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A medium-term comparison of hybrid hip replacement and Birmingham hip resurfacing in active young patients

R. P. Baker,
T. C. B. Pollard,
S. J. Eastaugh-Waring,
G. C. Bannister

From the Avon Orthopaedic Centre, Bristol, United Kingdom

We compared the medium-term clinical and radiological results of hybrid total hip replacement (THR) with metal-on-metal Birmingham hip resurfacing (BHR) in two groups of 54 young patients matched for age, gender, body mass index and pre-operative levels of activity.

The clinical outcome was assessed by the University of California, Los Angeles (UCLA) activity score, the Oxford Hip Score (OHS) and the EuroQol scores. Radiologically, all hips were assessed for migration and osteolysis, the hybrid THRs for polyethylene wear and the BHRs for a pedestal sign. The mean follow-up of the patients with a hybrid THR was ten years and for those with a BHR, nine years. Four patients with a hybrid THR and one with a BHR had died. In each group five were lost to follow-up. The revision rate of the hybrid THRs was 16.7% (9 of 54) and of the BHRs 9.3% (5 of 54) ($p = 0.195$). Radiographs of a further eight hybrid THRs demonstrated wear and osteolysis, and they await revision ($p = 0.008$). Of the unrevised BHRs 90% had radiological changes, of which approximately 50% had progressed over the previous four years. All hybrid THRs demonstrated linear polyethylene wear with a mean of 1.24 mm (0.06 to 3.03). The BHRs recorded superior OHS ($p = 0.013$), UCLA ($p = 0.008$), and EuroQol visual analogue scores ($p = 0.009$).

After nine years, patients with BHRs remained more active and had a lower rate of revision than those with hybrid THRs. Both groups demonstrated progressive radiological changes at medium-term follow-up.

Metal-on-metal hip resurfacing has been practised outside the originating centres for over a decade. These institutions report a 93% survivorship of the Conserve Plus (Wright Medical Technology Inc., Arlington, Tennessee) after eight years,¹ 93% with the McMinn (Corin Medical Ltd, Cirencester, United Kingdom) double heat-treated design after ten years² and 96% with the Birmingham Hip Resurfacing (BHR; Smith & Nephew, Memphis, Tennessee) at 12 years.³

Metal-on-metal hip resurfacing is subject to the specific complications of fracture of the femoral neck,^{4,5} avascular necrosis^{6,7} and pseudotumour formation,⁸ as well as aseptic loosening and osteolysis.² However, it has potential advantages over total hip replacement (THR) in that it preserves femoral bone stock, its hard bearing surface wears less than high density polyethylene, and its large head is associated with lower rates of dislocation.

Randomised controlled trials have shown no difference in the quality of life between metal-on-metal hip resurfacing and uncemented metal-on-metal THR after 1.1 years⁹ or in gait

after three months,¹⁰ but the activity scores at one year are higher after metal-on-metal hip resurfacing.^{11,12} Matched-case controlled comparisons of metal-on-metal hip resurfacing and uncemented metal- or ceramic-on-polyethylene THR show superior function after resurfacing.^{13,14} While all of the aforementioned studies describe resurfacing using hybrid methods of fixation with a cemented femoral component, and an uncemented acetabular component, only one, published at two periods of follow-up,^{15,16} has compared resurfacing with THR with similar hybrid fixation.

This study compares 54 of the first 63 BHRs performed by the senior author (GCB) with 54 hybrid THRs matched for age, gender, body mass index (BMI) and pre-operative level of activity, which were carried out just before the BHR was introduced. We have previously reported the early¹⁵ and five-year¹⁶ results of these cohorts in which the BHRs were functionally superior to the hybrid THRs. The aim of the current study was to compare the outcome of BHR with hybrid THR at a follow-up of approximately ten years.

■ R. P. Baker, FRCS(Tr & Orth), Specialist Registrar in Orthopaedic Surgery
■ S. J. Eastaugh-Waring, FRCS(Tr & Orth), Consultant Orthopaedic Surgeon
■ G. C. Bannister, MD, FRCS(Tr & Orth), Professor of Orthopaedic Surgery Avon Orthopaedic Centre, Southmead Hospital, Westbury-on-Trym, Bristol BS10 5NB, UK.

■ T. C. B. Pollard, FRCS(Tr & Orth), Specialist Registrar, Clinical Lecturer in Orthopaedic Surgery University of Oxford, Nuffield Orthopaedic Centre, Windmill Road, Oxford OX3 7LD, UK.

Correspondence should be sent to Mr R. P. Baker; email: richardbaker14@hotmail.com

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Patients and Methods

Between January 1996 and April 2001, 54 hips in 53 patients (13 women, 13 hips and 40 men, 41 hips) had a hybrid THR using the cemented CPT femoral component (Zimmer, Warsaw, Indiana), with an uncemented acetabular component and a press-fit polyethylene liner. The uncemented acetabular components included 29 Harris-Galante II (Zimmer), 16 ABG II (Stryker Orthopedics, Mahwah, New Jersey), seven Zweymuller (PLUS Orthopedics, Rotkreuz, Switzerland), one PFC (DePuy International, Leeds, United Kingdom) and one Hedrocel (Implex Corp, Allendale, New Jersey). A 28 mm modular metal femoral head was used in 45 hips and a ceramic in nine.

Between August 1999 and April 2001, 63 hips were resurfaced using the BHR (previously Midland Medical Technologies, Birmingham, United Kingdom, now Smith & Nephew, Memphis, Tennessee). This comprised a cemented femoral component and an uncemented hemispherical flanged hydroxyapatite- and porous-coated acetabular component. On no occasion during this period did the senior author decide at operation that a case was unsuitable for resurfacing and perform a THR instead. Of the 63 hips, two were revised for fracture of the femoral neck within six weeks of implantation and one for avascular necrosis after one year. There were six patients (six hips) who were not contactable, leaving 54 surviving BHRs in 51 patients (11 women, 13 hips and 40 men, 41 hips).

The operations were predominantly for primary osteoarthritis.^{15,16} All were performed through the posterior approach, which was extensile in the BHRs. No hybrid THRs had required further surgery following their primary procedure before recruitment to the study. All patients were allowed to bear full weight immediately post-operatively. Patients with BHRs commenced high-impact activity after three months but those with hybrid THRs were advised to avoid heavy manual work and high impact sport.

The BHRs were matched with hybrid THRs for gender, age at surgery (within five years), BMI (within 5 kg/m²) and their pre-operative level of activity before it was limited by symptoms. Activity was graded using the University of California, Los Angeles (UCLA) activity score.¹⁷ We matched patients within two points on the scale. The mean age of the patients with a BHR at initial arthroplasty was 49.8 years (18 to 67), their mean BMI was 25.7 kg/m² (19.7 to 35.1) and their mean pre-operative UCLA activity score was 9.0 points (6 to 10). The mean age of the patients with a hybrid THR was 50.4 years (21 to 66), their mean BMI 27.0 kg/m² (18.5 to 37.0) and their mean pre-operative UCLA activity score was 8.9 points (6 to 10).

All patients were invited to attend outpatient clinics, where they completed a questionnaire recording complications of their hip arthroplasty, the UCLA activity score,¹⁷ the Oxford hip score (OHS),¹⁸ and the EuroQol¹⁹ quality of life score. The UCLA activity score was used, as previously, with modifications for the British

population.^{6,16} The OHS was ranked from 12 (asymptomatic) to 60 (severe) to allow comparison with previous scores.¹⁶ The EuroQol EQ-5D scores were derived from the questionnaire validated for the United Kingdom (UK TTO value set).^{16,19}

Patients were asked to classify their running, sporting activity and heavy manual work within the last four weeks into the following categories: no trouble at all, very little trouble, moderate trouble, extreme trouble, tried but impossible and not attempted.

They were asked to record their satisfaction with the surgery as delighted, pleased, satisfied, a little disappointed and very disappointed. These measures of activity and satisfaction are not validated.

The medical notes were checked to ensure that no complications or re-operations had been missed. The early complications have been reported previously.^{15,16} Anteroposterior (AP) and lateral radiographs of each hip were taken and compared with the previous ones. Changes around the femoral and acetabular components of the hybrid THRs were described on the AP radiographs using the zones of DeLee and Charnley²⁰ and Gruen, McNeice and Amstutz²¹ and on the lateral radiographs using the additional zones of Johnston et al.²² Linear polyethylene wear was measured by the method of Dorr and Wan.²³ Radiological changes around the femoral component of the BHRs were recorded as in our previous study (Table I).¹⁶ Changes around the acetabular component in the BHRs were recorded as for the hybrid THRs.

Statistical analysis. The Mann-Whitney U test was used to compare the pre-operative age, UCLA activity and BMI, and the post-operative outcomes for UCLA activity, OHS, EQ-VAS, and EQ-5D. Fisher's exact test was used to compare pre-operative gender, the distribution of revisions and the responses to the questionnaire on participation in running, sport, heavy manual labour and overall satisfaction with the surgery. The Wilcoxon ranked-pairs test was used for paired comparisons of OHS and UCLA activity scores with the previous study¹⁶ within each group. The association of BMI and outcome (UCLA activity, OHS, EQ-VAS) was assessed using the Spearman rank correlation. Statistical analyses were performed in conjunction with a statistician. A p-value of < 0.05 was considered statistically significant.

Results

Of the hybrid THRs, nine had been revised, four patients had died and five were lost to follow-up, leaving 36 of 54 (67%) available for review. Of the BHRs, one patient had died, five had been revised and five were lost to follow-up, leaving 43 of 54 (80%) available for review. The mean follow-up for the hybrid THRs was 10.7 years (7.5 to 14.5) and for the BHRs it was nine years (8.2 to 10.3). The medical records of the patients who had died or were lost to follow-up indicated satisfactory clinical performance at their last review.

Table I. Classification of radiological appearance of femoral component after metal-on-metal resurfacing¹⁶

Classification type	Radiological appearance
0	No change
1	Pedestal sign but no migration
a	Sclerotic line confined to curved tip of stem
b	Sclerotic line confined to distal 1 cm of shaft of stem
c	Sclerotic line ± symmetrical lucent lines, extending proximally beyond distal 1 cm of shaft
2	Migration, usually into varus with asymmetrical lucent lines
3	Displaced fracture

In order to check that no bias had been introduced through loss to follow-up, the matching of the remaining patients in the cohorts was analysed. This revealed no differences in pre-operative age, gender and activity level but the BMI was significantly lower in the patients with a BHR (median 26.1 kg/m² in BHRs *versus* 28.7 kg/m² in hybrid THR, $p = 0.006$).

Functional outcome scores. The mean OHS for the hybrid THR was 19.1 (12 to 43) and for the BHRs 16.6 (12 to 46) ($p = 0.013$) at a mean follow-up of 10.7 and nine years respectively. There was no significant change in the OHS with time.

The BHRs had significantly higher UCLA activity scores than the hybrid THR. The mean UCLA activity score in the BHR group was 8.6 (2 to 10) and for the hybrid THR 6.65 (3 to 10) at final follow-up ($p < 0.0001$). There was no significant change in the UCLA activity score with time.

Because of the potential confounding effect of the higher BMI of the hybrid THR on post-operative outcomes, the associations of BMI with the OHS and the UCLA activity score were analysed. With both groups combined, the BMI was weakly associated with a worse UCLA activity score ($r = -0.219$) and OHS ($r = 0.203$), but neither association was statistically significant ($p = 0.056$ and $p = 0.075$ respectively).

The EuroQol EQ-VAS quality of life scores were significantly higher in the BHRs. The mean EQ-VAS was 82% (30% to 100%) in the BHRs and 65.6% (9% to 97%) in the hybrid THR ($p = 0.009$) at final follow-up. There was no difference with the five item EuroQol questionnaire. The mean EQ-5D score was 0.78 (0.06 to 1.00) in the hybrid THR and 0.84 (-0.18 to 1.00) in the BHRs.

During the four weeks before review, more patients with a BHR ran ($p = 0.003$), participated in sport ($p = 0.004$) and carried out heavy manual work ($p = 0.042$) than patients with a hybrid THR (Table II). The overall satisfaction was similar for both groups (Table III). A total of 58% (21 of 36) of patients with a hybrid THR and 67% (29 of 43) of patients with a BHR were delighted with their hip replacements ($p = 0.484$).

Radiological outcomes. Of the hybrid THR, five did not attend the outpatient clinic for radiological analysis but completed postal questionnaires. Their OHSs were 12, 12, 14, 18 and 30. Of these patients three had undergone radiological examination at 14, 15 and 24 months before completing the questionnaires which were used for serial comparison. Therefore 34 cases had radiographs for analysis. All hybrid THR demonstrated polyethylene wear with a mean of 1.2 mm (0.06 to 3.03). There was evidence of peri-articular osteolysis in 11 hips in association with polyethylene wear, with five having femoral lysis in Gruen zones 1 or 7. Lucent lines around the femoral component were noted in these cases, but they all corresponded to the areas of lysis in zones 1 or 7. There were no cases with lucent lines distal to these proximal zones. In two of the cases with femoral lysis there was also involvement of the acetabulum, with a further six patients having isolated acetabular lysis. Lucent lines were seen around the acetabular component in 11 hybrid THR (32%). No component had migrated. Stem subsidence had remained stable over the previous four years.

Of the BHRs, three patients were unable to attend for radiographs but completed a postal questionnaire. Their current OHSs were 12, 12 and 13. This left 40 radiographs of unrevised hips for analysis. Table IV summarises the radiological appearances and interval revisions from the five-¹⁶ and nine-year time-points. There was a general trend of progression of radiological appearances across the cohort. Of the nine hips with type 1c appearances at five years,¹⁶ one has been revised, three have progressed to type 2, of whom two cases have mild symptoms, and five have not progressed radiologically and remain asymptomatic. Of the cases with type 2 change at five years,¹⁶ three of the four with varus migration have been revised because they became symptomatic or had fractured. The fourth patient has developed some pain with an OHS of 19 but has declined revision. The one with valgus migration is asymptomatic and unchanged radiologically. There was no evidence of osteolysis in any patient.

Revisions. Of the 54 hybrid THR, nine (16.7%) have been revised, eight for osteolysis and one for recurrent dislocation. The lysis involved the femur only in zone 7 in one case, the acetabulum only in four cases, in zone 2 in all four but additional involvement in zone 1 in one, and in zone 3 in another. Both the femur and acetabulum were involved in three cases, all in zone 7 in the femur and zone 2 in the acetabulum. An identical revision procedure was performed in these patients. In order to avoid further polyethylene wear, the bearing surfaces were changed to ceramic-on-ceramic. As ceramic liners were not available for the original acetabular shells, the shell was exchanged for a Trident component (Stryker Orthopedics). Similarly, as neither a ceramic head nor appropriate collar was available for the CPT stem, this was revised to an Exeter (Stryker Orthopedics) cement-in-cement revision component as the cement mantle was uniformly good in all cases. Areas of lysis in the proximal femur at zones 1 and 7 and in the acetabulum were bone-grafted.

Table II. Participation in activities in the previous four weeks (number of hips, %)

Activity	Group	Trouble					Not attempted
		None	Very little	Moderate	Extreme	Impossible	
Running	Hybrid	2 (6)	2 (6)	1 (3)	4 (11)	4 (11)	23 (64)
	BHR*	13 (30)	8 (19)	2 (5)	3 (7)	2 (5)	15 (35)
Sports	Hybrid	11 (31)	3 (8)	0	3 (8)	2 (6)	17 (47)
	BHR	17 (40)	11 (26)	5 (12)	0	2 (5)	8 (19)
Heavy manual labour	Hybrid	6 (17)	5 (14)	6 (17)	3 (8)	0	16 (44)
	BHR	17 (40)	11 (26)	2 (5)	1 (2)	1 (2)	11 (26)

* BHR, Birmingham hip resurfacing

Table III. Patient satisfaction with the prostheses (number of hips, %)

Group	Delighted	Pleased	Satisfied	Disappointed	
				A little	Very
Hybrid	21 (58)	4 (11)	7 (19)	4 (11)	0
BHR*	29 (67)	8 (19)	0	5 (12)	1 (2)

* BHR, Birmingham hip resurfacing

The previous study¹⁶ identified nine cases with osteolysis at five years. Of these, three revisions were planned and have been performed; one further case had been revised before the current review and two are now awaiting revision following the most recent assessment. The final three patients remain under review because they have not progressed in terms of wear or lysis and are asymptomatic.

Of the 54 BHRs five (9.3%) have been revised, all for collapse of the femoral head secondary to avascular necrosis. All five had either type 1c or type 2 radiological changes at five years.¹⁶ Of these cases two presented acutely with displaced fractures whilst in the remaining three the decision was made electively to revise after they presented with pain. When all the failures of the first 63 cases are included, eight of 63 (12.7%) have been revised of which six (9.5%) were for avascular necrosis, of whom three (4.8%) had consequently fractured and presented acutely, and two (3.2%) for a fracture at six weeks.

Potential revisions. We intend to revise eight hybrid THR for pain, wear and osteolysis. These are the eight cases with acetabular lysis described in the radiological outcomes section earlier.

Table V records the breakdown of revisions and impending revisions according to the acetabular component and type of head. The Harris-Galante and Zweymuller components accounted for the majority of failures. The use of a ceramic head did not appear to protect against revision, although the numbers are too small to draw reliable conclusions.

New symptoms of varying severity which could indicate a failing arthroplasty have been reported in eight BHRs, six male and two female, with OHS scores of 14, 15, 17, 19, 19, 24, 26 and 44. Their radiological appearances were 1c,

Table IV. Radiological appearances and revisions for patients with Birmingham hip resurfacing. The percentages of the total number, excluding those lost to follow-up and those who refused radiographs, are given in parentheses. The three hips that were revised prior to the start of the study are not included

Status	Interval revisions with appearance immediately	
	Five years prior to revision	Nine years
Loss to follow-up or death	1	6
Declined radiographs	1	3
Radiological appearance		
Type 0	16 (30.8)	4 (8.9)
Type 1a	6 (11.5)	4 (8.9)
Type 1b	16 (30.8)	8 (17.8)
Type 1c	9 (17.3)	19 (42.2)
Type 2	5 (9.6)	5 (11.1)
Type 3/Revised	0	5 (11.1)

1a, 1b, 2, 2, 1b, 1b and 1b respectively. There had been no change in six over the previous four years including one type 2 pedestal, and two had progressed; 1c to 2 and 1b to 1c, respectively. Of the two cases with type 2 pedestals, one had an increase in the OHS of one point only, and the other of five points between five and nine years. There was no evidence of infection in any of the eight cases. They were all investigated by ultrasound or MRI and none had radiological evidence of pseudotumour. They remain under review. The serum metal ions were not measured.

Of these eight cases, one female (OHS 44, pedestal 1b) had always had a painful BHR. Her symptoms had not deteriorated but further investigation for pseudotumour was performed and was negative. A male patient was explored for groin pain and a recent onset of sciatic nerve palsy but there was no evidence of component loosening or pseudotumour. The sciatic nerve was adherent to dense scar tissue. It was released and a neurolysis performed which improved the palsy and pain. Histological examination of tissue adjacent to the hip joint revealed no evidence of aseptic lymphocytic vasculitis-associated lesion (ALVAL) or infection. His femoral component demonstrated a 1c pedestal sign on plain radiographs.

Table V. Revision and impending revision rates at a mean follow-up of 10.7 years in the hybrid total hip replacement group

Acetabular component	Head type	Number	Revised	Impending revision	% revised and impending
Harris-Galante*	Metal	26	5	6	42
Harris-Galante*	Ceramic	3	1	0	33
Zweymuller†	Metal	7	1	2	43
ABG‡	Metal	10	0	0	0
ABG‡	Ceramic	6	1	0	17
PFC§	Metal	1	1	0	100
Hedrocel¶	Metal	1	0	0	0

* Zimmer, Warsaw, Indiana

† PLUS Orthopedics, Rotkreuz, Switzerland

‡ Stryker Orthopedics, Mahwah, New Jersey

§ DePuy International, Leeds, United Kingdom

¶ Implex Corp., Allendale, New Jersey

Thus of the original 54 hybrid THRs, we have revised, explored or intend to revise 17 (31.5%) and of the 63 BHRs, nine (14.3%). Both groups have further cases that require close radiological follow-up. Hybrid THRs have so far created a greater revision burden than BHRs ($p = 0.022$).

Discussion

The cemented hip arthroplasty may fail prematurely in patients with osteoarthritis under the age of 50²⁴ and, although better results have been reported with impaction grafting²⁵ and 22.25 mm bearings,²⁶ loosening and wear remain the major complications.²⁷ Loosening has been successfully addressed by porous-coated hemispherical acetabular components²⁸⁻³⁰ but at the price of increased polyethylene wear and osteolysis.^{27,29,30} Wear has been reduced by hard bearing surfaces which reduce osteolysis at the expense, in some cases, of pseudotumour formation.⁸

This study gives a medium-term comparison of hybrid THR with bone preserving metal-on-metal large head devices in a young active population. Other similar comparisons have had follow-ups of less than three years.⁹⁻¹⁴ Both strategies continue to be used. The BHR has the lowest rate of revision of the hip resurfacings³¹ and remains a reasonable choice of implant. There are better hybrid uncemented metal-backed acetabular components currently available than the ones used in this study.³²⁻³⁴

The weak link of the BHR was the femoral component and of the hybrid THR polyethylene wear. The Harris-Galante was particularly prone to wear. None of the acetabular components of the BHRs required revision. The femoral components of the hybrid THRs were revised purely to enable a ceramic-on-ceramic articulation, and not because they were loose. In our hands, the cemented CPT femoral component has been very reliable in younger patients.³⁵ Among the BHRs, there were two early failures from fracture of the femoral neck within six weeks and one at one year due to avascular necrosis. These have been

included to allow comparison of the revision burden of the two devices. The fractures occurred during the learning curve of the senior surgeon and have been noted by other authors as being more prevalent early in a surgeon's experience.³⁶ The failures of the BHR have tended to be symptomatic and early. The principal mode has been avascular necrosis with no pseudotumours. Eight BHRs are painful and, despite investigation for infection and pseudotumour, currently show no clear indication for revision.

The hybrid THRs are showing wear and osteolysis resulting from the polyethylene used at the time. Failure has tended to occur later and be asymptomatic. The metal shell increases polyethylene wear, and while modern highly cross-linked polyethylene may be more durable, it will not save the young active patient from a revision arthroplasty unless it adds at least ten years to the survival of the bearing surface.

We anticipate increasing failure from both groups. Our experience with the hybrid THRs from a previous study suggests that the polyethylene will continue to wear with 50% of arthroplasties requiring revision by 15 years.²⁹ Half of the pedestal signs in the BHRs are progressive. We were uncertain of the significance of the changes observed and classified in our previous study.¹⁶ The current assessment suggests that cases which develop type 1c and 2 changes with varus migration are likely to fail. We would advocate careful counselling of patients with type 2 changes with a low threshold for revision before fracture occurs, and close radiological surveillance of type 1c cases.

The weaknesses of this study are that it is not randomised and may have inherent bias because the patients with a BHR were not restricted in heavy manual work or sport, whereas such activity was discouraged in those with a hybrid THR, because of concerns regarding wear. In fact, many of the patients with a hybrid THR (37%) disregarded the restrictions suggested.¹⁵ Our data demonstrate that the patients with a BHR achieved higher levels of activity than those with a hybrid THR, without an apparent increase in the rate of failure in the mid-term. The better UCLA activ-

ity and OHS scores achieved by the patients with a BHR may also be biased by loss to follow-up and the consequent difference in BMI of the two groups, which had a negative association with performance; however, this association did not reach statistical significance whereas the superior performance of the BHRs was of strong significance. There is a shorter follow-up for the BHR group which reflects a change in the senior author's practice as resurfacing became the first choice for the young patient.

The BHRs continue to maintain superior function to the hybrid THRs and have a lower rate of revision. While the indications for resurfacing may have narrowed, our data suggest that the BHR remains a reasonable option for the young adult with end-stage osteoarthritis of the hip.

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