Results of Birmingham hip resurfacing at 12 to 15 years

A SINGLE-SURGEON SERIES

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We report a 12- to 15-year implant survival assessment of a prospective single-surgeon series of Birmingham Hip Resurfacings (BHRs). The earliest 1000 consecutive BHRs including 288 women (335 hips) and 598 men (665 hips) of all ages and diagnoses with no exclusions were prospectively followed-up with postal questionnaires, of whom the first 402 BHRs (350 patients) also had clinical and radiological review.

Mean follow-up was 13.7 years (12.3 to 15.3). In total, 59 patients (68 hips) died 0.7 to 12.6 years following surgery from unrelated causes. There were 38 revisions, 0.1 to 13.9 years (median 8.7) following operation, including 17 femoral failures (1.7%) and seven each of infections, soft-tissue reactions and other causes. With revision for any reason as the end-point Kaplan–Meier survival analysis showed 97.4% (95% confidence interval (CI) 96.9 to 97.9) and 95.8% (95% CI 95.1 to 96.5) survival at ten and 15 years, respectively. Radiological assessment showed 11 (3.5%) femoral and 13 (4.1%) acetabular radiolucencies which were not deemed failures and one radiological femoral failure (0.3%).

Our study shows that the performance of the BHR continues to be good at 12- to 15-year follow-up. Men have better implant survival (98.0%; 95% CI 97.4 to 98.6) at 15 years than women (91.5%; 95% CI 89.8 to 93.2), and women < 60 years (90.5%; 95% CI 88.3 to 92.7) fare worse than others. Hip dysplasia and osteonecrosis are risk factors for failure. Patients under 50 years with osteoarthritis fare best (99.4%; 95% CI 98.8 to 100 survival at 15 years), with no failures in men in this group.

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Modern metal-on-metal (MoM) hip resurfacing (HR) was developed as a conservative option for young patients with the objective of delaying the need for a conventional total hip replacement (THR).[1] National Registers demonstrate that the results of HR are implant-specific, with the Birmingham Hip Resurfacing (BHR formerly Midland Medical Technologies, Birmingham, United Kingdom, now Smith & Nephew Orthopaedics Ltd, Warwick, United Kingdom) showing implant survival of 93.7%[2] and 92.9%[3] at eight and ten years, respectively. The results from series of the BHRs undertaken by designer surgeons[4,5] and from independent centres,[6-8] show medium-term implant survival ranging from 92% to 97% at between ten and 14 years. The Oswestry International Register of 5000 BHRs, performed by 141 surgeons worldwide, reports 95% implant survival at ten years.[9]

Advantages of HR over THR include a reduced incidence of dislocation (as a result of the large diameter of the resurfaced femoral head)[4-6] and an uncomplicated femoral revision which is attributable to the limited femoral bone resection needed for HR. There is some evidence that HR provides better function of the hip[10-12] and is associated with lower mortality[13,14] compared with THR. While studies from some centres have reported a low incidence of adverse reaction to metal debris (ARMD)[15] in the ten years following BHR,[4-8] others have predicted high rates of failure by this mechanism at eight years.[16]

Of the 3500 BHRs performed by the designer surgeon (DJWM) in the last 15 years, the earliest 1000 have now been followed up for between 12 and 15 years. Of these, the first 402 hips (350 patients) have undergone thorough clinical, radiological and functional assessment as required by the United States Food and Drug Administration (FDA) premarket approval process.

The aim of the study is to report the complications, failures and 12- to 15-year implant survivorship of the first 1000 BHRs, and the clinical, radiological and functional outcomes of the first 402 cases.

Patients and Methods

This study represents a consecutive series of the first 1000 BHRs (886 patients) performed

Table I. Primary diagnoses of 1000 hips (886 patients (%)) treated with the Bimingham hip resurfacing implant

	All ages, both genders (%)	**Men under 60 years at operation (%)**	**Men 60 years and above at operation (%)**	**Women under 60 years at operation (%)**	**Women 60 years and above at operation (%)**
	n = 1000	n = 491	n = 174	n = 260	n = 75
Osteoarthritis	763 (*76*)	393 (*80*)	158 (*91*)	145 (*56*)	67 (*89*)
Osteonecrosis	40 (*4*)	22 (*4*)	3 (*2*)	15 (*6*)	0 (*0*)
Hip dysplasia	103 (*10*)	20 (*4*)	7 (*4*)	68 (*26*)	8 (*11*)
Destructive arthritis	37 (*4*)	13 (*3*)	5 (*3*)	19 (*7*)	0 (*0*)
Inflammatory arthritis	18 (2)	10 (*2*)	0 (*0*)	8 (*3*)	0 (*0*)
Slipped epiphysis and/or Perthes' disease	25 (*3*)	23 (*5*)	0 (*0*)	2 (*1*)	0 (*0*)
Post-traumatic	14 (*1*)	10 (*2*)	1 (*1*)	3 (*1*)	0 (*0*)

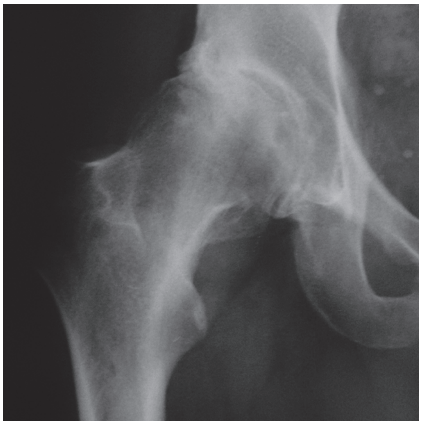


Fig. 1a

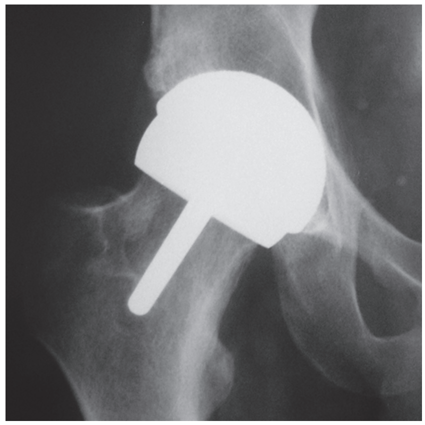


Fig. 1b

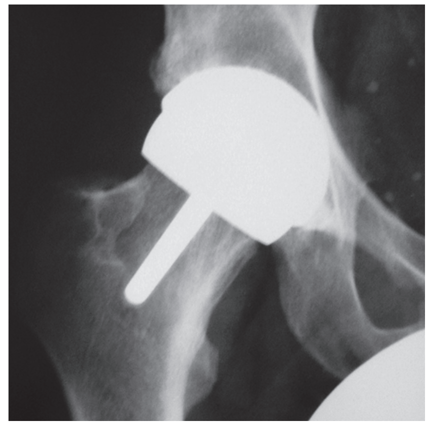


Fig. 1c

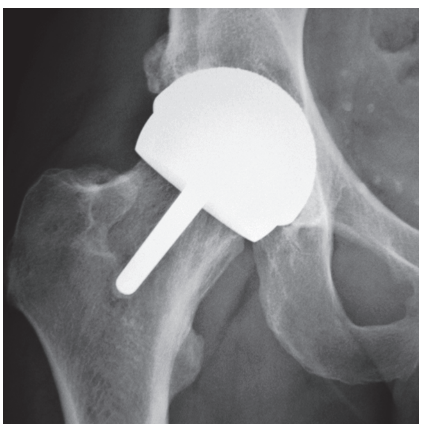


Fig. 1d

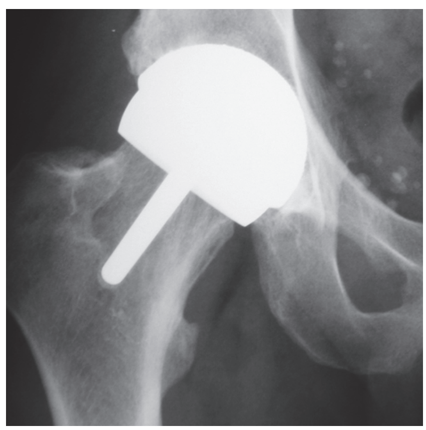


Fig. 1e

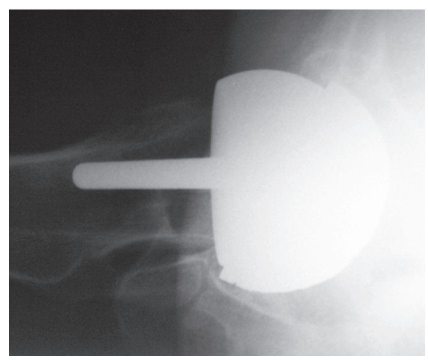


Fig. 1f

Radiological series showing a patient with primary osteoarthritis, who underwent a Birmingham hip resurfacing aged 38 years: a) pre-operatively, b) one, c) five, d) 10, e) and f) 15 years after operation. He is 54 now, continues to work full-time, regularly swims, skis and runs. His Oxford hip score is 14/12, Harris hip score 76/90. OsHIP score 95/100. The radiographs show no adverse features.

by a single surgeon (DJWM) between 1997 and 2000. No patient who underwent BHR surgery in the study period has been excluded from this analysis for any reason. Of the 1000 BHRs (886 patients), 335 were implanted in women (288 patients) and 665 were in men (598 patients). Mean follow-up was 13.7 years (12.3 to 15.3). The mean age of the patients at operation was 53 years (15 to 84 years) and 817 hips (81.7%) were operated between the ages of 40 and 65 years. Primary osteoarthritis (OA) was the most common diagnosis (763 hips (76%), 551 (83%) in men, 212 (63%) in women), followed by dysplasia (103, (10%) of all hips). Diagnosis details are given in Table I (Fig. 1).

The BHR (Smith & Nephew) has a cemented femoral component. The acetabular component has a porous surface coated with a calcium hydroxyapatite coating to allow cementless implantation. Both components are

Table II. Modes and times to failure in the 38 Birmingham Hip resurfacing revisions

Failure mode	Number (%)	Mean age at primary procedure in years (range)	Mean time to failure in years (range)	Female	Male
Femoral neck fracture	4 *(0.4)*	56.6 (34.7 to 75.1)	0.2 (0.1 to 0.4)	2	2
Femoral head collapse	13 (*1.3)*	50.4 (34.5 to 58.8)	8.7 (0.7 to 14.0)	6	7
Cup loosening	2 (*0.2)*	58.0 (50.3 to 65.7)	10.6 (9.7 to 11.6)	1	1
Osteolysis	2 (*0.2)*	57.5 (50.2 to 64.8)	9.0 (7.0 to 10.9)	1	1
Unexplained groin pain	3 (*0.3)*	44.8 (25.9 to 55.1)	8.5 (6.1 to 11.0)	2	1
Debris Reaction ARMD*	7 (*0.7)*	53.7 (46.7 to 58.6)	10.6 (9.8 to 11.5)	7	0
Infection	7 (*0.7)*	51.9 (39.6 to 61.8)	5.1 (2.5 to 11.6)	6	1

*ARMD, adverse reaction to metal debris

manufactured from as-cast high-carbon cobalt–chrome alloy with 4 mm increments in the diameter of the femoral component, and 2 mm increments for the acetabular component.

An extensile posterior approach was used[1,17-19] to obtain a 360° view of the acetabulum for optimal component positioning. The intended acetabular component inclination angle was 40°, with 20° anteversion, and the femoral component placed in neutral or mild valgus relative to the femoral neck. The acetabulum was under-reamed by 2 mm relative to the component to allow primary press-fit fixation. The exceptions to this rule were patients, usually women, with very small sclerotic acetabulae who are under-reamed by 1 mm to avoid the risk of acetabular fracture, and in some large men with soft cancellous bone exposed in the reamed acetabulum, the socket is under-reamed by 3 mm.

Patients were reviewed at two months with clinical and radiological assessment. Between two months and ten years, follow-up was conducted independently by the Oswestry Outcomes Centre (OOC) by annual postal questionnaires. From ten years onwards, postal follow-up has been continued by the McMinn Centre.

We attempted to establish the reason for revision in every case based on the history, clinico-radiological and laboratory findings. Revision of either component for any reason was taken as the end-point for implant survival. All surviving patients were contacted, by post, through their general practitioner or next of kin, or via the National Strategic Tracing Service, and the status of their implant was recorded.

Clinical and radiological assessment was carried out on the first 350 patients (402 hips). These results were audited by the sponsor (Smith & Nephew) and by FDA-authorised independent auditors. Patients were sent a functional questionnaire including Oxford Hip Score (OHS),[20] Harris Hip Score (HHS),[21] Oswestry-modified Harris Hip Score (OsHIP, including a 5-point patient-satisfaction question),[9] and modified University of California Los Angeles (UCLA) activity assessment.[17] The OHS was used as described in its original form, with the score at 60 to 12, worst to best. At their appointment for clinical review, the completed questionnaires were collected, and patients underwent conventional radiographs (standing anteroposterior (AP) and horizontal beam lateral views), metal ion measurement and a multi-slice metal artefact reduction sequence (MARS) CT scan. Activity level, in terms of steps taken per year, was recorded using the StepWatch 2 system (CymaCorp, Mountlake Terrace, Australia).[22]

Radiographs were assessed by a Consultant Musculoskeletal Radiologist blinded to the clinical and functional outcomes. De Lee and Charnley acetabular zones[23] and Amstutz femoral stem zones and scores[24] were used. Grades 7 to 9 (incomplete or complete radiolucencies ≥ 2 mm in three zones with or without component migration of ≥ 3 mm) were considered radiological failures. The surgeons (JD, CP) also assessed the radiographs during the clinical review and the two sets of independent observations (surgeon and radiologist) were compared for inter-observer variability. Thinning of the femoral neck was assessed using the method described by Hing et al,[25] with a 10% reduction in neck diameter considered significant. The acetabular inclination and stem–shaft angles were measured (HZ) using standard techniques.[24,25] The interteardrop line was used as the reference to measure the inclination angle. The results of the multi-slice CT assessment and metal ion levels will be published separately.

Statistical analysis. Statistical calculations were performed on MedCalc Version 12.2.1 (MedCalc Software, Ostend, Belgium) and the R statistical package (R Foundation for Statistical Computing, Vienna, Austria). The impact of parameters (covariates) on survival were tested using the Cox proportional hazard regression. The significance of any model covariates was tested using the Wald statistic, which is actually the calculated covariate value divided by its standard error with the result squared. It has a chi-squared distribution. The 'quality' of a regression model was assessed using Akaike Information Criteria (AIC), where not only the goodness of the fit but also the number of covariates is considered, thus providing a tool for regression model selection.

Survival curves were produced based on the hazard ratios (HR) calculated. Inter-observer agreement for the radiology was measured using weighted Kappa and the nomenclature of Landis and Koch.[26] For all the statistics, a

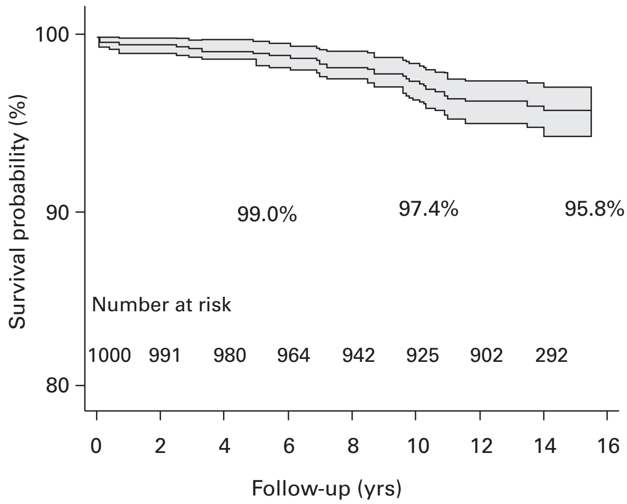


Fig. 2

Kaplan–Meier survival analysis with 95% confidence intervals shown, of the first 1000 consecutive BHRs, including all ages, all diagnoses and both genders.

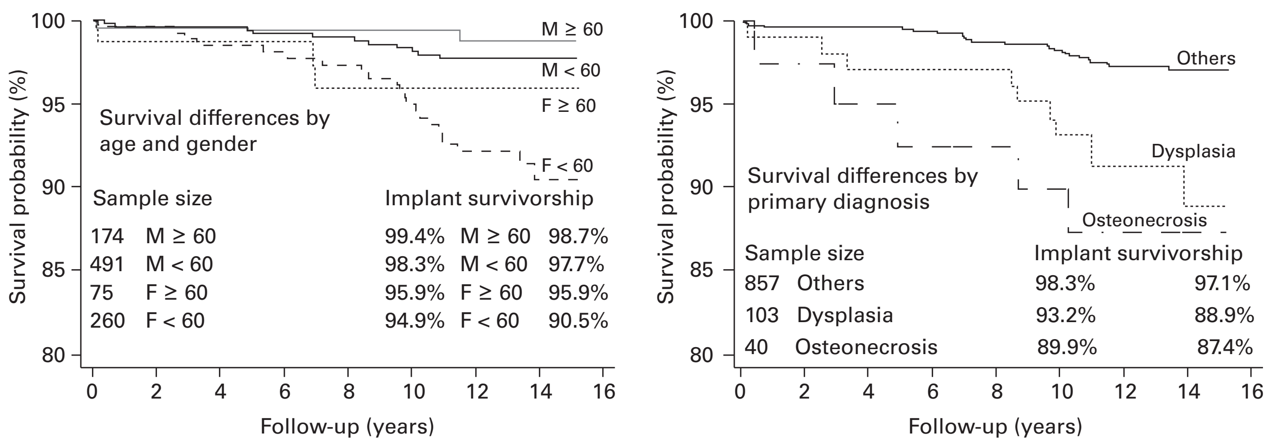


Fig. 3

Differences in Kaplan–Meier survivorship based on age, gender and primary diagnosis.

p-value < 0.05 was considered statistically significant. 95% confidence intervals (CI) are shown where appropriate.

Results

In total, 59 patients (68 hips) died from unrelated causes between 0.7 and 12.6 years following surgery, of which two had been revised prior to their death. Two patients had intra-operative notching of the femoral neck, with no later adverse effects. One patient sustained a posterior dislocation five years post-operatively, following a fall from a ladder. Recurrent dislocation ensued which was successfully treated with a double-breasted capsular repair.

There were 38 revisions (3.8%), in 36 patients which were performed at a median of 8.7 years (mean 7.6 years; 0.1 to 13.96) following implantation (Table II). In all, six patients with bilateral BHRs underwent revision; in two of these patients, both BHRs were revised. Of the 38 revisions, 24 were performed in Birmingham and 14 were performed elsewhere.

Overall implant survival was 97.4% (95% confidence interval (CI) 96.9 to 97.9) at ten years and 95.8% (95% CI 95.1 to 96.5) survival at 15 years respectively (Fig. 2). Survival was worse in women compared with men at 15 years (91.5%, 95% CI 89.8 to 93.2) in women *versus* (98.0%; 95% CI 97.4 to 98.6) in men (Fig. 3) and in young women (< 60 years) compared with older women (≥ 60 years) (90.5%; 95% CI 88.3 to 92.7 *vs* 95.9%; 95% CI 94.6 to 97.2). Using Cox regression, the diagnosis of

Table III. Cox Regression model in men and women. For categorical covariates (diagnosis and bilaterality), exp(b) offers the instantaneous relative risk of an event, at any time, with the risk factor present*versus* absent, given all other covariates are equal. For continuous covariates (age, American society of anaestheologists (ASA) grade and head size) it is the relative risk with an increase of 1 in the value of the covariate. The diagnosis of dysplasia is the only covariate that has a significant influence in women (p = 0.05), and the diagnosis of avascular necrosis (AVN) (femoral head osteonecrosis) has a significant influence in men (p = 0.0001)

	In women			In men		
Covariate	**HR (95% CI)**	**Wald**	**p-value**	**HR (95% CI)**	**Wald**	**p-value**
Age at operation	1.01 (0.97 to 1.05)	0.40	0.53	1.03 (0.97 to 1.09)	0.67	0.41
ASA grade[26]	1.32 (0.55 to 3.17)	0.39	0.53	0.69 (0.18 to 2.66)	0.28	0.59
Head size	1.03 (0.66 to 1.59)	0.01	0.90	0.96 (0.80 to 1.15)	0.19	0.66
AVN	1.17 (0.15 to 9.27)	0.02	0.89	14.33 (3.69 to 55.70)	14.63	0.0001
Dysplasia	2.46 (1.00 to 6.04)	3.82	0.049	0.00 (0.00 to 0.00)	0.00	0.97
Bilateral (v unilateral)	0.86 (0.34 to 2.18)	0.10	0.75	0.68 (0.15 to 3.16)	0.23	0.63

HR, hazard ratio for revision; CI, confidence interval; Wald, Wald statistic

femoral head avascular necrosis (AVN) ($p = 0.005$) and hip dysplasia ($p = 0.049$) were found to have a significant influence on implant survival, while age at operation ($p = 0.213$), gender ($p = 0.146$), American Society of Anaesthesiologists (ASA) grade[27,28] ($p = 0.674$), head size ($p = 0.139$), or whether unilateral or bilateral ($p = 0.766$) did not. AVN alone was found to have a significant influence in men ($p < 0.001$) and dysplasia ($p = 0.049$) alone in women (Table III). When reduced to just gender and diagnosis, the model offers the best fit in terms of AIC.

For women with developmental hip dysplasia, implant survival was 96% (95% CI 93.8 to 98.2), 91% (95% CI 87.7 to 94.3) and 85% (95% CI 80.2 to 89.8) at five, ten and 15 years respectively. In patients of either gender < 50 years of age with osteoarthritis, survival was 100% at five years and 99.4% (95% CI 98.8 to 100) at ten and 15 years. There were no failures in men in this group, while in women in this group, survival was 100%, 97.3% (95% CI 94.6 to 100) and 97.3% (95% CI 94.6 to 100) at five, ten and 15 years respectively.

Femoral failures (collapse of the femoral head or fracture of the femoral neck) occurred in 17 hips (1.7%) (Table II) (Fig. 4). All fractures of the femoral neck occurred in the first four months following surgery. In seven femoral failures treatment was performed by conversion to a large diameter MoM THR, leaving the BHR acetabular component *in situ*. The remainder were revised to a non-MoM THR. Failures related to wear, which were considered to include acetabular component loosening, unexplained groin pain, osteolysis and ARMD, occurred in 14 hips (1.4%). All of these cases were revised to a non-MoM THR. Of the six patients (seven hips) that failed due to ARMD (0.7%), four patients (five hips) showed strong reaction to nickel on lymphocyte transformation test, one did not undergo the test, and in the other, the cells were inadequate for it. No patient who underwent revision for ARMD in our centre had major complications, muscle necrosis or re-revision. Of the patients who underwent revision elsewhere, none reported major complications or re-revision.

Of the 793 patients living with unrevised hip resurfacings (896 unrevised hips), 754 (95.1%) patients have at least one completed current hip score, either OHS, OsHIP or HHS. Mean OsHIP scores have consistently exceeded 90% over the study period (Fig. 5). Of 754 cases, 18 (2.4%) currently have a poor OsHIP score (< 70/100),[29] and 10 of 603 (1.7%) have a poor Oxford score (34 to 60 points).[30] The mean UCLA activity Level Scale is 7.8, with 82% (467 of 570 patients) remaining active (levels 7 to 10), 68% (387 of 570 patients) regularly participating in very active events (8 to 10), and 23% (133 of 570 patients) participating in impact sports.[10,11]

A subgroup of 350 patients, comprising the first 402 hips in the series, underwent more detailed clinical and radiological follow-up. The mean age of these patients was 53.2 years (23 to 84). At the latest follow-up, 23 patients (28 hips) had died, including one patient (one hip) who had previously undergone revision, and 18 patients (20 hips) had undergone revision surgery. Of the remaining 355 hips, 302 were reviewed in clinic and 14 sent radiographs and questionnaire responses by post. As such, 316/355 surviving hips (89%) had radiological follow-up and 325/355 (91.5%) had clinical scores. Mean OSHIP score was 94% (standard deviation (SD) 9.1) and 93% (SD 9.9) at five and ten years respectively, and 93% (SD 10.1) at the most recent follow-up. Mean HHS was 85 (standard deviation (SD) 9.8) and mean OHS was 15 (SD 5.3) (Table IV). Mean activity level at the most recent follow-up was 1.8 million cycles per year (0.5 to 4.1). The mean range of flexion of the operated hip was 128° (85° to 140°). No patient had a fixed abduction, adduction, or rotation deformity. Satisfaction was categorised into two groups: ‘satisfied’ (comprising patients who were ‘pleased’ or ‘extremely pleased’), and ‘dissatisfied’ (comprising those reporting no improvement, and those who report themselves worse or much worse than pre-operatively). Fewer than 1% of patients were dissatisfied at any interval in the study period.

The mean angle of inclination of the acetabular component was 43° (SD 5.1°), with three hips being outliers with

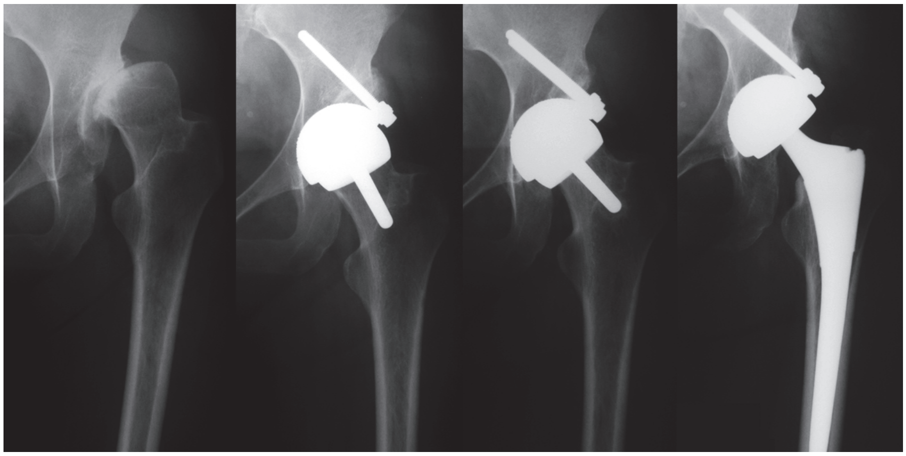
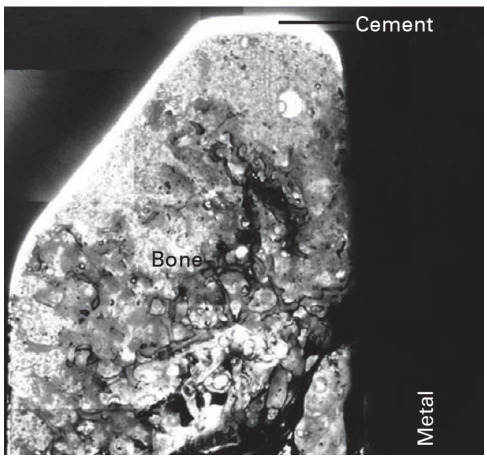


Fig. 4a



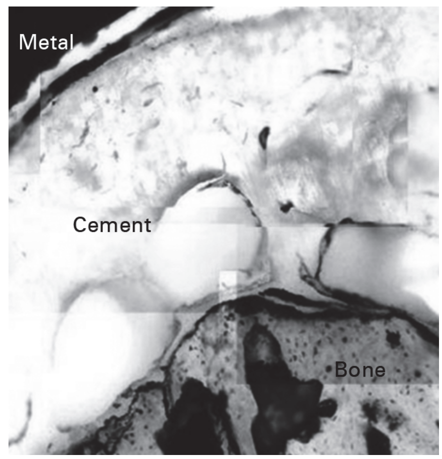


Fig. 4b Fig. 4c Fig. 4d

Radiological series of a 34-year-old female with developmental dysplasia treated with a Dysplasia Birmingham Hip resurfacing a) Initial radiographs show good component position. Later, diagnosed with systemic lupus, she was administered steroids and immuno-suppressants. A year later her radiographs showed varus migration of femoral component, suggesting possible femoral loosening. The patient continued to mobilise without symptoms. Eight years later she fell down, sustained a femoral head fracture and had to be converted to a total hip replacement. b) The retrieved femoral head was sectioned and a radiograph was taken. The specimen was then stained with methylene blue/basic fuchsin c)12.5X and d) = 100X magnification) which confirm that the bone in the femoral head is vascular and viable; and that the femoral component was not loose as seen from the intact bone–cement and cement–implant interfaces. Histology also suggested a series of microfractures in the femoral head, which had spontaneously healed, possibly resulting in the early migration. The migration, however, stabilised until the subsequent fall and basal fracture.

inclination > 55°. The mean stem–shaft angle was 143° (SD 6.1°). Diffuse thinning of the femoral neck (compared with radiographs taken at two months) was present in 16 hips (5.1%) in 15 patients, but none progressed after the first five years. Focal resorption of the inferomedial or superolateral neck (which may be the result of impingement) was present in 14 hips (4.4%) in 14 patients.

Acetabular radiolucencies were present in a single zone (grades 1 to 3) in 9/316 hips (2.8%), and in two zones (grades 4 to 6) in 4/316 (1.3%). No hips had a radiolucency in all three acetabular zones. Femoral radiolucencies were present in one zone in 11/316 (3.5%), in two zones in 0/316 (0%) and in three zones in 1/316 (0.3%). Thus, there were no radiological acetabular failures and one radiological femoral failure. There was substantial agreement between the degree of acetabular radiolucency as assessed by the radiologist and the surgeons (weighted Kappa κ = 0.74, 95% CI 0.62 to 0.86), but poor agreement in the assessment of femoral radiolucencies, with the surgeons diagnosing a greater number than the radiologist (κ = 0.29, 95% CI 0.10 to 0.48). Inter-observer reliability for the summary findings was substantial (κ = 0.63, 95% CI 0.49 to 0.77). On CT, the acetabular radiolucencies (9/288) were a mean size of 1.6cm^2 (1 to 3.4), and the femoral radiolucencies (4/288) were a mean size of 1.1cm^2 (1 to 2.4). No radiolucency was deemed extensive enough to affect component stability or to justify a revision procedure. Aside from the seven hips revised for symptomatic effusions, no asymptomatic solid pseudotumours or large effusions were detected by CT.

Small effusions were seen in 16 of 288 hips (5.6%) of the BHRs and also in 2/79 (2.5%) of contralateral unoperated hips where arthritic change was present at the time of

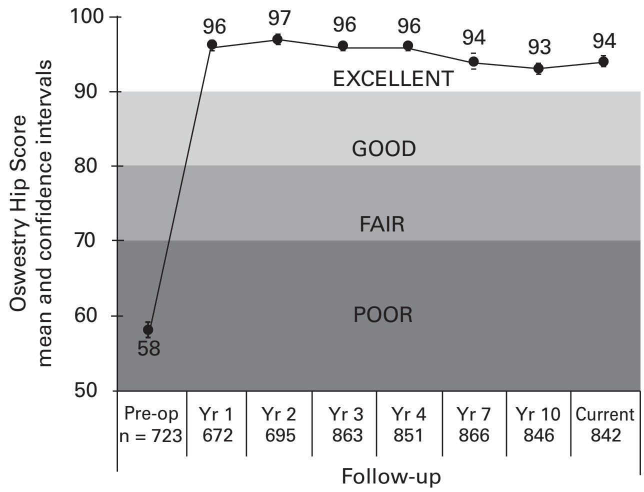


Fig. 5

Oswestry modified Harris hip score (OsHIP) postal questionnaire responses over the years following implantation. Marchetti's grade boundaries shown.

Table IV. Hip function scores in the clinico-radiological cohort.

	OSHIP	HHS	OHS	UCLA
Range (Best possible score to worst)	(100 to 0)	(90 to 0)	(12 to 60)	(10 to 1)
Mean (expressed as % of best possible score)	93 (93)	85 (94)	15 (94)	7.8
Standard deviation	10.1	9.8	5.3	1.1
95% confidence interval	1.1	1.1	0.6	0.1
Quartile 1	90	84	12	7.0
Median (expressed as % of best possible score)	98 (98)	88 (98)	13 (98)	8 (80)
Quartile 3	100	90	15	8
Excellent + Good (%)	89	91	96	82 (level 7 to 10) Active

OSHIP, Oswestry Hip Score; OHS, Oxford Hip Score; HHS, Harris Hip Score; UCLA, University of California Los Angeles Activity scale

review. There was no evidence of muscle necrosis or other changes in soft-tissue in either hip in any patient.

Discussion

The introduction of the BHR followed 6.5 years of pre-clinical testing and clinical pilot studies.[1] Despite the array of pre-clinical and post-marketing strategies and trials, the catastrophic failure of other resurfacing devices demonstrate that these do not guarantee implant survivorship in real life.[31-36] Charnley first introduced the practice of following up his first three years' THR implantations through periodic review or questionnaires over 15 years.[37] We have followed a similar pattern of follow-up through prospective annual outcomes scores by the OOC and periodic clinical and radiological assessments at our centre. This is the 15-year report of the earliest three years and 1000 BHR implantations by the inventor surgeon.

There are both strengths and limitations to this study. First, it is a prospective case series rather than a randomised controlled trial (RCT). However, unlike in pharmaceutical research, RCTs are not the only study design suitable for the introduction and monitoring of new surgical devices.[38] Second, as this is a report from the designer centre, there is potential for bias. In an attempt to minimise bias, prospective questionnaire evaluations were conducted by an independent centre, and the radiological assessment included a contribution by a radiologist blinded to the clinical outcome. Third, this is a single surgeon series from a high volume hip surgeon (DJWM) who had performed around 500 MoM resurfacings prior to the present study, which minimises the learning curve effect and may limit the external validity of this study. However comparable medium-term results from other centres[4-8] and national registers[2,3] suggest that, following adequate training, this technique is reproducible.

A strength of this study is the low rate of loss to follow-up. All patients had their survival and revision status confirmed; 95.1% of surviving patients with unrevised hips had clinical outcome scores at latest follow-up and 89% of hips in the clinical and radiological review group (316/355) had a radiological assessment. Another strength is that the device used in the present study and the implantation technique have remained unchanged, (other than the subsequent addition of

2 mm head size increments), throughout the study and to the present day. In a previous cohort, containing hips before and after the addition of the additional head sizes, it was found that the change had no effect on implant survival,[4] suggesting that the results in this report may be translated to devices currently in use.

At 15 years, the results of this study in terms of all-cause implant survival (98.0%; 95% CI 97.4 to 98.6 in men and 91.5%; 95% CI 89.8 to 93.2 in women) compare well with results from other centres[4-8,12] and joint registers[2,3] confirming that the BHR is a reliable and effective procedure. A recent report has suggested that HR may only be suitable in men with bearing diameters > 54 mm.[39] In contrast, the Australian register demonstrates that in a national series, among men with osteoarthritis (OA) under 65 years (the largest single group requiring a resurfacing), HR (of any diameters) has a 1.3% lower cumulative implant revision rate (6.5% to 6.7%) than THRs (7.8% to 8.7%) at ten-year follow-up.[3]

The risk of revision following conventional THR is three to five times higher in young patients compared with older patients.[40] In the Australian Register, the rate of revision increases from 7.3% (95% CI 6.0 to 8.9) in men over the age of 75, to 10.3% (95% CI 8.9 to 11.7) in men under 55, and this increase is more marked in women (from 5.0%; 95% CI 4.6 to 5.5 to 12.7%; 95% CI 10.5 to 15.2).[3] The three Nordic registers report a revision rate of 17% in young people (< 50 years) at ten years.[41] A large series of the most widely-used cemented THR has reported a revision rate of 8% at 12 years and 19% at 15.[42,43] However, in that series only 10% were under 50 years of age at the time of surgery, 57.2% had died (at a mean of 8.3 years, 0 to 16 years) by the time of analysis, and only 8% (26) of the original series (325) continued in low-stress sport or moderate manual labour following surgery. In the present series, in which over 30% of hips (317/1000) were implanted in patients below the age of 50 years, the overall revision rate of 4.2% compares well with previous series of THR. The best results in this series were seen in men and women under the age of 50 years with osteoarthritis. The BHR is a viable option in this relatively young active population who fare poorly with conventional THR.

Femoral failures (neck fractures and collapse) are unique to HR and represent a risk which has to be accepted in the interest of conserving bone. In our series, there were no instances of femoral loosening which is superior to a previous series of a different implant, with a different technique of cementing in which 8% of patients were revised for femoral loosening.[44]

Metal reactions with osseous and soft-tissue damage,[45] with features representing hypersensitivity-induced necrosis,[46,47] cytotoxicity[48] and osteolysis[49] have been reported following HR. The incidence and severity of these complications are implant-specific, with one centre predicting a rate of failure by ARMD of 4% at eight years.[16] Our series demonstrates that with well-implanted BHRs the incidence of ARMD is < 1% at 12 to 15 years. Of the seven revisions for ARMD, three were revised at our centre. These patients had effusions but had no muscle necrosis, and there were no major complications or early re-revisions following revision surgery contrary to the ARMD results from other centres[16] and with other devices.[15] Our findings are supported by results from other centres at nine to 11 years.[5,6,12] Osteolysis, loosening, unexplained pain and ARMD may all be a consequence of wear. At 15 years, the failure rate due to all of these mechanisms combined is 1.4% overall, and only 0.5% in men. This low incidence strongly supports the view that resurfacing is a suitable option for both genders, but is particularly suited to men.

Radiological assessment showed no impending acetabular failures and only one radiological femoral failure, which suggests that there is unlikely to be a precipitous drop in survival in the years following this report. In the present series, the prevalence of radiolucencies which were not deemed failures (those of grades 1 to 6), compare well with other series reporting such radiolucencies in 5% to 7% of femoral, and 1% of acetabular component regions.[7,44] Our results confirm earlier reports that thinning of the neck does not progress after five years.[7] The number of cases with focal resorption representing impingement (4%) compares well with other reports of up to 20% impingement.[44]

This study reports a rate of implant survival of 95.8% (95% CI 95.1 to 96.5) in patients of all ages and diagnoses at 15 years, and of 98.0% (95% CI 97.4 to 98.6) in men alone, with a low incidence of radiological abnormalities. This suggests that the BHR is a viable conservative alternative to THR. Patients (both men and women) under the age of 50 years with osteoarthritis have the best results. Osteonecrosis and dysplasia are risk factors for failure. The incidence of ARMD is less than 1%. The high hip function and patient satisfaction scores suggest that the expectations of this relatively young cohort are adequately met.

Supplementary material

Four tables showing range of movement, longitudinal assessment, radiological findings and ten-year results compared with the current study, as well as a figure showing a radiological series of a patient with severe SUFE are available alongside the online version of this article at www.bjj.boneandjoint.org.uk.

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