Technical note

Reconstruction of tibia by ipsilateral vascularized fibula and allograft

12 cases with malignant bone tumors

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We treated 12 patients with a primary sarcoma of the tibia by resection and centralization of the ipsilateral vascularized fibula with preserved vascularization. The reconstruction was combined with an allograft. The median bone defect after tumor resection was 14 (8–24) cm. The anastomosis between the allograft and the recipient bone was stabilized by a plate or screws or Kirschner-wires. To reconstruct the soft tissues, 8 patients underwent a gastrocnemius plasty and 2 patients a free vascularized flap of the latissimus dorsi muscle. The mean follow-up period was 2.5 (2–3.5) years. 2 years after implantation, union ≥ 75% of the anastomosis area was noted in 10 patients. A deformity or fracture of the distal junction occurred in 7 patients with a screw or Kirschner-wire fixation. Neither deformity nor fracture developed in the 5 patients with plate-fixation.

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An allograft shell implanted around a vascularized fibula may overcome the disadvantages of an isolated allograft or fibula graft. We report this technique and the outcome in 12 patients with tibial defects after tumor surgery. The procedure is a modification of a technique originally described by Capanna et al. (1991).

Patients and methods

Between 1991 and 1993, we treated 15 patients with a primary sarcoma of the tibia. No patient had visible metastases at presentation. 12 patients (7 men) were followed for more than 2 years and are reported. The median age was 14 (7–54) years. The defect after tumor excision was a median of 14 (8–24) cm (Table).

Allografts were retrieved from cadaver donors and processed according to the criteria of the European Association for Musculoskeletal Transplantation (EAMST 1993). 10 allografts were sterilized by 26,000 Gy. 2 allografts were implanted after having been deep-frozen.

7 patients received pre- and postoperative chemotherapy. 5 patients with Ewing's sarcoma also underwent preoperative and partial postoperative irradiation; total doses ranged between 45 and 75 Gy.

Surgery

The fibula was osteotomized 5–8 cm longer than the resected tibia. After dividing the intraosseous membrane, the peroneus vessels were exposed and the fibula was moved anteromedially. An allograft of the same length as the resected part of the tibia was prepared and "wrapped" around the fibula to support the grafted fibula against longitudinal stress. The junction sites between allograft and recipient bone were fixated by Kirschner (K)-wires (2 cases), cortical screws (2 cases), screws and wires (2 cases) or a long plate (5 cases) (Figure). Case 2 underwent an arthrodesis between the distal graft and the talus. A long leg-cast was applied for 1.5–2 months. Partial weight bearing was started 3 months after operation and full-weight bearing after a further 6 months. 8 allografts were covered by the gastrocnemius muscle and 2 allografts were covered by a free vascularized flap of the latissimus dorsi muscle. 2 allografts were covered by muscles remaining after removal of the tumor. The nutrient vessels of the fibula were ruptured in case 5 and it became a non-vascularized fibula graft.

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Patient data

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	11	M	1	IIB	2	12	2	1	1 (45)	50	100	3	–	27	1
2	15	M	2	IIB	3	18	1	2	–	100	100	–	–	28	1
3	12	F	2	IIB	3	18	1	2	–	50	100	–	–	24	2
4	15	M	2	IIB	2	12	3	2	–	50	50	4	3,4 (20)	36	2
5	13	M	1	IIB	1	24	1	1	1 (54)	20	0	–	–	24	2
6	8	M	1	IIB	1	13	3	1	1 (30) 2 (45)	100	100	1 (1) 5 (11) 4 (11)	2 1 –	24	2
7	15	M	2	IIA	2	8	1	2	–	50	100	–	–	24	1
8	30	F	2	IIB	3	14	1	2	–	100	100	–	–	36	1
9	23	F	3	IA	2	14	2	–	–	100	100	4,5 (16) 6 (36)	3,4 (16)	36	1
10	7	F	1	IIB	2	20	3	1	1 (54)	100	100	1 (1) 5 (15) 4 (24)	2 1 3,4 (26,32)	36	2
11	54	M	4	IIB	1	12	2,3	–	–	100	50	5 (12)	4 (12)	42	2
12	8	F	1	IIB	1	12	2	1	1 (45)	70	80	4 (10)	3,4 (12)	36	2

A Number
B Age
C Sex
D Diagnosis
  1 Ewing's sarcoma
  2 osteosarcoma
  3 adamantinoma
  4 malignant fibrous histiocytoma
E Surgical stage (Enneking et al.1980)
  IA
  IB
  IIA
  IIB
F Site
  1 proximal
  2 diaphysis
  3 distal
G Length of allograft (cm)
H Fixation
  1 plate
  2 screw
  3 Kirschner-wire
I Chemotherapy
  1 CESS: protocol of cooperative Ewing's sarcoma study
  2 COSS: protocol of cooperative osteosarcoma study
J Irradiation
  1 preoperative
  2 postoperative
K Union at 2 years after surgery (above) (%)
L Union at 2 years after surgery (below) (%)
M Complications (months)
  1 skin necrosis or infection
  2 infection
  3 tibia vara
  4 anterior curvature of tibia
  5 junction fracture
  6 local recurrence of tumor
N Additional treatment (months)
  1 conservative treatment
  2 wound revision
  3 corrective osteotomy
  4 plating
O Follow-up (months)
P Functional results
  1 excellent
  2 good

Follow-up and evaluation

Patients were followed at 3-month intervals. On each follow-up examination, the union of the graft to the host bone was radiologically classified into 4 grades, according to the ISOLS system (Glasser and Langlais 1991): excellent–osteotomy line no longer visible, good–fusion ≥ 75% of the cortical thickness and osteotomy line still visible, fair–fusion 25–75% of the cortical thickness, and poor–no evidence of callus or fusion < 25% of the cortical thickness.

The median length of follow-up was 32 (24–42) months. Evaluation of function was performed on the most recent follow-up examination, using Enneking's (1987) system. There was 1 local recurrence 3 years after surgery.

Results

Complications

1 patient developed an incomplete peroneal nerve palsy which resolved. 1 patient had a superficial skin infection and another patient a superficial skin necrosis. They were treated by wound debridement and then healed.

Deformity of the junction sites without fracture developed in 3 of 7 patients (cases 1, 4, and 12) with fixation by screws or K-wires. Case 1 had no treatment and cases 4 and 12 underwent osteotomy and fixation with a plate.

Fractures developed in the other 4 patients who had fixation by screws or K-wires. Case 9 had a deformity of the distal junction, developed a fracture and underwent osteotomy with plating. Cases 6, 10, and 11 spontaneously developed a fracture at the distal junction 11, 15, and 12 months after surgery, respectively. Cases 6 and 10 underwent closed treatment with a long leg-cast and case 11 had fixation with a plate. After closed treatment, deformity of the distal junction developed in both cases, case 10 underwent osteotomy with plating and case 6 was not treated.

Union

Within 2 years after surgery, cases 4, 9, 11, and 12

underwent additional revision surgery of the junction with a cancellous bone graft because of deformity or fracture. Of the 12 patients, 5 had excellent healing (Figure), 5 had good, 1 (case 4) fair, and 1 (case 5) no healing 2 years after the operation.

Function

At the final follow-up, 5 patients had excellent and 7 had good function, mainly because of deformity of the lower leg, slight weakness of muscle strength or slightly restricted activity.

Discussion

Revascularization of conventional fibula grafts requires approximately 6 months to be complete and almost 40% of the interstitial lamellae still remains necrotic after 2 years (Enneking 1987a). In recent years, the vascularized fibula graft has been widely used (Taylor 1977, O'Brien 1977, Weiland et al. 1983). The advantage of this technique is better and faster incorporation of the graft.

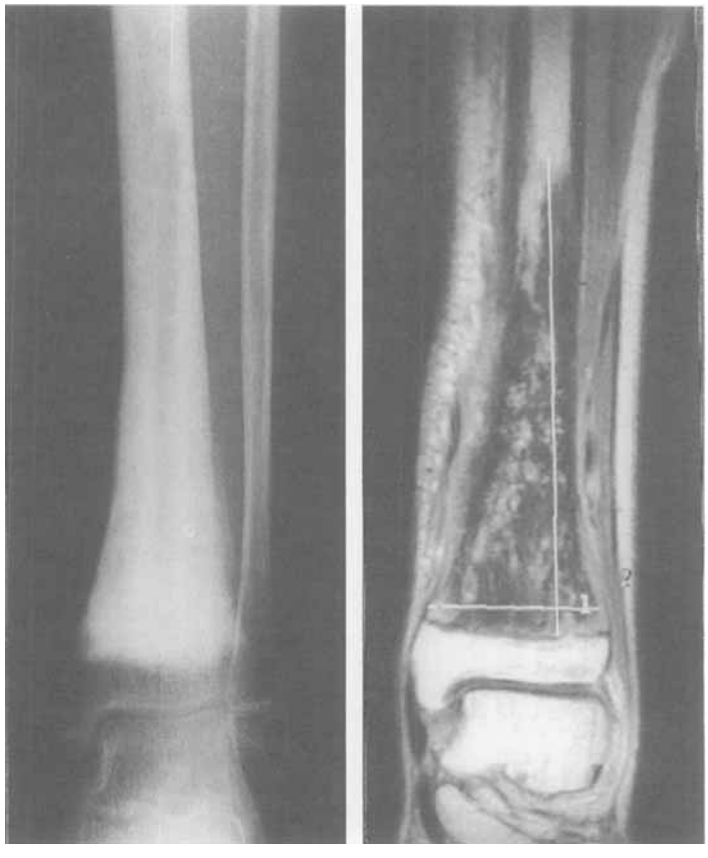
However, the strength of the vascularized fibula graft may be insufficient. Although hypertrophy often occurs and can be seen on radiographs at an average of 18 months after surgery, hypertrophic bone fractures have been reported (Lazar et al. 1993). A vascularized fibula graft in the leg should be protected against fatigue fracture during the first few years after implantation. To solve these problems, we used a combination of an allograft and a vascularized fibula graft after resection of tibial tumors. By placing the allograft around the fibula, good stabilization and protection against longitudinal stress were achieved.

Capanna (1994) reported the results of a contralateral vascularized fibula transfer, supplemented with a massive allograft. The disadvantages of this method are that a microvascular surgeon is required, both legs are operated, and the operation time is long. With our method, only 1 leg is operated, skin and soft tissue closure are easy because of smaller volume of the lower leg due to centralization of the fibula, and the operation time is short.

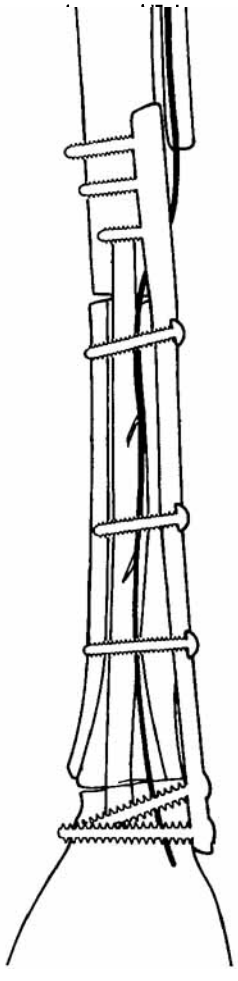
Use of a primary gastrocnemius transposition flap is a useful and simple technique for coverage of implants, following extensive soft-tissue and bone resection (Malawer and Price 1984). In our study, all allografts could be completely covered by muscles, which seems to be required to increase the speed of healing of the junction and to prevent infection.

We had problems with fractures or deformity of the distal junction. These occurred in all patients with fixation by screws or K-wires. Patients with fixation by a plate had no deformity or fracture of the junction. At the time of insertion of the screws through the plate, the feeding vessels of the fibula should not be injured. A few screws are probably sufficient to fix the allograft and the fibula between the end of the recipient bone.

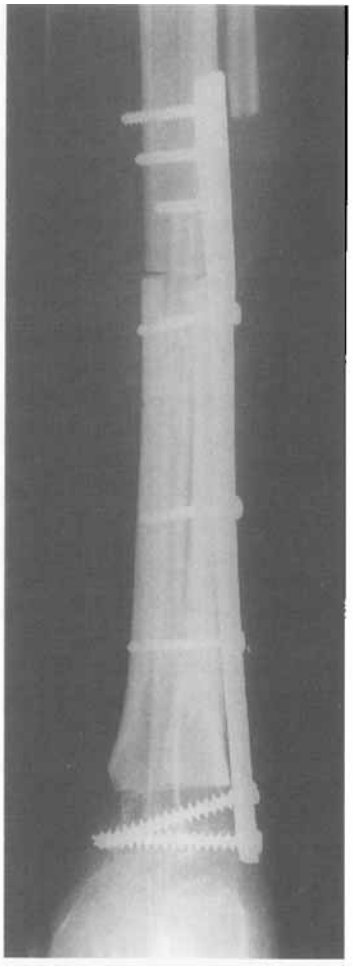
Case 2. Osteosarcoma of the distal tibia.



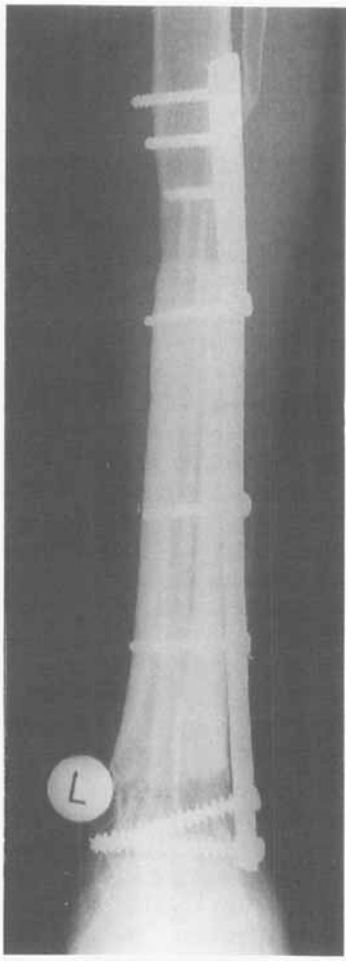
Preoperatively. T1-weighted MR imaging with Gd-DTPA.



Line drawing of the surgery.



1 month after surgery.



2 years after surgery.

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