Recalcitrant posttraumatic nonunion of the humerus

23 patients reconstructed with vascularized bone graft

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ABSTRACT – We treated 23 patients with recalcitrant posttraumatic humeral shaft nonunion with vascularized bone grafts (fibula 10, femur 10 and scapula 3). 21/23 patients healed primarily. Venous thrombosis in the graft necessitated postoperative thrombectomy in 2 patients. Complications at the donor site were trivial. We used a vascularized fibular graft in patients with a large bone defect and with poor intrinsic stability of the nonunion site and a corticoperiosteal femoral graft in atrophic nonunion without a substantial bone defect. The scapula graft is easy to transfer to the surgical neck of the humerus on its pedicle.

Posttraumatic nonunion of the humeral shaft is uncommon. The incidence ranged from 0% to 13% in a large series of patients (Foster et al. 1985, Healy et al. 1987). An unsuccessful previous operation, inadequate fracture fixation or bone defect and infection have all been associated with a poor outcome (de Boer et al. 1990, McKee et al. 1996, Ring et al. 1997). Nonunion has been treated successfully with a variety of techniques including intramedullary nailing (Paramasivan et al. 2000), compression plating with bone-grafting (Ring et al. 2000) or an external fixator (Lammens et al. 1998, Patel et al. 2000). Reported rates of bony union with these methods range from 82% to 95%, but these procedures are sometimes difficult to perform (Foster et al. 1985, Healy et al. 1987). Vascularized bone grafting is advantageous (Moran and Wood 1993), especially in patients with local devascularization and infection (Duffy et al. 2000). We analyzed our experience with vascularized bone transfer in humeral shaft nonunion retrospectively.

Patients and methods

Between 1985 and 2000, we treated 23 patients with 23 posttraumatic nonunions of the humeral shaft with vascularized bone grafts (Table 1). The initial treatment of the fracture had been surgical in all patients. 15 patients presented with loose or broken implants and 4 had a history of septic nonunion. 15 patients showed atrophic nonunion and 4 had hypertrophic nonunion. The fracture was transverse in 15 patients and oblique or comminuted in 8. Primary treatments at the time of fracture included: plate fixation in 12 patients, intramedullary nail in 7, Kirschner wire fixation in 3 and external fixator in 1.

We used the fibula as a donor bone graft in 10 patients, a corticoperiosteal graft from the medial supracondylar region of the femur (Sakai et al. 1991) in 10 and the scapula in 3. Supplemental cancellous grafts from the iliac crest were packed between the refreshed nonunion and fibular graft. A peroneal skin flap was simultaneously transferred to ensure the survival of the fibular graft in all cases. A skin flap supplied by blood from the descending genicular vessels was transferred in 8 cases to guard against loss of the graft. All scapula grafts were transferred to the proximal third of the

humerus and two of them were on their pedicles. Bone union was assessed by standard radiography or tomography. The mean follow-up period after vascularized bone grafting was 24 (6–53) months.

Results (Table 1)

21/23 patients healed primarily. The other 2 healed after additional secondary bone-grafting and a change in internal fixation. The radiographic bony union between the humerus and fibula took 6 (4–10) months in the 9 patients. The mean time for union was 4 (2–6) months in the 9 patients given a femoral graft and 7 (4–8) months in the 3 scapula cases. Postoperative venous thrombosis required revision surgery in 2 patients, of whom 1 had been given a fibular graft and the other a femoral graft. Immediate thrombectomy and reanastomosis were performed and these grafts survived. The only graft site complications were transient mild paresthesia in the saphenous nerve area in 3 patients.

Table 1. Clinical data on 23 patients

A	B	C	D	E	F	G	H	I	J	K	L	M
1	24	M	2	36	D	0		Fi	6	P	6	
2	27	M	2	36	D	1.5	RNP	Fi	10	VFG	4	
3	37	M	2	68	D	0		Fi	7	VFG	5	
4	38	M	2	12	D	2	RNP	Fi	11	VFG	6	T
5	45	F	2	14	M	2		Fi	11	IR	5	
6	46	F	2	16	P	1		Fi	11	P	6	
7	55	F	2	26	D	2.5		Fi	8	IR	6	
8	59	F	1	12	M	4		Fi	12	VFG	10	D
9	63	F	2	20	D	3	Inf	Fi	10	P	–	N
10	71	F	3	24	P	3	RNP	Fi	14	VFG	4	
11	28	M	2	18	D	0		Fe	–	IR	2	
12	31	F	1	8	D	0		Fe	–	P	4	P
13	35	M	2	18	D	1		Fe	–	IN	3	
14	40	F	3	24	M	1	RNP	Fe	–	P	3	P
15	47	F	2	12	M	0		Fe	–	P	3	
16	51	M	2	18	M	0	Inf	Fe	–	P	6	T
17	52	M	2	16	D	1		Fe	–	IR	18	N
18	53	M	2	10	M	1	RNP	Fe	–	P	6	
19	58	F	1	12	P	0		Fe	–	IR	6	
20	58	F	1	6	D	0		Fe	–	P	3	P
21	27	M	2	6	P	0	Inf	Sc	5	Sc	4	
22	56	F	2	12	P	1		Sc	6	IR	8	
23	80	M	2	6	P	1	Inf	Sc	6.5	Sc	8	
Mean	47		2	19		1			9		6	

A Case
B Age
C Sex
D Number of previous operations
E Interval (months)
F Fracture level
  D distal
  M middle
  P proximal
G Bone defect (cm)
H Comorbidity
  RNP radial nerve palsy
  Inf infection
I Donor
  Fi fibula
  Fe femur
  Sc scapula
J Graft length (cm)
K Fixation method
  P plate
  VFG vascular fibular graft
  IR intramedullary rod
  Sc scapular graft
L Bony union (months)
M Complication
  T thrombosis
  D delayed union
  N nonunion
  P paresthesia

Discussion

Vascularized bone grafting has several advantages in the treatment of nonunion (Moran and Wood 1993). The living bone graft can provide osteogenic cells, improve vascularity at the bone junction, eliminate infection and enhance the intrinsic stability at the site of nonunion, thereby permitting simpler and more rapid fracture healing (Duffy et al. 2000). A review of the literature, however, yielded only a few reports of vascularized bone grafting for nonunion of the humeral shaft. Weiland et al. (1979) had a single case. Wood (1987) reported 3 patients with nonunion of the humerus reconstructed by a vascularized fibular graft, 2 of which resulted in primary bone union while 1 failed due to unreliable vascularity of the bone graft. Jupiter (1990) had 4 patients, 3 went on to primary bony union, but 1 required secondary plating because of inadequate primary fixation. Yajima et al. (1998) described a single case of scapula

Table 2. Donor selection for nonunion of the humerus

Donor bone	Indication
Fibula	Large bone defect Poor intrinsic stability at the nonunion site
Femur [a]	Pseudosynovial atrophic nonunion without a significant bone defect
Scapula	Surgical neck of the humerus

[a] Corticoperiosteal graft

transfer for posttraumatic humeral head necrosis and 5 patients with a fibula transfer for nonunion of the humerus. They all went on to primary bony union.

We found that vascularized bone grafting was a reliable reconstructive procedure for recalcitrant nonunion where conventional bone-grafting had failed. Fibula grafts were advantageous in patients with large bone defects (> 3 cm) and poor intrinsic stability of the nonunion site, especially in the distal third of the humerus (Table 2). Vascularized corticoperiosteal grafts, supplied by the descending genicular artery and vein (Sakai et al. 1991), were useful in atrophic nonunion without substantial bone defects. This graft preserves the cambium layer, and therefore has an excellent osteogenic capacity and can easily cover a nonunion because of its elasticity. A considerable amount of cancellous bone can also be transferred simultaneously. Vascularized scapula grafts are especially advantageous in nonunion of the proximal third, since they can be transferred without a microsurgical anastomosis, and in poor-risk patients with vascular disease.

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