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Birmingham hip resurfacing versus cementless total hip arthroplasty in patients 55 years or younger: A minimum five-year follow-up

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ABSTRACT

Objective: The optimal reconstructive method for advanced degenerative hip disease in young adults is a topic of ongoing discussion. The purpose of this study is to report the largest single institution experience from the United States on the outcomes of Birmingham hip resurfacing (BHR) vs. cementless total hip arthroplasty (THA) in patients 55 years or younger at a minimum follow-up of five years. Currently, BHR is the only FDA-approved hip resurfacing implant available in the US.

Methods: A cohort of 505 patients representing all BHR cases performed at our institution between 2006 and 2010 was compared with an identical size cohort of consecutive patients who underwent primary cementless THA. Exclusion criteria were age greater than 55 years, non-elective cases, revision procedures, and those performed for fractures, tumors, or by low-volume arthroplasty surgeons. THAs with metal on metal articulation were also excluded.

Outcomes: assessed were all-cause reoperations, complications, patient satisfaction, and mortality. After exclusions, 442 patients with BHR and 327 with THA were included.

Results: Mean follow-up was 73.2 months. After controlling for potential confounding factors, multivariate analyses showed significant increase in the rates of revision surgery ($p < 0.001$), overall complications ($p < 0.001$), all-cause reoperations ($p = 0.014$), and mortality ($p < 0.001$) in the THA cohort. Component loosening was the most common cause for revision in the THA group. Patients with THA were also less likely to be satisfied ($p = 0.046$).

Conclusions: This is largest US study to report on the midterm outcomes of BHR vs. THA. The results demonstrate favorable results for BHR in patients 55 years or younger. Long-term multicenter studies are needed to better understand the optimal patient characteristics when deciding between THA versus BHR.

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1. Introduction

While total hip arthroplasty (THA) is widely regarded as the gold standard treatment for end-stage degenerative hip disease in elderly patients, the optimal reconstructive method in younger patients remains a topic of ongoing discussion. As younger patients tend to be more active and are likely to outlive their prostheses, demands for increased durability, higher function, and bone preservation have attracted interest in hip resurfacing arthroplasty (HRA) as an alternative to THA. Reported advantages of HRA include maintenance of proximal femur mineral bone density,¹ restoration of hip joint biomechanics,² higher range of motion and

activity level,^{3,4} greater improvement in general health,⁵ lower dislocation rate,⁶ reduced mortality,⁷ and superior cost-effectiveness in younger male patients.⁸ Disadvantages of HRA, on the other hand, include longer learning curve, need for extended surgical exposure, less forgiveness to component malposition, adverse reactions to metal ions, and limitations with certain anatomic abnormalities.⁹

A few studies comparing HRA to THA have been published in recent years with variable results. Some are challenged by the need to interpret national joint registries based on procedure codes, which often don't take into account preoperative diagnosis, surgeon volume, and recalled devices.¹⁰ Others had small sample sizes, were limited to the diagnosis of primary osteoarthritis, included hybrid fixation THAs, or focused on implant survivorship as the primary outcome.^{11,12}

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The purpose of this study is to report the largest single institution experience from the United States on the outcomes of Birmingham hip resurfacing (BHR) vs. cementless THA in patients 55 years or younger at a minimum follow-up of five years. Currently, BHR is the only FDA-approved hip resurfacing implant available in the US. Specific outcomes assessed in this study are all-cause complications, aseptic revision, mortality, and patient satisfaction.

2. Materials and methods

IRB approval was obtained. Between 2006 and 2010, 505 patients aged 55 years or younger underwent primary BHR (Smith and Nephew, Memphis, TN) in our health care system. This cohort was compared with another consecutive series of 505 patients who underwent primary cementless THA during the same period and were of the same age range. Exclusion criteria were less than 60 months follow-up, non-elective procedures, and procedures performed for tumors or by low-volume arthroplasty surgeons (defined as performing less than 50 BHRs or THAs per year). Additionally, THAs with metal on metal (MoM) bearing were excluded. 442 patients with BHR and 327 with THA met the aforementioned criteria and were included in the analyses. Among the surgeons in our institution, twenty-one met the requirement for performing high-volume THAs while only one met the same criterion for BHRs. The most common femoral implants used for THA were Citation (50.7%, Stryker, Kalamazoo, MI), Accolade TMZF (17.1%, Stryker, Kalamazoo, MI), Synergy (8.8%, Smith and Nephew, Memphis, TN), Corail (DePuy Synthes, Warsaw, IN), and S-ROM (4.9%, DePuy Synthes, Warsaw, IN). The most common acetabular implants were Trident (74%, Stryker, Kalamazoo, MI), Pinnacle (9.1%, DePuy Synthes, Warsaw, IN), and Reflection (8.8%, Smith and Nephew, Memphis, TN).

An electronic medical record (EMR) chart review was performed to collect the following demographic variables: age, sex, body mass index (BMI), Charlson Comorbidity Index (CCI), and preoperative diagnosis. Preoperative diagnoses were classified as either primary osteoarthritis (OA) or non-primary OA. Preoperative and postoperative X-rays were reviewed to confirm the correct procedure (BHR or cementless THA) and that no prior ipsilateral reconstructive surgery had been performed. Postoperative outcomes assessed were all-cause complications, aseptic revision, mortality, and patient satisfaction. Complications included infections (superficial and periprosthetic), instability, component loosening, periprosthetic fractures, symptomatic adverse reaction to metal ions, and venous thromboembolism (VTE). Patients with missing five-year follow-up were contacted via telephone or email. Participation was voluntary and no financial compensation was provided.

Results for continuous variables were summarized using means and standard deviations. Categorical variables were described using counts and percentages. Numeric variables were compared between groups using Wilcoxon's rank-sum test. Categorical variables were compared using either Pearson's chi-squared test or Fisher's exact test. Multivariate modeling was performed using logistic regression. For each dependent variable, model covariates were chosen via backwards selection by *P* value so that each regression model had no more predictors than approximately the number of events divided by ten. All analyses were done using R software (R version 3.2.3 (2015-12-10), Vienna, Austria) assuming a 5% level of significance.

3. Results

In total, 442 patients with BHR and 327 patients with THA had complete 5-year follow-up. Mean follow-up was 73.2

months (range 0–123.5 months). There were 8 patients (1.8%) in the BHR group and 26 in the THA group (7.9%) who experienced one of the primary outcomes before the minimum 60 months required follow-up and were included in the analyses. The demographic features of the two groups are presented in Table 1. Three variables (age, sex, and preoperative diagnosis) were statistically different between the BHR and THA groups, and were therefore included in multivariate logistic regression models to control for their potential confounding effects.

Univariate and multivariate analyses showed statistically significant differences favoring BHR in rates of overall complications ($p < 0.001$), aseptic revision surgery ($p < 0.001$), mortality ($p < 0.001$), and patient satisfaction ($p = 0.046$) (Tables 2 and 3). Instability was significantly higher in the THA group ($p = 0.001$), but the incidence was too small to model in a multivariate setting. No differences were found in the rates of symptomatic adverse reaction to metal ions, periprosthetic fracture, and VTE. Tables 2 and 3 summarize the complete results of the univariate and multivariate analyses.

Acetabular component loosening was the most common cause of revision after THA, while periprosthetic femoral neck fracture was the most common cause of revision after BHR. Among those who were deceased, 5 died within 90 days from index surgery for THA and 1 for BHR. Table 4 lists the cause of death in the study cohorts.

Table 1
Demographic features of the study groups.

	BHR	THA	P-Value
N	442	327	
Age (years)	48.2 ± 6.2	46.8 ± 7.4	0.033 ^W
Sex			
Male	317 (71.7%)	161 (49.2%)	<0.001 ^C
Female	125 (28.3%)	166 (50.8%)	
BMI	30.3 ± 6.9	30.1 ± 7.7	0.028 ^W
CCI	1.67 ± 0.9	1.89 ± 1.3	0.07 ^W
Preoperative diagnosis			
Primary OA	277 (62.7%)	151 (46.2%)	<0.001 ^C
Non-Primary OA	165 (37.3%)	176 (53.8%)	

BHR = Birmingham hip resurfacing; THA = total hip arthroplasty; BMI = body mass index; CCI = Charlson Comorbidity Index; total hip arthroplasty; OA = osteoarthritis; C: Pearson's Chi-squared test with Yates' continuity correction; W: Wilcoxon rank sum test with continuity correction.

Table 2
Unadjusted midterm outcomes of BHR vs. THA.

	BHR	THA	P-Value
All complications	26 (5.88%)	68 (20.8%)	<0.001 ^C
Component loosening	1 (0.2%)	18 (5.5%)	<0.001 ^F
Periprosthetic fracture	4 (0.9%)	4 (1.22%)	0.73 ^F
Instability	0 (0%)	8 (2.45%)	0.001 ^F
Aseptic revision	9 (2.04%)	31 (9.48%)	<0.001 ^C
Additional surgery (non-revision)	6 (1.36%)	16 (4.89%)	0.004 ^F
Infection			
Superficial	7 (1.58%)	12 (3.67%)	0.11 ^C
Periprosthetic	2 (0.45%)	7 (2.14%)	0.049 ^F
Adverse reaction to metal ions	1 (0.23%)	0 (0%)	>0.99 ^F
VTE	5 (1.13%)	5 (1.53%)	0.75 ^F
Patient satisfaction (yes)	95.31%	88.11%	0.014 ^C
Death	2 (0.45%)	20 (6.12%)	<0.001 ^F

BHR = Birmingham hip resurfacing; THA = total hip arthroplasty; VTE = venous thromboembolism; C: Pearson's Chi-squared test with Yates' continuity correction; F: Fisher's Exact Test for Count Data.

Table 3

Multivariable logistic regression analyses adjusted for the demographic differences.

Outcome	P Value	Odds Ratio (95% Confidence Interval)
Component loosening	0.002	0.040 (0.002–0.197)
Aseptic revision	<0.001	0.218 (0.095–0.454)
Additional surgery (non-arthroplasty)	0.014	0.295 (0.103–0.744)
Infection (deep or superficial)	0.014	0.361 (0.153, 0.794)
Death	<0.001	0.067 (0.011–0.234)
All complications	<0.001	0.269 (0.162–0.434)
Patient satisfaction	0.046	2.28 (1.02–5.20)

BHR = Birmingham hip resurfacing; THA = total hip arthroplasty.

Table 4

Cause of death in the study cohorts.

	BHR (n = 2)	THA (n = 20)
Cancer	1	6
Unknown		5
Congestive heart failure		2
Pneumonia		2
Cardiac arrest		1
Myocardial infarction		1
Sepsis (from diabetic foot ulcers)		1
Postoperative respiratory failure		1
Seizure		1
Trauma	1	

BHR = Birmingham hip resurfacing; THA = total hip arthroplasty.

4. Discussion

The choice between THA and HRA in younger patients with advanced degenerative hip disease is a topic of ongoing discussion. Despite its wide use in Europe, HRA has not gained such popularity in the United States, in part due to concerns of adverse reaction to metal ions resulting in the recall or withdrawal of a number of devices. A few studies comparing THA to HRA have been published; however, most were either comprised of small samples limited to the diagnosis of primary OA, or were national database searches based on procedure codes irrespective of preoperative diagnosis, surgeon volume, or recalled devices.^{10–12} In a series of 1638 HRAs from the Nordic Arthroplasty Register Association (which includes Denmark, Norway, and Sweden), the rate of aseptic revision was much higher for HRA, except for men under 50 years of age and when Birmingham hip resurfacing (BHR) was used.¹⁰

In this study, we present our institutional experience on the midterm outcomes of BHR vs. modern, non-MoM cementless THA in patients 55 years or younger. The study found several differences between the two groups favoring BHR, which are consistent with previous reports. Baker and colleagues¹¹ reported a retrospective review of 54 patients who had either BHR or hybrid THA (cemented femoral component and press-fit acetabular component). Primary OA was the predominant diagnosis and patients' ages ranged from 18 to 66 years. At a mean follow-up of 9 years for BHR and 10 years for THA, both activity and quality of life scores were significantly higher in the BHR group. Moreover, there was a tendency towards higher patient satisfaction (67% vs. 58%, $p = 0.484$), lower revision rate (9.3% vs. 16.7%, $p = 0.195$), and reduced mortality rate (1.8% vs. 7.5%, no p -value reported) among BHR patients. In another study, Haddad and colleagues¹² published a prospective, attempted randomized study comparing BHR with cementless THA in patients under 55 years of age. 80 patients were enrolled in the study, which had a mean follow-up of 12.1 years (range 10–14 years). Exclusion criteria were BMI > 40, American Society of Anesthesiologists score of 3, and inflammatory arthritis. The study

found greater functional scores among BHR patients both in the immediate and long-term periods with a significantly higher proportion of patients involved in sports and heavy manual work. Most importantly, there were no differences in metal ions levels, adverse reactions to metal ions, or quality of life measures between the two interventions. No additional outcomes were reported in this study.

While the risk factors for poor outcomes are outside the scope of this study, we found that female sex was an independent risk factor for both aseptic revision and poor patient satisfaction. It is important to mention that in June 2015, BHR was voluntary withdrawn for use in females of all ages. This was triggered by United Kingdom's National Institute of Clinical Excellence (NICE) raising the ten-year implant survival requirement to 95%. Based on the National Joint Registry of England and Wales, there were higher failure rates in females compared to males with only males achieving the 95% benchmark set forth by NICE.

The primary limitation of this study is its retrospective design, which resulted in multiple implants and surgeons in the THA group while only one surgeon in the BHR group. This BHR surgeon was the only one who met the high-volume BHR criterion. We attempted to minimize the potential confounding effect related to surgeon experience by including only procedures performed by high-volume arthroplasty surgeons. Another potential limitation is that the surgical approach was not controlled for in the analyses. However, our group has previously shown that the surgical approach had no effect on the midterm outcomes after THA.¹³

The study has several strengths. It is the largest report on BHR vs. THA experience in the US and most findings were consistent with previous smaller reports. By reviewing individual patient charts (as opposed to administrative databases), we were able to extract more accurate data. We had greater than 80% follow-up in each group. The study excluded devices not available in the US, MoM THA, hips with prior arthroplasty procedures, and procedures performed by low-volume surgeons, thereby eliminating potential confounding factors. Moreover, the study was not limited to patients with primary OA. This is important because other etiologies (e.g., inflammatory, avascular necrosis, developmental deformities) are common causes of advanced hip disease in the younger population. The demographic factors that were different between the surgical groups (age, sex, and preoperative diagnosis) were included in the logistic regression models for the primary outcomes to control for their potential confounding effects.

In summary, we found favorable results for BHR compared to THA in patients 55 years or younger when performed by an experienced surgeon. Specifically, BHR was associated with decreased rates of postoperative complications, revision surgery, and mortality. Patient satisfaction was also significantly higher following BHR. There is a need to for multi-center prospective studies to better understand the optimal patient characteristics when deciding between THA versus BHR.

Conflict of interest

The authors have none to declare.

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