Hemiarthroplasty Versus Total Shoulder Arthroplasty for Shoulder Osteoarthritis

A Matched Comparison of Return to Sports

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Background: Return to activity is a commonly used indication for shoulder hemiarthroplasty (HA) compared with total shoulder arthroplasty (TSA). Despite clinical studies demonstrating better functional outcomes after TSA, the literature has failed to show a difference in return to sports.

Purpose: To compare rates of return to sports in a matched cohort of TSA and HA patients with a preoperative diagnosis of glenohumeral osteoarthritis (OA).

Study Design: Cohort study; Level of evidence, 3.

Methods: A prospectively collected registry was queried retrospectively for consecutive patients who underwent HA. Inclusion criteria were preoperative diagnosis of OA and more than 2 years of follow-up. After meeting the inclusion criteria, all HA patients were statistically matched to a TSA patient. All patients had end-stage OA with significant glenohumeral joint space narrowing.

Results: At final follow-up, 40 HA patients and 40 TSA patients were available. The average (±SD) age at surgery was 65.7 ± 10.5 years and 66.2 ± 9.6 years for the HA and TSA groups, respectively (P = .06). Average follow-up was 62.0 months and 61.1 months for the HA and TSA groups, respectively (P = .52). Average American Shoulder and Elbow Surgeons scores improved from 36.3 to 70.2 for HA patients and from 34.0 to 78.5 for TSA patients ($P < .001$ for both); final scores were not significantly different between groups (P = .21). Average visual analog scale pain scores improved from 6.3 to 2.2 for HA patients and from 6.1 to 0.6 for TSA patients ($P < .001$ for both). HA patients had significantly worse final visual analog scale scores compared with the TSA group (P = .002). Significantly more TSA patients were satisfied with their surgery compared with HA patients (100% vs 70%) (P = .01). Of both groups, 65.5% of HA patients (19 of 29) returned to at least 1 sport postoperatively compared with 97.3% of TSA patients (36 of 37) ($P < .001$). Average timing for return to full sports was 5.5 ± 4.2 months and 5.4 ± 3.1 months for the HA and TSA groups, respectively (P = .92). Significantly more TSA patients returned to higher upper extremity use sports (P = .01).

Conclusion: In patients with OA, rate of return to sports was significantly better after TSA compared with HA. HA patients had significantly more pain, worse surgical satisfaction, and decreased ability to return to high upper extremity use sports. For patients with OA who wish to return to sporting activities, these results help manage expectations.

Keywords: hemiarthroplasty; osteoarthritis; total shoulder arthroplasty; sports

The main goal of shoulder arthroplasty is to improve function, pain, and quality of life. With the evolution of prostheses, expectations from patients are increasing in terms of longevity and return to daily activities. This demand is coupled with the exponential rise of hemiarthroplasties (HAs) and total shoulder arthroplasties (TSAs) performed each year.[15] As more active patients become operative candidates through expanding indications, athletic expectations must be taken into account.

In patients with osteoarthritis (OA), there continues to be debate over whether TSA or HA should be used. Proponents of HA argue that the procedure has shorter operative times, lower cost, and less demanding technical aspects.[10,16,17] Opposition to TSA in young active patients

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results from concerns regarding implant longevity and glenoid loosening.[25] Although glenoid failure after TSA does occur, the need for glenoid resurfacing after HA has been reported at even higher rates.[26] More recent higher level studies have determined that TSA is superior to HA for treatment of primary glenohumeral OA in terms of pain relief, function, range of motion, and patient satisfaction.[2,7,26] Despite these results, HA continues to be a common procedure performed by recent orthopaedic residency graduates.[19]

This hesitancy to perform TSA in athletic patients is best demonstrated from studies surveying shoulder specialists on sports allowed after either TSA or HA. Golant et al[11] reported that HA patients were allowed to return to a higher number of sports than TSA patients. Magnussen et al[18] found higher intensity of sport allowed after HA compared with TSA. In these studies, surgeons limited sporting activities because of concern for glenoid loosening. Even with strong evidence of functional benefits of TSA, return to athletics continues to be cited as a reason to perform a HA in patients with OA.

In the most recent Cochrane review on this topic, Singh et al[28] found only a functional improvement in TSA over HA for OA but stated that “no other clinical benefits were found.” This may be because older activity-related studies have failed to find any difference in return to sports between these groups. Zarkadas et al[31] evaluated 99 patients, comparing TSA and HA for postoperative activities. They reported no difference in pain or activity level between groups. Another study by McCarty et al[20] evaluated 21 HA procedures and reported an 81% rate of return to physical activities. Minimal comparative analysis was done, but the authors reported no significant difference in return to sports. In addition, both studies used mixed diagnoses without subgroup analysis. Given the small of number of patients with OA studied and limited data on rates of return to athletics, further study is needed.

This study aimed to compare (1) rates of return to sports after HA and TSA and (2) functional and pain scores after HA and TSA for glenohumeral OA. We hypothesized that overall rate of return to sports will be significantly higher after TSA, with these patients having better function and pain scores.

METHODS

We conducted a retrospective review of patients collected by our prospectively collected shoulder arthroplasty registry. After institutional review board approval was obtained, the registry was queried for patients who underwent HA from 2000 to 2013. Inclusion criteria were a preoperative diagnosis of OA and a minimum of 2 years of follow-up. Exclusion criteria were any other preoperative diagnosis, previous shoulder arthroplasty before the patient’s studied procedure, and less than 2 years of follow-up. All patients had end-stage OA with significant glenohumeral joint space narrowing and osteophyte formation. After meeting the final inclusion criteria, all remaining HA patients were matched to a TSA patient by preoperative diagnosis, age (±5 years), sex, body mass index (BMI), dominant extremity, and follow-up period (±6 months). All patients in the cohort received a Biomet Comprehensive HA or Biomet Comprehensive TSA. All procedures were performed in a similar fashion. All TSAs and HAs were performed through a deltopectoral approach.

Study personnel contacted patients and administered the questionnaire by telephone. In addition to 1 mailed survey, 4 telephone attempts were made to reach patients. If patients failed to respond, they were considered lost to follow-up. Data from the prospective registry included preoperative American Shoulder and Elbow Surgeons (ASES) scores and visual analog scale (VAS) pain scores.

A total of 105 consecutive HA patients were screened; 45 HA patients met the final inclusion criteria and 45 TSA patients were matched to these individuals. Three patients were lost to follow-up and 2 from each group declined to participate (12%). Forty patients in each group were available at final follow-up. Three TSA patients (7.5%) and 11 HA patients (27.5%) were not included in the analysis of the return-to-sports questions because they did not participate in any sports preoperatively.

Initial preoperative diagnoses, BMI, age, medical comorbidities, and operative complications were obtained from patient records. All of these parameters were confirmed with patients during questioning. The questionnaire included sport-related questions and has previously been used in the literature (see the Appendix, available online at http://ajsm.sagepub.com/supplemental).[8,9] Objective outcomes including postoperative stiffness and instability were determined based on patient responses. For fitness sports, this was based on a similar categorization by Wylde et al[30] and Naal et al.[23] Fitness sports were defined as lightweight training or resistance bands and gym attendance greater than 2 hours per week. Nature sports were defined as biweekly participation in at least 1 of the following activities: hunting, fishing, shooting, boating, and/or horseback riding. These sports were all identified by the authors as being low-demand activities with low upper extremity use, similarly to other studies.[3,13] Given the similarity of these activities, the authors inferred that, when combined, these sports encompass the exercise intensity and shoulder involvement experienced by the typical outdoor sportsman/sportswoman engaging in nature sports. Previous definitions in the orthopaedic literature were used to assign demand level for each sport.[8,31] To further define disability from an upper extremity arthroplasty, sports were also categorized by high or low upper extremity usage (Table 1).[8] To prevent any overestimation of rates of return by patients starting a new sport postoperatively, direct rates of return were calculated. Only patients who participated in sports preoperatively were used in the calculation of rates of return. Overall, return to sport and level of sport were determined based on the questionnaire.

Statistical Analysis

A post hoc power analysis was performed with the primary outcome of return to sport and 40 patients in each group

TABLE 1
Demand Categorization by Sport

Category	Sport
Demand level	
Low	Golf, bowling, swimming, fitness sports, nature sports
Medium	Rowing, cycling, cross-country skiing, doubles tennis, softball, downhill skiing, baseball, flag football
High	Running, basketball, singles tennis
Amount of upper extremity use	
Low	Cycling, dancing, downhill skiing, fitness sports, nature sports, running
High	Basketball, baseball, bowling, doubles and singles tennis, rowing, softball, swimming, cross-country skiing, golf

achieved appropriate power using G*Power set at 0.95. Because this was a post hoc analysis, no expected variance and magnitude of difference was used to calculate power. Matching was performed using a SAS macro developed by Bergstralh et al,[1] which implements a greedy matching algorithm. This method calculates a distance between every case and every control (D_{ij}) as a weighted sum of the absolute differences between cases and controls for selected matching variables. After the cases and controls are randomly sorted, the first case is matched with the closest control based on D_{ij}. This process continues for each case and is repeated until the desired number of controls has been matched to every case. For this study, 1 control was matched to each case on the variables age (±5 years), sex (exact), and follow-up period (±6 months), and they all had the same weight. Paired *t* tests were used to compare the 2 study populations for continuous variables, and chi-square/Fisher exact tests were used to compare categorical variables. Changes in patient-reported outcome measures were also assessed using paired-samples *t* tests. Tests were conducted using 2-sided hypothesis testing with statistical significance set at $P \leq .05$ (SPSS, version 19.0; IBM Corp).

RESULTS

Demographics

Forty HA patients and 40 TSA patients were available at final follow-up. Average age at surgery was 65.7 years (range, 42.7-87.7 years) and 66.2 years (range, 47.7-87.6 years) for the HA and TSA groups, respectively ($P = .06$). Average follow-up was 62.0 months (range, 24.6-90.2 months) and 61.1 months (range, 24.1-89.9 months) for the HA and TSA groups, respectively ($P = .52$). There was an equal ratio of men to women in both groups (17 men and 23 women). Average BMI was 28.9 ± 6.6 and 28.7 ± 5.9 for the HA and TSA groups, respectively ($P = .89$). The dominant extremity was involved in 65.0% of participants (26 of 40) in both groups ($P > .99$) (Table 2). In addition, 42.5% of HA patients (n = 17) and 32.5% of TSA patients (n = 13) had surgery on their opposite shoulder ($P = .49$). There was no statistical difference between groups with regard to comorbidities. Seventy percent of HA patients (n =28) noted postoperative problems with their shoulder compared with 15% of TSA patients (n = 6) ($P < .001$). The most common complaints were chronic pain and stiffness: 50% of HA patients (n = 20) and 2.5% of TSA patients (n = 1) complained of chronic pain ($P < .001$), whereas 32.5% of HA patients (n = 13) and 12.5% of TSA patients (n = 5) described stiffness in their shoulder ($P = .06$).

TABLE 2
Patient Demographics[a]

	HA Group (n = 40)	TSA Group (n = 40)	*P* Value
Average age, y	65.7	66.3	.06
Average follow-up, mo	62	61.1	.52
Male/female sex, n	17/23	17/23	>.99
Average body mass index, kg/m^2	28.9	28.7	.89
Dominant extremity, %	65	65	>.99

[a]There were no statistically significant differences between groups by demographic factors. HA, hemiarthroplasty; TSA, total shoulder arthroplasty.

At final follow-up, 4 patients in the HA group (10%) underwent revision surgery at an average of 4.8 years (range, 3.4-7.7 years). Two patients underwent conversion to TSA for glenoid arthritis and 2 underwent conversion to reverse TSA (1 for glenoid arthritis and 1 for recurrent dislocation). The rate of revision for glenoid arthritis was 7.5% (3 of 40) in the HA group. Two patients in the TSA group underwent revision surgery at an average of 5.2 years (range, 3.8-7.2 years). One patient underwent revision TSA for recurrent dislocation, and 1 underwent reverse TSA for pain and stiffness. All patients played sports preoperatively and returned to their sports postoperatively. No patients in the TSA group underwent revision surgery for glenoid loosening, and there were no infections in either group.

Outcome Scores

Average ASES scores improved from 36.3 to 70.2 and from 34.0 to 78.5 for the HA and TSA groups, respectively ($P < .001$ for both). Final ASES scores were not significantly different between groups ($P = .12$). Average VAS scores improved from 6.3 to 2.2 and from 6.1 to 0.6 for the HA and TSA groups, respectively ($P < .001$ for both). HA patients had significantly worse final VAS scores compared with TSA patients ($P = .002$). With regard to the instability portion of the ASES (1-10), HA patients complained of significantly more instability ($P < .001$); 70% of HA patients (n = 28) and 100% of TSA patients (n = 40) were satisfied to very satisfied with their surgery ($P = .01$) (Table 3).

Sports Outcomes

Compared with 97.3% of TSA patients (36 of 37), 65.5% of HA patients (19 of 29) returned to at least 1 sport postoperatively ($P < .001$). Average timing for return to full sports was

TABLE 3
Outcome Scores[a]

Outcome Measure	HA Group (n = 40)	TSA Group (n = 40)	P Value
Postoperative ASES score	70.2 ± 23.7	78.5 ± 26.8	.12
Postoperative VAS score	2.2 ± 2.9	0.6 ± 1.0	.002
Postoperative instability	1.6 ± 1.6	0.2 ± 0.9	<.001
Satisfaction with surgery, % good to excellent	70	100	.01
Satisfaction with sports, % good to excellent	58.6	94.5	<.001

[a]Data are presented as averages ± SD unless otherwise indicated. TSA patients did significantly better in all categories except postoperative ASES score. ASES, Average American Shoulder and Elbow Surgeons; HA, hemiarthroplasty; TSA, total shoulder arthroplasty; VAS, visual analog scale.

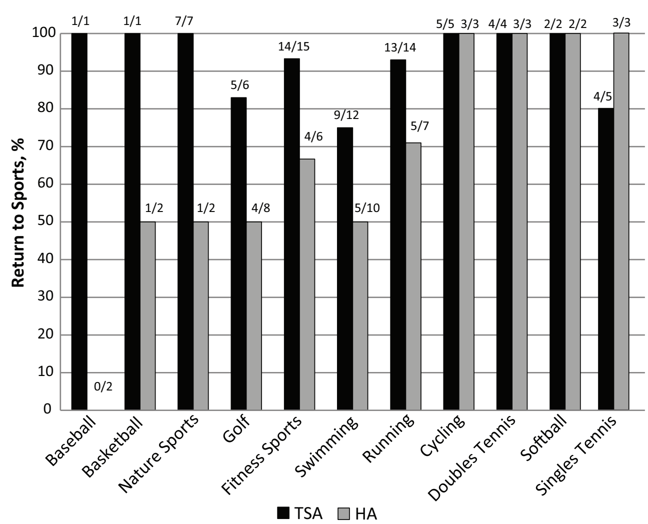

Figure 1. Comparison of return to sports in TSA and HA patients by individual sports. Individual participation is listed above each bar. HA, hemiarthroplasty; TSA, total shoulder arthroplasty.

5.5 ± 4.2 months and 5.4 ± 3.1 months for the HA and TSA groups, respectively (*P* = .92). Average weekly participation in sports was 2.9 hours and 3.1 hours for the HA and TSA groups, respectively (*P* = .53). One patient in the TSA group stopped playing sports because of pain, compared with 10 patients in the HA group who stopped playing sports because of the surgery (n = 5), pain (n = 3), or lack of interest (n = 2).

For the HA group, direct rates of return were available for doubles tennis (3 of 3; 100%), softball (2 of 2; 100%), singles tennis (3 of 3; 100%), cycling (3 of 3; 100%), running (5 of 7; 71.4%), fitness sports (4 of 6; 66.7%), nature sports (1 of 2; 50%), swimming (5 of 10; 50%), golf (4 of 8; 50%), basketball (1 of 2; 50%), bowling (0 of 0; 0%), and baseball (0 of 2; 0%). No HA patients participated in downhill skiing or yoga. For the TSA group, direct rates of return were available for cycling (5 of 5; 100%), doubles tennis (4 of 4; 100%), softball (2 of 2; 100%), basketball (1 of 1; 100%), baseball (1 of 1; 100%), nature sports (7 of 7; 100%), fitness sports (14 of 15; 93.3%), running (13 of 14; 92.9%), singles tennis (4 of 5; 80%), golf (5 of 6; 83.3%), swimming (9 of 12; 75%), downhill skiing (1 of 2; 50%), and yoga (1 of 3; 33%). No TSA patients participated in bowling (Figure 1).

There was a significant difference in return to low-demand sports, with 56.5% of HA patients (12 of 23) and 96.4% of TSA patients (27 of 28) returning (*P* = .001); 66.6% of HA patients (6 of 9) and 100% of TSA patients (9 of 9) returned to medium-demand sports (*P* = .20), and 62.5% of HA patients (5 of 8) and 88.8% of TSA patients (16 of 18) returned to high-demand sports (*P* = .28). For the highest demand level postoperatively, 10 HA and 11 TSA patients achieved low demand, 3 HA and 5 TSA patients achieved medium demand, and 6 HA and 20 TSA patients achieved high demand.

For low upper extremity use sports, 73.3% of HA patients (11 of 15) and 95.0% of TSA patients (19 of 20) returned (*P* = .14). Significantly more TSA patients (20 of 23; 87.0%) than HA patients (9 of 19; 47.3%) returned to higher upper extremity use sports (*P* = .01) (Table 4).

Finally, 67.5% of HA patients (27 of 40) and 85.0% of TSA patients (34 of 40) stated that their physical fitness was the same or improved after surgery (*P* = .11). For patients who had surgery on the opposite side, 100% of TSA patients (9 of 9) returned to sports, compared with 50% of HA patients (5 of 10) (*P* = .03). Significantly more TSA patients (94.4%; 34 of 36) were satisfied with their ability to play sports after surgery compared with HA patients (57.9%; 11 of 19) ($P < .001$). In addition, significantly more HA patients (45%) felt hindered from doing sports because of their shoulder replacement compared with TSA patients (12.5%) (*P* = .003).

DISCUSSION

In patients with glenohumeral arthritis, return to sports was significantly better after TSA (97.3%) compared with HA (65.5%). In addition, HA patients had significantly worse pain and satisfaction at final follow-up. HA patients also had a trend toward functionally worse ASES scores, although this failed to reach statistical significance. Although it continues to be debated, studies have found significantly worse pain scores, functional differences, and range of motion after HA compared with TSA.[2,7,26] Even with this literature, there are currently no reports of better return to sports after TSA.[20,31] In fact, the patient's desire to return to sporting activities is often cited as an indication to perform a HA over a TSA. This arose from concerns regarding eventual glenoid loosening after TSA. However, to our knowledge, few studies have actually investigated the relative effectiveness of these procedures in achieving the patient's sporting goals in the first place.

Even with a number of studies investigating comparative outcomes of TSA and HA, our investigation has many unique findings. Our results demonstrate a significantly higher rate of return to any sport after TSA. Overall, our 97.3% rate of return to sports after TSA is similar to other previous studies reporting 75% to 100%.[3,14,20] Only 1 study reported HA rates of return to sports at 67.5%, which is comparable with our rate of 65.5%. [8] To our knowledge, ours is the first study to

TABLE 4
Rate of Return for Demand and Upper Extremity Use by Age Group[a]

Age Group, y	Rate of Return				
	Low Demand	Medium Demand	High Demand	Low UE Use	High UE Use
TSA					
<50	2/2 (100)	1/1 (100)	3/3 (100)	2/2 (100)	4/4 (100)
50-60	6/6 (100)	3/3 (100)	3/3 (100)	7/7 (100)	5/5 (100)
60-70	19/27 (70.4)	6/8 (75)	10/11 (90.9)	19/24 (79.2)	16/22 (72.7)
≥70	7/8 (87.5)	2/2 (100)	2/3 (66.7)	6/6 (100)	5/7 (71.4)
HA					
<50	2/3 (66.7)	2/2 (100)	1/1 (100)	2/2 (100)	3/4 (75)
50-60	4/8 (50)	3/5 (60)	5/6 (83.3)	4/5 (80)	8/14 (57.1)
60-70	7/16 (43.8)	5/5 (100)	3/5 (60)	6/10 (60)	9/16 (56.3)
≥70	1/2 (50)	None	None	1/1 (100)	0/1 (0)

[a]Individual rates of return are listed by both demand level and intensity of UE use. Values are reported as n/total for age group (%). HA, hemiarthroplasty; TSA, total shoulder arthroplasty; UE, upper extremity.

demonstrate significantly better rates of return to any sport after TSA compared with HA.[20,31]

Further analysis by demand level showed that significantly more TSA patients returned to lower demand sports, but there was also a trend toward significance in both the medium- and high-demand groups. These findings are comparable to those of Zarkadas et al,[31] who demonstrated a similar trend for all levels of demand, although they did not find any significant differences. Grouping by demand in shoulder arthroplasty has less significance than in studies of the lower extremity.[4,21,23] For example, in this study, running is considered to have high demand but low upper extremity use. Without using upper extremity use, bias may be given to TSA. As a result, we further categorized sports by upper extremity use, similar to studies by Garcia et al.[8] We found significantly more TSA patients returned to higher upper extremity use sports than HA patients. Excellent return to higher upper extremity use is valuable information because this demonstrates TSA's ability to return athletic patients to their presymptomatic function.

In addition to return to sports outcomes, our functional and symptom results are worthy of further discussion. HA patients had significantly worse VAS scores than their matched TSA counterparts. Furthermore, a significantly higher number of HA patients complained of chronic pain. These findings are similar to those of previous reports.[2,24,27] In addition, we found a trend toward improved functional ASES scores in TSA patients (an 8.7-point difference from HA patients). In a meta-analysis, Singh et al[28] found significantly higher ASES scores (a 10.5-point difference) in OA patients with TSA compared with HA. Similar to our results, Lo et al[17] found a trend but no significant difference in their randomized control trial between HA and TSA groups, with an overall difference of 9.0 points on ASES scores between groups. Finally, TSA patients in our study had significantly higher surgical satisfaction. These results are similar to those of Radnay et al,[26] who reported that significantly more TSA patients (96.7%) were satisfied with their surgery compared with HA patients (80.4%). Overall, the functional and satisfaction outcomes of this study further emphasize the benefit of TSA at midterm follow-up.

Given previous studies favoring TSA compared with HA, one might expect higher activity use allowed after TSA. Recent surveys of expert shoulder surgeons indicate that higher demand and upper extremity use sports are more acceptable in HA patients compared with TSA patients.[12,18] In a recent survey of ASES members, Golant et al[11] reported that 87% of surgeons allowed return to sports for HA patients compared with 76.5% for TSA patients. Regarding contact sports, only 45.4% of surgeons allowed participation after TSA compared with 64.9% after HA. Some of these results may be attributable to continued concern for longevity of the TSA prosthesis or previous indications for HA in young active patients.[25] This is despite long-term HA data on young athletic patients demonstrating poor results.[6,29] In addition, Day et al[5] reported excellent longevity with TSA at 87% survival after 15 years. Given these results and the current literature available, we recommend TSA in active patients, although further evaluation is needed with regard to glenoid loosening.

An additional reason for surgeons' preference for HA with regard to sports may be the lack of significant findings between groups. To date, only 2 studies have evaluated return to athletic activities comparing HA and TSA. Zarkadas et al[31] evaluated 47 HA and 52 TSA patients and found no difference in pain or activity participation between groups. In addition, no rates of return to sports could be calculated because no preoperative sports evaluation was done. Another study by McCarty et al[20] evaluated 21 HA and 54 TSA patients, with a combined 81% rate of return to sports. The authors reported no difference in the rate of return to sports between procedures. Aside from this single calculation, no further analysis between HA and TSA was reported. To our knowledge, our study is the first to demonstrate a significant difference in return to sports after TSA compared with HA.

One of the main limitations of this study is the retrospective collection of data, in addition to the concern for recall bias. Ideally, a prospective comparative study would have improved the strength of our results. To prevent recall bias, patient responses were cross-referenced with their original records. Furthermore, the results of this study are more subjective rather than objective, given the use of a telephone questionnaire, and should be interpreted as such. An additional limitation is the lack of review of postoperative radiographs, which may have given us further insight into glenoid loosening in these patients. Without review of radiographs, we cannot comment on wear rates with increasing activity. Because our TSA cohort had less than 5 years of follow-up, there may be glenoid wear or loosening without clinical indications for revision. To this point, comparative data from Radnay et al[26] showed that revision after total shoulder replacement for glenoid loosening was much lower than the need for glenoid resurfacing for arthritis after HA. Individual motivation to return to sports may also vary; as such, a different cohort of patients may have had different results. Finally, we did not investigate range of motion, which may have given further insight into functional impairment, although these data have not been utilized in previous shoulder arthroplasty sport studies.[3,20,22] In addition, this would not likely have added to the distinctiveness of the current investigation because multiple studies have demonstrated improved range of motion after TSA compared with HA.[2,9,26,31] Although this study has limitations, the data presented are crucial to the physician with an active patient who is a surgical candidate for a shoulder arthroplasty.

CONCLUSION

In this short-term follow-up study, rate of return to sports was significantly better after TSA, although further studies are needed to review glenoid loosening. In addition, HA patients had significantly more pain, worse satisfaction, and a decreased ability to return to high upper extremity use sports. For active patients with OA who wish to return to sporting activities, this study demonstrates superiority of anatomic total shoulder replacement.

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