Acta Orthop. Belg., 2007, **73**, 551-557

ORIGINAL STUDY

The use of allografts in paediatric orthopaedic surgery

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Autograft harvesting in a growing child sometimes leads to disastrous consequences. Allograft can advantageously replace autograft in the majority of the cases. This overview presents the most frequently used allografts in paediatric orthopaedic surgery and discusses their benefits. Illustrative cases are presented to highlight specific indications.

Keywords : bone grafts ; allografts ; paediatric orthopaedic surgery.

INTRODUCTION

Bone grafts are widely used in paediatric orthopaedic surgery. Autogenous bone grafts remain the "gold standard" in reconstructive surgery because of their osteoinductive, osteoconductive, and non-immunogenic properties. The iliac crest is the most common donor site because of easy access and procurement, and availability of large quantities of both cortical and cancellous bone. The fibula is another common donor site. The fibula is used owing to its mechanical strength. Free non-vascularised fibular grafts harvested subperiosteally can be used to fill defects of long bones (*4*) or as structural struts in spinal arthrodesis (*1*). Structural tibial grafts are also widely used for anterior fusions in children with severe kyphosis and kyphoscoliosis (*16*). The fascia lata is also a source of autograft to reconstruct a ligament or as interposition material (*8*).

Nevertheless autograft harvesting in a child is not trivial and is not without consequences. An additional surgical approach is often needed resulting in further postoperative local pain, surgical scar and increased surgical time. Moreover some major complications may occur. Documented donor site complications associated with iliac graft harvesting include pain, nerve and arterial injury, peritoneal perforation, sacroiliac joint instability, and herniation of abdominal contents through defects in the ilium (*13*). Strict observation of relevant anatomic considerations will help in avoiding these complications (*13*). In a child, iliac graft harvesting may disturb iliac wing growth (*14*). Harvesting more than 2 cm of fibula in a growing child leads to distal migration of the fibular head in 75% of the cases, talar tilt in 45%, proximal migration of the lateral malleolus in 55% and diaphyseal tibial valgus in 20% (*11*). Some authors recommend using a tibiofibular screw in all patients whose growth

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No benefits or funds were received in support of this study

plates are open (*10*). Incomplete regeneration of the fibula has been observed in 58% of the cases (*11*). Stress fracture may occur after tibial autograft harvesting (4%) (*2*).

If a bone bank is available all the autografts could be advantageously replaced by allografts. The most important benefit is to avoid donor site morbidity and postoperative pain and all the possible complications. The surgical time is also decreased. Another advantage is the unlimited availability of the allograft (for instance more than 10 cm of fibula can be obtained).

The goal of this paper is to present different examples of allograft use with their advantages.

FIBULAR ALLOGRAFT

Structural fibular strut allograft is used owing to its mechanical properties, as it provides a stable and rigid construct in the immediate postoperative period, more efficiently than a femoral cortical ring (*15*). It can be used in spinal arthrodesis. After hemivertebra resection in a child for example, it is very useful to prevent collapse of the two adjacent vertebral bodies and to avoid a postoperative kyphosis (*1*) (fig 1).

This strut role is also used in subtalar extra-articular arthrodesis (Grice procedure). The fibula is shaped to fit in the tarsal sinus and to restore the normal relationship between talus and calcaneus (fig 2).

A fibular allograft can also be cut in wedge shape to keep the opening of an osteotomy. For example, to correct a forefoot adduction, a closing wedge osteotomy of the cuboid is combined with an opening wedge osteotomy of the first cuneiform bone. The resected bone from the cuboid is often too brittle to maintain the opening. A wedge of freeze-dried fibula can be useful in this indication (fig 3).

The fibula can also be used to fill an important bone defect and to avoid fracture after hardware removal. For example, removal of a proximal femoral nail weakens the femoral neck with a subsequent risk of fracture. Filling the proximal part of the nail cavity with freeze-dried fibular sticks can prevent fracture (fig 4).

FREEZE-DRIED CANCELLOUS BONE

Freeze-dried cancellous bone is generally used to fill bone defects, such as after curettage of a

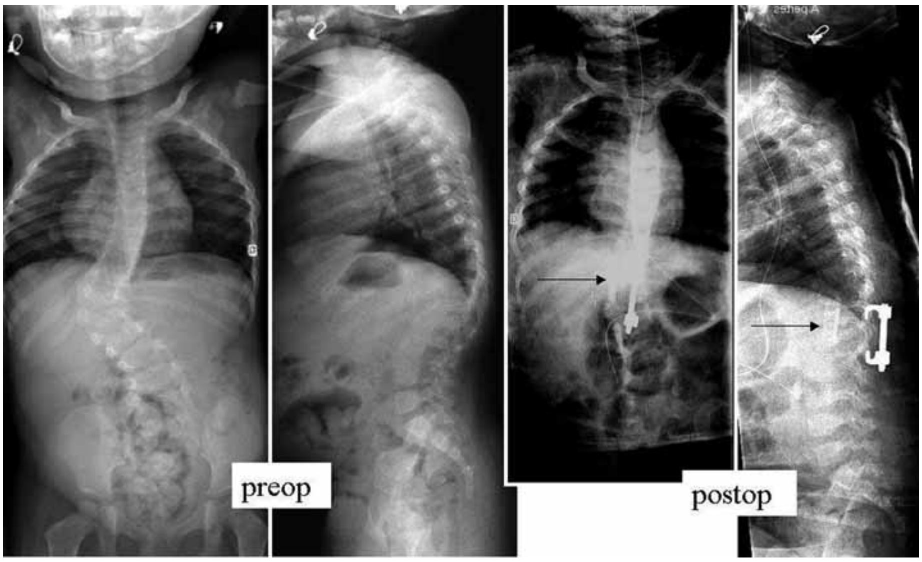

Fig. 1. — A 18-month-old infant with congenital kyphoscoliosis due to a right hemivertebra located between T12 and L1. Successive radiographs showed progression of the scoliotic curve. Surgical correction by hemivertebra resection (double anterior and posterior approach) and arthrodesis with a posterior baby-CD. A freeze-dried fibular strut (arrows) is placed anteriorly to avoid vertebral bodies collapse and to correct the kyphosis.

Fig. 2. — A 7-year-old boy with progressive peripheral axonal neuropathy. His right foot evolved to a neurological flatfoot, with walking difficulties. Correction by talocalcaneal screw fixation and extraarticular arthrodesis (Grice procedure). A freeze-dried structural fibular allograft (arrow) has been used.

Fig. 3. — A 7-year-old boy with sequella of idiopathic club-foot operated twice and referred to our institution for equinus, adduction and supination recurrence. Correction with Achilles tendon lengthening, posterior tibiotalar and subtalar capsulotomies combined with open wedge osteotomy of the first cuneiform, closing wedge osteotomy of the cuboid and hemitransplantation of the tibialis anterior tendon to the cuboid. A freeze-dried fibula graft shaped into a wedge (black arrow) was used to maintain the opening wedge osteotomy. After 2 years, the graft is osseointegrated (white arrow).

benign tumour. After curettage of an enchondroma, bone grafting is generally not necessary except if there is an important fracture risk (fig 5).

Freeze-dried cancellous allograft bone can also be used in posterior spinal fusion as a substitute or an adjunct to the patient's own autologous bone (*12*). The fusion rates obtained compare favourably with those achieved with autologous bone (*12*).

FASCIA LATA ALLOGRAFT

Human fascia allografts are treated with solvent detergents, freeze-dried for conservation and gamma irradiated (25,000 Gy) for sterilisation (*3*). They are appreciated for their tensile properties and are used for instance for ligamentoplasty. Flynn and Yap have compared autografts and freeze-dried allografts of fascia lata (*9*) and have noted comparable results. A fascia lata allograft can be used as a biological tension band to reconstruct posterior vertebral elements after resection in children, to avoid kyphosis progression with growth (*7*). Fascia lata is very useful to reconstruct the annular ligament in a missed Monteggia fracture (fig 6). Fascia lata can alternatively be used as interposition

Fig. 4. — A 10-year-old boy who sustained a subtrochanteric pathological fracture of the femur due to a simple bone cyst. Osteosynthesis with a proximal femoral nail (PFN) permitted to obtain healing of both fracture and cyst. After 20 months, the nail was removed and the holes were filled with allograft fibular sticks. Osseointegration was completed after 20 months. The child recovered full range of motion of the hip without significant leg length discrepancy.

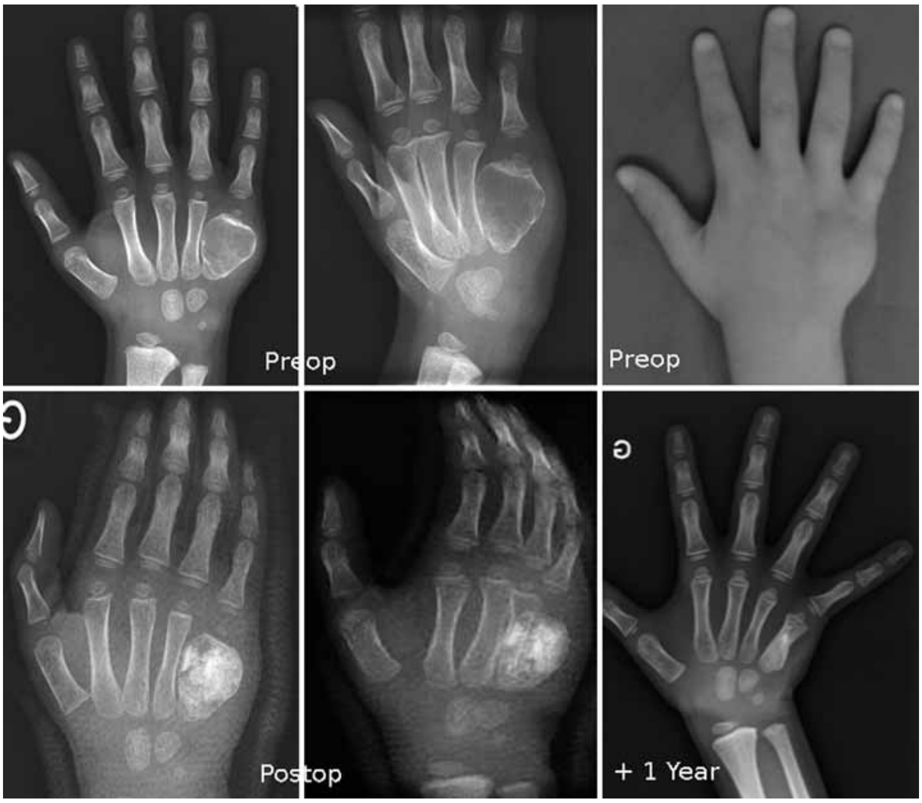

Fig. 5. — A 4-year-old boy with a voluminous enchondroma of the fifth metacarpal bone becoming cumbersome and painful. Curettage and filling with freeze-dried cancellous bone. Result after one year.

Fig. 6. — A 6-year-old girl referred for limited elbow flexion to 95° two months after a missed Monteggia fracture. The radial head is anteriorly dislocated. A lengthening-angulation osteotomy of the ulna was performed, combined with plasty of the annular ligament using a freeze-dried fascia lata allograft. Two months postoperatively the ulnar osteotomy has healed and the radial head is in its anatomical position.

Fig. 7. — A 15-year-old female with symptomatic talocalcaneal synostosis. The coalition was resected and a freeze-dried fascia lata allograft was interposed.

material, such as after tarsal coalition resection, where interposition of a fascia lata allograft helps to avoid synostosis recurrence (fig 7).

MASSIVE BONE ALLOGRAFT

Massive bone allografts are useful to restore bone stock in case of segmental bone defect due to neoplastic process, arthroplasty revision or trauma. Advantages of allografts compared with metallic implants are to restore a physiologic joint and to permit better reinsertion of muscles. Generally, the graft that would best fit the bone defect is selected based on a comparison of radiographs of the allograft with those of the patient. An antero-posterior view and a lateral view of the patient's bone are templated. These templates are compared to allografts templates, and the best fitting allograft is selected. Some bones, such as the iliac bone, have a complex tri-dimensional geometry which renders this matching difficult. In cases where implantation of an osteochondral allograft at the hip, knee or ankle is contemplated, it is difficult to preoperatively evaluate with 2-D templates the congruence between, for instance, the patient's femoral head and an acetabulum allograft, or between the patient's femoral condyles and a tibial epiphysis allograft. Persisting mismatch may lead to disasters in terms of joint instability, with a subsequent risk of joint dislocation. Two other main potential complications may be observed in case of suboptimal or poor matching : non-union and fracture. Enneking and Campanacci *(6)* reported that accurate and intimate contact at the osteotomy site

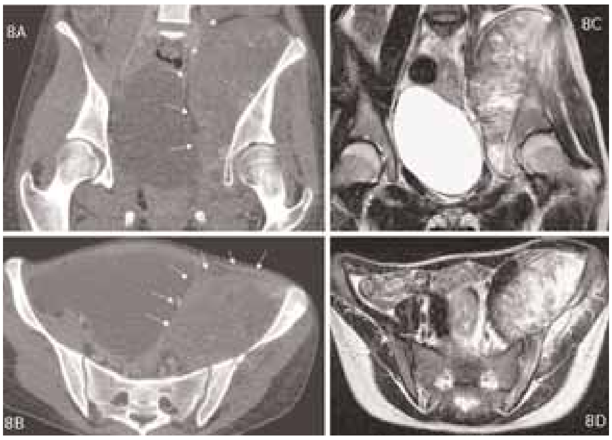

Fig. 8. — A 16-year-old female with Li-Fraumeni syndrome presenting with a voluminous osteosarcoma of her left hemipelvis with endopelvic extension. A&B : CT Scan ; C&D : MRI showing extension in the 3 areas of Enneking *(5)* and in the sacral ala as well.

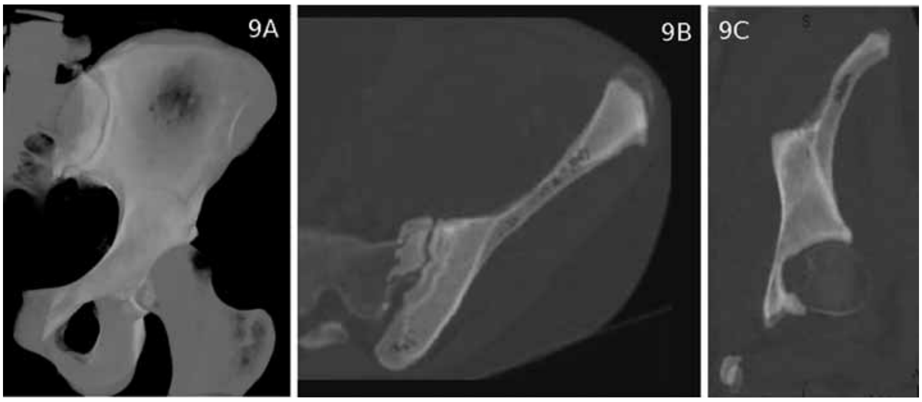

Fig. 9. — Same patient as figure 8. To identify the best-matching allograft, the allograft (light grey) has been registered together with the patient's pelvis (dark grey). A : tridimensional registration ; B : transverse slices ; C : sagittal slices. A perfect congruency is obtained between the acetabula of the patient and of the allograft. This made it possible to perform osteochondral allografting retaining the patient's femoral head.

Fig. 10. — Same patient as figures 8 & 9. Postoperative result after resection and reconstruction with a massive hemipelvis allograft. Early ambulation was allowed with crutches and partial weight bearing.

seemed to promote and accelerate union. They underlined the need for a rigid, precise contact in the host-allograft reconstruction, thus eliminating stress concentration areas (*6*).

Selection of the best massive bone allograft to fit optimally into a bone defect is a real problem in bone banking. The current method using standard radiographs is not optimal, mainly due to errors related to lack of tridimensional visualisation and also to radiographic enlargement. Good matching has direct consequences both on stability and on allograft-host bone contact. Good stability of the construct allows for early or immediate weight bearing. A new method developed in our laboratory uses a CT-scan based 3D-registration procedure (figs 8, 9, 10). The CT-scan of the patient is registered together with that of all available allografts, and the matching is controlled with a tridimensional viewer. This permits to test the congruency preoperatively before osteochondral allografting and to select the most appropriate allograft.

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