Hip resurfacing arthroplasty as an alternative to total hip arthroplasty in patients aged under 40 years

A retrospective analysis of 267 hips

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Aims

The aims of the study were to report for a cohort aged younger than 40 years: 1) indications for HRA; 2) patient-reported outcomes in terms of the modified Harris Hip Score (HHS); 3) dislocation rate; and 4) revision rate.

Methods

This retrospective analysis identified 267 hips from 224 patients who underwent an hip resurfacing arthroplasty (HRA) from a single fellowship-trained surgeon using the direct lateral approach between 2007 and 2019. Inclusion criteria was minimum two-year follow-up, and age younger than 40 years. Patients were followed using a prospectively maintained institutional database.

Results

A total of 217 hips (81%) were included for follow-up analysis at a mean of 3.8 years. Of the 23 females who underwent HRA, none were revised, and the median head size was 46 mm (compared to 50 mm for males). The most common indication for HRA was femoroacetabular impingement syndrome (n = 133), and avascular necrosis ((n = 53). Mean postoperative HHS was 100 at two and five years. No dislocations occurred. A total of four hips (1.8%) required reoperation for resection of heterotopic ossification, removal of components for infection, and subsidence with loosening. The overall revision rate was 0.9%.

Conclusion

For younger patients with higher functional expectations and increased lifetime risk for revision, HRA is an excellent bone preserving intervention carrying low complication rates, revision rates, and excellent patient outcomes without lifetime restrictions allowing these patients to return to activity and sport. Thus, in younger male patients with end-stage hip disease and higher demands, referral to a high-volume HRA surgeon should be considered.

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Take home message

- This study represents the largest retrospective analysis of hip resurfacing arthroplasty (HRA) specifically for patients aged under 40 years.
- This study establishes HRA as a viable bone preserving intervention for younger patients, carrying low complication rates, low revision rates, and high patient satisfaction without lifetime activity or sporting restrictions.

Introduction

The best reconstructive method for young adults with degenerative hip disease is an ongoing topic of discussion. While total hip arthroplasty (THA) is a consistent, reproducible procedure, it has been associated with loss of bone stock and lifetime activity restrictions that preclude high demand activities, including running and contact sports.[1] Hip resurfacing arthroplasty (HRA) represents an alternative solution that preserves femoral bone stock, and has excellent stability with low dislocation rates.[2–4] For young patients aged under 40 years presenting to a sports medicine or hip preservation clinic with signs of end-stage joint disease, referral to a reconstructive specialist is an important decision. Fouilleron et al[5] reported 92% of patients who underwent HRA returned to running. Similarly, Naal et al[6] reported 98% of patients returned to a mean of 4.6 sport disciplines, including downhill skiing, tennis, football, and soccer; moreover, return to sports occurred within the first three months after surgery. Both reports measure their findings due to concerns of implant survivorship and revision risk.

Not all adult reconstructive surgeons perform HRA, as multiple factors have limited widespread adoption in the USA. Among these are concerns regarding adverse reactions from the metal-on-metal (MoM) articulation, revision risk due to femoral neck fracture, and technical challenges. Historical studies reporting failures in the HRA literature are limited by the inclusion of patients, surgeons, and implants that would not meet modern expectations in terms of implant metallurgy, unique component positioning, and patient selection.[7–13] Previous studies have investigated the benefits of HRA in clinical outcomes. Halawi et al[14] published a minimum five-year follow-up of HRA and THA in patients aged 55 years and younger, and found that HRA had advantages in multiple outcomes measures, including dislocations, component loosening, revisions, re-operations, deep infections, patient satisfaction, and mortality. Furthermore, patients undergoing HRA have reported greater improvement in general health status and higher activity levels compared to those undergoing THA.[22] A 2012 registry-based cohort study found that patients with HRA had a significantly lower risk of death in men of all ages, compared to uncemented and cemented THA, potentially due to pressurization of the medullary canal from clinical and subclinical emboli showering.[16] Similarly, a 2013 study by Kendal et al[17] reported described lower mortality rates in patients undergoing HRA compared to both cemented and uncemented THA (3.6% vs 6.1% and 3.0% vs 4.1%, respectively) after accounting for multiple confounding variables such as age, sex, indication, and comorbidity. Presently, it is thought that larger and younger male patients are better suited for HRA due to the ability to implant a greater head size, which decreases the risk of edge loading and maintains fluid film lubrication, thereby leading to fewer instances of metallosis, elevated ion levels and adverse local tissue responses such as pseudotumor.[18] While conventional THA remains a more technically facile and reproducible operation, the restrictions on activity, availability of bone stock in future revisions, potentially increased mortality rate, and thigh pain are non-negligible considerations in the younger, high demand patient population with end-stage hip disease.[7,19,20]

For patients who have suffered from avascular necrosis (AVN), untreated chronic femoroacetabular impingement syndrome (FAIS), slipped capital femoral epiphysis (SCFE), or other pathologies resulting in hip pathology at a young age, the option of THA is less than ideal for this higher demand population due to the associated activity restrictions and increased revision risk. HRA represents an excellent bone preserving alternative that meets the demands of this unique population without imposing lifelong activity restrictions (i.e. running, impact sports, anterior or posterior hip precautions). Many patients that present to a hip preservation or sports medicine clinic may be quite young. This paper presents the outcomes of HRA in patients aged under 40 years. The objectives of the study are to report: 1) indications for HRA; 2) patient-reported outcomes in terms of the modified Harris Hip Score (HHS); 3) dislocation rate; and 4) revision rate. We hypothesize HRA represents a safe hip operation that carries excellent outcomes for this challenging population with end-stage hip disease and high functional demands, including return to sport.

Methods

Patients

Patient records from a single, high volume fellowship-trained surgeon (PJB) performing HRA at a tertiary referral centre were reviewed. The Birmingham Hip Resurfacing system (Smith & Nephew, USA) was used in each HRA in this study through the direct lateral approach of the hip. We recommend a conservative postoperative return to activities, with six weeks of partial weightbearing using crutches, and avoidance of strenuous exertion, running and jumping for a full year. Inclusion criteria were aged less than 40 years and follow-up for ≥ two years. During the 2007 to 2019 period, 3,722 HRAs were performed, and 3,455 procedures were excluded for age > 40 years. Of 267 hip resurfacing procedures performed on patients aged under 40 years between 2007 and 2019, 217 hips (81%) met criteria for follow-up and were included in the study.

Outcomes

All patients were followed using a prospectively maintained institutional database. Indication for surgery, age, laterality, sex, date of surgery, date of last follow-up, and documentation of any subsequent surgery were noted for each hip included. From this data, demographic summary statistics (sex, age) and descriptive statistics characterizing indication for surgery and femoral implant size were generated. Modified Harris Hip Scores calculated at one-, two-, and five-year follow-up were documented. The dislocation and revision rates were recorded. For patients who underwent revision surgery, the chart was reviewed in detail and context of the revision procedure was presented.

Statistical analysis

Descriptive statistics were calculated for demographic variables. All analyses were undertaken using the Excel version 14.5.4 (Microsoft, USA) and R Version 3.6.3 (R Foundation for Statistical Computing, Austria).[21] A p-value < 0.05 was set to determine statistical significance.

Results

A total of 217 hip resurfacing procedures performed in 205 patients aged under 40 years at a single institution (Cleveland Clinic Foundation, Cleveland, Ohio, USA) from July 2007 to December 2019 were included in this analysis. Of these, 193 HRAs were performed in males (88.9%) and 24 in females (11.1%). The mean age at operation was 33.4 years (14 to 39). The median femoral head resurfacing component size was 50 mm for males (44 to 58) and 46 mm for females (42 to 48) (Figure 1).

For the included patients, the mean follow-up was 3.8 years (2 to 12.7). A total of 74 hip resurfacings (27.7%) had five or more years of follow-up available. The most common primary diagnoses were femoroacetabular impingement syndrome (FAIS) (n = 133; 61.3%), avascular necrosis (n = 53; 24.4%), and hip dysplasia (n = 7; 3.2%). A full list of primary diagnoses leading to resurfacing is displayed below in Table I.

Modified Harris Hip Scores (HHS) were collected for all 217 HRAs as a clinical assessment of hip function. At two years postoperatively, the average HHS was 100 (standard deviation (SD) 0.13). At five years postoperatively, the average HHS was 100 (SD 0). Examples of patients who underwent HRA for FAIS and AVN are demonstrated in Figures 2 and 3, respectively.

No hip dislocations or femoral neck fractures occurred. No patients had abnormally elevated metal ions, although metal ion levels were obtained only with clinical concerns. There were no adverse local tissue responses, or pseudotumors. Among this cohort, four reoperations were performed at a mean time of 45 months. In two of these, no component revision was required (removal of heterotopic ossification, and incision and drainage). One deep infection (0.46%) required component removal at 42 months in an intravenous drug user with concurrent disc space infection. Overall aseptic implant survivorship was 99.0% at a mean of 46 months follow-up. Survivorship in females, and aseptic survivorship in males with osteoarthritis (OA), was 100%. Each hip revision and reoperation is analyzed individually in Table II.

Table I. Primary diagnoses of patients undergoing hip resurfacing.

Primary diagnosis	Patients, n
Femoroacetabular impingement syndrome	133
Avascular necrosis	53
Hip dysplasia	7
Perthes' disease	7
Slipped capital femoral epiphysis	6
Rheumatoid arthritis	4
Seronegative spondyloarthropathy	4
Prior septic arthritis	3

Discussion

In this study, we retrospectively reviewed 217 HRAs in patients aged under 40 years performed by a single high-volume surgeon at a tertiary referral centre from 2007 to 2019 with a minimum follow-up of two years. Despite the follow-up rate of 81%, this represents the largest cohort of HRAs studied in this unique and challenging patient population. Mean postoperative HHS was maximally reached at 100 at two and five years, indicating excellent patient-reported outcomes. For this cohort, we report a low aseptic revision rate of 0.5% (n = 1) with a mean follow-up of 3.8 years. Survivorship in females – although not advocated – and aseptic survivorship in males with end-stage disease was 100%. No dislocations occurred, likely due to the large head size, direct lateral surgical approach, or a combination of both. This low revision rate combined with excellent postoperative functional outcomes without activity, range of motion, and sporting restrictions demonstrates that HRA represents an excellent intervention in the young, high demand patient population with high future revision risk. These findings support the notion that high demand patients presenting to a sports or hip preservation clinic should be considered for referral to a high volume HRA surgeon.

In comparison to previous hip resurfacing series, this cohort was limited to patients under 40 years of age, where a surgeon may hesitate to offer THA. The most common indication for HRA in this younger cohort was FAIS (n = 133; 61.3%), followed by AVN (n = 53; 24.4%), and congenital hip dysplasia (n = 7; 3.2%). These findings vary slightly from those previously reported in literature. A 2014 analysis of 1,000 hips treated with HRA reported the most common indication to be OA (n = 763; 76%), followed by dysplasia (n = 103; 10%) and osteonecrosis (n = 40; 4%).[22] However, 'primary OA' does not preclude the diagnosis of FAIS-induced OA. We believe that the most common condition treated in this series, end-stage FAIS with secondary osteoarthritis, is likely the most common pathology affecting young hips. We note the presence of a pistol-grip deformity best seen on a frog lateral radiograph,[23,24] varus alignment of the head on the neck, retroversion of the head, anterosuperior eburnated bone, and a labral tear. These morphological changes can be corrected at the time of hip resurfacing.[25] End-stage FAI may be recognized more frequently once the surgeon is aware of these findings. We agree with other groups that “primary” OA in this age group is rare.[26]

In the present study, the modified Harris Hip Score (HHS) was assessed as the primary patient-reported outcome measure (PROM) to determine subjective hip function after resurfacing. PROMs are important quality metrics that are useful in holistically determining the success of an implant and its ability to improve the subjective quality of life for implant recipients. A touted advantage of hip resurfacing is the ability to offer younger patients the ability to live more active lifestyles, which may be essential in improving quality-of-life and patient satisfaction. Moreover, the preservation of bone stock may offer more normal gait,[27,28] fewer concerns for leg length discrepancy[29,30] improved proprioception,[31] and no persistent thigh pain found in the THA population.[32] These nuanced differences likely contribute to the patient returning to sports and high demand activities. Currently,

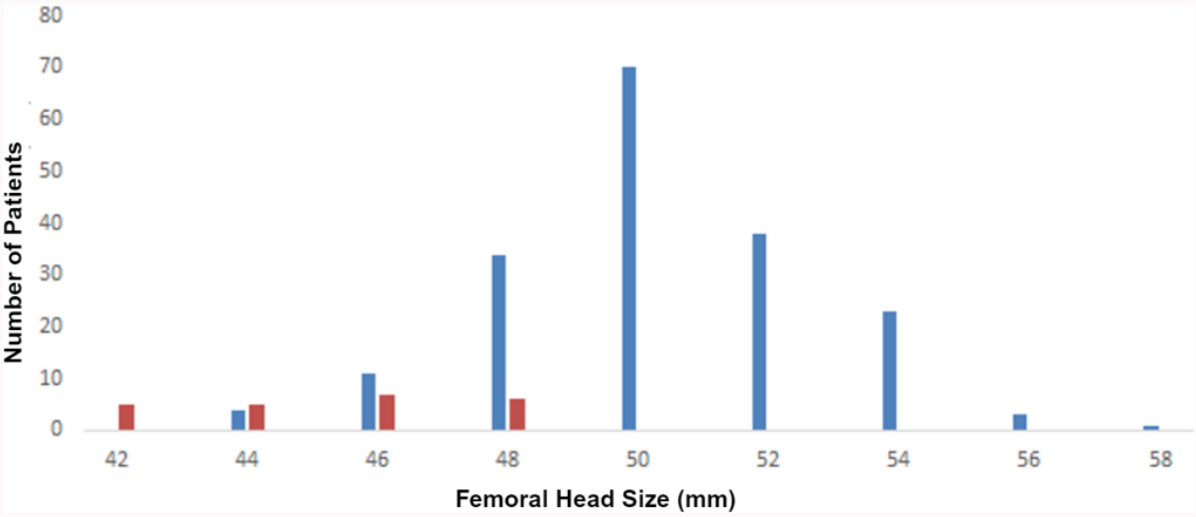

Fig. 1
Distribution of femoral head sizes, stratified by patient sex

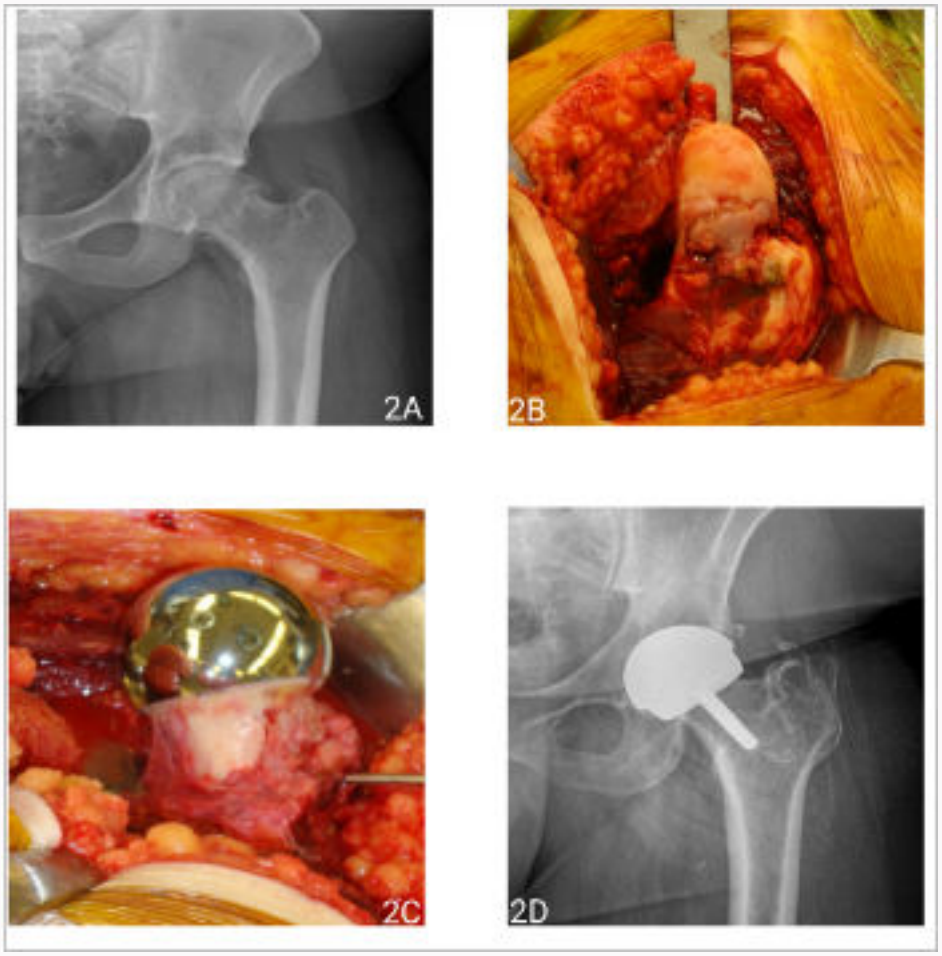

Fig. 2
Preoperative anteroposterior radiographs a) of a 31-year-old male with femoroacetabular impingement. Intraoperative photos (b) demonstrate the deformity before and after resurfacing. Eight-year postoperative radiographs (c and d) demonstrate HRA with excellent fixation, no loosening or subsidence, and minimal asymptomatic heterotopic ossification.

several studies have confirmed excellent PROMs after HRA. Samuel et al[33] investigated PROMs and patient satisfaction for 350 individuals who underwent hip resurfacing procedures. Overall, the group found that patients who required revision had significantly lower HHS scores compared to those who did not require revisions. They also demonstrated that males

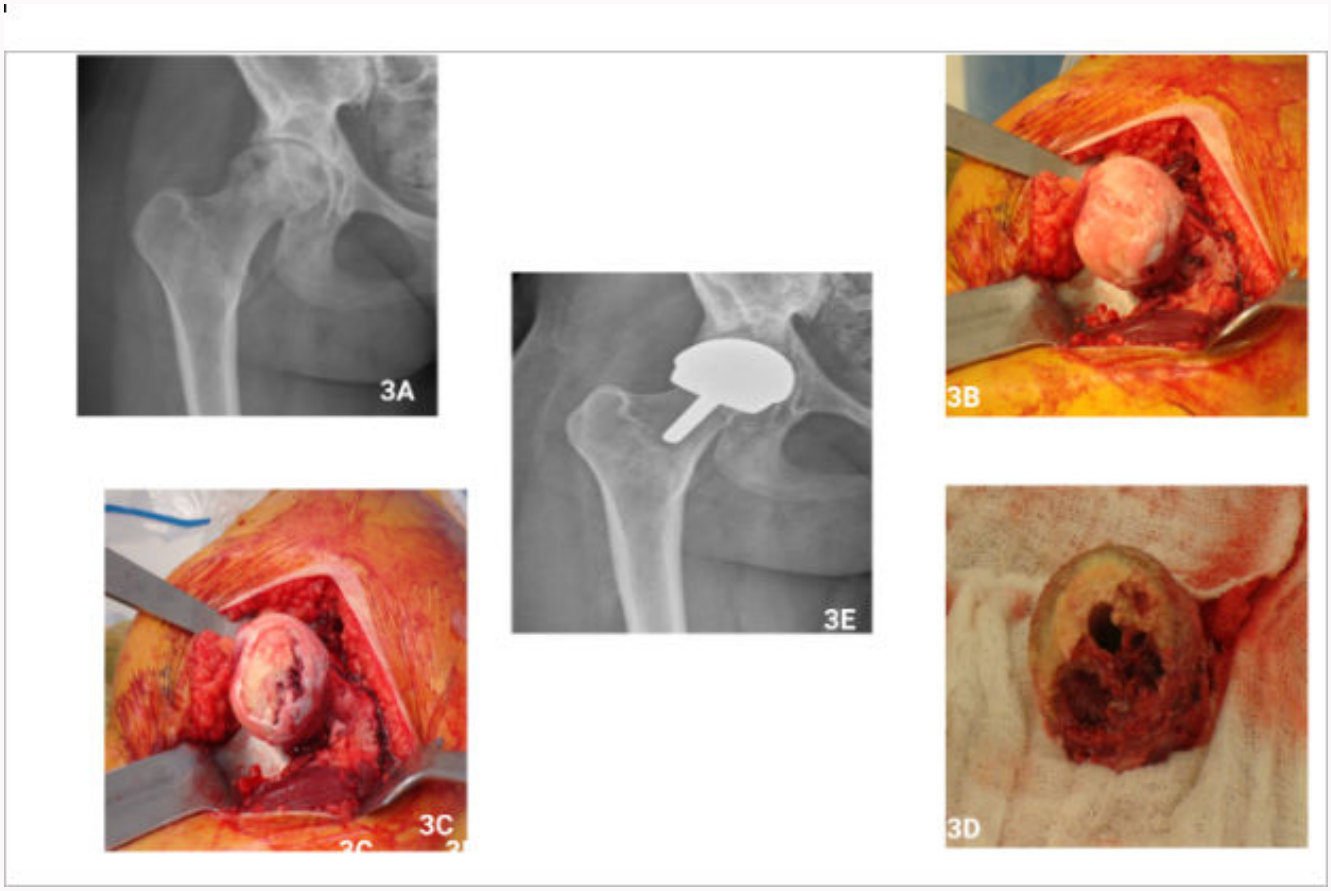

Fig. 3
Preoperative radiographs (a) of an 18-year-old female who experienced avascular necrosis one year after completing treatment of Ewing's sarcoma. Intraoperative photos (b, c, and d) demonstrated a collapsed femoral head with nearly 40% bone loss. Ten-year postoperative radiographs (e) demonstrate excellent fixation without loosening or subsidence.

Table II. Revision cases specific details and indications.

Patient	Age, yrs	Sex	Indication for primary HRA	Head size, mm	Postoperative time to revision/reoperation, mnths	Indication
1	30	M	Avascular necrosis	44	39	Femoral head collapse and inversion of acetabular component (subsidence)
2	27	M	Ankylosing spondylitis	50	48	Postoperative drainage of unknown aetiology
3	34	M	Femoroacetabular impingement	52	51	Heterotopic ossification (noncompliance with postoperative celecoxib)
4	32	M	Femoroacetabular impingement	50	42	Infection/septic arthritis with psoas abscess

HRA, hip resurfacing arthroplasty.

had significantly higher HHS scores compared to females. However, it should be noted that the median age of the study population was 53. A 2009 study found that, at one year after arthroplasty, patients with HRA reported significantly improved Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) scores than patients with THA ($p = 0.041$).[15] These patients also reported superior scores in all Short Form 36 (SF-36) domains ($p < 0.05$).[15] Additionally, an analysis of 51 THAs and 53 HRAs in 2006 found that patients with HRA reported significantly higher quality of life scores than patients with THA (0.9 vs 0.78; $p = 0.003$) as well as significantly higher levels of activity as measured by UCLA activity score (9 vs 7; $p < 0.001$).[34] Our study further supports these findings, reporting excellent HHS with mean scores of 100 and 100 at two- and five-years post-resurfacing, respectively. While specific sports-related questionnaires were not asked of the study group, HRA allows patients to return to their activities without dislocation precautions or activity

restrictions, potentially contributing to the significant increase in PROMs.

In our cohort of 217 hip resurfacing procedures, two revisions were performed, one for late deep infection in an intravenous drug abuser, indicating an overall revision rate of 0.92%, and an aseptic revision rate of 0.46% with a mean time to revision of 3.4 years. In addition, there were two reoperations, one for excision of heterotopic ossification (0.46%), and one incision and drainage for infection (0.46%). It should be noted that the first of these might have been prevented had the patient been compliant with postoperative celecoxib to obviate the known complication of heterotopic ossification.[35] Several previous studies have reported similarly excellent survivorship for hip resurfacing. In 2021, Amstutz et al[36] conducted an investigation of 355 patients who underwent HRA, which demonstrated an 83.5% 20-year survivorship, indicating the long-term durability of the implant. In a separate study, Gani et al[37] investigated the long-term survivorship of 105 patients who underwent HRA, showing an 86.7% survivorship in a cohort with a mean follow-up of 14.9 years. In 2014, Daniel et al[22] reported a HRA revision rate of 3.8% with a mean follow-up of 13.7 years. In 2018, a review of 360 hips reported a similarly low revision rate of 4.3% with an average follow-up of 7.2 years.[38] We also report no dislocations in our cohort, which remains one of the most common complications after THA. Several studies confirm this finding as an advantage of HRA to THA.[39] The total incidence of hip dislocation after THA has been widely reported, ranging from 1% to as high as 10% in some, with dislocation being the most common indication for revision THA (17.3%).[40–42] Thus, the ability to mitigate this risk makes HRA an attractive solution in younger patients. Should the HRA fail, the revision may require only a standard stem with a dual-mobility bearing into the existing resurfacing socket.

Although the senior author (PJB) no longer performs or advocates for HRAs on females, it is worth mentioning that none of the 23 females in the cohort experienced any complications or failures related to MoM hip resurfacing. It should be noted that these procedures were carried out before the manufacturer's withdrawal in 2015 for implants of any size within females or head sizes below 48 mm for males. Cobalt and chromium levels were not obtained as a routine, but whenever there were clinical concerns or prior to a second side procedure. All patients with follow-up metal ion levels (n = 185) had cobalt and chromium levels below three parts per billion. Advanced imaging was obtained if the patient had clinical symptoms and elevated metal ion levels. Three studies reported in the *American Journal of Sports Medicine* describe the value of HRA as a procedure offering return to activities and sports disallowed with THA.[1,5,6] However, all three caution survivorship of the young patient population undergoing HRA. Our findings demonstrate HRA is a safe and reproducible procedure among high-volume surgeons that may potentially offer a tremendous advantage over THA in terms of quality of life for patients seeking to resolve their pain and disability of a destructed hip joint without sacrificing participation within a sport. Although our protocol permits full return at one year postoperatively, Sandiford et al[43] describes patients successfully returning at three months with the same preoperative intensity. Given the paucity of surgeons performing HRA, most patients are unaware that there exists an alternative procedure that will permit full activities. Moreover, arthroplasty surgeons who are not trained in HRA are less likely refer to a HRA specialist. Thus, patient referral remains the most critical element for these young, high demand male patients with end-stage joint disease.

Our study has several limitations. The hip resurfacing procedures analyzed in this study were performed at one institution by a single surgeon who has extensive experience performing HRA. This restriction in our cohort selection may limit the generalizability of the reported findings. Previous studies have determined that there exists a learning curve both in avoiding early complications as well as achieving optimal component positioning.[31,44] Given the relative rarity of this procedure in the USA, it is likely that few surgeons currently have both the experience and the comfort level to perform hip resurfacing with proficiency. However, previous registry studies and other single-institution cohort analyses indicate that similar results with this technique are reproducible.[22,45–48] Another limitation lies within the follow-up period of the study. While our study demonstrated an average follow-up of 3.8 years providing context short- to medium-term outcomes, it did not capture long-term outcomes following HRA. Therefore, further investigations are warranted to assess the impact of long-term outcomes for patients who underwent HRA. In addition, while we report revisions that have been documented in our institution's cohort, patients unsatisfied with their hip resurfacing may have elected to have a revision performed at a different institution, and thus may not have been captured by this study in the subpopulation of patients lost to follow-up. We were unable to compare this cohort to a matched-control cohort of patients undergoing THA. Such a cohort would be useful in making a more direct comparison of revision rates and patient reported outcome measures. Despite the lack of a matched-control group, our findings provide valuable evidence supporting the effectiveness of HRA as a bone-preserving procedure with excellent outcomes for high-risk younger patients. Furthermore, our study did not directly assess radiological measurements of component positioning. However, early complications like femoral neck fracture and dislocation that may have been evident from postoperative radiographs did not occur. Therefore, our study emphasized the assessment of complications and the need for revision following HRA. Although the HHS scores were excellent, there exist ceiling effects with this PROM which may fail to delineate nuance.[49] Specifically, HHS does not capture high demand activities and sports and thus this cohort cannot comment on activity demand. Finally, it is also important to note that despite the limitation of losing 19% of the cohort, this study represents the largest cohort of hip resurfacing patients aged under 40 years reported to date, providing valuable understanding of the outcomes of hip resurfacing in this population.

In conclusion, for younger patients with higher functional expectations and increased lifetime risk for revision, HRA is an excellent bone preserving intervention and carries low complication rates, low revision rates, and excellent patient outcomes without lifetime restrictions allowing these patients to return to activity and sport. Thus, in younger male patients with end-stage hip disease and higher demands, referral to a high volume HRA surgeon should be considered.

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Data sharing

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