Using this scale, our results ranged from 67 to 80 (mean 75) (Figs 5 and 6).

Radiological union was defined when at least three out of four cortices of the tibia showed bony continuity or bridging callus.



Figs 5A and B: (A) Immediate postoperative X-ray; (B) At 3 months follow-up showing signs of union

The mean time for radiological healing was 12 weeks; it ranged from 8 weeks to 36 weeks.

There were four cases (9.7%) of superficial infection. Three of them were from open fractures (two of them were grade II and one was grade I) and all were at the site of the open wound. Treatment was by surgical debridement followed by IV antibiotics.

There was one case of aseptic nonunion which needed bone grafting at 6 months to achieve complete union. The nonunion was diagnosed after three follow-up reviews at 1-month intervals showed no radiological signs of bone formation or progress to healing.

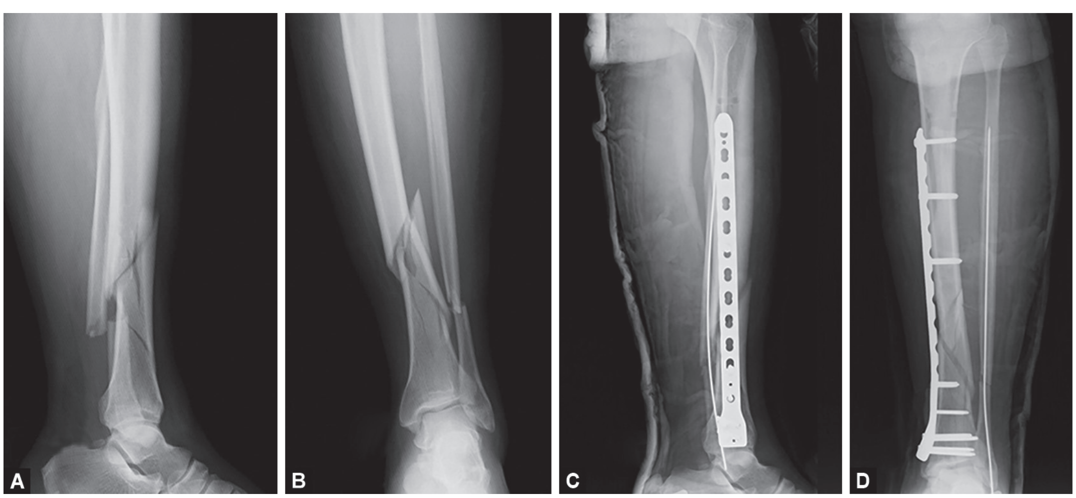
Discussion

The management of comminuted tibial fractures is variable. Nonoperative treatment is used for stable fractures with minimal displacement but malunion, shortening, and stiffness of the nearby joints are common.[6,7] Open reduction of comminuted tibia fractures and internal fixation with plate requires a large incision, significant soft tissue dissection to achieve anatomical reduction with ensuing complications including infection (range 8.3–23%),[8,9] delayed and nonunion (range 8.3–35%).[10–12]

A balance between anatomical reduction and soft tissue stripping is required in order to avoid complications. Clinical practice has shifted from the mechanical concept of absolute stability to the biological concept of functional reduction using indirect methods and minimally invasive plate osteosynthesis (MIPO) techniques with relative stability. However, minimally invasive techniques do not allow direct visualization of the fracture and, hence, intraoperative fluoroscopy is required to confirm the reduction.

In our study, early surgical fixation was done for the majority of patients with a mean time to surgery of 5 days. The average time of union was 11.5 weeks which is comparable to other studies on percutaneous plating of tibial fractures.[13,14]

The average operative time of 80 minutes is also comparable to other studies of fixation of tibia by interlocking nails or MIPO plating.[15,16] The cases which needed fibular fixation took about 15 minutes longer but helped to restore the coronal alignment and the length of the leg and facilitated subsequent steps in the surgery. The average intraoperative blood loss was 53.6 (range 20–20 mL), which is considered minimal blood loss, without using tourniquet. Notably, this is comparable to other studies in which a tourniquet was used.[17]



Figs 6A to D: (A and B) Preoperative, lateral and anteroposterior X-ray views of comminuted both bone leg fracture; (C and D) Postoperative X-rays, lateral and anteroposterior views, showing functional reduction and fixation by plate osteosynthesis

The complications in this study were limited to five cases. Superficial infection was noticed in four patients during early follow-up after 1 week as redness around the wound sutures. All infections resolved after surgical debridement and intravenous antibiotics administration. There was one case of aseptic nonunion. Here the patient was a 60-year-old smoker and hypertensive. The relative old age and smoking may explain the occurrence of nonunion. Bone graft was added to achieve union.

Conclusion

Cases treated by biological plating methods show a low incidence of complications including wound infection, nonunion and the need of additional procedures. The application of a temporary monolateral external fixator was found to be helpful in terms of shortening of the operation time, by aiding the reduction and maintenance of reduction whilst plating was carried out. Fixation of the fibula by intramedullary flexible nail can be used to facilitate bony realignment especially in cases with simple fibular fractures.

Consent

A written, informed consent was obtained from all the patients authorizing the treatment, radiological and photographic documentation. They were informed and consented that the data would be submitted for publication.

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