

Research Article

Reverse Shoulder Arthroplasty Provides Durable Outcomes Regardless of Diagnosis and Pathology

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Introduction

As surgical indications for reverse shoulder arthroplasty (RSA) have expanded, appropriate patient counseling and shared decision-making should be informed by

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clinical outcomes specific to each indication for RSA. While RSA has traditionally been indicated in patients with rotator cuff arthropathy (RCA), it has been employed increasingly in patients with osteoarthritis and in intact rotator cuff with better-reported outcomes. To compare patient-reported outcomes (PROs) and postoperative range of motion (ROM) following RSA for patients with RCA compared to those with rotator cuff-intact glenohumeral OA.

Methods

All patients undergoing RSA from January 2016 to September 2021 by a single surgeon at a single institution were retrospectively identified through a prospectively collected database. Patients indicated for RSA secondary to OA without rotator cuff pathology were compared to patients indicated for RSA secondary to RCA. Patient-reported outcomes (PROs), including the Simple Shoulder Test (SST), American Shoulder and Elbow Surgeons (ASES), Shoulder Arthroplasty Smart (SAS) score, and University of California-Los Angeles (UCLA) scores, as well as active range of motion (ROM) were measured preoperatively and at a minimum 2-year follow-up, with outcomes between groups based on RSA indication compared.

Results

A total of 107 patients (n=71 RCA group, n=36 OA group) were identified, with no difference in patient demographics. No significant differences between groups were appreciated at the final follow-up based on SST ($p = 0.765$), ASES ($p = 0.437$), SAS ($p=0.782$), or UCLA ($p = 0.313$) scores, or ROM (all, $p<0.622$). One patient (2.8%) in the OA group underwent revision surgery due to dislocation, while one patient (1.4%) in the RCA group required revision due to an infection associated with the spacer.

Conclusion

Patients undergoing RSA for glenohumeral OA without rotator cuff pathology reported comparable patient reports outcomes and ROM values at a minimum 2-year follow-up compared to patients indicated for RSA secondary to RCA.

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INTRODUCTION

The performance of shoulder arthroplasty has dramatically increased over the last two decades, due in large part to the increased utilization and popularity of reverse shoulder arthroplasty (RSA). Specifically, the use of RSA has come to represent approximately 60% of all shoulder arthroplasty procedures as of 2017 (Best et al. 2021). Coupled with favorable outcomes, this rise in RSA utilization has occurred secondary to increased surgeon comfort, and implant familiarity, as well as the expanding of indications for RSA (Werner, Wong, Mahony, et al. 2016). While initially designed for the treatment of degenerative glenohumeral joint osteoarthritis (OA) with rotator cuff insufficiency, known as rotator cuff (RTC) arthropathy (RCA) (S. W. Young et al. 2013; D. Cuff et al. 2012), indications now include acute proximal humeral fractures (D. J. Cuff and Pupello 2013; Gulotta 2015), proximal humeral nonunions and malunions (Raiss

et al. 2014; Willis, Min, Brooks, et al. 2012), massive RTC tearing without OA (Harreld, Puskas, and Frankle 2011), OA with posterior glenoid deficiency (Mizuno et al. 2013), revision arthroplasty (Budge et al. 2013; Walker et al. 2012), inflammatory arthritis (A. A. Young et al. 2011), and reconstruction following tumor resection (Dieckmann, Liem, Gosheger, et al. 2013; De Wilde, Boileau, and Van der Bracht 2011).

In patients with OA with an intact RTC, the use of anatomic total shoulder arthroplasty (TSA) has been represented as the gold standard of care (Wright, Keener, and Chamberlain 2020; Waterman, Dean, Naylor, et al. 2020; Sowa, Bochenek, Bühlhoff, et al. 2017). However, investigations have shown the potential for anatomic glenoid component loosening/failure and development of RTC dysfunction, including rotator cuff tendon tears, tendonitis, or muscle atrophy (B. Schoch et al. 2015), following TSA beyond 10-15 year follow-up (Evans et al. 2021; McLendon

et al. 2017; A. A. Young et al. 2012). These findings have led to an interest in RSA being utilized in patients with OA with an intact RTC (Steen, Cabezas, Santoni, et al. 2015), in which favorable outcomes have been reported in multiple investigations (Mizuno et al. 2013; Polisetty, Colley, and Levy 2021; McFarland et al. 2016; Coscia et al. 2021). Recently, up to 33% of all RSA procedures performed in the United States have been reported to be performed in patients with primary OA and an intact RTC (Best et al. 2021). Revision rates have also been reported to be lower in patients with OA undergoing RSA compared to TSA (Brown et al. 2020). Meanwhile, other authors have reported less favorable functional outcomes in patients undergoing RSA for OA with an intact RTC (Werner, Wong, Mahony, et al. 2016; Brown et al. 2020; Saini, Pettit, Puzzitiello, et al. 2022).

This study fills a gap in the understanding the long-term outcomes of RSA in patients with OA and an intact RTC. While RSA has proven successful in treating RCA, the different underlying pathology in patients with an intact RTC requires dedicated exploration. Our findings are essential for guiding clinical decisions, particularly when selecting the most appropriate surgical intervention for patients with OA who still have a functional RTC but may face future degeneration.

As such, the role and outcomes for patients undergoing RSA with glenohumeral OA without RTC tearing remain uncertain. The purpose of this investigation was to compare patient-reported outcomes (PROs) and postoperative range of motion (ROM) following RSA for patients with RCA compared to those with rotator cuff-intact OA. We hypothesized that patients with glenohumeral OA without RTC tearing would report similar outcomes when compared to patients undergoing RSA for RCA.

METHODS

STUDY DESIGN

Institutional review board approval was granted prior to study initiation. A single institution's electronic medical record database was queried to identify patients who had undergone RSA between 2016 and 2021. Patients were separated into two groups: 1) patients who underwent RSA for glenohumeral OA with an intact RTC and 2) patients who underwent RSA with RCA. Inclusion criteria consisted of the following: (1) patients $\geq$ 18 years of age, (2) patients with documented primary RSA for glenohumeral OA with an intact RTC or RCA, and (3) documented clinical outcomes at a minimum 2-year follow-up. Exclusion criteria consisted of the following: (1) prior ipsilateral shoulder surgery, (2) concomitant ipsilateral periarticular shoulder fracture, (3) previous ipsilateral humerus fractures, (4) patients without a minimum of 2-year follow-up data, (5) active infection, and (5) a history of systemic inflammatory diseases.

PATIENT EVALUATION AND DATA ANALYSIS

Two independent investigators (*initials blinded for peer review*) retrospectively reviewed patients' medical records. Patient demographics were collected and included age, sex, body mass index (BMI), race, comorbidities (hypertension, diabetes, cardiac disease, history of smoking), and time to follow-up. The primary outcomes were PROs including the Shoulder Arthroplasty Smart (SAS) score, Simple Shoulder Test (SST), University of California-Los Angeles (UCLA) score, and American Shoulder and Elbow Surgeons (ASES) score. Active forward flexion, external rotation, and internal rotation were also collected. Internal rotation was scored according to the highest anatomical level they were able to reach with their hand (0 = lateral thigh, 1 = greater trochanter, 2 = glutes, 3 = sacrum, 4 = L4 to L5, 5 = L1 to L3, 6 = T8 to T12, 7 = $\geq$ T7).

SURGICAL PROCEDURE

A single, fellowship-trained shoulder surgeon performed an RSA on all patients via a standardized technique. All patients received the Equinox (Exactech, Inc., Gainesville, FL, USA) RSA system using a deltopectoral approach with a subscapularis tenotomy.

STATISTICAL ANALYSIS

Statistical analyses were conducted using R version 4.2.2 (R Foundation for Statistical Computing). Descriptive statistics were utilized to report patient demographics. Categorical variables were presented using counts, while continuous variables were expressed as mean $\pm$ standard deviation. Two-sided Student's t-tests and chi-squared tests were employed to evaluate differences between cohorts for continuous and categorical variables, respectively. Fisher's exact test was used to assess differences in complication rates between the groups. A significance level of $p < 0.05$ was set.

RESULTS

PATIENT DEMOGRAPHICS

A total of 120 RSA patients were initially identified through the retrospective database to meet our inclusion/exclusion criteria. Of these, 13 patients were lost to follow-up. A total of 107 patients (n=36 glenohumeral OA with intact RTC, n=71 RCA) ultimately met the inclusion/exclusion criteria. No differences in baseline patient demographics, including age, sex, body mass index (BMI), mean follow-up, dominant side affected, ethnicity, and comorbidities were found between the two groups ([Table 1](#)).

PREOPERATIVE PATIENT-REPORTED OUTCOME SCORES AND RANGE OF MOTION

No significant differences in preoperative SST ($p=0.956$), ASES ($p=0.512$), UCLA ($p=0.799$), SAS ($p=0.953$) scores, or active forward flexion ($p=0.300$), abduction ($p=0.389$), ex-

Table 1. Patient Demographics

	Rotator Cuff Arthropathy (N=71)	OA with Intact Rotator Cuff (N=36)	p
Sex (M/F)	49/22	23/13	0.593
Age, yr	73.6 ± 6.4	72.2 ± 9	0.384
Mean Follow-up, mo	44.3 ± 15.1	46.9 ± 19.7	0.497
BMI, kg/m ²	30.4 ± 7	29 ± 6.2	0.301
Dominant side affected, (%)	49 (69)	18 (50)	0.540
Ethnicity, (%)			0.780
Caucasian	67 (94.4)	33 (91.7)	0.535
African American	2 (2.8)	1 (2.8)	
Hispanic	2 (2.8)	2 (5.6)	
Comorbidities			
Diabetes, (%)	7 (9.9)	5 (13.9)	
Hypertension, (%)	13 (18.3)	9 (25)	
Cardiac Disease, (%)	1 (1.4)	3 (8.3)	
History of Smoking, (%)	0	1 (2.8)	

Legend: M, male; F, female; BMI, body mass index; OA, osteoarthritis; yr, year; mo, month

Table 2. Preoperative Patient-Reported Outcomes and Range of Motion

Outcome	Rotator Cuff Arthropathy (N=71)	OA with Intact Rotator Cuff (N=36)	p
SST	2.9 ± 2.2	2.9 ± 2.3	0.956
ASES	31.4 ± 14.1	29.4 ± 14.7	0.512
UCLA	11.7 ± 3.7	11.9 ± 3.7	0.799
SAS	35.9 ± 8.7	35.8 ± 9.2	0.953
Forward Flexion, °	67.9 ± 26.8	74.1 ± 33.2	0.300
Abduction, °	57.3 ± 20.7	61.7 ± 26.2	0.389
External Rotation, °	18.2 ± 14.9	17 ± 15.5	0.696
Internal Rotation Score	1.4 ± 0.8	1.5 ± 1.2	0.444

Legend: SST, Simple Shoulder Test; ASES, American Shoulder and Elbow Surgeons score; UCLA; University of California – Los Angeles score; SAS, Shoulder Arthroplasty Smart score; °, degrees; OA, osteoarthritis

ternal rotation (p=0.696), or internal rotation scores (p=0.444) were reported between the two cohorts (Table 2).

POSTOPERATIVE PATIENT-REPORTED OUTCOME SCORES AND RANGE OF MOTION

No significant differences in preoperative SST (p = 0.765), ASES (p = 0.437), SAS (p=0.782), UCLA (p = 0.313) scores, or active forward flexion (p=0.244), abduction (p=0.120), external rotation (p=0.303), or internal rotation score (p=0.622) were reported between the two cohorts (Table 3).

REVISION RATE

One patient (2.8%) in the OA group underwent revision surgery due to dislocation, while one patient (1.4%) in the RCA group required revision due to an infection associated with the spacer. Complication rates between the OA and RCA groups were comparable, with no statistically significant differences observed. Fisher's exact test indicated no significant association between the groups and complication rates (p = 1.000).

DISCUSSION

Our study shows that RSA delivers similar outcomes for patients with GHOA and an intact RTC as it does for those with RCA. This finding is key for surgeons making treatment decisions, suggesting that RSA is a strong option even for patients with a functional rotator cuff who might traditionally be considered for TSA. This evidence pushes us to consider RSA more broadly in clinical practice, especially for patients where the future integrity of the rotator cuff is in question.

Good postoperative PROs including in SST, ASES, UCLA, and SAS scores, along with forward flexion, abduction, internal and external ROM values were appreciated in both groups following RSA at final follow-up. While anatomic TSA has traditionally been considered the gold standard for the treatment of patients with glenohumeral OA (Sowa, Bochenek, Bühlhoff, et al. 2017; Denard et al. 2013), the success of the TSA implant relies on the presence of an intact and functional RTC complex to preserve glenohumeral kinematics (Wright, Keener, and Chamberlain 2020). De-

Table 3. Postoperative Patient-Reported Outcomes and Range of Motion

Outcome	Rotator Cuff Arthropathy (N=71)	OA with Intact Rotator Cuff (N=36)	p
SST	9.7 ± 2.8	9.9 ± 2.5	0.765
ASES	80.1 ± 17.5	77.1 ± 19	0.437
UCLA	30.7 ± 5	29.6 ± 5.3	0.313
SAS	74.5 ± 11.3	73.8 ± 11.4	0.782
Forward Flexion, °	156.3 ± 21.8	161.1 ± 19.2	0.244
Abduction, °	136.4 ± 29	145.3 ± 26.8	0.120
External Rotation, °	41.9 ± 18.4	45.6 ± 16.6	0.303
Internal Rotation Score	3.1 ± 1.7	3.3 ± 1.8	0.622

Legend: SST, Simple Shoulder Test; ASES, American Shoulder and Elbow Surgeons; UCLA; University of California – Los Angeles; SAS, Shoulder Arthroplasty Smart score, °, degrees; OA, osteoarthritis

spite TSA, fatty degeneration of the RTC has been reported to occur, resulting in age-related RTC dysfunction, leading to poor outcomes, decreased ROM, and poor patient satisfaction following TSA (Edwards et al. 2002). In addition, glenoid component loosening has been reported to occur at long-term follow-up (Evans et al. 2021; McLendon et al. 2017), associated with decreased PROM scores (B. S. Schoch, Wright, Zuckerman, et al. 2019) leading to high rates of reoperations.³² Specifically, Evans et al (Evans et al. 2021). reported that 40 patients undergoing 44 TSA procedures, glenoid loosening was seen in all patients at 20-year follow-up, while secondary RTC dysfunction occurred in approximately 73% of patients. As such, while TSA continues to represent the traditional implant of choice for patients with glenohumeral OA with a functional RTC, RSA may help minimize complications associated with TSA implants, however further studies with long-term follow-up are warranted to determine the incidence of complications secondary to glenoid loosening and RTC dysfunction following RSA in these patients.

No significant difference in PROs, based on SST, ASES, SAS and UCLA scores, were appreciated in patients undergoing RSA for RCA versus glenohumeral OA with an intact RTC. This finding is comparable to outcomes reported in prior studies comparing outcomes based on indications for RSA. Steen et al (Steen, Cabezas, Santoni, et al. 2015). examined 24 consecutive patients undergoing RSA for glenohumeral OA with an intact RTC secondary to persistent posterior subluxation or improper glenoid seating, matched against 96 patients undergoing anatomic TSA. The authors reported no significant difference in ROM, functional outcomes, or revision rates, with a higher incidence of glenoid component loosening radiographically following TSA. Meanwhile, Kirsch et al (Kirsch, Puzzitiello, Swanson, et al. 2022). reported no significant differences in Visual Analogue Pain scale (VAS), ASES, or Single Assessment Numeric Evaluation (SANE) scores when comparing 134 patients matched based on age, sex, BMI, preoperative ASES, active forward elevation, and Walch glenoid morphology undergoing RSA for glenohumeral OA without RTC tearing (n= 67 patients) versus RCA (n=67 patients) at minimum 2-year follow up. The authors also reported no significant differences in complication rates between TSA and RSA pa-

tients. Furthermore, Saini et al (Saini, Pettit, Puzzitiello, et al. 2022). demonstrated that patients with OA and intact RTC (n=198 patients) had significantly improved active range of motion (forward flexion, internal rotation, external rotation) and postoperative-outcome scores (SANE, ASES, and VAS) when compared to patients with RCA (n=113 patients) at a minimum 2-year follow-up. In addition, 97.5% of patients in the glenohumeral OA group met the minimally clinically important difference (MCID) for ASES (versus 86.7% with RCA; $p<0.01$). Furthermore, 90.4% of patients in the glenohumeral OA group met the substantial clinical benefit (SCB) for ASES compared to 71.7% in the RCA group ($p<0.01$). As such, multiple investigations have reported favorable clinical and functional outcomes in patients undergoing RSA for glenohumeral OA with an intact RTC, demonstrating the role of RSA as a viable alternative to TSA in this patient population. While our study effectively compares RSA outcomes between patients with intact RTC and those with RCA, including a third cohort undergoing traditional anatomic TSA could offer additional comparative insights. Future research incorporating traditional TSA patients would help clarify the relative benefits of RSA versus TSA for individuals with glenohumeral OA and an intact RTC.

Complications were reported in two patients. One patient (2.8%) with glenohumeral OA and an intact rotator cuff experienced dislocation, while another patient with RCA (1.4%) required revision reverse shoulder arthroplasty due to infection. Fisher's exact test indicated no statistically significant difference in complication rates between the groups ($p = 1.000$). McFarland et al (McFarland et al. 2016). observed that in 42 consecutive patients with primary glenohumeral OA and an intact RTC with severe glenoid bone loss undergoing RSA with a mean follow-up of 36 months, baseplate loosening was appreciated in only 2% (n=1) of patients, while notching was observed in 19% (n=8) of patients. Meanwhile, in their retrospective review of 27 RSA procedures performed for glenohumeral OA without RTC tearing with a B2 glenoid and mean follow-up of 54 months, Mizuno et al (Mizuno et al. 2013). observed complications in 15% (n=4) of patients. These complications consisted of postoperative nerve palsies complications (n=3) and glenoid component loosening (n=1). While

complications appear to be low in reported studies, the potential for glenoid component loosening remains a concern, and further long-term studies are required to better understand the durability of these components..

In contrast, other investigations have reported the presence of an intact RTC to contribute to inferior outcomes following RSA. Namely, Werner et al (Werner, Wong, Mahony, et al. 2016). reported in their prospectively collected evaluation of a shoulder arthroplasty registry that in patients undergoing RSA with minimum two-year follow-up, the presence of an intact RTC was associated with poor postoperative improvement, along with male sex, depression, higher baseline ASES score, and a higher total number of medical comorbidities. The presence of an intact RTC may suggest greater preoperative function, limiting the potential of patients to achieve greater postoperative satisfaction following RSA compared to patients without a functional RTC. While no studies have evaluated outcomes following RSA in patients with glenohumeral OA with an intact RTC based on cuff integrity, RSA effectively obviates the need for a functional RTC based on component design, making RSA a viable option in patients with glenohumeral OA and an intact, but potentially insufficient or weakened RTC at high risk for further dysfunction and tearing (Wright, Keener, and Chamberlain 2020).

Our study has several limitations that should be acknowledged. First, the retrospective design introduces the

potential for selection bias; however, we mitigated this by using a well-defined cohort and applying strict inclusion and exclusion criteria. Second, the relatively small sample size may limit the generalizability of the findings. Despite this, our results are consistent with existing literature, supporting their validity. Additionally, all surgeries were performed by a single, experienced surgeon at a single institution, which may limit the applicability of the findings to other settings. Nevertheless, this consistency in surgical technique and follow-up care enhances the internal validity of our results. Lastly, the short-term follow-up may not capture long-term outcomes, yet the study provides valuable early postoperative insights that are critical for immediate clinical decision-making.

CONCLUSION

Patients undergoing RSA for glenohumeral OA without rotator cuff pathology reported comparable patient reports outcomes and ROM values at a minimum 2-year follow-up compared to patients indicated for RSA secondary to RCA.

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