Research Article

Clinical Outcomes After Reverse Total Shoulder Arthroplasty in Patients With Primary Glenohumeral Osteoarthritis Compared With Rotator Cuff Tear Arthropathy: Does Preoperative Diagnosis Make a Difference?

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ABSTRACT

Introduction: The primary purpose of this study was to evaluate the clinical outcomes of patients who underwent reverse total shoulder arthroplasty performed for primary glenohumeral osteoarthritis (GHOA) with an intact rotator cuff compared with rotator cuff tear arthropathy (CTA).

Methods: This was a retrospective review of prospectively collected data including consecutive patients who underwent primary reverse total shoulder arthroplasty for GHOA or CTA with a minimum of 2-year follow-up. Baseline patient demographics and clinical outcomes including active range of motion, American Shoulder and Elbow Surgeons (ASES) score, Single Assessment Numerical Evaluation, and visual analog scale for pain were collected. Univariate and multivariate regression analyses were performed to evaluate the effect of preoperative diagnosis on clinical outcomes.

Results: Patients with a preoperative diagnosis of GHOA demonstrated significantly better postoperative active forward elevation (138.6° versus 127.3°; $P < 0.01$), external rotation (54.2° versus 43.8°; $P < 0.01$), and change in internal rotation (Δ 2.1 points versus Δ 1.2 points; $P < 0.01$). Patients with GHOA demonstrated significantly better postoperative ASES (86.8 versus 76.6; $P < 0.01$), Single Assessment Numerical Evaluation (89.7 versus 78.5; $P < 0.01$), and visual analog scale scores (0.63 versus 1.2; $P < 0.01$). Minimal clinically important difference for ASES score was achieved by 97.5% of patients with GHOA compared with 86.7% of patients with CTA ($P < 0.01$), whereas substantial clinical benefit was achieved by 90.4% of patients with GHOA and 71.7% of patients with CTA ($P < 0.01$). After a multivariate linear regression analysis, postoperative ASES scores were independently associated with previous ipsilateral shoulder surgery ($P = 0.042$), preoperative ASES score ($P = 0.01$), and primary diagnosis of GHOA ($P < 0.01$).

Conclusion: RTSA performed in patients with GHOA and an intact rotator cuff is associated with improved functional and clinical outcomes compared with those patients treated for CTA.

Level of Evidence: Level III Therapeutic Study

Utilization of reverse total shoulder arthroplasty (RTSA) has dramatically increased because clinical indications have expanded.[1-2] Originally designed for the treatment of rotator cuff tear arthropathy (CTA), RTSA is now commonly used in the setting of comminuted proximal humerus fractures, inflammatory arthropathies, and revision arthroplasty.[3-6] Although anatomic total shoulder arthroplasty (TSA) has traditionally been the treatment of choice for primary glenohumeral osteoarthritis (GHOA) with an intact rotator cuff, RTSA has emerged as a popular surgical option for these patients.[5,7-10] A recent epidemiologic study reported that nearly 33% of all RTSAs performed in the United States were for the treatment of primary GHOA with an intact rotator cuff.[11] This shift in utilization can be explained by recent evidence demonstrating high rates of glenoid component loosening and secondary rotator cuff failure beyond 10 to 15 years follow-up.[12,13] In addition, RTSA may result in more predictable implant longevity in patients with advanced glenoid deformity (Walch B2, B3, and C glenoids), given its improved fixation of the glenoid.[14] Furthermore, long-term data from the Australian Orthopedic Association National Joint Replacement Registry indicate higher cumulative revision rates with TSA in comparison to RTSA when performed for GHOA.[15] Given the higher risk of long-term revision coupled with recent evidence indicating similar clinical outcomes and value when comparing TSA and RTSA,[8-10] there has been an evolution toward using RTSA more routinely in the setting of GHOA with an intact rotator cuff.

Clinical evidence supporting the evolving indications for RTSA in patients with GHOA and an intact rotator cuff is currently limited. Although recent data suggest that RTSA can provide similar clinical outcomes in patients with CTA or GHOA, other authors have reported that RTSA in the setting of GHOA and an intact rotator cuff demonstrates poorer functional improvements.[7-16] Therefore, the purpose of this study was to investigate the clinical outcomes of a large consecutive series of patients undergoing RTSA for GHOA with an intact rotator cuff compared with those with CTA. We hypothesized that patients with GHOA and an intact rotator cuff would demonstrate similar improvements in the range of motion and functional outcome scores compared with those patients with CTA.

Methods

Patient Selection

After approval from the Institutional Review Board, a retrospective review of prospectively collected data from an institutional database ("Outcomes Based Electronic Research Database" platform), was performed to identify all consecutive patients who underwent primary shoulder arthroplasty between 2015 and 2018. All procedures were performed by a single high-volume fellowship-trained shoulder and elbow surgeon at a large private institution. Patients were included in this study if they underwent primary RTSA for GHOA or CTA with a minimum of 24 months follow-up, had complete preoperative and postoperative functional outcomes scores, and had preoperative advanced imaging (MRI or CT scan) available to assess glenoid morphology. Patients were excluded from this study if they had a primary diagnosis other than GHOA or CTA (ie, proximal humerus fracture, fracture sequelae, inflammatory arthropathy, osteonecrosis, or post-capsulorraphy degenerative joint disease) or had an incomplete clinical follow-up. The DJO AltiVate Reverse Total Shoulder Prosthesis (DJO) was used in 311 (99.0%) patients. The remaining three (1.0%) patients received the Aequalis Ascend Flex Reverse Total Shoulder Prosthesis (Wright Medical) and thus were excluded from statistical analysis.

Surgical Technique

All surgeries were performed by the senior author under general anesthesia and an interscalene nerve block when possible. A deltopectoral approach was used in each case. The biceps tendon (if intact) was tenodesed to the pectoralis major tendon. A subscapularis peel was performed and repaired to the lesser tuberosity with a combination of simple and Mason-Allen sutures at the conclusion of each procedure. A lateralized glenosphere with a diameter of 32 mm was used in 284 cases (91%), and a 36-mm glenosphere was used in 27 cases (9%). No patients in the study required glenoid bone-grafting or baseplate augmentation.

Clinical Outcome Assessment

Patient demographics including age, sex, body mass index, medical comorbidities, smoking status, American Society of Anaesthesiologists score, and history of previous ipsilateral shoulder surgery were recorded from the electronic medical record. Active shoulder range of motion (AROM), including forward elevation, external rotation, and internal rotation, was measured at the initial preoperative visit and the last documented postoperative visit. Internal rotation was reported as a 10-point scale based on the most cephalad midline segment of the back that could be reached as described by Levy et al[17]: buttock/greater trochanter (2 points), sacrum-L4 (4 points), L3-L1 (6 points), T12-T8 (8 points), and T7-T1 (10 points). Patient-reported outcome measures (PROMs) including the American Shoulder and Elbow Surgeons (ASES) score, Single Assessment Numerical Evaluation of the Shoulder (SANE) score, and visual analog scale (VAS) for pain were prospectively recorded and analyzed using proprietary electronic software (Outcomes Based Electronic Research Database). Postoperative complications such as baseplate failure, infection, scapular notching, instability, stress fracture, continued pain, and revision surgery were prospectively recorded.

Radiographic Outcomes

Preoperative plain radiographs and advanced imaging (CT and MRI) were reviewed independently and in duplicate by two orthopaedic surgeons for all patients. Patients with GHOA were categorized according to the modified Walch classification using the available preoperative MRI or CT scans to assess glenoid morphology.[18,19] Preoperative radiographs and CT scans were used to categorize the rotator cuff tear cohort according to the Hamada et al[20] and Favard[21] classifications. All classifications of glenoid morphology were determined by consensus. Any discrepancies between the two reviewers were independently assessed by a senior author. Rotator cuff integrity in patients with GHOA was confirmed using preoperative MRI for 143 (72.2%) patients and intraoperative visual assessment alone for the 55 (27.8%) remaining patients.

Statistical Analysis

The primary clinical outcome measure was the postoperative ASES score. Secondary outcome measures included postoperative SANE, VAS-pain, shoulder AROM, and complications. An univariate analysis was performed to compare baseline characteristics and PROMs, as well as absolute postoperative and preoperative to postoperative changes in PROM scores between groups. Statistical tests performed included the Wilcoxon rank-sum, student *t*, chi-square, and Fisher exact tests, when appropriate. Improvements in ASES scores were compared with the threshold minimally important clinical difference (MCID) (10.3, SD 3.3) and substantial clinical benefit (SCB) (25.9, SD 2.9) values for RTSA as reported by Simovitch et al.[22,23] A multivariable linear regression was used to assess for the association between preoperative diagnosis and absolute postoperative ASES scores while controlling for age, sex, history of previous ipsilateral shoulder surgery, and preoperative ASES score. The alpha risk was set to 0.05 for all tests to estimate statistical significance. All statistical analysis was performed using SPSS statistical software (version 25; SPSS).

Results

A total of 311 of 418 (74%) consecutive patients meeting the inclusion and exclusion criteria were included in this study. One hundred ninety-eight (63.7%) patients with GHOA and an intact rotator cuff and 113 (36.3%) patients with CTA who underwent primary RTSA were noted. For perspective, a total of 214 patients underwent primary TSA for GHOA during the study period. The mean duration of follow-up for patients with GHOA was 28.1 (SD 7.6) months and 27.6 (SD 7.3) months for patients with CTA ($P > 0.05$). No statistically significant differences existed regarding baseline age, sex, body mass index, comorbid conditions, or American Society of Anaesthesiologists score ($P > 0.05$) (Table 1). Patients with CTA reported significantly higher rates of previous ipsilateral shoulder surgery (50.0%) than patients with GHOA (19.2%) ($P < 0.01$).

Patients with GHOA had the following glenoid morphology: A1 (n = 55, 27.8%), B2 (n = 57, 28.8%), or B3 (n = 49, 24.7%) (Table 2). Patients with A2 (n = 21, 10.6%), B1 (n = 9, 4.5%), C (n = 2, 1%), and D (n = 5, 2.5%) morphologies comprised a smaller proportion of patients with GHOA. Patients with CTA were categorized according to the Hamada and Favard classifications. The distribution of patients according to Hamada classification was as follows: grade 1 (n = 2, 1.8%), grade 2 (n = 31, 27.4%), grade 3 (n = 22, 19.5%), grade 4 (n = 52, 46.0%), and grade 5 (n = 1, 0.9%). The most common morphologies according to the Favard

Table 1. Comparisons of Preoperative Patient Characteristics Between Groups

Parameter	GHOA	CTA	*P* value
Total, n (%)	198 (63.7)	113 (36.3)	N/A
Age (yr), avg (SD)	72.0 (6.0)	71.2 (9.6)	0.44
Female, n (%)	120 (60.6)	69 (61.6)	0.97
Follow-up (mo), avg (SD)	28.1 (7.6)	27.6 (7.3)	0.6
BMI, avg (SD)	31.1 (6.2)	30.0 (5.7)	0.1
Comorbid conditions, n (%)			
Depression	50 (25.3)	26 (23.0)	0.83
Diabetes	37 (18.7)	20 (17.7)	0.86
Smoker	9 (4.5)	6 (5.3)	0.77
ASA score, n (%)			
1	4 (2.0)	0	0.15
2	146 (73.7)	78 (69.0)	
3	47 (23.7)	31 (28.3)	
4	0	1 (0.9)	
Previous ipsilateral shoulder surgery, n (%)	38 (19.2)	56 (50.0)	<0.01[a]

ASA = American Society of Anesthesiologists, Avg = average, BMI = body mass index, CTA = cuff tear arthropathy, GHOA = glenohumeral osteoarthritis, N/A = not applicable
[a]Denotes statistical significance at $P < 0.05$.

Table 2. Preoperative Radiographic Assessment of Shoulder Pathology by Diagnosis

Parameter	GHOA (n = 200)	CTA (n = 114)
Preoperative glenoid Walch classification, n (%)[a]		
A1	55 (27.8)	—
A2	21 (10.6)	—
B1	9 (4.5)	—
B2	57 (28.8)	—
B3	49 (24.7)	—
C	2 (1.0)	—
D	5 (2.5)	—
Preoperative glenoid Favard classification, n (%)[b]		
E0	—	56 (49.6)
E1	—	5 (4.4)
E2	—	13 (11.5)
E3	—	31 (27.4)
E4	—	3 (2.7)
Preoperative shoulder Hamada classification, n (%)[b]		
1	—	2 (1.8)
2	—	31 (27.4)
3	—	22 (19.5)
4	—	52 (46.0)
5	—	1 (0.9)

CTA = cuff tear arthropathy, GHOA = glenohumeral osteoarthritis
[a]Walch classification only evaluated on patients with the diagnosis of GHOA.
[b]Favard and Hamada classifications only evaluated on patients with CTA.

classification consisted of patients with E0 (n = 56, 49.6%), E3 (n = 31, 27.4), and E2 (n = 13, 11.5%) glenoids.

No statistically significant differences were comparing the preoperative ASES, SANE, and VAS-pain scores for patients with GHOA or CTA ($P > 0.05$) (Table 3). Patients with GHOA demonstrated significantly greater postoperative ASES score (86.8, SD 13.6 versus 76.8, SD 18.9; $P < 0.01$), SANE score (89.7, SD 15.9 versus 78.5, SD 22.0; $P < 0.01$), and VAS-pain (0.63, SD 1.4 versus 1.2, SD 2.1; $P < 0.01$). Patients with GHOA also demonstrated a significantly greater change in ASES score compared with those patients with CTA (51.7, SD 19.4 versus 39.7, SD 24.9) ($P < 0.01$). MCID for ASES score was achieved by 97.5% of patients with GHOA compared with 86.7% of patients with CTA ($P < 0.01$), whereas SCB was achieved by 90.4% of patients with GHOA and 71.7% of patients with CTA ($P < 0.01$).

Patients with GHOA had better preoperative active forward elevation (92.1°, SD 23.8) compared with the CTA cohort (80.0°, SD 33.5) ($P < 0.01$). Patients with CTA demonstrated markedly better preoperative internal rotation scores (3.3, SD 1.6) than those patients with GHOA (2.6, SD 1.0) ($P < 0.01$). Postoperatively, patients with GHOA had significantly better AROM in forward elevation (138.6°, SD 15.5 versus 127.3°, SD 25.1, $P < 0.01$) and external rotation (54.2°, SD 17.2 vs 43.8°, SD 21.9, $P < 0.01$). Patients with GHOA demonstrated significantly improved change in internal rotation (Δ 2.1, SD 1.6) compared with the CTA group (Δ 1.2, SD 1.8) ($P < 0.01$).

A multivariate analysis controlling for age, sex, history of previous ipsilateral shoulder surgery, and preoperative ASES scores demonstrated that a preoperative diagnosis of GHOA was the single best predictor for higher absolute postoperative ASES scores (beta-coefficient 9.3, 95% confidence interval [CI] 5.4 to 13.1, $P < 0.01$) (Table 4).

Table 3. Univariate Comparisons of Outcomes by Preoperative Diagnosis

Outcome	GHOA, Avg (SD)	CTA, Avg (SD)	*P* value
ASES score			
Pre-op	35.2 (15.6)	36.9 (18.9)	0.4
Post-op	86.8 (13.6)	76.6 (18.9)	<0.01[a]
Δ	51.7 (19.4)	39.7 (24.9)	<0.01[a]
Reached MCID (n, %)	193 (97.5)	98 (86.7)	<0.01[a]
Reached SCB (n, %)	179 (90.4)	81 (71.7)	<0.01[a]
Sane score			
Pre-op	31.1 (20.2)	31.8 (20.6)	0.76
Post-op	89.7 (15.9)	78.5 (22.0)	<0.01[a]
Δ	58.6 (26.3)	46.7 (27.3)	<0.01[a]
VAS-pain score			
Pre-op	6.1 (2.3)	5.6 (2.6)	0.08
Post-op	0.63 (1.4)	1.2 (2.1)	<0.01[a]
Δ	−5.4 (2.4)	-4.3 (3.3)	<0.01[a]
Forward elevation (°)			
Pre-op	92.1 (23.8)	80.0 (33.5)	<0.01[a]
Post-op	138.6 (15.5)	127.3 (25.1)	<0.01[a]
Δ	47.1 (27.5)	47.2 (32.8)	0.96
External rotation (°)			
Pre-op	26.4 (13.0)	28.0 (16.3)	0.41
Post-op	54.2 (17.2)	43.8 (21.9)	<0.01[a]
Δ	28.0 (19.1)	16.5 (23.3)	<0.01[a]
Internal rotation (score)[b]			
Pre-op	2.6 (1.0)	3.3 (1.6)	<0.01[a]
Post-op	4.7 (1.6)	4.5 (1.5)	0.34
Δ	2.1 (1.6)	1.2 (1.8)	<0.01[a]

ASES = American Shoulder Elbow Surgeon Score, avg = average, CTA = cuff tear arthropathy, GHOA = glenohumeral osteoarthritis, MCID = minimal clinically important difference, SANE = Single Assessment Numeric Evaluation, SCB = substantial clinical benefit, VAS = Visual Analog Scale

[a]Denotes statistical significance at $P < 0.05$.

[b]IR graded as follows: 2, from the hip to the buttock; 4, sacrum to L4; 6, L3-L1; 8, T12-T8; 10, higher than T8.

Twenty-one patients (6.7%) sustained an orthopaedic-related postoperative complication (Table 5). No significant differences were observed in overall complications between the GHOA (n = 10, 5.0%) and the CTA (n = 11, 9.7%) cohorts ($P > 0.05$). Patients with CTA (n = 6, 5.3%) demonstrated significantly higher rates of acromial stress fractures compared with patients with GHOA (n = 2, 1.0%) ($P < 0.05$). No significant differences were noted between any of the remaining complications for either group. The remaining complications for patients with GHOA included the following: two intraoperative fractures, four transient neuropraxias, one traumatic hardware failure after a biking accident, and one traumatic baseplate failure. The remaining complications in the CTA group included two dislocations managed with closed reduction, one nickel allergy, one delayed wound healing, and one hematoma.

Discussion

The results of this study demonstrate that patients with GHOA and an intact rotator cuff have improved clinical outcomes after RTSA compared with those patients with CTA. A multivariate analysis demonstrated that a

Table 4. Linear Regressions Model for Variables Associated With Postoperative ASES Scores

Parameter	Beta[a]	Standardized Beta[b]	*P* value
Age	-0.12 (-0.36 to 0.11)	-0.06	0.29
Sex	3.1 (-0.52 to 6.6)	0.09	0.094[c]
Previous ipsilateral shoulder surgery	-4.2 (-8.2 to -0.15)	-0.12	0.042[c]
Preoperative ASES score	0.14 (0.03 to 0.24)	0.14	0.01[c]
Diagnosis of GHOA	9.3 (5.4 to 13.1)	0.27	<0.01[c]

ASES = American Shoulder Elbow Surgeon Score, GHOA = glenohumeral osteoarthritis
[a]Beta coefficient values with 95% confidence intervals in parentheses, signifying the strength of association between the dependent variable and the variable of interest.
[b]Standardized beta coefficient, weighted to allow for comparison of the relative strength of association with the dependent variable between the variables of interest
[c]Denotes statistical significance at $P < 0.05$.

preoperative diagnosis of GHOA was the single strongest predictor for higher postoperative ASES scores. Patients with GHOA also demonstrated markedly better improvement in postoperative SANE score, VAS-pain, and active range of motion compared with patients with CTA. Furthermore, the percentage of patients who achieved MCID and SCB for the ASES score was markedly higher for those patients with GHOA compared with CTA. Our findings substantiate the use of RTSA as a viable surgical option for patients with GHOA.

The effectiveness of RTSA in patients with GHOA has been increasingly demonstrated in multiple studies.[5,7,9,10,24,25] Wright et al[10] reported that patients older than 70 years with GHOA and an intact rotator cuff can achieve similar clinical outcomes after RTSA compared with those who underwent TSA. Waterman et al[7] reported that RTSA in patients with GHOA demonstrated similar improvements in ASES, SANE, VAS, and active forward elevation when compared with patients undergoing RTSA for CTA.[7] Polisetty et al[9] further demonstrated that RTSA can provide similar clinical outcomes and values in patients with GHOA when compared with TSA. Our study uniquely demonstrated that despite both cohorts having similar preoperative characteristics and baseline function, patients with GHOA performed better on all postoperative functional outcome scores and AROM measurements with a similar complication profile as patients with CTA. One possible explanation for the different findings is the increased power of our study because of the substantially larger cohort of patients with GHOA (n = 200) compared with the study by Waterman et al,[7] which only had 43 patients. We hypothesize that the intact rotator cuff in patients with GHOA provides balanced force coupling and dynamic stability after RTSA allowing for more notable improvements in

Table 5. Surgical Complications by Preoperative Diagnosis

Complication, n(%)	GHOA (n = 198)	CTA (n = 113)	*P* value
Total complications	10 (5)	11 (9.7)	0.14
Intraoperative fracture	2 (1)	—	0.54
Allergic reaction to implant material	—	1 (0.9)	0.37
Delayed wound healing	—	1 (0.9)	0.37
Hematoma	—	1 (0.9)	0.37
Transient neurapraxia	4 (2)	—	0.3
Dislocation	—	2 (1.8)	0.13
Acromial stress fracture	2 (1)	6 (5.3)[a]	0.03[b]
Implant failure	2 (1)[c]	—	0.54

CTA = cuff tear arthropathy, GHOA = glenohumeral osteoarthritis
[a]Includes one traumatic stress fracture from a fall.
[b]Denotes statistical significance at $P < 0.05$.
[c]One traumatic hardware failure and one traumatic baseplate failure.

postoperative AROM and patient-reported outcome scores. In addition, patients with CTA have a higher likelihood of postoperative acromial stress fractures, which may limit functional outcomes.[26]

Previous clinical evidence examining the use of RTSA for GHOA has not consistently demonstrated favorable outcomes.[16,27] Werner et al[16] reported that patients with an intact rotator cuff and higher ASES scores at the time of surgery correlated with poor postoperative improvements (defined as improvement in ASES score <12) after RTSA. Boileau et al[27] further demonstrated that RTSA in patients with greater than 90° of active forward elevation preoperatively was a risk factor for lower patient satisfaction scores. Both studies suggest higher preoperative function limits the potential to achieve postoperative satisfaction after RTSA. The results of this study refute these findings by demonstrating that patients with GHOA performed markedly better across all postoperative variables when compared with patients with CTA. This was indicated not only across the absolute value of postoperative outcome scores but also by the overall change in values for ASES, SANE, and VAS pain scores. Patients with GHOA also showed the same degree of improvement for active forward elevation as those patients with CTA, despite having a mean preoperative forward elevation value of 92° compared with 80° in CTA. These findings further suggest that RTSA can provide predictable clinical improvement regardless of rotator cuff status and preoperative function. We hypothesize that our study not only provided a larger cohort of patients with GHOA but also a MCID value that was based on procedure type rather than a diagnosis of rotator cuff disease, which may account for more favorable outcomes compared with Werner et al.[16] This study also included a larger proportion of patients who received RTSA as an index procedure, which may explain the differences in postoperative improvements when compared with the findings of Boileau et al.[27,28]

This study has numerous strengths. This is the largest study to date examining functional outcomes in patients with GHOA and an intact rotator cuff treated with RTSA. Our study has nearly four times the number of patients treated with RTSA for GHOA compared with the next largest series, which adds notable power to our findings. Our study also represents a consecutive series of patients with a high follow-up, which minimizes the risk of selection bias. All clinical outcomes were prospectively collected and maintained an in institutional database, therefore minimizing recall bias. In addition, this study reports the clinical outcomes of RTSA across a wide breadth of glenoid morphologies in GHOA, whereas previous studies tended to report the outcomes of RTSA for more severe glenoid morphologies.[5,7,10] Despite the variable severity of glenoid wear patterns, MCID and SCB were obtained by 97.5% and 90.6% of patients with GHOA, respectively, suggesting that glenoid morphology in GHOA may not adversely affect the clinical improvements after RTSA.

This study has several limitations. The retrospective nature of the study may introduce certain biases; however, this is limited by including a consecutive series and having prospective data collection. These data also reflect a single surgeon's experience with an evolving practice trending toward the more frequent use of RTSA in patients with primary GHOA. Therefore, the results may not be generalizable. In addition, although previous literature has described the MCID and SCB values for RTSA, this is not unique to patients with a preoperative diagnosis of GHOA. With the data available, we were unable to determine these values for our specific patient cohort.[29,30] Finally, although our results demonstrated favorable short-term outcomes, longer term follow-up is necessary to assess the durability of these results.

Conclusion

Patients with GHOA and an intact rotator cuff demonstrate markedly better functional and clinical outcomes after RTSA compared with patients with CTA at short-term follow-up. Expanding indications for RTSA coupled with the findings of this study suggest that RTSA is a viable surgical option in the management of GHOA. Future studies with long-term follow-up should be performed to assess the longevity of clinical improvements and implant survivability for RTSA in the setting of GHOA.

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