The purpose was to analyse two reported risk factors on the outcome of Birmingham Hip Resurfacing (BHR). We reviewed consecutive BHR arthroplasties and found 1,476 cases eligible for analysis. The mean follow-up was 7.3 years. Patients were classified into groups according to their head size and body mass index (BMI). Statistical analysis examined the follow-up Oxford Hip Scores (OHS) and revision rates between groups.

In the large head group (50mm and above) the OHS was 0.5 points higher (p=0.003) than the small head group. In the non-obese group (BMI <30) it was 0.3 points higher (p=0.007). No significant difference in the survival of the implants by either head size or by BMI was detected.

BHR is a suitable option offering good survival and higher functional outcomes in non-obese patients (BMI<30) with larger femoral head diameters (50 and above). Although results are statistically significant such a small difference in OHS will rarely show significant clinical difference. Therefore, despite previous reports, BHR may be a reliable option offering predictable clinical results in these scenarios.

**Keywords**: hip resurfacing ; patient outcome assessment ; femoral head prosthesis ; obesity ; total hip replacement

**INTRODUCTION**

Total hip resurfacing arthroplasty and metal on metal bearing surfaces have undergone a cyclic period of promising interest and large scale implantation with a subsequent decrease in popularity. What at one point was reported as an excellent implant for both young and elderly patients turned unpopular amongst patients and clinicians due...
to increasing reports of potential drawbacks and adverse events. (23). The recall of the once popular ASR (DePuy) was widely covered in the press and orthopaedic literature. (1,5,11). However, the Birmingham Hip Resurfacing (BHR, Smith & Nephew) has continued to show good outcomes, with a 10A rating from the Orthopaedic Device Evaluation Panel (ODEP) in the United Kingdom. (16) Although different models have some common features, patenting laws dictate none can be identical and varying outcomes have thus been reported. (3,21) In addition, many factors independent of the bearing surface and prosthesis type have been shown to influence the outcome of hip replacement surgery. (3,18)

We performed a review of the literature to find potential risk factors that might influence the outcome of MoM hip resurfacing replacements. We found that head size, sex and obesity have been reported as potential factors. (9,12,17). It has been reported that head size alone is the best predictor of revision (12). The previously reported worse outcome of women is only indirectly related to prognosis, after multivariate analysis, as female patients have smaller head sizes than males.

The purpose of this study is to analyse the effect of head size and obesity on revision rates and functional outcomes. Our null hypothesis was that there is no difference in survival rates or functional outcomes between large and small head diameters, and between low and high BMIs.

**MATERIALS AND METHODS**

We reviewed 1,637 consecutive hip resurfacing procedures performed in an independent centre (McMinn Centre, Birmingham) between March 2002 and November 2011. 161 hips were excluded from analysis. 70 hips had incomplete data, 22 hips were revised (revision rate 1.47%), 19 hips died, 17 hips withdrew and 33 were lost to follow up. This left 1,476 hips eligible for analysis. The mean follow up was 7.3 years (range: 1-10 years)(Standard Deviation: 2.82).

All patients had a pre-operative Oxford Hip Score (OHS) collected and were subsequently contacted on a yearly basis by post and asked to fill in a questionnaire, which included a repeat OHS. Direct enquiry regarding revision that may have occurred in other units was made by specifically asking in another questionnaire sent yearly. All information was collected and stored by the Outcomes Team at St. Helier Hospital, Carshalton, Surrey (UK). The study was approved by the local audit committee and performed following the Declaration of Helsinki principles with consent obtained from the study subjects.

To assess the effect of head diameter we split the patients into two groups, head diameter equal to and above 50mm (large head size) and another below 50mm (small head size). This was chosen as it roughly represents the middle of the size range of the BHR (38-58 mm) and in our cohort it represents the point that obtains the most equal group numbers. In addition, this distinction has been used by other authors in the past and is now widely accepted (7).

To assess the effect of Body Mass Index (BMI) we divided patients into two groups based on BMIs equal to and above 30 (obese group) and below 30 (Non-obese group) as defined by the World Health Organisation (WHO). Overweight would be considered if a patient has a BMI between 25 and 29, obese between 30 and 40 and morbidly obese beyond 40. (22)

We have also focused on analysing “poor performers”. A snapshot at the 5-year postoperative point was taken to look at the characteristics of those patients whose OHS was found to be 1 or more standard deviations below the mean. This equates to those with an OHS below 43. Their characteristics were compared to those with scores above those points.

**Statistical analysis**

The first set analyses compared the baseline characteristics between head size and BMI groups. Continuous variables were all found to be normally distributed, and thus were compared between groups using the unpaired t-test. Categorical variables were compared between groups using the Chi-square test.

Subsequent analyses examined the follow-up Oxford scores between head size and BMI groups.
Due to the repeated measurements from the same patients over time, the analyses were performed using multilevel regression methods.

A series of different analyses were used to compare between groups. Initially a simple (unadjusted) comparison of the follow-up results between groups was made. A second analysis adjusted for any baseline differences in Oxford scores between groups. Finally additional analyses also account for any differences in baseline variables between groups. An external statistician contracted to our department performed all statistical analysis.

Survival analysis was subsequently performed examining how time to revision varied by both femoral head size and BMI. Kaplan-Meier graphs were used to give graphical representation of the data.

RESULTS

We found that those with larger head sizes were significantly (p<0.001) older, taller, heavier, more likely to be obese, and more likely to be male when compared to smaller head sizes. Similarly those in the obese group were significantly more likely to be male and to have a large head size when compared to the non-obese group (Table I).

Post-operative OHS were significantly skewed towards the higher end of the OHS scale with over 50% of patients having the maximum score of 48 (Fig. 1).

We found that larger head sizes had significantly higher OHS at all time-points (p<0.001) when compared to hips with smaller head sizes (Fig. 2). Regression analysis, both adjusted and unadjusted for differences between the groups, showed the difference in scores between the two groups stayed constant over time (Table II). We attempted to look at each head size as an independent variable but were unable to because of statistical reasons. The numbers are too small in some head size groups; additionally, there would be too many groups to realistically interpret the data.

Similar results were seen when comparing the obese and non-obese groups. The non-obese group had significantly higher OHS at all time-points (p<0.001) when compared to the obese group.

Fig. 1. — Post operative Oxford Hip Score (OHS) values

Fig. 2. — Oxford Hip Scores over time for the two groups of patients. Small head size = 48 and below. Large head size = 50 and above

Fig. 3. — Oxford Hip Scores over time for the two groups of patients. BMI <30 (non-obese), BMI >=30 (obese group),

Acta Orthopædica Belgica, Vol. 82 - 3 - 2016
The results of the survival analysis suggested no significant difference in the survival of the implants by either head size or by BMI. Graphical illustrations of these results are shown in two Kaplan-Meier plots with 95% confidence intervals. (Fig. 4 and 5)

**DISCUSSION**

This study has some limitations. Firstly, no comparison between functional outcomes was made with radiological outcome since we had no access to this data. Secondly, although we analysed two potential risk factors for failure, there are others that might contribute to outcome. These include implant positioning, bone density, subchondral bone cysts and adverse reaction to metal debris (ARMD). (12) Finally, this study was performed using cases from a single institution and by the designer surgeon, therefore minimizing the variability of surgeon related factors. Revision rates in our study are very low and compare to some of the published literature, but we

Table I. — Demographics. The figures reported are the mean and standard deviation for the continuous variables, and the number and percentage for the categorical variables. P-values indicating the significance of the results are also reported.

<table>
<thead>
<tr>
<th>Variable</th>
<th>BMI&lt;30 (n=1288)</th>
<th>BMI≥30 (n=188)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>54.1 (9.6)</td>
<td>55.1 (9.6)</td>
<td>0.19</td>
</tr>
<tr>
<td>Male gender</td>
<td>902 (70%)</td>
<td>195 (98%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Right operation side</td>
<td>657 (51%)</td>
<td>107 (54%)</td>
<td>0.44</td>
</tr>
<tr>
<td>Large head size</td>
<td>747 (58%)</td>
<td>186 (99%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Oxford score baseline</td>
<td>26.2 (8.3)</td>
<td>25.9 (8.5)</td>
<td>0.69</td>
</tr>
</tbody>
</table>
Table II. — Oxford scores comparison of the two groups (large and small head size). The first column gives the p-value for the interaction between time and group. The end two columns relate to the group differences assuming a constant post-op difference between groups. The mean difference in Oxford scores between the two head size groups is given along with a corresponding confidence interval. P-values indicating the significance of the group difference are also reported. Categorical variables. P-values indicating the significance of the results are also reported.

<table>
<thead>
<tr>
<th>Adjustments</th>
<th>Time interaction P-value</th>
<th>Group difference(^{(*)}) Mean (95% CI)</th>
<th>Group P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unadjusted</td>
<td>0.26</td>
<td>0.5 (0.2, 0.8)</td>
<td>0.003</td>
</tr>
<tr>
<td>Baseline Oxford score</td>
<td>0.29</td>
<td>0.3 (0.0, 0.6)</td>
<td>0.06</td>
</tr>
<tr>
<td>Base Oxford + demographics(^{(*)})</td>
<td>0.30</td>
<td>0.3 (-0.1, 0.8)</td>
<td>0.14</td>
</tr>
</tbody>
</table>

\(^{(*)}\) Reported as large head circumference minus small head circumference

Table III. — Oxford scores comparison of the two groups (obese and non-obese). The first column gives the p-value for the interaction between time and group. The end two columns relate to the group differences assuming a constant post-op difference between groups. The mean difference in Oxford scores between the two head size groups is given along with a corresponding confidence interval. P-values indicating the significance of the group difference are also reported.

<table>
<thead>
<tr>
<th>Adjustments</th>
<th>Time interaction P-value</th>
<th>Group difference(^{(*)}) Mean (95% CI)</th>
<th>Group P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unadjusted</td>
<td>0.44</td>
<td>-0.3 (-0.5, -0.1)</td>
<td>0.007</td>
</tr>
<tr>
<td>Baseline Oxford score</td>
<td>0.35</td>
<td>-0.4 (-0.6, -0.1)</td>
<td>0.002</td>
</tr>
<tr>
<td>Base Oxford + demographics(^{(*)})</td>
<td>0.74</td>
<td>-0.6 (-0.8, -0.3)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

\(^{(*)}\) Reported as obese minus non-obese

\(^{(*)}\) Adjusted for baseline Oxford score, age, gender, obesity

**Fig. 4.** — Kaplan-Meier plot showing survival estimates for both small and large head size. Differences are not statistically significant between groups. (p=0.56)

**Fig. 5.** — Kaplan-Meier plot showing survival estimates for both BMI <30 and >=30. Differences are not statistically significant between groups. (p=0.61)
intended to focus more specifically on functional evaluation in order to identify the variables that may not function as well.

Patients with a large head size were found to have statistically significantly higher OHS post-operatively, which were on average 0.5 units higher. After adjusting for differences in demographics between groups, the large head size group had follow-up Oxford scores that were, on average, 0.3 units higher than those for patients with a small head size although not statistically significant. When analysing obesity, the statistically significant difference in OHS between the obese and non-obese groups was 0.3 units in the unadjusted analysis, which increased to 0.6 units after adjusting for baseline scores and other demographics. This is shown to be statistically significant.

When assessing total hip arthroplasties, there is some controversy on whether obese patients demonstrate differences in post-operative functional scores and complication rates than non-obese. (15,24) When differentiating the groups between obese, morbidly obese and super-obese we found no data in the literature to suggest that super-obese perform worse than obese in functional scores. (8,13,14,19)

Other studies on hip resurfacing have suggested that implant brands are a factor influencing the outcome. The good results observed in our study are similar to those reported in the literature. BHR implants currently have the best longevity of the resurfacing hip prostheses included in the National Joint Registry (NJR) and this is reflected in the published literature (4).

Where there is shown to be consistent data regarding the better performance of larger femoral heads, when assessing the effect of BMI there is some controversy. The adverse effect of excessive weight has been reported to influence the risk of developing hip osteoarthritis (6), to be detrimental on the survival of hip prostheses (2) and to be associated complications such as aseptic loosening (20). However, several studies show no differences between obese and non-obese patients regarding complication rates or early outcomes of total hip arthroplasties (10,15).

Although a very low revision rate has been found and this was not affected by head size or BMI, our study is not primarily intended to analyse the survival of the implant. It is aimed to guide surgeons to predict differences in functional outcome in obese and larger head diameter patients. BHR would theoretically be better offered to non-obese patients with large femoral head diameters resulting in better functional scores. However, our results would not discourage obese or small head diameter patients to have this operation. We suggest that a statistically significant difference in the OHS of 0.5 in the larger head diameter and of 0.3 in the obese groups, is not likely to account for a clinically significant difference. We believe that regardless of the head size and BMI, the election of the implant and a high volume surgeon are of first importance to achieve the best results.

Prospective randomized control trials comparing hip resurfacings for obesity and head diameter would be encouraged although difficult to perform. National joint registries should be able to provide some further information regarding these two variables with the use of large number of patients.

ACKNOWLEDGEMENT

Authors would like to thank Mr Paul Bassett for his contribution of statistical consultation, Mrs June Riordan and the Outcome team at St. Helier hospital for data collection and Miss Jocelyn Buly for the study preparation.

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