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Do Revised Hip Resurfacing Arthroplasties Lead to Outcomes Comparable to Those of Primary and Revised Total Hip Arthroplasties?

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Abstract

Background A theoretical clinical advantage of hip resurfacing (HR) is the preservation of femoral bone. HR femoral component revision reportedly yields postoperative function comparable to that of primary THA.

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However, few studies have looked at the outcome of both HR femoral and acetabular side revisions.

Questions/purposes We determined whether (1) patients undergoing HR revision to THA have perioperative measures and outcome scores comparable to those of patients undergoing primary THA or revision of primary THA and (2) patients undergoing HR revision of both components have perioperative measures and outcome scores comparable to those of patients undergoing HR revision of the femoral component only.

Methods We retrospectively reviewed and compared 22 patients undergoing revision HR to a THA to a matched (age, sex, BMI) group of 23 patients undergoing primary THA and 12 patients undergoing primary THA revision. Patients completed the WOMAC and SF-12 questionnaires before surgery and at latest followup (range, 24–84 months for HR revision, 28–48 months for primary THA, and 24–48 months for revision THA). Blood loss, days in hospital, complications, and outcome scores were compared among groups.

Results We observed no differences in SF-12 scores but observed lower WOMAC stiffness, function, and total scores in the HR revision group than in the primary THA group. Patients undergoing HR revision of both components had comparable SF-12 and WOMAC stiffness, function, and total scores but overall lower WOMAC pain scores compared to patients undergoing HR revision of the

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femoral side only. The HR revision group had greater intraoperative blood loss compared to the primary THA group but not the revision THA group.

Conclusions The perioperative measures and outcome scores of HR revision are comparable to those of revision THA but not primary THA. Longer followup is required to determine whether these differences persist. Patients undergoing HR revision of one or both components can expect comparable stiffness and function.

Level of Evidence Level IV, therapeutic study. See the Instructions for Authors for a complete description of levels of evidence.

Introduction

As metal-on-metal (MoM) hip resurfacing (HR) is entering its second decade, its role in the treatment of hip arthritis is becoming better defined, with current survivorship at 10 years between 88% and 95% [2, 26]. With regard to patient function, four recent prospective randomized trials have demonstrated HR is as good as a primary THA [11, 15, 21, 27]. In addition, when compared to large-head MoM THA, the level of metal ion release and incidence of adverse tissue events are reportedly lower [5, 11]. However, because the most commonly reported complications with HR (neck fracture, aseptic loosening of the femoral component, adverse tissue reactions) ultimately lead to THA, the clinical outcome of these revision surgeries is an important variable when considering HR [25]. Although clinical studies of revised HR arthroplasties have reported perioperative measures and outcome scores comparable to those of primary THA, most of these studies focused on HR femoral component revisions only [4, 6, 12]. Eswaramoorthy et al. [10] and Sandiford et al. [23] showed comparable outcome scores in patients undergoing a revision of HR and in matched patients with primary THA when the revision of both femoral and acetabular components was required. However, Grammatopoulos et al. [13] reported inferior Oxford Hip Scores after HR revisions for pseudotumor, compared to revisions for fracture and primary THA. Finally, although the quality-of-life scores associated with revision THAs are reportedly inferior to those of primary THAs [20, 22], it is unclear whether the function in patients with revised HR compares to the function of patients with revised primary THA. Analysis of Australian Orthopaedic Association National Joint Replacement Registry data shows comparable rerevision rates of HR and all-component THA [7].

We therefore determined whether (1) patients undergoing HR revision have perioperative measures and outcome scores comparable to those of patients undergoing primary THA and patients undergoing revision of primary THA and (2) patients undergoing revision of both

the femoral and acetabular components of an HR have perioperative measures and outcome scores comparable to those of patients undergoing revision of the HR femoral component only.

Patients and Methods

Between 2004 and 2009, 552 HR arthroplasties were performed at our center. Of those, 21 hips required revision surgery, representing a revision rate of 3.8% during that time. An additional five HR arthroplasties performed elsewhere underwent revision surgery at our center, for a total of 26 revised hips. We excluded three hips that underwent isolated acetabular component revision. Therefore, 22 HR revision patients (23 hips; one bilateral revision) were included for analysis. We retrospectively reviewed and compared these patients to patients undergoing a primary THA with no prior surgery and patients undergoing their first revision surgery of a THA. No patients were lost to followup. No patients were recalled specifically for this study; all data were obtained from medical records and radiographs.

Because the failed HR, primary THA, and failed THA groups were not randomly assigned, we performed a propensity analysis [19] to account for some potential confounding factors and selection biases. A propensity score for treatment was developed using a multivariable logistic regression model with sex, age, and BMI as independent variables, which were known or suspected to influence group assignment or to affect our various clinical outcome measures. Propensity scores were used to match patients in the failed HR group to the primary THA and failed THA groups using a SAS[®] macro (SAS Institute Inc, Cary, NC, USA). Using a greedy 1:1 matching procedure, the SAS[®] macro selected match pairs using a propensity score that was identical to five decimal places of probability [8]. Comparative demographic and baseline outcome data are presented (Table 1).

Between 2004 and 2009, approximately 600 primary THAs and 80 revision THAs were performed each year at our institution. Only patients with no prior hip surgery were included in this study. Based on our propensity analysis with 1:1 matching, 23 primary hips (18 men, five women; median age, 53.4 years; range, 43–60 years) were selected for comparison with the HR group. Indications for these primary THA surgeries were osteoarthritis ($n = 14$) and avascular necrosis ($n = 9$). Implants used for the primary THA are summarized (Table 2). Based on our propensity analysis, 12 patients undergoing a revision THA (six men, six women; median age, 53.0 years; range, 40–68 years) were selected for comparison with the HR group. Indications for revision THA surgeries were aseptic cup

Table 1. Demographic data

Variable	HR revision (n = 22)	Primary THA (n = 23)	Revision THA (n = 12)	p value
Age (years)*	52.2 (46.4, 58.1)	53.4 (49.5, 58.1)	53.0 (47.0, 60.5)	0.762
BMI (kg/m ²)*	28.4 (26.1, 32.3) (n = 19)	29.1 (25.9, 32.4)	29.7 (26.5, 30.7) (n = 9)	0.872
Male, female	16, 6	18, 5	6, 6	
Indication for primary surgery				
Osteoarthritis	14	14	4	
Avascular necrosis	2	9	1	
Developmental dysplasia of hip	3	0	0	
Other	1	0	0	
Unknown	2	0	7	
Surgical approach (n)				
Posterolateral	16	8	3	
Anterior	4	12	0	
Direct lateral	0	3	9	
Surgical hip dislocation with greater trochanteric osteotomy	2	0	0	

* Values are expressed as median, with quartiles in parentheses; the remaining values are expressed as number of patients; HR = hip resurfacing.

Table 2. Summary of implants used in primary THAs

Implant	Number of patients
Femoral stem	
Accolade® (Stryker Orthopaedics, Mahwah, NJ, USA)	13
Profemur® TL (Wright Medical Technology, Inc, Memphis, TN, USA)	10
Bearing system	
Metal on highly crosslinked polyethylene	10
Ceramic on ceramic	10
Metal on metal	3

loosening (n = 5), aseptic stem loosening (n = 3), recurrent dislocation (n = 1), leg length discrepancy (n = 1), periprosthetic fracture (n = 1), and pain (n = 1). Femoral component revision was performed in five hips, four of which required modular restoration stems. Isolated acetabular component revision with replacement of the bearing surface was performed in seven hips. At baseline, no differences in demographics or outcome scores between patients who underwent cup or stem replacement were present. Patients in the HR revision, primary THA, and revision THA groups were followed for a minimum of 24 months (average, 37 months; range, 24–84 months), 24 months (average, 26 months; range, 24–48 months), and 28 months (average, 32 months; 28–48 months), respectively.

All implants used in our study had been previously approved for their intended use by the FDA. Initial HR

procedures were performed using Conserve® Plus (Wright Medical Technology, Inc, Arlington, TN, USA) (n = 20), Birmingham Hip™ Resurfacing (BHR) (Smith & Nephew Inc, Memphis, TN, USA) (n = 1), and an Articular Surface Replacement® (ASR) device (DePuy Orthopaedics, Inc, Warsaw, IN, USA) (n = 1). The BHR and ASR procedures were performed at another institution. This group included 16 men and six women (median age, 52.2 years; range, 42–63 years). Indications for revision included persistent pain (n = 10, two of which had a pseudotumor), femoral neck fracture (n = 6), aseptic cup loosening (n = 3), and femoral loosening (n = 3). None of the revised hips showed gross metallosis. Three of the 10 patients with persistent pain presented a substantial soft tissue collection with creamy coloration (Fig. 1). A pseudotumor, defined as a large soft tissue mass with bony destruction, was observed in two other patients. Both HR components were revised in 15 hips and only the femoral component was revised in seven hips. Implants used when revising HR are listed (Table 3).

Perioperative data (blood loss, length of hospital stay, complications) were recorded for each patient in all groups. Complications were defined as minor if no reoperation/intervention was required and as major if any reoperation/intervention or alteration in clinical care was required.

Clinical followup consisted of postoperative visits with the surgeon at 2 weeks, 3 months, 6 months, and annually thereafter. Each visit was comprised of a brief physical examination and standard AP and lateral radiographs. In addition, patients completed the WOMAC and SF-12

Fig. 1A–D (A) Preoperative and (B) postoperative radiographs show the hips of a 44-year-old man who underwent hybrid MoM HR (Conserve[®] Plus) for degenerative hip arthritis. (C) At 2 years postoperatively, the patient complained of increasing pain and sensation of fullness in his joint. (D) At the time of revision surgery, substantial collection was present, consistent with an adverse tissue reaction, and his hip was revised to a ceramic-on-ceramic THA.

Table 3. Summary of implants used in revision of failed hip resurfacing arthroplasties

Implant	Number of patients
Femoral stem	
Cementless	20
Accolade [®] (Stryker Orthopaedics, Mahwah, NJ, USA)	
Profemur [®] TL (Wright Medical Technology, Inc, Memphis, TN, USA)	
Cemented	2
Perfecta [®] (Wright Medical Technology, Inc, Memphis, TN, USA)	
Bearing system	
Metal on metal	9
Ceramic on ceramic	9
Metal on highly crosslinked polyethylene	4

questionnaires immediately before surgery and at latest followup.

Perioperative data and outcome scores were compared among the three study groups (Objective 1). Before comparison, data normality for each perioperative measure and outcome score in each group was analyzed using the

Shapiro-Wilk test. We analyzed the differences in the variances among groups using the Levene test. When data were normally distributed, the three-group comparison was performed using ANOVA with the Tukey-Kramer post hoc test for pairwise comparisons when groups had equal variances (which was the case for all group comparisons in this study). For data not normally distributed, the three-group comparison was performed using the Kruskal-Wallis test with the two-sided Mann-Whitney U post hoc test for pairwise comparisons. To compare patients undergoing revision of both femoral and acetabular HR components to those undergoing revision of the femoral side only (Objective 2), we performed the two-group comparisons using Student's t-test (with Welch correction when variances were unequal) when data were normally distributed and using the Mann-Whitney U test when data were not normally distributed. All statistical analyses were performed using SPSS[®] software (SPSS Inc, Chicago, IL, USA).

Results

We observed no differences among the three groups for the baseline WOMAC scores (Table 4). However, at followup, WOMAC stiffness, function, and total scores were different between the HR revision and primary THA groups

Table 4. Perioperative, baseline, and followup outcome data

Variable	HR revision (n = 22)	Primary THA (n = 23)	Revision THA (n = 12)	p value
Perioperative data				
Time to revision (months)*	18.7 (7.7, 34.7) (n = 22)	NA	92.9 (14.2, 121.7) (n = 12)	0.014 [§]
Blood loss (mL)*	540 (475–700) (n = 22)	400 (300–475) (n = 21)	400 (325–750) (n = 9)	0.012
Acetabular component outer diameter (mm) [‡]	56.4 (4.1) (n = 15)	53.5 (2.6) (n = 23)	56.3 (4.4) (n = 7)	0.027
Length of hospital stay (days)*	4.0 (3.0, 4.0) (n = 22)	3.0 (3.0, 4.0) (n = 2)	4.0 (4.0, 4.8) (n = 12)	0.149
Baseline WOMAC (points)				
Pain [‡]	45.0 (32.5, 65.0) (n = 13)	45.0 (48.8, 71.3) (n = 18)	55.0 (40.0, 62.5) (n = 6)	0.428
Stiffness [‡]	37.5 (18.7, 50.0) (n = 13)	37.5 (18.7, 50.0) (n = 18)	37.5 (21.9, 50.0) (n = 6)	0.750
Function [‡]	45.9 (22.2) (n = 13)	38.6 (20.5) (n = 17)	49.5 (15.9) (n = 6)	0.446
Total [‡]	43.1 (28.4, 60.9) (n = 13)	42.6 (22.1, 51.3) (n = 17)	48.4 (37.3, 62.8) (n = 6)	0.443
Baseline SF-12 (points)[‡]				
Mental	44.1 (14.4) (n = 11)	52.2 (14.2) (n = 17)	40.5 (10.0) (n = 6)	0.138
Physical	31.6 (7.5) (n = 11)	31.3 (7.0) (n = 17)	38.1 (13.8) (n = 6)	0.244
Followup WOMAC (points)*				
Pain	95.0 (68.8, 100) (n = 22)	95.0 (90.0, 100) (n = 23)	87.5 (70.0, 98.8) (n = 12)	0.392
Stiffness	62.5 (50.0, 100) (n = 22)	87.5 (75.0, 100) (n = 23)	75.0 (43.8, 87.5) (n = 12)	0.028
Function	77.9 (68.4, 93.4) (n = 22)	97.1 (89.7, 98.5) (n = 23)	83.1 (64.3, 95.2) (n = 12)	0.011 ^{,¶}
Total	79.1 (66.6, 95.3) (n = 22)	95.8 (88.8, 97.9) (n = 23)	83.9 (64.8, 94.3) (n = 12)	0.035 ^{,¶}
Followup SF-12 (points)*				
Mental	55.5 (35.2, 60.3) (n = 22)	55.2 (51.6, 59.1) (n = 23)	56.2 (42.1, 61.5) (n = 12)	0.662
Physical	33.1 (28.1, 41.7) (n = 22)	37.3 (33.7, 42.8) (n = 23)	40.7 (28.3, 49.6) (n = 12)	0.510

* Values are expressed as median, with quartiles in parentheses; [‡]values are expressed as mean, with SD in parentheses; [§]post hoc tests revealed a difference between HR revision and revision THA groups; ^{||}post hoc tests revealed a difference between HR revision and primary THA groups; [¶]post hoc tests revealed a difference between primary and revision THA groups; HR = hip resurfacing; NA = not applicable.

($p = 0.014$, $p = 0.016$, and $p = 0.033$, respectively), with lower values observed in the HR group. No differences in WOMAC pain were noted between the HR revision and revision THA groups. No differences in baseline or followup SF-12 scores were observed among the three groups.

Within the HR revision group, we observed lower ($p = 0.050$) WOMAC pain scores in patients requiring the revision of both components (median, 80.0; quartiles, 60.0, 100.0) compared to patients requiring the revision of only the femoral component (median, 100.0; quartiles, 95.0, 100.0) (Table 5). No other differences in perioperative

Table 5. Perioperative and followup outcome data after hip resurfacing revision of the femoral component only or both components

Variable	Femoral only (n = 7)	Both components (n = 15)	p value
Revision cause (number of patients)			
Persistent pain	0	8	
Femoral neck fracture	5	1	
Cup loosening	0	4	
Femoral loosening	2	1	
Pseudotumor	0	1	
Perioperative data			
Time to revision (months)*	3.9 (1.0, 49.2)	21.1 (16.8, 33.5)	0.180
Blood loss (mL) [†]	542.9 (340.9)	602.0 (154.2)	0.575
Length of hospital stay (days)*	4.0 (3.0, 4.0)	4.0 (3.0, 4.0)	0.786
Followup WOMAC (points)			
Pain*	100.0 (95.0, 100.0)	80.0 (60.0, 100.0)	0.050
Stiffness [†]	71.4 (21.3)	66.7 (26.2)	0.679
Function [†]	78.8 (11.3)	77.4 (20.1)	0.863
Total [†]	82.9 (9.6)	76.4 (20.2)	0.322
Followup SF-12 (points)*			
Mental	56.5 (26.1, 60.3)	54.5 (35.7, 60.4)	0.597
Physical	31.7 (26.9, 59.4)	35.7 (28.2, 38.6)	0.916

* Values are expressed as median, with quartiles in parentheses; [†]values are expressed as mean, with SD in parentheses.

Table 6. Outcome scores at latest followup based on surgical approach in the hip resurfacing revision group

Outcome	Score (points)		p value
	Anterior approach (n = 4)	Posterolateral approach (n = 16)	
WOMAC			
Pain	95.0 (10.0)	85.0 (17.9)	0.30
Stiffness	84.4 (18.8)	68.8 (22.4)	0.20
Function	94.1 (11.8)	76.6 (14.6)	0.04
Total	93.5 (11.7)	78.4 (14.3)	0.07
SF-12			
Mental	59.0 (5.9)	50.0 (12.5)	0.18
Physical	38.2 (9.4)	37.5 (12.2)	0.92

Values are expressed as mean, with SD in parentheses.

measures or outcome scores were observed. WOMAC pain, function, stiffness, and total scores tended to be higher for patients revised through an anterior approach (n = 4) than for patients revised through a posterolateral approach (n = 16), with only function being significant (p = 0.04) (Table 6). Further, when comparing patients in the HR revision group with adverse tissue reaction (n = 5; three soft tissue collections and two pseudotumors) versus other patients in the HR revision group (n = 17), no differences in outcome scores were observed (p > 0.2 for all scores).

At the time of surgery, intraoperative blood loss (p = 0.012) differed among the three groups. Post hoc tests

revealed it was greater (p = 0.002) in the HR revision group compared to the primary THA but not different from the revision THA group (Table 4). The lengths of hospitalization were also similar in all groups. In the failed HR group, one patient was treated with a short course of antibiotics for a minor wound infection. In the primary THA group, two minor surgical wound infections were treated with antibiotics. One patient, with a history of immunoglobulin M nephritis and peripheral vascular disease, developed heterotopic ossification requiring excision. One patient required revision for septic loosening of the acetabular component at 11 months postoperatively. No hip dislocations were encountered postoperatively in all three groups.

Discussion

Entering the second decade of MoM HR, the clinical effectiveness and relative indications of this surgical procedure have been well defined [24, 26], with the main causes of revision surgery being femoral or acetabular component loosening and/or femoral neck fracture. Initially, the majority of failures were on the femoral side, permitting preservation of the acetabular component [3], but patients who develop an adverse tissue reaction require both sides to be revised [13]. However, it is still unclear whether the revision of failed HR arthroplasties provides comparable clinical outcome scores depending on the cause of revision and on the need to revise only the femoral

component or both the femoral and acetabular components. Therefore, we determined whether (1) patients undergoing HR revision to THA had perioperative measures and outcome scores comparable to those of patients undergoing primary THA or revision of primary THA and (2) patients undergoing revision of both the femoral and acetabular components of an HR had perioperative measures and outcome scores comparable to those of patients undergoing revision of the HR femoral component only.

Our study has several limitations. First is the retrospective nature of the analysis and the resultant small sample size available to match patients adequately. Nevertheless, because all patients with revised HR were included and matched for age, BMI, and sex through a propensity analysis, we minimized potential biases and strengthened our conclusions, despite the small group sizes. Second, because of the different surgical approaches (anterior, posterior, surgical dislocation) used and the varied implant designs and fixation methods, it is unclear whether the differences in clinical outcome between the HR revision and primary THA groups may have been influenced by these variables. In addition, this makes it difficult to recommend a particular approach or method of fixation for the treatment of a failed HR. However, as in any revision situation, the surgical options are dictated by the need for access to the failed interface and reconstructing the bony anatomy.

We found worse WOMAC stiffness, function, and total scores in patients who underwent HR revision than in those who underwent primary THA. There were, however, no differences between the groups in followup WOMAC pain score and in the SF-12 scores. The difference in the WOMAC stiffness score observed may be in part due to the fact that the posterolateral approach was primarily utilized in the HR revision group (16 of 22), while the anterior approach (12 of 23) was preferentially used in the primary THA group. Maffiuletti et al. [16] reported increased stiffness in patients operated on through a posterior approach compared to patients operated on through an anterior approach. However, our results suggest multiple surgical interventions on the hip have a negative impact on function, which is consistent with the literature on revision hip surgery [22]. Our results differ from those of Ball et al. [4] and Mont et al. [18], when looking at revision of failed HR arthroplasties, which may be due to the larger number of patients requiring acetabular revisions in our series. Fifteen hips required revision of both components, which likely explains the increased intraoperative blood loss. Revision of both components has previously been identified as an independent risk factor for intraoperative blood loss in revision THA surgery [17]. The complication rate was similar in the HR revision and primary THA groups. Dislocation has been reported as being a frequent complication after THA revisions, occurring in 7.4% of patients in

a series of 1548 revisions at the Mayo Clinic [1]. In our study, there were no dislocations in the HR revision and revision THA groups. This finding may be explained by the generally good soft tissue envelope found in the HR group and the use of the lateral approach in the majority of the THA revisions. Perioperative measures and followup outcome scores were comparable in patients undergoing a HR or THA revision. Within the revision THA group, four of five femoral component revisions required the use of a modular restoration stem. Modular restoration stems were not required in the HR revision group. This finding supports the premise that preservation of the proximal femoral bone with HR density allows for easier femoral component revision in HR [14].

A subgroup analysis of the HR revision group revealed lower WOMAC pain scores among patients who underwent revision of both the femoral and acetabular components. There were no other differences in functional scores, suggesting these patients did not experience a decrease in function compared to patients who underwent only femoral component revisions. This is corroborated by data from the Australian Orthopaedic Association National Joint Replacement Registry, which reported similar rerevision rates, regardless of whether both components or the femoral component only was revised [9]. As femoral bone stock is preserved during HR, it would make sense that patients who have undergone the revision of only the femoral component would outperform those who had both the femoral and acetabular components revised. The lack of differences in outcome scores except for pain is likely a reflection of the younger patient population, who can recover more easily from a more challenging surgery involving the revision of the acetabular component.

Three patients who underwent HR revision had soft tissue collection intraoperatively, and another two patients had a pseudotumor. Interestingly, unlike Grammatopoulos et al. [13], we did not find any functional difference between patients who experienced an adverse tissue reaction (defined as those presenting a soft tissue collection intraoperatively and those with a pseudotumor) versus other patients. One possible explanation is the relatively short time between the initial HR and revision surgery, which may have limited the severity of the soft tissue damage. Also, Grammatopoulos et al. [13] analyzed the outcome scores of patients with pseudotumor exclusively, whereas we also included patients with soft tissue collection observed intraoperatively in our comparison. In any case, the number of patients experiencing an adverse tissue reaction (as defined above) was also small and therefore more patients would be required to confirm this observation.

Overall, our study suggests HR revision yields perioperative measures and outcome scores similar to those of revision THA. Intraoperative blood loss and WOMAC

stiffness, function, and total scores of patients with HR revision were relatively worse than those of patients undergoing primary THA. Longer followup would be required to determine whether these differences remain, which may be due to the higher rate of cup revisions. Finally, patients with HR undergoing a revision of either the femoral component or both the femoral and acetabular components can expect comparable stiffness and function. Further studies are required to assess whether long-term survival of revised HR differs from that of primary THA or revision THA.

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