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Bone grafting in cementless total hip replacement for congenital dysplasia of the hip

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Abstract We reviewed 27 cementless primary total hip replacements in patients with osteoarthritis secondary to congenital dysplasia of the hip. Autogenous bone grafting was used as augmentation. On average the follow-up period was 9 years. Two hips were revised and three acetabular components were considered loose. In hips with loose cups the average graft coverage was significantly greater than in stable hips. The use of a cementless acetabular component is encouraging for reconstruction, although extensive grafting should be avoided. Our study suggests that cementless reconstruction in dysplastic hips yields a satisfactory outcome.

Résumé Nous avons examiné 27 arthroplasties sans ciment chez les patients avec arthrose secondaire à une dysplasie congénitale de la hanche. Une greffe d'os autogène a été utilisé comme augmentation. La période moyenne de suivi a été 9 années. 2 hanches ont été révisées et 3 composants acetabulaires ont été descellés. Dans la hanche ayant les composants descellés, la couverture moyenne de la greffe était significativement supérieure à celle des hanches stables. L'utilisation des composants acetabulaires sans ciment est encouragée pour la reconstruction, bien que la greffe massive doive être évitée. Notre étude suggère que l'arthroplastie sans ciment avec greffe autogène pour les hanches dysplasiques est associée à un résultat satisfaisant.

Introduction

Total hip replacement (THR) in dysplastic hips is technically demanding due to the distorted anatomy. In the case that the dysplastic hip cannot provide sufficient osseous support for the cup inserted in the original acetabulum a structural bone graft is often indicated. Structural bone grafting enables restoration of the anatomical hip center and provides additional bone stock for future revision. However, the procedure is associated with possible resorption and collapse of the graft over time, resulting in an increased rate of late failures [9, 12, 14].

The unsatisfactory long-term outcomes using a cemented acetabular component have increased the interest in the cementless technique. However, the long-term outcome of THR for the dysplastic hip by using cementless, porous-coated acetabular component and bone graft remains to be evaluated.

Patients and methods

From 1986 to 1994 a total of 31 primary cementless THR with structural autogenous bone grafts were performed in 26 patients at our institution. All 31 cases were diagnosed with osteoarthritis secondary to dysplasia and dislocation of the hip. Of the 26 patients, 4 (4 hips) had not been available for follow-up for at least 6 years and were excluded from the present study. The remaining 22 patients (27 hips) formed the basis of this clinical and radiographic study. One patient (1 hip) had died 4 years before the termination of the present study, with an available follow-up period of 7.0 years. This patient was included in the analysis although the data are limited to the last follow-up.

Porous-coated Dual Geometry acetabular cups (DG cups) were used in 26 hips and a peripheral self-locking cup (PSL) in 1 hip. All the polyethylene liners were articulated with 22.225 mm femoral heads. Omnifit femoral stems were used in 15 hips and Omniflex stems were used in the remaining 12 hips. All the prostheses used in the study were manufactured by Osteonics (Allendale, N.J., USA).

The study group included 20 females (24 hips) and 2 males (3 hips), with an average age of 54 (39–72) years and an average body weight of 52.7 kg (range 40–65 kg) at the time of operation. The average follow-up period was 9.0 ± 2.3 (5.5–12.3) years. Using the system of Crowe et al. [3], we classified 8 hips as grade I,

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10 hips as grade II, 3 hips as grade III and 6 totally dislocated hips as grade IV.

A posterolateral surgical approach was taken in 21 hips and a posterior approach in 6. A femoral head autograft was used for superior or superolateral structural support of the acetabular cup. In

8 hips, morselised graft was added for filling of the voids. Patients began partial weight-bearing at approximately 8 weeks postoperatively with full weight-bearing at approximately 12 weeks.

Patients were followed-up at 3 and 6 months postoperatively and then annually thereafter. Preoperative and postoperative Harris hip scores (HHS) were assessed and all radiographs were examined by two investigators (H.O. and X.D.). Any change in the position of the acetabular component from the horizontal or vertical reference line measuring 3 mm or more or a change in the cup angle of 3° or more was considered to be a sign of loosening. Subsidence of more than 5 mm or the appearance of a circumferential radiolucent line along the stem was considered to reflect a loose stem. Graft resorption was graded as mild (less than one third resorption), moderate (one third to one half) and severe (more than half). Graft incorporation was assessed by radiographic evidence of osseous bridging of the interface between the graft and the ilium.

Computer-assisted two-dimensional linear wear measurements on digitized antero-posterior (AP) radiographs were performed by

Fig. 1 **A** Radiograph immediately after surgery. **B** Radiograph 8.7 years postoperatively showing continuous radiolucency around the acetabular component, with a width exceeding 2 mm. Cup migration was more than 5 mm

Fig. 2 **A** Preoperative radiograph of the right hip. **B** Radiograph immediately after surgery. Structural autogenous bone was used superolaterally. **C** Radiograph 6.6 years postoperatively. Eccentric location of the femoral head, suggesting massive polyethylene wear of the liner. The total linear wear and tear rate was 3.42 mm and 0.52 mm per year, respectively

using Canvas 6.0 software (Deneba Systems, Miami, Fla., USA). Linear polyethylene wear was calculated as the migration of the femoral head center relative to the cup center. The vertical and horizontal displacements of the hip center were measured on the digitized radiographs. With the teardrop line as the horizontal line, vertical displacement represented the distance between the cup center and the teardrop line, while horizontal displacement represented the distance between the cup center and the vertical line through the teardrop.

All data are expressed as mean $\pm$ SD and were analyzed with SYSTAT 9 (SPSS Inc, Chicago, Ill., USA). Kaplan-Meier survival rate was calculated at 12 years. Student's *t*-test, chi-square test and regression analysis were used to determine the statistical significance. A *P*-value of 0.05 or less was considered to be statistically significant.

Results

At the most recent follow-up examination, the average HHS was 86 points (range 34–99 points), which was significantly higher than the preoperative score (56 points, range 29–75 points, $P<0.01$). However, two patients showed deterioration in hip scores. One patient had a loose cup (Fig. 1) and the other a loose stem. The average cup abduction angle immediately following surgery was 52.1° and at the latest follow-up was 52.7°.

In 2 hips the cups alone were found to be definitely loose, the stems alone were definitely loose in 2 hips, and in 1 hip both components were loose. The 3 loose cups migrated over an average period of 39.8 months after the operation (range 19–61 months). At the most recent follow-up excessive polyethylene wear and trochanteric osteolysis were noted in one of these patients (Fig. 2).

Two surgical revisions have already been performed. One hip with a loose stem and acetabular osteolysis underwent both femoral and acetabular revision. The other revision was due to non-union of the greater trochanter. In this re-operation the polyethylene liner and the femo-

ral head were exchanged. Neither of the two cases was related to acetabular graft failure.

The combination of graft and host bone provided a complete support for the prosthesis on the AP view. In all hips the average graft coverage of the cup was 56% as seen on the AP views. In the 20 stable hips the coverage was 53%, the coverage in 6 hips (grade IV) with total dislocation was 57%. However, the average coverage in the 3 loose cups was 76%, in addition, the graft coverage in all 5 hips with loose components was 73%, both figures were significantly higher than those of the stable cups ($P<0.05$). With the chi-square test we found that prosthetic loosening was associated with a graft coverage area of greater than 50% ($P<0.05$).

All grafts showed signs of trabecular bridging and remodeling, and there was no case of graft collapse. Acetabular osteolysis was noted in 6 hips (6 patients). The average vertical displacement of the hip center was 20 mm and the average horizontal displacement of the hip center was 33.2 mm. Of the 3 loose cups, the horizontal displacement of the hip center was 45 mm in one cup; vertical displacement was 35 mm and 37 mm in 2 cups, respectively. We found no statistically significant relationship between the displacement of the hip center and the clinical complications.

Failure was defined as definite loosening and surgical revision for any reason. The final survivorship showed that the overall success rate for the entire study group was 73.5% at 12 years, and the cumulative survival rate was 80% and 84% for the femoral and the acetabular components, respectively (Fig. 3).

Discussion

Various techniques have been reported for acetabular reconstruction in the dysplastic hip. Previous reports have documented a high rate of cup loosening in long-term studies of THA with cemented acetabular component and bone grafting [9, 12, 14]. In contrast, cementless porous-coated acetabular components performed better. Tanzer et al. [15] reported a 3.5-year follow-up study of 140 consecutive acetabular revisions with cementless components. In 127 hips with bone grafting, only two cups were loose. They emphasized that porous-coated acetabular components provided a superior fixation compared to the cemented ones.

Femoral head bone grafting and porous-coated acetabular components used for dysplastic hips have also produced satisfactory short-term results. For example, Siber et al. [13] found that at an average of 3 years postoperatively, all porous-coated acetabular components maintained stability and acetabular graft healing was presumed in 18 of 19 cases. Hasegawa et al. [6] reported that autogenous acetabular bone grafts were fully incorporated and remodeled 18 months after surgery. Other authors have reported similar favorable short-term outcomes [1, 2].

As for the long-term follow-up with bone grafting, Morsi et al. [8] examined a series of 17 cementless and

Fig. 3 Kaplan-Meier survivorship curves for overall cumulative rates of success (solid line) and for acetabular components (dashed line), femoral components (dotted line), respectively. Failure was defined as definite loosening of the component and revision for any reason

13 cemented acetabular components. They showed 10% revision rate and no loose cups, suggesting that both types did equally well with regard to integrity and union of the graft at 8.1 years postoperatively.

In the present series with an average follow-up of 9 years, 3 cups (11%) were loose and 2 hips (7%) were revised. The loosening rate was lower compared to those of cemented THA with similar follow-up periods: 20% for Gerber et al. [4], 16% for Numair et al. [10] and 21% for Yoder et al. [16]. McQueary et al. [7] by using small acetabular components and methyl methacrylate in 63 dysplastic hips reported 10% cup loosening after 8.5 years.

During surgical operations we managed to locate the cup close to the original acetabulum. However, the positioning of the hip center is controversial, with location of the cup in the so-called high hip center recently becoming preferable. This procedure is supposed to be relatively simpler since less or no bone graft is needed. It is not a biomechanical disadvantage if the rotating center is placed high, but not lateral [5]. However, Stans et al. [14] reported significantly higher loosening rates of cups located outside the true acetabular region in comparison with those within this region. Furthermore, Pagnano et al. [11] suggested that superior positioning of the acetabular component even without lateral displacement led to increased rates of loosening of the femoral and acetabular components. Likewise, Yoder et al. [16] demonstrated higher rates of femoral loosening with acetabular components placed in a superior and lateral (i.e. non-anatomic) position. Of our 3 hips with loose cups, 2 were vertically displaced, and one was laterally displaced.

Mulroy et al. [9] reported that graft coverage of the acetabular component correlated with late loosening of the component. When the graft provided 40% of the total support of the component the failure rate was 67%. In contrast, when the grafts covered less than 40% of the components, the failure rate was 21%. Similarly, we found that prosthetic loosening was associated with graft coverage of more than 50%.

There was no relationship between the patient's age and acetabular loosening in the present study. However, compared to the normal population undergoing THR, the relatively young age of our patients partly explained the potentially higher risk of acetabular loosening. Information derived from plain radiographs alone is limited. At present, we use standard or three-dimensional computerized tomography for preoperative planning. This has enhanced our understanding of the deformed anatomy of the acetabulum and aided in determining the position of where the acetabular component should receive maximum bony support. When using cementless components it is essential to maximize the contact between the host bone and the porous surface to allow bony ingrowth. In some cases, this requires placing the cup higher than the anatomic center. Therefore, at present we prefer to place the cup without bone grafting at a higher position if suf-

ficient host bone is not available in the true acetabulum. Despite high acetabular coverage by bone grafts our study suggested that for dysplastic hips cementless THR was satisfactory at a 9-year follow-up period.

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