Incidence of adverse wear reactions in hip resurfacing arthroplasty: a single surgeon series of 2,600 cases

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ABSTRACT: A single surgeon performed 2,559 metal-on-metal hip resurfacing arthroplasties in 2,109 patients. The Corin Cormet 2000 (393 cases) and Biomet Recap implants (2,166 cases) were used in our series. In this study, the adverse wear failure (AWF) rate was 0.27%. At 10 years postoperatively, our Kaplan-Meier cumulative revision rate for AWF was 1% for all patients, 0.2% for men, 2.6% for women, and 9% for patients with a diagnosis of dysplasia. All AWF failures had component sizes ≤48 mm. All had metal ion levels above 15 ug/ml. All had acetabular inclination angles (AIA) ≥50° on standing pelvis radiographs. All had severe metallosis found at the time of revision. Six of the seven AWF cases were in women. There were no failures from pseudotumours without AWF (metallosis) in this series.

KEY WORDS: Hip resurfacing, Adverse wear, Pseudotumour, Hip arthroplasty, Metal-on-metal

INTRODUCTION

Several clinical series have investigated the incidence of pseudotumours around hip resurfacing (1-3), reporting rates varying from 0.1% to 1.8%. The Kaplan-Meier failure rate for pseudotumour was calculated at 4% at eight years in one series. It is not clear how much overlap exists between the clinical sign of a pseudotumour or the surgical diagnosis of adverse wear (AWF).

The in vitro volumetric wear rate for metal-on-metal bearings has been demonstrated to be 100 fold lower than traditional metal-on-polyethylene THR bearings (1). There has been concern that the metal ions released from these bearings may lead to some negative effect on the human body such as cancer, renal failure, or cardio toxicity (2-4) but current scientific evidence has not supported these hypotheses (5-7). In addition, numerous retrieval studies that have shown inflammatory tissue reactions around failed metal bearing implants (8, 9) however whether inflammatory reactions are more common around metal-on-metal bearings than other bearing types has not been shown. Recently, a unique type of inflammatory reaction has been described around metal-on-metal bearings by some authors (8, 10). They have been characterised as acute lymphocytic vasculitis associated lesions (ALVAL) (11). Some reports have suggested that metal ions in patients’ tissues may incite a lymphocyte-based immune response (5, 12, 13). However, neither skin sensitivity tests, blood lymphocyte activation tests, nor pathologic findings of ALVAL have been clinically validated as diagnostic tests for clinical metal hypersensitivity to wear debris of implants (14, 15).

We evaluated our database OrthoTrack (Midlands Orthopaedics, p. a., Columbia, SC, USA) for the incidence of failure due to adverse wear (AWF) or other pseudotumours. We considered pseudotumours to be present when there was evidence of a mass, either solid or cystic, that encompassed areas of chronic inflammation and tissue necrosis histologically with no evidence of primary failure due to other previously recognised causes. We considered these pseudotumours to be adverse wear failures (AWF) if
prominent metallosis was seen at the time of revision surgery. We had three hypotheses. The first was that pseudotumour was an uncommon failure mode for hip resurfacing. Secondly, that pseudotumours not associated with metallosis (adverse wear) were rare. Finally, that adverse wear failure was directly related to steeply inclined acetabular component inclination.

PATIENTS AND METHODS

Much confusion and controversy exists surrounding various terms used to describe inflammatory lesions seen in conjunction with metal bearings. Therefore we needed to clarify our terms carefully. Like others (1-3) we considered a pseudotumour to be present when there was evidence for a mass, either solid or cystic, that encompassed areas of chronic inflammation and tissue necrosis, severe enough to require revision. When the inflammatory mass contained significant metallosis in the presence of a metal-on-metal resurfacing there are two possible sources of metallosis: excess bearing wear and backside wear of a loose implant (in total hips there may also be trunion wear/corrosion). Therefore, when implants were well fixed, AWF (excess bearing wear) was the diagnosis. When a loose implant was also present, the cause of failure was less certain. In reality, a pseudotumour is actually a clinical sign; it is not truly a valid diagnostic category. There may be numerous causes for swelling around artificial implants. The hypothesis of allergic responses to metal has been advanced to explain these swellings (1). The possible causes of inflammatory reactions around implants are: AWF (excess bearing wear), loose implant, unrecognised infection, allergic response to normal wear debris, and numerous other benign causes (trochanteric bursitis, abductor tear, deep bleeding from trauma). It is known how often there may be benign unexplained swelling around implants. This report, as in previous series, did not consider minor swellings that were not revised (1-3).

In summary, at the time of revision surgery, all severe inflammatory swellings are termed pseudotumours. The presence of metallosis indicates either excess bearing wear or excess backside wear of a loose implant. AWF is defined as those cases where excess bearing wear is the most likely cause.

We have therefore defined adverse wear failure (AWF) as a surgical diagnosis made at the time of revision surgery with the findings of grey metallosis, milky fluid under pressure and reactive tissue inflammation. We suspect that these are caused by implant malposition, edge loading and excess bearing wear. When AWF is seen with well fixed implants, it is likely that the cause is excess bearing wear due to component malposition, if a loose implant is also present, the cause of the AWF is less certain. All complications and failures were recorded, including those that had revisions elsewhere (which were subsequently investigated). For locally revised cases, a final determination of the cause of failure was made at the time of revision surgery. Cases with metallosis were recorded. The AWF cases were also reviewed histologically.

This is a retrospective analysis of prospectively collected data. Approval for this study was obtained from our institutional review board. Between July 1999 and August 2011, 2,559 metal-on-metal hip resurfacing arthroplasties were performed in 2,109 patients by the senior author (TPG). A follow-up rate of 95% was achieved. Of 2,109 patients, 1,853 (72%) were male and 706 (28%) female. Eighteen patients (18 cases) died due to causes unrelated to their hip arthroplasty. At the time of death no implants had undergone revision. Mean patient age was 51 ± 8 years (range 11-78 years). The primary diagnosis was osteoarthritis in 1,970 (77%) cases, dysplasia in 280 (11%) cases, osteonecrosis in 158 (6%) cases, post trauma in 41 (2%) cases and other diagnoses in the remaining 110 (4%) cases. Four different implant types from two manufacturers were used. The first 20 (1%) cases used the uncemented Corin Cormet 2000 implant (Corin Group, Cirencester, Gloucestershire, UK) (16); the next 373 (16%) used hybrid Corin Cormet 2000 implants (9), the following 740 (31%) used hybrid Biomet Recap/Magnum implants (Biomet, Warsaw, IN, USA), and the latest group Biomet Recap/Magnum implants in 1,426 (56%) cases (17). Mean femoral component size was 50 ± 4 mm (range 40-64 mm); the most commonly implanted size was 52 mm for males and 44, 46 and 48 mm for females (approximately 28% for each size) (Fig. 1).

Postoperative follow-up including standard clinical questionnaires (including the Harris hip score, VAS pain scores and UCLA activity score) and radiographs at six weeks, one year, two years and yearly thereafter. Radiographic measurement of the acetabular inclination angle (AIA) was undertaken. Component anteverision was not measured on plane radiographs, as we believe, even with EBRA (Einzel Bild Roentgen Analyse) this is inaccurate. Langton has validated EBRA with a cadaver study, while...
Incidence of adverse wear reactions

All seven cases had either a preoperative MRI or CT confirming an inflammatory mass.

Statistical methods

In this study, the level of significance \( \alpha \) was defined as 0.05. Numerical variables were grouped as categorical data with the use of the thresholds suggested (1). Age was divided into two categories: <40 or \( \geq 40 \); implant size was separated into small (\( \leq 46 \text{ mm for women and } \leq 50 \text{ mm for men} \)) and large (>46 mm for women and >50 mm for men) groups as suggested by one previous clinical series (1); the primary diagnosis was grouped into three categories: osteoarthritis, dysplasia or others. A separate analysis undertaken for size where we simply defined large as any implant >48 mm, regardless of gender. The independent t-test was used to calculate the statistical difference between numerical data and the Chi-square test was performed to evaluate the statistical significances between categorical variables. Failures were presented in two ways: first as the number of revisions divided by the entire case number in the study group; secondly, as Kaplan-Meier survival analyses, in order to take time of revision after primary surgery into consideration. Endpoints were revision for AWF or revision for other causes. Also, Log-Rank tests were used to approximate the Chi-square tests to confirm the hypothesis that the survival functions between groups are the same across groups with weighting more on the longer survival times. Because we had a very small number of revisions due to AWF, Cox proportional hazards regression analysis could not be used. All the analyses were performed with use of OrthoTrack and JMP (SAS, Cary, North Carolina).

RESULTS

Incidence of revision for AWF and pseudotumour

Seven cases (0.27%) (six female patients and one male patient) out of 2,559 cases were diagnosed as AWF at the time of revision surgery (Fig. 2). There were two cases in our series where AWF was seen in conjunction with a loose component. In these cases it was not clear if the primary cause of failure was adverse bearing wear causing metallosis, or if the implant suffered failure of bone ingrowth first (loose implant) and then backside wear lead...
to the metallosis. One case was assigned a primary diagnosis of AWF and included in the seven cases of primary AWF, and the other was assigned the primary diagnosis of failure of acetabular bone ingrowth (loose implant). We encountered no (0/2669) cases of pseudotumour without metallosis.

If the reader wished to reassign these cases (AWF rate of 6/2559 = 0.23% vs. AWF rate of 8/2559 = 0.31%).

The histology on all seven adverse wear failures was reviewed; this revealed features of ALVAL including a non-specific inflammatory response characterised as fibrous tissue with blood vessels cuffed with lymphocytes. There were numerous macrophages. Metal staining was obvious to visual inspection and microscopically.

Metallosis was seen in only one of the 70 (2.7%) revisions due to other well-recognised causes of failure (discussed below). As mentioned above, this case was not assigned as an AWF. Detailed information about AWF was listed in Table I. AWF was diagnosed two to seven years postoperatively in the present study. On anterior-posterior pelvis radiographs (Fig. 3), all of the AIAAs in the supine position were above 50° and all the angles in the standing position were above 55°, except in one case.

Risk factor analysis

If AWF revision was used as the only endpoint, the Kaplan-Meier survival curve was 99% for the whole cohort and was 97% for women at eight years or later. The Log-Rank test detected a significantly higher revision rate due to AWF among female patients (P<0.001). If grouped by component size based on a previous group’s gender specific definition (1), no significant difference due to AWF among small size patients was found (P = 0.22). However, if large

Fig. 2 - Debris due to adverse wear after hip arthroplasty from metal-on-metal hip resurfacing arthroplasty.

Fig. 3 - Acetabular inclination angles in: A) the supine; and B) standing position for a patient whose right hip failed due to adverse wear (Case 5).

### TABLE I - DETAILED INFORMATION FOR THE ADVERSE WEAR RELATED REVISIONS

<table>
<thead>
<tr>
<th>Case</th>
<th>Gender</th>
<th>Age at surgery (yrs)</th>
<th>Diagnosis</th>
<th>Side</th>
<th>Supine AIA (°)</th>
<th>Standing AIA(*)</th>
<th>Co level</th>
<th>Cr level</th>
<th>Implant</th>
<th>Femoral size (mm)</th>
<th>Time from HSR (yrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1*</td>
<td>F</td>
<td>46</td>
<td>Dysplasia</td>
<td>Left</td>
<td>56</td>
<td>63</td>
<td>14</td>
<td>15</td>
<td>Hybrid Corin Cormet 2000</td>
<td>48</td>
<td>7</td>
</tr>
<tr>
<td>2*</td>
<td>F</td>
<td>46</td>
<td>Dysplasia</td>
<td>Right</td>
<td>52</td>
<td>61</td>
<td>14</td>
<td>15</td>
<td>Hybrid Corin Cormet 2000</td>
<td>48</td>
<td>7</td>
</tr>
<tr>
<td>3</td>
<td>F</td>
<td>53</td>
<td>OA</td>
<td>Left</td>
<td>60</td>
<td>64</td>
<td>173</td>
<td>111</td>
<td>Hybrid Biomet Recap</td>
<td>46</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>M</td>
<td>55</td>
<td>OA</td>
<td>Right</td>
<td>57</td>
<td>59</td>
<td>81</td>
<td>38</td>
<td>Hybrid Biomet Recap</td>
<td>48</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>F</td>
<td>48</td>
<td>OA</td>
<td>Right</td>
<td>55</td>
<td>65</td>
<td>132</td>
<td>69</td>
<td>Uncemented Biomet Recap</td>
<td>44</td>
<td>4</td>
</tr>
<tr>
<td>6</td>
<td>F</td>
<td>55</td>
<td>OA</td>
<td>Left</td>
<td>50</td>
<td>53</td>
<td>159</td>
<td>75</td>
<td>Uncemented Biomet Recap</td>
<td>48</td>
<td>3</td>
</tr>
<tr>
<td>7</td>
<td>F</td>
<td>63</td>
<td>Dysplasia</td>
<td>Left</td>
<td>66</td>
<td>73</td>
<td>90</td>
<td>56</td>
<td>Uncemented Biomet Recap</td>
<td>44</td>
<td>2</td>
</tr>
</tbody>
</table>

* The same bilateral patient.
Incidence of adverse wear reactions

Incidence of revision for other causes

There were 70 (2.7%) revisions for other causes (not wear related): 22 (0.8%) due to acetabular component loosening; 19 (0.7%) due to femoral neck fracture; 16 (0.6%) due to femoral component loosening, five (0.2%) due to deep infection, one (0.04%) for psoas tendinitis and one for (0.04%) for subtrochanteric fracture and six for other causes (0.2%). At 10 years postoperative, the revision rate was 2.8% for femoral component loosening and 2.4% for acetabular component loosening compared to 1% for AWF, based on Kaplan-Meier survival curves plotted for the entire database (Fig. 4).

TABLE II - PATIENT DEMOGRAPHIC INFORMATION FOR REVISION DUE TO ADVERSE WEAR (CHI-SQUARED TEST USED TO CALCULATE P-VALUES)

<table>
<thead>
<tr>
<th>Gender (%)</th>
<th>No revision</th>
<th>Revision</th>
<th>Total</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male cases</td>
<td>1852 (99.9)</td>
<td>1 (0.1)</td>
<td>1853</td>
<td>0.001</td>
</tr>
<tr>
<td>Female cases</td>
<td>700 (99.2)</td>
<td>6 (0.8)</td>
<td>706</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Laterality (%)</th>
<th>No revision</th>
<th>Revision</th>
<th>Total</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unilateral</td>
<td>1657 (99.9)</td>
<td>2 (0.1)</td>
<td>1659</td>
<td>0.04</td>
</tr>
<tr>
<td>Bilateral</td>
<td>855 (95)</td>
<td>5 (5)</td>
<td>900</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Age (yrs) (%)</th>
<th>No revision</th>
<th>Revision</th>
<th>Total</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;40</td>
<td>213 (100)</td>
<td>0 (0)</td>
<td>213</td>
<td>0.27</td>
</tr>
<tr>
<td>≥40</td>
<td>2339 (99.7)</td>
<td>7 (0.3)</td>
<td>2346</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mean (SD)</th>
<th>No revision</th>
<th>Revision</th>
<th>Total</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>OA</td>
<td>1966 (99.8)</td>
<td>4 (0.2)</td>
<td>1970</td>
<td>0.05</td>
</tr>
<tr>
<td>Dysplasia</td>
<td>277 (98.9)</td>
<td>3 (1.1)</td>
<td>280</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>309 (100)</td>
<td>0 (0)</td>
<td>309</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Implant size (mm) (%)</th>
<th>No revision</th>
<th>Revision</th>
<th>Total</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small: ≤46 woman or ≤50 men</td>
<td>1127 (99.6)</td>
<td>4 (0.4)</td>
<td>1131</td>
<td>0.48</td>
</tr>
<tr>
<td>Large: &gt;46 woman or &gt;50 men</td>
<td>1425 (99.8)</td>
<td>3 (0.2)</td>
<td>1428</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Implant type (%)</th>
<th>No revision</th>
<th>Revision</th>
<th>Total</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uncemented</td>
<td>20 (100)</td>
<td>0 (0)</td>
<td>20</td>
<td>0.78</td>
</tr>
<tr>
<td>Corin Cormet 2000</td>
<td>371 (99.5)</td>
<td>2 (0.5)</td>
<td>373</td>
<td></td>
</tr>
<tr>
<td>Cemented Corin 2000</td>
<td>738 (99.7)</td>
<td>2 (0.3)</td>
<td>740</td>
<td></td>
</tr>
<tr>
<td>Biomet Recap</td>
<td>1423 (99.8)</td>
<td>3 (0.2)</td>
<td>1426</td>
<td></td>
</tr>
</tbody>
</table>

*Five adverse wear cases occurred in the patients, whose both hips had a metal-on-metal hip arthroplasty.

Fig. 4 - The Kaplan Meier survivorship curves for the entire patient group with different revision end points.

DISCUSSION

All three hypotheses were supported by the data. In a review of all failures in a single surgeon’s 12-year experience with 2,559 hip resurfacing cases, with 95% follow-up, we found only seven (0.27 %) cases in five women and one man that had been revised for AWF. All seven had metallosis, markedly elevated metal ion levels and AlAs of greater than 50° on standing anterior-posterior pelvis x-ray (5/7 AIA>60°). All seven of our AWF cases could also be called pseudotumours. All seven of our pseudotumour cases were actually wear-related failures as described by DeSmet (5, 20, 21). We emphasise that there were no other revisions for pseudotumours due to unexplained inflammatory reactions without metallosis in our series. The total number of revisions for this series was 77 (3.0%); only 9% (seven) of these were AWF. Because our follow-up rate was 95%, a worst-case analysis would place our adverse wear failure rate at 5.27%.

We compare our results to three other large clinical series dedicated to pseudotumours (1-3) (Tab. III). The first large clinical series (1) from Oxford University in 2009, reported 67 revisions for all causes and determined that 26 (40%) were caused by pseudotumours in a series of 1,419 hip resurfacings with a mean follow-up of four years (0-9 years). The incidence of pseudotumours was calculated at 1.8%. The Kaplan-Meier failure rate for pseudotumour was 4%
at eight years. They found that pseudotumours were not related to acetabular component malposition. Risk factors for pseudotumours were found to be female gender, age under 40, small component size (varying by gender) and diagnosis of dysplasia. They used the BHR (Birmingham Hip Resurfacing, Smith and Nephew), Conserve Plus (Wright Medical), Recap/Magnum (Biomet) and Cormet 2000 (Co-rin) implant systems. They did not employ the ASR (DePuy) device or the Zimmer (Durom), which been removed from the market due to high failure rates.

It is not clear whether their pseudotumours were wear-related failures, because the diagnosis of pseudotumour was made from retrospective review of imaging studies, operative reports, and histology. What specific histologic findings that were considered diagnostic were not specified. Metallosis was not reported. In three cases, the
Acetabular components were loose. In one case the loose component was found to be loose before the symptoms of pseudotumour occurred, in the others the symptoms reportedly occurred first. How the symptoms of loosening and pseudotumour were differentiated was not described. Radiographs were available on 25/26, but the specific view (AP hip vs. AP pelvis, supine vs. standing pelvis) was not reported. The number of surgeons contributing to the cases and their level of training was not disclosed. The percentage of patients who were lost to follow-up was not reported.

The second report (3) is a single surgeon series of BHR from Newcastle, UK published in 2009. In 670 hip resurfacings with 1-10 year follow-up a 0.15% incidence (2/670) of pseudotumours was found. Neither case had ALVAL on histology. Acetabular component position was reported as AIA = 49° and anteversion of 25° in one case with metallosis; no AIA was given in the second case without metallosis and a possibly loose femoral component. Rate of failure due to other causes and the percentage of patients lost to follow-up were not reported.

The third report (25) a Canadian multicentre study reported four pseudotumour cases in 3,432 hip resurfacings (0.1%) with a mean follow-up of 3.4 years (2-9 years). Pseudotumours were defined as destructive soft tissue or osseous reaction adjacent to the metal-an-metal hip resurfacing confirmed at revision surgery. No Kaplan-Meir survivorship rates were given. Five different resurfacing brands were used, including 15.6% ASR and 24.1% Cormet implants. Missing information included: the number of surgeons contributing to the cases and their level of training, histology, presence or absence of metallosis, radiographic data and rate of failure due to other causes. The percentage of patients who were lost to follow-up was also not reported.

The method of screening for adverse wear or pseudotumours other than routine clinical follow-up was not described in any of these studies. The percentage of patients lost to follow-up was not provided in any study. Therefore a worst-case analysis cannot be performed. Ion levels were not reported in any of the failures in any study. Metallosis was only described in one study. One paper did not report AIA.

DeSmet (20) defined the “arc of coverage” as the angle subtended by a vertical line and a line connecting the center of rotation and the edge of the acetabular component. This useful concept allows us to understand several underlying causes that can predispose patients to develop edge loading and subsequently AWF. DeSmet has shown that three factors result in lower arc of coverage: high inclination angle of the acetabular component, a low profile bearing arc in the acetabular design, and smaller components in most large metal bearing systems. Isaac studied wear in metal-on-metal bearings when acetabular components were placed at AIA greater than 55° in the laboratory and found that after several million cycles, the wear rate dramatically increased as edge loading began to occur (22). All metal-on-metal bearings have a wear scar on both components. The wear scar gradually expands over time. If the acetabular component is too vertically inclined, the wear scar eventually contacts the edge of the acetabular component at which point the wear rate increases dramatically.

In 1978, Lewinnek proposed a safe zone for reducing the incidence of dislocation in small bearing THA (23), which has become widely accepted. Because large metal-metal bearings are more stable, Lewinnek’s safe zone does not apply. However, we believe it would be useful to define a safe zone that applies to bearing wear in large metal bearings. At the present time, we are unable to accurately measure anteversion in these bearings without CT scans (19). Hart has shown that excessive anteversion does correlate with wear failure, but that anteversion is a less important factor than inclination (24). In our experience, we have only noticed AWF in smaller components that are inclined more than 50° on standing pelvis x-ray. We have not yet seen AWF in implants that were optimally placed. We are unable to take into account anteversion. According to our data, it is likely that a higher inclination angle than 50° may be acceptable in patients with larger bearing sizes. It is important to note that this inclination limit is implant specific, our data being based on the Recap/Magnum and Cormet implants.

Weaknesses in our study include incomplete follow-up (95%), incomplete ion level testing (62%), and lack of information on component anteversion on the failed cases. We have not undertaken routine screening for fluid collections, because of the expense involved and the lack of knowledge about the significance of possible findings of asymptomatic fluid collections. Although we recorded revisions undertaken elsewhere, we have only indirect information on their cause of failure; none had AWF. Adverse bearing wear is a serious clinical problem that often requires revision surgery. Although ours is the most complete study on this topic so far, our AWF rate may still
underestimate the true magnitude of the problem. Therefore, further study is recommended on ion testing and three-dimensional imaging to help us better understand the exact incidence and time course of adverse wear and fluid collections around implants. We do not yet fully understand when wear is excessive and requires revision and when fluid collections are benign or when they predict progressive tissue destruction. Our data confirms that the vast majority of severe tissue reactions are due to excess bearing wear, primarily caused by implant malposition rather than some type of allergic response.

In summary our data suggests the following conclusions. Adverse wear related failures (AWF) are uncommon with the Biomet and Corin resurfacing systems (0.27%, Kaplan-Meier 1% at 10 years).

Pseudotumours without metallosis are extremely rare with hip resurfacings (0/2559).

AWF were seen with the Biomet and Corin systems only if the AIA on standing pelvis XR was >50 degrees. (5/7 failures had AIA>60).

An inclination limit for placing the Biomet and Corin devices is: AIA<50 degrees on standing pelvis XR. This likely also applies to other well-designed systems.

AWF are more common in women, dysplasia, and when femoral components <48 mm are used. These factors may be interdependent.

We therefore conclude that hip resurfacing with Biomet and Corin implants is unlikely to result in AWF if the acetabular component is orientated with the AIA is under 50° on standing AP pelvis x-ray. In women with dysplasia that require small femoral components there is less margin for error in acetabular component positioning. We did not need to invoke speculative diagnoses such as allergy to explain our failures. Adequately designed components exist; it is now up to surgeons to learn to place them accurately and reproducibly to avoid AWF.

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