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CASE REPORT

Case Report

Histologic Study of a Human Epiphyseal Transplant at 3 Years after Implantation

**J. Sales de Gauzy MD, F. Accadbled MD, PhD,
A. Gomez Brouchet MD, A. Abid MD**

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Abstract A 5-year-old boy underwent surgical excision of a Ewing's sarcoma of the proximal femur. Reconstruction was performed using an ipsilateral vascularized epiphyseal transplant and a femoral allograft. Local recurrence of the tumor necessitated hip disarticulation 3 years after the initial procedure. We then performed a histologic analysis of the transplant. The growth plate was still normal in structure but had richly vascularized hyperplastic layers. We observed bridging between the articular cartilage and the growth plate.

Introduction

Epiphysis transplant is an alternative for epiphyseal reconstruction in children. It allows restoration of joint function and growth potential [8]. Continued longitudinal and tridimensional growth of the transplant has been confirmed by clinical monitoring [6, 9, 12]. Moreover, experimental animal studies have shown, once the microvascular anastomosis has restored the blood supply to the growth plate, the epiphysis appears normal histologically [2, 11].

We report the case of a patient whose fibular epiphyseal transplant was excised 3 years after reconstruction of his right proximal femur. We performed a histologic analysis of the actual epiphysis.

Case Report

A 5-year-old boy presented with a Ewing's sarcoma of the right proximal femur. After neoadjuvant chemotherapy, he was treated with intraarticular wide excision of the proximal femur. Reconstruction was achieved using a proximal ipsilateral vascularized fibula. An allograft was first secured to the femur with a plate to reinforce the shaft of the fibular autograft. The latter then was inserted into the allograft and secured using two lag screws. The fibular head then was placed into the acetabulum. The length of the fibula matched that of the excised femur (Fig. 1). The fibular graft was connected via the anterior tibialis artery and fibular artery to the profunda femoris artery. The anterior tibialis vein was anastomosed to a superficial vein. Microscopic examination confirmed the margins were negative and the patient had a good response to the neoadjuvant chemotherapy, with less than 10% active tumor cells (Grade III according to the grading system of Huvos et al. [4]).

The patient was immobilized in a hip spica cast for 3 months. Adjuvant chemotherapy was given postoperatively with eight courses of vinblastine, actinomycin, and

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Each author certifies that his or her institution has approved the reporting of this case report, that all investigations were conducted in conformity with ethical principles of research, and that informed consent for participation in the study was obtained.

J. Sales de Gauzy, F. Accadbled, A. Abid
Department of Pediatric Orthopaedic Surgery, Hôpital des Enfants, Toulouse, France

A. Gomez Brouchet
Department of Pathology, Toulouse Rangueil University Hospital, Toulouse, France

F. Accadbled (✉)
Service de Chirurgie Orthopédique et Traumatologique, Hôpital des Enfants, 330, avenue de Grande Bretagne, 31059 Toulouse Cedex 9, France
e-mail: faccadbled@wanadoo.fr

Fig. 1 A postoperative anteroposterior radiograph of the right hip shows a fibular transplant placed in the acetabulum.

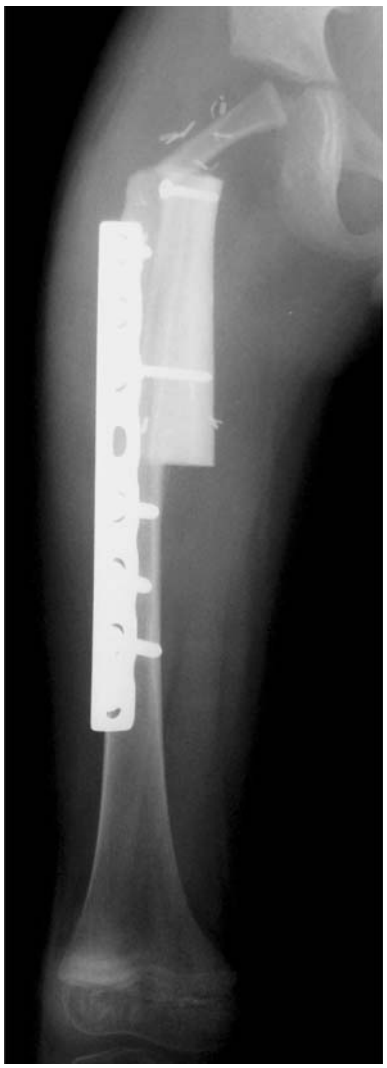

Fig. 2 A fracture at the junction between the fibular transplant and the allograft occurred 4 months postoperatively.

cyclophosphamide. Partial weightbearing was started after 3 months. At 4 months, a fracture of the fibular graft occurred and was treated with a hip spica cast (Fig. 2). Consolidation was obtained after 1 month (Fig. 3). Full weightbearing then was achieved with the patient wearing a knee brace for another 6 months.

Three years after surgery, our patient had no limb length discrepancy and walked unassisted with a mild limp. Hip range of motion was: 100° flexion, 0° extension, 30° abduction, 25° adduction, 25° internal rotation, and 30° external rotation. The donor site was clinically normal with no pain, weakness, ligament laxity, or paresthesia. Radiographs showed the graft had increased in length and width (Fig. 4). The distance between the center of the growth plate of the graft and the lower end of the plate increased by 25 mm (Fig. 3 versus Fig. 4). MRI showed no evidence of necrosis of the neofemoral head, which had increased in volume and remodeled to a more spherical shape. Its growth plate remained open (Fig. 5).

One month later, the patient reported pain at the site of the plate, which therefore was removed. Intraoperatively, the bone was deemed normal and of adequate strength. One month later, a spontaneous fracture occurred at the junction between the allograft and the native femur (Fig. 6). The fracture was treated with open reduction, plate fixation, and immobilization in a hip spica cast (Fig. 7). The patient then sustained another fracture below the plate after 6 months (Fig. 8) and thus had reoperation for plate removal, autologous iliac crest bone graft, and application of a long locking plate (Fig. 9). Bone biopsies also were performed and specimen revealed local recurrence of the Ewing's sarcoma at the junction between the shaft of the fibular graft and the distal femur (Fig. 10). Treatment then consisted of right hip disarticulation and chemotherapy. On microscopic examination, the margins of the resection were negative. Eighteen months after the

Fig. 3 The fracture united after immobilization in a hip spica cast for 1 month.

Fig. 4 An anteroposterior radiograph of the pelvis at 3 years' followup shows continued growth and bone remodeling with femoralization of the proximal fibula.

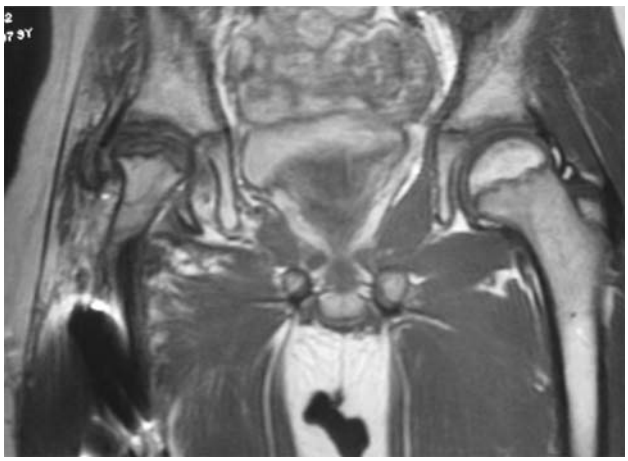

Fig. 5 A T2-weighted fat-suppressed spin echo, coronal view MR image taken at the 3-year followup shows the proximal fibula grown up with persisting growth plate, congruent joint, and no intraarticular effusion.

disarticulation, our patient has not had any additional recurrence.

Histologic analysis of the excised specimen (Fig. 11) was performed. The articular cartilage was remodeled. Around the fibular head, it was normal in structure with chondrocytes often gathered in groups. At the central part of the fibular head, the articular cartilage was replaced with richly vascularized fibrous tissue. Between the center and the periphery, we observed abundant immature chondrocytes forming fibrous cartilage and surrounding neoangiogenesis. The physis was mostly located directly underneath the articular cartilage or the richly vascularized fibrous cartilage. The physis consisted of four distinct layers all the way through, which were all hyperplastic. The intermediate layer was increased in height with high columns of chondrocytes. The cancellous bone located between the articular cartilage and physis contained adipose cells and was richly vascularized.

Discussion

Since the initial report of Taylor et al. [13] in 1975, studies have confirmed microvascularized bone transfer is an effective reconstruction for large segmental defects [12].

Fig. 6 A fracture at the junction between the fibular graft and the allograft occurred 2 months after the 3-year followup.

Fig. 8 A femoral shaft fracture occurred 6 months after the plate was applied.

Fig. 7 The fracture was treated with open reduction and plate fixation.

Fig. 9 This fracture was treated with open reduction, locking plate fixation, and autologous bone graft.

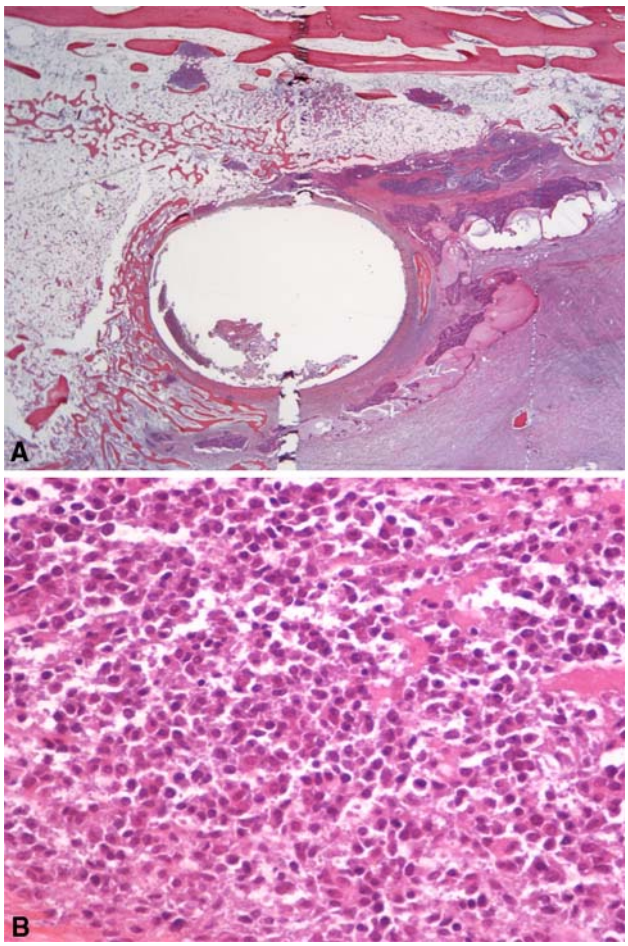

Fig. 10A–B (**A**) A photomicrograph shows recurrence of Ewing's sarcoma around a screw hole (Stain, hematoxylin and eosin; original magnification, ×10). (**B**) Multiple round cells related to Ewing's sarcoma, low cytoplasm content, and round or ovoid nuclei with low prominent nucleoli are seen in this photomicrograph (Stain, hematoxylin and eosin; original magnification, ×400).

Autologous epiphysis transplants have been reported more commonly in clinical practice [3, 8]. They are an effective alternative for epiphyseal reconstruction in children. Transplants can be used for treatment in various conditions, such as tumors and congenital or traumatic disorders of a long bone epiphysis in children. They have been used at various sites, including the proximal humerus, distal radius, and proximal femur [3, 8, 9]. The donor site is mainly the proximal fibula. Innocenti et al. [8] reported a series of 27 cases in skeletally immature patients with good morphologic and functional results at 2 to 14 years followup. We personally performed two other fibular epiphyseal transfers for reconstruction of one distal radius and one proximal humerus, both after excision of Ewing's sarcoma. The radius case presented an early slip of the fibular epiphysis with revision surgery and has an overall poor functional result. The humerus shows a good preliminary result at 7 months' followup with good range of motion and activity level.

The success of the procedure relies on the epiphyseal vascularization through microsurgical anastomoses [7]. The choice of the feeding pedicle is still controversial. The vascularized transfer of the proximal fibula usually is connected to the anterior tibialis artery [7]. Taylor et al. [14] reported the anterior tibialis artery provides an adequate blood supply to the epiphysis and the proximal ⅔ of the fibula. Mozaffarian et al. [10] reported the artery of the neck of the fibula is often a branch of the anterior tibialis artery, but in 24% of cases it is a branch of the popliteal artery that is not suitable for an anastomosis. They therefore suggested a preoperative angiogram to identify the origin of the artery of the neck. One report confirmed the growth and remodeling potential of an epiphyseal transfer with continued growth reported in approximately 70% of cases [5]. Blockey [1] reported histologic evidence of viability of the growth plate on a biopsy 1 year after a radius reconstruction and described enchondral ossification and irregularity and crowding of the columns of the growth plate.

Our case showed the viability of the growth plate after epiphyseal vascularized fibular transfer in a human. It remained intact and functional 3 years after the procedure. This confirms the results of previous experimental studies in dogs [2, 11].

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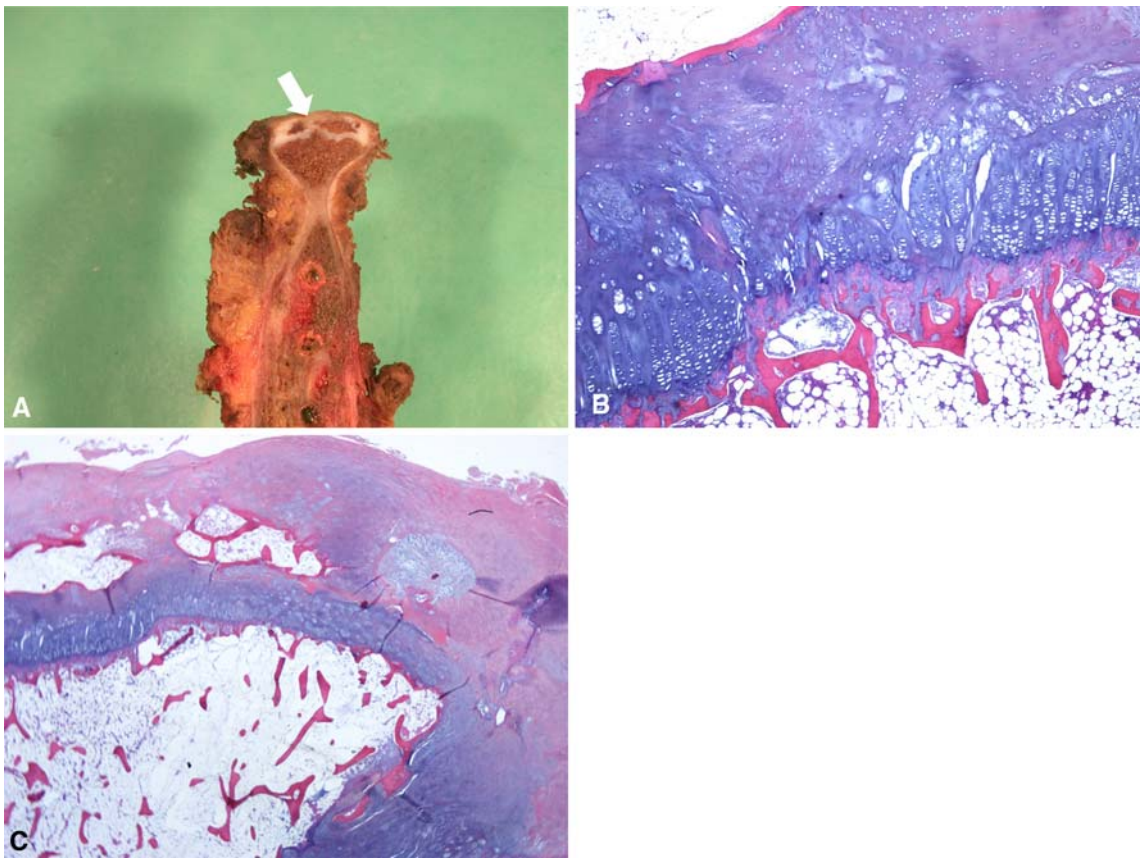

Fig. 11A–C (**A**) A coronal cut of the excised fibular epiphyseal transplant shows the connection between articular cartilage and the growth plate (arrow) and distal hypertrophy in relation to fracture healing. (**B**) Microscopic examination of the excised fibular epiphyseal transplant reveals neoangiogenesis and fibrocartilage formation at the junction between the articular cartilage and the growth plate corresponding to the arrow in (**A**) (Stain, hematoxylin and eosin; original magnification, ×10). (**C**) The growth plate with chondrocyte proliferation of the intermediate layer shows several groups of chondrocytes and taller columns of chondrocytes. (Stain, hematoxylin and eosin; original magnification, ×100).

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