British Journal of Plastic Surgery (2005) **58**, 425–430

ELSEVIER

BJPS
An International Journal of Surgical Reconstruction
www.bjps.com

Vascularised free fibular flap in bone resection and reconstruction☆

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Received 4 January 2004; accepted 3 November 2004

KEYWORDS
Allograft;
Free fibular flap;
Lower limb reconstruction

Summary This paper compares allograft alone and in combination with vascularised free fibular flaps (FFF) to reconstruct long bone defects after tumour excision.

We present 33 cases, 21 of these patients had reconstruction with an allograft alone as the initial procedure. Nine patients underwent reconstruction with FFF plus allograft plus iliac crest bone graft (ICG), two patients underwent reconstruction with a FFF and ICG and one patient underwent reconstruction with an allograft, a pedicled fibular flap and a FFF. The allograft was obtained from the Queensland Bone Bank and had been irradiated to 25 000 Gy.

In our experience ($N=21$) the complication rates with allograft alone were: delayed union 3, nonunion 7, fractured allograft 6, infection requiring resection of the allograft 3, other infections 2. The revision rate was 48% (10 cases of which five required a free fibular flap) and an average of 1.8 revision procedures were required. In the lower limb cases, the mean time to full weightbearing was 20 months and 40% were full weightbearing at 18 months. We felt that the high complication rate compared with other series may have been related to the irradiation of the graft.

FFFs were used in 18 cases, 12 cases were primary reconstructions and six were revision reconstructions. The mean fibular length was 19.4 cm (range 10–29 cm).

There were no flap losses and the FFF united at both ends of 11 of 12 primary reconstruction cases. One case had nonunion at one end, giving a union rate of 96% (23 of 24 junctions). When a FFF was used in combination with an allograft as a primary reconstruction, the allograft nonunion rate was 50% (five of 10 cases). The mean time to full weightbearing in the lower limb cases was 7.5 months and 100% were full weightbearing at 18 months.

The FFF hastens time to full weightbearing but does not appear to affect the complication rates of allograft. The number of revision procedures required is reduced in the presence of a FFF and is the latter is a useful technique for the salvage of refractory cases.

This paper has been presented in a preliminary form at the Centenary Surgical Oncology Conference 2001 Meeting, at the Princess Alexandra Hospital, Brisbane, Queensland, Australia, in August 2001. This paper in its current form was presented at the Royal Australasian College of Surgeons Annual Scientific Congress in Brisbane in May 2003.

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S0007-1226/$ - see front matter
doi:10.1016/j.bjps.2004.11.002

Primary high-grade malignant tumours of long bones include osteosarcoma, chondrosarcoma, Ewing's sarcoma, adamantinoma and malignant fibrous histiocytoma. In the past, these tumours were treated by limb amputation. Although these procedures were occasionally curative, they caused significant local morbidity and handicap. Advances in neoadjuvant chemotherapy have improved the prognosis of these patients by controlling, and in some cases eliminating, local recurrences and metastases. Furthermore, it is now possible to perform limb-salvage procedures after en bloc resection of tumours.

The options for reconstruction include endoprosthesis, allograft, non-vascularised autograft and vascularised autograft, or combinations of these above techniques. Tailor-made custom prostheses are manufactured to replace almost any part of the skeleton. The advantages of prosthetics include immediate stability and function with resultant early ambulation and full weightbearing when used in lower limb reconstruction. Unfortunately, they are prone to mechanical failure, implant or bone fracture, infection, dislocation and loosening.

Allografts may be used as intercalary grafts, osteoarticular grafts or as grafts to replace entire bones. Revascularisation of allografts is a slow, and often incomplete process. Autogenous (non-vascularised) cancellous or cortico-cancellous bone grafts contribute cells capable of new bone formation. Unfortunately, these grafts are unsuitable for defects greater than 6–8 cm in length and it is not possible to reconstruct a joint using a non-vascularised autograft. The term 'creeping substitution' has been coined (Phemister 1914) to describe the simultaneous processes of resorption and deposition which occur in osteogenesis and repair of bones. Allografts and devascularised autografts really provide a framework for inductive creeping substitution. Therefore, with allografts and devascularised autografts the processes of revascularisation and creeping substitution weaken the grafts, so predisposing to delayed union, nonunion, infection, fatigue fracture and resorption.

A vascularised autograft heals by primary union and not by creeping substitution. As such it represents the ideal bone graft because it can heal the loss of a large segment of bone, it provides viable autogenous bone, which actively participates in the healing process, it unites quickly, and remains reliably organised. Also it is alive and can resist and avoid contamination and defies resorption. It heals as a double fracture and not by the processes of creeping substitution. By virtue of its vascularity it is able to heal in a sclerotic bed. In skeletally immature individuals, incorporation of the proximal fibular metaphysis in a reconstruction can result in continued growth of the autograft. Finally, vascularised autografts are able to undergo hypertrophy resulting in increased strength.

Unfortunately, the strength of a vascularised fibular flap maybe insufficient until hypertrophy occurs. This has been reported to occur on average 18 months after surgery.[1] Furthermore, hypertrophic bone fractures have been reported and therefore some advocate protecting the vascularised fibular flap in the lower limb for the first few years after implantation.

Combining allografting with vascularised autografting should theoretically improve the outcome by combining the mechanical advantages of an allograft with the biological properties of a vascularised autograft. The vascularised autograft would hypertrophy and by placing a custom made allograft around the vascularised fibular flap, good stabilisation and protection against longitudinal stress should be achieved. This paper presents our experience of using allograft alone and in combination with a vascularised free fibular flap for reconstruction after en bloc tumour resection.

Patients and methods

This study assessed the clinical features of all patients undergoing long bone resection with a reconstruction using allograft alone and in combination with a vascularised free fibular flap. The earlier cases were assessed retrospectively and the latter cases were assessed prospectively. For the purposes of this study, a delayed union where there was no evidence of any callus formation or loss of definition of the osteosynthesis site at 6 months and/or the osteosynthesis was not fully united at 12 months.

Results

Allograft experience

A total of 21 cases underwent reconstruction with allograft alone (Table 1).

A total of 10 patients required revision of their allograft reconstruction. This gives a revision rate of 48% ($N=21$). Two patients required amputation due to infection and infection and recurrence of the tumour, respectively. Five cases required revision