



Birmingham hip resurfacing

THE PREVALENCE OF FAILURE

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Despite the increasing interest and subsequent published literature on hip resurfacing arthroplasty, little is known about the prevalence of its complications and in particular the less common modes of failure. The aim of this study was to identify the prevalence of failure of hip resurfacing arthroplasty and to analyse the reasons for it.

From a multi-surgeon series (141 surgeons) of 5000 Birmingham hip resurfacings we have analysed the modes, prevalence, gender differences and times to failure of any hip requiring revision. To date 182 hips have been revised (3.6%). The most common cause for revision was a fracture of the neck of the femur (54 hips, prevalence 1.1%), followed by loosening of the acetabular component (32 hips, 0.6%), collapse of the femoral head/avascular necrosis (30 hips, 0.6%), loosening of the femoral component (19 hips, 0.4%), infection (17 hips, 0.3%), pain with aseptic lymphocytic vascular and associated lesions (ALVAL)/metallosis (15 hips, 0.3%), loosening of both components (five hips, 0.1%), dislocation (five hips, 0.1%) and malposition of the acetabular component (three hips, 0.1%). In two cases the cause of failure was unknown.

Comparing men with women, we found the prevalence of revision to be significantly higher in women (women = 5.7%; men = 2.6%, $p < 0.001$). When analysing the individual modes of failure women had significantly more revisions for loosening of the acetabular component, dislocation, infection and pain/ALVAL/metallosis ($p < 0.001$, $p = 0.004$, $p = 0.008$, $p = 0.01$ respectively).

The mean time to failure was 2.9 years (0.003 to 11.0) for all causes, with revision for fracture of the neck of the femur occurring earlier than other causes (mean 1.5 years, 0.02 to 11.0). There was a significantly shorter time to failure in men (mean 2.1 years, 0.4 to 8.7) compared with women (mean 3.6 years, 0.003 to 11.0) ($p < 0.001$).

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Certain modes of failure of hip resurfacing arthroplasty have been well documented.¹⁻⁸ Fractures of the neck of the femur are the most common mode of failure,^{5,9} and aseptic lymphocytic vascular and associated lesions (ALVAL) have been identified as a new problem in arthroplasty surgery.⁶⁻⁸ However, small numbers involved in the studies and their relative infrequency has meant that little is known of the prevalence of less common modes of failure. The aim of this study is to identify the prevalence of failure of hip resurfacing arthroplasty and to analyse the reasons for it.

Patients and Methods

Between July 1997 and November 2002, the Oswestry Outcome Centre independently and prospectively collected data on 5000 Birmingham Hip Resurfacings (BHRs; Smith & Nephew, Bromsgrove, United Kingdom) performed by 141 surgeons, at 84 hospitals.

Of the original 5000 BHRs, 3346 (67%) were implanted in males and 1654 (33%) in females, (ratio 2:1). The mean age at the time of operation was 52.5 years (13 to 87); male 53.2 (19.6 to 75.7); female 51.1 (17.0 to 75.5). Prior to surgery, all patients consented to taking part in the follow-up protocol.

To date 4524 BHRs have survived at a mean follow-up of 7.1 years (0.2 to 11.0). Patients with 137 BHRs have died, those with 156 have been lost to follow-up and one was removed in a hindquarter amputation following a road traffic accident. Revision surgery was reported independently by the patient and when it had taken place, the Oswestry Outcome Centre contacted the operating surgeon to ascertain the mode of failure and the type of revision implant used. The modes of failure were then analysed. **Statistical analysis.** For normally distributed parametric data such as time to revision, Student *t*-tests were used. Comparison of risk

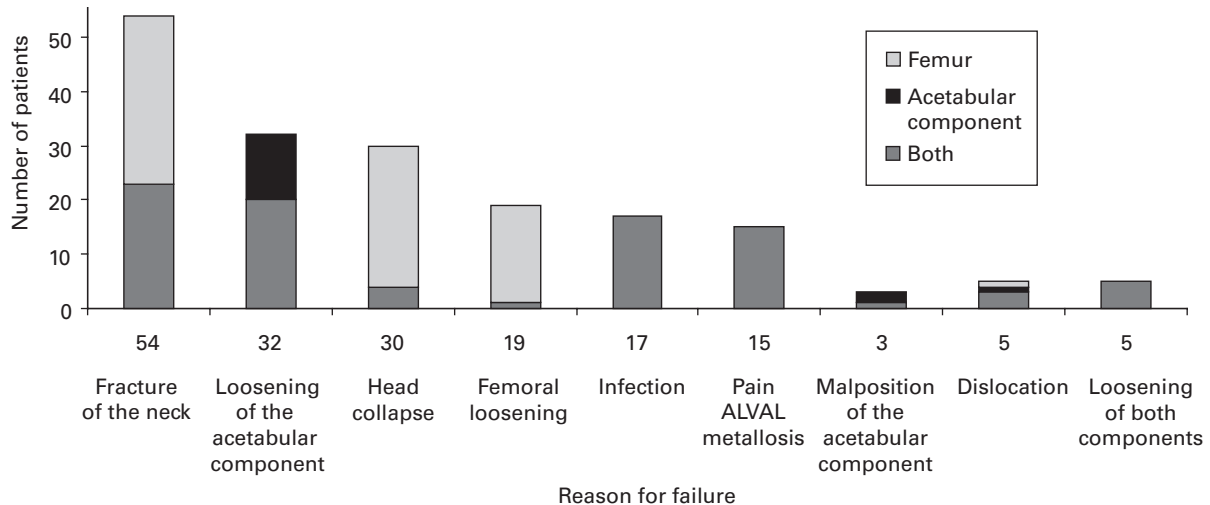


Fig. 1

Bar chart showing the prevalence of failure of total hip resurfacing (the distribution of single (femoral or acetabular) or both component revision is shown) (ALVAL, aseptic lymphocytic vascular and associated lesions).

Table I. The gender distribution for the modes of failure

Mode of failure	Total* (%)	Men (n = 3346)	Women (n = 1654)	p-value
All revisions	182 (3.6)	88	94	< 0.001
Fracture of the femoral neck	54 (1.1)	33	21	0.47
Loosening of the acetabular component	32 (0.6)	9	23	< 0.001
Head collapse	30 (0.6)	20	10	1.0
Femoral loosening	19 (0.4)	10	9	0.22
Infection	17 (0.3)	6	11	0.008
Pain/ALVAL†/metallosis	15 (0.3)	5	10	0.01
Malposition of the acetabular component	3 (0.1)	1	2	0.26
Dislocation	5 (0.1)	0	5	0.004
Loosening of both components	5 (0.1)	2	3	0.34

* Unknown mode of failure 2; 1 male, 1 female

† ALVAL, aseptic lymphocytic vascular and associated lesions

of failure was performed using a two-tailed Fisher's exact test. All were performed to a 95% confidence interval. A p-value < 0.05 was considered to be statistically significant.

Survival of the arthroplasty up to ten years was calculated by the Kaplan-Meier method. The endpoint for failure was defined as revision of part or all of the arthroplasty. Patients who could not be contacted were censored at the time of the last contact. Deaths without revision were censored at the time of death.

Results

A total of 182 (3.6%) BHRs required revision, most commonly because of fracture of the neck of the femur (54 hips, 1.1%), followed by loosening of the acetabular component (32 hips, 0.6%), collapse/avascular necrosis (AVN) of the femoral head (30 hips, 0.6%), loosening of the femoral component (19 hips, 0.4%), infection (17 hips, 0.3%), pain/ALVAL/metallosis (15 hips, 0.3%) loosening of both compo-

nents (five hips, 0.1%), dislocation (five hips, 0.1%), and malposition of the acetabular component (three hips, 0.1%) (Fig. 1). In two cases the cause of failure was unknown.

The prevalence of revision for any reason was significantly higher in women (94 women of 1654, 5.7%; 88 men of 3346 2.6%, $p < 0.001$). When analysing the individual modes of failure women had significantly more revisions for loosening of the acetabular component (women 23 of 1654; men nine of 3346, $p < 0.001$), dislocation (women five of 1654; men zero of 3346, $p = 0.004$), infection (women 11 of 1654; men six of 3346, $p = 0.008$) and pain/ALVAL/metallosis (women ten of 1654; men five of 3346, $p = 0.01$) (Table I, Figure 2).

There were 54 patients who had revision for a fracture of the neck of the femur. Of these, 31 (57%) required isolated revision of the femoral component, leaving the acetabular component *in situ*. However, 23 patients (43%) required revision of both components. There was

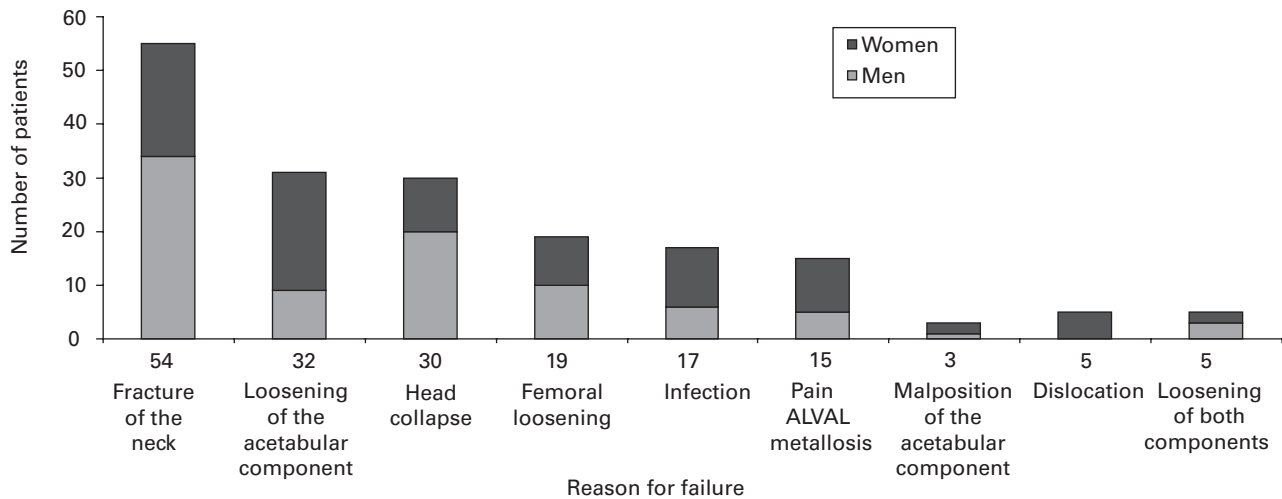


Fig. 2

Bar chart showing gender distribution for revision of hip resurfacings (ALVAL, aseptic lymphocytic vascular and associated lesions).

Table II. Pre-operative diagnosis in patients revised for loosening of the acetabular component

Pre-operative diagnosis	Men	Women	Potential adverse effect on stability of the acetabular component
Osteoarthritis	8	15	No
Acetabular dysplasia	0	1	Yes
Previous shelf procedure for acetabular dysplasia	0	1	Yes
Renal failure	0	1	Yes
Avascular necrosis of the femoral head following radiotherapy for pelvic osteosarcoma	0	1	Yes
Unknown	2	3	?

no significant gender difference in the prevalence of fractures of the neck of the femur (women = 33 of 1654, 1.3%; men = 33 of 3346 1.0%, $p = 0.47$).

The absolute risk of loosening of the acetabular component in women was 0.013 and in men 0.003. The relative risk for women *vs* men was 4.9 ($p < 0.001$). When looking at possible risk factors for loosening of the acetabular component, we found that females had a broader range of pre-operative diagnoses, some of which could adversely affect survivorship of the acetabular component (Table II). Excluding those patients, we still found a significant difference in the prevalence of loosening between women and men (women = 18 of 1654 1.1%; men = 10 of 3346 0.3%, $p < 0.001$). There was no significant difference between the female and male groups with regard to mean age (female, 51.9 (17.0 to 75.5); male 45.2 (19.6 to 75.7), $p = 0.19$).

Revision for infection was relatively more common in women compared with men (women, 11 of 1654, men six of 3346, $p = 0.008$). This difference could not be explained. Five patients (0.1%), all women, required revision for dislocation. There was no significant gender dif-

ference between the other causes of revision. The mean time to failure was 2.9 years (0.003 to 11.0) for all causes, with revision for fracture of the neck of the femur occurring earlier than for other causes (mean 1.5 years, 0.2 to 11.0) (Table III). There was a significantly shorter time to failure in men (mean 2.1 years, 0.04 to 9.6) compared with women (mean 3.6 years, 0.003 to 11.0) for all causes, $p < 0.001$; because men suffered a fracture earlier than women (men = mean 0.7 years, 0.4 to 4.6; women = 2.7 years, 0.02 to 11.0, $p = 0.0012$) (Table III)

Using revision for all causes of failure as the endpoint, Kaplan-Meier survival analysis showed a cumulative survival of 96.3% at seven years (95% CI 95.7 to 96.8) and 95.3% at ten years (95% CI 94.5 to 96.0) (Fig. 3).

Discussion

Our study has confirmed that the most common modes of failure following hip resurfacing are on the femoral side;¹⁰ with fracture of the neck of the femur (54 of 182, 29.7%), collapse of the head/AVN (30 of 182, 16.5%) and loosening of the femoral component (19 of 182, 10.4%) making up 56.6% (103 of 182) of the failures.

Table III. Mean time to revision surgery for the various modes of failure, with a comparison between men and women

Mode of failure	Mean time to failure in years (sd)			p-value
	Total	Men	Women	
All revisions	2.9 (0.003 to 11.0)	2.1 (0.04 to 9.6)	3.6 (0.002 to 11.0)	< 0.001
Fracture of the femoral neck	1.5 (0.02 to 11.0)	0.65 (0.04 to 4.6)	2.7 (0.002 to 11.0)	0.0012
Loosening of the acetabular component	2.4 (0.01 to 9.7)	1.5 (0.04 to 3.3)	2.7 (0.01 to 9.7)	0.16
Head collapse	3.9 (0.3 to 9.8)	3.5 (0.6 to 8.7)	4.6 (0.3 to 9.8)	0.28
Femoral loosening	3.7 (0.1 to 9.1)	3.3 (0.1 to 6.4)	4.0 (0.4 to 8.1)	0.50
Infection	3.1 (0.5 to 9.6)	2.6 (0.5 to 5.1)	3.4 (1.0 to 9.6)	0.53
Pain/ALVAL*/metallosis	5.2 (1.0 to 10.2)	3.6 (1.0 to 7.0)	6.0 (1.7 to 10.2)	0.16
Malposition of the acetabular component	4.2 (1.5 to 6.5)	1.5 (N/A [†])	5.5 (1.5 to 6.5)	N/A
Dislocation	3.9 (0.003 to 9.5)	0	3.9 (0.003 to 9.5)	N/A
Loosening of both components	3.4 (0.3 to 5.9)	2.0 (0.3 to 3.8)	4.1 (3.4 to 5.9)	1.0

* ALVAL, aseptic lymphocytic vascular and associated lesions

† N/A, not available

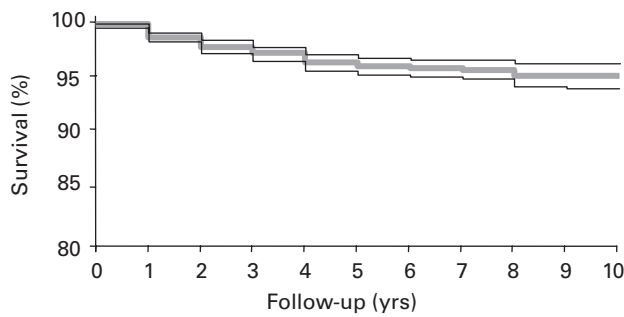


Fig. 3

Kaplan-Meier survival curve showing the Birmingham hip resurfacing prosthesis up to ten years.

Fracture of the neck of the femur has been the most extensively studied due to its relative prevalence and early appearance as a mode of failure.^{5,9} Shimmin and Back,¹¹ in a review of the Australian Joint registry, identified 50 patients (1.95%) with fractures from a cohort of 3429. They found a significant gender difference between the prevalence in men (0.96%) compared with women (1.98%; $p < 0.01$). This has been attributed to post menopausal women having a reduced bone density or the increased risk of over penetration of cement into osteoporotic bone. With follow-up of up to ten years, our study of 5000 primary resurfacings found an overall prevalence of fracture of 1.1% (54 of 5000). We found no significant gender difference between men (1.0%, 33 of 3346) and women (1.3%, 21 of 1654) ($p = 0.47$). We observed that men with fractures failed significantly earlier than women (men 0.7 years, 0.04 to 4.6; women, 2.7 years, 0.02 to 11.0; $p = 0.0012$) (Table III). The overall mean time for failure due to fracture in both cohorts was 1.5 years (0.02 to 11.0). Scheerlinck, Delpont and Kiewitt¹² in a worldwide retrieval analysis study concluded that fractures on the femoral side usually occur within the first nine months of surgery. This may be

the case in males, but in our experience fractures in females occur much later.

The second most common cause for revision of the femoral component in this series was collapse/AVN of the femoral head. In 2008, Lazarinis, Milbrink and Hailer¹³ described a case of avascular necrosis and subsequent fracture of the neck 3.5 years after hip resurfacing. They described this as an unusual, late complication.¹³ We disagree with this statement, since in our study 30 patients (0.6%) had collapse of the femoral head at a mean of 3.9 years (0.3 to 9.8). This represents 16.5% (30 of 182) of the patients requiring revision, the third most common cause. A patient in whom there is concern as to potential collapse of the femoral head and AVN needs to be followed up regularly for five or six years. Forrest et al¹⁴ has recommended positron emission tomography in conjunction with fluorine injection as a method of assessment of the femoral head after hip resurfacing.

Retrieval studies have suggested that the cause of failure of the femoral component after hip resurfacing is multifactorial. Varus positioning and undersizing of the femoral component, and notching of the superior neck have been associated with femoral neck fracture.^{10,15,16} Positioning of the femoral component into at least 10° of valgus results in more physiological stresses within the femoral neck,¹⁷ but care must be taken not to notch the superior neck. Zustin et al¹⁸ identified three morphologically distinct modes of femoral fracture; 51% of the failures due to fracture were classified as acute postnecrotic, 40% as chronic biomechanical and 8% as acute biomechanical. They found that acute biomechanical fractures were found exclusively in the neck and occurred earlier (mean 41 days, SD 57) than either acute postnecrotic failure (mean 149 days, SD 168) or chronic biomechanical fractures (mean 179 days, SD 165). Of their 107 retrieved specimens 59% had femoral fractures within the bone inside the femoral component, with osteonecrosis being the most frequent cause of fracture-related failures. The cement mantle, the depth of penetration of cement within the resurfacing head, bone density

and the clearance between the reamed head and the femoral component have all been associated with implant survival. With cementing there is the potential for thermal necrosis of the cancellous bone in the reamed head. Too much cement can lead to thermal necrosis, whereas an insufficient amount may cause mechanical failure and particle-induced osteolysis. Gill et al¹⁹ recommended a modified technique after they found temperatures at the cement-bone interface in excess of that reported to cause osteocyte death. They use a suction cannula in the lesser trochanter, generous pulse lavage and early reduction of the joint to reduce temperatures at the cement-bone interface. Gross and Liu²⁰ described 20 uncemented femoral resurfacings at a mean follow-up of 7.4 years. They had four revisions (20%) but none for aseptic failure of the femoral component. With such small numbers caution should be exercised before accepting cementless femoral fixation as a viable alternative to cementing, although no advantage of either with regard to the loading of femoral bone has been reported biomechanically using finite element analysis.²¹

A theoretical advantage of resurfacing arthroplasty is that a failed femoral component can be safely revised to a total hip replacement (THR). Ball et al¹⁰ compared early follow-up (46 months in the conversion arthroplasty group (21 hips), 57 months in the primary THR group (64 hips)) in these patients, and found comparable results in terms of surgical effort, safety and clinical outcomes. Of their 21 failed resurfacings, the acetabular component was retained at revision in 18 hips (86%) and both components were revised in three (14%). In our 54 revisions following fracture, the acetabular component was retained in only 31 hips (57%) and both components were revised in 23 (43%) (Fig. 1). The theoretical advantage of revision should only the femoral component fail may not be borne out in reality.

The long-term success of uncemented acetabular components in THR is well established.^{16,22,23} Loosening of the acetabular components of hip resurfacing has not been reported as a particular problem. In a review of 446 hip resurfacings (43 McMinn (Corin Medical Ltd, Cirencester, United Kingdom) and 403 BHRs), Daniel, Pynsent and McMinn²⁴ found no revisions for loosening of the acetabular component at a mean follow-up of 3.3 years (1.1 to 8.2). Amstutz et al²⁵ published a series of 400 Conserve plus hip resurfacings (Wright Medical Technology, Arlington, Texas). From this group only one hip (0.3%) was revised for acetabular loosening, but acetabular radiolucency was observed in 32% of cases, 26% in a single zone and 6% in two zones. In a multicentre review of 200 hip resurfacings at a mean of 19.5 months (3 to 47), Kim et al²⁶ found that 5% (10 of 200) were revised for loosening of the acetabular component. The surgical learning curve was felt to be the explanation and the authors anticipated that further surgical experience would lead to a decrease in this high early failure rate.

We found that acetabular loosening was the second most common cause of revision with a prevalence of 0.6% (32 of

5000). Acetabular loosening accounted for 17.6% (32 of 182) of all revisions. Women had a significantly higher proportion of loosening of the acetabular component than men (Table I). We propose two explanations for this gender difference. The observed rate of metal allergy is higher in women^{27,28} and the smaller head size of implants used may result in higher levels of debris from metal wear.²⁹ McBryde et al³⁰ looked prospectively at 655 BHRs with a mean follow-up of 3.5 years. From their 48 revisions (7.3%) they concluded that although female patients initially appear to have a greater risk of revision, the increased risk is related to the size of the femoral component and therefore only indirectly related to gender. De Hann et al³¹ noted that steeply inclined acetabular components, as a result of edge loading, disrupt fluid-film lubrication resulting in increased wear and higher serum concentrations of metal ions. More recently, Shimmin, Walter and Esposito³² showed how this finding is further compounded when a component with a small arc of cover is implanted. The articular arc of the BHR acetabular component varies with its size being proportionately smaller with a smaller size. Whilst a smaller articular arc may increase the range of movement before impingement, it also increases the risk of edge loading, especially if there is any malpositioning of the acetabular component. The manufacturer's literature recommends that acetabular components be implanted with an abduction angle of 45°. However, Jeffers et al³³ has shown that with the combination of reduced articular arc and altered centre-edge angle, the actual effective angle of inclination at the bearing surface is greater than this. If cell necrosis results from higher levels of metal debris then a smaller size of prosthesis in combination with susceptibility to allergy may explain our gender difference in loosening of the acetabular component.

Pandit et al⁶ described a series of 20 hip resurfacings, all in women, associated with soft-tissue swellings thought to be due to either a hypersensitivity or toxic reaction to metal wear debris. Compared with other studies, we found a relatively lower prevalence of 0.3% (13 of 5000) for pain/ALVAL/metallosis as a reason for revision, with 15 of 182 (8.2%) hips revised for this reason. Once again females had a significantly higher revision rate. Glyn-Jones et al³⁴ found an overall revision of 1.8% for pseudotumour in 1419 hip resurfacings in 1224 patients. At eight years revision for pseudotumour in males was 0.5% whilst in females it lay between 6.0% (> 40 years of age) and 13.1% (< 40 years of age). Langton et al³⁵ analysed 660 hip resurfacings and reported a 3.4% revision for failures related to metal debris.

Malpositioning of the acetabular component has recently also been implicated in pseudotumour formation.³⁶ Revision for malposition of the acetabular component was required in three of 182 (0.1%) in our series. There is a surgical learning curve associated with hip resurfacing and it is generally accepted to be a more complex procedure than THR. Both De Hann et al³⁷ and Kim et al²⁶ noted higher rates of failure due to malpositioning of the

acetabular component, attributing this to the technical challenges of performing resurfacing. It has been stated that most failures occur during the learning curve,⁵ but McBryde et al³⁰ found that revision was not associated with surgeon, surgeon experience or surgical approach. Furthermore, there is still no consensus on the number of resurfacings needed to overcome the learning curve. De Smet, Campbell and Gill³⁸ summarising the Ghent advanced hip resurfacing course 2009 stated that an orthopaedic surgeon should have a minimum experience of 200 conventional THRs before starting hip resurfacing. Opinion varied on the number of resurfacings needed to overcome the learning curve ranging from 20 (36% of voters), to 50 (28% of voters) and more than 50 (30% of voters).

Khan et al³⁹ published a multicentre series of 679 BHRs in 653 patients, implanted by non-inventing surgeons. There were 29 revisions (4.3%) with a cumulative survival of 95.7% at eight years. The risk of fracture of the neck was 1.6% which was higher than the combined published data of the inventing surgeons (0.2%). The series of 446 hips by Daniel et al²⁴ did not have any such fractures, and the series of 144 hips by Treacy, McBryde and Pynsent⁴⁰ had only one fracture. This suggests that the complication is not necessarily associated with the prosthesis and that its occurrence may be reduced by improved patient selection and surgical technique. Other series from independent centres have confirmed good mid-term results for BHR. Compared with our overall revision rate of 3.6%, Heilpern, Shah and Fordyce⁴¹ found a similar rate of 3.6% (110 BHRs, 98 patients) with survival of 96.3% at five years. Steffen et al⁴² reported a 3.8% revision rate (610 BHRs, 532 patients) with survival of 95.0% at seven years. In this series there was a 2.0% (12 of 610) failure from femoral fracture (12 of 23 hips revised), 0.7% (4 of 610) for aseptic loosening (4 of 23 hips revised) and 0.5% (3 of 610) possibly related to metal debris (3 of 23 hips revised).

From our cohort of 5000 hip resurfacings only 17 patients (17 hips) (0.3%) required revision for infection and five patients (five hips) (0.1%) for dislocation. This compares favourably to values published for THR. The 2007 Swedish Hip Arthroplasty Registry identified 290 revisions for dislocation from a cohort of 14 105 hip replacements (2.1%).⁴³ Similar values have been published from the United States. Mahomed et al⁴⁴ reviewed 61 568 primary total hip replacements from the Medicare population and found a dislocation rate of 3.1%. The British National Joint Registry Report looked at overall revision surgery for hip arthroplasty in 2008.⁴⁵ They found that 12% of revisions were for infection and 16% were for dislocation. Our series had 9.3% (17 of 182 hips) of revisions for infection and only 2.7% (5 of 182 hips) for dislocation. It is generally accepted that hip resurfacing has a lower dislocation rate. The inherent stability of a larger diameter femoral head has been recognised since it has a greater distance of excursion before subluxating or dislocating.

When comparing our study with recent reports from arthroplasty registries, the British National Joint Registry Report 2009 showed resurfacing to comprise 8% (5195 of 64 722) of the overall primary hip arthroplasties performed in 2008, with a revision rate at three years of 4.5% (male 3.7%, female 5.8%). The BHR arthroplasty had the lowest rate of resurfacing revision at three years, at 3.3%.⁴⁵ In 2009 the Australian National Joint Replacement Registry⁴⁶ showed hip resurfacing to comprise 7.6% of all primary hip arthroplasties, with a revision rate of 3.6%. The BHR arthroplasty was used in 50.9% of their resurfacings with an eight-year cumulative revision rate of 5.0%. The BHR seven-year cumulative revision rate was quoted as 4.8%.⁴⁶ Our 3.6% revision rate (BHR) at a mean of 7.1 years compares favourably. Although having a short mean time of follow up of 2.2 years (SD 1.7), the 2007 Swedish Hip Arthroplasty Registry⁴³ showed the BHR to comprise 51.3% of their total resurfacings, and quoted a resurfacing survival at five years as 96.9% (SD 2.3% 95% CI). This is comparable to our Kaplan-Meier survival analysis. Using revision for all causes of failure as the endpoint, we showed a cumulative survival of 96.3% at seven years and 95.3% at ten years (Fig. 3).

The main limitation of our study is that it lacks objective radiological follow-up. However, we aimed to identify the prevalence of revision for hip resurfacing arthroplasty and to analyse the reasons for failure. Radiological follow-up in isolation is probably not a reliable predictor of survival or function of hip prostheses. In a study from the Trent arthroplasty register, it was shown that gross radiological features of failure of an arthroplasty were not reliably seen to lead to revision when studying the same cohort of patients five years later.⁴⁷

It has been stated that prior to surgery there is little or no difference in the Western Ontario and McMaster Universities Osteoarthritis index⁴⁸ and the Short form-36⁴⁸ scores between patients waiting for THR compared with those waiting for hip resurfacing.⁵⁰ However, the latter patients have better function when compared with those awaiting THR. After hip resurfacing (BHR) patients report a significantly greater improvement in general health compared with those who have had a THR.⁴⁹ With this in mind, any necessary revision surgery in this younger, fitter and more active population is often viewed as disastrous by the patient and any functional deterioration after revision is not received well.

Despite the increasing interest and subsequent published literature on hip resurfacing arthroplasty, little is known about the prevalence of its complications. This is in part due to their relative infrequency and published studies containing small numbers of patients. Hip resurfacing has its own unique set of complications, including fracture of the neck of the femur. It is important to understand the prevalence of complications as well as the risk factors in order to appropriately select patients and adequately inform them prior to hip resurfacing arthroplasty.

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