Management of open tibial fractures type IIIB by segment transfer using limb reconstruction system fixator

Shady S. Elbeshry, Khaled A.A. Alabd

Orthopedic Department, Faculty of Medicine, Ain Shams University, Cairo, Egypt

Correspondence to Shady Samir, MD, 74 Raba Eladawaya Investing Buildings, Nasr City, Cairo, 11765, Egypt. Tel: +20 100 533 5392/ +20 121 162 0335; fax: 24142556; e-mail: shady_elbeshry@yahoo.com

Received: 17 April 2019
Revised: 9 May 2019
Accepted: 19 May 2019
Published: 18 August 2020

The Egyptian Orthopaedic Journal 2019, 54:110–115

Purpose
To evaluate the effectiveness of bone transport using limb reconstruction system (LRS) fixator and early coverage in open-type IIIB tibial fractures with massive bone and soft tissue loss.
Patients and methods
In this study, eight patients with type IIIB open tibial fractures were managed by initial debridement and fixation by LRS uniplanar external fixator. A second-stage rotational myocutaneous flap coverage and osteotomy for segment transfer was done within 14 days. All patients were followed up till full union.
Results
Full union was achieved in all patients. A total of five patients needed iliac bone graft at the docking site. Union occurred in an average external fixator index of 45.3 days/cm. No flap coverage infection occurred, and there was no significant limb malalignment. Significant limb shortening occurred only in one patient.
Conclusion
LRS fixator is an effective definitive method for management of open tibial fractures with massive bone loss and soft tissue defects. It is easy to apply, allows early intervention by plastic surgeons to obtain soft tissue coverage, and also allows early patient rehabilitation and joint mobilization.

Keywords:
limb reconstruction system, open tibial fracture, segment transfer

Egypt Orthop J 54:110–115

1110-1148

Introduction

The treatment of type IIIB open tibial fractures remains a challenge for orthopedic surgeons with respect to soft tissue and bony reconstruction [1]. Primary multidisciplinary approach by orthopedic and plastic surgeons has many advantages and is widely recommended [2]. Vascularized muscle flap surgery has made soft tissue coverage possible, even with large defects [3]. The limb reconstruction system (LRS) external fixator, which consists of clamps that can slide on a rigid rail, can be used to achieve bone transport [4].

In this study, we assessed the outcome of treatment of type IIIB open tibial fractures with soft tissue and bony defects by segment transfer using LRS fixator and early soft tissue coverage using a rotational myocutaneous flap.

Patients and methods

The procedures in this study were in accordance with the ethical standards of the responsible committee on human experimentation, and procedures were done with an informed consent of the patients.

A total of eight patients with open fracture of the tibia type IIIB were included in this study. The average age was 36 years (range: 22–51 years). The patients comprised five males and three females. All patients presented in the emergency reception following high-energy trauma resulting in open fracture with severe soft tissue affection, severe comminution, and significant diaphyseal bone loss. In all patients, the fracture involved the middle third of the tibia (Fig. 1).

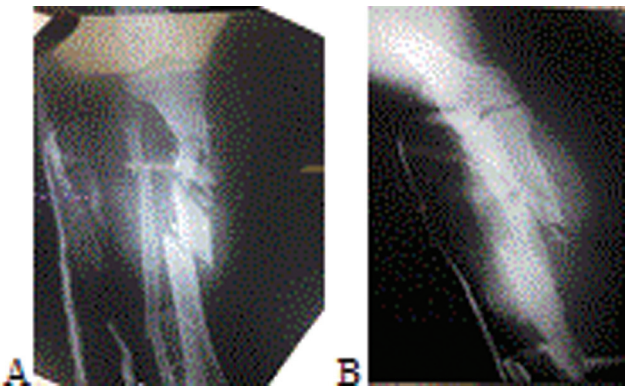
Plain radiographs were initially done. Bone survey was done to exclude other fractures, and neurovascular assessment of the injured limb was done. None of the patients had concomitant fractures except for the fibular fractures. None of the patients presented with neurovascular injury or compartment syndrome (Fig. 2).

Primary management comprises debridement, excision of all necrotic soft tissue, copious irrigation, and excision of all fragmented bone within the wound and preparing the proximal and

Figure 1

Patient no. 3, open tibial fracture grade IIIb.

Figure 2

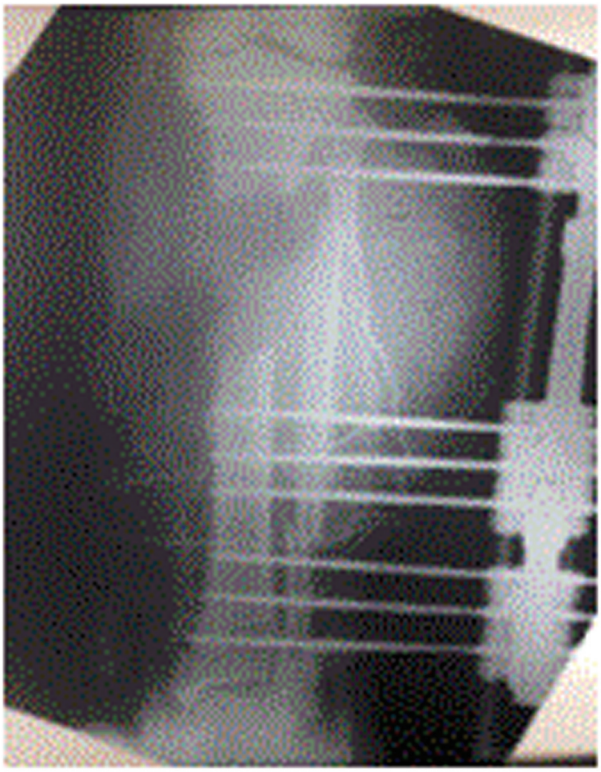


Pregnane X receptor (PXR) patient no. 3 showing extensive comminution of tibial diaphysis in anteroposterior (AP) view (a) and oblique view (b).

distal bone ends for segment transfer by resection of any spikes or bony irregularities. Primary fixation was done using 3 clamps LRS fixator, with 3 (5 mm diameter) half pins in each clamp. No primary wound closure was done. All half pins were applied perpendicular to the axis of the tibia. A 3.2-mm drill bit was used to make the track of each half pin, and then the half pin was applied using a T-handle to decrease the incidence of bone necrosis. Mechanical axis of the tibia was assessed during application of the fixator to ensure that there was no angular deformity in either the sagittal or frontal planes (Fig. 3).

All patients were kept on parenteral antibiotics and daily wound dressing for 10–14 days. During this period, all patients underwent a second-look debridement by orthopedic and plastic surgeons within 1 week from the primary surgery, followed by

Figure 3



Pregnane X receptor (PXR) after debridement and application of the frame.

a definite surgery in the form of coverage of the soft tissue defect by a rotational medial head of gastrocnemius flap with split-thickness skin graft performed by plastic surgeons, and in the same session, low-energy osteotomy was done by a Gigli saw for segment transfer (Fig. 4).

Segment transfer was started after a latent period of 7 days, at a rate and a rhythm of 0.5 mm every 12 h using a specific LRS distraction piece connected to the fixator (Fig. 5). Physiotherapy was encouraged to maintain active and passive knee and ankle range of motion.

In five patients, transfer was performed from distal to proximal using a distal metaphyseal osteotomy, and in three patients, transfer was done from proximal to distal using a proximal metaphyseal osteotomy.

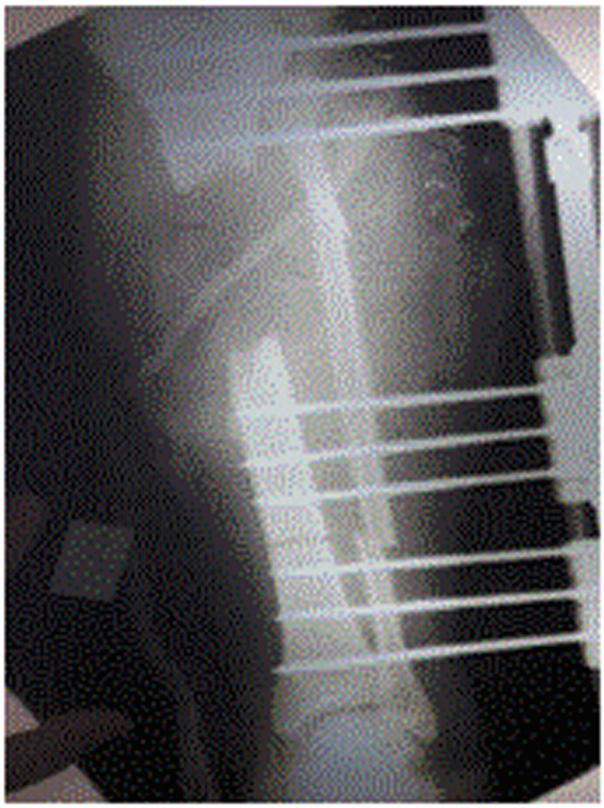
Follow-up in the outpatient clinic was done every week during the first 4 weeks and then every 2 weeks. Follow-up radiographs were done. Stability of pins and quality of regenerate were assessed in every visit.

The bony defect ranged from 6 to 12 cm, with an average of 8.25 cm. Docking site freshening and

Table 1 Patients' data and results

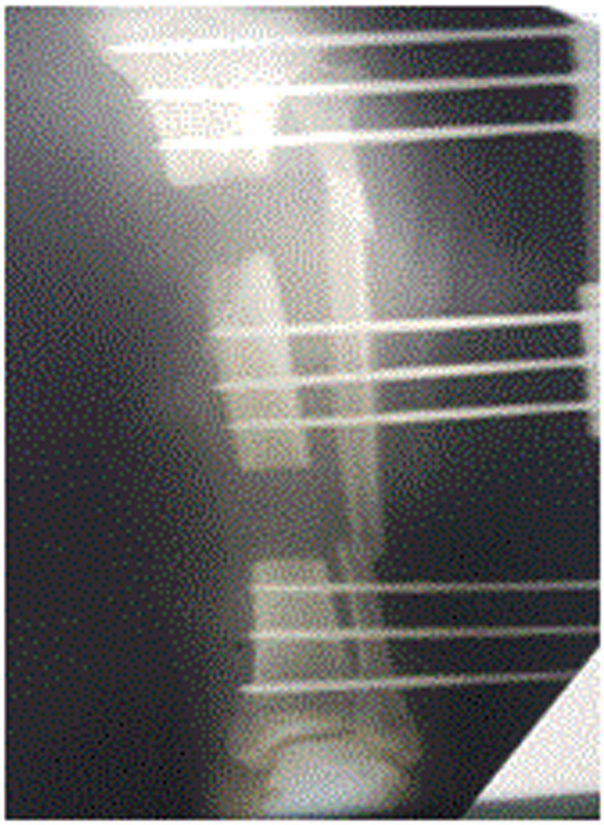
Patients no.	Age	Sex	Bone defect (cm^2)	Direction of bone transfer	Graft at docking site	Duration of fixation (days)	Limb length discrepancy (cm)
1	31	Male	8	From distal to proximal	Yes	380	1
2	40	Male	7	From proximal to distal	Yes	350	–
3	34	Female	9	From distal to proximal	Yes	440	2
4	22	Male	6	Fom distal to proximal	No	280	–
5	43	Female	12	From proximal to distal	Yes	500	3
6	30	Female	7	From distal to proximal	No	310	–
7	51	Male	9	From proximal to distal	Yes	410	1
8	39	Male	7	From distal to proximal	No	320	–

Figure 4



Pregnane X receptor (PXR) osteotomy for segment transfer from distal to proximal was done at the same session of myocutaneous flab.

Figure 5



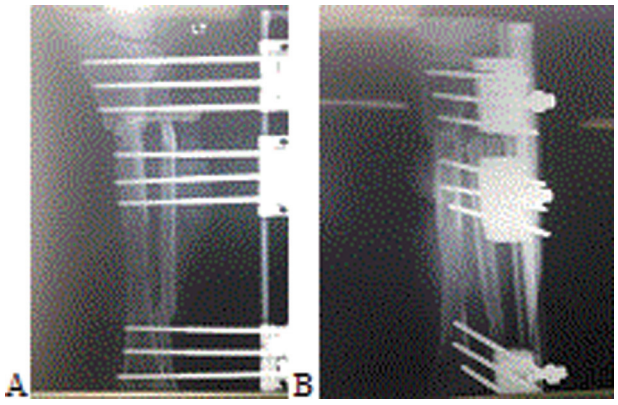
Segment transfer at a rate of 0.5 mm twice per day.

cancellous grafting were done in five patients, in whom there was no radiological evidence of union at the docking site after 6 weeks of bone contact. The fixator remained in place in all patients until full maturation of new bone and docking site union (Fig. 6).

In one patient, exchange of pins was done during the course of the fixator owing to pin loosening and pin-tract infection.

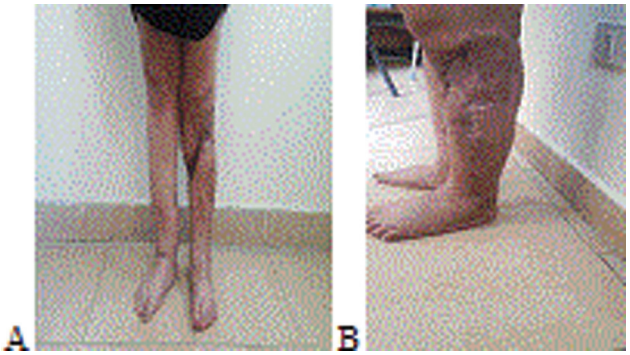
Removal of the fixator in all patients was followed by application of a patellar weight-bearing cast and gradual increase in weight bearing. After 2 weeks, the cast was removed,

Figure 6



Full union on pregnane X receptor (PXR) on anteroposterior (AP) view (a) and lateral views (b).

Figure 7



After removal of the frame, normal frontal (a) and sagittal (b) mechanical axes.

and the patients were encouraged to fully weight bearing (Fig. 7).

Results

The patients were followed up for a mean of 24 months postoperatively. All fractures united at a mean of 374 days. The docking site united with no need of bone grafting in three patients; in all of whom the bone transport was performed from distal to proximal. Docking site grafting was needed in five patients, including the three patients in whom bone transport was performed from proximal to distal and two patients in whom bone transport was performed from distal to proximal.

Pin-tract infection occurred in four patients and resolved in three of them after pin care and parenteral antibiotics. In one patient, a secondary procedure of debridement and exchange of two pins was performed owing to resistant pin-track infection.

Shortening occurred in four patients with a 1-cm shortening in two patients, 2-cm shortening in one patient, and 3-cm shortening in one patient. Only the patient with 3-cm shortening needed shoe raise (Table 1).

No malalignment of more than 5° occurred in any of the patients in either the frontal or sagittal planes. No rotational malalignment occurred in any of the patients.

None of the patients experienced failure of coverage or necrosis of the musculocutaneous flap. None of the patients had limitation in the knee or ankle joints range of motion. No cases of late regeneration or re-fractures were recorded.

Discussion

Open tibial fractures with bone defects represent a common problem. The conventional methods of treatment like nailing or external fixation with acute docking have high rate of complications including shortening and soft tissue healing problems [4].

Deep infection is a common complication in open tibial fractures with severe soft tissue loss [3]. Gustilo reported infection rate in 52% in type IIIB fractures [5].

Low rate of infection is related to the adequacy of debridement, skeletal stabilization, and obliteration of dead space by a well-vascularized muscle flap [2].

Gopal *et al.* [2] in their study on 84 patients with type IIIB and IIIC open tibial fractures used radical protocol of fix and flap. This technique included radical debridement of the wound, rigid fixation of the fracture, and early soft tissue coverage by vascularized flap. The authors reported a union rate of 100% using internal fixation (nail or plate and screws) in most of patients, and they only used segment transfer technique after temporary fixation in three patients with extensive comminution.

Granhed *et al.* [3] reviewed the results of nine patients with comminuted open fracture shaft tibia type IIIB and IIIC. They used a technique of radical debridement and acute shortening ($\leq$9 cm) to decrease the soft tissue defect downgrading the open fracture from stage III to stage II. Later on after coverage of soft tissue defect and improvement of patient general condition, lengthening of tibia was carried on by LRS from remote site from the fracture.

With the high rates of infection, an alternative method to compensate bone loss is bone transport, reported initially by Ilizarov who introduced corticotomy, which preserves intramedullary and endosteal circulation; however, preserving the periosteum and low-energy osteotomy are the most important determinants of good-quality regenerate [6].

Although LRS fixator is not claimed to be superior to the Ilizarov ring fixator, it has the advantage of being easy to handle, simple surgical technique, and light-weighted design, which allows easier soft tissue coverage procedures and access to soft tissue. LRS fixator is believed to have a better patient compliance compared with Ilizarov ring fixator, which has a high rate of patient dissatisfaction [4]. In this study, all patients started early knee and ankle range of motion exercises, and none of the patients had limitation of knee or ankle range of motion at the end of the follow-up (Fig. 6).

With the bone transport technique, morbidities such as limb length discrepancy and malalignment can be corrected as accurately as possible [7]. In this study, the mean bone transport was 8.25 cm, and the mean external fixation index was 45.3 days/cm. In comparable studies, the mean external fixation index was 1.4 months/cm in the study by Sen *et al*. [7], 45 days/cm in Atef and El Tantawy [8], 2.42 months/cm in Mikhail *et al*. [9], and 1.5 months/cm in Wani *et al*. [10].

In this study, we achieved union and normal limb alignment in all patients, with limb length equality in four patients, 1-cm shortening in two patients, 2-cm shortening in one patient, and 3-cm shortening in one patient. Only the patient with 3-cm shortening needed shoe raise.

Godina [11] brought a new dimension in the treatment of such injuries by the use of free tissue transfer very early, within a few days of injury.

It is believed that bringing healthy muscle into the fracture site is essential and that it introduces important cellular and hormonal elements to the healing process [12].

In this study, rotational medial head of gastrocnemius flap and osteotomy were performed 10–14 days after the initial debridement, during which the patients were kept on parenteral antibiotics. All patients underwent a second-look debridement within 1 week from the primary surgery, to provide the optimum conditions to avoid infection at the flap or at the osteotomy site. The ability to debride the wound depends on the surgeon's confidence that the resulting defect can be reliably filled with healthy tissue in a short period. In our study, no infection at the site of myocutaneous flaps or at the osteotomy sites was reported.

Complications in bone transport are mainly attributed to docking site problems, as bone ends lose their viability and their potential for union until apposition occurs, and many authors agree that bone grafting must be done at docking site in bone transport [7]. In this series, docking site grafting was needed in five patients, including the three patients in which bone transport was performed from proximal to distal and two patients in which bone transport was performed from distal to proximal.

The most common complication in accordance with other series was pin-tract infection. Pin-tract infection occurred in four patients and resolved in three of them after pin care and parenteral antibiotics. In one patient, a secondary procedure of debridement and exchange of two pins was performed owing to resistant infection.

The main weak points in this study is the low number of cases, which we contributed to that we only included in the study patients with only middle third fracture tibia and only type IIIB open fractures. Another weak point is that the results were evaluated by the same surgeons who conducted the operations, which may lead to bias.

Conclusion

In the management of open tibial fractures with massive soft tissue and bone loss, early radical debridement and bone transport using LRS fixator is a safe and successful method.

This technique allows union and maintenance of limb length and alignment, and early soft tissue coverage by myocutaneous flaps improves fracture site vascularity. Also it is resistance to infection, and has the potential for bone healing.

LRS is a defiant method that can be used from the start of treatment, and also it is less bulky than Ilizarov frame, so the patient is more cooperative and compliant during physiotherapy.

Financial support and sponsorship
Nil.

Conflicts of interest

There are no conflicts of interest.

References

1 Yokoyama K, Itoman M, Nakamura K, Uchino M, Tsukamoto T, Suzuki T. Primary shortening with secondary limb lengthening for Gustilo IIIb open tibial fractures: a report of six cases. J Trauma 2006; 61:172–180.

2 Gopal S, Majumder S, Batchelor AG, Knight SL, De Boer P, Smith RM. Fix and flap: the radical orthopaedic and plastic treatment of severe open fractures of the tibia. J Bone Joint Surg Br 2000; 82:959–966.

3 Granhed HP, Karladani AH. Bone debridement and limb lengthening in type III open tibial shaft fractures. Acta Orthop Scand 2001; 72:46–52.

4 Ajmera A, Verma A, Agrawal M, Jain S, Mukherjee A. Outcome of limb reconstruction system in open tibial diaphyseal fractures. Indian J Orthop 2015; 49:429–435.

5 Gustilo RB, Mendoza RM, Williams DN. Problems in the management of type III (severe) open fractures: a newclassification of type III open fractures. J Trauma 1984; 24:742–746.

6 Kulkarni M. Operative techniques of Ilizarov method. In: Kulkarani GS, editor. Textbook of orthopaedics and trauma. 1st ed. New Delhi: Jaypee Brothers; 1999. pp. 1510–1522.

7 Sen C, Kocaoglu M, Eralp L, Gulsen M, Cinar M. Bifocal compression-distraction in the acute treatment of grade iii open tibia fractures with bone and soft-tissue loss. J Orthop Trauma 2004; 18:150–157.

8 Atef A, El-Tantawy A. Management of open infected tibial fractures using Ilizarov concept. Eur J Orthop Surg Traumatol 2014; 24:403–408.

9 Mekhail AO, Abraham E, Gruber B, Gonzalez M. Bone transport in the management of post-traumatic bone defects in the lower extremity. J Trauma 2004; 56:368–378.

10 Wani N, Baba A, Kangoo K, Mir M. Role of early Ilizarov ring fixator in the definitive management of type II, IIIA, and IIIB open tibial shaft fractures. Int Orthop 2011; 35:915–923.

11 Godina M. Early microsurgical reconstruction of complex trauma of the extremities. Plast Reconstr Surg 1986; 78:285–920.

12 Gopal S, Giannoudis PV, Murray A, Matthews SJ, Smith RM. The functional outcome of severe open tibial fractures managed with early fixation and flap coverage. J Bone Joint Surg Br 2004;86861–867