Infected tibial nonunion

Good results after open cancellous bone grafting in 37 cases

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We treated 37 infected tibial shaft nonunions by debridement followed by open autogenous cancellous bone grafting in a 2-stage procedure. Additional surgery was done in 21 fractures including second debridement before bone grafting and/or a second limited bone grafting and/or a split-thickness skin grafting. All fractures healed after an average of 11 (8–16) months. During 2 years follow-up there were no recurrences of the infection. Two cases of early refracture occurred, both healed following new bone grafting.

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The treatment of infected tibial nonunions may consist of a one-stage (Coleman et al. 1946), or a two- or three-stage procedure (Hogeman 1949). When using a multiple-stage strategy, the aim has often been to obtain soft tissue coverage before bone grafting (Hogeman 1949, Jupiter et al. 1988).

We report our experience in 37 infected tibial nonunions treated with a multiple-stage procedure, including open cancellous bone grafting before skin coverage, as described by Papineau (1973), and stabilization by an external fixator until bony healing.

Patients and methods

37 infected tibial nonunions were treated according to the Papineau technique (1973) during the period 1976–1991 and were followed clinically and radiographically for 2 years. All patients were referred to us from other hospitals following unsuccessful primary treatment. There were 34 men and 3 women with a mean age of 31 (19–59) years. All fractures were sustained following a high-energy trauma, 17 fractures were initially open, while 20 were closed. Initially all fractures had been surgically treated with open reduction and internal fixation in 24 (plate 20, intramedullary rod 1, screws 3), while external fixation had been used in 13 fractures (Table 1). The Papineau procedure, was performed between 6 months and 2 years following the primary injury. At the time of this procedure there was a complete defect and diastasis of 1.5–3 cm between the bone fragments in 22 cases, while in 15 fractures there was a large bone defect, although with partial contact between the bone fragments.

The operative technique included a complete excision of the fistula and all necrotic soft tissue, removal of internal fixation devices, excision of necrotic bone, decortication and lavage (Figure 1). While the original technique included stabilization, using an intramedullary rod (Papineau 1973), we stabilized the fractures with a quadrilateral full-pin device according to Hoffmann-Vidal (Vidal et al. 1970) or a triangular half-pin device (Behrens and Searls 1986). The wounds were covered for 5 days with one layer of

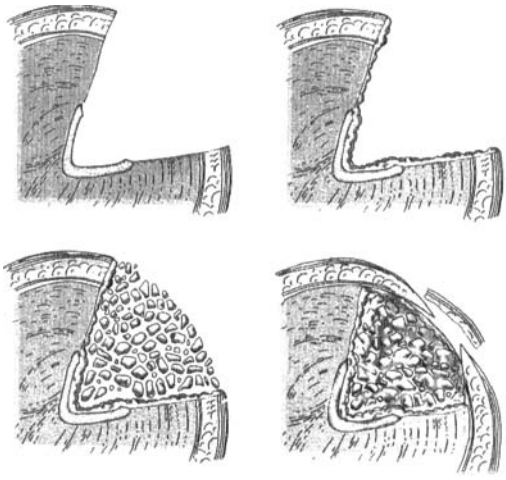

Figure 1.
Top left — Debridement of infected soft tissue and necrotic bone
Top right — Granulation tissue covers bone cavity and wound surfaces
Bottom left — Cancellous bone grafts filling entire cavity
Bottom right — Skin coverage, spontaneously or, if necessary, supplemented by split-thickness skin grafting.

Table 1. General data for 37 infected tibial nonunions treated with open cancellous bone grafting

A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	22	M	C	P		3x6	1	16			16	39	
2	19	M	C	P		3x5	1	17		yes	14	37	
3	42	M	C	P		3x4	1	16		yes	14	39	
4	41	M	C	P		3x4	1	12			12	33	
5	32	F	C	P		2x5	1	13			9	32	
6	21	M	C	P	1.5	3x8	1	15			14	47	
7	26	F	C	P		4x7	1	13		yes	16	39	
8	38	M	C	P		3x4	1	16		yes	12	41	
9	26	M	C	P	2	4x8	1	13		yes	14	46	
10	20	F	C	P	1.5	3x7	2	15			10	44	
11	25	M	C	P	2	3x8	2	15	yes		14	56	
12	32	M	C	P		3x5	1	14			12	42	
13	19	M	C	P	1.5	3x6	1	17			14	47	
14	26	M	C	P		4x7	2	16		yes	18	58	yes
15	41	M	C	P	1.5	3x6	1	14			14	43	
16	32	M	C	P	2	4x8	2	15	yes	yes	18	54	
17	28	M	C	P	1.5	3x7	1	16			14	48	
18	38	M	C	P	1.5	4x5	2	16		yes	14	43	
19	59	M	C	S		3x4	1	15			12	34	
20	36	M	C	R	1.5	3x6	1	16		yes	14	45	
21	32	M	O	P	1.5	4x5	1	17			12	47	
22	32	M	O	P	1.5	3x6	1	13		yes	14	43	
23	35	M	O	EF	1.5	4x7	1	14			16	45	
24	28	M	O	EF		3x5	2	15		yes	14	41	
25	25	M	O	EF		3x5	1	16		yes	14	40	
26	32	M	O	EF	2	4x8	2	19	yes	yes	20	52	
27	32	M	O	EF		3x6	1	16		yes	14	39	
28	34	M	O	EF	1.5	2x5	1	14			8	42	
29	51	M	O	EF	2.5	3x8	2	17	yes	yes	20	64	
30	23	M	O	EF		3x7	1	14		yes	16	56	yes
31	19	M	O	EF	1.5	4x6	1	15		yes	14	45	
32	34	M	O	EF	1.5	4x7	2	17	yes	yes	18	52	
33	37	M	O	EF	2.5	4x7	2	15			14	60	
34	55	M	O	EF	3.0	4x8	2	18		yes	16	72	
35	28	M	O	EF	2.0	4x8	2	16	yes	yes	20	56	
36	41	M	O	S		2x6	1	17			10	39	
37	39	M	O	S	1.5	3x7	1	12			16	47	

A Case
B Age
C Sex
D Type of fracture (closed, open)
E Type of primary fixation (plate, screws, IM rod, ext. fix)
F Diastasis between bone ends at time of bone grafting (cm)
G Skin defect at time of bone grafting (width x length in cm)
H Number of debridements before bone grafting
I Days from last debridement until bone grafting
J Mini Papineau
K Skin grafting
L Weeks from bone grafting until skin covering
M Weeks from bone grafting until bone healing
N Refracture

salve-impregnated gauze on the wound surface, followed by multiple layers of humid saline gauze. After 5 days, the gauze was removed for the first time after surgery. The wound was inspected, irrigated with saline and redressed. This procedure was repeated daily for 8–14 days, until the cavity was covered with granulation tissue, when the bone defect and the nonunion were grafted with an excessive amount of autologous cancellous bone taken from the posterior and, if necessary, also from the anterior crista iliaca. In one case where both posterior and one anterior crista had been used during previous surgery, sufficient bone was obtained by using the remaining anterior crista, in combination with bone from the greater trochanter in the femur on the same side as the tibial nonunion. The bone was cut into pieces of less than about 5 mm. The surface of the graft was then covered with salve and saline impregnated gauzes, while the skin was left without any attempt to close it. 5 days following bone grafting the dressing was carefully opened, without the bone graft being detached, and thoroughly washed once or twice daily until completely covered with granulation tissue. If the central area did not become fully coated with granulation tissue a second minor bone grafting was performed after curettage, mini-Papineau (Roy-Camille et al. 1976a, b). Later, if the grafted bone area did not become fully covered through spontaneous epidermialization from the wound edges, a split-thickness skin grafting was performed.

Figure 2. Case 34. A 55-year-old man with an infected segmental tibial nonunion.

6 months after initial trauma treatment with open cancellous bone grafting according to Papineau was started

16 months later, the fracture is healed.

Intravenous antibiotics based on the cultures were given before operation and continued for 3 days after operation. In 13 patients no further antibiotics were given while in 24 patients oral antibiotics were continued until soft tissue coverage. Staphylococcus aureus was the dominating organism although at the time of our procedure, cultures with mixed organisms were frequent.

Healing was assessed both clinically and radiographically. The fracture was considered radiographically healed when bone was bridging the previous nonunion gap.

Result

Bone grafting was performed 15 (12–19) days after debridement, when the cavity was fully covered by granulation tissue. At redressing, the blood clots on the bone graft were observed to be gradually replaced by granulation tissue entering the wound from the edges. Epidermialization of the granulation tissue also started at the edges of the wound and progressed towards the center. Complete coverage of the skin defect by epidermialization occurred in 17 cases, without any further surgical procedure within 2–4 months while in 20 fractures, following skin grafting. All fractures healed. The time from bone grafting until complete radiographic bone healing was on average 11 (8–16) months. At follow-up, the skin covering the central part of the previous defect was thin and in most cases adherent to the underlying bone although no patient needed reoperation because of problems related to the skin.

In 12 fractures an additional debridement was performed before bone grafting due to a persistent area within adequate granulation tissue. In 6 of these the

granulation tissue failed to cover the central part of the bone grafted area. An additional so-called mini-Papineau, including partial curettage and new bone grafting, was done after which the bone graft in all 6 cases became fully covered with granulation tissue within 2 months. In 17 fractures complete epithelialization occurred, while in 20 fractures split-skin grafting was performed 2–4 months after bone grafting, due to incomplete epithelialization. Complete coverage of the skin defect occurred within 3–5 months after the bone grafting in all cases.

2 patients had refractures 6 months following bone grafting. In one case, the refracture was open and occurred following a motorcycle accident 3 weeks after the external fixator device had been removed, while the second patient with refracture had fallen down a staircase. In both cases, the refracture was stabilized by external fixation. The patient with the open refracture was treated by a repeated open bone grafting, while the closed refracture was treated by an inter-tibiofibular grafting. Both refractures healed within 7 months following the refracture.

Discussion

Treatment of infected tibial nonunions is associated with 3 major problems: treatment of the infection, soft tissue coverage and bone healing. A common method of overcoming these problems, when using multiple-stage procedures, has been to strive for soft tissue coverage and treatment of the infection before addressing bone healing (Gordon and Chiu 1988, Jupiter et al. 1988, Paley et al. 1989, Green 1991, DiPasquale et al. 1994). The major problem with early skin closure is the risk of recurrence of the infection, due to infected fluid being entrapped in the cavity. Even after staged microvascular muscle transplantation, with bone grafting performed as a second procedure, there is a risk of recurrence of the infection (Gordon and Chiu 1988). The technique with muscle transplantation is also technically more difficult than the method used in our study. By using a reversed order of treatment with bone grafting before soft tissue closure, the risk of recurrence of infection may be reduced (Cabanela 1984). However, the success of the open cancellous technique depends on a complete excision of all infected soft tissue as well as all infected bone. A radical debridement is a prerequisite for the development of healthy granulation tissue on the bone and soft tissue surfaces. If there is any necrotic bone left or if the surface of the cavity is not fully covered with granulation tissue, an additional excision should be performed before bone grafting, as was done in almost 1/3 of our cases. After the bone transplant, the surface should be followed carefully and, if some part of the transplant becomes necrotic, usually in the center of the transplanted area, a new limited excision and bone grafting should be performed to facilitate healing. We did such a limited additional bone grafting in 6/37 fractures, with good result.

Prolonged antibiotic therapy seems unnecessary when using open cancellous bone grafting (Roy-Camille et al. 1976b, Cabanela 1984, Lortat-Jacob et al. 1985). This is probably because of the excessive mechanical cleaning achieved by the radical debridement, the daily lavage after surgery, and the free drainage of the excision area since no soft-tissue cover should enclose infectious fluid. Antibiotics should never be used to offset inadequate removal of necrotic and infected tissue. It has also been suggested that the autogenous cancellous bone itself may contribute to the resistance against infection when using open grafting techniques (Carnesale 1987).

We used the present method in cases with partial bone contact and cases with segmental defects up to 3 cm. In cases with extensive segmental defects, bone transport using an external fixator, such as the Ilizarov device might be an adequate alternative, as it makes it possible to deal with the nonunion as well as achieve lengthening during the same procedure (Paley et al. 1989). However, even if bone regenerates at the distraction site during transport of the bone segment, the need for additional surgery, including bone grafting, open reduction and fixation, may be high following bone transport technique in infected tibial nonunions (Pearson and Perry 1989).

The two refractures in the beginning of our experience highlighted the fact that the mechanical strength of the bone was still impaired at the time of healing. This may be attributed to the healing pathways when using large amounts of cancellous bone, but also to the prolonged treatment periods preceding the Papineau procedure. As a consequence of the two refractures, the treatment scheme was supplemented by the use of an orthosis or cast that allowed weight bearing after removal of the external fixation device. This additional protection against refracture was continued until radiographs showed reconstitution of dense cortical bone.

We consider open cancellous bone grafting to be a simple and reliable technique for dealing with difficult infected tibial nonunions. The technique can be used as a primary alternative in severe cases, but it may also act as a salvage procedure following failed attempts with other techniques.

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