The results of primary Birmingham hip resurfacings at a mean of five years
AN INDEPENDENT PROSPECTIVE REVIEW OF THE FIRST 230 HIPS

We report an independent prospective review of the first 230 Birmingham hip resurfacings in 212 patients at a mean follow-up of five years (4 to 6).

Two patients, one with a loose acetabular component and the other with suspected avascular necrosis of the femoral head, underwent revision. There were two deaths from unrelated causes and one patient was lost to follow-up. The survivorship with the worst-case scenario was 97.8% (95% confidence interval 95.8 to 99.5). The mean Harris hip score improved significantly (paired t-test, p < 0.05) from 62.54 (8 to 92) pre-operatively to 97.7 (61 to 100) at a mean of three years (2.1 to 4.3), then deteriorated slightly to a mean of 95.2 (47 to 100) at a mean of five years. The mean flexion improved from 91.5˚ (25˚ to 140˚) to 110.4˚ (80˚ to 145˚) at a mean of three years with no further improvement at five years (111.2˚; 70˚ to 160˚).

On radiological review at five years, one patient had a progressive lucent line around the acetabular component and six had progressive lucent lines around the femoral component. An overall survival of 98% reported at the centre of inception.

Our results with the Birmingham hip resurfacing continue to be satisfactory at a mean follow-up of five years.

The Birmingham hip resurfacing implant (BHR; Smith and Nephew-MMT, Birmingham, United Kingdom) has been available for the treatment of the young active patient with osteoarthritis (OA) since 1997. Early results with this implant have been encouraging with an overall survival of 98% reported at the centre of inception.

In Australia hip resurfacing now accounts for 7.5% of total hip replacements (THR) with a revision rate of 2.2% compared with 1.9% for THR. The most common reason for revision is fracture of the femoral neck in the early post-operative period. Other concerns associated with hip resurfacing include avascular necrosis, an increased incidence of heterotopic ossification and for metal-on-metal articulations in general, raised serum cobalt and chromium levels. The significance of the latter is unknown. Potential risks include metal hypersensitivity or toxicity, osteolysis and mutagenesis, but the long-term biological effects have yet to be defined conclusively.

Our independent review at three years confirmed better clinical and radiological results than those of the earlier generation of resurfacings at the same length of follow-up and we now present the results at a mean of five years of this cohort of patients.

Patients and Methods
Between April 1999 and June 2001, 230 consecutive primary BHRs were performed in 212 patients (140 male, 72 female) at our institution. The mean age at operation was 52.1 years (18 to 82). The mean height was 172.18 cm (150 to 195) and the mean weight was 80.62 kg (55 to 110), with a mean body mass index of 27.02 kg/m² (16.2 to 45.3). This group represents the first BHRs undertaken by the three senior authors (AJS, DAY, RED). The pre-operative diagnoses included OA, rheumatoid arthritis, avascular necrosis (AVN) and metabolic disease. Initial criteria for consideration for BHR were pain, limping, and limitation of daily activities in active men under the age of 75 years and active women under the age of 60 years. Outside these age
groups patients were considered to be suitable for a BHR on an individual basis. Relative contraindications included osteopenia, osteoporosis, poor proximal femoral bone stock, an abnormal proximal femoral anatomy and a leg-length discrepancy greater than 3 cm. Absolute contraindications included renal impairment due to the potential accumulation of metal ions, a known metal hypersensitivity and long-term steroid medication. Informed consent was obtained from all patients.

In total, there were 116 right and 114 left hips. In 17 patients bilateral resurfacings were included in the study. In one further patient with bilateral staged resurfacings only one hip was included in the study, the other having been implanted outside of the study time. A further 14 patients had previously had a THR before undergoing a BHR on their second hip.

**Operative technique.** The previously described operating technique using a posterior approach was used by the three senior authors (AJS, DAY, RED).14 The size of the acetabular component ranged from 44 mm to 66 mm and only one dysplasia component was used. The femoral components were 6 mm or 8 mm smaller than the acetabular component with which they articulated.

**Clinical analysis.** Pre-operative assessment included a Harris hip score (HHS)15 (the patients filled in question responses and author (CBH) measured angles with a goniometer), the short form-12 score (SF-12)16 and measurement of Charnley grades.17 Post-operative evaluation at a mean follow-up of three years and five years also included an Oxford hip score.18

**Radiological analysis.** Anteroposterior (AP) and lateral radiographs with a standard magnification of 115% were taken pre-operatively, at a mean of three years (2.1 to 4.3) and at a mean of five years (4 to 6) post-operatively were assessed by two independent observers (CBH, DLB) who were blinded to the patient details. Radiolucent lines were recorded around the femoral component as described by Amstutz et al19 and around the acetabular component according to DeLee and Charnley20 (Fig. 1). In addition, the pre-operative femoral neck-shaft angle and the post-operative stem femoral shaft angle were also measured21 (Fig. 1). The femoral implant was considered to be valgus if the femoral shaft angle was greater than the femoral neck-shaft angle by > 5˚ and varus if it was less by > 5˚. The abduction angle of the acetabular component was also recorded (Fig. 1) and the position of the stem relative to the femoral neck assessed on the lateral radiographs.14 The presence of heterotopic bone on AP and lateral radiographs was classified according to Brooker et al.22

**Statistical analysis.** Data were collected by independent observers (CBH, DLB) using Orthowave database software (Orthowave; Epinet, CRDa, Bruay, France). Statistical analysis was performed by an independent statistical consultant (MB) on data identified only by study participation numbers using SAS version 8.2 (SAS Institute Inc., Cary, North Carolina). Comparisons between groups were made using the chi-squared test for equal proportion, paired t-test, Student’s t-test and the Wilcoxon rank-sum tests when appropriate. A survival analysis was performed using a life table with failure defined as revision for any reason.23 Comparisons between Charnley groups were made using a one way analysis of variance (ANOVA).

The reliability of radiological measurements was determined by the two observers repeating the measurements on two separate occasions. An intraclass correlation coefficient was used to determine inter- and intraobserver
reliability. Logistic regression analysis was first used to compare the radiological features of radiolucent lines, notching and reactive sclerosis with all other variables to determine relevant predictors of failure. Multivariate models were determined using a stepwise selection procedure and validated using a backwards elimination procedure with the change in risk associated with each predictor variable presented as odds ratio. A two-sided p-value of 0.05 was considered to be statistically significant.

Results
Two patients died from unrelated causes but had well-functioning hips at their last review, and two had a revision procedure. The mean time to the latest follow-up of the remaining 226 hips was five years (4 to 6). One patient was lost to follow-up. Questionnaires were returned regarding 222 hips (98.2%), 208 (92.0%) were available for clinical review and 220 (97.3%) for radiological review. Those patients who were unwilling or unable to return questionnaires or to attend a clinical or radiological review were contacted and they confirmed that their implant had not been revised.

Clinical. The pre- and post-operative HHS and SF-12 scores according to the Charnley grade are summarised in Tables I and II. The mean HHS at five years was 95.24 (47 to 100) compared with 97.7 (60 to 100) which was statistically significant (paired $t$-test, $p = 0.001$). There was a significant change (paired $t$-test, $p = 0.0003$) in the SF-12 physical scores with a score of 53.9 (31.2 to 60.5) at three years and of 52.18 (16.3 to 62.9) at five years. There was significant change (paired $t$-test, $p = 0.009$) in the SF-12 mental score at five years of 55.5 (21.5 to 66.6) compared with that of 57.1 (31.6 to 64.6) at three years. The mean Oxford hip score at five years was 14.2 (12 to 32) compared with 13.5 (12 to 28) at three years, which was statistically significant (paired $t$-test, $p = 0.006$). The change in

TABLE I. Pre- and post-operative mean Harris hip score$^{15}$ according to the Charnley grade$^{17}$

<table>
<thead>
<tr>
<th>Charnley grade</th>
<th>Number of BHRs$^*$</th>
<th>Pain</th>
<th>Movement</th>
<th>Function</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-operative</td>
<td>162</td>
<td>21.2</td>
<td>7.9</td>
<td>34.8</td>
<td>63.9</td>
</tr>
<tr>
<td>3 years</td>
<td>162</td>
<td>43.3 $^\dagger$</td>
<td>8.9</td>
<td>45.5 $^\dagger$</td>
<td>97.7 $^\dagger$</td>
</tr>
<tr>
<td>5 years</td>
<td>95</td>
<td>42.0 $^\dagger$</td>
<td>8.6</td>
<td>46.1 $^\dagger$</td>
<td>96.7 $^\dagger$</td>
</tr>
<tr>
<td>B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-operative</td>
<td>53</td>
<td>16.3</td>
<td>7.6</td>
<td>32.3</td>
<td>56.2</td>
</tr>
<tr>
<td>3 years</td>
<td>52</td>
<td>43.9 $^\dagger$</td>
<td>8.8</td>
<td>48.7 $^\dagger$</td>
<td>99.4 $^\dagger$</td>
</tr>
<tr>
<td>5 years</td>
<td>87</td>
<td>42.5 $^\dagger$</td>
<td>8.4</td>
<td>45.7 $^\dagger$</td>
<td>96.6 $^\dagger$</td>
</tr>
<tr>
<td>C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-operative</td>
<td>15</td>
<td>20.7</td>
<td>8.8</td>
<td>35.3</td>
<td>64.8</td>
</tr>
<tr>
<td>3 years</td>
<td>14</td>
<td>36.7 $^\dagger$</td>
<td>8.3</td>
<td>40.5 $^\dagger$</td>
<td>85.5 $^\dagger$</td>
</tr>
<tr>
<td>5 years</td>
<td>42</td>
<td>39.5 $^\dagger$</td>
<td>8.2</td>
<td>42.4 $^\dagger$</td>
<td>90.1 $^\dagger$</td>
</tr>
</tbody>
</table>

* BHRs, Birmingham hip resurfacings
$^\dagger$ significant difference (one way ANOVA, $p < 0.05$) in the Charnley grades

TABLE II. Pre- and post-operative mean Short-form 12 (SF-12)$^{16}$ scores according to the Charnley grade

<table>
<thead>
<tr>
<th>Charnley grade</th>
<th>SF-12 physical</th>
<th>SF-12 mental</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-operative</td>
<td>31.1 (16.3 to 62)</td>
<td>58.6 (25 to 62)</td>
</tr>
<tr>
<td>3 years</td>
<td>54.1 $^\dagger$ (31.2 to 60.6)</td>
<td>56.9 (32.8 to 64.7)</td>
</tr>
<tr>
<td>5 years</td>
<td>53.7 $^\dagger$ (29.5 to 62.0)</td>
<td>56.1 (21.6 to 62.6)</td>
</tr>
<tr>
<td>B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-operative</td>
<td>30.3 (16.4 to 52)</td>
<td>60.5 (28 to 65)</td>
</tr>
<tr>
<td>3 years</td>
<td>54.1 $^\dagger$ (35.5 to 57.6)</td>
<td>57.7 (31.6 to 63.3)</td>
</tr>
<tr>
<td>5 years</td>
<td>53.5 $^\dagger$ (29.3 to 63)</td>
<td>55.4 (26.7 to 65.8)</td>
</tr>
<tr>
<td>C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-operative</td>
<td>31.5 (16.4 to 52)</td>
<td>52.2 (28 to 65)</td>
</tr>
<tr>
<td>3 years</td>
<td>48.2 $^\dagger$ (31.7 to 58.6)</td>
<td>55.9 (45.6 to 61.1)</td>
</tr>
<tr>
<td>5 years</td>
<td>45.9 $^\dagger$ (16.3 to 57.7)</td>
<td>53.3 (29.0 to 66.6)</td>
</tr>
</tbody>
</table>

* significant difference ($p < 0.05$) in the Charnley grades

Graph showing the pre- and post-operative mean (SD) hip flexion over five years.
mean flexion with time is shown in Figure 2; there was no significant difference (paired \(t\)-test, \(p = 0.09\)) between that at five years and at three years. Comparing the Charnley groups at five years, there was a significant difference in the HHS, SF-12 physical and Oxford scores and the range of flexion in the groups (Tables I and II). Multiple regression analysis showed no correlation between the worsening HHS at five years; age (\(p = 0.18\)), diagnosis (\(p = 0.97\)), migration of the implant (\(p = 0.42\)) or the presence of radiolucent lines around the component (\(p = 0.81\)).

Complications. The immediate post-operative complications have been previously described\(^{14}\) and were similar to those in other series.\(^{1,2}\) Of five patients with a nerve palsy (two sciatic, two femoral and one common peroneal nerve), all had recovered by the review at five years. Occasional painless clicking was reported in 52 hips (23%) and 12 (5.3%) had a painless squeaking at five years. There was no association between clicks or squeaks and radiolucent lines or migration of the femoral component. A sensation of ‘slipping’ of the BHR while standing still, which was uncomfortable but did not lead to instability, was reported in three hips.

One patient sustained a dislocation at four years. She had a spinal tumour excised three years after her BHR which had left her with loss of power, sensation and proprioception in the affected leg and was thought to have contributed to her dislocation. After reduction of the dislocation she continued to suffer episodes of subluxation with no further dislocations and was able to walk with a walking aid.

Failures. Two patients underwent revision. One has been previously described,\(^{14}\) a 42-year-old man with Charnley grade-C OA who underwent revision of a loose acetabular component to a THR at 18 months after the initial operation. A second patient, a 36-year-old woman with a BMI of 21.1 kg/m\(^2\), had a BHR for OA, but continued to complain of pain and was revised to a THR by an independent surgeon not involved in the primary surgery at 57 months after the initial operation. At operation cystic changes were noted in the femoral head and AVN was suspected. No histological analysis was available to confirm this.

Radiological. There were 220 complete sets of radiographs available for review. Intra- and interobserver measurement reliability for the angle of the stem, acetabular inclination angle and Brooker grade was determined using an intraclass correlation coefficient. The measurement reliability is summarised in Table III with all measurements showing at least substantial agreement (intraclass correlation coefficient > 0.6). Radiological magnification varied with measurement variability of 5 mm and therefore no measurements of radiolucent lines or thickness of the cystic area were made.

Radiolucent lines in zone 1 as described by DeLee and Charnley\(^{20}\) were found in four hips (Fig. 3). In one patient this radiolucent area appeared to have worsened since the previous review in 2005.\(^{14}\) The mean abduction angle of the acetabular component at five years was 44.5° (30° to 68°) compared with 45.8° (37° to 65°) at three years. This difference was not statistically significant (paired \(t\)-test, \(p = 0.08\)).

Radiological review of the femoral component showed that 17 hips (7.7%) had radiolucent lines in the zones described by Amstutz et al,\(^{19}\) six of which had progressed since the previous review\(^{14}\) (Fig. 4). A radiolucent area had formed in the femoral head or neck since the last review in 12 hips (5.5%), of which five appeared to show an increase in severity over the last two years (Fig. 5). Multiple regression analysis showed that reactive sclerosis and the presence of post-operative notching of the femoral neck were both significant predictors for the presence of radiolucent lines with an odds ratio (OR) of 3.45 (95% confidence intervals (CI) 1.41 to 8.48) and 2.88 (95% CI, 1.06 to 7.87), respectively.
Evidence of reactive sclerosis in Amstutz zone 2 which appeared to be non-progressive was seen in 37 hips (16.8%) (Fig. 6). Of the six hips (2.7%) which had evidence of notching on the immediate post-operative radiographs, five still had notching at their most recent review and the other had been lost to follow-up. Evidence of post-operative superolateral notching was seen in 23 hips (10.5%) and 18 (8.2%) had post-operative inferomedial notching of the femoral neck (Fig. 7). Significant narrowing of the femoral neck was found in two hips (1%), one of which had evidence of a notch on the immediate post-operative radiograph and one which had a notch that progressed to an undisplaced fracture, was treated conservatively, and united. Four patients had evidence of an avulsion fracture of the lesser trochanter.

At five years an overall varus alignment of the femoral component was noted with a mean of 0.8˚ (-20˚ to 18˚) when compared with the pre-operative neck-shaft angle and valgus alignment of a mean 2.9˚ (-20˚ to 18˚) at three years. This difference was statistically significant (paired t-test, $p = 0.006$). Migration of the femoral component into > 5˚ of varus occurred in 18 (8.2%) of the hips (mean -5.3˚; 95% CI, 2.1 to -8.5). A linear regression analysis showed that radiolucent lines around the stem of the femoral component were a significant predictor of varus migration. Femoral components with radiolucent lines migrated a mean of 3.8˚ more (total at five years) than those without (Student’s t-test, $p = 0.008$). There was no significant association of varus alignment with adverse clinical outcome. On the lateral radiograph, 115 components (52%) had an overall anterior alignment and there was no significant difference in the position of the implant when comparing radiographs at a mean of five years with those at three years (paired t-test, $p = 0.13$).

There was no significant difference in heterotopic ossification (HO) when comparing radiographs taken at a mean of five years with those at three years (paired t-test, $p = 0.06$). No further fractures of the femoral neck occurred during the time from radiological review at a mean of three years to the latest review.

**Radiological risk of failure.** The radiographs of four hips were considered to show implants at risk of failure due to 

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**Fig. 4**

Diagram showing the distribution of radiolucent lines in zones 1, 2 and 3 of Amstutz et al. in 17 patients.

**Fig. 5a**

Radiographs showing a radiolucent area (arrow) in the superior aspect of the femoral neck in a 27-year old woman, which had progressed from a) three years post-operatively to b) five years after Birmingham hip replacement.
Progressive radiological changes. In the first patient, a 27-year-old woman who had a BHR for OA, a radiolucent area was noted in the femoral neck at five years. Clinically, she had 100° of flexion, an HHS of 94, an Oxford hip score of 14, no complaints of pain and did not play any sports (Fig. 5). The second patient was a 62-year-old woman who had an initial diagnosis of OA. At four years after a BHR she had progressive radiolucent lines in Amstutz zones 1 and 2 and an inferior notch (Fig. 7). She had an HHS of 94 with 90° of flexion. In the third patient, a 61-year-old woman with an initial diagnosis of OA, there was evidence of progressive narrowing of the neck and a varus placement of her femoral component which appeared to be well fixed at five years after the BHR. The fourth patient was a 45-year-old man with a BMI of 37.6 kg/m², an initial diagnosis of AVN, radiolucent lines in Amstutz zones 1, 2 and 3 and a radiolucent zone in the inferior aspect of the neck which had progressed over the last two years. He had an HHS of 81, 100° of flexion and continued to work. While these patients had implants thought to be at risk of failure, they were asymptomatic and remain under review.

**Survivorship.** The cumulative survival rate at a mean of five years was 99.1% (95% CI, 97.1 to 100) with two patients revised. When considering the one patient who was lost to follow-up and the two patients who had died, if a worst-case scenario is assumed of failure in these patients, the survival at five years is 97.8% (95% CI 95.8 to 99.8).

**Discussion**

Recent reports of the newer generation of hip resurfacings have shown favourable early results as a result of improved design and metallurgy.1-3,14,24 The proposed advantages of hip resurfacing include preservation of bone stock, more reliable restoration of physiological biomechanics and a lower rate of dislocation.25-27 Early complications reported in the literature include fracture of the femoral neck, AVN, metal hypersensitivity and an increased incidence of HO.4,5,9,10,28,29 Our series continues to show good short-term survivorship of approximately 98% in agreement with previous studies.1,2,14 While we have identified cases of fracture of the femoral neck, AVN and HO in our series of 230 hips, no cases of metal hypersensitivity were found. In addition, we have reported the presence of reactive sclerosis and narrowing of the neck with the latter described in more detail in an earlier paper.30 Our rate of fracture was lower than the national average of 0.98% for males.3,5 We found that the undisplaced fracture of the femoral neck treated conservatively went on to union in agreement with previous studies.6,31 We had one episode of dislocation in a patient with a spinal tumour and the patients with HO continued to have a good functional outcome with no progression of the condition.

Radiological review at a mean of five years showed that non-progressive reactive sclerosis in Amstutz zone 2 was present in 17% of patients (Fig. 6). Reactive lines in well-fixed prostheses have previously been described in uncemented THR, cemented total knee replacement and BHR.32-34 They were found to be related to the distal polished part of the femoral stem in 78% of cases and to be non-progressive and not associated with failure of the THR.32 Freeman et al33 have shown histologically that reactive lines in well-fixed components consist of a thin (< 300 µm) connective-tissue layer comprising occasional macrophages and giant cells, but no other inflammatory cells. Biochemical studies of resurfacing hip arthroplasty by finite-element analysis has demonstrated stress concentration around the stem during midstance which may account for remodelling and increased bone density in this area.35 In our study a logistic regression analysis has shown an association between reactive sclerosis and radiolucent lines (OR 3.45, 95% CI, 1.41 to 8.48), but no association with migration of the femoral component, or adverse clinical outcome. Reactive sclerosis would appear to be a benign radiological feature from the evidence at five years, but further review is required to determine if it is a precursor to radiolucent lines and varus migration of the femoral component with time. We disagree with the conclusion of Pollard et al34 that reactive sclerosis and radiolucent lines represent AVN within the femoral head. Our prospective study showed no association of cystic changes within the neck and adverse radiological features such as migration of the component.

Our study has shown that 8% of femoral components migrated into > 5° of varus with radiolucent lines being a sig-
significant predictor of migration (five-year figures). Radiographs with radiolucent lines showed a mean migration with varus of 3.8° more than those without lucent lines. While migration of the femoral component was not associated with adverse clinical scores or pain, it may be a precursor to failure and these patients will be kept under careful review. The proportion of femoral components migrating matched the findings of Pollard et al.34 We also found a significant association of reactive sclerosis and superolateral notching of the femoral neck with radiolucent lines (OR 3.45, 95% CI, 1.41 to 8.48 and 2.88 95% CI, 1.06 to 7.87), respectively but no association with migration. This may indicate that the presence of reactive sclerosis and a superolateral notch increase the risk of developing radiolucent lines and migration, but this cannot be proved from the data at five years.

There was no association of superolateral notching with migration, indicating that this feature was not a secondary phenomenon of ‘uncovering’ of the femoral head after migration of the femoral component. Furthermore, while superolateral notching was associated with the presence of radiolucent lines, inferomedial notching was not. The postoperative notches found in both the superolateral and inferomedial regions of the femoral neck were not associated with pain or the range of movement of the hip. This implied that they were not caused by impingement of the femoral neck on the margin of the acetabular component, but may have been due to stress shielding by the components causing remodeling. This is an agreement with finite-element analysis using cadaver models which indicated bone resorption resulting from stress shielding in the bone underlying the implant in both superolateral and inferomedial regions of the femoral neck.36-38 Further ongoing radiological review is required to determine whether the neck continues to remodel with time or whether post-operative notching is a risk factor for failure.

We encountered one failure with revision for pain in which macroscopic evidence of AVN could be seen, and one patient thought to have an implant at risk of failure with marked cystic changes in the superior aspect of the femoral neck associated with a well-fixed component. The effect of resurfacing on the vascular supply and oxygenation to the femoral head and neck remains controversial. The oxygen concentration in the femoral head decreases during resurfacing to a variable extent39 and may or may not recover. Osteonecrosis has been noted in retrieved femoral heads after failed resurfacing, but the degree of vascular compromise in well-functioning implants is not known.28 Freeman40 and Whiteside et al41 described the effect of surgery on the blood supply to the femoral head and concluded that a vascular anastomosis develops between the epiphysis and metaphysis in osteoarthritic hips, so that stripping of the retinaculum does not devascularise the head. However, simulated notching of the femoral neck has been shown to reduce the blood supply to the femoral head implying that vascularity in the osteoarthritic head may still rely predominantly on extrasosseous vessels with damage predisposing to

![Fig. 7a](image1.png)

Radiographs showing an inferomedial notch (arrows) present at a) two years post-operatively and b) with progressive radiolucent lines in Amstutz zones 1 and 2 at the latest review, four years post-operatively.
Neither of our two patients described had intraoperative notching of their femoral neck to account for the cystic changes which developed.

We have presented the results at five years of the first 230 BHRs to be performed in our unit. Our findings continue to be favourable with 97.8% survivorship at a mean of five years after operation. We have had two failures and have identified four implants thought to show radiological signs of possible failure, but with a good clinical score being maintained. Together with the rest of the series, further clinical and radiological review is required. We have identified reactive sclerosis, superolateral notching of the femoral neck and radioluent lines as features of interest which may indicate implants at risk of failure, but the only feature found to be significantly associated with migration of the femoral component into varus was the presence of radiolucent lines around the stem of the femoral component.

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References