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Preoperative parameters that predict postoperative patient-reported outcome measures and range of motion with anatomic and reverse total shoulder arthroplasty

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Background: Preoperative factors that most influence postoperative outcomes of both anatomic total shoulder arthroplasty (aTSA) and reverse total shoulder arthroplasty (rTSA) are unknown. The purpose of this study was to identify the preoperative parameters that significantly influence postoperative outcomes of aTSA and rTSA.
Methods: The outcomes of 1089 aTSA patients and 1332 rTSA patients (mean follow-up period, 49 months) from an international registry with a single platform system were analyzed. A multiple linear regression model with backward stepwise selection identified the preoperative parameters that were significant predictors of postoperative clinical outcome metric scores and motion measures for both rTSA and aTSA.
Results: For both aTSA and rTSA patients, numerous preoperative parameters that influence postoperative outcomes were identified. Greater postoperative range of motion (ROM) was significantly influenced by greater preoperative ROM. For aTSA, greater postoperative American Shoulder and Elbow Surgeons (ASES) scores were significantly influenced by greater preoperative ASES scores, no history of shoulder surgery, and the presence of greater preoperative active external rotation. For rTSA, greater postoperative ASES scores were significantly influenced by greater preoperative ASES scores, no history of shoulder surgery, no history of tobacco use, less preoperative passive external rotation, and greater preoperative active external rotation.
Conclusions: This study quantified the preoperative predictors of postoperative clinical outcome metric scores and ROM for both aTSA and rTSA. Numerous significant associations were identified, including demographic and comorbidity risk factors. These associations may be helpful for surgeons to consider when counseling patients regarding aTSA versus rTSA and to establish more accurate expectations prior to surgery.

Successful outcomes of anatomic total shoulder arthroplasty (aTSA) and reverse total shoulder arthroplasty (rTSA) are well documented in the literature.[1,7,8,18,23–25] However, concerns exist regarding the variability of results, such as the unpredictable improvement in internal and external rotation after rTSA.[7,26,27] Although several associations for total shoulder arthroplasty (TSA) have been previously identified, such as preoperative diagnosis,[4,28] weak deltoid function,[3] depression,[29,30] sex,[7,22] body mass index (BMI),[2,9,14,15,17] medical comorbidities,[21] and patient age at the time of surgery,[5,7,10] the contribution of each to different postoperative outcome measures is unknown. Furthermore, the risk contribution of each of these parameters may be different between aTSA and rTSA.

The Institutional Review Board of the Medical University of South Carolina approved this study (Pro00030914) on November 9, 2018.

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No previous research has rigorously analyzed aTSA and rTSA outcomes in a large cohort to quantify the contribution of different preoperative parameters to predict postoperative patient-reported outcome measures (PROMs) and range-of-motion (ROM) measures. Levy et al[14] previously studied preoperative associations with motion in aTSA and found that preoperative motion significantly correlated with postoperative motion; however, their analysis was performed using Pearson correlations, which can only measure association, not prediction. Therefore, a more comprehensive analysis of both aTSA and rTSA outcomes is necessary to identify the contribution of different preoperative parameters to predict postoperative PROMs and ROM measures.

Studies using linear regression analysis have been performed to predict postoperative ROM after total knee arthroplasty.[19,20] They determined that the principal predictive factor for postoperative ROM was the amount of preoperative ROM, in which greater preoperative ROM was associated with greater postoperative ROM.[19,20] A similar type of analysis has yet to be performed with TSA owing to the lack of a large homogeneous cohort using a single implant with robust preoperative and postoperative patient data. A better understanding of the preoperative parameters that most significantly impact postoperative outcomes may help reduce the variability of outcomes by the design of more effective rehabilitation protocols and may also improve patient satisfaction by more accurately establishing patient expectations prior to surgery.

The purpose of this study was to analyze 2-year minimum outcomes from a multicenter international registry consisting of a single platform shoulder prosthesis and use a backward stepwise multiple linear regression statistical model to identify the preoperative parameters that most significantly influence postoperative PROMs and ROM measures with aTSA and rTSA.

Methods

An international multicenter registry composed of surgical procedures performed by 14 different fellowship-trained shoulder surgeons collected from 2005 through 2016 was used in this study. The database recorded patient demographic characteristics, comorbidities, diagnoses and/or indications, surgical technique information, information regarding implant type and size, preoperative and postoperative PROMs and ROM measures, radiographic outcomes, and intraoperative and postoperative complications.

All patients within this database underwent TSA with the same platform shoulder prosthesis (Equinoxe; Exactech, Gainesville, FL, USA), and each surgical procedure was performed through a deltopectoral approach. The study included aTSA patients with a diagnosis of osteoarthritis, avascular necrosis, or inflammatory arthritis and rTSA patients with a diagnosis of osteoarthritis, osteoarthritis or inflammatory arthritis with rotator cuff tear, or cuff tear arthropathy. Patients with a revision arthroplasty, a history of infection, an acute fracture, or fracture sequelae were excluded. Patients with intraoperative or postoperative complications or adverse events were also excluded to isolate the impact of preoperative and demographic parameters as it is assumed that the occurrence of an intraoperative or postoperative complication or adverse event would have the predominant impact on a particular patient's postoperative outcome.

The aforementioned criteria yielded 1089 aTSA patients (544 male and 545 female patients; mean age, 66.3 $\pm$ 8.6 years; average BMI, 29.9 $\pm$ 6.6) and 1332 rTSA patients (475 male and 857 female patients; mean age, 72.2 $\pm$ 7.6 years; average BMI, 28.6 $\pm$ 6.1). All patients had 2-year minimum follow-up; the mean follow-up period was 48.6 $\pm$ 25.1 months (53.6 $\pm$ 27.9 months for aTSA and 44.5 $\pm$ 21.8 months for rTSA). Outcomes were scored preoperatively and at latest follow-up using the shoulder function score (from 0 to 10), visual analog scale (VAS) pain score (from 0 to 10), American Shoulder and Elbow Surgeons (ASES) score, Simple Shoulder Test (SST) score, and University of California, Los Angeles (UCLA) score. ROM was evaluated with a goniometer by the implanting surgeon and/or the patient's physical therapist, including active abduction, active forward flexion, and active and passive external rotation. In addition, active internal rotation (IR) was measured by vertebral segments and scored by the following discrete assignment: 0°, 0; hip, 1; buttocks, 2; sacrum, 3; L5 to L4, 4; L3 to L1, 5; T12 to T8, 6; and T7 or higher, 7.

To determine the preoperative parameters that influenced postoperative PROMs and ROM for both rTSA and aTSA, multiple linear regression models with backward stepwise selection were used. Backward selection was used because a set of variables was previously selected based on prior knowledge. For the preliminary and final statistical models with unstandardized estimates, 95% confidence intervals and *P* values from the final model of the backward stepwise selection process were calculated with the significant regression coefficients and intercepts identified. The postoperative model prediction for a given parameter equated to the sum of the identified intercept and the cumulative sum product of the preoperative parameter value for a given patient and the identified regression coefficient. In addition, mean improvements in outcomes at latest follow-up for the aTSA and rTSA patient cohorts with 2 years' minimum follow-up were quantified using a 2-tailed unpaired *t* test to identify differences from preoperatively to postoperatively (improvement) for each outcome measure, in which $P < .05$ was deemed significant. All statistical analyses were performed with R software (version 3.5.2; R Core Team, Vienna, Austria) using stepAIC in the MASS package.

Results

The mean preoperative values, postoperative values, and improvements in outcomes at latest follow-up for aTSA and rTSA patients are presented in Table I. These results demonstrate that both aTSA and rTSA patients experienced a significant improvement in outcomes at latest follow-up for each PROM score and ROM measure collected. Tables II and III present the results of the backward stepwise regression model identifying the preoperative parameters that significantly influenced each postoperative PROM score and ROM measure for aTSA and rTSA patients, respectively. For both aTSA and rTSA patients, no single preoperative parameter significantly influenced all postoperative parameters. However, a significant contributor to each postoperative ROM measurement was the preoperative ROM value for that measurement, in which a larger preoperative value for abduction, forward flexion, active external rotation, or the IR score was associated with greater postoperative ROM for both aTSA and rTSA.

For aTSA patients, a larger preoperative VAS pain score was associated with less pain postoperatively and a larger preoperative SST or ASES score was associated with a greater postoperative outcome score. An interesting finding was that the preoperative shoulder function score or UCLA score was not predictive of either score's postoperative value. Of all the parameters evaluated by the aTSA model, the preoperative SST, UCLA, and ASES scores significantly influenced the most postoperative measures, in which each score predicted 4 postoperative parameters. By comparison, for rTSA patients, a larger preoperative VAS pain score was associated with less pain postoperatively and a larger preoperative shoulder function or ASES score was associated with a greater postoperative outcome score. For rTSA patients, the preoperative SST score or UCLA score was not predictive of either score's postoperative value. Of all the parameters evaluated by the rTSA model, preoperative active and passive external rotation significantly influenced the

Table I
Average preoperative values, postoperative values, and improvements in outcomes of aTSA and rTSA patients at latest follow-up

	Abduction, °	Forward flexion, °	Active external rotation, °	IR score	Shoulder function score	VAS pain score	SST score	UCLA score	ASES score
aTSA									
Preoperative	84.3 ± 30.1	97.8 ± 31.8	19.6 ± 19.4	3.1 ± 1.6	4.0 ± 2.0	6.4 ± 2.1	4.0 ± 3.0	14.1 ± 4.0	35.5 ± 16.3
Latest follow-up	127.3 ± 32.0	146.8 ± 28.7	50.5 ± 19.3	5.1 ± 1.4	8.5 ± 1.9	1.2 ± 2.0	10.7 ± 2.2	30.9 ± 4.9	85.9 ± 18.0
Improvement	44.2 ± 39.4	49.0 ± 36.8	32.1 ± 21.9	2.0 ± 1.9	4.6 ± 2.5	5.3 ± 2.7	6.7 ± 3.2	16.9 ± 5.5	51.2 ± 21.3
P value (preoperatively to postoperatively)	<.0001*	<.0001*	<.0001*	<.0001*	<.0001*	<.0001*	<.0001*	<.0001*	<.0001*
rTSA									
Preoperative	72.3 ± 34.6	85.6 ± 38.1	18.0 ± 21.8	3.2 ± 1.8	3.6 ± 2.0	6.1 ± 2.2	3.4 ± 2.6	13.1 ± 4.1	35.3 ± 15.3
Latest follow-up	118.5 ± 28.8	141.7 ± 23.6	36.1 ± 17.2	4.5 ± 1.6	8.2 ± 1.9	1.1 ± 2.0	10.0 ± 2.5	30.5 ± 4.5	83.4 ± 17.9
Improvement	47.3 ± 38.3	55.5 ± 41.2	19.2 ± 23.2	1.3 ± 2.1	4.5 ± 2.5	5.0 ± 2.7	6.6 ± 3.2	17.3 ± 5.4	48.0 ± 21.0
P value (preoperatively to postoperatively)	<.0001*	<.0001*	<.0001*	<.0001*	<.0001*	<.0001*	<.0001*	<.0001*	<.0001*

aTSA, anatomic total shoulder arthroplasty; *rTSA*, reverse total shoulder arthroplasty; *IR*, internal rotation; *VAS*, visual analog scale; *SST*, Simple Shoulder Test; *UCLA*, University of California, Los Angeles; *ASES*, American Shoulder and Elbow Surgeons.
* Statistically significant ($P < .05$).

most postoperative measures, in which each predicted 6 postoperative parameters, followed by the preoperative shoulder function and SST scores, in which each predicted 5 postoperative parameters.

For aTSA patients, the preoperative ASES score positively influenced postoperative active abduction and the postoperative shoulder function, UCLA, and ASES scores, whereas the postoperative ASES score was significantly influenced by a greater preoperative ASES score, no history of shoulder surgery, and the presence of greater preoperative active external rotation. By comparison, for rTSA patients, the preoperative ASES score negatively influenced postoperative active external rotation but positively influenced the postoperative IR, SST, and ASES scores, whereas the postoperative ASES score was significantly influenced by a greater preoperative ASES score, no history of shoulder surgery, no history of tobacco use, less preoperative passive external rotation, and greater preoperative active external rotation.

Regarding patient demographic characteristics and comorbidities for aTSA patients, greater patient age at the time of surgery negatively influenced postoperative active forward flexion and the postoperative VAS pain score. Patient sex influenced the postoperative IR score, in which female patients had a 0.5 greater IR score than male patients. Greater patient height positively influenced postoperative active abduction and the postoperative IR score, whereas greater patient weight negatively influenced postoperative active abduction and active forward flexion, as well as the postoperative IR score. Patient BMI did not significantly influence any postoperative ROM measure but was found to negatively influence the postoperative SST score. A history of shoulder surgery negatively influenced the postoperative shoulder function score by 0.4 points, the postoperative UCLA score by 1.3 points, and the postoperative ASES score by 3.5 points. The comorbidities of hypertension, heart diseases, and diabetes negatively influenced postoperative active external rotation and the postoperative IR score; with the exception of heart disease negatively influencing the postoperative SST score, comorbidities were not observed to influence any postoperative outcome metric score.

Regarding patient demographic characteristics and comorbidities for rTSA patients, greater patient age at the time of surgery negatively influenced postoperative active abduction and active forward flexion. Patient sex influenced postoperative active external rotation and the postoperative IR score, with female patients having nearly 4.5° more postoperative active external rotation and a 0.3 greater postoperative IR score than male patients. Greater patient height positively influenced postoperative active external rotation and the postoperative IR, shoulder function, SST, and ASES scores. However, patient weight did not influence any postoperative ROM or outcome measure for rTSA patients, and patient BMI was only observed to negatively influence the postoperative IR score. A history of shoulder surgery negatively influenced the postoperative shoulder function score by 0.5 points, the postoperative SST score by 0.5 points, the postoperative UCLA score by 1.1 points, and the postoperative ASES score by 3.2 points and negatively influenced postoperative active forward flexion by 7°. The comorbidities of hypertension, heart disease, and diabetes were not found to influence any postoperative ROM or outcome measure, with the exception of hypertension influencing postoperative active forward flexion. Tobacco use negatively influenced the postoperative IR score by 0.7 points, the postoperative shoulder function score by 0.6 points, the postoperative SST score by 1.2 points, the postoperative UCLA score by 1.6 points, and the postoperative ASES score by 8.7 points; however, tobacco use positively influenced the postoperative VAS pain score by 0.8 points.

Discussion

Both aTSA and rTSA are reliable options to improve pain and function in the arthritic and/or rotator cuff–deficient shoulder. However, in up to 13% of primary TSAs, pain and ROM improvements do not meet the expectations for a successful surgical procedure.[16,23–25,30] Factors affecting outcomes include age,[5,7,10] preoperative diagnosis,[4,28] sex,[7,22] BMI,[2,9,14,15,17] preoperative motion,[11,14,22] and arm lengthening in the setting of rTSA.[13] It is important to identify patients who are at risk of less improvement, in an attempt to match patient expectations with anticipated outcomes, as this population has been shown to be at risk of lower satisfaction after TSA.[12]

This study quantified the preoperative predictors of postoperative outcome metric scores and ROM measures with both aTSA and rTSA using continuous outcome measures. Multiple preoperative predictors of postoperative outcomes were identified using a backward stepwise multiple linear regression statistical model for multiple different PROM scores and ROM measures. Stepwise regression analysis is a more rigorous statistical method than Pearson correlations and can be used to assess both association and influence, in contrast to Pearson correlations, which only assess association. Greater preoperative ROM significantly and positively influenced postoperative ROM for both aTSA and rTSA. However, the preoperative VAS pain and ASES scores were the only PROMs predictive of postoperative values for both aTSA and rTSA.

Previous studies have evaluated preoperative risk factors for poor outcomes following both aTSA and rTSA.[2–5,7,9–11,13–17,19–22,26–30]

Table II
Backward stepwise regression of preoperative parameters for postoperative outcome scores and ROM for aTSA patients

Preop predictor	Regression coefficient, P value								
	Postop abduction (intercept = 51.5)	Postop forward flexion (intercept = 159.9)	Postop active external rotation (intercept = 43.1)	Postop IR score (intercept = 2.8)	Postop shoulder function score (intercept = 7.1)	Postop VAS pain score (intercept = 2.1)	Postop SST score (intercept = 10.0)	Postop UCLA score (intercept = 25.8)	Postop ASES score (intercept = 79.4)
Age at surgery	NS	−0.33, $P = .011$	NS	NS	NS	−0.02, $P = .036$	NS	NS	NS
Sex: male	NS	NS	NS	−0.49, $P = 004$	NS	NS	NS	NS	NS
Height	1.14, $P = .001$	NS	NS	0.05, $P = .009$	NS	NS	NS	NS	NS
Weight	−0.12, $P < .001$	−0.09, $P < .001$	NS	−0.01, $P < .001$	NS	NS	NS	NS	NS
BMI	NS	NS	NS	NS	NS	NS	−0.02, $P = .045$	NS	NS
Previous surgery: yes	NS	NS	NS	−0.030, $P = .035$	−0.38, $P = .022$	NS	NS	−1.25, $P = .009$	−3.49, $P = .023$
Comorbidities									
Hypertension	NS	NS	−7.42, $P = .002$	NS	NS	NS	NS	NS	NS
Heart disease	NS	NS	−6.76, $P = .004$	−0.61, $P < .001$	NS	NS	−0.49, $P = .020$	NS	NS
Diabetes	NS	NS	−4.51, $P = .046$	−0.33, $P = .049$	NS	NS	NS	NS	NS
Tobacco use	NS	NS	NS	NS	NS	NS	NS	NS	NS
Preop abduction	0.16, $P = .003$	NS	NS	NS	NS	−0.01, $P = .015$	NS	NS	NS
Preop forward flexion	NS	0.15, $P < .001$	NS	0.01, $P = .01$	NS	NS	NS	NS	NS
Preop active external rotation	NS	NS	0.38, $P < .001$	NS	0.02, $P = .017$	NS	NS	0.06, $P = .014$	0.16, $P = .042$
Preop passive external rotation	0.36, $P < .001$	NS	NS	NS	−0.02, $P = .017$	NS	NS	−0.06, $P = .008$	NS
Preop IR score	NS	NS	NS	0.10, $P = .007$	NS	NS	NS	NS	NS
Preop shoulder function score	NS	−2.53, $P = .002$	NS	NS	NS	0.08, $P = .039$	NS	−0.39, $P = .022$	NS
Preop VAS pain score	NS	NS	NS	NS	NS	0.12, $P < .001$	NS	NS	NS
Preop SST score	NS	−1.01, $P = .026$	1.02, $P = .002$	0.05, $P = .024$	NS	NS	0.10, $P = .003$	NS	NS
Preop UCLA score	−1.51, $P = .008$	1.09, $P = .033$	−0.89, $P = .004$	NS	NS	NS	0.07, $P = .034$	NS	NS
Preop ASES score	0.58, $P = .001$	NS	NS	NS	0.02, $P < .001$	NS	NS	0.06, $P = .026$	0.19, $P < .001$

ROM, range of motion; *aTSA*, anatomic total shoulder arthroplasty; *Preop*, preoperative; *Postop*, postoperative; *IR*, internal rotation; *VAS*, visual analog scale; *SST*, Simple Shoulder Test; *UCLA*, University of California, Los Angeles; *ASES*, American Shoulder and Elbow Surgeons; *NS*, not significant; *BMI*, body mass index.

Table III
Backward stepwise regression of preoperative parameters for postoperative outcome scores and ROM for rTSA patients

Preop predictor	Regression coefficient, P value								
	Postop abduction (intercept = 96.6)	Postop forward flexion (intercept = 167.7)	Postop active external rotation (intercept = −1.6)	Postop IR score (intercept = 1.7)	Postop shoulder function score (intercept = 5.1)	Postop VAS pain score (intercept = −0.7)	Postop SST score (intercept = 2.8)	Postop UCLA score (intercept = 29.8)	Postop ASES score (intercept = 43.8)
Age at surgery	−0.29, $P = .024$	−0.38, $P < .001$	NS	NS	NS	NS	NS	NS	NS
Sex: male	NS	NS	−4.38, $P = .014$	−0.32, $P = .034$	NS	NS	NS	NS	NS
Height	NS	NS	0.42, $P = .032$	0.04, $P = .015$	0.04, $P = .031$	NS	0.09, $P < .001$	NS	0.39, $P = .007$
Weight	NS	NS	NS	NS	NS	NS	NS	NS	NS
BMI	NS	NS	NS	−0.03, $P < .001$	NS	NS	NS	NS	NS
Previous surgery: yes	NS	−7.05, $P < .001$	NS	NS	−0.5, $P < .001$	NS	−0.49, $P = .006$	−1.13, $P = .001$	−3.23, $P = .014$
Comorbidities									
Hypertension	NS	5.38, $P = .031$	NS	NS	NS	NS	NS	NS	NS
Heart disease	NS	NS	NS	NS	NS	NS	NS	NS	NS
Diabetes	NS	NS	NS	NS	NS	NS	NS	NS	NS
Tobacco use	NS	NS	NS	−0.73, $P = .002$	−0.56, $P = .033$	0.81, $P = .005$	−1.17, $P = .001$	−1.6, $P = .02$	−8.74, $P = .001$
Preop abduction	0.19, $P < .001$	−0.16, $P < .001$	−0.11, $P < .001$	NS	NS	NS	NS	NS	NS
Preop forward flexion	NS	0.22, $P < .001$	NS	0.01, $P < .001$	NS	NS	0.01, $P = .004$	NS	NS
Preop active external rotation	0.17, $P = .001$	0.16, $P = .014$	0.021, $P < .001$	NS	NS	−0.01, $P = .04$	NS	0.03, $P = .039$	0.10, $P = .036$
Preop passive external rotation	NS	−0.18, $P = .004$	NS	NS	−0.01, $P = .004$	0.02, $P = .003$	−0.02, $P = .003$	−0.04, $P = .001$	−0.15 , $P = .002$
Preop IR score	NS	NS	NS	0.24, $P < .001$	NS	NS	NS	NS	NS
Preop shoulder function score	4.13, $P < .001$	0.97, $P = .029$	NS	NS	0.14, $P < .001$	−0.15, $P = .006$	NS	0.35, $P < .001$	NS
Preop VAS pain score	NS	−1.42, $P < .001$	NS	NS	NS	0.16, $P < .001$	NS	NS	NS
Preop SST score	NS	−0.74, $P = .049$	NS	−0.09, $P = .004$	0.06, $P = .017$	−0.08, $P = .008$	NS	0.18, $P = .007$	NS
Preop UCLA score	−1.71, $P = .007$	NS	0.90, $P = .001$	−0.07, $P = .006$	NS	0.11, $P = .003$	NS	NS	NS
Preop ASES score	NS	NS	−0.15, $P = .033$	0.02, $P < .001$	NS	NS	0.03, $P < .001$	NS	0.32, $P < .001$

ROM, range of motion; *rTSA*, reverse total shoulder arthroplasty; *Preop*, preoperative; *Postop*, postoperative; *IR*, internal rotation; *VAS*, visual analog scale; *SST*, Simple Shoulder Test; *UCLA*, University of California, Los Angeles; *ASES*, American Shoulder and Elbow Surgeons; *NS*, not significant; *BMI*, body mass index.

However, such studies are often limited by patient selection criteria or failure to evaluate normalized patient outcome data secondary to clinical improvements. These limitations can lead to interpretation bias and may explain the differences in risk factors reported in the literature. The results of our large outcome study consisting of 1089 aTSA patients and 1332 rTSA patients treated with the same shoulder system can assist future machine-learning predictive-modeling analyses,[6] such as clustering and decision tree analyses, by providing guidance for the particular preoperative factors that should be collected and reviewed when building and training those predictive models.

Using multiple linear regression models with backward stepwise selection, we found that preoperative ROM was predictive of postoperative ROM in the same plane of motion for both aTSA and rTSA. For aTSA, our finding was supported by the findings of Levy et al,[14] who showed preoperative motion to be associated with postoperative motion for aTSA using Pearson correlation coefficients. For rTSA, our finding was supported by the findings of Schwartz et al,[22] who evaluated 540 rTSAs using a multivariate logistic regression analysis and identified preoperative and intraoperative forward elevation as predictive of postoperative forward elevation.

Regarding the contribution of demographic parameters to outcomes, we found that patient age, sex, and height influenced ROM measures for both aTSA and rTSA, with limited influence on postoperative PROM scores. In addition, patient weight negatively influenced ROM measures for aTSA patients but not rTSA patients, and BMI had no significant effect on ROM measures or PROM scores for either aTSA or rTSA patients. Regarding the contribution of comorbidities, hypertension, heart disease, and diabetes negatively influenced internal and external ROM measures for aTSA patients but had no such effect on rTSA patients. For both aTSA and rTSA patients, the comorbidities of hypertension, heart disease, and diabetes had no influence on any PROM score. Conversely, a history of shoulder surgery was found to negatively influence ROM measures and PROM scores for both aTSA and rTSA patients. Finally, tobacco use had no negative effect on aTSA patients but was observed to negatively influence both ROM measures and PROM scores for rTSA patients. The literature supports some of our findings, whereas some of these identified risk factors are new. Levy et al[14] reported that diabetes and increased BMI were predictors of worse IR after surgery. In our study, diabetes was found to have a negative effect on both internal and external rotation after aTSA but not after rTSA. Conversely, we found that BMI did not negatively influence the IR score for aTSA patients but did negatively influence the IR score for rTSA patients. Schwartz et al[22] reported that male sex was associated with greater postoperative forward elevation for rTSA patients. In our study, we found no significant association between sex and overhead ROM for either aTSA or rTSA patients; however, male sex was associated with poorer postoperative IR following aTSA and poorer internal and external rotation following rTSA.

Only a few studies have previously evaluated predictors of postoperative PROM scores following either aTSA or rTSA.[5,10,30] In our study, the preoperative VAS, SST, and ASES metrics were predictive of their postoperative values for aTSA. Fehringer et al[5] similarly reported that the preoperative SST score was associated with a higher postoperative SST score in 102 aTSAs. Our observations of baseline PROM scores influencing postoperative scores should be considered relative to the minimal clinically important difference, as some studies have reported a ceiling effect,[16,30] in which patients with greater preoperative scores have less opportunity for functional improvement following TSA, thereby leaving them at greater risk of postoperative dissatisfaction.[12,23–25] For rTSA, the preoperative ASES score and VAS pain score were predictive of their postoperative values, whereas the preoperative SST and UCLA scores were not associated with their postoperative values. In contrast, Hartzler et al[10] reported that a higher SST score was predictive of poorer improvement in the SST score following rTSA using a multivariate binomial logistic regression.

This study has multiple limitations. We did not assess the status of the rotator cuff at the time of surgery or the quality of the rotator cuff muscle; both of these factors may have had an influence on postoperative outcomes, thereby affecting our predictive results. Furthermore, we did not stratify and analyze patients by diagnosis or categorize by type of glenoid deformity, nor did we assess any mental health parameters other than those considered by the PROMs used, although mental health parameters have previously been shown to affect patient-reported outcomes after TSA.[29,30] In addition, our use of data from multiple centers likely increased the variability of surgical indications and techniques; however, only 1 shoulder prosthesis was used, and standard data collection forms and methods were used at all sites according to registry guidelines. Conversely, the use of multiple sites improves the generalizability of our findings. Despite the aforementioned limitations, this study remains the largest and most statistically robust evaluation of preoperative parameters influencing outcomes of TSA.

Conclusion

Our study quantified the preoperative predictors of multiple different postoperative PROM scores and ROM measures with both aTSA and rTSA. Numerous significant associations were identified for both aTSA and rTSA, including demographic and comorbidity risk factors. These associations may be helpful for surgeons to consider when counseling patients regarding aTSA versus rTSA and to establish more accurate expectations prior to the procedure. Finally, these findings may be helpful to design more effective rehabilitation protocols for more targeted improvements following aTSA and rTSA, thereby achieving greater levels of patient satisfaction.

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Chris Roche is employed by Exactech.

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