Vascularised iliac graft as a method of acetabular augmentation in subluxed hip in adolescents

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Abstract This article presents the clinical experience of patients with a dysplastic subluxated hip treated with the same procedure involving a vascularised graft of iliac crest by sartorius muscle. This study was performed in three different centres, in two different countries, and in 31 patients with 37 hips (9 bilateral). All patients were clinically evaluated according to the Merle d'Aubigne scale and radiological measuring of acetabular coverage, Sharp angle, and CE angle. Walking ability preoperatively was 4.87 and postoperatively 5.12, which was not statistically significant. Preoperative inclination acetabular angle was $59.0^{\circ} \pm 6.23$ and postoperatively $37.5^{\circ} \pm 6.08$ ($P < 0.00001$). Preoperative CE angle was $-2.03^{\circ} \pm 13.5$ and postoperatively was $41.0^{\circ} \pm 12.3$ ($P < 0.00001$). Index head acetabulum had a preoperative coverage of $48.3\% \pm 13.0$ and postoperatively $100.8\% \pm 19.5$. The head sphericity did not show any statistically significant difference in relation to the results. The results obtained were satisfactory from every point of view, making this the procedure of choice in the armamentarium to delay the need for a total joint as treatment of early osteoarthritis in young adults.

Résumé Le but de ce travail est de présenter notre expérience clinique chez les patients présentant une subluxation de la

hanche, traités par une greffe iliaque vascularisée par le muscle sartorius. Cette étude a été réalisée dans trois centres différents de trois pays différents sur 31 patients avec 37 hanches (9 bilatérales). Tous les patients ont été évalués selon le score de Merle d'Aubigné et, sur le plan radiologique par la mesure de l'angle de couverture acétabulaire CE. Résultats: le score PMA marche préopératoire était de 4,87 et de 5,12 en postopératoire, sans différence significative. L'inclinaison acétabulaire était de $59 \pm 6,23$ en préopératoire et $37,5 \pm 6,08$ ($P < 0,00001$). L'angle CE préopératoire était de $2,03 \pm 13,5$ et de $41,0 \pm 12,3$ ($P < 0,00001$) en postopératoire. L'index de couverture de la tête a été de $48,3\% \pm 13$ en préopératoire et de $100,8 \pm 19,5$ en postopératoire. La sphéricité de la tête ne montrait pas de différences significatives. En conclusion, les résultats montrent qu'il s'agit d'un procédé tout à fait satisfaisant et de choix dans l'arsenal thérapeutique destiné à éviter une évolution arthrosique chez de tels patients.

Introduction

The dysplastic subluxed hip in young adults is still a subject of controversy. Many young patients that develop a hip osteoarthritis present some mechanical anomalies around the acetabulum or proximal femur [2]. The subluxed hip with partial contact with the acetabulum leads to alterations in weight bearing and concentrates stress in a small area of articular cartilage, leading to a degeneration of the cartilage and an early degenerative arthritis in early youth with marked alterations.

Many authors have demonstrated that young adult patients with a CE angle (hip centre edge angle) less than 16 degrees have a high risk of degenerative arthritis, specially when subluxation is present [13]. In many mechanically compromised hips, the factor that limits the

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treatment outcome is the amount of cartilage damage that has occurred before treatment [14].

Osteotomies modify the hip joint position, thus trying to avoid the progression of cartilage degeneration and its eventual reparation. This can be done either by a diminution of the force that the joint has to support or by enlarging the surface of the joint to improve the distribution of forces. When a congruent acetabulum can be redirected over the femoral head, a reconstructive osteotomy (periacetabular) should be used since the periacetabular osteotomy is the ideal method, especially for developmental hip dysplasia, allowing great movement at the acetabular level. The AP abduction–internal rotation view demonstrates the articular congruency and simulates the corrected joint position of a typical lateral and anterior coverage enhancing rotational osteotomy [7]. The persistence of fixed subluxation on this view is a contraindication to a rotational pelvic osteotomy. The presence of an incongruent acetabulum is a contraindication to a periacetabular osteotomy and is an indication for a pelvic salvage osteotomy, such as acetabular augmentation with a vascularised graft. Fawzy et al. [4], after studying 76 hips with symptomatic acetabular dysplasia treated by acetabular augmentation and reviewed for 11 years, found a survival analysis using conversion to total hip of 86% at 5 years and 46% at 10 years. Where there was none or slight narrowing of joint space, survival was of 97% at 5 years and 75% at 10 years, versus 76% at 5 years and 22% at 10 years when moderate or severe narrowing of the joint space was present. They concluded that shelf acetabuloplasty is a reliable and safe procedure giving medium term symptomatic relief for adults with acetabular dysplasia, with best results in cases of mild and moderate dysplasia with little arthritis.

Salvage procedures support the femoral head by providing a buttress superior to the hip capsule. With time this capsular tissue undergoes a metaplasia to a fibro cartilage, which is of course not comparable to hyaline cartilage. Thus the acetabular augmentation with a vascularised graft has a different indication to the rotational acetabular osteotomies. The vascularised iliac graft contains viable osteogenic cells, more in medullar than in cortical bone, and the fact of being vascularised, theoretically facilitates its incorporation to bone. Experimental work by Domagoj et al. [3] on ten cadavers showed that in obtaining a pediculated iliac graft, the deep circumflex artery was long enough as to allow transfer of the graft without requiring any microvascular anastomosis. They conclude that in all cadavers the length of the pedicle was sufficient to reach any position in the acetabular roof and thus provide good primary stability, local bone remodelling, and incorporation under load.

Using a vascularised iliac crest graft with the Sartorius muscle we obtained an enlargement of the weight bearing

surface. The vascularised graft does not compete with indications for re-orientation osteotomies. The indications are still painful incongruent hips when a reorientation is not possible. Our experience with nonvascularised graft is that Wilson or Stahelli types of graft reabsorb in the long-term follow-up about 40% totally and 80% partially, whereas we have not had bone reabsorption of our vascularised graft.

Before a total joint is considered in these young patients, many surgical procedures of osteotomies at the iliac or femoral level have been used. This article describes our experience with a new technique consisting of an augmentation of the superior and anterior margins of the acetabulum by a vascularised graft of the iliac crest based on the sartorius muscle.

Material and method

This study reviewed 31 patients with one or both hips subluxated, for a total of 37 hips, with a CE angle less than 16 degrees and all experiencing pain.

Patient hip details include:

- Six bilateral hips
- 17 right and 20 left hips
- 11 males and 20 females
- Mean age was 19 years ranging from 8 to 38 years
- Mean follow-up was 8 years ranging from 6 to 12 years

Diagnoses were:

- 24 dysplastic hips
- Six Perthes sequelae
- Five septic arthritis sequelae
- Two cerebral palsy

All patients were classified according to Merle d'Aubigne score to evaluate pain, mobility, and walking ability [6]. Preoperative pain was 4.06, mobility 5.73, and walking ability 4.87. All patients were studied radiographically [1, 5, 8–11, 14], measuring acetabular coverage, Sharp angle [13], and CE angle [12, 13]. Seven cases had had a previous surgical procedure performed. The presence of osteoarthritis allows them to be classified according to the Japanese Orthopaedic Association [9] (Table 1).

Twelve cases were in the prearthritic stage, 17 in early stages, and eight in the advanced stage. The angle of acetabular inclination was measured preoperatively and found to be $59.0^\circ \pm 6.23$ [8]. Acetabular head relationship measured in relation to CE angle [13] and the head acetabular index was 8.9, while the CE angle measurement had a mean of -2.03 ± 13.5 . The head acetabulum relationship [5]—normally between 70–100%, usually 90%—had a coverage of $48.3\% \pm 13.0$.

Table 1 Classification of osteoarthrosis according to the Japanese Orthopaedic Association

Stage	Criteria
Pre-arthrosis	Acetabular dysplasia without other signs
Early	Slight diminution joint line. Abnormal subchondral sclerosis
Advanced	Great diminution joint line. With or without sclerosis and/or cysts
Terminal	Obliteration joint space

At the femoral level we measured the head concentricity, drawing two lines 90 degrees to one another from the maximum arch border of head circumference. When the difference was less than 1.1 cm it was considered spherical [12]. The head concentricity was evaluated measuring the major and minor axes in an AP radiograph. Results with more than 1.1 cm difference dividing the major axis by the minor axis are considered deformed heads. In 15 hips the head was spherical and in 22 nonspherical.

All patients had a bone scintogram with 99 Tc (99 Technetium) pre- and postoperatively. The bone scan was repeated at 24 hours after administration of isotope. In the preoperative stage it was performed to assess the weight that was acting on the joint, and then was repeated at least 1 year after surgery showing a better distribution of weight forces and good vascular support to the graft.

Surgical technique

The surgical procedure was conducted as follows:

1. A hockey stick incision was made with short arm on the iliac crest and straight arm going distally from the

Fig. 1 Iliac crest resection site, down to the anterior superior iliac spine, continued by the sartorius muscle **Fig. 2** Position of the uncovered head of the femur

anterior superior iliac spine in the direction of the border of the patella.

2. The lateral cutaneous nerve was identified and protected.
3. The sartorius muscle was dissected.
4. A graft of iliac crest with the attachment of the sartorius muscle was freed and separated (Fig. 1).
5. A portion of the superior border of the external surface of iliac bone was scarified extrarticularly.
6. The graft was located extra capsularly and fixed by means of two screws, giving a correct coverage both superiorly and anteriorly (Figs. 2, 3, 4 and 5).
7. Muscles of the iliac crest are reattached.

Rehabilitation was started with active movements of the joint at 24 hours postoperation and weight bearing allowed at 3 months.

The continuous data giving an abnormal distribution were processed by the nonparametric method of Kraus Kal Wallis for independent groups. In the difference pre- and postoperatory the method of Wilcoxon and the Student *t* test were used. In all cases the significance value was $P \leq 0.5$ for two extremes. The distribution of data is expressed as arithmetic media $\pm$ standard deviation.

Fig. 3 Position of vascularised graft on finishing the procedure

Results

Evaluation according to Merle d' Aubigne provided the following data:

- Preoperative pain was 4.06 ± 0.68
- Postoperative pain was 5.43 ± 0.65 ($P < 0.0001$)
- Preoperative mobility was 4.73
- Postoperative mobility was 4.92 (nonstatistically significant)

All patients presented a diminution of hip flexion in the immediate postoperative evaluation which recovered after 6 months of physical therapy. Walking ability preoperatively was 4.87 and postoperatively 5.12, which was not statistically significant. Mean age of the 12 patients in the prearthrosis stage was 12.7 ± 3.14 years, in the 17 cases of early lesion stage 21.8 ± 6.00 , and in the eight cases of advanced stage it was 25.9 ± 7.22 ($P < 0.0002$). Preoperative inclination acetabular angle was $59.0^\circ \pm 6.23$ and postoperatively $37.5^\circ \pm 6.08$ ($P < 0.00001$). Preoperative CE angle was $-2.03^\circ \pm 13.5$ and postoperatively was $41.0^\circ \pm 12.3$ ($P < 0.00001$). The head acetabulum index had a preoperative coverage of $48.3\% \pm 13.0$ and postoperatively of $100.8\% \pm 19.5$. Head sphericity did not show any statistically significant differences.

Technetium 99 bone scintigram, as an index of joint stress, was positive in all patients. In the postoperative stage it was used in order to show the vascularisation of the graft. Comparing pain and coverage, we observed that when the

Fig. 5 Axial X-rays postoperatory. Observe the anterior augmentation of the acetabulum

patients had coverage less than 34%, the pain was more intense ($P < 0.036$). Comparing age and type of preoperative pain, we observed that in patients older than 20 years pain was more severe ($P < 0.044$). Two patients had postoperative lateral cutaneous nerve paraesthesiae, and another had a fracture of the screw fixing the graft, not affecting the outcome.

Fig. 4 Anteroposterior postoperative X-rays. Observe the coverage obtained by the graft and the fixation by two screws

Fig. 6 Postoperative angiography. Observe the vascularisation of the graft

Discussion

The iliac crest graft vascularised by the sartorius muscle provides an acetabular coverage, both superiorly and laterally, augmenting the articular surface in order to obtain a better distribution of weight bearing. None of our cases exhibited any reabsorption of the graft, and angiographic studies showed that vascularisation of the graft was maintained at follow-up.

All our patients had subluxed hips with a CE angle $<16^\circ$, which is considered an at risk group to develop degenerative arthrosis. The early signs appeared in the mean age group of 21.8 years and the advanced lesion in 25.9 years. The more intense pain was also observed in patients older than 20 years. These data suggest that the ideal moment for treatment is in patients younger than those above.

The percentage of head subluxation also showed a relation with the intensity of pain, showing that in patients with coverage less than 34%, the pain was more intense. Clinical evaluation showed that the most marked benefit of this operation was related to pain. Patients had a diminution of hip flexion in the immediate postoperative phase, which was probably due to the loss of the flexion action of the sartorius used for graft vascularisation. This mobility was regained in the first 6 months after operation, with a plan of rehabilitation, due to compensation from the other hip flexion.

The graft provides an adequate coverage demonstrated by the CE angle, Sharp angle, and the percentage of coverage obtained. The size of the graft makes the obtained coverage bigger, and in some cases, covers the entire femoral head.

The vascularity of the graft is provided through the sartorius muscle. One patient had a pelvic pathology nonrelated to the hip that required a digital angiography. Such a study allowed us to observe the circulation to the iliac graft through the sartorius muscle as shown in the Fig. 6.

The graft is stabilised and fixed by two screws, allowing early active rehabilitation (Figs. 4 and 5). In no case did we had a graft reabsorption. One patient had a fracture of the

screw, but did not require additional surgery. The fatigue of the material was probably due to the continuous weight bearing acting on the graft

The postoperative paraesthesiae of the lateral cutaneous nerve, present in two patients, were due to the manipulation required on obtaining the graft and the anatomical variations at this level.

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