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Early prophylactic autogenous bone grafting in type III open tibial fractures

Cumhur C. KESEMENLI, Ahmet KAPUKAYA, Mehmet SUBAŞI, Huseyin ARSLAN, Serdar NECMIOĞLU, Cuma KAYIKÇI

From the Medicine Faculty of Dicle University, Diyarbakir, Turkey

The authors report the results achieved in patients with type III open tibial fractures who underwent primary autogenous bone grafting at the time of debridement and skeletal stabilisation.

Twenty patients with a mean age of 35.8 years (range, 24-55) were treated between 1996 and 1999. Eight fractures were type IIIA, 11 were type IIIB, and 1 was type IIIC. At the index procedure, wound debridement, external fixation and autogenous bone grafting with bone coverage were achieved.

The mean follow-up period was 46 months (range, 34-55). The mean time to fixator removal was 21 weeks (range, 14-35), and the mean time to union was 28 weeks (range, 19-45). Skin coverage was achieved by a myocutaneous flap in 2 patients, late primary closure in 4, and split skin grafting in 14. One (5%) of the patients experienced delayed union, and 1 (5%) developed infection.

In tibial type III open fractures, skin coverage may be delayed, using the surrounding soft tissue to cover any exposed bone after thorough débridement and wound cleansing. Primary prophylactic bone grafting performed at the same time reduces the rate of delayed union, shortens the time to union, and does not increase the infection rate.

INTRODUCTION

The tibia is one of the bones that most commonly suffer an open fracture (*12*). Despite newly developed fixation devices, skin and soft tissue closure techniques, and recent developments in antibiotic therapy, the treatment of open tibial fractures remains a major issue (*2, 6, 9, 10, 14*). Various factors influence the healing of tibial fractures, including soft tissue injury, comminution, infection, initial fracture displacement, concomitant injuries, patient age, and treatment modality (*2*). Open tibial fractures with severe soft tissue injury, significant displacement, or comminution take longer to heal than more simple tibial fractures (*2, 3, 5, 8, 13, 15*).

In fractures resulting from high-energy trauma, early prophylactic bone grafting is recommended because delayed union is likely (*2, 8*). Charnley recommended prophylactic bone grafting, defined as grafting performed within the first 12 weeks, in order to reduce the time to union in tibial fractures (*2*). However, this time interval is often considered too long. There is still no consensus on the timing of early prophylactic bone grafting.

■ Cumhur Cevdet Kesemenli, MD, Associate Professor.
■ Ahmet Kapukaya, MD, Associate Professor.
■ Mehmet Subaşi, MD, Associate Professor.
■ Huseyin Arslan, MD, Associate Professor.
■ Serdar Necmioğlu, MD, Associate Professor.
■ Cuma Kayıkçı, MD, Assistant Professor.

Department of Orthopaedics and Traumatology. Medicine Faculty of Dicle University, Diyarbakir, Turkey.

Correspondence : Cumhur Cevdet Kesemenli, Department of Orthopaedics and Traumatology , Medicine Faculty of Dicle University, Diyarbekir / Türkey. E-mail : ccevdet@dicle.edu.tr.

Table I. — Demographic data

Age	Mechanism of injury	Clasification of open fracture	Soft tissue coverage	Infection	Delayed union
24	GS	3A	DPC	NO	NO
29	GS	3B	MCF	NO	NO
30	GS	3A	DPC	NO	NO
25	VA	3A	DPC	NO	NO
43	GS	3B	MCF	YES	NO
25	GS	3B	SSG	NO	NO
47	VA	3A	DPC	NO	NO
28	VA	3B	SSG	NO	NO
41	GS	3B	SSG	NO	NO
55	VA	3A	DPC	NO	NO
50	WA	3B	SSG	NO	YES
46	VA	3B	SSG	NO	NO
30	GS	3C	SSG	NO	NO
42	GS	3A	DPC	NO	NO
48	GS	3B	SSG	NO	NO
33	GS	3B	SSG	NO	NO
32	GS	3B	SSG	NO	NO
33	VA	3B	SSG	NO	NO
25	VA	3A	DPC	NO	NO

GS : Gunshot
WA : Work-related accident
VA : Vehicle accident
DPC : Delayed primary closure
MCF : Myocutaneous flap
SSG : Split skin graft.

In this study, the results of type III open tibial fractures treated by emergency surgery and aggressive debridement with simultaneous primary bone grafting and skeletal stabilisation are discussed.

MATERIALS AND METHODS

Twenty patients were treated for Gustilo type III open tibial fractures between 1996 and 1999. Their mean age was 35.8 years (range, 24-55) ; 16 (80%) were men and 4 (20%) were women. The cause of fracture was a gunshot injury in 12 cases (60%), a vehicle accident in 6 cases (30%), and a work-related accident in 2 cases (10%). Arteriography and exploration were carried out in cases with suspected vascular injury. One patient was determined to have an injury of the anterior and posterior tibial arteries. Patients whose extremities were thought to be salvageable according to Lange's criteria (*12*) were included in the study. Eight fractures were Gustilo type IIIA, 11 were type IIIB, and 1 was type IIIC (table I). Fracture types were classified according to the AO classification and were as follows : 2 type B_1, 2 type B_2, 9 type C_1, 2 type C_2, and 5 type C_3. Cases with segmental defect were excluded. Ipsilateral fibula fracture was present in all cases. A medial malleolus fracture was present in 3 cases. All patients underwent emergency surgery, and the wounds were lavaged with 0.9% NaC1 in the operating room and debrided (fig 1). A unilateral (fig 2a,b,c) or a circular external fixation (fig 3a,b,c) was applied for fracture stabilisation. The choice of fixator type was made based on the condition of the wound and whether or not soft tissue cover reconstruction was necessary. All patients received first generation cephalosporin and aminoglycosid for 5 days.

During the initial stabilisation, grafting with autogenous grafts taken from the iliac crest was performed in patients in whom soft tissue coverage was achieved by various methods. The surgical approach for bone grafting was determined according to the fracture configuration and the condition of the surrounding soft tissue. Grafts were placed in the posterior and lateral parts of the tibia, as well as between fragments. The bone was covered with a myocutaneous flap and rotation muscle

Fig. 1. — Type 3B open fracture

flap. Early primary skin suturing was not performed in any patients except the two with myocutaneous flaps. Of the remaining 18 patients, 14 underwent split skin grafting and 4 delayed primary closure. In cases treated with unilateral external fixation, plaster casts were applied postoperatively and patients were mobilised without weight bearing. Patients with circular external fixators, on the other hand, were instructed to bear as much weight as tolerated.

Patients were discharged and reviewed for physical examination and radiography every 4 weeks. Healing was considered complete when the following criteria were satisfied : sufficient callus formation on radiograph, no pathological movement when the fixator was loosened, and absence of pain and discomfort at the fracture site. Time to union, the infection rate, and the nonunion rate were determined.

RESULTS

Mean follow-up time was 46 months (range, 34-55), and mean time to fixator removal was 21 weeks (range, 14-35). After external fixator removal, walking casts were applied. Mean time in plaster cast was 6 weeks (range, 3-8). Mean time to union was 28 weeks (range, 19-43).

On arteriography of one patient with type IIIC open fracture caused by a gunshot, injury was identified in the anterior and posterior tibial artery. After unilateral external fixation, the fracture was repaired by a vascular surgery specialist with a graft taken from the contralateral leg.

A total number of 185 Kirschner (K) wires were used in 12 patients treated with external fixation, and pin-tract infection occurred around 18 (10%) of them. Forty-two Steinman pins were used in 8 patients treated with unilateral fixation, and pin site infection occurred around 5 (11%). Wire site infections were treated with local dressing and oral antibiotics. Five K wires and 2 Steinman pins were removed in cases that did not respond to treatment

Fig. 2a. — AP roentgenogram of grade III B open fracture.
2b. — Lateral roentgenogram of grade III B open fracture.
2c. — AP radiological appearance following unilateral external fixation.
2d. — Lateral radiological appearance following unilateral external fixation.
2e. — AP radiological appearance 26 months post ınjury.
2f. — Lateral radiological appearance 26 months post ınjury.

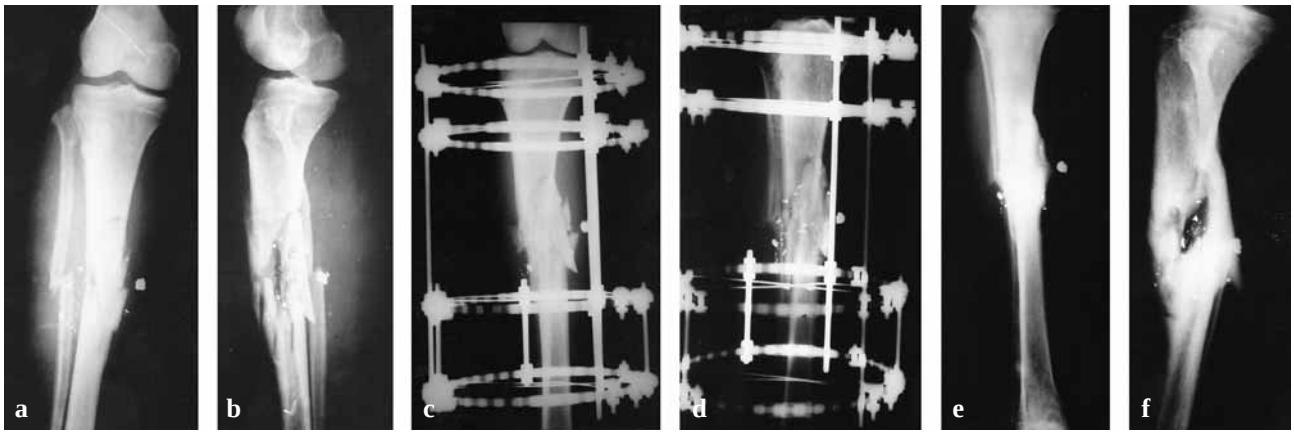

Fig. 3a. — AP radiograph of grade III B open fracture.
3b. — Lateral radiograph of grade III B open fracture.
3c. — AP radiological appearance following circular external fixation.
3d. — Lateral radiological appearance following circular external fixation.
3e. — AP radiological appearance after removal of external fixation.
3f. — Lateral radiological appearance after removal of external fixation.

for infection. Reflex sympathetic dystrophy occurred in one patient. Osteomyelitis developed in one patient (5%) 6 weeks postoperatively ; *Enterobacter cloacae* grew in this patient's culture. There was no response to antibiotics, and the patient underwent a second debridement, followed by sequestrectomy. Union was achieved in 19 patients. In one patient with delayed union, the unilateral external fixator was removed, autogenous grafting performed, and a circular external fixator was applied. Consolidation was achieved 3 months later. There were no cases of refracture.

All patients had restricted articular movement in the knee and ankle. After rehabilitation, 7 patients had plantar and dorsiflexion restriction in excess of 20º in ankle movements, and 5 had flexion restriction of less than 40º in knee range of movement.

DISCUSSION

Treatment of open tibial fractures is long and difficult, and frequently necessitates repeat surgery. These fractures are reported to have an infection rate of 3-40%, and a nonunion and delayed union rate of 40-60% (*2, 6, 8, 9, 10, 12, 14*). A wide variety of methods are used for treatment, of which bone transport has been gaining increased use and attention (*10*). However, it has disadvantages, such as being lengthy, having a high complication rate, and being technically difficult (*10*). An alternative technique is primary autogenous bone grafting, which does not involve cutting the soft tissue connections of the bone fragments, and is performed together with debridement in the early stage.

The advantage of early prophylactic autogenous bone grafting is agreed on by numerous authors (*1, 6, 16*). Behrens *et al* (*1*) have reported that union is achieved in less than 12 weeks with early prophylactic grafting performed within 4 weeks of injury. In a comparative study, Blick *et al* (*2*) reported that union was achieved in 57.4 weeks with late grafting, and in 45.7 weeks with early grafting. In a 5-patient study, Tropet *et al* (*14*) reported that type IIIB fractures healed in 24 weeks ; in the present study, the time to healing was on average 28 weeks. Despite general agreement on the advantage of early bone grafting, debate and controversy persist on the timing of early prophylactic autogenous bone grafting. There are two opposing views in this debate. Some favour grafting after a waiting period following soft-tissue reconstruction. The reason for the waiting period is concern over the risk of contamination in the closed wound, and graft necrosis. Blick *et al* (2) have performed bone grafting after

soft-tissue and skin reconstruction and reported successful results. In a comparative study on this subject, Fischer *et al* (*6*) stated that cases in which grafting was performed simultaneously with soft-tissue reconstruction had a high infection rate, and bone grafting should therefore be performed after skin coverage has been achieved. The second view, to which we subscribe, favours the simultaneous performance of bone grafting and soft-tissue reconstruction (*3, 7, 14*). Connolly (*4*) stated that it is more urgent to achieve fracture union than soft-tissue coverage in open fractures. Tropet *et al* (*14*) reported successful outcomes with one-stage emergency grafting. These studies, in contrast to those previously mentioned, demonstrate that the rates of graft necrosis and infection with this technique are not high enough to warrant concern. There was no case of graft necrosis in any of our patients.

One of the most significant factors affecting the success of early prophylactic bone grafting is infection. In a comparative study, Fischer *et al* (*6*) reported an 11% infection rate in early bone grafting before the achievement of soft tissue coverage, and a 5% rate with early bone grafting after the achievement of soft tissue coverage. Blick *et al* (*2*), on the other hand, reported an infection rate of 7.5% in early bone grafting after the achievement of bone coverage. In our series, this rate was 5%. The high infection rates in open fractures are multifactorial. We think it is wrong to attribute them to early grafting alone, but rather that open fracture treatment should be considered as a whole, and that each stage should be planned carefully, from debridement to the choice of stabilisation material (*8, 14*). Fischer *et al* (*6*) used intramedullary nails as a stabilisation method, a factor which has been noted to increase infection rates (*2, 8*). Thus we think that the infection rate is not increased by external fixation and emergency grafting following adequate wound cleansing and aggressive debridement.

In conclusion, we believe that aggressive debridement and wound cleansing followed by early prophylactic bone grafting in type III open tibial fractures within the first 24 hours, with delayed skin coverage and using the surrounding soft tissue to envelop the bone structures reduces nonunion and delayed union rates, shortens the time to union, and does not increase the infection rate.

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