Failed vascularized proximal fibular epiphyseal transfer for hip reconstruction following infection in children

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Abstract

Purpose Treatment of the sequellae of hip infection with epiphyseal destruction in children has had limited success to date. The aim of this study was to report mid-term results after hip epiphyseal reconstruction using a proximal vascularized fibular graft in three children presenting with massive epiphyseal destruction of the proximal femur following infection.

Methods Three children suffered from hip articular destruction type IVB according to the Choi classification after neonatal septic arthritis. The mean age at reconstruction was 4.3 years (range 3–6 years). The Hunka et al. criteria were used to evaluate the functional results, and the clinical evaluation was based on the Musculo-Skeletal Tumor Society (MSTS) score. Growth and fusion of the graft and hip morphology were evaluated on simple X-rays and by magnetic resonance imaging (MRI). A ratio between cephalic diameter and inter-acetabular gap was defined on the MRI scan as the “acetabular filling index”.

Results No intraoperative complication was reported. With a mean follow-up of 4.8 years (3–6 years), the MSTS score was 22.7/30 (range 20–26), while the average lower limb length discrepancy was 3 cm. Patient 1 required a secondary derotation osteotomy of the femur because of abnormal external rotation and a bad result due to the unexplained occurrence of a painful and stiff hip joint. A secondary distal transfer of the greater trochanter was

performed in patient 2, and good results based on Hunka et al.'s criteria were achieved. The X-rays of patients 1 and 2 showed signs of bone growth and a major remodeling process; the MRI filling indices were 83 and 67%, respectively. Patient 3 developed an early slipped capital (fibular) epiphysis 1 month postoperatively, which was treated by percutaneous pinning; this early complication led to a bad result with full resorption of the graft.

Conclusions In contrast to its success in upper limb reconstruction, in this series of three patients with hip articular destruction, articular reconstruction using a vascularized proximal fibula graft was disappointing and led to unsatisfactory results in terms of hip reconstruction. Such a procedure is complex and highly demanding, necessitating extremely intensive post-operative care. An early slipped capital epiphysis can lead to full graft resorption. Consequently, despite important adaptation and remodeling of the graft, the authors do not recommend this procedure at this location.

Keywords Epiphyseal transfer · Neonatal septic arthritis · Reconstructive surgical procedures · Vascularized fibula

Introduction

Osteoarticular infections in children can lead to very serious complications [1], with the hip being a particularly vulnerable location [2]. The most serious complication is a complete destruction of the cervico-cephalic complex, leading to an unstable and painful hip [2], associated with a globally shorter and hypotrophic lower limb. When the destruction is complete, treatments options are limited, ranging from no surgical intervention to hip arthrodesis

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[2–5]. Some authors have proposed using a vascularized iliac crest autograft [6] or a trochanteroplasty [7, 8], but the long-term functional results of these procedures have been disappointing to date.

Articular reconstruction procedures using a vascularized fibula graft have been used in oncologic surgery of the upper limb, with good results [9]. This ambitious procedure was applied to one patient's hip for the first time in 2003 [10], following oncologic resection. Here, we report the mid-term results of three epiphyseal reconstructions using a vascularized fibular autograft for destroyed and unstable hips due to the sequelae of septic arthritis of the hip. Our hypothesis was that, in very young children, this reconstruction could lead to a more anatomical restoration of the hip and a better functional outcome.

Patients and methods

Patients

Three children were included in this study, all of whom suffered from neonatal hip septic arthritis. Articular destructions were classified as type IVB according to the Choi et al. [5] classification or 2B according to the Forlin et al. [11] classification (see Fig. 1a)—absence of femoral head, dislocated hip, and an important potential loss of

length [12]. Clinical preoperative characteristics of our patients are shown in Table 1. A Trendelenburg limp was always found, although it was not painful.

Surgical procedure

Each patient was examined in a reclined position under general anesthesia. The average time of the procedure was 10.3 h (range 10–11), and each procedure was performed by the same surgical team (FC, AG, and JB). The Smith–Petersen's approach was used, with an anterior arthrotomy, showing the articular cavity filled with fibrotic tissue and chondral debris. An additional lateral femoral approach was performed for the oblique tunnel and the subtrochanteric osteotomy. This tunnel was performed using an arthroscopic ancillary (Arthrex, Lezennes, France), and the purpose of the procedure was to open the cervico-diaphyseal angle in coxa valga. The femur was systematically shortened using a subtrochanteric osteotomy (15–20 mm).

The fibular graft was harvested using a lateral approach on the ipsilateral knee. The proximal part of the fibula was used, vascularized by the anterior tibial vascular pedicle. The lateral collateral ligament was cut leaving a short part of it on the fibula, which was used as a fixation method in the acetabulum.

The graft was then transposed to the hip and positioned into the femoral tunnel. The proximal tibio-fibular joint

Fig. 1 Reconstruction of the right hip with vascularized proximal fibula in patient 2. **a** Preoperative X-ray in standing position showing the complete destruction of the epiphysis and the pelvis tilt. **b** Post-operative X-ray with iliofemoral external fixator. **c** Last follow-up X-ray after distal greater trochanter transfer. **d** Magnetic resonance imaging scan after 4 years of follow-up showing good remodelage and filling index

Table 1 Clinical results with hip range of movement and limb length discrepancy

Clinical characteristics	Case no. 1	Case no. 2	Case no. 3
Gender	Male	Male	Female
Age at surgery (years)	4	3	6
Flexion pre-/post- surgery (°)	120/0	160/100	160/140
Extension pre-/post- surgery (°)	0/–30	0/0	0/0
Abduction pre-/post- surgery (°)	60/10	60/10	80/70
Adduction pre-/post- surgery (°)	30/–10	40/40	30/70
External rotation pre-/post- surgery (°)	80/0	60/30	95/60
Internal rotation pre-/post- surgery (°)	90/0	80/20	70/70
Limb length discrepancy pre-/post- surgery (mm)	25/30	30/20	40/40

Values are given as preoperative values/values at time of review

cartilage was oriented toward the acetabulum, slightly towards the pubis. An anchor was used to fix the part of the lateral collateral ligament still attached to the fibula to the acetabulum (Mitek, Depuy International, Leeds, UK). An end-to-end microsurgical anastomosis with the medial circumflex femoral vascular pedicle was then performed. An Ilio-Femoral Hoffmann external fixator was also positioned (see Fig. 1b), and the procedure was completed by hip spica cast immobilization.

Post-operative care and physiotherapy

An anti-thrombosis treatment (25 mg aspirin per day) was prescribed for 1 month. The external fixator was removed between the fourth and sixth month, and the total immobilization time ranged from 5 to 7 months. No weight bearing was allowed during this time, but the patient could use a wheelchair. After the removal of the plaster immobilization cast, a Thomas splint was used for an average of 13 months (range 11–17 months) in combination with a part-time traction of 18 h per day. The first patient stayed 3 months in a rehabilitation center for intensive physiotherapy.

Evaluation of the results

The Hunka et al. [13] criteria were used to evaluate the functional results. A result was considered to be satisfactory when it met the following conditions: a stable hip joint, flexion >50°, fixed flexed deformity (flexum) <20°, pain free, and good daily life capabilities. The clinical evaluation was based on the Musculo-Skeletal Tumor Society (MSTS) score [14], using six functional criteria (pain, functional discomfort, patient satisfaction, use of a walking stick, walking capabilities). The residual length inequality was also evaluated.

The radiological evaluation protocol used simple X-rays and magnetic resonance imaging (MRI). Bone consolidation was evaluated according to De Boer et al. [15], and both graft growth and fusion were evaluated. The

epiphyseal anatomy was analyzed on X-rays with the neck-to-shaft angle (CC'D) and the hip offset (distance between the most lateral point of the greater trochanter and pubis center). The cervical length (coronal cuts), the cephalic diameter and the inter-acetabular horns gap (transversal cuts) were calculated on the MRI scans (Fig. 1d). The ratio between cephalic diameter and the inter-acetabular gap was defined as the “acetabular filling index”. All measurements were performed by two independent observers using the DICOM software (Rubo Medical Imaging, Uithoorn, The Netherlands).

Results

The children were 4, 3, and 6 years old, respectively, at the time of the surgery and were 10, 8.5, and 9 years old at the last follow-up. The mean follow-up time was 4.8 years (range 3–6 years).

Clinical results

Range of movement and length inequality in the three patients are shown in Table 1.

The results of the treatment are shown in Tables 2 and 3 in terms of the MSTS and Hunka et al.'s scores. At the last follow-up, the children were walking without orthosis. Patient 1 developed a progressive and painful stiffening of his hip 6 years after the initial surgery. An arthrogram revealed a persisting cavity without intra-articular bone bridges (see Fig. 2). At the last follow-up, the result was unsatisfactory due to a functional arthrodesis with a flexion of 30° and a rotation and abduction of 10°.

Patient number 3 also had an unsatisfactory result due to graft resorption and a persisting hip instability.

Radiological results

The radiological evaluation results shown in Table 4 demonstrate that patient 1 had experienced a transversal

Table 2 Functional evaluation based on the Musculo-Skeletal Tumor Society score [14] at the last follow-up

Functional evaluation	Case no. 1	Case no. 2	Case no. 3
Last follow-up (years)	6	5.5	3
Functional criteria			
Pain/5	5	5	5
Function/5	2	4	3
Satisfaction/5	3	4	3
Help for walking/5	5	5	5
Walking capability/5	2	4	3
Range of movement/5	3	4	3
MSTS score/30	20	26	22
MSTS score (%)	66	87	73

MSTS score, Musculo-Skeletal Tumor Society

Table 3 Functional evaluation using Hunka et al.'s score [13]

Hunka et al. criteria	Case no. 1	Case no. 2	Case no. 3
Global result	Unsatisfying	Satisfying	Unsatisfying
Stable hip	Yes	Yes	No
Hip flexion	0	100	140
Hip flexum	30	0	0
Pain	No	No	No
Capabilities for daily life	Yes	Yes	Yes

Fig. 2 Hip arthrography in patient number 1 (lateral view) was performed after 6 years of follow-up because of unexplained stiffness. The remodeling process on the epiphysis is spectacular and the articular space is good

and longitudinal growth phenomenon that resulted in an articular congruency after 6 years (Fig. 2) and that patient 2 had undergone partial growth, resulting in a “coxa brevis”-type joint. Patient 2 had a distal greater trochanter transfer, and the articular congruency was incomplete after 5 years (see Fig. 1c). Patient 3 demonstrated complete

Table 4 Morphological X-rays and magnetic resonance imaging results at last follow-up (compared to controlateral side value)

Radiological evaluation	Case no. 1	Case no. 2	Case no. 3
X-ray			
CCD angle (°)	110° (138°)	108° (130°)	–
Global Offset (mm)	115 (85)	95 (100)	–
MRI			
Cervico-cephalic length (mm)	72 (73)	57 (62)	–
Cephalic diameter (mm)	28 (38)	26 (42)	–
Inter-acetabular horn distance (mm)	34 (42)	39 (45)	–

No data are available for case 3 because of graft resorption

Values in parenthesis are for the controlateral hip

CDD angle, Centro-diaphyso-diaphysaire (neck-to-shaft) angle; MRI magnetic resonance imaging

Fig. 3 Complication with early slipped capital epiphysis after 1 month following surgery in patient number 3

graft resorption, leading to a comparable radiographic result at 5 years and preoperatively.

Complications

There were no per-operative complications.

Patient 3 developed a superior femoral slipped capital epiphysis (see Fig. 3) after 1 month, which was treated by

percutaneous axial pinning after reduction of the epiphysis in terms of internal rotation of the limb.

Due to a moderate external rotation deviation when walking (step angle = 40°), patient 1 underwent a second operation, which was a subtrochanteric femoral osteotomy that corrected the angle by 30°, associated with a 20° valgization. An aponeurosis section of the thigh abductor muscles was also involved in the same procedure.

Temporary paralysis of the common peroneal nerve occurred in patient 3. This condition improved with physiotherapy and a foot drop splint. An insignificant knee lateral laxity was also noted in this child. There was no major valgus or varus deformity of the knee.

Discussion

In our series of three pediatric patients, articular reconstruction of the hip using a vascularized fibula graft was a disappointing procedure. The management of sequellae after septic arthritis of the hip remains a challenge. The absence of the femoral head and a dislocated hip is the more severe sequellae, and the preferred treatment of these conditions is open to discussion. Fixed hip dislocation remains a very complicated situation for a future total hip arthroplasty (THA).

Several surgical reconstruction procedures have been described, such as trochanteroplasty [7], Ilizarov's reconstruction osteotomy [16, 17], and femoral head reconstruction using a vascularized iliac crest graft [6]. The main objectives of all these procedures are to restore articular stability, maintain the functional articular range of movement, eliminate pain, and reduce any inequality in limb length [6]. Trochanteroplasty is an old procedure that is often associated with other techniques, such as femoral varization and pelvic osteotomy [5, 18, 19]. It is indicated in children younger than 6 years. Nevertheless, the weakness of the abductor muscles lead to an unsatisfactory result, with the patient having a limp and an oblique pelvis. This procedure can also make any future THA difficult to perform. Cheng et al. [6] used a vascularized iliac crest graft instead of the trochanteroplasty, but with irreproducible results (three graft osteo-integrations out of seven cases). Choi et al. [5] abandoned this technique because of fixation failure and partial graft resorption. Ilizarov's osteotomy can be justified as a second-hand procedure after reconstruction failure or in an older child. It corrects the length problem, but the proximal valgization makes the THA procedure more difficult.

At present, there is no clinically satisfactory procedure for restoring the anatomy of the growing hip while preserving its vascular environment. Some authors even prefer no surgical treatment during childhood [2, 4, 10, 20]. Betz

et al. [12] and Wopperer et al. [2] only recommend contralateral epiphysiodesis to address the leg-length discrepancy.

Our option was to adapt the ongoing development of new vascularized fibular graft techniques in tumor surgery [8] to the reconstruction of the hip. This technique has lead to encouraging results when used in upper limb reconstruction [9] in which a major local remodeling capability was reported. This procedure can also restore the articular function as well as the growth potential in a single procedure [9]. However, its application to the hip is still exceptional. In 2003, Manfrini et al. [10] performed this procedure in a 4-year-old child after a tumor resection of the proximal femur. The result was satisfactory at the 4-year follow-up. Innocenti et al. [9] mentioned three hip cases out of 27 but did not report the results. To the best of our knowledge, there has been no study published on the application of this technique for treating severe sequellae of septic arthritis of the hip.

Based on our experience in our hospital, this procedure is not reproducible, as reported when used for the upper limb. It should be noted that the lower limb has to sustain a much higher level of stress due to the standing position. We report here a patient with a slipped capital epiphysis. This complication has not been reported to date for the upper limb. For this patient, a bone graft coming from the shortening femoral osteotomy was used around the metaphyseal part of the fibula graft (see Fig. 3). This technical trick may have modified the graft vascularization. Apart from this vascular hypothesis, local mechanical stress may also have favored the development of this complication, and the evolution to progressive total lysis of the graft resulted in a return to the preoperative condition for this patient. Graft resorption was also reported by Cheng et al. using the vascularized iliac crest graft [6]. Our first patient with a follow-up of 6 years shows remarkable graft remodeling in that the acetabulum filling index is 83% and both femoral necks length are symmetrical (Table 4). The acetabulum of the reconstructed joint had an underdevelopment compared to the normal contralateral side. Unfortunately, this very good radiological result is totally contradictory with the progressive unexplained joint stiffness.

The graft growth was less impressive in our second patient, with an acetabular filling index of 67% and an inferior neck length relative to normal (92% of the normal side). The radiological appearance at the last follow-up was compatible with osteochondritis. Nevertheless the clinical result remains good after 4.5 years.

Our unsatisfactory results have made us very cautious about the indications for this procedure. Post-operative care was very intensive for the children, such as a long immobilization time without weight bearing. The donor site

complications rate is also high. Innocenti et al. [9] report a two-thirds rate of patients with partial paralysis of the common peroneal nerve due to the dissection. This was a transient complication for one of our patients (patient number 3), but three patients out of the 24 in the series of Innocenti et al. [9] remained with definitive partial paralysis. Finally, the dissection of the fibular epiphysis implies a resection of the collateral lateral ligament, although no varus deformation was reported [21]. Our third patient still presents a slight asymptomatic lateral laxity after 3 years follow-up.

Based on our results and those reported in the literature, this procedure would seem to be more appropriate for upper limb reconstruction. The high rate of complications and above all the unfavorable outcome have caused us to rule out this procedure as a treatment option for severe sequelae following septic arthritis of the hip. At the present time, we do not recommend this procedure in such cases.

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