Risk factors for inflammatory pseudotumour formation following hip resurfacing

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Metal-on-metal hip resurfacing is commonly performed for osteoarthritis in young active patients. We have observed cystic or solid masses, which we have called inflammatory pseudotumours, arising around these devices. They may cause soft-tissue destruction with severe symptoms and a poor outcome after revision surgery. The aim of this study was to determine the incidence of and risk factors for pseudotumours that are serious enough to require revision surgery.

Since 1999, 1419 metal-on-metal hip resurfacings have been implanted by our group in 1224 patients; 1.8% of the patients had a revision for pseudotumour. In this series the Kaplan-Meier cumulative revision rate for pseudotumour increased progressively with time. At eight years, in all patients, it was 4% (95% confidence interval (CI) 2.2 to 5.8). Factors significantly associated with an increase in revision rate were female gender ($p < 0.001$), age under 40 ($p = 0.003$), small components ($p = 0.003$), and dysplasia ($p = 0.019$), whereas implant type was not ($p = 0.156$). These factors were inter-related, however, and on fitting a Cox proportional hazard model only gender ($p = 0.002$) and age ($p = 0.024$) had a significant independent influence on revision rate; size nearly reached significance ($p = 0.08$). Subdividing the cohort according to significant factors, we found that the revision rate for pseudotumours in men was 0.5% (95% CI 0 to 1.1) at eight years wheras in women over 40 years old it was 6% (95% CI 2.3 to 10.1) at eight years and in women under 40 years it was 13.1% at six years (95% CI 0 to 27) ($p < 0.001$).

We recommend that resurfacings are undertaken with caution in women, particularly those under 40 years of age but they remain a good option in young men. Further work is required to understand the aetiology of pseudotumours so that this complication can be avoided.

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Metal-on-metal hip resurfacing is recommended for the treatment of arthritis in younger, more active individuals.[1,2] It is considered a bone-preserving procedure with the low-wear advantages of a large-head metal-on-metal articulation.[3,4] There is some evidence to suggest that patients with metal-on-metal hip resurfacing attain higher levels of function than those with conventional hip replacements.[5] To date, over 80 000 of these have been performed worldwide, but the indications are not clearly defined. Some surgeons believe it is appropriate for many cases, including primary osteoarthritis (OA), arthritis secondary to hip dysplasia[6] and osteonecrosis,[7,8] whereas others advise caution when using resurfacing arthroplasty in patients with osteoarthritis secondary to dysplasia.[9]

Independent mid-term clinical evaluation of these devices suggests a failure rate comparable to that of conventional hip replacement,[10,11] although there are still no long-term clinical results available. There are several modes of failure in hip resurfacing,[12] with femoral neck fracture being the most common early cause.[13,14] A more serious complication that has recently been observed is a solid or cystic mass.[15-17] These masses can present with a range of imaging findings.[18] In 2008 we described 17 such cases, presenting with a variety of symptoms and suggested that their incidence at five years was about 1%. We called the mass an 'inflammatory pseudotumour'.[16]

Although the biological mechanisms responsible for pseudotumours are poorly understood, they have distinctive histological features[16,19] and are characterised by extensive soft-tissue necrosis, macrophages, granulomas and a perivascular lymphocytic infiltrate.[19] The incidence of clinically important pseudotumours and the factors that predispose to them are not clearly defined. This is partly because the soft-tissue response to metal-on-metal hip resurfacing is variable, ranging from a minimal reaction to a large and highly destructive infiltrative mass, but also because the incidence of pseudotumour tends to increase with time. In the past the numbers of reported cases were too low to study the predisposing factors.[16] We first began resurfacing in 1999 and have now implanted nearly 1500 devices.

The aim of this study was to determine the incidence of revision for pseudotumour following metal-on-metal hip resurfacing performed by our group in Oxford, United Kingdom. We can be certain of the diagnosis as these pseudotumours, which have led to revisions have been observed at operation and studied histologically. In order to determine how the incidence changed over time, and to investigate predisposing factors, we used Kaplan-Meier survival curves and Cox proportional hazards regression models.

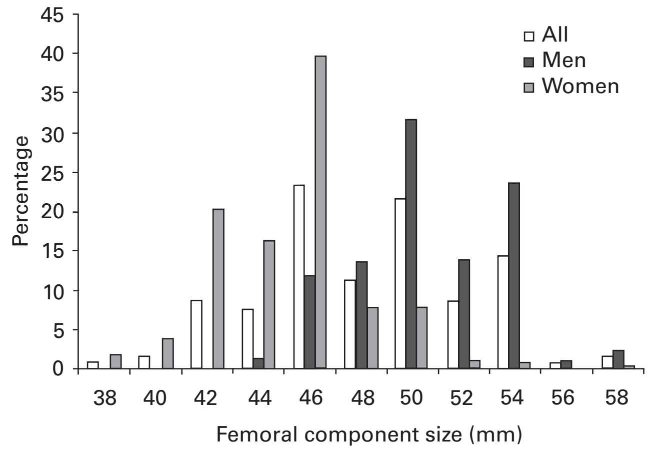

Fig. 1

Histogram showing the size of the femoral components implanted in men and women.

Patients and Methods

All hip resurfacing procedures performed between June 1999 and November 2008 were identified. The primary diagnosis, implant type and femoral size were recorded, along with demographic characteristics such as age and gender. We reviewed all revisions and identified, from preoperative imaging and operative findings, those with a pseudotumour. The final diagnosis of a pseudotumour was made from histological examination of samples from revisions.[16] The post-primary resurfacing radiographs of patients who subsequently developed pseudotumour were analysed to determine the acetabular inclination angle. The time to revision for pseudotumour was recorded, together with the time to the end of follow-up and the time to revision for other reasons in other patients. The frequency and time to revision for pseudotumour were compared between cases to identify the factors that might increase the risk of such revision.

Statistical methods. Data are presented as mean with SD, or as number (N) with percentage, depending on the distribution of the data. Continuous data (implant size and age) were categorised for the statistical analysis. Age was separated into two groups (< 40 and ≥ 40 years), and implant size into small (femoral component diameter ≤ 46 mm in women and ≤ 50 mm in men) and large (> 46 mm in women and > 50 mm in men). The primary diagnosis was considered in three groups: primary OA, OA secondary to dysplasia, and other. The statistical significance of associations between categorical variables was assessed using chi-squared statistics (with continuity correction for 2×2 tables), and testing for a linear trend if appropriate.

Independent samples *t*-tests were used to compare continuous variables between two groups. Time to revision was taken into account by using Kaplan-Meier survival analysis. Survival curves were plotted overall and for groups of cases, with log-rank chi-squared tests used to compare outcome between groups. The curves were either plotted with confidence limits or were stopped at the year when the number of patients dropped to 20. Cox proportional hazards regression analysis was used to estimate the independent effects of each factor in multiple regression models.

The analysis was undertaken using Stata version 10 (StataCorp, College Station, Texas), and SPSS version 15 (SPSS Inc., Chicago, Illinois). Throughout the analysis, 95% confidence intervals (CI) were used to express the uncertainty in the estimates, with statistical significance correspondingly taken at the 5% level ($p < 0.05$).

Results

Patients and implants. A total of 1419 metal-on-metal hip resurfacings were identified in 1224 patients. These procedures were undertaken in 720 (58.8%) males and 504 (41.2%) females. There were 390 bilateral cases. The mean age at implantation was 53.6 years (16.5 to 85.5). The primary diagnosis was recorded for 1306 procedures (92%). The most common primary diagnosis was OA, which accounted for 1152 (88.2%) implants, followed by OA secondary to dysplasia in 109 (8.3%). The remaining 45 (3.4%) were classified as other and included avascular necrosis in 27 (2.1%), osteonecrosis in five (0.4%), OA secondary to conditions other than dysplasia in 11 (0.8%) and rheumatoid arthritis in two (0.2%).

The Birmingham Hip Resurfacing (BHR, Smith & Nephew, Birmingham, United Kingdom), was the first device to be used (from 1999) and had been used most frequently, being implanted in 643 hips (45.3%). The Conserve Plus (C+) implant (Wright Medical Technology, Memphis, Tennessee) was used from 2003; 606 (42.7%) were implanted. The Recap (Biomet Ltd, Swindon, United Kingdom) was used from 2005; 128 (9.0%) were implanted. In addition, 18 (1.3%) Cormet (Corin, Cirencester, United Kingdom) metal-on-metal hip resurfacings were implanted between 1999 and 2001. The most commonly implanted femoral component sizes were 46 mm and 50 mm diameters, which were used in 324 (22.8%) and 304 (21.4%) hips, respectively (Fig. 1). For males the most

Table I. Details of the pseudotumour revisions

Case	Gender	Age at implantation (yrs)	Diagnosis*	Implant†	Femoral component diameter (mm)	Time to revision (yrs)
1	F	26.6	Dysplasia	BHR	46	3.1
2	F	28.7	Dysplasia	BHR	42	4.3
3	F	36.5	Dysplasia	BHR	42	2.6
4	F	38.9	Dysplasia	BHR	42	6.5
5	F	61.4	Dysplasia	C+	44	1.2
6	F	32.1	OA	BHR	46	5.5
7	F	35.6	OA	BHR	42	6.6
8	F	36.8	OA	BHR	46	2.0
9	F	39.9	OA	C+	42	2.0
10	F	42.1	OA	BHR	46	5.7
11	F	46.1	OA	Cormet	48	6.6
12	F	48.4	OA	BHR	50	5.4
13	F	51.4	OA	C+	40	4.3
14	F	52.3	OA	Cormet	44	3.8
15	F	52.4	OA	BHR	46	2.1
16	F	53.3	OA	C+	44	1.0
17	F	55.8	OA	C+	46	1.1
18	F	57.6	OA	BHR	42	3.0
19	F	59.1	OA	C+	44	1.6
20	F	63.3	OA	C+	42	1.5
21	F	67.0	OA	BHR	46	3.8
22	F	67.1	OA	BHR	46	3.3
23	M	52.5	OA	BHR	50	8.3
24	M	54.3	OA	BHR	50	3.5
25	M	60.1	OA	C+	48	1.1
26	M	59.8	OA	BHR	50	1.5

* OA, osteoarthritis

† BHR, Birmingham hip resurfacing; C+, Cormet plus

common size was 50 mm (n = 259, 31.1%); that for females was 46 mm (n = 228, 40.0%).

Frequency of revision for pseudotumour. There were 26 revisions for a confirmed diagnosis of pseudotumour (1.8%, Table I). Revision for a reason other than pseudotumour was recorded in a further 41 procedures (2.9%). The mean time to revision for the 26 pseudotumour revisions was 3.5 years (1 to 8.3), with revision for other reasons occurring at a mean of 0.95 years (0.01 to 5.21). The remaining 1352 metal-on-metal hip resurfacings which did not require revision were followed up for a mean of four years (0.05 to 9.45).

Radiographs were available for 25 of the 26 pseudotumours. The distribution of acetabular abduction angle of those resurfacings subsequently developing a pseudotumour is shown in Figure 2. The mean angle was 47.6° (22° to 75°). In three hips with extreme malposition there was evidence of acetabular loosening. In one this was due to early loosening before symptoms of pseudotumour occurred, and in the other two the loosening occurred late after the onset of symptoms.

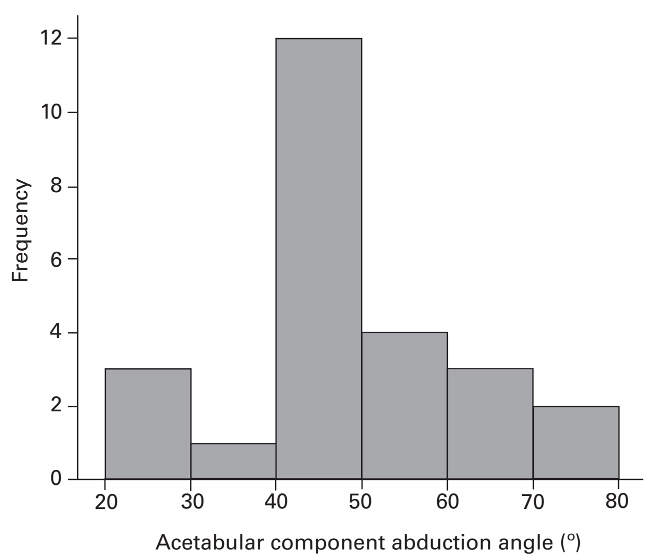

Fig. 2

Histogram showing the acetabular component abduction angle in hips that were subsequently revised for pseudotumour.

Factors associated with pseudotumour revision. The relationship between patient and implant characteristics and outcome, in terms of whether or not there was a revision for pseudotumour formation, are shown in Table II. More than three-quarters of the revisions were in women (22 of 26, 84.6%), with 22 (3.8%) female cases undergoing revision for pseudotumour, compared to four (0.5%) male patients (chi-squared test = 18.8, df = 1, $p < 0.001$). There was no significant difference in the incidence of revision for

Table II. Patient demographics for revision due to pseudotumour (chi-squared p-values shown)

	Revision for pseudotumour			
	No revision	**Revision**	**Total**	**p-value**
Gender (%)				
Male	830 (*99.5*)	4 (*0.5*)	834	
Female	563 (96.2)	22 (*3.8*)	585	< 0.001
Laterality (%)				
Unilateral	1007 (*97.9*)	22 (*2.2*)	1029	
Bilateral	386 (*99.0*)	4 (*1.0*)	390	0.24
Age (yrs) (%)				
< 40	126 (*94.0*)	8 (*6.0*)	134	
> 40	1267 (*98.6*)	18 (*1.4*)	1285	< 0.001
Mean (SD)	53.7 (9.6)	49.2 (11.8)	53.6 (9.7)	0.07
Diagnosis (%)				
Primary osteoarthritis	1132 (*98.3*)	20 (*1.7*)	1152	
Dysplasia	104 (*95.4*)	5 (*4.6*)	109	
Other	44 (*97.8*)	1 (*2.2*)	45	0.13
Implant size (mm) (%)				
Small: ≤ 46 women	930 (*97.5*)	24 (*2.5*)	954	
Large: ≤ 50 men	438 (*99.5*)	2 (*0.5*)	440	0.008
Implant type (%)				
BHR*	627 (*97.5*)	16 (*2.5*)	643	
Conserve+	598 (*98.7*)	8 (*1.3*)	606	
Recap	128 (*100*)	0 (*0*)	128	
Cormet	16 (*88.9*)	2 (*11.1*)	18	0.004

* BHR, Birmingham Hip Resurfacing

pseudotumour between bilateral and unilateral hip resurfacing (chi-squared 1.38, df = 1, p = 0.24).

The incidence of pseudotumour, per decade of age, is shown in Figure 3: there was a higher incidence in patients under 40 years. Age was therefore divided, *post hoc*, into two categories: < 40 years and > 40 years (Table II). Revision for pseudotumour occurred significantly more often in younger (< 40 years) than in older (≥ 40 years) patients (6.0% *vs* 1.4%; chi-squared = 14.09, df = 1, p < 0.001). The mean age at operation of patients with revision for pseudotumour was 49.2 years (SD 11.8), and for other patients 53.7 years (SD 9.6) (t = 2.34, df = 25.624, p = 0.07).

Revision for pseudotumour was more common in dysplasia than in those with other diagnoses (4.6% *vs* 1.8%; chi-squared = 2.78, df = 1, p = 0.095). However, overall, diagnosis was not a significant independent risk factor for revision for pseudotumour (chi-squared = 4.15, df = 2, p = 0.13) (Table II).

The relationship between revision rate and femoral component size is shown in Figure 4. Revisions occurred more frequently the smaller the implant (chi-squared for linear trend = 17.2, df = 1, p < 0.001). However, there was no clear size at which the incidence increased. For categorical analysis we set the cut off to be the mean size. Thus for women small size was ≤ 46 mm and large > 46 mm, and for men small was ≤ 50 mm and large > 50 mm (Table II). The risk of revision was higher with small sizes (chi-squared = 6.989, df = 1, p = 0.008).

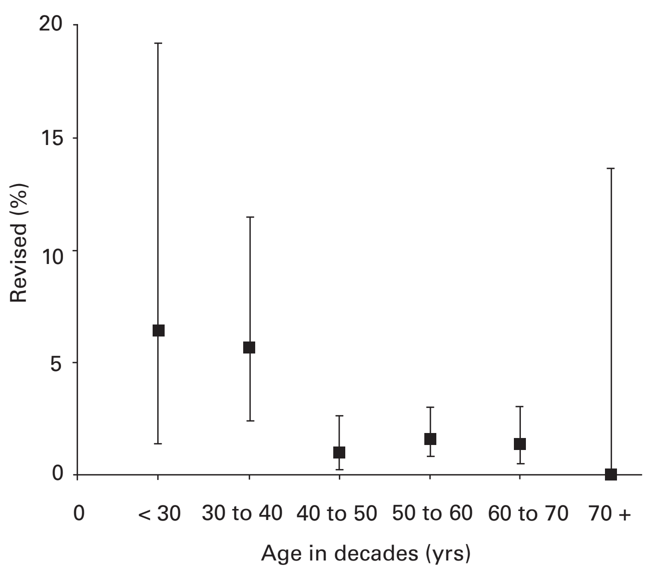

Fig. 3

Box plot showing the incidence of revision for pseudotumour, per decade of age (box plots indicate mean and whiskers show 95% confidence intervals).

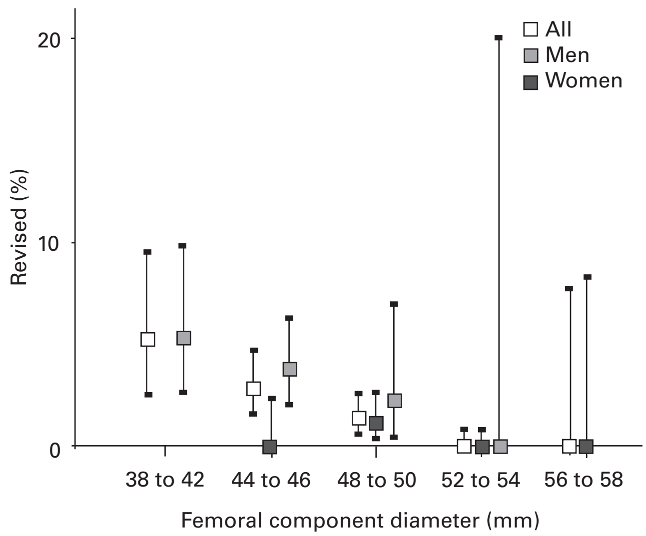

Fig. 4

Box plot showing the incidence of revision for pseudotumour and femoral component size (box plots indicate mean and whiskers show 95% confidence intervals).

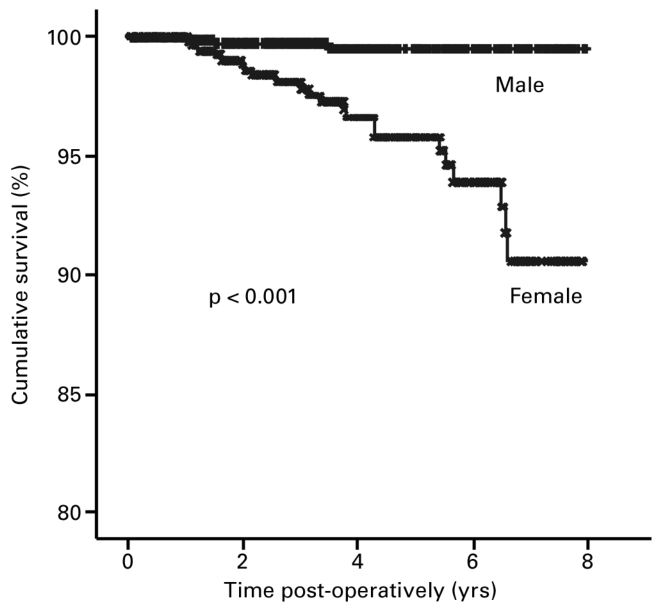

Fig. 6

The Kaplan-Meier survival curves for men and women, with revision for pseudotumour as failure.

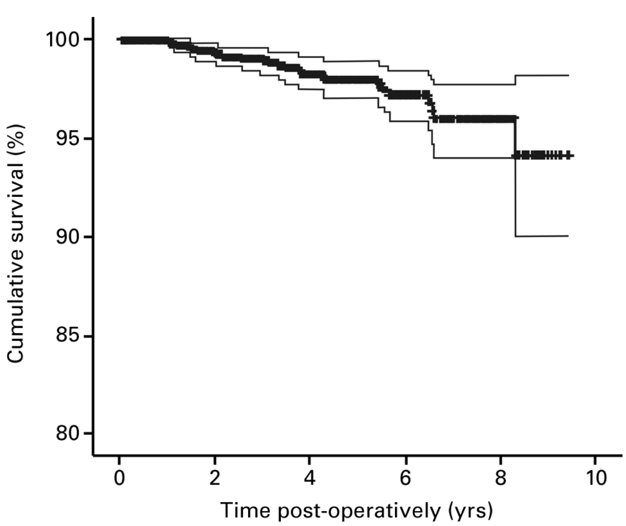

Fig. 5

The Kaplan-Meier survival curve for the whole cohort, with revision for pseudotumour as failure.

The risk of revision was related significantly to the type of implant (chi-squared = 13.2, df = 3, p = 0.004, Table II), with the Cormet implant having the greatest risk (11.1%). However, this difference is likely to be the result of the different length of follow-up of the different devices.

The patient and implant characteristics were interrelated, which limited the usefulness of these individual associations. Patients aged < 40 years were more likely to be female than those aged ≥ 40 years (53.7% *vs* 39.9%, chi-squared = 9.6, df = 1, p = 0.002). Those with OA, and particularly dysplasia, were more likely to be female than those with other diagnoses (41% *vs* 66% *vs* 24%, respectively; chi-squared = 32.8, df = 1, p < 0.001). Similarly, those with a smaller implant (≤ 48 mm) were more likely to be female than those with a larger implant (> 50 mm) (70% *vs* 9%; chi-squared = 527.0, df = 1, p < 0.001). The type of implant was not significantly related to gender (p = 0.1), although those who had a BHR were more likely to be aged under 40 than those receiving Conserve+, Cormet or Recap implants (13.5% *vs* 6.4%, 5.6% and 5.5%, respectively, chi-squared = 21.283, df = 3, p < 0.001).

Survival analysis. The Kaplan-Meier survival curve for the whole cohort, with revision for pseudotumour as failure, is shown in Figure 5. The cumulative revision rate increased progressively with time, although the annual revision rate remained relatively constant. At eight years the cumulative revision rate for pseudotumour was 4.0% (95% CI: 2.2 to 5.8). Beyond eight years the data become sparse, so the confidence intervals become wider. The Kaplan-Meier analysis of revision for pseudotumour was used to assess the individual effect of the various risk factors. The following were significant at eight years: for gender, the revision rate was 9.4% (95% CI: 4.7 to 14.1) for women and 0.5% (95% CI: 0 to 1.1) for men (log-rank chi-squared = 21.40, df = 1, p < 0.001) (Fig. 6). For age, the revision rate was 11.9% (95% CI: 3.3 to 20.5) for < 40 years and 2.7% (95% CI: 1.1 to 4.3) for ≥ 40 years (log-rank chi-squared = 8.92, p = 0.003) (Fig. 7). For implant size, the revision rate was 5.3% (95% CI: 2.8 to 7.8) for small components and 1.6% (95% CI: 0 to 4.0) for large (log-rank chi-squared = 8.76, p = 0.003) (Fig. 8). For diagnosis, the revision rate was 15.9% (95% CI: 0 to 34.1) for OA

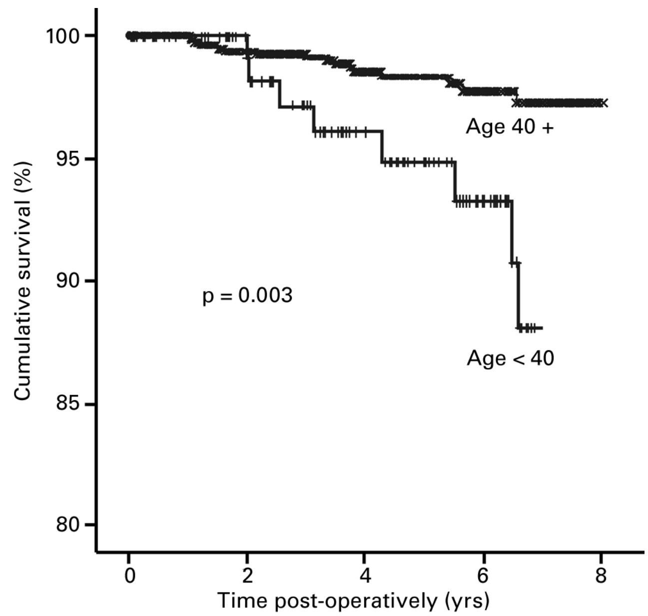

Fig. 7

The Kaplan-Meier survival curves for patients < 40 years and ≥ 40 years, with revision for pseudotumour as failure.

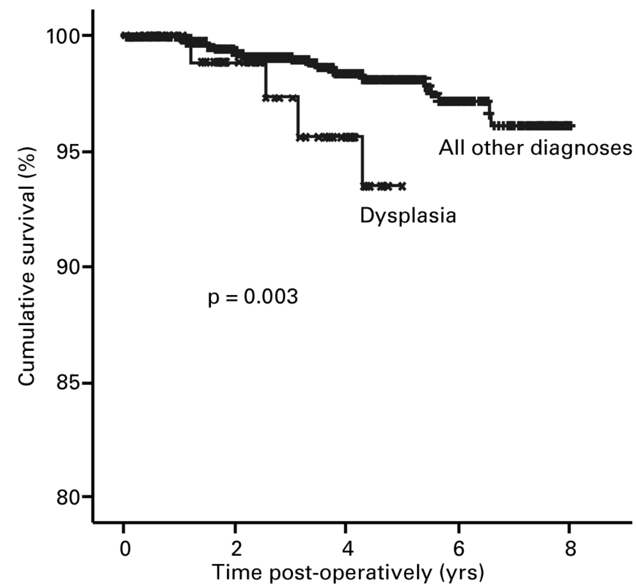

Fig. 9

The Kaplan-Meier survival curves comparing dysplasia and all other diagnoses with revision for pseudotumour as failure.

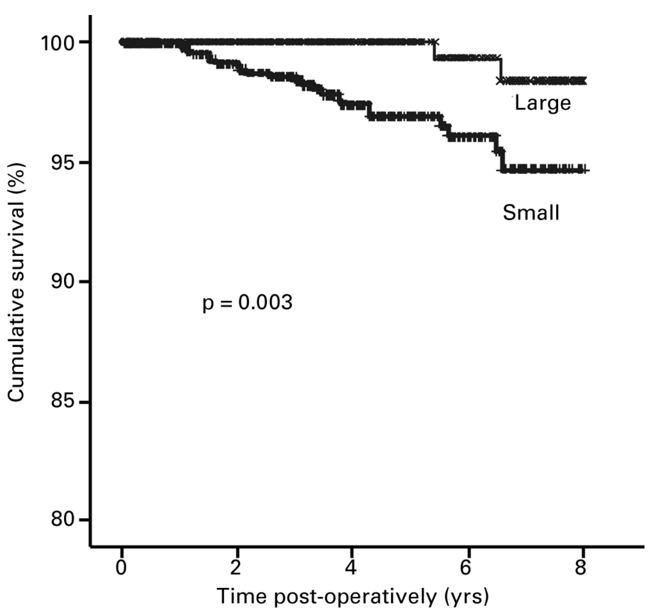

Fig. 8

The Kaplan-Meier survival curves for small and large components, with revision for pseudotumour as failure. Large components considered as > 50 mm for men and > 46 mm for women.

secondary to dysplasia and 3.9% (95% CI: 1.9 to 5.8) for all other diagnoses (log-rank chi-squared = 5.477, p = 0.019) (Fig. 9). The effects of implant type (log-rank chi-squared = 2.017, p = 0.156) were not statistically significant.

Applying Cox's regression analysis with the variables considered individually, gender (p < 0.001), age (p = 0.005), size (p = 0.01) and diagnosis (p = 0.026) had a significant effect on revision rate (Table III). When adjusting for these four variables in a multiple variable model, only gender (p = 0.002) and age (p = 0.024) had a significant independent effect. Size, treated categorically, was not significant (p = 0.08). However, when size was analysed as a continuous variable it had an effect that almost reached significance (p = 0.052) when adjustment was made for gender.

A final Kaplan-Meier analysis was undertaken based on the independent risk factors with analysis stopped (for each individual factor) at the year in which the patient number dropped below 20 so as to give a realistic prediction of failure rate in each group (Fig. 10). The revision rate at eight years for men was 0.5% (95% CI 0 to 1.1). The revision rate at eight years for women ≥ 40 years old was 6.2% (95% CI 2.3 to 10.1). The revision rate at six years for women < 40 years old was 13.1% (95% CI 0 to 27.8). The revision rate at six years for women < 40 years old with small (≤ 46 mm) components was 15.2% (95% CI 1.7 to 27.7).

Discussion

Inflammatory pseudotumours are an important complication of hip resurfacing.[16] They cause a spectrum of clinical problems, ranging from a small asymptomatic lesion picked up on a scan to a massive destructive infiltrative lesion causing severe symptoms.[16] In this study we focused on the severe end of the spectrum, only analysing pseudotumours that required revision surgery. The outcome of these revisions is often poor because of the destructive nature of the pseudotumour.[20,21]

Table III. Results of Cox's proportional hazards model (PHM) analysis, indicating the effects of demographic factors on the hazard ratio

Section	Variable	p-value	Hazard ratio
1			
Each variable entered into Cox PHM as the only variable considered	Gender (M:F)	< 0.001	8.2*
	Age (yrs) (> 40/≤40)	0.005	3.3*
	Size (large/small)	0.01	6.6*
	Diagnosis (dysplasia/other)	0.026	3.0*
	Implant	> 0.1	-
	Bilateral	0.081	0.4
2			
All variables listed entered together into Cox PHM	Gender (M:F)	0.002	5.5*
	Age (yrs) (> 40/≤40)	0.024	2.7*
	Size (large/small)	0.08	3.7
	Diagnosis (dysplasia/other)	0.386	1.6

* the factors that have a significant effect on revision due to pseudotumour

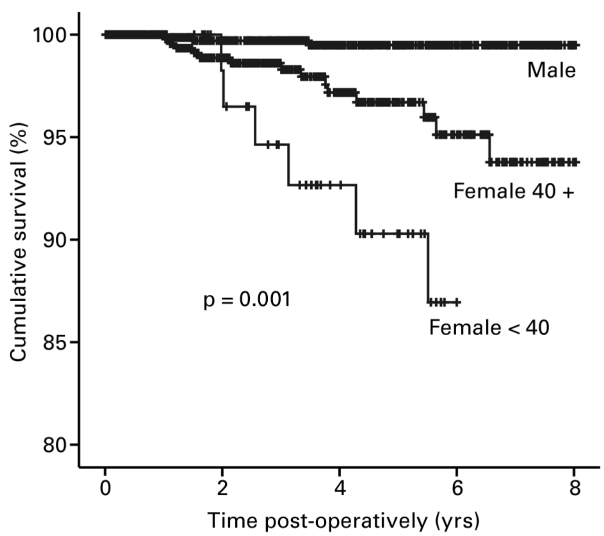

Fig. 10

The Kaplan-Meier survival curves for men, women < 40 years and women ≥ 40 years old, with revision for pseudotumour as failure.

In this series of 1419 hip resurfacings we are aware of 26 revisions for pseudotumour. At eight years the cumulative revision rate for pseudotumour was 4%, but in women it was 9% and in men was only 0.5%. The cumulative revision rate appears to be increasing progressively, and the annual revision rate is relatively constant. It is therefore likely that in the second decade the cumulative revision rate for pseudotumour will be higher than it was at eight years. The current and the predicted revision rates for pseudotumour formation in women are high, and surgeons should consider the risks and benefits carefully before undertaking hip resurfacing in women. In order to help surgeons reach a decision, further examination of the risk factors is necessary.

From our survival analysis we found that patient gender, age, component size and diagnosis all have a significant individual influence on the failure rate. Cox's proportional hazards model (considering only single factors) suggests that female gender, age under 40 years, small component size and dysplasia increase the failure rate by 8.2, 3.3, 6.6 and three times, respectively. These factors are, however, inter-related and thus do not represent independent effects. When these factors were all included in the Cox model the only factors that remained significant were gender (p = 0.002) and age (p = 0.024). Size possibly also had an independent effect (p = 0.08, and p = 0.05 if analysed as a continuous variable with gender). The cumulative revision rate for pseudotumours at eight years was 0.5% in men and 6.2% in women over 40 years. In women under 40 years it was 13.1% at six years. As the number of pseudotumours in our series is relatively small (n = 26) it is impossible to draw a firmer conclusion about the individual significance of the various risk factors.

It is not clear why women have an eightfold higher revision rate for pseudotumours than men. The possible reasons may include the increased prevalence of allergy in women because of wearing jewellery,[22,23] the increased range of movement,[24] which would be more likely to cause impingement, edge loading or different gait patterns. Younger patients may also have a larger range of movement and higher activity levels. It is not clear why smaller components cause a higher incidence of pseudotumours, but this may be because smaller bearings are less likely to cause hydrodynamic lubrication,[25,26] or are less likely to have adequate superior cover. Furthermore, it is possible that there is a higher risk of component malalignment if the components are small. The risk of malalignment and impingement is also likely to be higher in dysplasia. Previous studies have shown that acetabular component orientation in metal-on-metal hip resurfacing is an important factor in the function of these types of bearing. Steeply inclined components are more likely to give rise to higher blood metal ion concentrations,[27,28] although it should be noted that relatively high metal ions were also recorded for a number of well-orientated components in these studies. Both of these previous studies indicated that component orientation is more important with for smaller components. De Haan et al[27] also discussed the effects of design variations. In this study we measured the abduction angle of the acetabular component on pelvic radiographs for the pseudotumour cases: there was a wide variation in this angle, but the majority were in the range 30° to 50°. It is likely that implant position, component size and patient movement patterns all contribute to wear.

This study will have underestimated the incidence of pseudotumour in the population with a hip resurfacing. There are a number of reasons for this. In this study we report only pseudotumours in patients who have undergone a revision. In our previous report we found that only 70% had been revised.[16] We have patients with pseudotumours that have not been revised, either because they consider their symptoms insufficient to warrant revision or because they are currently undergoing investigation.[16] Furthermore, we have recently undertaken ultrasound screening of asymptomatic patients with a hip resurfacing at five years post-operatively, and found the incidence of asymptomatic pseudotumours in this group to be about 4%.[29] Additionally, we have only included in our study revisions for pseudotumours done at our hospital, but there may be patients in this series who have been revised elsewhere for pseudotumour.

It is interesting to speculate why the incidence of pseudotumours seems to be high in our unit. Although an overall incidence of 1.8% is higher than those of designer surgeons, it is also lower than that reported from other centres.[30,31] Initially, as we felt the large head made the procedure forgiving, we had broad indications for performing resurfacings and would readily implant a resurfacing in young active individuals of either gender, regardless of their size or history of metal allergy. Furthermore, with multiple surgeons contributing to our series it is possible that the number of technical errors may have been higher than in the designer series. Although there is a large range of acetabular component inclination, the mean abduction angle was satisfactory

We use the term 'pseudotumour' to encompass all masses, whether cystic or solid. Lesions described in different ways by other groups (eg. cyst, bursa, ALVAL), would be classified as a pseudotumour in our centre. This may also explain why we have a higher incidence. Nevertheless, each year we are finding an increase in the incidence of pseudotumour formation. We therefore expect that if other centres are not yet recognising problems with pseudotumours, they may well do in the future.

Inflammatory pseudotumours are a serious complication of metal-on-metal hip resurfacing. We have shown that the important independent risk factors are female gender, age < 40 years, and, possibly, smaller component size. In this study the cumulative revision rate for pseudotumours at eight years was 0.5% in men, 6.2% in women over 40, in women under 40 it was 13.1% at six years. We recommend that resurfacings are undertaken with caution in women, particularly those under 40 years old. In men, however, they remain a good option, with some advantages over conventional hip replacement in the younger, more active patient. Further work is needed to understand the aetiology of pseudotumours so that this complication can be avoided.

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