Position of the acetabular component determines the fate of femoral head autografts in total hip replacement for acetabular dysplasia


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We have reviewed 54 patients who had undergone 61 total hip replacements using bulk femoral autografts to augment a congenitally dysplastic acetabulum. There were 52 women and two men with a mean age of 42.4 years (29 to 76) at the time of the index operation. A variety of different prostheses was used: 28 (45.9%) were cemented and 33 (54.1%) uncemented. The graft technique remained unchanged throughout the series.

Follow-up was at a mean of 8.3 years (3 to 20). The Hospital for Special Surgery hip score improved from a mean of 10.7 (4 to 18) pre-operatively to a mean of 35 (28 to 38) at follow-up.

The position of the acetabular component was anatomical in 37 hips (60.7%), displaced less than 1 cm in 20 (32.7%) and displaced more than 1 cm in four (6.6%). Its cover was between 50% and 75% in 34 hips (55.7%) and less than 50% in 25 (41%). In two cases (3.3%), it was more than 75%.

There was no graft resorption in 36 hips (59%), mild resorption in 21 (34%) and severe resorption in four (6%).

Six hips (9.8%) were revised for aseptic loosening. The overall rate of loosening and revision was 14.8%. Overall survival at 8.3 years was 93.4%.

The only significant factor which predicted failure was the implantation of the acetabular component more than 1 cm from the anatomical centre of rotation of the hip.

Severe deficiency of the acetabulum resulting from developmental dysplasia of the hip (DDH) is difficult to reconstruct. Charnley and Feagin\(^1\) in 1993 stated that “total hip arthroplasty should be avoided in patients who have total congenital dislocation of the hip joint.” Various techniques have subsequently been developed to address this problem, but which one is best remains a matter of controversy.\(^2\)\(^-\)\(^8\)

Most authors agree that Crowe type II and III hips have a marked superolateral rim deficiency and a predictable anterior wall defect.\(^2\)\(^,\)\(^6\)\(^,\)\(^8\)\(^,\)\(^9\) Bulk autografting of the superolateral acetabulum with bone from the femoral head can be used to increase both the cover and the stability of the acetabular component. Autograft is biologically preferable to allograft. Careful preparation of the graft and its bed, stable fixation, and precise positioning, are essential technical factors.\(^8\)\(^,\)\(^10\)\(^,\)\(^11\)

The purpose of this study was to review the results of acetabular reconstruction in patients with congenital dislocation of the hip using bulk femoral head autograft, and to identify the factors that result in the best clinical outcome and survival. Although the prostheses have evolved over the years, the technique of grafting remains unchanged.

Patients and Methods

We reviewed 107 consecutive patients who had undergone a total of 133 primary total hip replacements (THRs) for severe osteoarthritis (OA) secondary to DDH between 1983 and 2002. We identified 61 hips in 54 patients in which the acetabular component had been supported by a femoral head autograft. There were 52 women and two men with a mean age of 42.4 years (29 to 76) at the time of the operation. There were 28 cemented (45.9%) and 33 non-cemented (54.1%) acetabular components in this group.

Each patient was operated on through a posterolateral approach, having had a percutaneous adductor tenotomy in the supine position. After exposing the acetabulum, a complete capsulectomy was carried out to display the dysplastic acetabulum. All soft tissue in the acetabulum was resected in order to define the medial wall. The ischial tuberosity and the obturator foramen were used as landmarks to
determine the true centre of the acetabulum. Acetabular reaming was deepened until the medial wall was exposed.

The initial decision to use graft was based on pre-operative templating, but the final decision was not made until the acetabulum had been exposed and reamed. The dimensions of the acetabulum were dictated by the final reamer which gave optimum anterior and posterior contact. The trial acetabular component was used to measure the percentage cover. If this was less than 70%, a bulk femoral head autograft was used.

The graft from the resected femoral head was prepared using powered instruments. We reamed off the articular cartilage but left the subchondral bone and the remaining cortex to allow adequate fixation. This was not always straightforward because of the presence of degenerative cysts. The femoral head was routinely cut in an L-shape. Then it was turned upside down and placed into the defect with the long side of the L superior to the acetabular rim. The graft was provisionally fixed with two 3.2 mm drill bits and then definitively with two tapped 6.5 mm cancellous screws. We did not use washers because the hard cortical bone allowed adequate compression.

Patients were evaluated using the Hospital for Special Surgery (HSS) hip scoring system. This was calculated pre-operatively retrospectively, and at the last follow-up visit. Pain, mobility, movement and function were assigned scores ranging between zero and ten points, up to a maximum of 40 points, then classified as excellent (> 31 points), good (22 to 31 points), fair (16 to 21 points), or poor (≤ 15 points). A minimum follow-up time of three years was chosen and the mean follow-up was 8.3 years (3 to 20). Each patient was contacted and examined by the surgeons (BA, AMT) who had been involved in their operation or care.

At follow-up, the pre-operative, immediate post-operative and most recent radiographs were assessed first for the Crowe grading of degree of subluxation/dislocation, second for whether the cup was fixed with or without cement, and then for the position of the acetabular component.

The Ranawat triangle (Fig. 1) was measured on post-operative radiographs to identify the correct position of the anatomical hip centre. Two parallel lines were drawn across the iliac crests and the ischial tuberosities, and a perpendicular dropped between them at a point 5 mm lateral to the intersection of Kohler’s and Shenton’s lines. The length of this line gave the height of the pelvis. The height of the acetabulum was equal to one-fifth of the height of the pelvis. The width of the acetabulum was equal to its height and its rim was represented by the hypotenuse of the triangle. The position of the acetabulum was considered to be anatomical if the centre of the prosthetic joint was at the midpoint of the hypotenuse.

The proportion of the acetabular component covered by the original acetabulum and the inclination of the acetabular component were measured on the immediate post-operative radiograph (Fig. 2). The cup and head diameter were measured and the fixation of the acetabular component was assessed. Signs of graft resorption, migration, loosening, or revision of the cup were sought from the final follow-up radiograph. The fixation of the cup was considered to have failed if the implant had migrated more than 2 mm or if there was a progressive continuous radiolucent line around a cemented component.

Survival of the acetabular component was assessed using the Kaplan-Meier method and the data were analysed for statistical significance using Pearson’s chi-squared test.

Results
Of the 61 hips, according to the Crowe classification, seven (11.5%) could be classified into group 1 pre-operatively, 27 (44.3%) into group 2, 23 (37.7%) into group 3, and four (6.6%) into group 4.

The mean pre-operative HSS functional hip score was 10.7 (4 to 18). This improved to a mean of 35 (28 to 38) at
follow-up. There was a marked increase in functional scores when the components were stable.

The position of the acetabular component was thought to be anatomical in 37 hips (60.7%), superolateral displacement of less than 1 cm was seen in 20 hips (32.7%), and displacement of more than 1 cm was seen in four (6.6%).

Acetabular component cover by original acetabular bone was evaluated by measuring the zones on the anteroposterior (AP) pelvic view (Fig. 2). The percentage in direct contact with original bone was between 50% and 75% in 34 hips (55.7%) and less than 50% in 25 hips (41%). There were only two hips (3.3%) in which more than 75% of the acetabular component was originally covered.

Acetabular component orientation was grouped as normal and high inclination subtypes. Components placed in abduction of more than 60˚ were regarded as outliers and included in the high inclination group. There was only one patient with high inclination of the acetabular cup. Resorption of the graft was evaluated by comparing the area occupied by the graft at follow-up with that on the postoperative radiograph. Graft consolidation was observed without any detectable resorption in 36 hips (59%). Graft consolidation is defined as trabecular continuity between graft and the host bone observed on plain radiographs. Resorption was mild (< 50%) in 21 of the hips (34.4%), and severe resorption was observed (> 50%) in four (6.6%).

Six cups were revised because of aseptic loosening (9.8%) as also were three acetabular components which had migrated by more than 2 mm. The overall combined rate of revision and aseptic loosening was 14.8% (nine hips). Kaplan-Meier survival analysis showed a 93.4% survival at 8.3 years with revision as the end-point. When revision for aseptic loosening was taken as an end-point then Kaplan-Meier survival analysis revealed an 87.3% survival at ten years. Pearson’s chi-squared test was used to estimate the effect of the factors leading to failure of the acetabular component. No significant difference was found between the cemented and the cementless group (Pearson’s chi-squared test, p = 0.186). The amount of cover of the acetabular component by native bone also had no significant effect on the rate of loosening (Pearson’s chi-squared test, p = 0.730). The only significant factor affecting acetabular survival was its position; all four patients with joint centre displacement of more than 1 cm in Ranawat’s triangle were revised (Pearson’s chi-squared test, p = 0.01). Univariate statistics indicated that the position of the acetabular component and the technique of cup fixation (cemented or uncemented) were the only factors with a significant effect on survival. These are the variables included in the Cox regression analysis for multivariate analysis. The position of the acetabular component had a significant effect on survival unrelated to the fixation type (whether cemented or uncemented). The revision risk was 6.44 (95% confidence interval (CI) 1.12 to 36.74) times higher in the components displaced more than 1 cm (p = 0.0036).

There were two post-operative superficial wound infections and two dislocations which were managed by closed reduction.

Discussion

In Crowe type II and III hips, proximal migration of the femoral head is accompanied by anterolateral acetabular bone deficiency. If, when replacing the hip, the acetabular component is sited in the correct anatomical position, a part of it may be left uncovered and therefore unsupported.8,10,11,15,16 Under these circumstances an alternative technique or an additional procedure should be considered to achieve primary stability. Of the suggested techniques, high hip replacement and cement augmentation have given indifferent results.4 Cotyloplasty gave very promising results in the short term, but the intentional violation of the medial acetabular wall increased the intra- and post-operative morbidity and may well compromise revision.5,7

The use of femoral head autograft has been reported with mixed results.16-23 According to Gerber and Harris8 and Mulroy and Harris10 autogenous grafting in DDH is effective up to seven years, but deterioration often occurs resulting from graft collapse. In these series, the acetabular
rate of failure was 21% after seven years and 46% after 12. Although all the grafts were said to have united initially, they were subsequently resorbed by late revascularisation and creeping substitution.

If an autograft is to survive for more than four years, it must be well consolidated and revascularised. Once consolidated, it behaves like host bone and further resorption is unlikely. We believe that the late failures in our series were a consequence of polyethylene debris-related aseptic loosening of the acetabular component rather than to graft resorption.

The extent to which the acetabular component needs to be covered by autograft has previously been thought to be significant. Many authors have proposed that if this exceeds 50% the rate of failure will be higher. However, we had 25 patients (41%) in whom the host bone contact was less than 50%, and there was no greater rate of failure in the group.

Some authors have reported a preference for cementless acetabular components. Our series showed no significant difference between cementless or cemented components, provided the component is placed at the anatomical centre of rotation.

High inclination of the acetabular component is well-known to increase polyethylene wear and early loosening. It is a frequent radiological finding after reconstruction of the dysplastic acetabulum when graft augmentation has not been performed; the increased inclination helps to obtain better cover of the component under the dysplastic superior rim. In this study it only occurred once.

Acetabular augmentation with a bulk femoral autograft has considerable advantages over other techniques. Autograft bone is available from the patient’s own femoral head and increases the bone stock for future operations. Restoration of the anatomical hip centre reduces the joint reaction force. The main disadvantages are the technical difficulty of the procedure and occasional graft resorption.

Johnston, Brand and Crowninshield found that the load on the hip was significantly reduced by placing the acetabular component as far medially, inferiorly and anteriorly as possible. This reduced the muscle effort, joint contact force and the moment at the junction of the neck and of the femoral component, and at the same time substantially restored limb length.

Anatomical placement of the acetabular component in patients with a high DDH is also supported by clinical studies in the literature. Linde, Jensen and Pilgaard reported a higher rate of mechanical loosening when the acetabular component was placed above the roof of the true acetabulum. They found that 42% of cemented Charnley components were loose after a mean of nine years if the component had been positioned outside the true acetabulum, but only 13% if it had been placed inside. Stans et al reported an 83.3% failure rate when the acetabular component was positioned outside the true acetabulum.

Pagnano et al proposed that placing the acetabular component superiorly, with or without lateral displacement, increases the rate of loosening in patients with Crowe type II congenital displacement of the hip. By contrast, Mackenzie, Kelley and Johnston could find no correlation
between superior or lateral placement of the component and the rate of loosening. In our series, the rate of loosening was higher in those patients whose hip rotation centre was displaced superolaterally by more than 1 cm and we therefore agree that improper placement of the acetabular component results in aseptic loosening (Fig. 3).

In conclusion, reconstruction of the dysplastic acetabulum with bulk femoral head autograft was successful in 93.4% of cases after a mean 8.3 years. Superolateral placement of the cup dramatically alters the biomechanics of the hip and adversely affects graft healing and survival. No benefits in any form have been received or will be received from a commercial party relating directly or indirectly to the subject of this article.

References