Removal of acetabular bone in resurfacing arthroplasty of the hip
A COMPARISON WITH HYBRID TOTAL HIP ARTHROPLASTY

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Resurfacing arthroplasty of the hip is being performed more frequently in the United Kingdom. The majority of these patients are younger than 55 years of age, and in this group the key benefits include conservation of femoral bone stock and the potential reduction in the rate of dislocation afforded by the larger resurfacing head. Early aseptic loosening is well recognised in patients younger than 55 years of age, and proponents of resurfacing believe that the improved wear characteristics of the metal-on-metal bearing may improve the long-term survival of this implant. There has been some concern, however, that resurfacing may not be conservative of acetabular bone.

We compared a series of 33 consecutive patients who had a hybrid total hip arthroplasty with an uncemented acetabular component and a cemented femoral implant, with 35 patients undergoing a Birmingham hip resurfacing arthroplasty. We compared the diameter of the implanted acetabulum in both groups and, because they were not directly comparable, we corrected for patient size by measuring the diameter of the contralateral femoral head. The data were analysed using unpaired t-tests and analysis of covariance.

There was a significantly larger acetabulum in the Birmingham arthroplasty group (mean diameter 56.6 mm vs 52.0 mm; p < 0.001). However, this group had a significantly larger femoral head diameter on the contralateral side (p = 0.03). Analysis of covariance revealed a significant difference between the mean size of the acetabular component implanted in the two operations. The greatest difference in the size of acetabulum was in those patients with a larger diameter of the femoral head. This study shows that more bone is removed from the acetabulum in hip resurfacing than during hybrid total hip arthroplasty, a difference which is most marked in larger patients.

Metal-on-metal resurfacing of the hip is being performed with increasing frequency in the United Kingdom.1 Its theoretical advantages include the conservation of femoral bone stock, the absence of polyethylene wear debris, enhanced stability2 and an improved range of movement compared with total hip arthroplasty (THA).3

Historically, there have been higher rates of aseptic loosening of THAs in the groups younger than 55 years of age,4,5 leading to revision, although more recent reports of a modern cementless implant are encouraging.6 Proponents of resurfacing believe that the metal-on-metal bearing may improve the longevity of this implant,7 and that its stability and range of movement are advantageous in a younger age group.

Although hip resurfacing conserves femoral bone, the same may not apply to the acetabulum. This is because the size of the acetabular component implanted is related to the diameter of the femoral head and neck. During resurfacing, notching of the femoral neck when preparing the proximal femur has been associated with fracture of the neck,8 which must be avoided. The external acetabular diameter in a Birmingham hip (BHR, Midland Medical Technology, Stoke Prior, UK) is a minimum of 6 mm greater than the external diameter of the prosthetic femoral head in order to provide a sufficiently rigid construct and reduce the stress within the acetabular component.

This may result in the use of a larger acetabular component than in a conventional hip arthroplasty for the same patient and may affect acetabular revision should the resurfacing fail. Our aim, therefore, was to use a radiographic technique to evaluate whether more bone is indeed removed from the acetabulum at hip resurfacing than at THA.

Patients and Methods
This was a retrospective study. Between March 2001 and December 2002, 47 patients received...
a metal-on-metal hip resurfacing and 47 a hybrid THA, all performed by a single surgeon (JPH). The implants used were the BHR (Midland Medical Technology), or a cemented Exeter femoral stem (Stryker, Newbury, UK) with a 28 mm head, and an uncemented acetabular component, either an ABG II (Stryker) or a Trilogy (Zimmer, Warsaw, Indiana). The three acetabular components used in the study all subtend a true hemisphere of 180°.

The BHR was used in patients who were younger and more active than those receiving a THA, but who understood the limited long-term results of the resurfacing design. The surgeon had been performing the Birmingham hip resurfacing (BHR) for three years before this study and was experienced in both resurfacing and THA. All radiographs were templated pre-operatively and all hips were exposed through a posterior approach. The technique of acetabular preparation was the same for both the BHR and the THA acetabular components. Peripheral osteophytes were removed and sequential reaming began from 40 mm upwards, in 2 mm increments. The aim was to impact all uncemented components solidly against the true floor of the acetabulum, with circumferential concentric exposed acetabular bone. For THA, reaming ceased when sufficient stable bone had been exposed to the periphery of the socket, usually determined by its anteroposterior diameter. For the BHR this end-point was governed by the size of the implant, this being the reason for the study.

Comparison was made between the implanted acetabular diameters in both groups as obtained from the operating theatre records. In order to assess the similarity of the groups, the age, gender and the diameter of the femoral head in the contralateral femur were compared, the latter being regarded as a measure of the size of the patient. Measurements were taken from standardised post-operative anteroposterior radiographs of the pelvis, centred on the symphysis pubis, with the patient lying supine and their big toes approximated in order to maintain consistent femoral rotation. Radiographs taken three months after operation were used, as they were of better quality than the initial post-operative views. In order to ensure accurate results the magnification of the radiograph was obtained by comparing the radiographic diameter of the implanted ipsilateral femoral component with the actual diameter of the femoral implant.

Although 93 patients were enrolled in this study, 25 were excluded for a variety of reasons, which included an abnormal contralateral hip creating difficulty in measuring the diameter of the contralateral femoral head accurately in 18 patients, poor-quality radiographs in four and dysplasia of the hip in three. The total number of radiographs included in the study was therefore 33 in the hybrid THA group, and 35 in the resurfacing group. All patients had primary osteoarthritis. The mean age of the resurfacing group was 50 years (SD 5.6) and in the THA group 63 years (SD 11.4). The ratio of men to women was higher in the resurfacing (2:1) than in the THA group (5:6).

**Statistical analysis.** We obtained the mean implanted acetabular diameters for both the BHR and the THA groups, as well as the mean femoral head diameters corrected for magnification. The implanted acetabular diameter was compared between the groups using an unpaired *t*-test with the femoral head sizes being similarly correlated. In order to allow for the dependence of the implanted acetabular diameter on the diameter of the femoral head, an analysis of covariance was performed. The standard analysis was extended to assess whether any relationship between the size of the acetabular component and the femoral head diameter differed between the types of operation (test for interaction). Values for *p* < 0.05 were regarded as significant.

**Reproducibility.** As a result of the straightforward measurements taken from the radiographs we were confident of the accuracy of our measurements. However, to ensure the validity of the study we assessed the reproducibility of our own assessments. Ten randomly selected sets of radiographs were measured both initially and after several weeks by two of the authors (JML, IS). The number of measurements which varied for the same observer on two occasions, and between different observers, is recorded in Table I. With the exception of one measurement, all differences were of 1 mm and no trend was noted in the repeated assessments.

**Results**

There was a high level of agreement between different observers, and for one observer on different occasions.

The distribution of femoral head diameters broken down by quartiles (< 43.8 mm, 43.8 to 47.1 mm; 47.1 mm to 50.7 mm, > 50.7 mm), and for each type of operation is shown in Figure 1. The mean femoral head diameter was larger in the BHR (48.0 mm) than in the THA group (45.7 mm); this difference was statistically significant (*p* = 0.03; 95% confidence interval (CI) for difference in means 0.3 to 4.2). The implanted acetabular diameter showed an even greater difference, with a mean diameter of 56.5 mm in the BHR group and 52.0 mm in the THA group. This was also

<table>
<thead>
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<th>Table I. Reproducibility of the measurements</th>
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<tr>
<td><strong>Number of different measurements (mm)</strong></td>
</tr>
<tr>
<td>Measurement</td>
</tr>
<tr>
<td>Difference</td>
</tr>
<tr>
<td>Implant diameter</td>
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<tr>
<td>Femoral head diameter</td>
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</table>
The analysis of covariance showed that the interaction was significant \( p < 0.001 \), indicating that the rate of change of the size of the cup with that of the femoral head was different for the two types of operation. This is illustrated in Figure 2, where the lines of best fit for the two types of operation are shown. For smaller heads there is little difference between the implanted acetabular diameters used in the different operations. However, for larger heads the mean implanted acetabular diameter is substantially greater in resurfacing.

Table II shows the mean difference in implanted acetabular diameter between BHR and THA for two sample patients, with femoral head diameters of 42 and 53 mm, respectively. This demonstrates a negligible difference in the acetabular component implanted using the two techniques and the change in volume of bone removed for the smaller patient. However, in the larger patient the difference is substantial (5.4 mm; 95% CI 3.7 to 7.1).

For the range of femoral head diameters in this study, Figure 3 illustrates the extra volume of bone removed in a BHR, with 95% confidence intervals. No relationship between gender and implanted acetabular diameter could be found, although women generally have smaller diameters of the femoral head and therefore lie at the left-hand end of the curve in Figure 3.

**Discussion**

With encouraging results,\(^1,^9\) and the increasing use of hip resurfacing,\(^1\) there is a need for a better understanding of the key differences between this procedure and conven-

### Table II. Volume of bone removed for two example patients

<table>
<thead>
<tr>
<th>Femoral head diameter (mm)</th>
<th>Mean acetabular diameter (mm)</th>
<th>Difference (mm) (95% CI)</th>
<th>Change in volume of bone (cm³)</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>BHR*</td>
<td>THA†</td>
<td></td>
</tr>
<tr>
<td>42</td>
<td>50.2</td>
<td>49.7</td>
<td>0.5 (-1.0 to 1.9)</td>
</tr>
<tr>
<td>53</td>
<td>61.9</td>
<td>56.5</td>
<td>5.4 (3.7 to 7.1)</td>
</tr>
</tbody>
</table>

* BHR, Birmingham hip resurfacing  
† THA, total hip arthroplasty  
‡ CI, confidence interval
tional THA. The advantages of resurfacing are an increased range of movement because of the larger femoral head/neck ratio delaying the point of impingement and enhanced stability. Preservation of femoral bone stock is also an advantage. Subjectively, our patients who underwent resurfacing had increased activity levels compared to those undergoing THA, as suggested by Schmalzried et al, who are discharged earlier, usually on the third post-operative day, and report an excellent, natural feeling to the hip after the procedure. As yet we have been unable to assess this improvement in activity objectively, and as the patient group is preselected to have higher functional demand we anticipate difficulties in validating any assessment.

Although it is clear that a BHR conserves femoral bone stock, no publication to date has answered the question of whether more bone is removed from the acetabulum in hip resurfacing. Our results demonstrate that for patients with a given femoral head diameter, the implanted acetabular component is generally larger for a resurfacing procedure. With larger femoral heads this difference can be very noticeable. For bigger patients, a larger acetabular component may, in some individuals, make implantation more difficult as a result of the thin anterior and posterior walls of the bony acetabulum after reaming. More critical, however, is the effect of the increased reaming on subsequent revision surgery. This depends on the survival of the acetabular component, which has so far been promising. The greatest increase in the size of acetabular component implanted was seen in large men who also tended to be young, high-demand patients who, historically, have poor survival rates after THA. In these patients it is important to use the smallest appropriate prosthesis femoral head size to avoid notching the femoral neck.

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