Hip Int 2013; 23 (3): 250-258 DOI: 10.5301/hipint.5000030

ORIGINAL ARTICLE

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

Thomas P. Gross, Fei Liu

Midlands Orthopaedics, p. a., Columbia, South Carolina - USA

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*

Accepted: January 4, 2013

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, 2559 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 anteversion 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

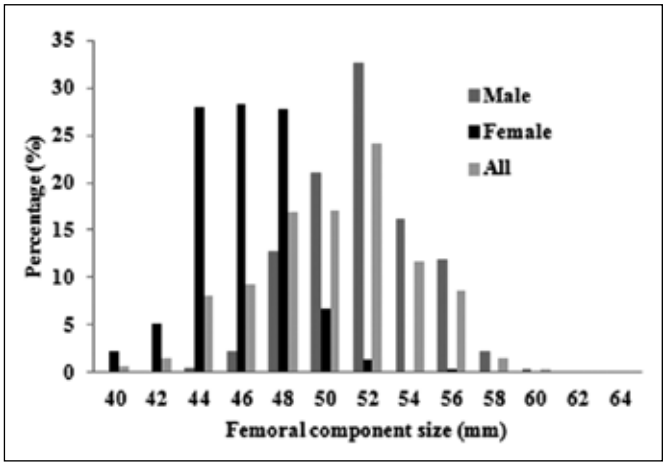

Fig. 1 - *Histogram representing the femoral component size used in the whole, male and female patient groups.*

Cobb has shown that it is not reliable when compared to CT (18, 19).

Routine blood ion level testing commenced in May 2009, 10 years after starting hip resurfacing. We contacted all patients who were beyond two years follow-up and recommended testing. Subsequently, prospective testing on all patients two years post surgery was undertaken. A single test at two years was chosen in order to account for the known 1-2 year run-in phase of wear with metal-on-metal bearings. A cutoff of 10 ug/L was used to trigger further investigation with three-dimensional studies. The cutoff level of 10 ug/L was chosen based on our personal experience; we have not yet seen a case of adverse wear failure with a level below 15 ug/L. Of those patients having reached a minimum of two years follow-up in our database, we have been able to obtain ion levels on 62%, resulting in approximately 1,600 ion tests. We do not present ion level analysis for several reasons. The focus of this report is as a clinical series to estimate the rate of AWF that can be expected in a large hip resurfacing practice. We wish to compare our rate of failure to those previously published in clinical series to aid the hip surgery community to establish a proper benchmark. Our ion level testing is not complete enough for formal inclusion in the analysis. Although much work has been done on ion level testing by others, a reference range has not yet been established. We do not yet have adequate data to propose a reference range ourselves. This will be the topic of future reports.

For all seven cases of AWF we evaluated supine and standing pelvic radiographs, blood metal ion levels and histology. All seven cases had either a preoperative MRI or CT confirming an inflammatory mass.

Statistical methods

In this study, the level of significance α 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 ≥40; implant size was separated into small (≤46 mm for women and ≤50 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

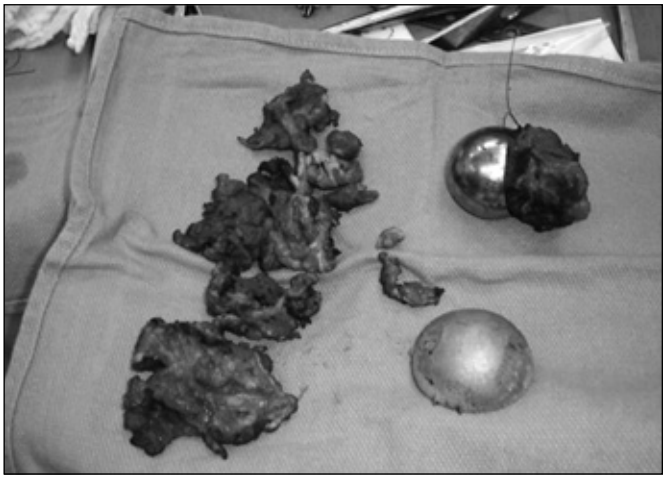

Fig. 2 - *Debris due to adverse wear after hip arthroplasty from metal-on-metal hip resurfacing arthroplasty.*

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.

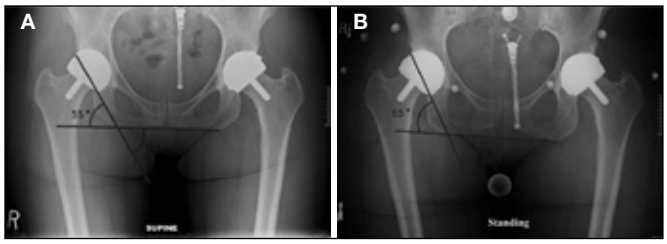

Fig. 3 - *Acetabular inclination angles in:* ***A)*** *the supine; and* ***B)*** *standing position for a patient whose right hip failed due to adverse wear (Case 5).*

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 AIAs 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

TABLE I - DETAILED INFORMATION FOR THE ADVERSE WEAR RELATED REVISIONS

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

* The same bilateral patient.

size was simply defined as components >48 mm, regardless of gender, then a significantly higher failure rate due to AWF was detected for small sizes (P<0.001). Log-Rank test also detected a significantly higher revision rate due to AWF in dysplasia patients compared to patients with other diagnoses (P<0.001). Risk analyses were listed in Table II.

Incidence of revision for other causes

There were 70 (2.7%) revisions 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 tendonitis 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)

	Revision for adverse wear			
	No revision	**Revision**	**Total**	**P-value**
Gender (%)				
Male cases	1852 (99.9)	1 (0.1)	1853	0.001
Female cases	700 (99.2)	6 (0.8)	706	
Laterality (%)				
Unilateral	1657 (99.9)	2 (0.1)	1659	0.04
Bilateral	855 (95)	5* (5)	900	
Age (yrs) (%)				
<40	213 (100)	0 (0)	213	0.27
≥40	2339 (99.7)	7 (0.3)	2346	
Mean (SD)	51 (±8)	52 (±6)	51 (±8)	
Diagnosis (%)				
OA	1966 (99.8)	4 (0.2)	1970	0.05
Dysplasia	277 (98.9)	3 (1.1)	280	
Other	309 (100)	0 (0)	309	
Implant size (mm) (%)				
Small: ≤46 woman or ≤50 men	1127 (99.6)	4 (0.4)	1131	0.48
Large: >46 woman or >50 men	1425 (99.8)	3 (0.2)	1428	
Implant type (%)				
Uncemented Corin Cormet 2000	20 (100)	0 (0)	20	0.78
Cemented Corin Cormet 2000	371 (99.5)	2 (0.5)	373	
Cemented Biomet Recap	738 (99.7)	2 (0.3)	740	
Uncemented Biomet Recap	1423 (99.8)	3 (0.2)	1426	

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

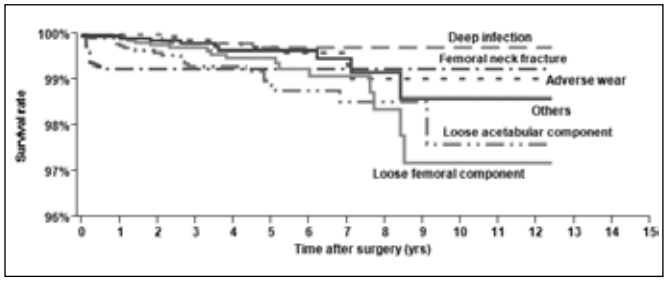

Fig. 4 - *The Kaplan Meier survivorship curves for the entire patient group with different revision the end points.*

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 AIAs 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%

TABLE III - COMPARISON BETWEEN ALL FOUR STUDIES

	Oxford (10)	Current Study	Newcastle (3)	Canadian (25)
# cases	1419	2559	670	3432
Follow-up: Mean (range) (unit: yrs)	4 (0-9)	4 ± 3 (0-12)	* (1-10)	3.4 (2-9)
Percent Follow-up achieved	*	95%	*	*
Metallosis recorded	no	yes	yes	no
Surgeon experience	*	2559	670	*
Age: Mean (range) (unit: yrs)	53.6 (16.5 to 85.5)	51 ± 8 (11 to 78)	52	51.2 (16-88)
Patient under age 40 (#,%)	134 (9%)	213 (8%)	*	*
Gender (# and %Female)	504 (41.2%)	706 (28%)	247 (37%)	793 (23.1%)
Dysplasia (#, %)	109 (8.3%)	280 (11%)	*	*
Small femoral component size (≤46 mm in women or ≤50 in men)	954 (67%)	1131 (44%)	*	*
Implant type				
BHR (Smith/Nephew)	643 (45.3%)	0	(100%)	1317 (38.4%)
Conserve (Wright)	606 (42.7%)	0	0	460 (13.4%)
Cormet (Stryker)	18 (1.3%)	393 (15%)	0	293 (8.5%)
Cemented Recap (Biomet)	128 (9%)	740 (29%)	0	0
Uncemented Recap (Biomet)	0	1426 (56%)	0	0
ASR (DePuy)	0	0	0	534 (15.6%)
Durom (Zimmer)	0	0	0	827 (24.1%)
Mitch	0	0	0	1 (0.3%)
Wear risk				
BHR (Smith/Nephew)	2.5%	-	0.1%	0.3%
Conserve (Wright)	1.3%	-	-	0
Cormet (Stryker)	11%	0.5%		0
Cemented Recap (Biomet)	0	0.3%	-	-
Uncemented Recap (Biomet)	-	0.2%	-	-
Total revisions	66 (4.7%)	77 (3%)	*	*
Wear revision	26 (1.8%)	7 (0.3%)	2 (0.1%)	4 (0.1%)
Kaplan-Meier failure rate (Wear only) at 8 yrs				
all patients	4%	1%	*	*
Patients under 40 yrs old	11.9%	0%	*	*
Dysplasia	15.9%	9%	*	*
Women	9.4%	2.9%	*	*
Small implant size	5.3%	1%	*	*

*Data not included in the study.

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 (Corin) 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% Durom 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.

Financial support: No financial support was secured for this study.

Conflict of interest: The authors declare that they have no conflict of interest.

Address for correspondence:
Fei Liu, PhD
Research Director
Midlands Orthopaedics, p. a.
1910 Blanding Street
Columbia, SC 29201, USA
feilresearch@gmail.com

REFERENCES

1. Anissian HL, Stark A, Gustafson A, Good V, Clarke IC. Metal-on-metal bearing in hip prosthesis generates 100-fold less wear debris than metal-on-polyethylene. Acta Orthop Scand. 1999;70(6)578-82.
2. Cobb AG, Schmalzreid TP. The clinical significance of metal ion release from cobalt-chromium metal-on-metal hip joint arthroplasty. Proc Inst Mech Eng H. 2006;220(2):385-98.
3. Malviya A, Holland JP. Pseudotumours associated with metal-on-metal hip resurfacing: 10-year Newcastle experience. Acta Orthop Belg. 2009;75(4):477-83.
4. Bhamra MS, Case CP. Biological effects of metal-on-metal hip replacements. Proc Inst Mech Eng H. 2006;220(2):379-84.
5. Langton DJ, Joyce TJ, Jameson SS, et al. Adverse reaction to metal debris following hip resurfacing: the influence of component type, orientation and volumetric wear. J Bone Joint Surg Br. 2011;93(2):164-71.
6. Willert HG, Buchhorn GH, Fayyazi A, et al. Metal-on-metal bearings and hypersensitivity in patients with artificial hip joints. A clinical and histomorphological study. J Bone Joint Surg Am. 2005;87(1):28-36.
7. Kalbfleisch JD, Prentice RL, eds. The statistical analysis of failure time data. New York: Wiley & Sons, 1980;462.
8. Pandit H, Glyn-Jones S, McLardy-Smith P, et al. Pseudotumours associated with metal-on-metal hip resurfacings. J Bone Joint Surg Br. 2008;90(7):847-51.
9. Gross TP, Liu F, Webb LA. Clinical outcome of the metal-on-metal hybrid Corin Cormet 2000 hip resurfacing system: an up to 11-year follow-up study. J Arthroplasty. 2012;27(4):533-8.
10. Glyn-Jones S, Pandit H, Kwon YM, Doll H, Gill HS, Murray DW. Risk factors for inflammatory pseudotumour formation following hip resurfacing. J Bone Joint Surg Br. 2009;91(12):1566-74.
11. Watters TS, Cardona DM, Menon KS, Vinson EN, Bolognesi MP, Dodd LG. Aseptic lymphocyte-dominated vasculitis-associated lesion: a clinicopathologic review of an under-recognized cause of prosthetic failure. Am J Clin Pathol. 2010;134(6):886-93.
12. Whittingham-Jones PM, Dunstan E, Altaf H, Cannon SR, Revell PA, Briggs TW. Immune responses in patients with metal-on-metal hip articulations: a long-term follow-up. J Arthroplasty. 2008;23(8):1212-8.
13. Fujishiro T, Moojen DJ, Kobayashi N, Dhert WJ, Bauer TW. Perivascular and diffuse lymphocytic inflammation are not specific for failed metal-on-metal hip implants. Clin Orthop Relat Res. 2011;469(4):1127-33.

14. Hallab NJ, Anderson S, Stafford T, Glant T, Jacobs JJ. Lymphocyte responses in patients with total hip arthroplasty. J Orthop Res. 2005;23(2):384-91.
15. Kwon YM, Thomas P, Summer B, et al. Lymphocyte proliferation responses in patients with pseudotumors following metal-on-metal hip resurfacing arthroplasty. J Orthop Res. 2010;28(4):444-50.
16. Gross TP, Liu F. Metal-on-metal hip resurfacing with an uncemented femoral component. A seven-year follow-up study. J Bone Joint Surg Am. 2008;90(Suppl 3):32-7.
17. Maloney WJ, Schmalzried T, Harris WH. Analysis of long-term cemented total hip arthroplasty retrievals. Clin Orthop Relat Res. 2002;(405):70-8.
18. Langton DJ, Sprowson AP, Mahadeva D, Bhatnagar S, Holland JP, Nargol AV. Cup anteversion in hip resurfacing: validation of EBRA and the presentation of a simple clinical grading system. J Arthroplasty. 2010;25(4):607-13.
19. Hart AJ, Dandachli W, Schlueter-Brust K, Henckel J, Cobb J. Large ball metal on metal hips obscure cup angle measurement on plain radiographs. Hip Int. 2009;19(4):323-9.
20. De Haan R, Pattyn C, Gill HS, Murray DW, Campbell PA, De Smet K. Correlation between inclination of the acetabular component and metal ion levels in metal-on-metal hip resurfacing replacement. J Bone Joint Surg Br. 2008;90(10):1291-7.
21. De Haan R, Campbell PA, Su EP, De Smet KA. Revision of metal-on-metal resurfacing arthroplasty of the hip: the influence of malpositioning of the components. J Bone Joint Surg Br. 2008;90(9):1158-63.
22. Williams S, Leslie I, Isaac G, Jin Z, Ingham E, Fisher J. Tribology and wear of metal-on-metal hip prostheses: influence of cup angle and head position. J Bone Joint Surg Am. 2008;90(Suppl 3):111-7.
23. Lewinnek GE, Lewis JL, Tarr R, Compere CL, Zimmerman JR. Dislocations after total hip-replacement arthroplasties. J Bone Joint Surg Am. 1978;60(2):217-20.
24. Hart AJ, Ilo K, Underwood R, et al. The relationship between the angle of version and rate of wear of retrieved metal-on-metal resurfacings: a prospective, CT-based study. J Bone Joint Surg Br. 2011;93(3):315-20.
25. Beaulé PE; Canadian Hip Resurfacing Study Group. A survey on the prevalence of pseudotumors with metal-on-metal hip resurfacing in Canadian academic centers. J Bone Joint Surg Am. 2011;93(Suppl 2):118-21.