Evaluation of two surgical techniques for acetabular reconstruction in total hip replacement for congenital hip disease

RESULTS AFTER A MINIMUM TEN-YEAR FOLLOW-UP

We have evaluated the results of total hip replacement in patients with congenital hip disease using 46 cemented all-polyethylene Charnley acetabular components implanted with the cotyloplasty technique in 34 patients (group A), and compared them with 47 metal-backed cementless acetabular components implanted without bone grafting in 33 patients (group B). Patients in group A were treated between 1988 and 1993 and those in group B between 1990 and 1995. The mean follow-up for group A was 16.6 years (12 to 18) and the mean follow-up for group B was 13.4 years (10 to 16).

Revision for aseptic loosening was undertaken in 15 hips (32.6%) in group A and in four hips (8.5%) in group B. When liner exchange was included, a total of 13 hips were revised in group B (27.7%). The mean polyethylene wear was 0.11 mm/yr (0.002 to 0.43) and 0.107 mm/yr (0 to 0.62) for groups A and B, respectively. Polyethylene wear in group A was associated with linear osteolysis, and in group B with expansile osteolysis.

In patients with congenital hip disease, when 80% cover of the implant can be obtained, a cementless acetabular component appears to be acceptable and provides durable fixation. However, because of the type of osteolysis arising with these devices, early exchange of a worn liner is recommended before extensive bone loss makes revision surgery more complicated.

Reconstruction of the acetabulum during total hip replacement (THR) in congenital hip disease may be problematic. The difficulties encountered at operation may vary depending on the local anatomical abnormalities present in the three types of congenital hip disease, i.e., dysplasia, low dislocation and high dislocation, and are reflected in the results of surgery.

Several techniques have been described to overcome the problems of acetabular deficiency at THR when cover of the acetabular component with host bone is not complete. Those most commonly used are augmentation of the superolateral aspect of the acetabular rim with a bulk bone graft, placement of the acetabular component to create a high hip centre, medialisation of the hip centre by employing the cotyloplasty technique, and the use of hemispherical, small-diameter, metal-backed cementless components with or without bone grafting.

The purpose of this study was to evaluate the results after a minimum of ten years follow-up (10 to 18) of two surgical techniques. Firstly, the cotyloplasty technique, which involves medialisation of the acetabular floor by creating a controlled comminuted fracture of the entire medial wall, impaction of autogenous morcellised bone graft, and implantation of a small all-polyethylene acetabular component of the Charnley series with cement (Fig. 1a), or secondly the use of a hemispherical cementless, small-diameter, modular metal-backed acetabular component without bone grafting (Fig. 1b). The latter procedure has been undertaken since 1990, when metal-backed prostheses were introduced into our hospital, provided at least 80% cover of the implant with host bone could be obtained in the true acetabulum.

Patients and Methods
In 99 consecutive THRs in 73 patients with congenital hip disease, the acetabulum was replaced either by a moulded all-polyethylene Charnley component (DePuy, Leeds, United Kingdom) fixed with cement (Simplex P; Howmedica, Rutherford, New Jersey) after cotyloplasty (49 hips in 37 patients, group A) during the period 1988 to 1993, or by a modular hemispherical, metal-backed non-cemented porous-coated titanium component, without bone grafting (50 hips in 36 patients, group B)
The diameter of the femoral head was 22.25 mm. In group B, a cemented monoblock Charnley prosthesis was used for 30 hips and the Harris CDH modular prosthesis for 16 hips. In all cases the cemented acetabular component by host bone cannot be obtained, a) the cotyloplasty technique, and b) the use of a cementless, modular metal-backed acetabular component, without bone grafting.

Diagrams of the two surgical techniques used to reconstruct the acetabulum in congenital hip disease, when complete coverage of the acetabular component by host bone cannot be obtained, a) the cotyloplasty technique, and b) the use of a cementless, modular metal-backed acetabular component, without bone grafting.

between 1990 and 1995. Two patients (two hips) from group A and one patient (one hip) from group B were excluded from the study because they did not attend for follow-up, as well as one patient (one hip) from group A and two patients (two hips) from group B because of infection. Thus, in the final evaluation there were 33 patients (46 hips) in group A and 34 patients (47 hips) in group B. The age of the patient, their gender, weight, height and the pre-operative diagnoses are listed in Table II. Two patients (two hips) from group A and three patients (four hips) from group B died at five (three patients) and eight (two patients) years after operation, at which stage they were all asymptomatic.

The patients included in the study represent a consecutive non-selected group operated on by the senior author on the latest radiograph by the presence of radiolucent lines and expansile osteolytic lesions, which were recorded.

Two surgical techniques for acetabular reconstruction in total hip replacement for congenital hip disease

Table I. Classification system of congenital hip disease in adults according to Hartofilakidis et al1,5,6

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Pathoanatomy of the acetabulum (verified during surgery)</th>
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<tbody>
<tr>
<td>Dysplastic hip</td>
<td>The femoral head is contained within the original acetabulum despite the degree of subluxation</td>
<td>Segmental deficiency of the superior wall. Secondary shallowness due to fossa-covering osteophyte</td>
</tr>
<tr>
<td>Low dislocation</td>
<td>The femoral head articulates with a false acetabulum that partially covers the true acetabulum</td>
<td>Complete absence of the superior wall. Anterior and posterior segmental deficiency. Narrow opening and inadequate depth (true acetabulum)</td>
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<tr>
<td>High dislocation</td>
<td>The femoral head is completely out of the true acetabulum and has migrated superiorly and posteriorly</td>
<td>Segmental deficiency of the entire acetabular rim Narrow opening Inadequate depth Abnormal distribution of bone stock, mainly located superoposteriorly (true acetabulum)</td>
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The patients were examined at three, six and 12 months post-operatively, and once-yearly thereafter. Clinical evaluation was performed using the Merle d’Aubigné and Postel scale as modified by Charnley. Radiologically, the hips were assessed with anteroposterior pelvic radiographs taken soon after operation and those obtained at the latest follow-up examination. Three parameters were evaluated: linear wear, peri-acetabular osteolysis and acetabular loosening. Polyethylene wear was determined as described by Livermore, Ilstrup and Morrey. To measure the linear polyethylene wear in the offset-bone cemented acetabular components, because of the asymmetry of the polyethylene and the unknown direction of the linear penetration in any particular case, we used the methods of Charnley and Halley and Wroblewski.

Osteolysis was assessed around the acetabular component on the latest radiograph by the presence of radiolucent lines and expansile osteolytic lesions, which were recorded.
according to the three zones described by DeLee and Charnley. Linear osteolysis was defined as the presence of a radiolucent space at the cement-bone or implant-bone interface of at least 1 mm. Expansile focal osteolysis was defined as a sharply-demarcated radiolucent space with a rounded or scalloped appearance extending away from the component. The approximate size of these lesions was measured with calipers in terms of their longest diameter and the widest diameter perpendicular to the defined longest axis. Magnification was corrected with the use of the known diameter of the femoral head.

Acetabular components were classified as loose when migration was > 2 mm in a vertical or horizontal direction, or there was a continuous radiolucent line > 1 mm wide at the cement-bone or the implant-bone interface.

Statistical analyses were performed with the Mann-Whitney U test for continuous variables and the chi-squared test with Yates’ correction for categorical variables. The level of statistical significance was set at p < 0.05. Survival analysis, to assess the life-span of the acetabular component in the two surgical techniques, was performed using the Kaplan-Meier method with the endpoint as revision of the acetabular component due to aseptic loosening. A separate survival analysis and those with high dislocation, from both groups combined, was 11% (2 of 18), 34.5% (10 of 29) and 34.8% (16 of 46), respectively.

The overall mean annual rate of wear of the acetabular components in group A was 0.11 mm/year (0.002 to 0.43), and in group B was 0.107 mm/year (0 to 0.62) (Mann-Whitney U test, p = 0.6). The mean annual rate of wear of the 15 acetabular components revised for aseptic loosening in group A was 0.17 mm/year (0.044 to 0.43), that of the four cases in group B was 0.31 mm/year (0.012 to 0.62) (Mann-Whitney U test, p = 0.4). In the nine exchanged liners in group B the mean annual rate was 0.13 mm/year (0.036 to 0.204).

Peri-acetabular osteolysis was observed in 16 hips (34.8%) in group A, and in seven hips (14.9%) in group B (chi-squared test, p = 0.026). The lytic lesions associated with the cemented acetabular components were linear in all cases, and in the 15 hips that required revision for loosening in group A, they were observed in all three zones. In one of these hips there was also an expansile lytic lesion in zone I. The lytic lesions associated with the cementless acetabular components were localised and expansile in all cases. A total of 11 lytic lesions were observed in relation to seven cementless acetabular components. The lesions varied in size from 3 mm × 5 mm to 18 mm × 24 mm; four were located in zone I, four in zone II, and three in zone III.

Survival analysis. With revision of the acetabular component for aseptic loosening as the endpoint, the cumulative success rate of the components used after cotyloplasty was 95.4% (95% CI 89.2 to 100) at ten years when 42 hips were at risk and 81.5% (95% CI 73.4 to 89.6) at 14 years.

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**Table II. The demographic details of both groups**

<table>
<thead>
<tr>
<th>Group</th>
<th>Number of patients (hips)</th>
<th>Mean age in yrs (range)</th>
<th>Gender (M:F)</th>
<th>Mean weight in kg (range)</th>
<th>Mean height in cm (range)</th>
<th>Mean follow-up in yrs (range)</th>
<th>Diagnosis</th>
</tr>
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<tbody>
<tr>
<td>A</td>
<td>34 (46)</td>
<td>50 (25 to 69)</td>
<td>1:33</td>
<td>66.83 (48 to 89)</td>
<td>156 (143 to 176)</td>
<td>16.6 (12 to 18)</td>
<td>Dysplasia</td>
</tr>
<tr>
<td>B</td>
<td>33 (47)</td>
<td>47 (27 to 70)</td>
<td>2:31</td>
<td>62.21 (47 to 84)</td>
<td>156 (140 to 167)</td>
<td>13.4 (10 to 16)</td>
<td></td>
</tr>
</tbody>
</table>
* LD, low dislocation; HD, high dislocation
when 38.5 hips were at risk. That of the cementless metal-backed components was 97.7% (95% CI 93.3 to 100) at ten years when 42.5 hips were at risk and 90.3% (95% CI 83.9 to 96.7) at 14 years when 24.5 hips were at risk (log-rank test, p = 0.29) (Fig. 2). When liner exchange was included in the number of failures of the latter group, the cumulative success rate at ten years dropped to 90.8% (95% CI 84.3 to 97.3) when 41 hips were at risk and at 14 years dropped to 69.5% (95% CI 55.8 to 83.2) when 24 hips were at risk (log-rank test, p = 0.19) (Fig. 3).

The follow-up examination of the 22 patients (29 hips) of group A who retained the original acetabular component was undertaken at a mean of 16.6 years (13 to 18) post-operatively and of the 28 patients (38 hips) from group B who retained the original acetabular component at a mean of 13.4 (12 to 16) (Figs 4 and 5).

For patients who retained the original component, the score for pain, on the modified Merle d’Aubigné and Postel scale improved from a mean of 2.6 points (1 to 4) preoperatively to a mean of 5.1 points (5 or 6) post-operatively for patients in group A, and in patients from group B from a mean of 2.8 points (2 to 4) to a mean of 5.5 points (5 or 6) for patients in group B. Similarly, the score for function improved in group A from a mean of 2.3 points (1 to 3) to a mean of five points (4 to 6), and in group B from a mean of 2.6 points (3 to 6) to a mean of 5.4 points (3 to 6). Finally, the score for movement in group A improved from a mean of three points (1 to 5) to a mean of 4.5 points (2 to 6), and in group B from a mean of 2.6 points (1 to 5) to a mean of 4.8 points (3 to 5).

**Discussion**

The major technical problem during total hip replacement in patients with congenital hip disease, especially in cases with low and high dislocation, is the reconstruction of the acetabulum, given that the placement of the component at the level of the true acetabulum remains ideal for mechanical reasons.1,15,16 However, cover of the acetabular component with host bone and sufficient fixation at the level of the true acetabulum is not always possible. The use of a bulk structural autologous graft from the femoral head to augment the superolateral aspect of the acetabular rim was initially proposed by Harris et al.2 Although the short-term clinical results of this technique were excellent, the failure rate after approximately 12 years was high (46%).17,18 This may be related to the complex pathoanatomy encountered at the level of the true acetabulum, and the abnormal distribution of stresses combined with the unfavourable long-term biological behaviour of structural grafts.5,19 A few authors supported proximal placement of the acetabular component,3,4 yet at a proximal level the lever arm for body weight is much longer than that of the abductors, resulting in excessive loading of the hip joint. In addition, at this level shearing forces acting on the acetabular component may lead to early loosening,6 and in unilateral cases a proximally-sited acetabular component perpetuates limping and limb-length discrepancy.1

Until 1990, in all THR’s performed by us for congenital hip disease, and when complete cover of the acetabular component with host bone could not be obtained, a cotyloplasty was used. Since 1990, when metal-backed prostheses became available, cementless hemispherical modular metal-backed prostheses have been used without augmentation of the superolateral rim of the acetabulum, provided at least 80% cover of the implant with bone could be obtained.1,5,6

The limitations of this study are its retrospective nature, the use for technical reasons of two methods to measure polyethylene wear, the use of femoral heads with different diameters in a number of group B patients, and the longer follow-up for the cotyloplasty group (12 to 18 years) com-
pared with that for the cementless group (10 to 16 years). It is noteworthy that the cementless components were used in less severe cases as 80% cover had to be available. Nevertheless, all the operations were performed by the same surgeon in two demographically-comparable groups of patients, with a minimum ten-year follow-up. There have been a few studies examining the outcome of the acetabular component in THR for congenital hip disease, in relation to the type of the deformity, but to our knowledge no evaluation of different surgical techniques has been reported.

The present study shows a significant statistical difference in the aseptic loosening of the acetabular component between the two methods. There are several reasons for...
this. Cotyloplasty was used in more deficient hips. By definition, this technique results in weaker bone for fixation and the offset-bone component was required in the majority of those cases. Chougle et al.\textsuperscript{26} also noticed a higher rate of loosening with the use of offset acetabular components in similar circumstances to our own. The offset component, despite providing almost 10 mm thickness of polyethylene in its upper weight-bearing part, revealed a higher rate of loosening, probably because of impingement of the neck of the stem against the rim of the component, as wear of the polyethylene increased.\textsuperscript{26}

The revision rate for the cementless group was increased when liner exchange due to wear and peri-acetabular osteolysis was included. The excellent fixation achieved with cementless components used in the 1990s, but with an increased revision rate due to problems with the liner and osteolysis, has been described in the Swedish hip register.\textsuperscript{29}

It has been suggested that modular cementless acetabular components contribute to the increased wear that is a leading cause of aseptic loosening.\textsuperscript{30-33} In our study, the mean linear rate of wear of the polyethylene in cemented non-modular and cementless modular acetabular components was not statistically significantly different. Although modularity does not seem in itself to increase linear wear notably or the amount of debris generated, it may provide, through backside wear, new pathways of access for particulate debris to reach the host bone.\textsuperscript{24}

The effect of modularity of the femoral component on the outcome of the acetabular component has also been a matter of concern. It has been suggested that such designs could increase polyethylene wear through fretting, corrosion and third-body wear.\textsuperscript{35} In our study, the mean rate of wear of the polyethylene in both cemented and cementless acetabular components articulating with modular and monoblock femoral components was not statistically significantly different (p = 0.41).

It has been reported that a polyethylene thickness of 5 mm or less in metal-backed components could lead to unsatisfactory results.\textsuperscript{36,37} However, in our study we found no correlation between the thickness of the polyethylene and the failure rate of the cementless acetabular components.

The association between wear rate and osteolysis in THR has been well documented by Dumbleton, Manley and Edin.\textsuperscript{38} These authors concluded that osteolysis is observed rarely at a mean annual rate of wear < 0.1 mm/year. In our study, the mean annual wear in both cemented and cementless acetabular components presenting with osteolysis was > 0.15 mm/year. Patterns of osteolysis differ in association with cemented and cementless acetabular components.\textsuperscript{12,39} In our series, as in those previously mentioned,\textsuperscript{12,39} linear osteolysis was present mainly in association with cemented acetabular components, and expansile osteolysis in association with cementless components.

In our patients the overall survival of the shell/liner of the cementless components was less than that of the cemented components. However, the use of cementless metal-backed components, without augmentation of the superolateral aspect of the acetabular rim, is preferred when at least 80% cover of the implant with host bone can be obtained, because it provides a secure and lasting fixation. In the event of failure of the liner in the presence of a well-fixed metal shell, it is possible to undertake early intervention with exchange of the worn liner prior to the development of extensive osteolysis. The introduction of improved designs with a more stable locking mechanism, the use of the cross-linked polyethylene and the potential to use hard-on-hard bearings may lead to longer survival of the cementless components used for reconstruction of the acetabulum. Cotyloplasty remains a reliable alternative in selected cases.\textsuperscript{1,3}

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No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

References


