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Predictors of poor and excellent outcomes following reverse shoulder arthroplasty for glenohumeral osteoarthritis with an intact rotator cuff

Abdulaziz F. Ahmed, MD[a], Evan A. Glass, BS[b,c], Daniel P. Swanson, BS[b,c], James Patti, BS[d], Adam R. Bowler, BA[b,c], Kiet Le, PA-C[b,c], Andrew Jawa, MD[c], Jacob M. Kirsch, MD[c,*]

[a]*Department of Orthopaedic Surgery, Harvard Medical School, Massachusetts General Hospital, Boston, MA, USA*
[b]*Boston Sports and Shoulder Research Foundation, Waltham, MA, USA*
[c]*Department of Orthopaedic Surgery, New England Baptist Hospital, Boston, MA, USA*
[d]*Tufts University School of Medicine, Boston, MA, USA*

Background: As the indications for reverse total shoulder arthroplasty (RSA) continue to evolve, it has been more commonly utilized for the treatment of glenohumeral osteoarthritis with an intact rotator cuff (GHOA). Given the increased use of RSA for GHOA, it is important to identify factors influential of clinical outcomes. In this study, we sought to identify variables predictive of clinical outcomes following RSA for GHOA.

Methods: Patients undergoing primary RSA for GHOA between 2015 and 2020 were retrospectively identified through a prospectively maintained, single surgeon registry. Eligible patients had complete patient-reported outcome measures and range of motion measurements with a minimum 2-year follow-up. Univariate analysis was utilized to compare characteristics and outcome measures of patients with poor and excellent outcomes, which was defined as postoperative American Shoulder and Elbow Surgeons (ASES) scores in the bottom and top quartiles, respectively. Multivariate linear regression was performed to determine factors independently predictive of postoperative ASES score.

Results: A total of 230 patients were included with a mean follow-up of 33.4 months (SD 13.2). The mean age of the study population was 71.9 (SD 6.1). Two hundred twenty-four patients (97.4%) surpassed the minimal clinically important difference and 209 patients (90.1%) achieved substantial clinical benefit for ASES score. Preoperative factors differing between the poor and excellent outcome groups were sex (male: poor 37.9%, excellent 58.6%; $P = .041$), opioid use (poor 24.1%, excellent 5.2%; $P = .009$), ASES score (poor 32.9, excellent 41.0; $P = .011$), and forward elevation (poor 92°, excellent 101°; $P = .030$). Linear regression demonstrated that Walch B3 glenoids (β 7.08; $P = .010$) and higher preoperative ASES scores (β 0.14; $P = .025$) were predictors of higher postoperative ASES score, while postoperative complications (β −18.66; $P < .001$) and preoperative opioid use (β −11.88; $P < .001$) were predictive of lower postoperative ASES scores.

Conclusion: Over 90% of patients who underwent RSA for GHOA with an intact rotator cuff experienced substantial clinical benefit. An unsurprising handful of factors were associated with postoperative clinical outcomes; higher preoperative ASES scores were slightly

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*Reprint requests: Jacob M. Kirsch, MD, 840 Winter St, Waltham, MA 02451, USA.
E-mail address: jmkirschmd@gmail.com (J.M. Kirsch).

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associated with higher postoperative ASES, whereas preoperative opioid use and postoperative complications were associated with lower postoperative ASES. Additionally, Walch glenoid type B3 was associated with higher postoperative ASES, indicating that patients with posterior glenoid defects are not predisposed to poor clinical outcomes following RSA. These results serve as a resource to improve preoperative patient counseling and manage postoperative expectations.

Level of evidence: Level III; Retrospective Cohort Comparison; Prognosis Study

Keywords: Reverse total shoulder arthroplasty; glenohumeral osteoarthritis; outcomes; predictors; patient-reported outcomes measures; Walch

The utilization of primary shoulder arthroplasty in the United States has increased substantially, largely driven by the increased use of reverse total shoulder arthroplasty (RSA). RSA increased by 191.3% between 2011 and 2017 compared to an increase of 38.5% in anatomic total shoulder arthroplasty (TSA) during the same period.[8] The surge in RSA procedures is multifactorial, however, largely secondary to the expansion of surgical indications. Initially, RSA was reserved for massive irreparable rotator cuff tears and cuff tear arthropathy[2,5]; however, indications for RSA have expanded to include those not originally approved by the FDA, including glenohumeral osteoarthritis with intact rotator cuff (GHOA),[14] proximal humerus fractures,[23] instability arthropathy,[8] and revision for failed arthroplasty. Although TSA has historically been the gold standard treatment for GHOA, postoperative rotator cuff failure and glenoid component loosening still continue to be problematic and may make some surgeons more likely to consider RSA in the setting of GHOA.[4,18]

Since being integrated as a common treatment option for GHOA, the RSA has led to substantial postoperative improvement in pain and function for the vast majority of patients, comparable to that of the TSA.[14,19,25,27,34] There is still considerable pushback in equating the outcomes of RSA to TSA, though the referenced evidence often originates from studies that fail to differentiate between preoperative diagnoses for RSA.[3,11,31] Recent studies have distinguished GHOA as an indication that reliably yields significantly better outcomes compared to other indications, including arthropathies related to rotator cuff insufficiency. A recent study by Forlizzi and colleagues found that a primary diagnosis of GHOA was the strongest predictor of excellent outcomes after RSA when compared to other diagnoses.[12] In addition, Saini and colleagues demonstrated superior clinical outcomes after RSA when treated for GHOA compared to rotator cuff arthropathy.[26] Furthermore, a lower revision rate was reported by Brown et al for patients in the Australian Orthopaedic Association National Joint Replacement Registry who underwent RSA for GHOA compared to other diagnoses.[6]

Patients with GHOA differ from those with rotator cuff deficiencies and should be studied separately. Given the exponential growth in RSA utilization for GHOA, it becomes increasingly important to elucidate the predictors of poor and excellent outcomes. In this study, we sought to determine which factors are predictive of postoperative clinical outcomes after primary RSA in patients with GHOA. The primary outcome studied was postoperative ASES score, whereby factors were assessed based on their influence of this clinical outcome metric.

Methods

Patient selection

This retrospective cohort study utilized a prospectively maintained surgical outcomes database (OBERD, Columbia, MO, USA) with a 75% follow-up at 2 years after surgery to identify patients who underwent primary RSA for GHOA between September 2015 and July 2020. Inclusion criteria consisted of a primary diagnosis of GHOA with an intact rotator cuff, the procedure being a primary shoulder arthroplasty, a minimum follow-up of 2 years, and complete preoperative and postoperative PROMs and ROM measurements. Patients were excluded if they underwent RSA for any other indication (ie, proximal humerus fracture, rotator cuff arthropathy, massive irreparable rotator cuff tear, instability arthropathy, avascular necrosis, postcapsulorrhaphy arthropathy, or revision arthroplasty), had previously undergone ipsilateral shoulder arthroplasty surgery, or were lacking complete preoperative and postoperative outcomes.

Surgical technique

All procedures were performed by the senior author (A.J.). A deltopectoral approach was taken in all cases. A subscapularis peel was performed and repaired when possible prior to closure in all patients. The rotator cuff was assessed intraoperatively through direct visual assessment to confirm integrity in all cases, and the supraspinatus was kept in continuity when possible. The same reverse total shoulder arthroplasty system was used in all cases (AltiVate Reverse; DJO Surgical, Austin, TX, USA), though component sizing differed based on patient anatomy. Glenospheres ranged from 32 to 40 mm in diameter with a center-of-rotation lateralized by 2 – 10 mm. A standard-length, uncemented, inlay humeral component with a 135° neck-shaft angle was used in all cases. Bone grafts were not indicated or used for any patients. Following surgery, all patients followed an at-home physician-directed rehabilitation protocol. Shoulder range of motion was restricted using an immobilizer for 2 weeks after surgery. Active and active-assisted forward flexion began after 2 weeks and

external and internal rotation were permitted after 6 weeks. Strengthening and a progressive return to activities were typically permitted after 3 months.

Study variables

Patient characteristics included age, sex, body mass index, the American Society of Anesthesiologists comorbidity score, prior ipsilateral nonarthroplasty shoulder surgery, history of diabetes mellitus, hypertension, hyperlipidemia, thyroid disease, depression, daily opiate use, and the presence of rheumatoid or inflammatory arthritis.

PROMs included the visual analog scale (VAS) for pain, the Single Assessment Numerical Evaluation for the shoulder, and the American Shoulder and Elbow Surgeons (ASES) score. Active ROM measurements included forward flexion, external rotation at the side, and internal rotation up the back. Forward flexion and external rotation were measured with a traditional goniometer by the senior author (A.J.). Internal rotation was measured on a 10-point scale based on the uppermost vertebrae reached by the patient's thumb of the examined arm, as first proposed by Levy et al: 2 points for buttock or greater trochanter, 4 points for sacrum to L4, 6 points for L3 to L1, 8 points for T12 to T8, and 10 points for T7 to T1.[16]

Postoperative complications recorded prospectively included instances of infection, instability, nerve injury, acromial stress fracture, scapular notching, persistent pain, and the need for revision surgery.

Statistical analysis

The primary clinical outcome measured was postoperative ASES score at a minimum of 2 years after surgery. Patients with postoperative ASES scores in the top quartile were categorized as having excellent outcomes, and those with postoperative ASES scores in the bottom quartile were categorized as having poor outcomes.

Descriptive statistics were performed on the entire study population to find means and standard deviations (SD), medians and interquartile ranges, or proportions and frequencies of all demographic and clinical data collected. A univariate analysis was then performed to compare demographic and clinical outcome data between the group of excellent outcomes and the group of poor outcomes. Depending on the distribution of data, the unpaired t-test or Mann-Whitney U-test was used for continuous variables and Fisher's exact test or chi-squared test was used for categorical variables.

A multivariate linear regression was conducted to test for independent association between patient demographics/clinical outcomes and a higher postoperative ASES score. Outcomes of this analysis were given as β-coefficients with 95% confidence intervals (CI). Better and worse outcomes, as used throughout the text, refers to higher and lower postoperative ASES scores, respectively. These terms are not synonymous with excellent and poor outcomes as previously described as they are not quartile-based but instead are used when discussing the results of the multivariate linear regression with the dependent variable being postoperative ASES score.

All differences between groups were noted as statistically significant if $P < .05$. All statistical analyses were performed using R statistical software (version 4.2.1; R Foundation for Statistical Computing, Vienna, Austria).

Results

Patient baseline characteristics and preoperative outcome data

The final cohort included 230 patients who underwent primary RSA for GHOA with a mean follow-up duration of 33.4 months (SD 13.2). The mean age was 71.9 years (SD 6.1) with females comprising 57.8% of all patients. 15.2% of patients had undergone an ipsilateral nonarthroplasty shoulder surgery in the past. The incidence of various comorbidities within the study cohort are given in Table I.

Postoperatively, the mean ASES score was 87.8 (SD 14.4) and the mean Single Assessment Numerical Evaluation score was 91.1 (SD 12.4). The median VAS pain score was 0.0 (interquartile ranges 0.0-1.0). Two hundred twenty-four patients (97.4%) surpassed the minimal clinically important difference and 209 patients (90.1%) achieved substantial clinical benefit (SCB) for ASES score, as defined by Simovitch et al as an increase of 10.3 and 25.9, respectively.[28,29] Cohort-wide baseline PROMs and ROM are provided in Table I.

Univariate analysis comparing poor and excellent outcome subcohorts

Patients were stratified into quartiles based on postoperative ASES scores. Patients in the top quartile were classified as "excellent," and patients in the bottom quartile were classified as "poor." Factors associated with excellent outcomes were male sex ($P = .041$), higher preoperative ASES score ($P = .009$), higher preoperative forward flexion ($P = .030$), lower postoperative VAS pain score ($P < .001$), higher postoperative forward flexion ($P < .001$, respectively), and higher postoperative external rotation ($P = .004$). The only factor associated with poor outcomes was preoperative opioid use ($P = .009$). Factors that were not significantly different between poor and excellent groups ($P > .05$) included age, BMI, insurance type, glenoid wear pattern, comorbidities, American Society of Anesthesiologists score, prior ipsilateral nonarthroplasty shoulder surgery, preoperative VAS pain score, preoperative external rotation, and postoperative complications (Table II).

Multivariate analysis: predictors of postoperative ASES score

After adjustment with multivariate linear regression, preoperative ASES score ($\beta = 0.14$; CI 0.02, 0.26; $P = .025$) or a B3 Walch classification ($\beta = 7.08$, CI 1.71, 12.45; $P = .010$) were

Table I Baseline demographic and clinical data

Parameter	Data (n = 230)
Age (yr)	71.9 ± 6.1
Sex	
Female	133 (57.8)
Male	97 (42.2)
Insurance type	
Medicare or Medicaid	152 (66.1)
Private	73 (31.7)
Workers' compensation	5 (2.2)
Follow-up period (mo)	33.4 ± 13.2
Walch	
A1	47 (20.4)
A2	29 (12.6)
B1	14 (6.1)
B2	66 (28.7)
B3	62 (27.0)
C	5 (2.2)
D	7 (3.0)
BMI	30.8 ± 6.5
ASA class	
1	7 (3.0)
2	169 (73.5)
3	54 (23.5)
4	0
Comorbid conditions	
Depression	60 (26.1)
Diabetes	42 (18.2)
Obesity	104 (45.2)
Smoking status	
Never	104 (45.2)
Former	117 (50.9)
Current	9 (3.9)
HTN	142 (61.7)
HLD	103 (44.8)
Thyroid disease	43 (18.7)
Rheumatoid arthritis or inflammatory arthritis	6 (2.6)
Previous ipsilateral shoulder surgery	35 (15.2)
Preoperative opioid use	29 (12.6)
VAS pain score	
Preoperative	5.7 (4.0, 7.4)
Postoperative	0.0 (0.0, 1.0)
Δ	−5.0 (−7.0, −3.6)
ASES score	
Preoperative	37.2 ± 16.4
Postoperative	87.8 ± 14.4
Δ	50.5 ± 19.3
MCID reached	224 (97.4)
SCB reached	209 (90.9)
SANE score	
Preoperative	30.0 ± 21.1
Postoperative	91.1 ± 12.4
Δ	61.1 ± 23.9
Forward flexion	
Preoperative	92 ± 26
Postoperative	140 ± 16
Δ	29 ± 20
External rotation	
Preoperative	26 ± 14
Postoperative	55 ± 17
Δ	48 ± 28
Internal rotation*	
Preoperative	0.0 (0.0, 2.0)
Postoperative	2.0 (2.0, 6.0)
Δ	2.0 (1.0, 4.0)
Postoperative complication	7 (3.0)

BMI, body mass index; *ASA*, American Society of Anesthesiologists; *HTN*, hypertension; *HLD*, hyperlipidemia; *VAS Pain*, visual analog scale for pain; *SANE*, Single Assessment Numerical Evaluation; *ASES*, American Shoulder and Elbow Surgeons score; *MCID*, minimal clinically important difference; *SCB*, substantial clinical benefit.

$x \pm s$ denotes mean and standard deviation; *m (1Q, 3Q)* denotes median and interquartile range; *n (%)* denotes count and frequency.

* Internal rotation was measured on a 10-point scale based on the uppermost vertebrae reached by the patient's thumb of the examined arm, as first proposed by Levy et al[19]: 2 points for buttock or greater trochanter, 4 points for sacrum to L4, 6 points for L3 to L1, 8 points for T12 to T8, 10 points for T7 to T1.

predictors of higher postoperative ASES score, and having postoperative complications (β = −18.66; CI −28.92, −8.4; $P < .001$) or preoperative opioid use (β = −11.88; CI 221217.47, −6.3; $P < .001$) were predictors of lower postoperative ASES score. There were no other factors that were predictive of postoperative ASES score (Table III).

Complications

There were 4 postoperative complications noted in the study population. One patient had onset of persistent pain in their operative shoulder starting 21 months after surgery. This patient had underlying inflammatory arthritis and experienced similar pain in various other joints. No further shoulder surgery was indicated. One patient developed postoperative pneumonia and was subsequently treated successfully. One patient had a radial nerve injury associated with surgery, which had fully recovered by their 6-month postoperative visit without further treatment. One patient was noncompliant with the rehabilitation protocol and was diagnosed with a greater tuberosity fracture in their operative shoulder at their 2-week postoperative visit, though the nature of the injury is unknown. This was treated nonoperatively with sling use and healed successfully.

Discussion

This study demonstrates that preoperative opioid use and developing a postoperative complication may be significant

predictors for having poorer outcomes after RSA when performed for GHOA, whereas a higher preoperative ASES score and glenoid with Walch B3 type may be significant predictors of better outcomes. Certain other parameters varied between patients with poor and excellent outcomes on univariate analysis, including sex and preoperative forward flexion, but were not statistically significant in multivariate analysis. It is also important to acknowledge the parameters that did not affect outcomes adversely, such as patients' age, BMI, insurance type, comorbid conditions, and prior ipsilateral surgery. These findings, combined with over 90% of patients achieving SCB, underscore the overwhelming success of RSA for the treatment of GHOA. Given the growing popularity of treating GHOA with RSA, these results serve to inform surgeon decision-making and impact preoperative counseling.

Although preoperative ASES scores were predictive of postoperative ASES scores in this study, prior findings have indicated no association between the two when analyzing data from a cohort of mixed indications.[12] Other studies in shoulder arthroplasty have reported a significant association between preoperative and postoperative scores. In a retrospective study by Martin et al on 352 RSAs, preoperative ASES scores below 54 were significantly predictive of lower postoperative scores.[17] Wong et al has demonstrated that patients with preoperative ASES pain and function at the lowest quintiles had the lowest postoperative scores compared with patients at the top quintiles.[33] Both aforementioned studies found that patients with the lowest preoperative ASES scores achieved minimal clinically important differences and SCB s at a higher rate, whereas those with higher preoperative ASES scores could not attain clinically important values due to a ceiling effect.

The Walch glenoid type B3 seemed to be predictive of greater postoperative ASES scores when compared to type A1 glenoid. This suggests that RSA achieves improved outcomes even in substantial posterior glenoid wear without the need for augments or glenoid bone grafting. Similarly, several studies have reported significant improvement in functional outcomes for advanced glenoid deformities after RSA for GHOA. Mizuno et al demonstrated that RSA resulted in excellent functional outcomes and ROM at a mean follow-up of 44 months when performed for GHOA with severe retroversion and posterior subluxation without cuff insufficiency.[20] Collin et al reported similar excellent improvement after RSA for GHOA with posterior glenoid deficiency and humeral subluxation with intact cuff at a minimum follow-up of 5 years.[9] In a prior study by Pettit et al comparing the outcomes of RSA for GHOA with intact cuff demonstrated excellent short-term improvement in outcomes regardless of the severity of preoperative glenoid deformity.[24] Despite the abundance of literature demonstrating positive results following RSA in patients with posterior glenoid defect, the outcome superiority that we found in patients with a B3 glenoid relative to the reference (type A1) still appears odd. These findings may be attributed to certain demographic differences between patients in our study cohort with B3 versus other Walch types that were not included in the analysis due to a limited number of degrees of freedom. However, the important finding here is that patients with severe posterior glenoid erosion (type B3) do not experience worse outcomes than patients with only concentric erosion (type A2) or no erosion at all (type A1).

Preoperative opioid use has been reported numerously as a significant predictor of poor patient-reported outcomes, which is supported by our results. This issue is potentially multifactorial and reliant on opioid tolerant patients' expectations and pain levels. In a study on 68 RSAs performed for cuff tear arthropathy, opioid tolerant patients yielded significantly worse postoperative ASES and Constant scores compared to opioid naïve patients.[21] In a retrospective analysis on 264 primary RSAs for various indications, preoperative opioid use was a significant predictor of inferior ASES scores and ROM compared to opioid naïve patients.[1] Likewise, in a prior study by Carducci and colleagues, preoperative opioid use was associated with inferior ASES scores for patients who underwent RSA for various indications.[7] Another significant negative predictor of postoperative outcomes after RSA for intact cuff was developing a postoperative complication, which is unsurprising as such complications would lead to pain and stiffness, and impede the expected recovery from surgery.

In terms of prior ipsilateral non-arthroplasty shoulder surgery, we found no significant association with either excellent or poor outcomes after RSA for primary GHOA. Likewise, Erickson et al reported in a matched cohort study that prior rotator cuff repair was not associated with poor patient-reported outcomes after RSA at a follow-up of 2 and 5 years.[10] In contrast, Forlizzi et al found that prior shoulder surgery was associated with a 2.7x risk of poor clinical outcomes following RSA for mixed indications.[12] Interestingly, a study on 2217 patients from the Danish Shoulder Arthroplasty Registry found prior rotator cuff surgery to be a significant predictor of revision due to periprosthetic joint infection at 14 years of follow-up.[13] Our current study involves patients with a single indication – GHOA with an intact rotator cuff – while previous studies were heterogenous in indication. Therefore, prior shoulder surgery likely plays a larger role in patients with indications other than GHOA. However, the proportion of patients in our sample who underwent previous shoulder surgery was low (15.2%) and therefore may not accurately represent its effect on final outcome.

When evaluating the current literature, the effect of patients' sex on the outcomes of RSA has been reported with mixed results. In our current study, multivariate analysis revealed that patient sex did not affect outcomes after RSA for GHOA. Likewise, Forlizzi et al demonstrated that females were not associated with worse outcomes after receiving RSA for mixed indications at a minimum follow-up of 2 years.[12] In contrast, Wong et al reported in a

Table II Univariate comparison between patients with poor outcomes and those with excellent outcomes

Parameter	Top quartile (n = 58)	Bottom quartile (n = 58)	*P* value
Preoperative factors			
Age (yr)	71.3 ± 5.8	71.3 ± 6.9	.988
Male sex	34 (58.6)	22 (37.9)	.041*
Insurance type			
Medicare or Medicaid	36 (62.1)	35 (60.3)	>.999
Private	20 (34.5)	20 (34.5)	
Workers' compensation	2 (3.4)	3 (5.2)	
Walch			
A1	6	16	.140
A2	11	8	
B1	5	3	
B2	17	16	
B3	17	10	
C	1	1	
D	1	4	
BMI	30.4 ± 7.1	32.0 ± 6.7	.245
ASA class >2	14 (24.1)	16 (27.6)	.832
Comorbid conditions			
Depression	9 (15.5)	19 (32.8)	.051
Diabetes	12 (20.7)	13 (22.4)	>.999
Obesity	24 (41.4)	31 (53.4)	.265
Smoking status			
Never	25 (43.1)	29 (50.0)	.727
Former	30 (51.7)	27 (46.6)	
Current	3 (5.2)	2 (3.4)	
HTN	36 (62.1)	40 (69.0)	.558
HLD	27 (46.6)	22 (37.9)	.452
Thyroid disease	8 (13.8)	12 (20.7)	.461
Rheumatoid or inflammatory arthritis	2 (3.4)	1 (1.7)	>.999
Previous ipsilateral shoulder surgery	4 (6.9)	10 (17.2)	.154
Preoperative opioid use	3 (5.2)	14 (24.1)	.009*
Preoperative VAS pain score	5.5 (4.0, 7.7)	6.3 (5.0, 8.0)	.101
Preoperative ASES score	41.0 ± 17.2	32.9 ± 16.4	.011*
Preoperative forward flexion	101 ± 25	92 ± 22	.030*
Preoperative external rotation	29 ± 15	28 ± 12	.618
Postoperative factors			
Postoperative VAS pain score	0.0 (0.0, 0.0)	2.0 (0.0, 3.0)	<.001*
Postoperative forward flexion	147 ± 12	132 ± 19	<.001*
Postoperative external rotation	59 ± 15	50 ± 17	.004*
Postoperative complication	1 (1.7)	5 (8.6)	.206

BMI, body mass index; *ASA*, American Society of Anesthesiologists; *HTN*, hypertension; *HLD*, hyperlipidemia; *VAS Pain*, visual analog scale for pain; *ASES*, American Shoulder and Elbow Surgeons score.

$x \pm s$ denotes mean and standard deviation; *m (1Q, 3Q)* denotes median and interquartile range; *n (%)* denotes count and frequency.

* Denotes statistical significance with alpha risk at 0.05.

prospective study on 117 patients who underwent RSA that women had significantly lower ASES scores ($P = .009$) and Short Form 12 Physical Component scores ($P = .008$) when compared to men.[32] Likewise, Friedman et al reported worse postoperative outcomes scores in women after RSA for mixed indications at an average follow-up of 37 months. In a multicenter study of 2364 patients and a mean follow-up of 45.9 months, In contrast, Okohora et al reported that woman had greater improvement in ASES and Simple Shoulder Test scores when compared to men.[22] Unlike the aforementioned studies, our study isolates the outcomes of RSA in patients with primary GHOA. Thus, this study provides insight on the lack of association between patient-reported outcomes and patients' sex with greater internal validity in this subset of patients.

In terms of insurance type, our study did not find any association with excellent or poor outcomes after RSA for primary GHOA regardless of the type of insurance. It is

Table III Multivariate linear regression: predictors of postoperative ASES score

Parameter	ß coef (95% CI)	*P* value
Age	0.07 (−0.25, 0.40)	.668
Female sex	−0.30 (−4.21, 3.61)	.880
Walch classification (Ref = A1)		
A2	3.82 (−2.50, 10.13)	.235
B1	5.75 (−2.35, 13.84)	.163
B2	5.00 (−0.18, 10.19)	.059
B3	**7.08 (1.71, 12.45)**	**.010***
C	4.80 (−8.04, 17.63)	.462
D	−1.51 (−12.78, 9.76)	.792
Insurance type (Ref = Medicare/ Medicaid)		
Private insurance	−0.49 (−4.51, 3.52)	.808
Workers' compensation	−5.87 (−18.36, 6.62)	.355
BMI	−0.01 (−0.33, 0.31)	.967
ASA score >2	−0.63 (−5.27, 4.02)	.791
Smoking status (Ref = Never)		
Former	2.53 (−1.13, 6.20)	.174
Current	7.26 (−2.28, 16.80)	.135
Has diabetes	−0.63 (−5.50, 4.24)	.798
Rheumatoid or inflammatory arthritis	5.12 (−6.35, 16.59)	.380
History of prior shoulder surgery	−1.98 (−7.06, 3.10)	.444
Preoperative opioid use	**−11.88 (-17.47, -6.30)**	**<.001***
Preoperative ASES	**0.14 (0.02, 0.26)**	**.025***
Preoperative forward flexion	0.02 (−0.07, 0.10)	.725
Preoperative external rotation	−0.05 (−0.20, 0.09)	.464
Postoperative complication	**−18.66 (-28.92, -8.40)**	**<.001***

CI, confidence interval; *BMI*, body mass index; *ASA*, American Society of Anesthesiologists; *ASES*, American Shoulder and Elbow Surgeons score.

* Denotes statistical significance with alpha-risk at 0.05.

important to note that we only had 5 cases with workers' compensation which hinders any conclusion for this insurance type. Sabesan et al reported in a case-controlled study of 203 patients that insurance type did not significantly impact outcomes after shoulder arthroplasty performed by a single-surgeon. However, prior studies have reported inferior results for patients with Medicaid/Medicare insurance and workers' compensation. In a study on 491 shoulder arthroplasties, Medicare-insured patients had lower postoperative ASES scores compared to other insurance types.[15] Another study with 91 shoulder arthroplasty procedures reported that patients with Medicaid and workers' compensation patients had significantly lower ASES scores when compared to privately insured patients.[30] Likewise, Forlizzi and colleagues demonstrated patients with private insurance were associated with excellent clinical outcomes after RSA for mixed indications.[12] Such mixed findings indicate a multifactorial basis for RSA outcomes and a potentially confounded effect of insurance type. Nonetheless, our current results aid in counseling patients with isolated GHOA when discussing RSA.

This study has several strengths. To the best of our knowledge, this is the first study to evaluate the predictors of RSA outcomes in a sample of patients homogenous with a GHOA diagnosis. Moreover, the sample drew from a consecutive series of patients with a high degree of follow-up (75%). In addition, all preoperative and postoperative variables and outcome measures were collected prospectively. All procedures were performed by a single shoulder and elbow fellowship-trained surgeon, in turn reducing the effect of technical variation and improving data validity. To eliminate confounding variables, we have employed univariable and multivariable analyses.

However, this study is not without limitations. This study reflects a single surgeon experience, which introduces a sampling bias and limits the generalizability of our results to other surgeons and institutions. Furthermore, the nature of a retrospective chart review and analysis may have introduced a selection bias, although the data were extracted from a prospectively maintained database. The prospectively maintained database relies on patient cooperation to schedule and attend clinical follow-ups at a minimum of 2 years. However, the largely excellent outcomes in patients undergoing RSA for GHOA has led to clinical follow-up attrition, limiting this study's follow-up rate to 75% and slightly decreasing the reliability of our data. Lastly, our statistical analysis was performed without correcting for multiple comparisons, which may be recommended in analyses that include a large quantity of comparisons to avoid significant findings due to chance. However, in this level III, retrospective study, we feel that the exploratory nature of our analyses precludes the need for these corrections. We offer these exploratory investigations as considerations for which factors may influence different outcomes, aside from our direct hypothesis. Exploratory statistics present opportunities for future hypothesis testing. We feel the purpose of these investigatory analyses are to provide additional thought and potentially lead to future, properly controlled-for studies.

Conclusion

Few factors truly impacted the clinical outcomes of patients undergoing RSA for GHOA in this study, with over 90% of patients experiencing SCB. However, in this preliminary data set, a handful of factors seemed to

be associated with postoperative clinical outcomes on multivariate analysis; higher preoperative ASES score was associated with better clinical outcomes, and preoperative opioid use and postoperative complication are associated with worse clinical outcomes. Additionally, Walch glenoid type B3 was associated with better clinical outcomes, which indicates that patients with severe posterior glenoid erosion are not predisposed to a worse prognosis after RSA. These preliminary results serve as a resource to conduct well designed studies to investigate the effects of these features to improve preoperative patient-counseling and manage postoperative expectations.

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