



Reconstruction of distal tibial defects following resection of malignant tumours by pedicled vascularised fibular grafts

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The aim of this study was to evaluate the oncologic and functional outcome after wide resection of malignant tumours of the distal tibia and reconstruction of the defect by ipsilateral pedicled vascularised fibular graft and ankle arthrodesis.

Thirteen patients (9 males and 4 females) with primary malignant tumours of the distal tibia were treated by wide resection. The mean age of the patients at the time of surgery was 15 years. The fibula was mobilised to fill the defect, pedicled on the peroneal vessels. The average size of the defects reconstructed was 10 cms. Patients were evaluated functionally using the Musculoskeletal Tumor Society evaluation system.

The mean duration of follow-up was 27 months. Chest metastases developed in 4 patients and local recurrence in one. The mean functional score was 80% at the time of last follow-up. The average time to union of the graft both proximally and distally was 6 months. Complications were minimal and did not affect the functional outcome.

Reconstruction of distal tibial defects with an ipsilateral pedicled vascularised fibular graft is a technically easy reconstructive option which offers a predictable long standing functional outcome.

Keywords : bone resection ; bone tumours ; reconstruction ; pedicled vascularised fibular graft.

INTRODUCTION

The distal tibia is a rare site for malignant bone tumours, yet it presents a challenging treatment problem. Limb sparing operations have been a

standard treatment procedure in the management of malignant tumours of the upper and lower extremities because they are oncologically as safe as amputations and provide a superior function of the limb as compared to amputated limbs fitted with a prosthesis (13). This may not be the case when treating malignant tumours of the distal tibia. The subcutaneous location and its proximity to the neurovascular bundle and tendons – which are plastered over the bone – may not allow an oncologically safe resection. Moreover, the function of a below knee amputation fitted with a modern prosthesis is excellent whereas limb salvage surgery with various distal tibial reconstructive modalities offer unpredictable functional outcome. Several methods have been used for distal tibial reconstructions. These include : vascularised grafts (4), prostheses (11), allografts, bone transport and combinations thereof (10).

The use of a vascularised fibular graft – pedicled on the peroneal vessels – has been reported in the literature as early as 1940s when Wilson used it to

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reconstruct congenital tibial defects (14). Since then, it has been used to reconstruct tibial defects caused by different aetiologies. Agiza reported its use in osteomyelitic defects (2), Chacha *et al* (5) and Chung and Chung (6) used it in reconstructing traumatic defects and non unions. In 1994, Ellingson and Rand (7) reported its use in knee arthrodesis as a treatment of infected total knee replacements.

In this study we used the ipsilateral vascularised pedicled fibula with ankle arthrodesis to reconstruct distal tibial defects created after resection of malignant tumours. Our aim was to evaluate the functional and oncologic outcome of this procedure.

PATIENTS AND METHODS

During the period from July 2000 to September 2004, 19 patients with distal tibial malignant tumours were treated in our institution. Thirteen patients were managed by limb salvage procedures whereas the rest were treated by below knee amputations. Patients who had limb salvage procedures were 9 males and 4 females with an average age of 15 years (range : 8 to 34). The patients were staged by local radiographs, magnetic resonance imaging, computed tomography of the chest and a bone scan. Closed or open biopsies were done for *de novo* patients whereas slide revision was done for patients who were referred to us after being biopsied in other institutions. Eleven patients were diagnosed as osteosarcoma and 2 patients as Ewing's sarcoma. All the patients were stage IIB according to the Enneking staging system (8). They all received neoadjuvant chemotherapy. Surgery was done 2-3 weeks after the last preoperative chemotherapy cycle. A wide margin of resection was achieved in all patients. The average size of the resultant bony defect was 12 cm (range : 8 to 17). The defect was reconstructed by the ipsilateral vascularised fibular graft (IVF) pedicled on the peroneal vessels. The transferred fibula was fixed proximally in the tibial medulla and distally in the dome of the talus aiming at ankle arthrodesis. Fixation was done using K-wires, circlage wires or cancellous screws in all patients. In one patient, fixation was augmented with the use of a ring external fixator (table I).

Technique of reconstruction by IVF

- Utilising the same incision used for tumour resection, a subperiosteal osteotomy of the fibula was done 1 cm above the level of the tibial cut.

- Another fibular subperiosteal osteotomy was done at the level of the ankle.
- The fibula was then mobilised medially taking great care not to strip it from its overlying muscles and to maintain the integrity of its periosteum.
- The lateral aspect of the periosteum should remain as a continuous sheet from above the proximal osteotomy to below the distal one.
- Proximally the fibula was inserted in the tibial medulla after widening it with a reamer. It was fixed using a circlage wire.
- Distally it was inserted in the dome of the talus after denuding it from its cartilage.
- The ankle was adjusted in neutral rotation and no angulation. The fibula was fixed to the talus by 2 screws or K-wires, taking care that they did not disrupt the subtalar joint.

Contraindications for IVF reconstruction

1. The anterior and posterior tibial pulsations must be felt preoperatively. If the posterior tibial pulsations are not felt and resection would include the anterior tibial vessels, this type of reconstruction would be contraindicated.
2. Distal tibial resections that will include part of the adjacent fibula.
3. Intra articular extension of the tumour.
4. Pathological fracture of the adjacent fibula that ends in non union or malunion.

The average operative time for the whole procedure (resection and reconstruction) was 3 hours (range : 2 to 4). The average blood loss was 300 cc (range : 100 to 500).

Postoperative Care

All patients were put in an above knee cast except the patient in which the fixation was augmented with a ring external fixator. When radiographs showed signs of union proximally and distally the cast was removed and either a below knee cast or a weight bearing brace was used until complete union and hypertrophy of the graft. Gradual weight bearing was only allowed after radiologic evidence of union. Full weight bearing without a brace was allowed only after graft hypertrophy.

Patients were followed up every 6 weeks in the first 6 months following the operation then 3 monthly for the following 2 years then 6 monthly thereafter.

Radiographs were done in every visit whereas a chest CT was done every 3 months during the first year and every 6 months thereafter.

All the patients had postoperative chemotherapy and none received radiotherapy.

RESULTS

The average duration of follow-up was 27 months (range : 16 to 90). The end point for evaluation was the last follow-up visit, death or amputation.

All patients were evaluated radiologically, functionally, oncologically and for the presence of any complication.

Radiological outcome

The average time for complete union of the proximal and distal graft-host junctions was 6 months (range : 4 to 8). Signs of callus formation appeared as early as 6 weeks following the surgery. The intact periosteal sleeve also showed bone formation proximally and distally that ultimately united the fibula proximal and distal to the osteotomy sites to the graft enhancing the strength of the reconstruction.

The graft was seen to hypertrophy with time and reached the size of the tibia 18 months following the surgery (fig 1).

Two patients (Cases 4 and 10) had non union at the proximal graft-host junction. They were managed successfully by iliac crest bone grafting.

Functional outcome

This assessment was done using the Musculo-skeletal Tumour Society scoring system (9) that assesses 6 parameters ; pain, functional activity, emotional acceptance, use of external supports, walking distance and gait. Each entity has a score of 5 points with the total being 30 points.

The average functional score was 24/30 points (80%). The minimum score was 73% and the maximum was 90%.

Pain : all patients had no or minimal pain not requiring analgesia.

Functional activity : all patients could resume their occupations and some returned to their sports activities.

Emotional acceptance : all the patients were satisfied with the surgery.

Use of external supports : none of the patients required external supports.

Walking distance : all the patients had normal or slightly reduced walking distances.

Gait : all the patients had a visible limp.

The patients had normal range of motion of the ipsilateral knee and retained a normal range of motion of the subtalar joint.

Oncological outcome

One patient (7.6%) developed local recurrence 20 months postoperatively and was managed with a below knee amputation (case 4).

Four patients (30%) developed chest metastases at 8, 12, 22 and 24 months postoperatively (Cases 5, 13, 4 and 3 respectively). The latter 2 patients had metastatectomies but all 4 patients died of disease.

Complications

Two patients (cases 2 and 9) had superficial wound infection and were treated conservatively by repeated dressings and had an uneventful recovery.

One patient (case 7) had a stress fracture 18 months postoperatively and healed completely after cast immobilisation.

Nine patients (cases 1, 2, 3, 4, 6, 9, 10, 11, 12) had leg length discrepancy 1-3 cm and were managed by a shoe lift.

Two patients (cases 7 and 11) had slight (less than 10 degrees) varus angulation at the proximal graft-host junction but the deformity was minor and did not warrant any surgical interference (table I).

DISCUSSION

We believe that this is the first study to report a series of patients in which a pedicled vascularised fibular graft was used to reconstruct distal tibial defects created after resection of malignant tumours.

Several authors have previously reported using other techniques for reconstructing distal tibial defects. Bishop *et al* (4) reported the use of free vascularised grafts. Lee *et al* (11), Abudu *et al* (1) and Natarjan *et al* (12) reported their experience in using

Table I. — Patients with distal tibial sarcoma treated by wide resection and ipsilateral vascularised pedicled fibular graft

Case	Sex	Age (years)	Diagnosis	Operation	FU (months)	RL	Hardware	LR	Metastases	Complications	Functional Score*
1	Male	12	Osteosarcoma	WR + PF	90	21 cm	Wires	No	No	LLD	27
2	Female	8	Osteosarcoma	WR + PF	80	12 cm	Wires	No	No	Superficial infection, LLD	24
3	Female	8	Osteosarcoma	WR + PF	28	10 cm	Ilizarov + screws	No	Yes	LLD	24
4	Male	15	Osteosarcoma	WR + PF	20	15 cm	Screws	Yes	Yes	Non union, LLD	22
5	Male	14	Osteosarcoma	WR + PF	8	18 cm	Wires & screws	No	Yes	Bone metastases	22
6	Male	12	Osteosarcoma	WR + PF	47	16 cm	Wires & screws	No	No	LLD	25
7	Male	15	Osteosarcoma	WR + PF	41	18 cm	Wires & screws	No	No	Stress fracture, varus angulation	27
8	Male	34	Osteosarcoma	WR + PF	35	9 cm	Wires	No	No		27
9	Male	17	Ewing's sarcoma	WR + PF	30	10 cm	Wires & screws	No	No	Superficial infection, LLD	27
10	Female	17	Osteosarcoma	WR + PF	19	15 cm	Wires & screws	No	No	Non union, LLD	22
11	Male	11	Ewing's sarcoma	WR + PF	19	14 cm	Wires	No	No	Varus angulation, LLD	24
12	Female	17	Osteosarcoma	WR + PF	17	12 cm	Wires	No	No	LLD	24
13	Male	19	Osteosarcoma	WR + PF	16	22 cm	Wires	No	Yes		22

WR + PF : Wide resection and pedicled fibular graft

FU : Follow-up

RL : Resection length

LR : Local recurrence

LLD : Limb length discrepancy

* Musculoskeletal Tumor Society scoring system (9).

custom made prostheses. Laitinen *et al* (10) reported a series of 14 distal tibial tumours that were managed by different reconstructive procedures ; prosthesis, bone transport, allografts and vascularised grafts.

The average functional outcome of the patients in this study was 80%. This is similar to that reported in the literature for patients reconstructed with custom made prostheses. However, the functional outcome of the prosthetic reconstructions deteriorates with time whereas that of the pedicled fibula does not (1, 11, 12).

Ankle arthrodesis associated with this reconstructive procedure was not a source of pain in the patients and had a minimal effect on their walking distance. However all the patients had a visible

limp. All could resume their occupational activities and half of them could participate in sports.

The distal tibia is not surrounded by muscles, which makes this site more prone to skin problems and infection following any reconstructive procedure. The infection rate in this study was 15%. This is less than that associated with prosthetic replacements, which can reach as high as 50% (1, 11). Moreover, since the fibular graft is a viable tissue, infection was treated conservatively and had no impact on the graft or limb survival, whereas infection associated with prosthetic reconstruction affected limb survival in 30 - 50% of patients (1).

Reconstructing distal tibial defects by free vascularised grafts was reported by Bishop *et al* (4). It has the same advantages as the current procedure



Fig. 1. — Male 14 years, osteosarcoma distal tibia. 1a : Plain radiograph showing osteosarcoma of the distal tibia. 1b & 1c : Plain anteroposterior and lateral views 24 months following wide resection and reconstruction by pedicled fibular graft, showing union of the graft proximally and distally. The graft has hypertrophied and reached the size of the original tibia.

but it is a longer procedure that entails microvascular anastomosis with its associated morbidities.

The incidence of local recurrence (7%) and chest metastases (30%) in this series is similar to that reported for osteosarcoma in other sites of the body. This is different from what was reported by Zeytoonjiyan *et al* (15). They reported lower incidences of metastases and death for distal leg sarcomas (10% versus 27%).

The average time for complete union of the graft was 6 months, which is similar to that reported for free vascularised grafts. We allowed full weight bearing without a brace after graft hypertrophy (18 months). Although this could be done earlier if the pedicled fibula was augmented with an allograft or autoclaved bone, yet we believe that the augmentation with non viable tissues may be associated with a higher incidence of complications.

The two cases of nonunion at the proximal graft host junction were due to inadequate fixation. They healed completely in 3 months following iliac crest bone grafting.

Stress fracture in the middle of the graft occurred in one patient. This is a known complication associated with vascularised grafts ; it has been attributed to loss of protective feedback, possibly due to disturbance of mechanoreceptors along the periosteum of the transferred fibula (3). The fracture healed completely after casting for 2 months.

Leg length discrepancy was an inevitable complication especially in skeletally immature patients. This was due to resection of the distal tibial physal plate and the restricted mobility of the pedicled fibula which cannot be pulled distally but rather pushed medially. Thus immediate lengthening was not possible and patients postoperatively would have normal leg length or shorter by 1-2 cm.

Several disadvantages are associated with the current reconstructive technique, mainly loss of ankle mobility and shortening causing a visible limp. However, the technique has several advantages. It can bridge tibial defects irrespective of their size. It has a predictive outcome regarding union and hypertrophy. It is an inexpensive and

short procedure offering a durable functional limb that is psychologically more acceptable than amputation.

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