We report the outcome at a minimum of five years of 110 consecutive metal-on-metal Birmingham Hip Resurfacing arthroplasties in 98 patients. The procedures were performed between October 1999 and June 2002 by one surgeon. All patients were followed up clinically and radiologically. The mean follow-up was 71 months (60 to 93). Revision of either component was defined as failure.

The mean Harris Hip score at follow-up was 96.4 (53 to 100). The mean Oxford hip score was 41.9 (16 to 57) pre-operatively and 15.4 (12 to 49) post-operatively (p < 0.001). The mean University of California Los Angeles activity score was 3.91 (1 to 10) pre-operatively and 7.5 (4 to 10) post-operatively (p < 0.001).

There were four failures giving a survival at five years of 96.3% (95% confidence interval 92.8 to 99.8). When applying a new method to estimate narrowing of the femoral neck we identified a 10% thinning of the femoral neck in 16 hips (14.5%), but the relevance of this finding to the long-term outcome remains unclear.

These good medium-term results from an independent centre confirm the original data from Birmingham.

Until recently,1-3 the results of hip replacement in younger patients with greater physical demands have been less predictable than in older, less active patients.4-6 Patient expectations have also risen, with many younger patients anticipating a return to normal levels of function, including sporting activity. Resurfacing has been seen as an attractive option for many years, but until recently problems associated with the manufacture of the articulating materials resulted in excessive wear, producing low survival rates.7-9 Hip resurfacing restores the normal anatomy and biomechanics of the hip joint and provides near-normal proximal femoral anatomy and loading.10-12 Should subsequent revision surgery be required, almost all the femoral bone stock has been retained.

The metal-on-metal Birmingham Hip Resurfacing arthroplasty (BHR) (Smith and Nephew Inc., Memphis, Tennessee) was introduced into clinical practice in 1997, drawing the experience gained from earlier versions and improvements in manufacture and materials technology.13,14 Preliminary results for the BHR have been promising,1-3,15,16 with the first series reporting a minimum five-year follow-up emanating from the design centre.3 The survival and functional results were encouraging and suggested that this implant would be well suited for use in patients with higher demands.1

We report the results of an independent series of BHRs performed by one surgeon (MJFF), who visited Birmingham to be trained in the technique. This series comprises his first 113 resurfacings and therefore includes the often-discussed ‘learning curve’.

Patients and Methods

All patients who underwent BHR at Kent and Sussex Hospital between October 1999 and May 2002 were included in the study. This group comprised 101 patients with 113 BHRs, of whom 98 patients with 110 BHRs were available for follow-up. Of these, 41 were women and 57 men, with a total of 65 right-sided BHRs and 45 left. The mean age at operation was 54.4 years (35 to 75). In the 12 patients who had bilateral procedures (12%), seven were staged interventions and five were conducted under a single anaesthetic. In the same period, 212 total hip replacements (THR) were performed. Osteoarthritis was the main diagnosis leading to resurfacing (Table I).

All the operations were performed by a single surgeon. The decision to resurface was made based on the patient’s age, activity level and bone density. In the women, bone densitometry was performed if there was any suspicion of osteoporosis from their history or plain
Table I. Diagnosis of the 110 hips

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Number of hips (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Osteoarthritis</td>
<td>97 (88.2)</td>
</tr>
<tr>
<td>Avascular necrosis</td>
<td>4 (3.6)</td>
</tr>
<tr>
<td>Rheumatoid arthritis</td>
<td>3 (2.8)</td>
</tr>
<tr>
<td>Psoriatic arthropathy</td>
<td>2 (1.8)</td>
</tr>
<tr>
<td>Congenital dislocation</td>
<td>4 (3.6)</td>
</tr>
</tbody>
</table>

pre-operative radiographs. Patients with a physiological age of more than 60 years, proven osteoporosis on dual energy X-ray absorptiometry (DEXA), as defined by the World Health Organisation or severe anatomical or structural deformity were excluded. Informed consent was obtained and patients were counselled regarding risks specific to this implant, such as neck fracture and metal ion release.

The outcome measures used were the Oxford hip score (OHS), Harris hip score (HHS), University of California Los Angeles (UCLA) activity scale and patient satisfaction. An anteroposterior (AP) radiograph of the pelvis was used to calculate the positioning of the implant as well as to identify the presence of heterotopic bone formation, as described by Brooker et al.

The stem-shaft angle and acetabular inclination were measured as described by Beaulé et al., which defines the stem-shaft angle as the angle between the stem and the anatomical axis of the femoral shaft, and the acetabular inclination angle as the angle between a line across the face of the acetabular component and the interteardrop line.

Thinning of the femoral neck was measured at the implant-neck junction perpendicular to the inferior cortex of the neck. The distance from the superior margin of the lesser trochanter to this junction was also measured. This measurement was repeated on the pre-operative radiograph or the contralateral hip if the pre-operative radiographs were not available. From these measurements, a neck thinning ratio was then calculated (Fig. 1) with the ratio determined by dividing by the most recent follow-up neck width by the immediate post-operative neck width. Neck thinning was defined as present when there was a reduction in the initial ratio by 10%.

The mean surface arthroplasty risk index was calculated for our failures as described by Beaulé et al. In this assessment, the relative risk of failure increases 12-fold if the risk index is three or greater. In addition, the radiographs were examined for the presence of radiolucencies in the three femoral and four acetabular zones as described by Amstutz et al.

Operative technique. The pre-operative radiographs were templated to assess the probable size of the intended component and its orientation. All patients underwent a standard pre- and post-operative regimen. Antibiotic prophylaxis comprised 1.5 g of cefuroxime administered intravenously at induction, with two further doses of 750 mg at eight and 16 hours post-induction. With the patient in the lateral position and under combined spinal and general anaesthesia an extended posterior approach to the hip joint was used in a clean-air operating theatre. The short external rotators were released, the gluteus maximus was detached from its insertion at the linea aspera, and a circumferential capsulotomy was performed. The femoral head was dislocated anteriorly and the acetabulum reamed sequentially. Peripheral acetabular osteophytes were excised and a trial component which was 1 mm smaller than the intended final implant was used to confirm a tight fit had been obtained. If this fixation was satisfactory, the definitive acetabular component was then impacted. Standard Birmingham instrumentation was used to align and position the guide rod for the preparation of the femoral head using the lateral cortical pin and out-rigger. The head was reamed to accept a femoral component that matched the implanted acetabular component. The femoral implant was positioned and secured with Simplex (Howmedica International, Limerick, Ireland) low-viscosity cement. The hip was then reduced and the short external rotators and gluteus maximus tendon repaired.

Mobilisation was commenced on the first post-operative day with immediate full weight-bearing as tolerated. A Zimmer frame was used until the patient was considered safe with sticks. Patients considered at high risk received low-molecular-weight heparin for thromboprophylaxis for the duration of the in-patient stay, and all were prescribed anti-embolism stockings and had pneumatic foot pumps applied. Haemoglobin levels were checked on the first post-operative day and an AP radiograph of the pelvis was obtained. Patients were discharged home when they were able to mobilise independently.

Follow-up. Patients were reviewed at six weeks and three months post-operatively when a further AP radiograph of the pelvis was obtained. They were seen again at six months and one year post-operatively when a further AP pelvic radiograph was obtained. They were then discharged from routine follow-up. For the purposes of this study all patients were recalled for further clinical and radiological assessment at the most recent follow-up.

Statistical analysis. The changes in the pre- and post-operative hip scores were compared for statistical significance using the Mann-Whitney U test. A p-value < 0.05 was considered significant.

Results

The mean length of stay in hospital was six days (4 to 12). The mean follow-up was 71 months (60 to 93). Of the original 101 patients, three were lost to follow-up; one had died of amyloidosis unrelated to the resurfacing, but at the time of death had not undergone a revision. These patients are not included in any statistical analysis. Among the remaining 98 patients (110 BHRs) there were no dislocations, superficial or deep wound infections or thromboembolic complications.
Four patients underwent revision surgery at a mean time to revision of 27 months (16 to 33). The first revision was for avascular necrosis of the femoral head (Fig. 2), which was confirmed histologically. The patient had suffered from a slipped upper femoral epiphysis which had been pinned as a child, and so might have already had some compromise to the blood supply to the femoral head. The femoral component was revised at 16 months to an uncemented component with a large modular head.

In the second patient, revision was required because of a fracture of the femoral neck, probably secondary to movement of the acetabular component resulting in retroversion...
and impingement. This was also revised to an uncemented femoral component with a large modular head, while retaining the original acetabular component.

The third revision was for aseptic loosening of an acetabular component in a patient who had a previous congenital dislocation of the hip (Fig. 3). A cemented femoral component and an uncemented acetabular component were used at revision, 31 months after the original resurfacing.

The final revision was for aseptic loosening of both components. Infection was excluded before revision by a negative aspiration, and revision using a cemented femoral and an uncemented acetabular component was undertaken 28 months post-operatively by surgeons at a different centre.

The mean surface arthroplasty risk index as defined by Beaulé et al for our four revisions was 2.25 (2, 3, 1 and 3, respectively). Therefore, two of our patients reached the threshold value for a 12-fold increase in the relative risk of failure.

There was one fracture of the femoral neck treated non-operatively with a good result, and there was one retained lateral femoral guide pin that required re-operation.

Survival analysis using the Kaplan-Meier method showed a survival of 96.3% (95% confidence interval (CI) 92.8 to 99.8) at 60 months (Fig. 4).

The mean OHS pre-operatively was 41.9 (16 to 57) and at final post-operative review was 15.4 (12 to 49), which was a statistically significant change (Mann-Whitney U test, p < 0.001).

The mean UCLA activity score improved from a mean of 3.91 (1 to 10) pre-operatively to 7.5 (4 to 10) post-operatively (Mann-Whitney U test, p < 0.001).

Of the 94 patients followed up who had not undergone revision surgery, 89 were satisfied. Four were dissatisfied because of residual pain, although two of these stated that they would still have the surgery again. One was unable to answer because of severe Alzheimer’s disease.

The mean femoral stem-shaft angle was 130.9° (127° to 148°), with a mean acetabular inclination angle of 36° (22° to 47°) immediately post-operatively. At five years’ follow-up the stem-shaft angle of one patient was 112°. This

Fig. 3a

Fig. 3b

Fig. 3c

Radiographs of loosening of the acetabular component at 31 months a) anteroposterior and b) lateral views showing a radiolucent line around the component and c) following revision.
patient had sustained a peri-prosthetic fracture of the femoral neck which had been treated non-operatively, and which had united in varus.\textsuperscript{27} This patient was, therefore, excluded from our radiological analysis. The mean stem-shaft angle in those hips which had required revision was 135.8° (129° to 138°). There was no significant difference compared with those that did not require revision. Thinning of the femoral neck was present in 16 hips (14.5%) at final review. Heterotopic ossification was present in 19 hips (17%) and was Brooker grade 1\textsuperscript{24} in 15 hips and grade 2 in four. Radiolucent lines around the femoral component as described by Amstutz et al\textsuperscript{26} were present in seven hips (6%). None was wider than 1 mm. No lucent lines were found in the four acetabular zones.\textsuperscript{27}

Discussion
This series presents a minimum five-year follow-up not emanating from the designing centre. The survival rate of 96.3% (95% CI, 92.8 to 99.8) at five years in our series falls within the National Institute for Clinical Excellence (NICE) guidelines.\textsuperscript{28} Treacy et al\textsuperscript{1} reported a five-year survival rate of 98%, and Daniel et al\textsuperscript{3} reported a revision rate of 0.2% in their series at a mean follow-up of 3.3 years. Although the survival for our series is not quite as good as those achieved by the surgeon-inventor group,\textsuperscript{1,3} we still believe the BHR to be well suited for use in fit and active patients.

In two of our failures the surface arthroplasty risk index was high. This index had not been described when their operations were performed, but may be useful in case selection to avoid future failures.

The mean stem-shaft angle in those hips requiring revision was 135.8°. Other papers have suggested a link between a low stem-shaft angle and failure,\textsuperscript{29-31} but this was not found in our series.

Our mean acetabular inclination was 36°. Beaulé et al\textsuperscript{32} report a mean inclination angle of 41.8° in their paper. We have encountered no problems related to a closed acetabular component position, but there is evidence that this can reduce metal ion production, although it remains controversial.\textsuperscript{32}

Survivorship compares well with similar studies using conventional hip replacements,\textsuperscript{33} and concerns regarding high rates of early complications and failures are not borne out.\textsuperscript{15,34} The more extensive surgical dissection compared with conventional THR seems to have no detrimental effect on the outcome.

The radiological analysis allowed us to examine the development of thinning of the femoral neck. This occurred in 16 hips (14.5%) in our series, but the relevance of neck thinning to outcome in the longer term has yet to be established. A recent paper published by Hing et al\textsuperscript{35} which analysed a narrowing of the femoral neck using a slightly different method found that 77% of 163 resurfacing showed some narrowing, with 27.6% of their hips exceeding 10% narrowing at a mean follow-up of five years (4 to 6).

Our results, which include the surgeon’s learning experience with the BHR, show a 96.3% survival at five years and do not differ greatly from the results achieved by the surgeon-inventors group.\textsuperscript{1,3} This gives us confidence to continue using this implant.

We would like to thank Finsbury Orthopaedics for their help in making this project possible.

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References


