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Original research

Hip Resurfacing vs Total Hip Arthroplasty in Patients Younger than 35 Years: A Comparison of Revision Rates and Patient-Reported Outcomes

Drake G. LeBrun, MD, MPH *, Tony S. Shen, MD, Patawut Bovonratwet, MD, Rachelle Morgenstern, MPH, Edwin P. Su, MD

Department of Orthopaedic Surgery, Adult Reconstruction and Joint Replacement, Hospital for Special Surgery, New York, NY, USA

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ABSTRACT

Background: Hip resurfacing arthroplasty (HRA) and total hip arthroplasty (THA) are two treatment options for end-stage degenerative hip conditions. The objective of this single-center retrospective cohort study was to compare implant survival and patient-reported outcomes (PROs) in young patients (≤35 years) who underwent HRA or THA.

Methods: All patients aged 35 years or younger who underwent HRA or THA with a single high-volume arthroplasty surgeon between 2004 and 2015 were reviewed. The sample included 33 THAs (26 patients) and 76 HRAs (65 patients). Five-year implant survival and minimum 2-year PROs were compared between patient cohorts.

Results: Three patients in the THA group (9%) were revised within 5 years for instability (n = 1), squeaking (n = 1), or squeaking with a ceramic liner fracture (n = 1). No patients who underwent HRA were revised. The University of California, Los Angeles, activity score, modified Harris Hip score, and Hip Dysfunction and Osteoarthritis Outcome Scores for Joint Replacement increased by 74%, 64%, and 49%, respectively, among all patients. Compared to the HRA cohort, patients who underwent THA had lower preoperative and postoperative University of California, Los Angeles, activity, modified Harris Hip score, and Hip Dysfunction and Osteoarthritis Outcome Scores for Joint Replacement scores, yet there were no differences in the absolute improvements in any of the three measures between the two groups.

Conclusions: Excellent functional outcomes were seen in young patients undergoing either HRA or THA. Although young patients undergoing THA started at lower preoperative baseline and postoperative PROs than patients undergoing HRA, both groups improved by an equal amount after surgery, suggesting that both HRA and THA afford a similar degree of potential improvement in a young population.

Introduction

Hip resurfacing arthroplasty (HRA) and total hip arthroplasty (THA) are two treatment options for end-stage degenerative hip conditions including osteoarthritis, avascular necrosis, and inflammatory arthritis [1-4]. Both procedures offer pain relief, return to function [5,6], and restoration of natural hip biomechanics [7]. Although HRA was initially developed as a temporizing measure for

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* Corresponding author. 535 E 70th St, New York, NY 10021, USA. Tel.: +1 469 358 5445.
E-mail address: lebrundr@hss.edu

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young patients before THA, the indications for HRA have expanded given that it affords bone preservation, closer resemblance to normal hip biomechanics, increased function, and enhanced stability [8-13]. There are, however, notable concerns regarding HRA including increased technical demand [14], metallosis [15], pseudotumor formation [16], and femoral neck fracture [17].

Young patients are increasingly undergoing hip arthroplasty procedures such as HRA and THA for end-stage degenerative conditions [18,19]. Although several studies have described the outcomes of hip arthroplasty in young patient populations, the definition of "young" is variable and ranges from under 21 to under 55 [4,20-23]. Furthermore, these studies have largely been case series reporting the outcomes of one procedure or another with few studies comparing HRA to THA. Retrospective and prospective studies that have compared THA to HRA have largely been in older patient populations [4,11,24-26]. We, therefore, performed a retrospective cohort study evaluating revision rates and patient-reported outcomes (PROs) in patients aged 35 years or younger undergoing HRA or THA. We hypothesized that revision rates and changes in function and PROs would be similar between the two treatment cohorts.

Material and methods

Study sample

All patients aged 35 years or younger who underwent THA or HRA with a single high-volume arthroplasty surgeon consecutively from February 2004 to May 2014 were identified from a prospectively maintained, single-center, institutional registry. A retrospective cohort study was performed to evaluate the study sample as a whole and compare the THA cohort to the HRA cohort. The study was approved by the institutional review board.

The decision to perform HRA or THA was made on a case-by-case basis according to factors such as the patient's diagnosis, activity level, medical comorbidities including renal disease, disease severity, gender, acetabular size, femoral bone quality and morphology, and leg length discrepancy. Absolute contraindications to HRA included metal hypersensitivity, renal insufficiency, inadequate bone stock to support the femoral implant, and severe osteoporosis. All patients undergoing HRA were informed of the risks associated with metal-on-metal HRA. All patients were treated with HRA using the posterior approach. Patients in the THA cohort were treated using either the posterior or anterior approach based on the appropriateness of each procedure and patient wishes.

Covariates and outcomes

Demographic data, clinical features, and functional measures were collected. Functional assessments and PROs included the University of California, Los Angeles, (UCLA) activity scale [27], modified Harris Hip Score (mHHS) [28], and Hip Disability and Osteoarthritis Outcome Score for Joint Replacement (HOOS-JR) [29] at minimum 2 years postoperatively. Data on revisions within 5 years were also collected. Baseline cobalt and chromium measurements were obtained at the first annual postoperative visit among patients who underwent HRA. Follow-up labs were performed every 2 to 5 years, except in patients with elevated levels (>7 parts per billion [ppb]/side), in which case metal ion measurements were obtained every 6 to 12 months. Serum metal ion levels were not routinely obtained in patients undergoing THA.

Statistical analysis

Descriptive statistics were used to summarize quantitative data. Normality was assessed using the Kolmogorov-Smirnov test. Parametric continuous variables are reported as means ± standard deviations, and nonparametric continuous variables are reported as medians (range). Categorical variables are reported as frequencies and percentages. t-Tests and rank-sum tests were used to compare parametric and nonparametric variables, respectively. Chi-square and Fisher's exact tests were used to compare categorical variables. Kaplan-Meier analysis with 95% confidence intervals and the log-rank test were used to assess the revision rate within the first 5 years postoperatively. Multiple imputation was used to examine the potential influence of missing PRO data by generating 50 imputed data sets. A 2-sided type I error rate of 0.05 was used to indicate statistical significance. Stata 15.1 (College Station, TX) was used for statistical analysis. Institutional review board approval was obtained before the start of this study.

Results

Thirty-three THAs (26 patients) and 76 HRAs (65 patients) were included (Table 1). Patients undergoing THA were more often female, younger, and had lower body mass indices. The most common diagnosis for patients undergoing either THA or HRA was avascular necrosis. Median cup size was 56 mm in patients undergoing HRA and 50 mm in patients undergoing THA ($P < .001$), and the mean head size was 50 mm in patients undergoing HRA and 32 mm in patients undergoing THA ($P < .001$). Among patients undergoing HRA, baseline and follow-up median chromium values were 2.1 ppb (interquartile range 1.5 to 3.7) and 1.9 ppb (interquartile range 1.4 to 3.6), respectively. Cobalt values were 1.6 ppb (interquartile range 1.2 to 2.7) and 1.5 ppb (interquartile range 1.2 to 2.9), respectively. Bearing surfaces and implants used are described in Table 2.

Three patients in the THA group were revised. All three patients had undergone THA via a posterolateral approach. One patient with a ceramic-on-polyethylene implant was revised to a lipped liner for recurrent anterior instability at 9 months postoperatively (other components maintained) and had no further dislocation events within 5 years. Another patient with alumina-on-alumina ceramic-on-ceramic implants was revised to oxidized zirconium (Oxinium; Smith & Nephew, Memphis, TN) on polyethylene for squeaking at 3 years postoperatively. Another patient with alumina-on-alumina ceramic-on-ceramic implants was revised to oxidized zirconium implants at 3.5 years postoperatively for squeaking that progressed to mechanical grinding. Intraoperatively, the patient was noted to have some impingement of the superolateral femoral neck against the cup with external rotation. Once the cup was exposed, the liner was noted to be fractured at the junction between the dome and the band, possibly due to impingement. In addition to these 2 patients, one other patient with a ceramic-on-ceramic THA (3 of 11, 27%) experienced audible squeaking from their unilateral THA but did not undergo revision. No patients in the HRA group were revised. Despite the small sample size, patients in the THA were more likely to undergo revision within 5 years ($P = .008$) based on log-rank testing (Fig. 1).

Significant postoperative improvements were seen in the UCLA, mHHS, and HOOS-JR scores in both treatment groups (Table 3). Patients undergoing THA had consistently lower baseline scores, as well as lower postoperative scores, than patients undergoing HRA for all three functional measures. However, both patients undergoing HRA and THA had equal improvements in UCLA scores (3.5 vs 2.7, $P = .397$), mHHS scores (35.6 vs 35.9, $P = .930$), and HOOS-JR scores (31.7 vs 26.0, $P = .366$) postoperatively. Similar findings

Table 1
Demographic and clinical data of extremely young (≤35) patients undergoing primary total hip arthroplasty or hip resurfacing arthroplasty.

Variable	Total sample		Hip resurfacing		Total hip arthroplasty		*P* value
	n	%	n	%	n	%	
Patients	91		65		26		
Hips	109		76		33		
Female	34	31%	8	11%	26	79%	<.001
Median age (y) (IQR)	31.4 (25.7, 33.6)		32.2 (27.7, 33.9)		27.9 (22.6, 32.3)		.004
Median BMI (kg/m^2) (IQR)	25.8 (22.9, 29.0)		26.2 (24.3, 29.6)		23.3 (20.6, 27.1)		.005
Obese (BMI > 30 kg/m^2)	22	20%	16	21%	6	18%	.829
Diagnosis							<.001
Avascular necrosis	37	34%	20	26%	17	52%	
Primary osteoarthritis	19	17%	17	22%	2	6%	
Femoracetabular impingement	19	17%	19	25%	0	0%	
Developmental dysplasia of the hip	15	14%	7	9%	8	24%	
Posttraumatic arthritis[a]	8	7%	6	8%	2	6%	
Inflammatory arthritis	8	7%	4	5%	4	12%	
Tumor	3	3%	3	4%	0	0%	
Laterality							.756
Left	52	48%	37	49%	15	45%	
Right	57	52%	39	51%	18	55%	

BMI, body mass index; IQR, interquartile range.
[a] Patients (n = 4) with a history of slipped capital femoral epiphysis who all underwent hip resurfacing.

were seen for all comparative analyses in the sensitivity analysis using multiple imputation to account for missing data.

Discussion

With the increase in hip arthroplasty procedures in younger individuals [18,19], there is a need to further define the survivorship, hip function, and overall level of activity in young patients after THA or HRA. The present study demonstrated excellent clinical outcomes in patients aged 35 years or younger who underwent THA or HRA. Furthermore, the present study found that THA was more commonly performed in patients with lower preoperative functional status, and both groups had similar absolute improvements in all three outcome measures.

Excellent survivorship and functional improvements have been reported in young patients undergoing HRA [4,20-23,30-32]. Van Der Straeten et al. [4] found that overall survivorship in a series of 11,382 HRA procedures in patients aged 50 years or younger was 88.9% at 22 years. A similar study by Gaillard and Gross [33] of 1285 HRA procedures in patients aged 50 years or younger found 10-year survivorship of 96.5%. Similar results have been seen in young patients undergoing THA. Eskielinen et al. [30] found implant survivorship of >90% at 10 years among 5607 THAs performed in patients aged 55 years or younger. Among younger patients, Makarewich et al. [21] and Pakos et al. [31] found survivorship of 82% and 90.3%, respectively, in very young patients (≤30 years at the time of surgery). However, many of these studies are case series without a comparison group. This study adds to the existing literature on hip arthroplasty in young patients by highlighting some of the baseline functional differences in young patients undergoing THA or HRA and the fact that both groups have similar magnitudes of improvement in their functional outcome measures.

One important finding from this study is that patients who underwent THA had lower preoperative and postoperative PROs

Table 2
Bearing surfaces and implants used in the study sample.

Variable	Hip resurfacing, n = 76 hips		Total hip arthroplasty, n = 33 hips		*P* value
	n	%	n	%	
Bearing surfaces					<.001
Ceramic-on-ceramic	0	0%	11	33%	
Ceramic-on-polyethylene	0	0%	20	61%	
Metal-on-metal	76	100%	2	6%	
Femoral implant					
Birmingham hip resurfacing	76	100%	0	0%	
Smith + Nephew Anthology	0	0%	28	85%	
Depuy Synthes S-ROM	0	0%	2	6%	
MicroPort Profemur	0	0%	2	6%	
Stryker Secur-fit	0	0%	1	3%	
Acetabular implant					
Birmingham hip resurfacing	76	100%	1	3%	
Smith + Nephew R3	0	0%	29	88%	
MicroPort Lineage	0	0%	1	3%	
Depuy Synthes Pinnacle	0	0%	1	3%	
Stryker Trident	0	0%	1	3%	
Median cup size (mm) (IQR)	56 (52, 58)		50 (48, 52)		<.001
Median head size (mm) (IQR)	50 (46, 52)		32 (28, 32)		<.001

IQR, interquartile range.

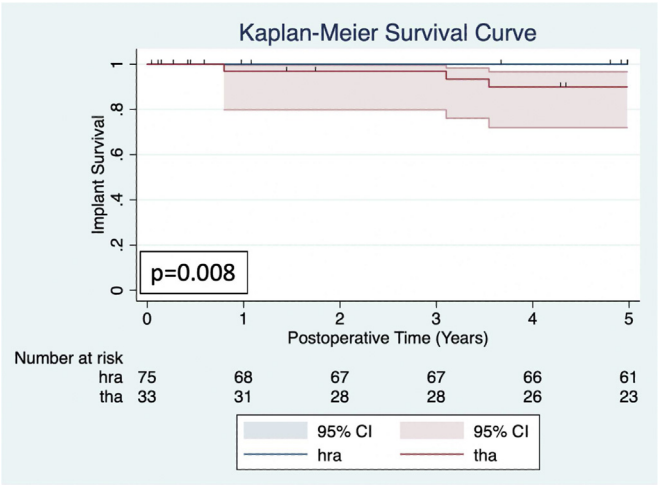

Figure 1. Kaplan-Meier plot comparing 5-year all-cause revision between patients undergoing hip resurfacing arthroplasty or total hip arthroplasty. *P*-value based on the log-rank test. Shading indicates 95% confidence intervals for each cohort. hra, hip resurfacing arthroplasty; tha, total hip arthroplasty.

relative to patients who underwent HRA yet had similar improvements in all measured outcomes. This is in contrast to a recent study [5] comparing return to sport and function in men (no age restriction) undergoing THA or HRA, which found that patients had similar baseline UCLA scores, but patients who underwent HRA had higher postoperative UCLA scores. Patients who underwent HRA also had higher HHS and HOOS Quality of Life scores postoperatively, but the changes from baseline were not evaluated. In their study of 1285 patients younger than 50 years undergoing HRA, Gaillard and Gross [33] found that patient UCLA scores improved from 5.4 to 7.6, which was similar to a smaller study by Krantz et al. [23] in patients younger than 30 years showing score improvements from 5.5 to 7.6. Our study also found lower preoperative UCLA scores and higher postoperative UCLA scores in patients who underwent HRA. When comparing patients who underwent HRA to those who underwent THA, Fowble et al. [34] found that among 89 hips, patients who underwent HRA had larger improvements in HHS and UCLA scores than patients who underwent THA. In a 1:1 assessor-blinded randomized controlled trial, Costa et al. found that hip function per the HHS or Oxford hip score was similar between HRA and THA at 12-month and 5-year follow-up visits [26,35].

Another important finding from this study relates to the increased revision risk in patients undergoing THA (9% at 5 years compared to no revisions in the HRA group). Notably, two of the three revisions were related to bearing issues such as squeaking or ceramic liner fracture (in a patient who had previously complained of squeaking), whereas the other revision was for instability in a patient with a ceramic-on-polyethylene implant. Therefore, although the overall revision rate was 9% in the THA cohort, when patients were broken down by bearing surface, 2 of 11 (18%) hips with ceramic-on-ceramic implants required revisions, whereas 1 in 20 (5%) hips with ceramic-on-polyethylene required revisions. In a meta-analysis of 13 randomized controlled trials, Si et al. [36] found that the incidence of component-related noise and ceramic fracture were 15 times and 6 times higher among ceramic-on-ceramic implants than those among ceramic-on-polyethylene implants, respectively, but there was no significant difference in terms of revision rates. In a separate meta-analysis of randomized controlled trials comparing ceramic-on-ceramic to ceramic-on-polyethylene, Hu et al. [37] found no significant differences with respect to revision between the two bearing surface groups. In their study involving 238 ceramic-on-ceramic hips requiring revision, Migaud et al. [38] found that 37 (16%) were directly related to ceramic use such as squeaking or breakage. Similarly, Porat et al. [39] found that among 1697 ceramic-on-ceramic THAs, the overall revision rate was 2.2%, with the bearing surface accounting for 13% of these revisions.

The reasons for the differences between HRA and THA in our study are multifactorial. Patients underwent THA or HRA on the basis of multiple criteria related to age, sex, bone quality, proximal femoral and acetabular bony morphology, patient preferences, and expectations. These differences are evident, in part, in the demographic differences in the treatment groups, which are similar to those in another recent study comparing HRA to THA [22]. Furthermore, patients who underwent HRA were more active and had better hip function at baseline, consistent with expectation and baseline outcome measures. This is part of the reason why patients undergoing THA had lower baseline functional scores and PROs than those undergoing HRA. Nonetheless, the fact that overall improvements in UCLA, mHHS, and HOOS-JR were similar between groups suggests that both treatment modalities can restore function by a similar magnitude, but young patients undergoing THA may remain slightly less active or functional due, in part, to starting at a lower baseline. This is important to understand especially when counseling young patients on their anticipated outcomes after HRA or THA.

This study has limitations. First, there are multiple factors influencing the decision to pursue HRA or THA, so we expect the treatment groups to differ across covariates relevant to this decision such as age, sex, baseline function, and preoperative diagnosis (which will differentially affect proximal femoral and acetabular bone stock, influencing the decision to pursue HRA or THA). Despite these expected differences, we believe these findings represent the spectrum of young patients undergoing HRA and THA. We further recognize that these populations are somewhat distinct, given the relative or absolute contraindications to HRA such as poor proximal femoral bone stock or acetabular deficiency, women of childbearing age desiring to get pregnant, renal failure, and metal hypersensitivity [40]. Baseline demographic and functional differences are, therefore, expected and likely contributing to the differences seen in this study between the two groups' outcomes. Second, the study is a single-center single-surgeon retrospective study, and therefore, the generalizability of the study sample may be limited. Third,

Table 3
Patient-reported outcome measures of extremely young (≤35) patients undergoing primary total hip arthroplasty or hip resurfacing arthroplasty at minimum 2-year follow-up.

Variable	Total sample		Hip resurfacing		Total hip arthroplasty		*P* value
	n = 109		n = 76		n = 33		
	Mean	SD	Mean	SD	Mean	SD	
UCLA							
Preop	4.6	2.3	5.2	2.4	3.2	1.1	**.002**
Postop	8.2	1.8	8.4	1.6	6.7	2.3	**.023**
Difference	3.4	2.3	3.5	2.3	2.7	2.3	.397
mHHS							
Preop	56.2	13.4	58.9	14.3	50.2	8.6	**.010**
Postop	92.2	10.5	94.4	8.2	86.7	13.5	**.026**
Difference	35.7	14.7	35.6	14.4	35.9	15.6	.930
HOOS-JR							
Preop	60.1	15.0	64.0	12.6	52.7	16.7	**.026**
Postop	91.7	12.8	96.5	6.7	80.6	16.5	**<.001**
Difference	29.7	17.8	31.7	15.0	26.0	22.2	.366

SD, standard deviation.
Values are reported as means (standard deviations). *P*-values are reported according to the t-test or Wilcoxon rank-sum test depending on whether the data were parametric or nonparametric, respectively. Statistically significant values are bolded.

despite a long date range of over 10 years, the sample size was small, particularly in the THA cohort. However, the sample size is close to other studies of young patients undergoing hip arthroplasty [4,20-23]. Fourth, there was incomplete follow-up with this study with some patients missing minimum 2-year PROs or 5-year survivorship data. These issues are partly mitigated by a sensitivity analysis using multiple imputation to account for missing data which demonstrated similar findings to the original analysis [41]. Finally, the lack of radiographic parameters related to component positioning is another important limitation of this study as malpositioning is associated with postoperative complications including squeaking and ceramic fracture [42,43].

Conclusions

Excellent early clinical outcomes were seen in young patients aged 35 years or younger undergoing either HRA or THA. Young patients who underwent THA had lower UCLA, mHHS, and HOOS-JR scores preoperatively and postoperatively than patients who underwent HRA, but both groups improved by an equal amount in all three metrics after surgery, suggesting that both HRA and THA afford a similar degree of potential improvement in a young population.

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