Vascularised rib graft defects of the diaphysis of the humerus in children

A REPORT OF TWO CASES

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In our practice sequestration of the shafts of long bones in children because of acute osteomyelitis continues to be a problem. Conventional procedures for bone grafting are likely to fail. Vascularised grafts with microvascular anastomosis are technically demanding with a high rate of failure. Transfer of the rib on its vascular pedicle to achieve anterior fusion in the thoracic spine is now well established and the length of the pedicle available is adequate to allow grafting of a diaphyseal defect in the humerus. We describe the successful use of this procedure in two patients.

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The techniques described by Carrell¹ made distant transfer of vascularised bone grafts a possibility and the advent of the operating microscope led to important advances in microsurgery. Before this, traditional bone grafting, which depended on 'creeping substitution', had been used.

In 1970 McKee² successfully accomplished the first microvascular transfer of the rib to the mandible. This was dependent on the periosteal blood supply and not the primary medullary circulation. Subsequently, Adelaar et al² found that in order to survive on their periosteal circulation alone, anterior rib grafts required both arterial and venous anastomoses.

In 1974 Ostrup and Fredrickson³ described an alternative technique for rib transfer using a composite graft in which the posterior intercostal artery and vein were used as a vascular pedicle. This preserved both the periosteal and medullary blood supplies. Hagan and Buncke⁴ described the orthopaedic application of this technique. They used a composite rib graft with overlying soft tissue and skin to bridge a tibial defect of 6 cm with anastomosis of the intercostal vessels to the anterior tibial vessels in the leg. The effectiveness of these free vascularised rib grafts remains a matter of debate since most have been unsuccessful in the long term.⁵

In 1980 Bradford⁶ reported the use of a vascularised rib graft on its pedicle for anterior fusion of the thoracic spine. In 1983 McBride and Bradford⁷ treated six patients with symptomatic post-traumatic kyphosis using anterior spinal fusion with a vascularised rib pedicle graft. There was rapid incorporation of the graft and thus a shorter period of external immobilisation.

Bradford and Daher⁸ used a vascularised rib graft to stabilise spinal kyphosis in 25 patients and found that healing of the graft occurred within 11 weeks of insertion. Lascombes et al⁹ stated in their anatomical study that the mean length of the pedicle available for the eighth to the tenth ribs was more than 5 cm and the useful length of bone was 12 cm. This can be used for fusion of four to six lumbar or thoracic vertebrae. Shaffer et al,¹⁰ in studies on dogs, showed that vascularised grafts retained greater viability and better mechanical properties during incorporation of the graft. Louw¹¹ used vascularised rib grafts for anterior fusion in tuberculosis of the thoracic and thoracolumbar spine and obtained fusion after a mean of 3.3 months.

The successful outcome of bone grafts depends on revascularisation. Experimental studies have shown the superiority of vascularised bone grafts in bony union. Healing is more rapid and hypertrophy is more consistent than with non-vascularised grafts. They have also been shown to have better mechanical properties. Berggren, Weiland and Dorfman¹² compared the viability of vascularised rib grafts which had both medullary and periosteal blood supply with those with only a periosteal circulation. They found no difference in the viability of these two types of graft.

We have used a pedicle rib graft to bridge a defect in the

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Fig. 1

Photograph showing the exposed fifth rib. The arrow indicates the part of the rib to be excised subperiosteally to give the pedicle.

humerus. To our knowledge, this has not been previously reported.

Patients and Methods

We report the use of a pedicle rib graft for a defect in the diaphysis of the humerus after sequestration due to acute osteomyelitis in two children.

Operative procedure. The rib is exposed through a standard posterolateral thoracotomy incision. The pleural cavity is opened by two incisions one above and one below the chosen rib leaving a cuff of muscle attached to it. The posterior 6 cm of the rib is excised subperiosteally leaving a pedicle 6 cm in length (Fig. 1). The anterior part is excised 3 cm anterior to the anterior axillary fold. The recipient area in the arm is exposed and the proximal and distal ends of the metaphyseal bone prepared to receive the graft, which is tunnelled to the site of the defect in the humerus through the axilla. Fixation of the graft is secured by an external fixator with 2.5 mm Schanz screws passed

Fig. 2a

Fig. 2b

Case 1. Radiographs showing the defect in the diaphysis of the proximal humerus.

through the acromion and the upper and lower ends of the humerus. The screws are held by clamps to a 3 mm rod.

Case 1. An eight-year-old boy presented with abnormal mobility and shortening of the right upper arm, limitation of elbow movement and a discharging sinus. He gave a history of swelling of the right arm four years previously for which Ayurvedic treatment was followed by a fibular graft to bridge the defect in the humerus. Radiographs (Fig. 2) showed a sequestrum in the distal humerus. Excision of the sinus and sequestrectomy were performed and one week later a vascular pedicle rib graft using the anterior part of the fifth rib was utilised to bridge the defect. The

Fig. 3a

Fig. 3b

Diagrams indicating a) the rib graft lying in its bed showing the extent of the soft-tissue dissection and b) the harvesting of the graft.

Fig. 4

Fig. 5

Fig. 6

Fig. 7a

Fig. 7b

Case 1. Figure 4 – Digital subtraction angiograph showing patency of the intercostal vessels. Figure 5 – Radiographs showing union of the rib graft and the bony bridge (arrow). Figure 6 – Photograph showing functional elevation and abduction of the shoulder with the bony prominence in the axilla. Figure 7 – Anteroposterior (a) and lateral (b) radiographs of the humerus after 42 months showing good bony union.

pedicle (Fig. 3) contained the intercostal muscle cuff and the periosteum in addition to the intercostal vessels to facilitate handling. The bone was stabilised as described above. Digital subtraction angiography (Fig. 4) was performed one week after the grafting procedure and showed patency of the intercostal vessels. The external fixator was removed at 12 weeks after radiological bony union at both the proximal and distal ends of the graft had been confirmed. Some new bone was also seen along the pedicle of the graft. The limb was protected in a plaster splint for a further two weeks. At follow-up at 15 weeks a bony mass was palpable in the axilla which prevented abduction. New bone had formed along the pedicle (Fig. 5). It was partially excised to improve abduction. When last reviewed, 42 months after surgery, a non-tender bony mass was still

present in the right axilla but it did not obstruct movement. There were no problems with activities of daily living. The patient had 90° of abduction at the shoulder and fixed flexion of 30° at the elbow (Fig. 6) beyond which flexion to 110° was possible. There was a persistent shortening of 8 cm. Radiographs (Fig. 7) showed good bony union with hypertrophy of the graft.

Case 2. An 18-month-old child presented with a four-day history of pain and swelling of the left arm and shoulder. Previously, injections had been given into the deltoid region for fever. Examination revealed a febrile child with an abscess in the left arm. This was drained and a sequestrum removed from the humerus resulting in a defect of 4 cm (Fig. 8).

Two weeks later the gap was bridged using a vascu-

Fig. 8

Fig. 9b

Fig. 9a

Case 2. Figure 8 – Radiographs showing a diaphyseal defect in the left humerus with a sequestrum (arrow). Figure 9 – Anteroposterior (a) and lateral (b) radiographs showing hypertrophic nonunion after a fall sustained 26 months after the operation.

larised rib graft from the left fourth rib and stabilised by an external fixator. The graft fractured within the soft-tissue sheath during transfer to the arm, but united satisfactorily.

The fixator had to be removed at eight weeks because of pin-track infection and loosening. The arm was then immobilised in a plaster 'U' slab. At four months the distal end of the graft had not united and costal cartilage was found to be attached to it. The cartilage was excised and the site of nonunion curetted and fixed with a Kirschner (K-) wire. Six weeks later the distal end of the graft had united radiologically and the K-wire was removed. One year later the patient fell and sustained a fracture through the middle of the graft. The limb was immobilised in a plaster slab. The fracture showed hypertrophic nonunion when last seen 26 months after the operation (Fig. 9).

Discussion

A vascularised rib graft has distinct advantages when compared with a graft from either the iliac crest or the fibula because of its long vascular pedicle. The curved nature of the bone can be a disadvantage.

Diaphyseal defects of the long bones remain a problem. The advent of ring fixator systems and bone transport has improved our ability to deal with this in the bones of the lower limb, but a diaphyseal defect in the upper limb due to sequestration after acute osteomyelitis may still present difficulty.

Bony defects are conventionally treated by bone grafting which acts as a scaffold for the ingrowth of new bone by a process of creeping substitution. When massive defects are involved this process is prolonged and it is difficult to maintain stability of the bone especially if it is infected. To overcome these problems vascularised bone grafts were introduced and the first successful report of this procedure with microvascular anastomosis was in 1975.⁴ The rib on its vascular pedicle, the intercostal artery, was used successfully to reconstruct the mandible by microvascular anastomosis.⁵ Subsequently, the technique was used without microvascular anastomosis to correct a kyphotic deformity of the thoracic spine.⁴

The advantage of a vascularised bone graft, either as a free graft or on its vascular pedicle, is that the osteocytes are preserved. Incorporation of the graft is similar to that of union of a fracture and does not take place by creeping substitution. The period of immobilisation required is therefore reduced.

This operation requires microvascular expertise, is technically demanding and has a significant rate of failure.⁵

Transfer of a rib on its vascular pedicle without microvascular anastomosis to bridge a diaphyseal defect in the humerus is a simple and satisfactory solution to a complex problem.

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References

1. Carrell A. Results of the transplantation of blood vessels, organs and limbs. *JAMA* 1908;51:1662-7.

2. **Sowa DT, Weiland AJ.** Clinical application of vascularised bone autografts. *Orthop Clin North Am* 1987;18-2:257-73.
3. **Ostrup L, Fredrickson JM.** Distal transfer of a free living bone graft by microvascular anastomosis: an experimental study. *Plast Reconstr Surg* 1974;274:52.
4. **Hagan KF, Buncke HJ.** Treatment of congenital pseudarthrosis of the tibia with free vascularised bone graft. *Clin Orthop* 1982;166:33-44.
5. **Weiland A, Daniel RK.** Microvascular anastomosis for bone grafts in the treatment of massive defects in bone. *J Bone Joint Surg [Am]* 1979;61-A:98-103.
6. **Bradford DS.** Anterior vascular pedicle bone grafting for the treatment of kyphosis. *Spine* 1980;5:318-23.
7. **McBride GG, Bradford DS.** Vertebral body replacement with femoral neck allograft and vascularised rib strut graft: a technique for treating post-traumatic kyphosis with neurologic deficit. *Spine* 1983; 8:406-15.
8. **Bradford DS, Daher YH.** Vascularised rib grafts for stabilisation of kyphosis. *J Bone Joint Surg [Br]* 1986;68-B:357-61
9. **Lascombes P, Grosdidier G, Olry R, Thomas C.** Anatomical basis of the anterior vertebral graft using a pediculated rib. *Surg Radiol Anat* 1991;13:259-63.
10. **Shaffer JW, Davy DT, Field GA, Bensusan JS, Kellis GJ.** The superiority of vascularised compared to non-vascularised rib grafts in spine surgery shown by biological and physical methods. *Spine* 1988;13:1150-4.
11. **Louw JA.** Spinal tuberculosis with neurological deficit: treatment with anterior vascularised rib grafts, posterior osteotomies and fusion. *J Bone Joint Surg [Br]* 1990;72-B:686-93.
12. **Berggren A, Weiland A, Dorfman H.** Free vascularised bone grafts: factors affecting their survival and ability to heal to recipient bone defects. *Plast Reconstr Surg* 1982;19:69.