Preoperative Single Assessment Numeric Evaluation Score Predicts Poor Outcomes After Reverse Shoulder Arthroplasty for Massive Rotator Cuff Tears Without Arthritis

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abstract

Limited clinical evidence is available to help to predict poor outcomes after reverse shoulder arthroplasty (RSA) among patients with massive rotator cuff tears without glenohumeral arthritis. A retrospective case-control study was performed for patients who underwent RSA for massive rotator cuff tear without glenohumeral arthritis (Hamada score ≤3) and had a minimum of 2 years of follow-up. Preoperative risk factors for poor outcomes were subsequently analyzed. Sixty patients (mean age, 71.4±7.4 years) met the inclusion criteria. Of these, 18 (30%) patients had poor outcomes (case group). The case group had significantly worse postoperative Single Assessment Numeric Evaluation (SANE) (61.6±29.5 vs 84.9±14.1, respectively; *P*=.002), American Shoulder and Elbow Score (58.9±22.5 vs 82.2±14.2, respectively; *P*<.001), and Simple Shoulder Test (5.4±3.6 vs 8.5±2.4, respectively; *P*=.002) scores compared with the control group. **[AQ1: OK as edited?]** Patients with poor outcomes had significantly higher preoperative SANE scores compared with control subjects (40.4±28.4 vs 18.8±15.7, respectively;**[AQ2: OK?]** *P*=.021). The results of this study suggest that patients with better overall preoperative function, as represented by higher SANE scores, have a greater likelihood of poor functional outcomes after RSA for massive rotator cuff tears without glenohumeral arthritis. [*Orthopedics*. 202x;xx(x):xx-xx.] **[AQ3: Please add two or three sentences to the abstract.]**

Significant controversy exists regarding the management of patients with massive rotator cuff tears. Although massive tears in the setting of glenohumeral arthritis can be managed effectively with reverse shoulder arthroplasty (RSA),[1-5] no clear consensus exists on the management of massive rotator cuff tears without glenohumeral arthritis. Several nonoperative[6-8] as well as surgical options exist, including arthroscopic debridement,[9-11] partial repair,[12,13] tendon

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transfer,[14,15] superior capsular reconstruction,[16-18] subacromial balloon interposition,[19] and RSA.[20-23] Further, limited comparative evidence exists to stratify patients with massive rotator cuff tears without glenohumeral arthritis based on treatment and predictors of functional outcomes.

Clinical outcomes after RSA for massive rotator cuff tears are generally favorable; however, certain patients have inferior outcomes without an obvious reason.[21,24] Recent literature has attempted to identify risk factors for poor outcomes to help to guide clinical decision making.[20-23,25-27] Various definitions of poor outcomes,[23,26-29] coupled with substantial study heterogeneity, limit the clinical applicability of previously identified risk factors to help to predict poor outcomes after RSA for patients with massive rotator cuff tears without glenohumeral arthritis. Therefore, we sought to identify preoperative variables associated with poor outcomes after RSA. We hypothesized that better preoperative function, as identified by either patient-reported outcome scores and/or objective clinical data, would be associated with a higher likelihood of a poor clinical outcome.

Materials and Methods

A retrospective review of all patients undergoing primary RSA between 2012 and 2015 at a single institution with a minimum of 2-year follow-up was conducted after institutional review board approval was obtained (#20E.321).**[AQ8: Please identify this number.]** A total of 900 shoulder arthroplasty procedures (anatomic and reverse) with 2-year follow-up were reviewed to identify patients undergoing primary RSA. Similar to previous literature,[20,21,23] all patients were reviewed independently by 2 reviewers who were blinded to the outcome data, using the Hamada classification[30] to differentiate cuff tear arthropathy from massive rotator cuff tears without arthritis. Initial disagreement between the reviewers was resolved by consensus. The RSA procedure was indicated for patients who had persistent shoulder pain and dysfunction that did not respond to nonoperative treatment at the discretion of the treating surgeon. Operative reports were reviewed to confirm the deficient rotator cuff status at the time of RSA.

All procedures were performed by 8 fellowship-trained shoulder surgeons. Consistent with previous literature,[21,23] all patients who were identified as having radiographic changes consistent with Hamada score of 3 or less were included. Patients were excluded if they had previous ipsilateral shoulder infection, fracture, inadequate radiographs, previous shoulder surgery other than arthroscopy or rotator cuff repair, concomitant tendon transfer, or a neuropathic etiology of shoulder pathology. Electronic medical records were reviewed to collect data on baseline demographics, preoperative and postoperative range of motion, and postoperative complications. Patient-reported outcomes, including Single Assessment Numeric Evaluation (SANE), American Shoulder and Elbow Score (ASES), and Simple Shoulder Test (SST) scores, were prospectively recorded both preoperatively and at a minimum of 2 years postoperatively in an institutional database. Postoperative radiographs at final follow-up were evaluated to assess scapular notching and component loosening.[31]

A case-control analysis similar to that of Hartzler et al[23] was designed to identify risk factors for poor clinical outcomes after RSA for massive rotator cuff tears without glenohumeral arthritis (Hamada score ≤3). Various criteria have been used previously to define poor clinical outcomes after RSA, without a unanimously accepted standard.[23,26-28] Given the lack of unanimously accepted criteria for poor outcome, we included several definitions of poor outcome that have been previously reported in the literature, including a postoperative ASES score of less than 50,[28] change in ASES score of less than 12,[26] change in SST score of 1 or less,[23] postoperative active forward elevation of less than 90°,[25] and revision surgery. Additionally, Gowd et al[29] reported the minimal clinically important difference (MCID) in the SANE score after shoulder arthroplasty. Earlier studies by both Hartzler et al[23] and Werner et al[26] included failure to meet the MCID of a particular outcome as a criterion for poor outcome, and on this basis, we included a change in SANE score of less than 29 as an additional criterion for poor outcome after RSA. Patients who were identified as having at least 1 of the described criteria for poor outcome were defined as the cases, and the remainder of the patients served as control subjects.

Previous risk factors that have been either identified or previously investigated for patients with poor outcomes after RSA for massive rotator cuff tears without osteoarthritis were identified during study design. In addition to the association with patient-reported outcome scores (ASES, SST, and SANE),[23,26,27] we sought to identify whether an association existed between younger age (<60 years),[23] higher preoperative SST score (SST score ≥7),[23] preoperative active forward elevation greater than 90°,[21,22] and previous shoulder surgery[27,32,33] with inferior outcomes after RSA for massive rotator cuff deficiency.

Statistical Analysis

Descriptive statistics were determined and expressed as mean, range, standard deviation, and percentage. In comparing qualitative variables, chi-square analysis was undertaken when assumptions were met. Otherwise, Fisher's exact test was performed. Continuous variables were assessed with the Mann–Whitney *U* test because of the nonparametric nature of the data. Receiver operating characteristic analysis was performed to evaluate the SANE score as a discriminating threshold with poor outcomes. The area under the curve was used to define the sensitivity and specificity of the selected cutoff val-

ues. All statistical analysis was performed with the Statistical Package for the Social Sciences (SPSS), version 26 (IBM Corp). The alpha risk was set to 0.05 for all tests to estimate statistical significance.

Results

Sixty patients (mean age, 71.4±7.4 years) were included after application of the inclusion and exclusion criteria. Eighteen (30%) patients met the definition for poor outcome and defined the case group. Six of the 18 (33%) patients met multiple criteria for poor outcome, and the remainder of patients satisfied a single criterion for poor outcome (**Table 1**). Mean follow-up for the entire cohort was 30 months (range, 24-61 months), with no significant difference between groups (*P*=.654). Baseline demographics, including age, sex, body mass index, and Charlson Comorbidity Index, were similar between the groups (**Table 2**).

Patients in the poor outcome group showed inferior outcomes across all measures compared with the control group at a minimum of 2 years postoperatively. The case group had significantly worse postoperative SANE (61.6±29.5 vs 84.9 ±14.1, respectively; *P*=.002), ASES (58.9±22.5 vs 82.2±14.2, respectively; *P*<.001), and SST (5.4±3.6 vs 8.5±2.4, respectively; *P*=.002) scores. Further, compared with preoperative scores, the case group had a significantly worse change (Δ) in SANE (20.5±31 vs 66.1±19.6, respectively; *P*<.001), ASES (26.3±23.7 vs 49.7±18, respectively; *P*=.002), and SST (3.0±4.2 vs 6.2±2.5, respectively; *P*=.003) scores. **[AQ9: OK as edited?]** The mean change in ASES and SST scores for both groups exceeded the MCID, whereas only the mean change in SANE score for the control group exceeded the MCID (**Table 3**). Patients with poor outcomes had significantly higher preoperative SANE scores compared with control subjects (40.4±28.4 vs 18.8±15.7, respectively;**[AQ10: OK?]** *P*=.021). Therefore, receiver operating characteristic analysis was performed and showed preoperative SANE scores of greater than 33 to be significantly associated with poor functional improvement (*P*=.004), with a sensitivity of 60% and a specificity of 85%. The case group also had decreased postoperative active forward elevation compared with the control group; however, this difference was not statistically significant (113°±29° vs 145°±22°, respectively; *P*=.13).

Univariate analysis was performed to evaluate the association between preoperative risk factors and poor outcomes. No significant association was found between preoperative active forward elevation greater than 90°, age younger than 60 years, preoperative SST score of 7 or greater, and a history of previous shoulder surgery with poor outcomes (*P*>.05) (**Table 4**). There were no postoperative infections, nerve injuries, dislocations, incidences of component loosening, or baseplate failures in the entire cohort. One patient in the case group and 3 patients in the control group had an acromial stress fracture postoperatively. Scapular notching was observed among 7 patients (grade 1, 6 patients; grade 2, 1 patient), and only 1 of these patients was in the case group (grade 1).

Table 1

Distribution of Patients Based on Poor Outcome Criteria and Hamada Classification

	Hamada classification, No. **[AQT1: Need to add n value to each classification?]**		
Criteria	**1**	**2**	**3**
ASES <50	4 (22.2%)	1 (3.3%)	1 (8.3%)
ASES Δ <12	3 (16.7%)	1 (3.3%)	2 (16.7%)
SANE Δ ≤29	6 (33.3%)	4 (13.3%)	2 (16.7%)
SST Δ ≤1	4 (22.0%)	2 (6.7%)	1 (8.3%)
Revision surgery	0	0	0
AFE <90°	2 (11.1%)	1 (3.3%)	0

Abbreviations: AFE, active forward elevation; ASES, American Shoulder and Elbow Surgeons score; SANE, Single Assessment Numeric Evaluation score; SST, Simple Shoulder Test score; Δ, change.

Table 2

Baseline Demographics

Characteristic	Control subjects	Cases	*P*
No.	42	18	
Sex, female/male, No.	20/22	14/4	.031
Age, mean±SD, y	70.2±7.4	74.0±6.9	.141
Follow-up, mean**[AQT2: Correct?]** (range), mo	30 (24-61)	30 (24-53)	.654
Body mass index, mean±SD, kg/m^2	28.2±4.2	30.5±5.4	.107
Charlson Comorbidity Index, mean±SD	4.0±1.0	4.5±1.3	.265

Discussion

According to the criteria used in this study, 30% of patients with massive rota-

Table 3

Change in Functional Outcomes

Outcome	Controls (n=42)	Cases (n=18)	*P*
ASES			
Preoperative, mean±SD	32.5±15.6	33.2±18.3	.943
Postoperative, mean±SD	82.2±14.2	58.9±22.5	<.001
P	<.001	.002	
Δ ASES, mean±SD	49.7±18.0	26.3±23.7	.002
Δ ASES>MCID, No.	32	8	
SANE			
Preoperative, mean±SD	18.8±15.7	40.4±28.4	.021
Postoperative, mean±SD	84.9±14.1	61.6±29.5	.002
P	<.001	.03	
Δ SANE, mean±SD	66.1±19.6	20.5±31.0	<.001
Δ SANE>MCID, No.	31	10	
SST			
Preoperative, mean±SD	2.5±2.0	2.4±2.3	.555
Postoperative, mean±SD	8.5±2.4	5.4±3.6	.002
P	<.001	.012	
Δ SST, mean±SD	6.2±2.5	3.0±4.2	.003
Δ SST>MCID, No.	30	5	

Abbreviations: AFE, active forward elevation; ASES, American Shoulder and Elbow Surgeons score; MCID, minimally important clinical difference; SANE, Single Assessment Numeric Evaluation score; SST, Simple Shoulder Test score; Δ, change.

Table 4

Preoperative Risk Factor Assessment

	No.		
Risk factor	Controls (n=42)	Cases (n=18)	*P*
Age <60 y	3 (7.1%)	0	.547
Preoperative forward elevation >90°	17 (40.5%)	7 (38.9%)	.908
Previous shoulder surgery	14 (33.3%)	6 (33.3%)	1.000
SST ≥7	1 (2.9%)	1 (5.9%)**[AQT4: Please check all numbers in red.]**	1.000
SANE >33	5 (15.2%)	9 (64.3%)	.004

Abbreviations: SANE, Single Assessment Numeric Evaluation score; SST, Simple Shoulder Test score.

tor cuff tears without glenohumeral arthritis experienced a poor functional result after RSA. Previously reported preoperative risk factors, including active forward elevation of greater than 90°, age younger than 60 years, preoperative SST score of 7 or greater, and a history of previous shoulder surgery, were not found to be predictive of a poor functional outcome. Higher preoperative SANE score was the only factor in this study that was found to be associated with a greater likelihood of poor outcome after RSA for massive rotator cuff tears without glenohumeral arthritis.

Few studies have investigated the role of RSA among patients with massive rotator cuff tears without glenohumeral arthritis.[20-23] Mulieri et al[21] reported that, despite improved overall outcome scores, 32% of patients with massive cuff tears without arthritis (Hamada score ≤3) who were treated with RSA would not have the same surgery again. The reasons for this finding were largely unclear. Similarly, in our study, 30% of patients were defined as having a poor outcome despite having a mean change in ASES and SST scores that exceeded the MCID.[34,35] Hartzler et al[23] attempted to identify risk factors for poor improvement after RSA in a retrospective case-control study with 74 patients (Hamada score ≤3). The mean age of the patients was 72 years, which is similar to the mean age in our study (71.4 years). Cases were defined as patients who experienced a change in SST score of 1 point**[AQ11: Correct word?]** or less (13 patients), and control subjects had a change in SST of 2 points**[AQ12: OK?]** or greater (61 patients). The principal findings of this study were that age younger than 60 years, neurologic dysfunction, and preoperative SST score of 7 or greater were independently associated with poor functional improvement. However, each of these variables was found for only 3 patients in the case group, subjecting these findings to a risk of fragility.[23,36] Our current study did not find these factors to be predictive of poor functional improvement. However, our study does support the notion proposed by Hartzler et al[23] that patients with better preoperative function are at risk for poor outcomes after RSA.

Several recent studies have reported an association between better preopera-

tive outcome scores and worse outcomes after RSA.[23,26,27,37] Werner et al[26] evaluated 150 patients undergoing RSA in a prospectively collected registry. Regression analysis showed that poor functional improvement was associated with higher baseline ASES scores, male sex, an intact rotator cuff, depression, and a higher number of comorbidities. Similar to the findings in the current study, patient age (mean, 72 years) was not associated with poor outcomes.[26] Unlike Werner et al,[26] sex and comorbidity (assessed via the Charlson Comorbidity Index) were not associated with poor outcomes in our study. Carducci et al[27] also sought to define factors associated with poor improvement for patients undergoing RSA. Multivariate regression modeling showed that previous shoulder surgery was the only factor associated with poor outcome and functional improvement. Additionally, patients in the poor improvement group showed significant clinical improvement and better function preoperatively**[AQ13: OK as edited?]** based on the ASES score (42.2 vs 26, respectively;**[AQ14: OK?]** $P<.001$). Our study did not detect a difference in preoperative ASES score; however, we did detect a difference of similar magnitude in preoperative SANE score among patients with poor improvement. In contrast to Carducci et al,[27] we did not find previous shoulder surgery to be significantly associated with poor functional improvement.

Although the exact outcome measure and threshold are controversial, it does seem evident that certain patient-reported outcomes are predictive of poor improvement for a subset of patients after RSA. The SANE score is a simple way to assess patient-perceived shoulder pain and function. Our study found that a SANE score of greater than 33 was associated with a greater likelihood of poor improvement after RSA for massive rotator cuff tears without arthritis. Identifying preoperative predictors of poor improvement among patients with massive rotator cuff tears without arthritis is important because these patients may be better treated nonoperatively or with a variety of joint-preserving procedures.[10,11,16-18,38,39]

This study had several limitations. The retrospective nature of this study subjected it to possible bias. Additionally, we did not have complete preoperative advanced imaging that would allow us to assess the extent of rotator cuff pathology. The decision to perform RSA was not standardized and was based on the overall clinical assessment of experienced shoulder surgeons. Another limitation of this study was that all postoperative assessment was retrospectively gathered from review of the electronic medical record. Additionally, our risk factor analysis was subject to confounding variables that could have influenced the results.

This study had numerous strengths. We identified a relatively unique population of patients with massive rotator cuff tears without arthritis who underwent RSA. We elected to use several criteria reported in the literature for poor functional improvement because no clear definition exists. This approach allowed us to increase our capture and made the results more generalizable because they are not subject to the potential limitations of a particular outcome measure. We identified a cohort of patients who did significantly worse after RSA without an obvious reason (eg, infection, dislocation, nerve injury) for the discrepancy in outcome. The only factor we identified that was significantly associated with a poor outcome was better overall preoperative function, as measured by SANE score. We also discerned a threshold for the SANE score that was significantly associated with a greater likelihood of poor outcome. This information can potentially guide clinical decision making when considering the management of patients who have massive rotator cuff tears without arthritis.

Conclusion

The results of this study show that higher preoperative SANE scores are associated with a greater likelihood of poor outcomes after RSA for massive rotator cuff tears without glenohumeral arthritis. Thirty percent of patients identified by the criteria in this study had a poor outcome after RSA, without an obvious reason and despite improvements in ASES and SST scores that were greater than the reported MCID. It is possible that the cohort of patients who had poor improvement may have benefited more from a joint-preserving operation or continued nonoperative management. A comparative study with other treatment options for massive rotator cuff tears without arthritis is needed to further define the role of RSA for this indication.

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