Revision of metal-on-metal resurfacing arthroplasty of the hip

THE INFLUENCE OF MALPOSITIONING OF THE COMPONENTS

R. De Haan, P. A. Campbell, E. P. Su, K. A. De Smet
From the University Hospital, Brussels, Belgium

We have reviewed 42 patients who had revision of metal-on-metal resurfacing procedures, mostly because of problems with the acetabular component. The revisions were carried out a mean of 26.2 months (1 to 76) after the initial operation and most of the patients (30) were female.

Malpositioning of the acetabular component resulted in 27 revisions, mostly because of excessive abduction (mean 69.9°; 56° to 98°) or insufficient or excessive anteversion. Seven patients had more than one reason for revision. The mean increase in the diameter of the component was 1.8 mm (0 to 4) when exchange was needed.

Malpositioning of the components was associated with metallosis and a high level of serum ions. The results of revision of the femoral component to a component with a modular head were excellent, but four patients had dislocation after revision and four required a further revision.

Resurfacing arthroplasty of the hip is being performed more often with encouraging results. Most of the patients are young and active males. The advantages of hip resurfacing include the resection of less bone, a reduced risk of dislocation because of the larger resurfacing head and easier conversion to a secondary procedure if failure occurs. Inevitably, the number of revisions for failed resurfacings will increase. The reasons for failure include fracture of the femoral neck, loosening of the femoral component, osteonecrosis of the head of the femur and malpositioning of the components. Campbell et al. described the mechanisms for failure of resurfacing and found that the femoral component was involved most often. Ball, Le Duff and Amstutz also recently described the revision of 21 hip resurfacing arthroplasties because of failed femoral components.

The importance of the optimal placement of the components has been highlighted previously. Malpositioning will produce a relatively high risk of impingement and edge loading. In metal-on-polyethylene total hip replacement (THR), a malpositioned acetabular component is associated with a high wear rate of polyethylene, but in metal-on-metal procedures impingement may also result in a high level of wear with a subsequent increase in the serum levels of metal ions. The unknown long-term consequences of the products of metal wear are a concern.

Our study addresses the reasons for revision and evaluates the options and results in a predominantly female group of patients with a failed resurfacing arthroplasty of the hip which had been performed at a specialist centre.

Patients and Methods
Between February 2001 and February 2007 the senior surgeon (KADS) undertook 42 revisions of failed metal-on-metal hip resurfacing arthroplasties. Of the primary procedures, 30 had been performed elsewhere and he had carried out the remaining 12. The initial operations were performed between June 1996 and February 2006. The original diagnosis was osteoarthritis in 32 patients, congenital dysplasia in five and osteonecrosis in five.

Assessment of patients with a failed or painful hip resurfacing included anteroposterior and false-profile standing radiographs and routine clinical examination using the Harris hip score. The radiographs were analysed for positioning of the acetabular and the femoral components, fracture of the femoral neck, narrowing of the neck and osteolysis.

A total of 30 Birmingham Hip Resurfacings (BHR) (Smith & Nephew, Memphis, Tennessee), five Conserve+ (Wright Medical Technology, Arlington, Tennessee), four Articular Surface Replacements (ASR; DePuy, Warsaw, Indiana), two McMinn (Corin, Cirencester, United Kingdom) and one DUROM
arthroplasty (Zimmer, Winterthur, Switzerland) were revised at a mean of 26.2 months (1 to 76) after implantation. The mean age at revision was 49.6 years (18 to 70) and 30 patients were female. A posterolateral approach was used in 39 patients and an anterolateral approach in three. Attempts were made to preserve well-fixed, well-positioned acetabular and femoral components. When the acetabular component had to be revised, it was removed using chisels to minimise bone loss. The retrieved components and peri-prosthetic tissue were sent to a specialised laboratory for independent study and reporting.

Routine post-operative rehabilitation and thromboprophylaxis were carried out. All the patients with a revision to a THR in which both components had been revised and the size of the head decreased, wore an anti-dislocation hip-brace for six weeks. The patients were reviewed clinically and radiologically at six weeks and one, three and five years post-operatively. The Harris hip scores were recorded.

The radiographs were analysed by an independent observer (KADS) using the protocol described by Widmer.15 Optimum placement of the acetabular component was defined as 40° of abduction (30° to 50°) and 20° of anteversion (15° to 25°). The desired valgus angle of the femoral component was between 135° and 145° or not more than 15° from the anatomical neck. The femoral component was placed within 10° of a neutral position of ante- and retroversion. Components placed outside these parameters were considered to be malpositioned.

Table I. Reasons for revision in the 42 patients (49 reasons)

<table>
<thead>
<tr>
<th>Reason for revision</th>
<th>Number of patients (%)</th>
<th>Mean time to revision (mths)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malpositioning of the acetabular component</td>
<td>27 (64)</td>
<td>22 (3 to 70)</td>
</tr>
<tr>
<td>Malpositioning of the femoral component</td>
<td>7 (17)</td>
<td>25 (6 to 67)</td>
</tr>
<tr>
<td>Loosening of the femoral component</td>
<td>6 (14)</td>
<td>56 (22 to 76)</td>
</tr>
<tr>
<td>Fracture of the neck</td>
<td>4 (10)</td>
<td>3 (1 to 9)</td>
</tr>
<tr>
<td>Osteolysis</td>
<td>3 (7)</td>
<td>42 (37 to 50)</td>
</tr>
<tr>
<td>Loosening of the acetabular component</td>
<td>2 (5)</td>
<td>25 (23 to 27)</td>
</tr>
</tbody>
</table>

Results
The main presenting symptoms for revision were pain (38 patients, 90%) and mechanical symptoms (29 patients, 69%), such as impingement or limited movement. The mean Harris hip score before revision was 73 (40 to 96). In some cases the patient reported only vague symptoms in the joint which did not limit activity or range of movement, and therefore maintained a good score.
The reason for revision was malpositioning of the acetabular component in 27 patients (64%) (Table I, Fig. 1), followed by that of the femoral component in seven (17%) and loosening of the femoral component in six (14%). Other reasons included fracture of the femoral neck in four, loosening of the acetabular component in two and osteolysis (both acetabular and femoral) in three. Osteolysis was due to failure of remodelling in response to loosening and not because of wear and metal sensitivity in one patient. The second had severe metallosis, and in the third, the femoral head was vascular and viable but was undergoing remodelling including narrowing of the neck, secondary to metal sensitivity.

In seven patients there was more than one reason for revision. In six there was both a malpositioned acetabular and femoral component and in one a malpositioned acetabular component with loosening of the femoral component. The intra-operative findings were impingement in 14 patients (33%), metallosis in 12 (29%), narrowing of the neck in eight (19%) and osteolysis in seven (17%). The histological features of metal sensitivity were found in tissues obtained at revision in three patients who had presented with radiological osteolysis and narrowing of the neck.6,17

The four revisions because of a fracture were carried out after a mean of three months (1 to 9) after the initial procedure. Revisions because of a malpositioned acetabular component were performed after a mean of 22 months (3 to 70; Table I).

Table II. Differences in the size of the acetabular component before and after revision

<table>
<thead>
<tr>
<th>Acetabular component difference (mm)</th>
<th>Number of patients (posterolateral approach)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-2</td>
<td>2</td>
</tr>
<tr>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>+2</td>
<td>14</td>
</tr>
<tr>
<td>+4</td>
<td>3</td>
</tr>
<tr>
<td>+6</td>
<td>2*</td>
</tr>
<tr>
<td>+8</td>
<td>1*</td>
</tr>
<tr>
<td>Total</td>
<td>32</td>
</tr>
<tr>
<td>Mean (mm)</td>
<td>1.75</td>
</tr>
</tbody>
</table>

* patients revised by anterolateral approach

Fig. 2a

a) Radiograph of a hip resurfacing arthroplasty in a 60-year-old patient. The femoral component was placed in excessive valgus and there was notching of the femoral neck. The primary hip resurfacing was replaced by a cemented total hip replacement after six months and b) photograph of a cross-section through the retrieved femoral head showing notching of the femoral neck.

Fig. 2b
with a mean value of 69.9° (56° to 98°), in the second (n = 2), there was insufficient abduction with a mean value of 23.0° (14° to 32°), in the third (n = 6), the acetabular component lay in excessive anteversion with a mean of 40.5° (34° to 58°) and in the fourth (n = 13), there was insufficient anteversion with a mean value of 2.7° (-15° to +13°). The acetabular component had been placed in malposition in more than one plane in 11 patients. All the patients who were revised for a malpositioned acetabular component presented with mechanical symptoms and there was a good correlation between the radiological appearance and the intraoperative findings.

In seven cases which had been revised for a malpositioned acetabular component only, it was possible to preserve the resurfacing arthroplasty. The revised acetabular component was placed in a position of 40° of abduction and 20° of anteversion. In ten patients with a fracture or a malpositioned femoral component, a stem with a modular head was used, retaining the well-fixed, well-positioned acetabular component. In the other 25 cases, the resurfacing arthroplasty was replaced by an uncemented or hybrid ceramic-on-ceramic total hip replacement (THR). No revision components were used.

In 32 patients the acetabular component was changed. The mean increase in the diameter of the acetabular compo-
nent in this group was 1.8 mm (-2 to +8). The first three revisions in which the acetabular component was changed were carried out through an anterolateral rather than a posterolateral approach. The mean increase in the diameter of the component using the anterolateral approach (n = 3) was 6.7 mm (6 to 8), but when using the posterolateral approach (n = 29) it was 1.2 mm (-2 to +4; Table II).

Malpositioning of the femoral component was found in seven patients and in five of these there was impingement between the neck of the femoral component and the edge of the acetabular component. In two cases the femoral component was in excessive valgus, in one of which there was nothing of 8 mm of the lateral aspect of the femoral neck (Fig. 2). Notching carries a risk of fracture and can cause impingement because of the low offset from the femoral neck. In one patient in whom the femoral component was in an excessive valgus position, it was shifted too far posteriorly. Two femoral components were in excessive varus and another lay in retroversion.

The mean time of follow-up after revision was 32 months (12 to 87). Before revision the mean Harris hip score was 73 (40 to 96) which increased to a mean of 90 (42 to 100). There was no difference in the score of the patients who had retained the resurfacing arthroplasty compared with those who had been converted to a THR. There was no apparent association between the original diagnosis and the reason for revision. The cause of revision did not influence the clinical results.

Malpositioning of the components can result in a high rate of wear. In 12 of the patients revised for malpositioning, a large, metal-stained bursa containing copious amounts of brown or creamy fluid under pressure was present in the joint (Fig. 3). These hips underwent extensive soft-tissue resection to remove the contaminated material. Histologically, these tissues were characterised by abundant macrophages often containing visible metal particles and haematin pigment. There was a variable amount of necrosis and lymphocytic infiltration. Three additional patients, all women, with radiological osteolysis and a clinical history of pain had the histological features of metal sensitivity with extensive lymphocyte aggregates, plasma cells, necrosis and deposition of fibrin. All three obtained relief from pain upon conversion to a ceramic-on-ceramic THR.

**Complications.** Four female patients had one or more dislocations after revision. They had a mean position of the acetabular component of 44° of abduction (36° to 50°) and 31° of anteversion (26° to 40°) after revision. The mean femoral offset relation \(^{18}\) between the revised side and the contralateral side was 0.95 (0.67 to 1.10). The mean acetabular component offset relation \(^{18}\) between the revised side and the contralateral side was 0.99 (0.85 to 1.18). One of these patients required a further revision for impingement of the ceramic-on-ceramic components. Three other patients had a second revision, one because of loosening of the revised acetabular component, one because of loosening of the primary resurfacing femoral component and the third because of protrusion of the revised acetabular component. These secondary procedures were carried out after a mean of 25 months (9 to 40) following the first revision. One of these patients developed heterotopic ossification of Brooker grade I.\(^{19}\)

**Discussion**

Within this group of 42 resurfacing arthroplasties implanted by a number of surgeons with different levels of experience, malpositioning of the acetabular component was the main cause of revision. The angle of abduction ranged from 14° to 98° and that of anteversion from -15° to +58° in these components. While the exact incidence of this complication is unclear because most of the cases came from elsewhere, malpositioned acetabular components (27 patients) accounted for 64% of the revisions in our series. This is in contrast to other published series in which femoral failures were the predominant cause of revision.\(^{5,20}\)

Hip resurfacing arthroplasty is a technically more demanding procedure compared with a THR because the femoral head may obscure the exposure of the socket. Accurate positioning of the implant is of paramount importance to ensure a low wear rate of metal-on-metal bearings. Surface arthroplasty of the hip is less forgiving of malpositioned implants than THR with metal-on-polyethylene bearings. In hip resurfacing, positioning of the implants to avoid impingement is vital. The ratio between the femoral head and femoral neck is smaller than in THR which increases the risk of impingement. Malpositioned components may cause symptoms due to prosthesis-bone impingement, soft-tissue impingement or painful local tissue reactions to the high rate of wear of the metal bearing undergoing edge-loading\(^{6,21}\) which occurs on the opposite side of the acetabular component to the impingement (Fig. 4). This is in contrast to a THR with a hard-on-soft bearing in which the impingement leads to deformation and wear at the site of contact.

While some patients with malpositioned components seek revision for pain or gait-related problems, others have only mild or tolerable pain. There is increasing understanding of the relationship between malpositioning of the components, high wear and its associated products in the joint, including particles and ions.\(^{10}\) We consider that assessment of the levels of serum ions is necessary to aid in the decision as to the revision of resurfacing components.

One commonly cited advantage of hip resurfacing is that it makes conversion to a secondary procedure easier if failure occurs.\(^{1,17}\) However, in our series seven patients (17%) had a complication, four needed a second revision and four had one or more dislocations. These last four patients were all female and the resurfacing prostheses had been replaced by a THR. Thus, 20% of the revisions to a THR had complications and 16% of these had one or more dislocations, three of which occurred within the first six weeks, all during sexual intercourse. We consider that these dislocations occurred because the stability of the prostheses had been reduced for several reasons. Ceramic-on-ceramic bearings of 28 mm in two patients and 32 mm in two were used giving a decrease.
in the diameter of the head after revision. While metal femoral components of a larger diameter could have been used, ceramic-on-ceramic implants were preferred in order to reduce any further burden of chromium and cobalt metal particles and ions. Secondly, because the metallolos had affected large amounts of the capsular tissues, removal of these decreased the stability which the capsule normally provides to the hip. The high pre-operative Harris hip score indicated that the patients with a hip resurfacing had high levels of activity and would expect a rapid recovery to their normal level of function after revision, although stability of the joint may have been compromised. Lastly, correction of the excessive angle of anteverision of the acetabular component and the decrease in both the acetabular component and femoral offset may have affected stability.

For most cases, the posterolateral approach had been used for the revision. Although this second operation can potentially damage the soft tissues and the blood supply to the femoral head further, we have no evidence to indicate that this induced loosening in the acetabular component-only revisions. Revision components were not used in any of the re-operations, but implants with choices in the available range of size were used to ensure good stability of the reconstructed hip.

Revision of the acetabular component of a hip resurfacing arthroplasty may be performed successfully with a minimal increase in loss of acetabular bone. In the acetabular components revised via a posterolateral approach, the mean increase in the diameter of the components was only 1.2 mm, but in the three patients revised via the anterolateral approach, a much larger acetabular component was required. Two of the four patients with post-revision dislocation and one of the patients needing a second revision had the resurfacings revised through an anterolateral approach. It should be noted that these anterolateral cases were the first three in the entire revision series.

Given the difficulties encountered with a typical incision, visualisation may be even more difficult with a smaller incision. These have grown in popularity and are being used more often for resurfacing arthroplasty to improve the speed of rehabilitation and reduce post-operative pain. However, the use of smaller incisions, particularly during the learning curve, may place the hip at higher risk for malpositioned components.

Revisions necessitated by fractures of the femoral neck and loosening of the femoral component, or those involving only an exchange of the acetabular component are typically uncomplicated and have few post-revision dislocations because the large femoral head is preserved. Revisions for malpositioning are often more complicated. When major soft-tissue damage or necrosis is encountered, either because of high wear and metallosis or from metal sensitivity reactions, a complete change of prosthesis is required. We currently advise using titanium implants and ceramic-on-ceramic bearings in order to exclude a new burden of cobalt-chromium wear products. Ceramic-on-ceramic bearings are used because their low wear is more suited to the young age of these patients, but the reduction in the size of the head combined with the soft-tissue damage may lead to a higher risk of dislocation even in cases in which leg length and offset are restored.

Supplementary Material

A further opinion by Mr W. Hart is available with the electronic version of this article on our website at www.jbjs.org.uk

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