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ORIGINAL STUDY

Good midterm results after Birmingham hip resurfacing and total hip arthroplasty

Luc Vanlommel, Peter Mertens, Karl Brabants

From the ZNA Middelheim, Antwerp, Belgium

The aim of this study is to determine the functional outcome and midterm survival rates of the Birmingham Hip Resurfacing and Birmingham Total Hip Arthroplasty.

This retrospective, observational study included 150 surgeries (46 resurfacing procedures and 104 arthroplasty procedures) performed in 127 patients from 2005 to 2012. The Resurfacing and Arthroplasty study groups were evaluated with clinical (Harris Hip Score and Hip Disability and Osteoarthritis Outcome Score) and radiological follow-up. Cobalt and chromium levels were measured via blood samples.

No revisions were required in either study group. Femoral stem osteolysis was observed in three patients in the Arthroplasty group. No osteolysis was observed in the Resurfacing group. Significantly higher clinical scores were observed in the Resurfacing group (p=0.04 and p=0.04, respectively). The average level of metal ions were similar in both groups.

Both groups showed excellent midterm clinical and radiographic results with 100 percent survival rates. Additional follow-up is required to monitor future changes in blood metal ion levels.

Keywords : arthroplasty ; hip ; resurfacing ; metal-on-metal (MOM) articulation.

INTRODUCTION

Historically, metal-on-metal (MOM) articulations were introduced as an alternative for conventional total hip arthroplasty (THA) to reduce the wear rate and eventual failure seen with THA using polyethylene bearings. After a successful start, the use of MOM THA decreased due to the high failure rate of the first-generation MOM THAs and the increasing popularity of the Charnley prosthesis. Since polyethylene wear remained a point of concern and improvements were made in MOM THA designs, MOM articulations regained popularity in the last decade and were used widely *(9,10,21,29)*. The theoretical advantages of MOM articulations were less volumetric wear with lower failure rates, and increased stability and range of motion due to larger-diameter femoral heads *(19,28)*.

Also, a bone-preserving, MOM resurfacing hip arthroplasty (RHA) was developed and used in young, active patients who experienced unsatisfactory results after conventional THA *(5,8,14)*.

The results of both the MOM THA and RHA were promising with good survival and functional outcomes, but concerns arose regarding the consequences of high metal ion levels – the so-called adverse reaction to metal debris (ARMD) attributed

■ Luc Vanlommel, MD
■ Peter Mertens, MD
■ Karl Brabants, MD
ZNA Middelheim, Lindendreef 1, 2020 Antwerp, Belgium
Correspondence : Luc Vanlommel , ZNA Middelheim, Lindendreef 1, 2020 Antwerp, Belgium. Telephone : +32(0) 471674172.
E-mail : luc.vanlommel@gmail.com

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to the corrosive metal interaction between the femoral head and acetabular liner *(17,18,20,23,25,27,29,30)*. Recent studies reported higher ARMD rates in MOM THA compared to MOM RHA in some devices, like ASR (DePuy Orthopaedics, Warsaw, IN, USA) and Durom (Zimmer Inc., Warsaw, IN, USA) *(15,25)*. Once these implant-related problems were detected in several national joint registries and postmarket surveillances, worldwide recommendations were released to avoid the use of MOM THA and RHA because of high rates of complications in MOM RHA devices *(24,28)*. However, not all designs suffered from such high failure rates. The Birmingham Hip Resurfacing (BHR ; Smith & Nephew Orthopaedics Ltd, Warwick, UK), one of the more commonly used MOM RHA, has been reported to have lower revision rates compared to other RHAs *(13)*. In the present study, the Birmingham acetabular cup was also used as a MOM THA (BHR/THA). The goal of this study was to determine the functional outcome and midterm survival rates of the BHR and BHR/THA.

MATERIAL AND METHODS

From 2005 to 2012, 161 consecutive patients (190 hips) received a BHR (n = 57 ; 30%) or BHR/THA (n = 133 ; 70%) at our institution. After approval by the ethics committee, patients underwent follow-up to obtain all data necessary for this retrospective study. Indications for hip replacement surgery were primary degenerative osteoarthritis, avascular necrosis, or posttraumatic arthritis.

Patients were excluded from the study if they had secondary arthritis due to inflammatory disease or bleeding disorders. Other reasons for exclusion included posttraumatic arthritis where adequate fixation was precluded, revision surgery, or infection. Finally, patients were excluded if they were deceased, unable to conduct the questionnaires due to aging or dementia, unwilling to join the study, or lost to follow-up (Table 1).

After applying the exclusion criteria, the research population consisted of 127 patients with 150 THAs (Table 2). 39 patients (46 hips) received a BHR, and 96 patients (104 hips) received a BHR acetabular cup with a stemmed femoral component (BHR/THA) (Synergy or Anthology, Smith & Nephew Inc., Memphis, TN, USA). Age younger than 65 years was an indicator for BHR.

All procedures were performed in our institution by the two senior orthopaedic surgeons (K.B. and P.M.) using the same prosthesis design (BHR cup with resurfacing or with stemmed femoral component). Exposure of the hip was obtained using an anterolateral approach in all patients. First-generation cephalosporin was given the hour before surgery and continued for 24 hours intravenously. A third-generation cementing technique was utilized when using a stemmed femoral component in patients with an osteoporotic bone condition. All patients followed the same postoperative rehabilitation protocol with crutches and partial weight-bearing for 6 weeks.

All patients who joined the study signed an informed consent, and were seen in the outpatient clinic by a senior orthopaedic assistant (L.V). Patients were asked to complete the validated

Table 1. — Patient Exclusion Criteria

Reason for Exclusion	n	Percentage
Posttraumatic arthritis	2	1.2
Bleeding disorder	2	1.2
Inflammatory disease	3	1.9
Aging/dementia	6	3.7
Deceased	4	2.9
Heterotopic ossifications	2	1.2
Unwilling to participate	8	5.0
Lost to follow-up	5	3.1
Total number of patients excluded	**34**	**21.1**

Table 2. — Preoperative Demographic Data for Study Patients by Implant Type

	BHR (n=46)	BHR/THA (n=104)	P-value
Age*	60.8 (± 6.2)	66.7 (±8.5)	0.01
Female gender⁺	18 (39.1%)	38 (36.5%)	0.82

* Presented as mean (range), ⁺ presented as n (percentage). Abbreviations : BHR, Birmingham hip resurfacing ; SD, standard deviation ; THA, total hip arthroplasty.

Hip Disability and Osteoarthritis Outcome Score (HOOS), and Harris Hip Score (HHS) *(11,22)*. Standardised radiographs (anteroposterior pelvis, and anteroposterior and lateral hip) were taken to record aseptic loosening or wear. The HOOS consists of seven subscores : symptoms, stiffness, pain, pain during activities, activities of daily living (ADL), sport, and quality of life. The HHS consists of eight subscores : pain, limp, need for support, walking distance, stairs, ADL, public transport, and sitting.

All clinical scores used for data analyses were obtained at the latest follow-up appointment after hip replacement surgery. Revisions for any reason were registered. Using the De Lee/Charnley acetabular zones and Amstutz femoral stem zones, all stems and cups were analysed for radiolucent lines indicating loosening or wear *(1,7)*. A blood sample was taken to determine the concentration of cobalt and chromium ions at final follow-up assessment. Reference values of the laboratory were 0.00 to 0.60 µg/L for cobalt and 0.5 to 2.10 µg/L for chromium.

Statistical analysis was performed using the SAS statistical package version 9.2 (SAS Institute, Cary, NC, USA). Patient demographic data, clinical scores, and postoperative radiographic data were registered as the mean and range. Differences in baseline variables were tested for statistical significance with Student t-test for continuous variables and a chi-square test for categorical variables. The Kruskal-Wallis test was used to compare the two groups on the HSS and HOOS scores. P-values smaller than 0.05 were considered significant. Power calculation was performed before the study, indicating that our sample had a power of 84% with an alpha of 0.05 to detect a minimally clinically relevant difference of five points in the HHS.

RESULTS

After a mean of 8.2 years follow-up (range, 4 to 10 years), no revision was required in any of the study participants.

In the BHR/THA group, three patients showed osteolysis around the femoral stem : one in Zone 1, one in Zone 6, and one in Zones 1 and 7. Seven other patients revealed a radiolucent line (RLL) around the cup : Zone 1 in three hips, Zones 2 and 3 in two hips, Zone 2 in one hip, and Zone 3 in one hip. None of these patients had any complaints suggestive of loosening of their hip implants, and follow-up radiographs showed no progression of these radiolucent lines which indicated stability.

In the BHR group, only one patient showed a RLL around the femoral component in Zone 2, which remained stable during follow-up. Two patients showed signs of osteolysis around the cup, one in Zone 1 and one in Zone 3, with progression of the osteolysis in the latter patient.

Chromium and cobalt levels were assessed from 42 (91.3%) patients in the BHR group and 86 (82.7%) patients in the BHR/THA group. The remaining patients refused to have an assessment of their blood metal ion levels.

The healthy range of chromium levels in the blood is 0.5 to 2.10 µg/L, and the healthy range of cobalt levels in the blood is 0.00 to 0.60 µg/L. The average level of chromium in the BHR group was 9.4 µg/L, and the average level of chromium in the BHR/THA group was 4.8 µg/L ($p = 0.12$). The average cobalt level in the BHR group was 7.7 µg/L, and the average cobalt level in the BHR/THA group was 6.7 µg/L ($p = 0.72$). One female patient with BHR-related lower back, hip, and thigh pain showed elevated chromium and cobalt levels after 4 years of follow-up. Radiographic evaluation of this patient showed osteolysis in Zone 3, and she was scheduled for a computed tomography (CT) scan given concern around a possible ARMD. The CT showed a large cystic supra-acetabular lesion (2.8 cm × 3.8 cm × 1 to 7 cm) with signs of loosening around the cup in Zone 3. There were no signs of stem loosening. Since the CT also showed moderate osteoarthritis of the lumbar spine, indicating the patient's complaints were more likely the result of lower back pathology, the patient was referred to the spine surgeon for further investigation.

The BHR group showed significantly higher clinical scores in both the HHS ($p = 0.04$) and HOOS ($p = 0.04$) compared to the BHR/THA group (Table 3 and Table 4). Regarding the subscores in the HHS, the most important difference was found in the pain and climbing stairs scores (both $p = 0.02$). Other subscores in the BHR group were not

Table 3. — Postoperative Harris Hip Score by Implant Type

	BRH	BHR/THA	P-value
TOTAL	85.3 (±8.9)	80.5 (± 13.7)	0.04
Pain	42 (±4.1)	38.2 (± 7.7)	0.02
Limp	10.4 (±1.5)	9.8 (± 2)	0.06
Support	10.5 (±1.3)	10.3 (± 2)	0.41
Walking distance	9 (± 2.4)	8.9 (± 2.5)	0.77
Stairs	3.8 (± 0.6)	3.4 (± 1)	0.02
Activities	3.8 (± 0.6)	3.5 (± 0.8)	0.11
Public transport	1.0 (± 0)	1.1 (± 1.4)	0.51
Sitting	4.9 (±0.4)	4.91 (±0.4)	0.72

Abbreviations, BHR ; Birmingham Hip Resurfacing, THA ; Total Hip Arthroplasty.

Table 4. — Postoperative Hip Disability and Osteoarthritis Outcome Score by Implant Type

Subscore Type	BHR	BHR/THA	P-value
Symptoms	3.9 (± 1.3)	4.4 (± 2.2)	0.12
Stiffness	2.4 (± 0.9)	3.1 (± 1.7)	0.02
Pain	1.2 (± 0.4)	1.7 (± 1.7)	0.04
Pain/activities	10.3 (± 2.9)	12.7 (± 5.8)	0.01
Function daily living	21.5 (± 6.9)	24 (± 12.1)	0.21
Function sport / recreation	6.3 (± 3)	7.8 (± 4.6)	0.05
Quality of life	5.6 (± 2.6)	6.9 (± 3.9)	0.05
TOTAL	51.1 (± 15.4)	60.7 (± 28.3)	0.04

Abbreviations : BHR, Birmingham hip resurfacing ; THA, total hip arthroplasty.

significantly different. The stiffness score and pain during ADL score in the HOOS in the BHR group were significantly better (p = 0.02 and p = 0.01, respectively).

DISCUSSION

The popularity of MOM bearings has waned after several national registries reported significantly higher revision rates for MOM bearings, with revision rates of MOM THA and RHA being two – to threefold higher compared to the reversion rate of conventional THA *(23,25)*. National and international recommendations have globally led to a near halt in the use of these type of prostheses. Some devices have even been pulled from the market *(24-26)*. Literature showed that additional risk factors like female gender, small femoral head sizes, and steep placement of the cup resulting in edge loading are associated with higher failure rates after MOM THA. However, some MOM devices with a different design and tribology seemed to perform very well with a good long-term clinical and radiological follow-up *(6)*.

The main objective of this study was to evaluate and compare the clinical results and revision rates of patients with BHR and the large MOM-headed BHR/THA.

This study has several limitations. First of all, it has been conducted in a retrospective manner. All patients with the types of prostheses mentioned above were sought using the hospital electronic registry system and were asked to participate in this study. After informed consent was obtained, patients were sent a letter inviting them for an outpatient clinic appointment. It is, therefore, possible that there is a certain selection bias regarding the data of unsatisfied patients with possible inferior clinical scores who were unable or unwilling to participate. As this data were not included in this study (specifically, the 5% of patients who were unwilling to participate possibly due to an inferior result), scores may be overestimated.

All components used in this study were from one manufacturer and comprised one type of prosthesis. This precludes possible confounders from different types of prostheses. Additional studies are required to confirm the results of this study, investigating other types of prostheses and other manufacturers. Also, all surgeries were performed by two senior surgeons — both with vast experience in performing THA.

While no revisions were performed in our study group after a follow-up ranging from 4 to 10 years, the patients who were lost to follow-up could underestimate this finding. A study performed by Jack et al with a large population using the BHR

showed a cumulative revision percentage of 3.2% in the MOM RHA group and 4.9% in the MOM THA group after five years *(12)*. Also, a very recent study from Brooks et al, with a cohort of 927 patients (1033 hips) published an overall survivorship of 99.2% at 2 to 5.7 years follow-up. Aseptic survivorship in males under the age of 50 was 100% *(4)*.

An important reason for revision is the ARMD resulting in pseudotumours and metallosis in patients with high blood levels of metal ions *(17,27)*. Given that THA and RHA have a large-diameter bearing surface, failures rates due to metal wear were expected to be similar in large-head THA and RHA systems, but several studies published higher blood levels of chromium and cobalt in large-head THA *(2,9)*.

Possible explanations for the high metal-ion release are corrosion from the non-articulating surface and hollow-backed femoral head, and the torque at the head-neck junction in the MOM THA, which produces more wear *(15)*. In this study, metal ion levels were slightly, but not significantly, higher in the BHR group. Our findings correlate with the study by Langton et al who found no difference in serum metal ion levels comparing MOM RHA and MOM THA *(3)*. In Langton's study, in one patient who complained of groin pain and had high levels of chromium and cobalt, magnetic resonance image showed a pseudotumour and the patient was scheduled for revision.

The findings of this study demonstrate good clinical results and excellent survival with the BHR and BHR/THA methods. While many published studies evaluated the survival of MOM RHA and MOM THA, and more specifically the BHR, very little is known about the functional outcome of the BHR compared to the BHR/THA. One recent study by Kostensalo et al showed higher HHS scores for BHR compared to the BHR/THA group one year after hip replacement surgery *(16)*. However, the researchers did not mention the statistical significance of their findings. The findings of our study comparing the clinical scores between these groups at a mean follow-up of 8.2 years are comparable with the Kostensalo et al study, whose results show a significantly higher HHS and HOOS score in the BHR group compared to the BHR/THA group.

Several risk factors are assumed for increased metal debris in the BHR/THA group. Due to higher metal ion levels, one could expect inferior outcomes in the BHR/THA group. The assumption does not seem to apply to the present study as there was no difference found in the level of metal ions between groups. The higher scores could be due to the younger average age of the BHR group, as previous reports have shown excellent results when using a BHR in relatively younger patients *(20)*.

In conclusion, despite the concerns about MOM THA and RHA both BHR and BHR/THA methods showed excellent clinical and survival scores after a midterm follow-up. Additional follow-up is needed to monitor the possible increase of blood metal ion levels over time, which may lead to complications that can result in failure.

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