Do Young, Active Patients Perceive Advantages After Surface Replacement Compared to Cementless Total Hip Arthroplasty?

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Abstract

Background Potential advantages suggested but not confirmed for surface replacement arthroplasty (SRA) over THA include lower frequency of limp, less thigh pain, less limb length discrepancy, and higher activity.

Questions/purposes We therefore determined whether patients having SRA had a limp, thigh pain, or limb length

discrepancy less frequently or had activity levels higher than patients having THA.

Methods In a multicenter study, we surveyed 806 patients aged 18 to 60 years with a pre-morbid UCLA activity score of 6 or more who underwent hip arthroplasty for noninflammatory arthritis at one of five orthopaedic centers. Patients had either a cementless THA with an advanced bearing surface ($n = 682$) or an SRA ($n = 124$). The patients

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were demographically comparable. Specific telephone survey instruments were designed to assess limp, thigh pain, perception of limb length, and activity levels. Minimum followup was 1 year (mean, 2.3 years; range, 1.1–3.9 years).

Results When controlled for age, sex, and premorbid activity level, patients with SRA had a higher incidence of complete absence of any limp, lower incidence of thigh pain, lower incidence of perception of limb length discrepancy, greater ability to walk continuously for more than 60 minutes, higher percentage of patients who ran after surgery, greater distance run, and higher percentage of patients who returned to their most favored recreational activity.

Conclusions When interviewed by an independent third party, patients with SRA reported higher levels of function with fewer symptoms and less perception of limb length discrepancy compared to a similar cohort of young, active patients with THA.

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

Introduction

The role of surface replacement arthroplasty (SRA) versus THA for young, active patients continues to be controversial. It is generally agreed, when all patients and all implants are considered, the revision rate is greater after SRA than after THA [21]. When results are stratified by age, sex, and diagnosis, however, different conclusions can be drawn. Males younger than 55 years with osteoarthritis, for

instance, reportedly have a somewhat lower revision rate than those with THAs in that patient population [29]. However, in addition to revision rates, there have been increasing concerns regarding adverse tissue reactions related to SRA. Pandit et al. [16, 35] reported 20 pseudotumors in 17 patients after SRA and estimated approximately 1% of patients would develop a pseudotumor within 5 years. The same group, however, estimated an increased risk of pseudotumor formation as high as 13% in females younger than 40 years [16, 35]. There has been a wide discrepancy in the estimated incidence of pseudotumors, with a multicenter Canadian study reporting only four tumors in 3432 arthroplasties, for an incidence of only 0.10% [7]. In addition to concerns regarding the increased revision rate and adverse tissue reactions [19], it is generally accepted there is a learning curve associated with the adoption of hip resurfacing [4, 12]. Patient selection is also an issue with SRA, as a relatively small percentage of the population with hip arthritis qualifies as reasonable candidates for hip resurfacing [11, 32]. Patient selection is much less of an issue with THA, as the vast majority of patients with end-stage arthritis of the hip are potential candidates for hip arthroplasty. In addition, the margin for error for replacement of components in THA is generally more forgiving, due to concerns regarding metal ion levels with SRA. Increased anteversion has been correlated with increased metal ion levels after SRA [10, 19, 22], which is not as much of a concern with non-metal-on-metal THA.

Given the high survivorship and low complication rate of THA [23], SRA must demonstrate a similar complication rate in addition to some clinical advantage to warrant continued use of this procedure. There are a number of potential advantages of hip resurfacing, including return to higher activity levels [14, 21, 27, 30, 39, 40], less activity-related thigh pain [21, 40], and fewer complications with postoperative limb length discrepancy [15, 27, 40] and limp [21, 27]. Fowble et al. [14], however, pointed out patients who undergo SRA have characteristics different from those of patients who undergo THA, including a higher preoperative UCLA activity score, which was associated with higher function and a higher postoperative UCLA activity score but also a higher incidence of slight or mild pain. These differences in pre- and postoperative

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activity scores between patients receiving SRA and THA have also been reported by Vail et al. [39] and Mont et al. [30]. This is an example of the difficulty in comparing results of SRA with THA. First, patients must be compared in terms of age and activity level. Second, an adequate sample size must be evaluated to have adequate statistical power to compare specific subgroups. Finally, specific questions must be designed to assess domains important to patients that may not be addressed in current rating scales, such as perception of thigh pain, limb length discrepancy, or return to most favored activity. Patients and physicians view the results of hip arthroplasty differently, especially when suboptimal results are achieved [24]. Furthermore, Mancuso et al. [26] reported only 40% to 50% of patients have all their expectations met after THA, so the incidence of symptoms after THA is likely higher than what is reflected in the literature.

We therefore designed a study to determine whether there were any of the following perceived advantages by patients after SRA versus THA: (1) less frequent limp, (2) less frequent thigh pain, (3) less limb length discrepancy, or (4) higher activity levels.

Patients and Methods

To participate in a survey, we retrospectively identified 1366 eligible men aged 18 to 60 years or women aged 18 to 55 years at time of surgery who had THA or SRA (1188 THAs, 178 SRAs) at one of five centers between January 2005 and July 2007. We used a multicenter study to minimize selection bias from a large group of young, active patients whose age and activity level would make them potential SRA or THA candidates. In an attempt to capture young, active patients who were most likely to be employed at the time of surgery, age limits were determined by the average age of retirement in the United States (62–65 years old) and because women tend to leave the workforce earlier than men. Patients were systematically excluded for known complications that would compromise comparison of well-performing implants and medical comorbidities that would limit their activity level. All retained patients also had to have a UCLA score of 6 or more before they were limited by hip pain to be able to group patients based on premorbid activity level. Of the 1366 patients, 119 were found to have exclusions during the screening section of the questionnaire: postoperative infection (six THAs), fracture (two THAs), dislocation (seven THAs, one SRA), or revision (17 THAs, two SRAs); limited activity level because of an operation on the opposite hip (34 THAs, six SRAs); and premorbid UCLA score of less than 6 (39 THAs, five SRAs). Furthermore,

70 were in households who refused to participate in a survey, and 44 individuals refused to participate. An additional 156 participants were never available, 108 were not found due to bad address/phone number, 48 were contacted but did not complete the interview, nine were deceased, and six had a language barrier that prevented them from completing the survey. This left 806 of the 1247 eligible patients with completed surveys. We used the American Association for Public Opinion Research response rate calculator [1] to compute the percentage of all eligible or potentially eligible cases that resulted in a completed interview:

$$\frac{\text{number of completed interviews}}{\text{total sample} - \text{known ineligible sample}} = \frac{806}{(1366 - 119)} = 65\% \text{ response rate}$$

The final study group was 66% male with an average age of 50 years at the time of surgery (Table 1). The minimum followup was 1 year (mean, 2.3 years; range, 1.1–3.9 years).

Five total joint centers were selected to participate in this multicenter, retrospective data collection study. Institutional review board (IRB) approval was obtained for Washington University (St Louis, MO, USA) to serve as the coordinating center. Each participating center obtained approval from its IRB of oversight. All five centers had registries in place that allowed them to produce a list of patients who met inclusion criteria including age, date of surgery, and complete contact information for each patient. Four of the five sites performed both THA and SRA using implant designs by six different manufacturers: Biomet, Inc (Warsaw, IN, USA) (13%); DePuy Orthopaedics Inc, a Johnson & Johnson company (Warsaw, IN, USA) (20%); Smith & Nephew, Inc (Memphis, TN, USA) (20%); Stryker Orthopaedics (Mahwah, NJ, USA) (25%); Wright Medical Technology, Inc (Arlington, TN, USA) (1%); and Zimmer, Inc (Warsaw, IN, USA) (21%). At the fifth site, young, active patients received metal-metal big-head THA with a monoblock acetabular component (M2a-Magnum™, Biomet, Inc). At the other sites, SRA was performed based on patients meeting criteria for SRA [12, 32] with Birmingham Hip™ Replacement (Smith & Nephew, Inc) (n = 119) and Conserve® Plus (Wright Medical Technology, Inc) (n = 5). The indications for SRA were (1) adequate bone stock to support the device, (2) avascular necrosis involving less than 25% of the femoral head, (3) BMI of 35 kg/m² or less, (4) limb length discrepancy of less than 1 cm, (5) absence of large cysts larger than 1 cm, (6) no known metal hypersensitivity or moderate/severe renal insufficiency, (7) relatively normal bony anatomy, and (8) women not of childbearing potential. At three of the four centers

Table 1. Demographics and premorbid UCLA scores

Variable	All patients	Standard-head (≤ 32 mm) THA	Big-head (> 32 mm) THA	SRA	p value
Number of patients	806	359	323	124	
Male (number of patients)	531 (65.9%)	195 (54.3%)	236 (73.1%)	100 (80.6%)	< 0.001
Female (number of patients)	275 (34.1%)	164 (45.7%)	87 (26.9%)	24 (19.4%)	
Age at surgery (years)*	50 (48.9–49.9)	49 (47.8–49.4)	50 (49.5–51)	50 (48.8–51)	0.01
Followup (years)*	2.3 (2.3–2.4)	2.6 (2.5–2.6)	2.3 (2.2–2.4)	1.6 (1.5–1.6)	< 0.001
UCLA score (number of patients)					< 0.001
10	306 (38.0%)	109 (30.5%)	121 (37.5%)	76 (61.3%)	
9	107 (13.3%)	34 (9.5%)	52 (16.1%)	21 (16.9%)	
8	98 (12.2%)	57 (15.9%)	31 (9.6%)	10 (8.1%)	
7	61 (7.6%)	34 (9.5%)	24 (7.4%)	3 (2.4%)	
6	233 (28.9%)	124 (34.6%)	95 (29.4%)	14 (11.3%)	
Score missing [†]	1	1	0	0	

* Values are expressed as mean, with 95% CI in parentheses; [†]the number of respondents who did not answer activity rating scale questions; SRA = surface replacement arthroplasty.

performing SRA, 95% to 100% of patients receiving SRA specifically sought and requested SRA, while at the fourth center, SRA was requested by about 50% of patients. Patients who underwent THA at these four sites either had one of several relative contraindications for SRA or the choice was based on surgeon preference and practice to perform THA unless patients specifically requested SRA.

All patients receiving THA had cementless stems with an advanced bearing surface: ceramic-ceramic (21%), metal-metal (31%), or highly crosslinked polyethylene articulating with femoral heads of cobalt-chromium (21%), ceramic (21%), or OxiniumTM (6%; Smith & Nephew, Inc). Surgical approaches utilized were two incision (4%), anterolateral (33%), direct anterior (5%), posterolateral (54%), and direct lateral (4%). Posterolateral (99%) and direct lateral (1%) approaches were used for patients receiving SRA.

To eliminate observer bias, an independent, blinded third party performed all data collection. The University of Wisconsin Survey Center (UWSC) at the University of Wisconsin–Madison (Madison, WI, USA) was selected for their expertise in collecting health data for state and federal agencies [8, 36] and having no affiliation with any of the participating centers. UWSC worked with the research team at Washington University to design an instrument that would collect a specific series of questions regarding satisfaction, activity level, and symptoms after hip arthroplasty. UWSC staff studied the literature on questionnaire design and suggested what is shown to be the most valid and reliable research methods [17, 28]. A formal review was conducted to design questions using the most valid scales and scale labels. Selected questions were adapted from commonly used orthopaedic scores with demonstrated reliability and validity, including the Hip Disability and Osteoarthritis Outcome

Score [31], the Modified Harris hip score [6, 18], the UCLA Activity Score [2], and the Patient-Specific Index [41]. UWSC programmed the instrument using state-of-the-art computer-assisted telephone interviewing techniques and the leading software, Computer-Assisted Survey Execution System (CASES), developed at the University of California–Berkley (Berkley, CA, USA) for the purpose of conducting scientific research studies. A formal pretest was conducted to review the flow of questions and to fine-tune the interview process to most effectively obtain the required data.

Each center reviewed its joint registry and provided the list of all 1366 patients known to meet eligibility criteria to the coordinating center at Washington University where they were compiled into a master database. The implant details were removed and only the contact information and date and side of surgery were provided to UWSC to ensure an anonymous, blinded administration of the survey. The coordinating center maintained a comprehensive list of implant details to decode by implant type after interviews were complete, before data analysis. Patients received advance notification letters approximately 1 week before they were contacted by the survey center. Interviewers read a telephone script to obtain verbal consent before administering the survey. A screening section ensured participants met inclusion criteria and was also used to collect the premorbid UCLA score (Appendix 1). Participants who passed screening proceeded to answer a series of questions regarding satisfaction and return to activity, employment, and sexual function. Survey methodology and detailed results of the employment questionnaire have been reported previously [33]. This report focuses on those specific questions suggested as potential differences between SRA and THA, including activity level (walking and running), perceived symptoms (thigh pain and limb length discrepancy), and

Table 2. Descriptive statistics of outcomes of interest between SRA and THA

Outcome of interest	Number of patients/respondents (%)			p value
	Standard-head (≤ 32 mm) THA	Big-head (> 32 mm) THA	SRA	
No limp, last 30 days	166/358 (46.4%)	161/322 (50.0%)	87/124 (70.2%)	< 0.001
Able to walk > 1 hour, last 30 days	185/358 (51.7%)	181/321 (56.4%)	84/123 (68.3%)	0.006
Tried to run since surgery	266/359 (74.1%)	224/323 (69.3%)	116/124 (93.6%)	< 0.001
Ran > 1 mile since surgery	24/266 (9.0%)	31/223 (13.9%)	29/116 (25.0%)	< 0.001
Felt difference in leg length	68/358 (19.0%)	69/322 (21.4%)	11/124 (8.9%)	0.008
Felt thigh pain	140/357 (39.2%)	110/323 (34.0%)	24/124 (19.4%)	< 0.001
Experienced grinding/popping or heard clicking, last 30 days	26/358 (7.3%)	34/323 (10.5%)	23/124 (18.5%)	0.002
Participated in preferred activity, last 30 days	158/281 (56.2%)	148/254 (58.3%)	78/109 (71.6%)	0.021

SRA = surface replacement arthroplasty.

return to most preferred activity (Appendix 2). The Patient-Specific Functional Scale (PSFS) [9, 20, 37, 41] was incorporated to determine whether there were recreational or sports activities that patients wanted to participate in but had to limit before surgery because of their hip. Questions regarding symptoms and function had five response categories as described by Likert [25]. The responses were grouped into two categories of “never/rarely” and “sometimes/often/extremely often” for comparison during data analysis, based on the methodology described by Bourne et al. [5]. Missing responses were excluded from the statistical analysis.

Implant types were classified according to bearing surface and head size. For the first round of analysis, we categorized patients into the following five groups: standard-head (≤ 32 mm) THA ($n = 359$), modular metal-metal big-head (> 32 mm) THA ($n = 117$), monoblock metal-metal big-head THA ($n = 90$), non-metal-metal big-head THA ($n = 116$), and SRA ($n = 124$). There were no differences between the big-head THA groups so they were combined, which left us with three groups for final analysis: standard-head (≤ 32 mm) THA (359 patients), big-head (> 32 mm) THA (323 patients), and SRA (124 patients). The SRA group had a higher ($p < 0.001$) percentage of men than both the standard- and big-head THA groups (80.6% versus 54.3% and 73.1%, respectively). The mean age at surgery was lower ($p = 0.01$) in the standard-head THA group (49 years; 95% CI: 47.8–49.4 years) than in the big-head THA group (50 years; 95% CI: 49.5–51 years) and the SRA group (95% CI: 48.8–51). Patients with standard-head THA had the longest ($p < 0.001$) mean followup (2.6 years; 95% CI: 2.5–2.6), followed by big-head THA (2.3 years; 95% CI: 2.2–2.4) and SRA (1.6 years; 95% CI: 1.5–1.6). More ($p < 0.001$) patients with SRA reported a preoperative UCLA score of 9 or 10 (97 patients [78.2%] versus 27 with

UCLA 6–8), compared to patients with big-head THA (173 patients [53.6%] versus 150 with UCLA 6–8) and 40% of the patients with standard-head THA (143 patients [40%] versus 215 with UCLA 6–8) (Table 1).

We used descriptive statistics to present categorical data with frequency and percentage. Multivariate analysis was conducted to examine the outcomes (presence or absence of limp, incidence of thigh pain, incidence of perception of limb length discrepancy, ability to walk continuously for more than 60 minutes, percentage of patients who ran after surgery, distance run, percentage of patients who returned to their most favored recreational activity) among groups, after adjusting for age, sex, and preoperative UCLA scores. If the group effect was significant ($p < 0.05$), we fit the categorical data in logistical regression or generalized estimating equation model to conduct post hoc analysis. Statistical procedures were performed using SAS[®] 9.1 (SAS Institute Inc, Cary, NC, USA).

Results

After adjusting for age, sex, and preoperative activity level, patients with SRA were more likely to report they never limped while walking than both THA groups (Table 2). There was no difference between the big- and standard-head THA groups when reporting limp. Additionally, there was no difference between rates of limp attributable to stem type or surgical approach, just to presence of a stem.

Patients with SRA had a lower incidence of thigh pain than patients with THA. Of the patients who reported they had felt thigh pain since surgery, the THA groups were more likely to have felt thigh pain in the last 30 days than the SRA group. There was no difference between the big- and standard-head THA groups when reporting thigh

pain. Eighty percent of the stems utilized were of the same design category, proximally coated tapered titanium stems, which are generally associated with a low incidence of thigh pain.

The SRA group reported less perception of limb length discrepancy than patients with THA. The big-head THA group was the most likely group to report feeling a difference in limb length, followed by the standard-head THA group and then the SRA group. The big-head THA group was more likely to report the operative side felt longer than the standard-head THA group, while the SRA group reported the operative side felt shorter.

Patients with SRA reported higher levels of activity compared to patients with THA. The SRA group was more likely than either THA group to walk continuously for more than 1 hour, and the standard-head THA group was more likely to walk continuously than the big-head THA group. When patients were asked whether they had tried to run since surgery, even for just a few steps, the SRA group was the most likely group to have tried to run, followed by the standard-head THA group and then the big-head THA group. However, when the patients who had tried to run reported the farthest distance they had run, the SRA group ran the most distance, but the big-head THA group reported running farther than the standard-head THA group. The SRA group, on the other hand, did experience grinding or popping or heard clicking more frequently than the THA groups. When we compared the percentage of patients who returned to their most favored activity after surgery in the SRA and THA groups stratified according to activity level (highly active: premorbid UCLA score = 9 or 10; less active: premorbid UCLA score = 6–8), the high-activity patients were more likely to return to their most favored activity after surgery in the SRA group than in either THA group (Table 3). There was no difference between THA groups or for patients with lower UCLA scores.

When we examined whether there were differences in demographic factors between responders and nonresponders, we found nonresponders were younger than patients who completed the questionnaire (Table 4). Nonresponders were also more likely to have standard-head THA and less likely to have SRA. There were no differences to report based on sex or joint center.

Discussion

There are a number of potential advantages suggested but not proven for SRA over THA, including clinical advantages such as return to higher activity levels and less activity-related thigh pain and fewer complications with postoperative limb length discrepancy and limp (Table 5) [14, 15, 21, 26, 27, 30, 39, 40]. Given the high survivorship

Table 3. Three-group comparison of return to preferred activity stratified by preoperative UCLA activity score

UCLA score	Number of patients participating in preferred activity			p value
	Standard-head (≤ 32 mm) THA (n = 281)	Big-head (> 32 mm) THA (n = 254)	SRA (n = 109)	
6, 7, or 8	100 (64.1%)	66 (62.3%)	14 (73.7%)	0.634
9 or 10	58 (47.5%)	82 (55.4%)	64 (71.1%)	0.003

SRA = surface replacement arthroplasty.

Table 4. Differences between responders and nonresponders

Variable	Responders (n = 806)	Nonresponders (n = 441)	p value
Sex (number of patients)			0.442
Male	531 (66%)	300 (68%)	
Female	275 (34%)	141 (32%)	
Age at surgery (years)*	50 (49–50)	48 (47.1–48.6)	< 0.001
Implant type (number of patients)			0.001
Standard-head THA	359 (45%)	233 (53%)	
Big-head THA	323 (40%)	168 (38%)	
SRA	124 (15%)	40 (9%)	
Participating center (number of patients)			0.065
Center 1	222 (28%)	101 (23%)	
Center 2	190 (24%)	93 (21%)	
Center 3	110 (14%)	74 (17%)	
Center 4	211 (26%)	117 (27%)	
Center 5	73 (9%)	56 (13%)	

* Values are expressed as mean, with 95% CI in parentheses; SRA = surface replacement arthroplasty.

and low complication rate of THA [23], SRA must demonstrate a similar complication rate in addition to some clinical advantage to warrant continued use of this procedure. We designed a study to determine whether there were any perceived advantages by patients after SRA versus THA: (1) less frequent limp, (2) less frequent thigh pain, (3) less limb length discrepancy, or (4) higher activity levels. Specific questions were designed to assess these domains important to patients that may not be addressed in current rating scales. To minimize concerns regarding selection bias, a multicenter study was designed to collect data from a large group of young, active patients whose age and activity level would make them potential SRA or THA candidates. To eliminate observer bias, an independent, blinded third party performed all data collection.

We acknowledge limitations in our study design. First, although data collection was performed in a blinded, unbiased manner, there was still the potential for selection bias in

Table 5. Studies of perceived advantages of SRA over THA

Study	Country	Number of subjects (by sex)	Age (years)*	Surgical procedure	Followup (years)*	Limp	Thigh pain	Leg length discrepancy	Return to activity
Fowble et al. [14]	USA	85 (58% male)	47 (27–75)	THA (n = 35) SRA (n = 50)	2.0–4.2				Higher pre- and postoperative UCLA scores reported for SRA group
Girard et al. [15]	Canada	104 (63% male)	47 (25–64)	THA (n = 55) SRA (n = 49)				Radiographic evaluation showed no difference in preoperative leg length inequality between THA and SRA groups Leg-length inequality was restored within $SD \pm 4$ mm in 86% of SRA group and 60% of THA group	
Mancuso et al. [26]	USA	405 (42% male)	66 (28–88)	THA	4.4 (3–6)	31% of patients had a residual limp			95% of patients cited improved ability to exercise and play sports as a preoperative expectation, and 78% of these patients reported that expectation was fulfilled postoperatively
Mont et al. [30]	USA	108 (67% male)	55 (35–79)	THA (n = 54) SRA (n = 54)	3.3 (2.0–5)				Higher postoperative activity score in SRA group
Vail et al. [39]	USA	136 (47% male)	52 (17–92)	THA (n = 84) SRA (n = 52)	2.95 (2–4)				Higher postoperative activity score in SRA group

Table 5. continued

Study	Country	Number of subjects (by sex)	Age (years)*	Surgical procedure	Followup (years)*	Limp	Thigh pain	Leg length discrepancy	Return to activity
Vendittoli et al. [40]	Canada	191 (65% male)	50 (18–65)	THA (103 hips) SRA (107 hips)	1		No difference in thigh pain between THA and SRA groups 1 year post-operatively	Radiographic evaluation showed less leg length discrepancy in SRA group postoperatively	Higher postoperative UCLA score in SRA group and greater percentage returned to higher level activity 1 year postoperatively
Current study	USA	806 (66% male)	50 (19–60)	Standard-head THA (n = 359) Big-head THA (n = 117) SRA (n = 124)	2.3 (1.1–3.9)	SRA group more likely to report complete absence of any limp than THA groups	SRA group reported lower incidence of thigh pain than THA groups	SRA group reported less perception of limb length discrepancy than THA groups	SRA group reported higher levels of activity than THA groups

* Values are expressed as mean, with range in parentheses; SRA = surface replacement arthroplasty.

the patients receiving SRA. The vast majority of patients receiving SRA requested SRA, which may introduce a subtle bias we cannot account for, as patients requesting a new procedure may be more prone to give a positive response. This was a retrospective study and patient selection was not agreed on ahead of time. Patients with SRA were also more likely to respond, which might introduce a bias in favor of SRA because responders may be more likely to have better outcomes compared to nonresponders. We tried to overcome this with a large sample size and specifically questioning patients regarding their activity level before they were limited by their SRA. We also limited the sample to patients younger than 60 years who were at a high activity level before being limited by their hip symptoms. The higher activity level obtained by the patients with SRA, including running and returning to very high levels successfully, are the domains that are probably most prone to selection bias. The improved ability to walk and absence of limp or thigh pain, however, are much less likely to be prone to selection bias and appear to be a likely advantage of SRA over THA. Second, this was a retrospective study of patients who were at least 1 year postoperative, which introduced the potential for recall bias. We limited the date range for inclusion in an attempt to minimize this concern. Third, the telephone questionnaire was a novel development and therefore was not formally validated. However, these questions were based on standard hip assessments commonly reported in the literature [2, 6, 18, 31, 41], some of which have not been formally validated. The questions were tested on a sample population, and the telephone algorithm was developed by professionals in healthcare data collection [8, 36]. Finally, we did not collect the number of patients excluded from each center before the survey for known complications, and we did not collect data from patients found during the screening section of the questionnaire to have had complications. While there are numerous reported complications with SRA, a learning curve has been described for SRA. Previous studies have reported, among hip specialists, the early results were much better compared to the general population of surgeons and the short-term complication rate was very low [12, 34]. Therefore, our results may be specific to our group of hip specialists who almost all used the Birmingham Hip™ SRA implant, which provides the best results in the Australian Joint Registry [3].

Our observations indicate patients do perceive objective advantages of SRA over THA in some domains. Patients with SRA reported less limp while walking. Mancuso et al. [26] noted absence of postoperative limp was among the most important predictors of patient satisfaction after hip arthroplasty.

The SRA group also reported a lower incidence of thigh pain. The responses to the questions of limp and thigh pain would not be expected to be prone to selection bias and seem

far more likely to be the result of the presence of a cementless femoral stem in a THA but not in an SRA. The stem could explain the substantial difference in the presence of thigh pain in patients with THA compared to those with SRA.

A perceived limb length discrepancy was more common after THA than after SRA. This has been suggested as an advantage of SRA; however, this, to our knowledge, has not been quantified in the past. While we did not have radiographs to objectively measure the relative limb length, the perception of limb length discrepancy is more important to the patient than the radiographic appearance and patients with SRA did perceive absence of a limb length discrepancy a higher percentage of the time compared to patients with THA. Another bias favoring patients with SRA, however, is SRA is relatively contraindicated in patients with limb length discrepancy of greater than 1 cm [32] so patients with SRA are preselected to be less likely to have a limb length discrepancy.

Patients with SRA were more likely to run greater than a mile, to try to run, or to run for exercise than the patients with either big- or standard-head THA. Despite the large sample size, this result could be prone to selection bias in that patients that seek SRA may be more motivated to run postoperatively and may be given fewer restrictions by their surgeon regarding impact activities. A recent large survey of total joint specialists indicated 71% instructed their patients with THA not to jog or participate in other high-impact activities [38]. There were, however, additional apparent advantages related to SRA compared to THA. Patients reported a higher incidence of being able to walk for more than an hour and to walk for 30 minutes continuously. Young, active patients often have a specific activity with which they have difficulty, which is a primary motivating factor for them to seek surgical intervention. A number of studies have centered around identifying activities important to patients considering reconstructive surgery. This concept has been quantified in the PSFS [9, 20, 37, 41]. We incorporated this concept into our study and discovered patients with SRA did, indeed, have a higher rate of success in returning to their most favored activity, but only those at the highest activity levels (premorbid UCLA score of 9 and 10), which involves running or cutting sports. Of note, more than 70% of American arthroplasty surgeons prohibit or strongly discourage their patients from such activities [38]. This could be a factor in a substantially higher percentage of patients with SRA returning to the higher activity level. Patients who did not run for exercise in the last 30 days were questioned as to why they did not run and only 33.3% indicated it was because of their surgeon's recommendation. Of the remainder, the most common reason for not running was because they preferred another type of exercise.

Patients with SRA did have a higher incidence of noise generation (18.5%) compared to standard-head or big-head THA (7.3% and 10.5%, respectively). One previous report

indicated this is normally transient and not related to patient satisfaction or clinical results [13]. It is nevertheless a potential source of concern and warrants further study.

In conclusion, our study of more than 800 patients with arthroplasty from five total joint centers provides some objective evidence of probable advantages for SRA over THA. In the short term, once a patient has recovered past 1 year, our patients with SRA perceived advantages in terms of less frequent limp and less thigh pain. There is also evidence that patients return to a higher activity level and are able to return to running and cutting sports at a higher rate after SRA and are less likely to notice a limb length discrepancy; however, these advantages may be more prone to selection bias. Our findings may be specific to the surgeons and the implants utilized and might not be generalizable to all SRA performed by total joint centers. Furthermore, the observational nature of this study and the uncontrolled risk of bias factors should be considered when interpreting the findings. High-volume surgeons reportedly have a lower complication rate with SRA [34]. Although high revision rates after SRA have led to product recalls, problems with recalled devices were largely technique-related, and none of the SRA devices utilized in our study have been the subject of a recall. These findings may not represent the literature, as our data suggest, in the hands of experienced surgeons using the best implants, there is a higher likelihood that patients would perceive objectively better results. The advantages of SRA we found warrant continued utilization and examination of SRA in selected patients.

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Appendix 1: Screening Section: Premorbid UCLA Score

1. In the year before your (left/right) hip became painful, did you ever participate in impact sports such as jogging, tennis, skiing, acrobatics, ballet, heavy labor, or backpacking?
Yes = Go to Question 2
No = Go to Question 3
2. In the year before your (left/right) hip became painful, did you participate in impact sports less than once per week or at least once per week?
At least once per week = UCLA 10
Less than once per week = UCLA 9
No = Go to Question 3

3. In the year before your (left/right) hip became painful, did you participate in very active events, such as golf or bowling, at least once per week?
Yes = UCLA 8
No = Go to Question 4
4. In the year before your (left/right) hip became painful, did you participate in active events, such as bicycling, at least once per week?
Yes = UCLA 7
No = Go to Question 5
5. In the year before your (left/right) hip became painful, did you participate in moderate activities, such as swimming, unlimited housework, or shopping, at least once per week?
Yes = UCLA 6
No = End survey

Appendix 2: Questions Suggested as Potential Differences Between Surface Replacement Arthroplasty and THA

1. In the last 30 days, how often have you limped while walking?
Never, rarely, sometimes, very often, or extremely often
2. In the last 30 days, how long have you been able to walk continuously?
0 to 15 minutes, 16 to 30 minutes, 31 to 60 minutes, 61 minutes to 2 hours, or more than 2 hours
3. Since your hip was operated on, have you tried to run, even for just a few steps?
 - If “yes”: Since your hip operation, what is the farthest distance you have run?
A few steps only, more than a few steps up to a quarter of a mile, more than a quarter of a mile up to 1 mile, more than 1 mile up to 5 miles, or more than 5 miles
4. Do you ever feel a difference in the length of your legs?
 - If “yes”: Does the length of the leg on your (left/right) side where you had your hip operation feel longer or shorter than your other leg?
5. Do you ever feel pain in your (left/right) thigh on the side where you had your hip operation?
 - If “yes”: In the last 30 days, about how often did you experience pain in your (left/right) thigh?
Never, rarely, sometimes, very often, or extremely often
6. In the last 30 days, about how often did you experience grinding or popping or hear clicking or other noises in your (left/right) hip?
Never, rarely, sometimes, often, or extremely often
7. During the last 30 days, how often did you do/play/etc Activity 1 (most preferred activity)?

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