

Large segmental necrosis of the tibia with deep infection after open fracture

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Fifteen patients with large segmental necrosis of the tibia with deep infection, following open fractures, were treated according to the Burri-Papineau protocol. After radical debridement, the segmental bone defects averaged 8.4 (5-15) cm. Necrectomy, external fixation, and open cancellous grafting, in a two-stage procedure, gave infection control in 14 cases and bone healing in 12. Additional procedures, i.e., plating and posterolateral bone grafting, provided union in another 2 cases. One patient underwent amputation. Functional results in the other 14, after a follow-up averaging 4 years, were good in 9 cases, fair in 3, and poor in 2.

Radical removal of infected and necrotic bone and soft tissue, i.e., necrectomy, is almost mandatory in the treatment of posttraumatic osteomyelitis (Burri et al. 1973, Papineau 1973, Roy-Camille et al. 1976, Vécsei and Barquet 1981). In the treatment of severe lower leg open fractures with deep infection, necrectomy may therefore cause large segmental bone defects.

We have used the protocol of delayed open cancellous grafting, as described by Burri et al. (1973) and Papineau (1973), for bridging such defects. We report a consecutive series of 15 patients with open segmental defects of the tibia averaging 8.4 cm after necrectomy.

Patients and methods

The Burri-Papineau protocol was used to treat 15 patients with posttraumatic major segmental necrosis of the tibia with exposed bone and deep infection, which had drained for 3 weeks or more (Table 1). All the patients were men. The mean

age was 32 (18-56) years. The initial injuries were compound open fractures of the lower leg caused by high-energy trauma. Primary treatment consisted of early debridement and different methods of bone immobilization, such as traction, cast, pins, screws, or external fixation.

On admission to our department, all the patients had substantial bone exposure, deep infection, and large segmental necrosis of the tibia. The interval between the initial injury and our treatment averaged 9 (5-24) weeks.

Bacteriologic culture was positive in 13 patients, i.e., *Staphylococcus aureus* in 9, *Pseudomonas aeruginosa* in 1, *Proteus mirabilis* in 1, *Escherichia coli* in 1, and mixed infection of *Staphylococcus aureus* and *Proteus mirabilis* in 1. Forty-eight hours before surgery, a high-dose parenteral antibiotic therapy, based on sensitivity tests, was begun and continued for an average of 9 days.

The first surgical procedure included removal of loosened implants and necrectomy, followed by external fixation. Two types of frames were used: a quadrilateral frame supplemented with a cast in 6 patients and an AO-type unilateral biplanar frame (Burri and Claes 1981, Etter et al. 1983) in 9 patients.

The segmental defect was packed with vaseline gauze, which was removed on the fifth day. Irrigation was performed with saline-isotonic

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Table 1. Fifteen cases of large segmental necrosis of tibia with deep infection and skin defects after open fractures treated according to the Burri-Papineau protocol

A	B	C	D	E	F	G	H	I	J	K	L	M
1	m/25	5	1	2	12	2	nu, c, sg		1	u	96	g
2	m/21	8	1	1	11	2	u, c, e				94	f
3	m/37	8	1	1	6	1	u, c, e				80	f
4	m/48	6	1	1	10	2	u, c, e				73	p
5	m/51	11	1	2	5	1	u, c, e				69	p
6	m/21	6	1	1	9	1	c, sg	su	5	h	50	g
7	m/44	24	2	1	5	1	u, c, e				47	g
8	m/25	12	2	1	6	1	u, c, e				42	g
9	m/27	8	2	1	7	1	nu, c, e		2	u	24	g
10	m/56	7	2	2	15	1	nu, p, sd		3	fa	34	a
11	m/18	10	2	1	8	1	u, c, sg	rf	4	u	31	f
12	m/21	5	2	2	11	1	u, c, e				24	g
13	m/36	5	2	1	8	1	u, c, sg	rf	4,6	u	20	g
14	m/28	6	2	1	8	1	u, c, e				28	g
15	m/51	8	2	1	5	1	u, c, sg	su	5	h	20	g

A case

B sex/age

C weeks from injury

D external fixation, 1 quadrilateral frame and posterior half-brace cast, 2 unilateral biplanar frame (AO tubular system)

E number of necrectomies

F length of bone defect (cm)

G number of graftings

H primary outcome, c control of infection, e epithelization,

nu nonunion, p persistent infection, sd skin defect persisted, sg split thickness skin graft, u union

I complications; rf refracture, su skin ulceration

J further treatment, 1 DCP plate and bone grafting, 2 posterolateral bone grafting, 3 free vascularized bone-muscular transplant, 4 cast brace, 5 sg split thickness skin graft, 6 bone graft

K final outcome, u union, h healed, fa failure

L months follow-up

M function, g good, f fair, p poor, a amputation

solution and the wound was repacked. Irrigation and packing was repeated every second day until granulation tissue covered the bone and soft-tissue surfaces. While this was achieved in 2 to 4 weeks after one necrectomy in 11 patients, 4 patients required two necrectomies.

Then, the second procedure was performed. The defect was completely filled with autologous cancellous grafts from the iliac crest. Longitudinal slotting of the bone ends and circumferential clearing of the granulation tissue around the bone ends were performed to permit insertion of grafts and to improve continuity between bone and graft. One graft procedure was performed in 12 patients and two grafts in 3 patients. The wound was dressed with vaseline gauze, and the cycle of irrigation and dressing was repeated as in the first stage until the grafted bone was covered with granulation tissue.

Spontaneous epithelialization of the wound occurred in 10 patients, whereas split-thickness skin grafts were required in 4 cases.

The external fixator was removed on an average 7 (3-11) months after its application. Eleven of 81 Bonnel or Schanz screws had to be exchanged because of loosening.

After fixator removal, progressive weight bearing under the protection of a brace with adjacent

joints free was encouraged. The brace was used for 1 to 2 years.

The 15 patients were reviewed after 4 (2-8) years. Function was considered 1) good if shortening was ≤ 2 cm, if malalignment was $\leq 7^\circ$, and if joint motion limitation was ≤ 15 percent; 2) fair if one of these criteria was missing; and 3) poor if two or all three criteria were missing.

Results

Bone union and control of infection were achieved in 12 patients (Figure 1). In 2 patients, infection subsided, but nonunion persisted. Insufficient bone grafts and late instability of the frame appeared to be the main causes. Internal fixation with a DCP plate and another bone graft resulted in union in 1 of the 2 patients (Figure 2) and a posterolateral bone graft in the other.

One patient with a 15-cm-long defect and poor vascularity of the lower leg had persistent infection and nonunion. A free vascularized bone-muscle transplant also failed and an amputation was performed.

Satisfactory skin coverage was achieved in 14 patients. However, skin ulceration occurred in 2 cases secondary to mild trauma, and split-thickness skin grafts were applied.

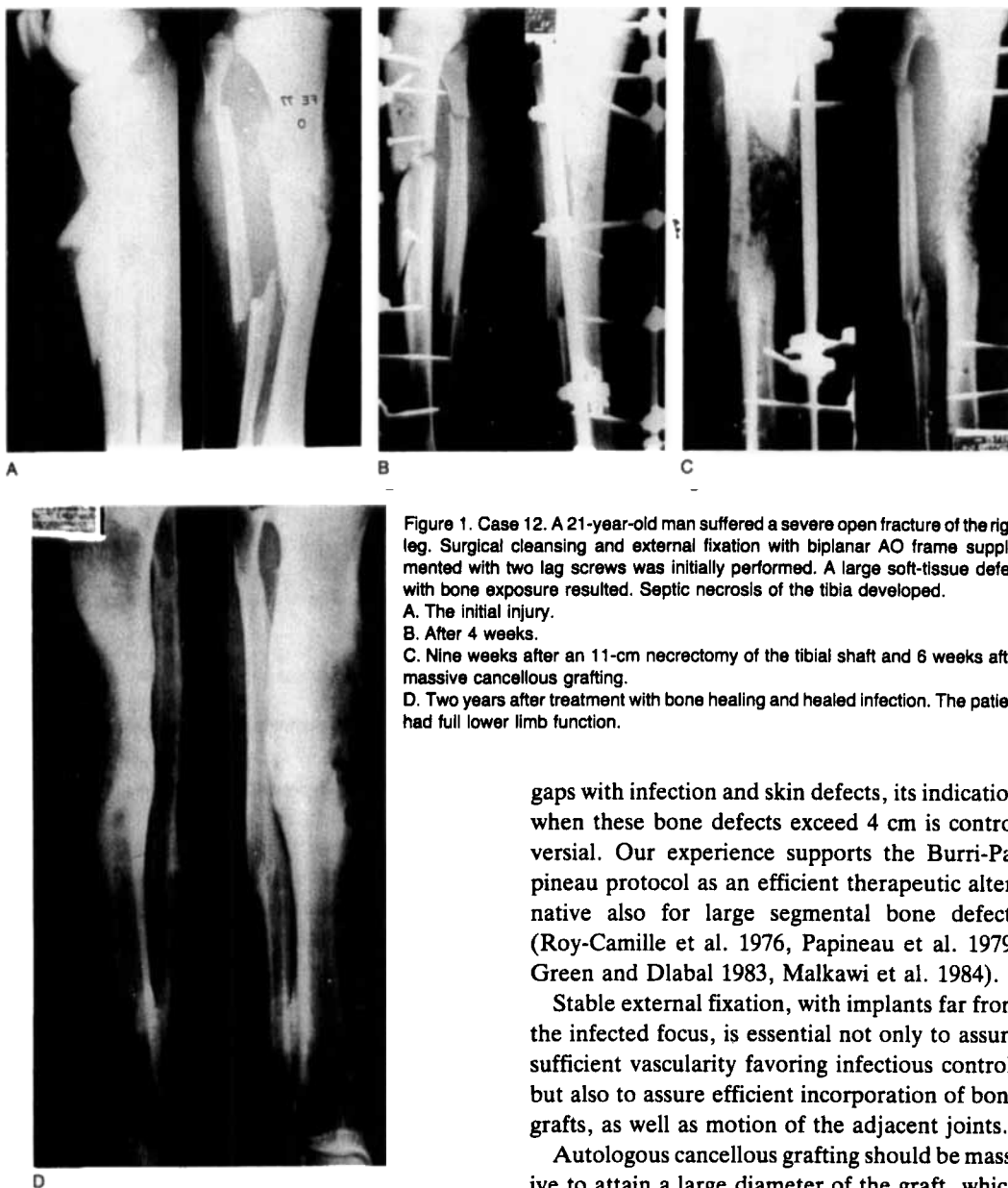


Figure 1. Case 12. A 21-year-old man suffered a severe open fracture of the right leg. Surgical cleansing and external fixation with biplanar AO frame supplemented with two lag screws was initially performed. A large soft-tissue defect with bone exposure resulted. Septic necrosis of the tibia developed.

A. The initial injury.

B. After 4 weeks.

C. Nine weeks after an 11-cm neurectomy of the tibial shaft and 6 weeks after massive cancellous grafting.

D. Two years after treatment with bone healing and healed infection. The patient had full lower limb function.

gaps with infection and skin defects, its indication when these bone defects exceed 4 cm is controversial. Our experience supports the Burri-Papineau protocol as an efficient therapeutic alternative also for large segmental bone defects (Roy-Camille et al. 1976, Papineau et al. 1979, Green and Dlabal 1983, Malkawi et al. 1984).

Stable external fixation, with implants far from the infected focus, is essential not only to assure sufficient vascularity favoring infectious control, but also to assure efficient incorporation of bone grafts, as well as motion of the adjacent joints.

Autologous cancellous grafting should be massive to attain a large diameter of the graft, which enhances mechanical resistance after incorporation. Grafting can be repeated by the anterolateral or posterolateral approach. Certain technical details have improved our results. First, we tried to avoid persistent irrigation over the cancellous grafts because too many pieces of bone were lost; instead, we performed mechanical cleansing of the focus with irrigation for about 30 minutes every day, and then repacked the wound with vaseline gauze. The second factor was prolonged use of braces, which protect the incorporated bone until it undergoes remodeling to acquire mechanical strength.

Refracture occurred in 2 patients, 6 and 8 months after grafting, due to falls when not using the recommended brace. Both patients were treated by plaster cast, but another bone-grafting procedure was needed in 1 of them.

Among 15 patients, function was good in 9, fair in 3, and poor in 3 including the amputation case.

Discussion

Although the two-stage protocol adopted is commonly accepted for the management of short bone

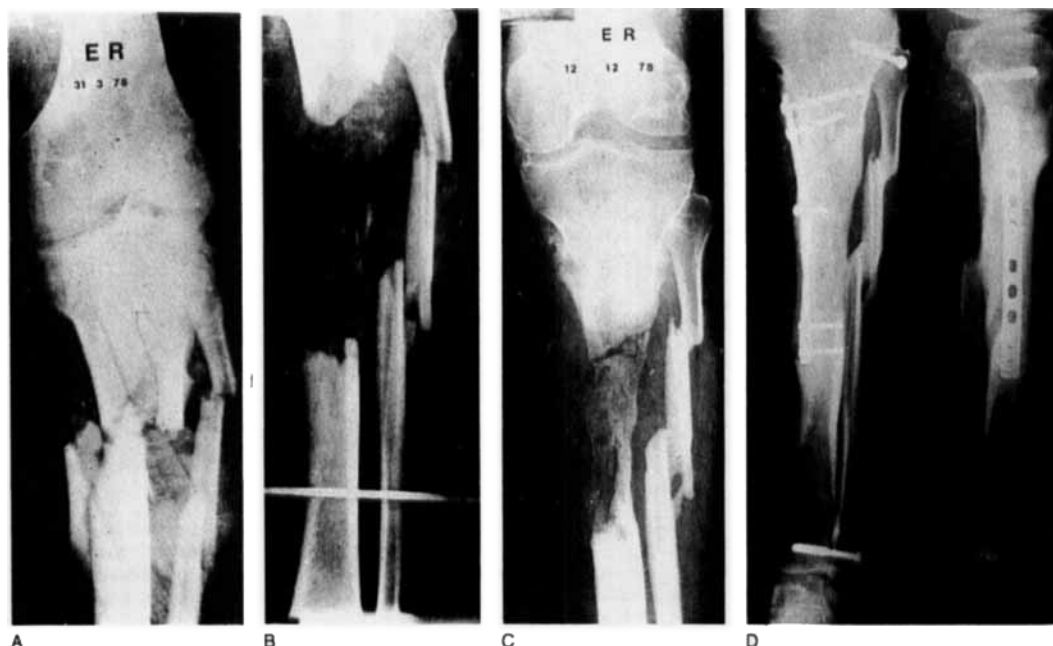


Figure 2. Case 1. A 25-year-old man suffered a severe open fracture of the left leg. Surgical cleansing and fixation with Kirschner wires and a posterior half-brace was performed. A large soft tissue defect resulted, and a large septic necrosis of the tibia developed.

A. The initial injury.

B. Six weeks after the initial injury and 2 weeks after massive cancellous grafting. A 12-cm segmental necrectomy of the tibia had been performed 3 weeks after the injury.

C. Seven months after bone grafting, with nonunion at the proximal part of the graft mass.

D. Seven years later. Internal fixation with an AO plate and cancellous grafting had been performed 6 years before, after other procedures – tibioperoneal arthrodesis, etc. – had failed, leading to union in 5 months.

Spontaneous epithelialization provides satisfactory coverage in many cases, except for large defects where skin grafting is needed.

The protocol is indicated provided that there is

good vascularity of the lower leg, that long-standing and stable external fixation can be applied, and that sufficient autologous cancellous bone is available.

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