J Shoulder Elbow Surg (2022) 31, S94–S102

ELSEVIER

Journal of Shoulder and Elbow Surgery

www.elsevier.com/locate/ymse

Reverse shoulder arthroplasty yields similar results to anatomic total shoulder arthroplasty for the treatment of humeral head avascular necrosis

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Background: Avascular necrosis (AVN) of the humeral head frequently results in humeral head collapse and end-stage arthritic changes of the glenohumeral joint. Despite the recent proliferation of reverse total shoulder arthroplasty (RTSA), reports on the use of RTSA for AVN remain limited. The purpose of this study was to document the outcomes of shoulders indicated for RTSA in the setting of humeral head AVN and compare these with AVN shoulders indicated for the gold standard, anatomic total shoulder arthroplasty (aTSA).

Methods: A retrospective review of a multinational shoulder arthroplasty database was performed between August 2005 and August 2017. All shoulders with a preoperative diagnosis of AVN (aTSA in 52 and RTSA in 67) were reviewed. The shoulders in the RTSA cohort were matched (1:1) to shoulders with cuff tear arthropathy, whereas the shoulders in the aTSA cohort were matched (1:1) to shoulders with primary osteoarthritis. The mean follow-up period was 47 months (range, 24-130 months) for RTSA and 54 months (range, 24-124 months) for aTSA. Shoulders were evaluated for active range of motion (ROM) and patient-reported outcome measures (PROMs) prior to surgery and at latest follow-up. Patients treated with RTSA were compared with both the aTSA study cohort and the control group using the Student t test or χ^2 test as indicated.

Results: RTSAs performed for AVN demonstrated significant improvements in all ROMs and PROMs. Patients undergoing aTSA for AVN were significantly younger than those undergoing RTSA (59 years vs. 73 years, $P < .001$). At similar follow-up points, the RTSA cohort demonstrated significantly greater improvement in abduction (+51° vs. +32°, $P = .03$) whereas the aTSA cohort demonstrated significantly greater improvement in internal rotation. Postoperative University of California, Los Angeles scores (30 vs. 27, $P = .014$) and visual analog scale scores (1.4 vs. 2.4, $P = .025$) were better after RTSA; however, these differences between prosthesis types did

The WCG Institutional Review Board approved this study (tracking no. 20091701).

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https://doi.org/10.1016/j.jse.2021.11.011

not exceed the minimal clinically important difference. When compared with the control patients, the patients undergoing RTSA for AVN showed similar improvements in all ROMs and PROMs. Similarly, aTSA performed for AVN resulted in comparable improvements in pain, ROMs, and PROMs compared with aTSA performed for primary osteoarthritis.
Conclusion: RTSA results in similar PROMs to aTSA in the treatment of AVN. Therefore, surgeons should continue to consider other patient factors such as glenoid bone loss and rotator cuff status when selecting implant polarity in patients with AVN.
Level of evidence: Level III; Retrospective Cohort Comparison Using Large Database; Treatment Study

Keywords: AVN; osteonecrosis; range of motion; outcome measures; atraumatic; post-traumatic

Avascular necrosis (AVN) of the humeral head is a condition that may ultimately result in collapse of the humeral head and end-stage arthritic changes of the glenohumeral joint. As a result of this disease process, arthroplasty is often indicated and has been frequently associated with favorable outcomes in the literature.[5,13,14] Multiple studies have demonstrated the efficacy of anatomic total shoulder arthroplasty (aTSA) at both mid- and long-term follow-up for the treatment of AVN.[5,8,11]

Despite expanding indications for reverse total shoulder arthroplasty (RTSA), there are relatively few reports evaluating the effectiveness of RTSA for the treatment of humeral head AVN.[1] Given the increasing use of RTSA compared with aTSA, it is important to understand how certain preoperative diagnoses can affect the ultimate outcome. Improved knowledge of the results of RTSA and aTSA for the treatment of humeral head AVN may help guide treatment.

The purpose of this study was to document the outcomes of shoulders undergoing RTSA in the setting of humeral head AVN and compare these with AVN shoulders undergoing the gold standard, aTSA.[13,14] Furthermore, we sought to compare the outcomes of shoulder arthroplasty for the treatment of humeral head AVN with a cohort of case-matched shoulders treated for cuff tear arthropathy with RTSA or primary osteoarthritis with aTSA. We hypothesized that patients receiving aTSA would have improved range of motion (ROM) and patient-reported outcome measures (PROMs) as compared with the RTSA cohort but that both cohorts would demonstrate significant improvements in both ROMs and PROMs following surgical intervention.

Methods

A retrospective review of a multinational single-implant shoulder arthroplasty database (Exactech, Gainesville, FL, USA) was performed between August 2005 and August 2017. All shoulders with a primary preoperative diagnosis of AVN and a minimum 2-year follow-up period were identified. Shoulders treated with hemiarthroplasty (HA) were eliminated. Patient demographic characteristics and information regarding prior surgical procedures, injections, and comorbidities were collected. Prospectively collected preoperative and final postoperative active ROMs, as well as PROMs, were reviewed for all patients. ROM measurements included forward elevation (in degrees), abduction (in degrees), external rotation (in degrees), and internal rotation scored according to Flurin et al.[2] Measurements were performed using a standardized protocol by the performing surgeon or research assistant. PROMs included Simple Shoulder Test (SST), American Shoulder and Elbow Surgeons (ASES), and Shoulder Pain and Disability Index (SPADI) scores. The Constant score and University of California, Los Angeles (UCLA) score, which are combinations of patient-reported outcomes and physician examination inputs, were also assessed. ROM and PROM differences were compared with the minimal clinically important difference (MCID) for RTSA or aTSA as described by Simovitch et al.[18] Postoperative radiographs were reviewed by the performing surgeon using a standardized system. Revision surgical interventions and adverse effects were recorded.

Shoulders were then case matched (1:1) according to age, sex, body mass index, and follow-up period to a cohort of patients treated for cuff tear arthropathy with RTSA. Similarly, patients treated with aTSA for AVN were case matched (1:1) to a cohort of patients treated for primary osteoarthritis by use of the same matching criteria.

Statistical analysis

All statistical analyses were performed using MATLAB (version 9.9 [release R2020b]; The MathWorks, Natick, MA, USA). All categorical data were analyzed with χ^2 testing, whereas continuous data were evaluated using the Student t test. The α level for all tests was set at .05 for statistical significance. The matching analysis was performed using the ''optimal pair matching method''—a propensity score cohort matching method in the computer programming software R (R Foundation for Statistical Computing, Vienna, Austria).

Results

After application of the inclusion criteria and matching, 67 patients undergoing RTSA for AVN were identified and matched to 67 patients undergoing RTSA for cuff tear arthropathy. The mean follow-up period was 47 months (range, 24-130 months) for the RTSA study cohort compared with 42 months (range, 24-123 months) for the control group ($P = .277$). Similarly, 52 aTSA shoulders treated for AVN were evaluated at a mean follow-up of 54

Table I Demographic characteristics for all groups

Clinical metric	aTSA without AVN	aTSA with AVN	*P* value for aTSA without vs. with AVN*	RTSA without AVN	RTSA with AVN	*P* value for RTSA without vs. with AVN†	*P* value for aTSA vs. RTSA‡
Demographic characteristics							
Patients, n	52	52	—	67	67	—	—
Age, yr	59 ± 10	59 ± 11	.849	74 ± 7	73 ± 7	.504	<.001
Female sex, n	30	31	.844	48	48	>.999	.171
Height, in	168 ± 10	168 ± 10	.774	163 ± 10	163 ± 8	.870	.018
Weight, lb	81 ± 16	81 ± 19	.980	79 ± 19	79 ± 16	.990	.556
BMI	29 ± 6	29 ± 6	.950	29 ± 6	30 ± 6	.832	.451
Follow-up, mo	53 ± 32	54 ± 36	.907	42 ± 21	47 ± 27	.277	.245
Comorbidities, n (%)							
Hypertension	19 (36)	21 (41)	.578	30 (45)	35 (52)	.441	.292
Diabetes	4 (7)	7 (13)	.314	10 (15)	11 (17)	.727	.557
Prior surgery	9 (17)	14 (27)	.242	14 (21)	23 (34)	.083	.391
Injections	25 (48)	17 (33)	.112	21 (31)	19 (29)	.750	.651

aTSA, anatomic total shoulder arthroplasty; *AVN*, avascular necrosis; *RTSA*, reverse total shoulder arthroplasty; *BMI*, body mass index.
Data are presented as mean ± standard deviation unless otherwise indicated.
* *P* value calculated from *t* test performed between aTSA without AVN and aTSA with AVN.
† *P* value calculated from *t* test performed between RTSA without AVN and RTSA with AVN.
‡ *P* value calculated from *t* test performed between RTSA with AVN and aTSA with AVN.

months (range, 24-124 months) compared with 53 aTSA control shoulders evaluated at a mean follow-up of 32 months (range, 24-151 months) ($P = .907$).

RTSA performed for AVN resulted in significant improvements in pain (from 6.6 to 1.4, $P < .001$), abduction (from 72° to 125°, $P < .001$), forward elevation (from 82° to 141°, $P < .001$), external rotation (from 12° to 37°, $P < .001$), and active internal rotation (from 3.2 to 4.6, $P < .001$). All outcome scores demonstrated significant improvements from preoperatively to postoperatively ($P < .001$). All ROMs and outcome score improvements exceeded the MCID.

RTSA vs. aTSA for AVN

Patients undergoing RTSA for AVN were significantly older than those treated with aTSA (73 years vs. 59 years, $P < .001$) (Table I). Women were more commonly treated for AVN in both the aTSA (60%) and RTSA (72%) cohorts. Clinical signs of rotator cuff insufficiency were observed in no patient who underwent aTSA for AVN vs. 33% of patients with AVN who received RTSA ($P < .001$). When compared with patients with aTSA performed for AVN, patients treated with RTSA for AVN demonstrated lower preoperative abduction (72° vs. 84°, $P = .066$), forward elevation (82° vs. 97°, $P = .026$), and active external rotation (12° vs. 18°, $P = .169$) (Tables II and III). Postoperatively, both the RTSA and aTSA groups showed significant improvements in all ROMs and outcome scores as compared with preoperative values. A significantly greater improvement in abduction was observed in the RTSA cohort (+51° vs. +32°, $P = .031$), which exceeded the combined aTSA-RTSA MCID.[18] Greater active internal rotation was obtained in the aTSA cohort, which showed a mean improvement of 2.3 as opposed to 1.3 in the RTSA cohort ($P = .020$). The RTSA study cohort had lower postoperative visual analog scale (VAS) pain scores (1.4 vs. 2.4, $P = .025$), but the difference between prosthesis types did not exceed the combined aTSA-RTSA MCID.[18]

RTSA for AVN vs. RTSA controls

With respect to the AVN RTSA cohort vs. the RTSA control cohort, both groups demonstrated similar preoperative pain, ROM, and outcome scores. In both cohorts, postoperative values and improvements in ROM and outcome scores were similar, all exceeding the MCID.

Anatomic total shoulder arthroplasty for AVN vs. aTSA controls

With respect to the AVN aTSA cohort vs. the control cohort, the preoperative SST score was significantly greater (4.4 vs. 2.9, $P = .039$) and the SPADI score was significantly lower (79 vs. 91, $P = .028$) in the control cohort (Table II). Postoperatively, the control cohort had greater abduction (128° vs. 111°, $P = .018$) but statistically similar forward elevation (136° vs. 149°, $P = .061$). The postoperative VAS pain score was lower in the control cohort (1.3 vs. 2.4, $P = .020$), although the relative change compared with the preoperative score was similar (–4.6 vs. –4.1, $P = .547$). Additionally, the postoperative ASES score (85 vs. 74, $P = .007$) and UCLA score (30 vs. 27, $P = .045$) were higher in the control cohort, whereas the postoperative SPADI score was significantly lower (17 vs. 33, $P = .002$).

Table II Preoperative data, postoperative data, and differences in aTSA control group vs. aTSA group with AVN

Time of measure	aTSA without AVN	aTSA with AVN	*P* value
Active abduction, °			
Preoperative	88.3 ± 32.5	84.0 ± 31.5	.533
Last postoperative	127.9 ± 32.5	111.2 ± 33.6	.018*
Delta	35.6 ± 37.0	32.0 ± 34.8	.668
Active forward elevation, °			
Preoperative	102.6 ± 40.0	97.4 ± 33.9	.513
Last postoperative	148.6 ± 29.6	135.8 ± 33.9	.061
Delta	40.6 ± 36.7	45.9 ± 29.2	.500
Active external rotation, °			
Preoperative	22.7 ± 18.7	17.5 ± 20.7	.226
Last postoperative	46.0 ± 20.6	40.4 ± 18.3	.177
Delta	25.8 ± 20.9	28.4 ± 20.1	.593
Active internal rotation			
Preoperative	3.2 ± 1.5	3.0 ± 2.0	.633
Last postoperative	4.8 ± 1.4	5.0 ± 1.6	.631
Delta	1.6 ± 2.1	2.3 ± 2.2	.194
VAS score for daily pain			
Preoperative	5.8 ± 2.3	6.4 ± 1.9	.236
Last postoperative	1.3 ± 2.3	2.4 ± 2.5	.020*
Delta	−4.6 ± 3.4	−4.1 ± 2.9	.547
SST score			
Preoperative	4.4 ± 3.1	2.9 ± 2.5	.039*
Last postoperative	10.5 ± 2.6	9.5 ± 2.8	.087
Delta	5.9 ± 3.3	7.0 ± 3.1	.166
Constant score			
Preoperative	40.2 ± 16.3	35.5 ± 12.3	.235
Last postoperative	72.2 ± 15.0	66.2 ± 17.2	.106
Delta	29.3 ± 19.8	32.6 ± 14.9	.531
ASES score			
Preoperative	40.2 ± 17.2	32.5 ± 13.5	.039*
Last postoperative	85.2 ± 19.5	74.1 ± 21.3	.007*
Delta	44.6 ± 25.0	44.3 ± 21.7	.956
UCLA score			
Preoperative	15.4 ± 4.4	13.9 ± 3.8	.120
Last postoperative	52.9 ± 32.2	27.3 ± 5.9	.045*
Delta	14.2 ± 7.1	14.9 ± 4.7	.666
SPADI score			
Preoperative	79.3 ± 22.0	91.0 ± 19.2	.028*
Last postoperative	16.8 ± 24.7	33.1 ± 27.9	.002*
Delta	−59.2 ± 30.0	−65.0 ± 30.0	.452

aTSA, anatomic total shoulder arthroplasty; *AVN*, avascular necrosis; *VAS*, visual analog scale; *SST*, Simple Shoulder Test; *ASES*, American Shoulder and Elbow Surgeons; *UCLA*, University of California, Los Angeles; *SPADI*, Shoulder Pain and Disability Index.
Data are presented as mean ± standard deviation.
* Statistically significant ($P < .05$).

When improvements compared with preoperative values were evaluated, both groups demonstrated similar improvements in pain, ROM, and outcome scores.

Complications and reoperations

In the AVN RTSA cohort, 2 complications were noted (3%); however, these did not require revision surgery (Table IV). Symptomatic glenoid component loosening developed in 1 patient in the AVN aTSA cohort (2%), and revision surgical intervention was ultimately required for symptomatic aseptic glenoid loosening. These differences in complications and revisions were not statistically significant ($P = .717$ and $P = .258$, respectively). In the aTSA control cohort, 6 complications (11.5%) occurred, requiring 4 revision operations (7.7%). The differences were not statistically significant ($P = .051$ and $P = .172$, respectively) when compared with the AVN aTSA group. In the RTSA control cohort, there was 1 complication (1.5%) that required a revision operation (1.5%). The differences were

Table III Preoperative data, postoperative data, and differences in RTSA control group vs. RTSA group with AVN

Time of measure	RTSA without AVN	RTSA with AVN	*P* value for RTSA without AVN vs. RTSA with AVN	*P* value for RTSA with AVN vs. aTSA with AVN
Active abduction, °				
Preoperative	64.3 ± 23.6	71.8 ± 34.0	.167	.066
Last postoperative	120.8 ± 28.8	124.6 ± 34.6	.522	.053
Delta	55.3 ± 30.1	51.2 ± 43.4	.578	.031*
Active forward elevation, °				
Preoperative	82.8 ± 33.4	81.5 ± 36.0	.838	.026*
Last postoperative	139.8 ± 25.8	140.5 ± 26.4	.884	.437
Delta	55.6 ± 40.8	57.2 ± 44.6	.843	.188
Active external rotation, °				
Preoperative	15.6 ± 16.1	11.6 ± 21.7	.260	.169
Last postoperative	36.8 ± 15.5	36.8 ± 14.8	.981	.278
Delta	21.7 ± 19.6	24.6 ± 27.2	.535	.482
Active internal rotation				
Preoperative	3.2 ± 1.8	3.2 ± 1.8	.880	.543
Last postoperative	4.3 ± 1.7	4.6 ± 1.6	.328	.219
Delta	1.2 ± 1.9	1.3 ± 1.5	.625	.020*
VAS score for daily pain				
Preoperative	6.6 ± 2.0	6.6 ± 1.9	.836	.587
Last postoperative	1.3 ± 2.2	1.4 ± 2.2	.741	.025*
Delta	−5.2 ± 2.4	−5.4 ± 2.7	.810	.048*
SST score				
Preoperative	3.3 ± 2.4	2.5 ± 2.2	.090	.417
Last postoperative	9.9 ± 2.5	9.6 ± 2.7	.477	.969
Delta	6.5 ± 3.1	6.8 ± 3.2	.700	.782
Constant score				
Preoperative	33.1 ± 10.1	30.9 ± 12.1	.377	.139
Last postoperative	67.3 ± 13.9	68.8 ± 12.3	.577	.428
Delta	34.9 ± 15.7	35.1 ± 13.6	.950	.527
ASES score				
Preoperative	31.8 ± 14.4	30.5 ± 13.2	.634	.485
Last postoperative	81.2 ± 19.8	80.2 ± 19.4	.772	.111
Delta	48.8 ± 21.0	47.7 ± 22.3	.787	.485
UCLA score				
Preoperative	12.7 ± 3.5	12.2 ± 3.6	.380	.035*
Last postoperative	29.9 ± 5.7	30.2 ± 5.3	.781	.014*
Delta	17.2 ± 6.1	17.4 ± 5.9	.826	.054
SPADI score				
Preoperative	90.6 ± 19.4	88.0 ± 19.8	.521	.502
Last postoperative	22.9 ± 25.8	26.9 ± 27.3	.392	.235
Delta	−67.8 ± 25.6	−58.9 ± 29.4	.115	.369

RTSA, reverse total shoulder arthroplasty; *AVN*, avascular necrosis; *aTSA*, anatomic total shoulder arthroplasty; *VAS*, visual analog scale; *SST*, Simple Shoulder Test; *ASES*, American Shoulder and Elbow Surgeons; *UCLA*, University of California, Los Angeles; *SPADI*, Shoulder Pain and Disability Index. Data are presented as mean ± standard deviation.

* Statistically significant ($P < .05$).

not statistically significant ($P = .563$ and $P = .319$, respectively) when compared with the AVN RTSA group.

Discussion

Both aTSA and RTSA improve pain and function in patients with end-stage AVN of the humeral head. When compared with preoperative values, both the RTSA and aTSA cohorts demonstrated significant improvements in all ROMs and functional scores. The patients treated with RTSA demonstrated significantly greater relative improvements in abduction, VAS scores, and final postoperative UCLA scores, with decreased internal rotation, as compared with those treated with aTSA, despite being 13 years older on average. It is important to note, however, that although these differences met the level of statistical significance in this study, the published MCID for aTSA and RTSA has been

Table IV Summary of all adverse events in all 4 groups

	aTSA control	aTSA with AVN	*P* value for aTSA control vs. aTSA with AVN	RTSA control	RTSA with AVN	*P* value for RTSA control vs. RTSA with AVN	*P* value for aTSA with AVN vs. RTSA with AVN
Complications	6 of 52 (11.5%): aseptic glenoid loosening (2), post-traumatic pain (2), subscapularis tear (1), and infection (1)	1 of 52 (2%): glenoid loosening	.051	1 of 67 (1.5%): dislocation	2 of 67 (3.0%): acromial fracture (1) and scapular fracture (1)	.563	.717
Revisions	4 of 52 (7.7%): aseptic glenoid loosening (2), subscapularis tear (1), and infection (1)	1 of 52 (2%): glenoid loosening	.172	1 of 67 (1.5%): dislocation	0 of 67 (0%)	.319	.258
Scapular notching grade, n	NA	NA					
0				38	44		
1				3	2		
2				3	2		
3				2	0		

aTSA, anatomic total shoulder arthroplasty; *AVN*, avascular necrosis; *RTSA*, reverse total shoulder arthroplasty; *NA*, not applicable.

reported as 7° ± 4° for abduction, 1.6 ± 0.3 for the VAS pain score, and 8.7 ± 0.6 for the UCLA score,[18] indicating that only relative improvement in abduction in our study met the levels of both statistical and clinical significance. Furthermore, these operations were likely performed for different indications given the selection criteria for aTSA and RTSA prostheses. However, our results show that RTSA is as successful as aTSA when performed in patients with AVN. Furthermore, when compared with control patients with cuff tear arthropathy, patients who underwent RTSA for AVN appeared to have similar outcomes.

Despite the increasing indications and proliferation of RTSA,[10] there remains a relative paucity of literature describing the outcomes of RTSA for AVN of the humeral head. Dilisio et al[1] reported on a limited case series of 3 patients who presented with humeral head AVN after arthroscopic intervention who achieved satisfactory results with RTSA. Although the literature may be lacking for RTSA, multiple studies have described the outcomes of aTSA for AVN of the humeral head. In one foundational study, Hattrup and Cofield[5] described a cohort of 127 patients, 71 treated with HA and 56 treated with aTSA, and reported subjective improvement in 70 of 88 patients (80%) available for follow-up at a mean of 8.9 years, with a mean final ASES score of 63.

Our study patients had a mean final ASES score of 72 after aTSA for AVN compared with 80 after RTSA. One possible explanation for the greater ASES score in this series may be the advances in aTSA techniques in the intervening 20 years. Because of the early failures of metal-backed glenoids,[20,21] a shift toward the use of cemented, all-polyethylene pegged components occurred. However, these components also suffer from high rates of radiographic loosening. In 2017, McLendon et al[7] reported on 330 aTSAs with cemented, all-polyethylene pegged components with a mean clinical follow-up period of 7.2 years. The rate of component survival free from radiographic failure was reported as 92% at 5 years but only 43% at 10 years, indicating a high mid-term failure rate.[7] These high rates of glenoid loosening can also lead to worse overhead ROM and lower PROMs, which may explain the differences between these studies.[17]

Compared with traditional all-polyethylene components, the system used in this study (Equinoxe; Exactech) offers a hybrid glenoid component with an ingrowth central cage. This component, which was used predominantly in this study, has been shown to have lower rates of radiolucent glenoid lines (9.0% vs. 37.6%), glenoid loosening (1.3% vs. 3.8%), and surgical revision (2.5% vs. 6.9%) at a mean of 50 months' follow-up as compared with traditional all-polyethylene glenoids.[3] The reduced incidence of radiolucent lines with caged glenoids, which were included in this study, may also explain the improved function compared with historical controls.

Additional studies have evaluated shoulder arthroplasty following AVN of the humeral head. Mansat et al[6] reported on the outcomes of 19 shoulders with atraumatic AVN of the humeral head treated with either HA (n = 14) or aTSA (n = 5). At a mean of 7 years' follow-up, they found excellent results in 7 shoulders, satisfactory results in 9, and unsatisfactory results in 3, with an average Constant score of 58 and a pain-free shoulder in slightly more than 80% of patients. Similarly, Orfaly et al[9] evaluated 21 shoulders in 19 patients treated with HA (n = 15) or aTSA (n = 6) and found significant improvements in the mean SST score, postoperative VAS score, elevation, external rotation, and internal rotation. Schoch et al evaluated separate cohorts of post-traumatic AVN[14] and atraumatic AVN[13] and found significant improvements postoperatively with respect to pain, elevation, and external rotation in both cohorts, although they advocated performing HA for atraumatic AVN[13] and aTSA for post-traumatic AVN.[14] In our study following both aTSA and RTSA, both cohorts showed similar postoperative improvements comparable with those previously reported in the literature, which would suggest that RTSA performs as well as the current gold standard (aTSA).

Postoperatively, aTSA performed for AVN demonstrated lower ROMs and outcome scores compared with control patients treated for osteoarthritis. The greatest differences were observed in overhead ROM including abduction (128° vs. 111°, $P = .018$) and forward elevation (149° vs. 136°, $P = .061$). Significantly lower outcome scores were also observed in the AVN group compared with the control group, including the ASES score (85 vs. 74, $P = .007$), UCLA score (30 vs. 27, $P = .045$), and SPADI score (17 vs. 33, $P = .002$). One possible cause of these differences may be the inclusion of post-traumatic AVN patients in this study, who have been shown to have lower postoperative overhead ROM compared with patients with atraumatic AVN.[13,14] Furthermore, prior surgery was more common in the AVN group, which has been shown to be a risk factor for inferior clinical outcomes.[12] The inclusion of these patients may have led to the differences seen when compared with control patients with primary osteoarthritis.

In this study, we observed 1 complication after aTSA (2%) and 2 complications after RTSA (3%) for AVN, with 1 reoperation in the aTSA cohort. There were 6 complications in the aTSA control group (11.5%) and 1 in the RTSA control group (1.5%); these findings were statistically similar to the those in the study groups. This result is in contrast to the results of previous studies that have shown higher risks of complications in shoulders with prior surgery, which was more common in both study cohorts.[12] These values compare favorably with respect to the literature, in which the percentages have ranged from 0%[6] to 32.3%.[5] It is important to recognize that these previous studies have focused exclusively on HA and aTSA and that the only study evaluating RTSA after AVN in the absence of prior failed open surgery reported no complications, albeit in a limited case series.[1]

This study has several limitations. First, the average follow-up period was <4 years for the RTSA group and 4.5

years for the aTSA group, which is too short to evaluate long-term survivorship. However, it would be expected that patients have achieved maximal function by this time point.[19] Moreover, this is a database study with the inherent limitations and weaknesses associated with such a design. Additionally, the etiology of AVN—atraumatic vs. traumatic—was not consistently available from the multicenter database; therefore, we were unable to separately analyze this. Given that studies have suggested that post-traumatic AVN is better treated with aTSA over HA,[14] one could surmise that the omission of AVN etiology is significant. To minimize the poorer outcomes associated with HA, these patients were eliminated from our study. Furthermore, the primary focus of our study was to evaluate RTSA by comparing it with the well-published success of aTSA for AVN. Finally, from evaluation of the database, the rationale of why patients underwent RTSA vs. aTSA for AVN was unclear and left completely to surgeon discretion. Although RTSA and aTSA are performed for different pathologies based on glenoid bone loss and rotator cuff status, aTSA is the current gold standard for the treatment of end-stage AVN with an intact rotator cuff and warrants comparison to judge the function of RTSA. This study is not meant to encourage the use of RTSA over aTSA for all patients with AVN. It is important to highlight that there was likely selection bias in this cohort regarding implant polarity selection, as aTSA patients were, on average, 14 years younger than patients treated with RTSA. This age difference would potentially introduce favorable bias into the aTSA group for overhead elevation.[4,15,16] Similarly, the RTSA group would have the potential for greater ASES scores and lower SPADI scores given the older age of this group.[4] However, RTSA patients still demonstrated significant improvements in ROMs and PROMs that exceeded the MCID and remained similar to aTSA patients for all measures except improvement in abduction, which was significantly greater in the RTSA group.[18]

Conclusion

Both RTSA and aTSA provide excellent surgical options to improve pain and function for humeral head AVN with an acceptable complication profile. RTSA provides comparable improvements in pain and outcome scores to aTSA in patients with AVN when clinical factors preclude placement of an aTSA.

Disclaimers:

Funding: This study received no outside funding.
Conflicts of interest: Carl Tams is an employee of Exactech.

Jean David Werthel receives royalties from FH Orthopedics and is a paid consultant for Zimmer.

Thomas Wright receives royalties from Exactech and Wolters Kluwer Health–Lippincott Williams & Wilkins and is a paid consultant for Exactech.

William Aibinder is a paid consultant for Exactech.

Richard Friedman is a paid consultant for Exactech and receives royalties from Exactech.

Joseph J. King owns stock in Pacira Pharmaceuticals and is a paid consultant for Exactech.

Bradley Schoch is a paid consultant for Exactech and receives royalties from Exactech, Innomed, Buxton, and Responsive Arthroscopy.

The other authors, their immediate families, and any research foundations with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

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