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Reverse total shoulder arthroplasty for patients with minimal preoperative pain: a matched-cohort analysis

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Background: Profound improvements in function have been described in patients following reverse total shoulder arthroplasty (RSA). Previous studies have demonstrated young age, high preoperative function, and neurologic dysfunction to be predictors of poor functional improvement. However, no study to date has focused on patients electing to undergo RSA for function more than pain. The purpose of this study was to compare the outcomes of RSA in patients with minimal preoperative pain with those in patients who have higher baseline pain.
Methods: We performed a retrospective matched-cohort study of RSA patients treated by a single surgeon with a minimum of 2 years' follow-up. Patients with at least moderate baseline pain (function-pain group), predefined by existing literature as a visual analog scale pain score > 3, were matched 3:1 based on sex, indication, and age to patients with minimal pain (function group), defined as a visual analog scale score ≤ 3. Patient-reported outcome measures, active range of motion, and overall satisfaction were compared. The percentage of maximal improvement in outcomes and the proportion of patients exceeding the established threshold that predicts excellent satisfaction were also compared.
Results: A total of 260 patients (195 in function-pain group and 65 in function group) were selected for matched analysis with a similar sex distribution; the mean age was 73.1 years, and the mean follow-up period was 50 months. No differences in most recent postoperative function, overall improvement in functional scores, and active motion were found between patients in the 2 groups ($P > .05$). However, pain scores improved only in patients with at least moderate baseline pain ($P < .0001$). Patient satisfaction was significantly different ($P = .035$), as 10.8% of patients who elected to undergo RSA for function were unsatisfied. The function cohort also had worse percentage of maximal Simple Shoulder Test score ($P = .034$) and American Shoulder and Elbow Surgeons score ($P < .0001$) improvement, and a lower proportion of these patients exceeded the threshold for the percentage of maximal improvement that predicts an "excellent" outcome ($P < .0001$).
Conclusion: RSA patients with minimal preoperative pain achieve significant improvements in function and motion similar to those who choose to undergo RSA for both pain and function, but they are less satisfied and are less likely to achieve an excellent outcome. Patients electing to proceed with RSA with minimal pain should be counseled accordingly.
Level of evidence: Level III; Retrospective Cohort Comparison; Treatment Study

Keywords: Patient satisfaction; pain; reverse shoulder arthroplasty; clinical outcomes; shoulder function; percent of maximal improvement

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Reverse total shoulder arthroplasty (RSA) has led to reliable improvements in both pain and function for patients with cuff tear arthropathy and irreparable massive rotator cuff tears.[1,16,22,23,29] With such remarkable improvement in function, RSA has seen tremendous growth in its utilization, with indications expanding to include osteoarthritis, fracture sequelae, acute fractures, and revision surgery.[14,15] Patients with limited motion related to rotator cuff insufficiency are often considering RSA even when pain is minimal. These conditions represent indications to perform an RSA primarily for functional improvement rather than pain relief.

Moreover, despite the overall success of RSA, certain patients have been shown to achieve less-than-optimal clinical results after surgery. Hartzler et al[10] found that young age, high preoperative function, and neurologic dysfunction were indicators of poor functional improvement. Studies reporting on patient satisfaction for RSA found that patients with higher physical function and pain scores preoperatively are less likely to realize significant improvement after surgery, possibly reflecting diminishing returns.[20,21,30] In general, the patients' perception of their preoperative level of function and motion is an important predictor of postoperative outcomes after arthroplasty.[2] As a result, knowledge of expected outcomes based on preoperative pain and function levels can help guide discussions with patients and support patient-based, informed decision making.

To date, no study has reported on the clinical outcomes and satisfaction in the patient population electing to undergo RSA without significant or moderate preoperative pain. The purpose of this study was to identify and compare the outcomes of RSA in patients with minimal preoperative pain scores with those in patients with higher baseline pain scores. The focus was on multiple patient-reported outcome measures (PROMs), active range of motion, and patient satisfaction. We hypothesized that lower baseline pain would be associated with lower satisfaction after RSA despite significant functional improvement.

Methods

Study design

A retrospective matched-cohort study was performed using our institutional shoulder and elbow repository, identifying all patients undergoing RSA from November 2006 to December 2017. Inclusion criteria were used to select all patients with complete preoperative and postoperative data along with a minimum 2-year follow-up. Two cohorts were created based on the level of preoperative pain using established definitions from previous literature on the visual analog scale (VAS) pain score.[4,13] Patients with mild baseline pain (VAS score $\leq$ 3), thereby undergoing RSA mostly for function, comprised the investigational group (function group). A control group of patients with moderate or severe preoperative pain (VAS score $>$ 3) was generated (function-pain group), and a matched-cohort analysis was performed to compare the 2 groups. Patients in the control group were matched to the investigational group in the largest possible ratio (3:1) based on sex, indication, and age ($\pm$5 years).

Surgical technique

All procedures were performed by a single shoulder and elbow fellowship-trained surgeon who performs shoulder arthroplasty at a high volume annually at a single institution, using the same surgical technique through a deltopectoral approach and using the DJO RSP system (2006-2010), Monoblock RSP system (2011-2015), or AltiVate RSA system (2016-2017) (DJO Surgical, Austin, TX, USA). These implant systems use a glenosphere with a more lateralized center of rotation and a 135° neck-shaft angle. Soft tissue balancing was achieved through the use of polyethylene humeral shells of neutral, 4 mm, and 8 mm, with standard and semiconstrained options. All patients were treated by an identical postoperative rehabilitation protocol with a shoulder immobilizer for the first 6 weeks and patient-directed pendulum exercises, followed by a 6-week period of active stretching and delayed strengthening for 3 months.

Data and statistical methods

Per our registry protocol, PROMs including the American Shoulder and Elbow Surgeons (ASES) score, Simple Shoulder Test (SST) score, and VAS pain score were routinely collected from patients at preoperative and postoperative intervals. In addition, active range of motion was reported through goniometer-based measurements of external rotation and forward elevation. Internal rotation was measured based on the highest vertebral level reached behind the back. Patient satisfaction was reported postoperatively as excellent, good, satisfactory, or unsatisfactory. To control for a ceiling effect when patients have high preoperative scores, the percentage of maximal improvement in outcomes was also calculated.[1,2] DeVito et al[7] established 61.3% of maximal improvement in the SST score and 68.3% of maximal improvement in the ASES score as the thresholds that predict excellent satisfaction after RSA. As a result, the proportion of patients exceeding these defined thresholds was compared between the cohorts. Patients with minimal preoperative pain (function cohort) were also stratified based on characteristics of pseudoparesis—broadly defined as the inability to actively raise the affected arm above shoulder level (90°) with the presence of a rotator cuff tear—for secondary analysis.[28]

Data were compared by either the independent-samples t test or the Mann-Whitney U test for continuous variables when appropriate and the Fisher exact test for categorical variables. These tests of significance were 2-tailed, and $P < .05$ was deemed statistically significant.

Results

The query of our institutional repository identified 429 RSA patients with a preoperative VAS pain score $>$ 3 (function-pain group) and 75 with a lower baseline VAS pain score (ie, $\leq$3; function group). Of these patients, 330

Table I Demographic data of reverse shoulder arthroplasty patients in function group (preoperative VAS score ≤ 3) and function and pain group (preoperative VAS score > 3) matched 3:1

	Function group (n = 65)	Function-pain group (n = 195)	*P* value
Mean age, yr	72.3 ± 7.0	73.1 ± 7.6	.443
Mean follow-up (range), mo	49 (24-138)	50 (24-130)	.871
Sex distribution, n (%)			>.999
Male	31 (48)	93 (48)	
Female	34 (52)	102 (52)	
Indication, n (%)			>.999
Cuff tear arthropathy	22 (34)	66	
Locked anterior dislocation	1 (2)	3	
Failed hemiarthroplasty or TSA	10 (15.4)	30	
Malunion	6 (9.2)	18	
Osteoarthritis	23 (35.4)	69	
Failed rotator cuff repair	2 (3)	6	

TSA, total shoulder arthroplasty.

in the function-pain group (77%) and 65 in the function group (87%) had complete preoperative data with minimum 2-year follow-up. A total of 195 patients in the function-pain group were included in a 3:1 matched analysis with the 65 patients in the function group. The groups were well matched (Table I) in terms of indication ($P > .999$), age ($P = .443$), and follow-up (range, 24-138 months; $P = .871$) and showed an equal sex distribution (48% male and 52% female patients, $P > .999$). The mean age in the function and function-pain groups was 72.3 and 73.1 years, respectively. The underlying indications for RSA in both cohorts included osteoarthritis without cuff tear (35.4%), cuff tear arthropathy (34%), failed total shoulder arthroplasty or failed hemiarthroplasty (15.4%), malunion (9.2%), failed rotator cuff repair (3%), and locked anterior dislocation (2%).

Patients in both cohorts demonstrated statistically significant improvements from preoperatively to most recent postoperative status in functional outcome scores (SST and ASES) and improvements in active motion (Table II). However, pain scores and internal rotation did not improve in patients with minimal preoperative pain (function cohort). On comparison of the groups, patients treated with RSA for only function demonstrated a significantly lower percentage of maximal improvement in SST ($P = .034$) and ASES ($P < .0001$) scores (Table III). A significantly lower proportion of patients in the function group exceeded the previously defined threshold for the percentage of maximal improvement that predicts excellent outcomes for both SST ($P < .0001$) and ASES ($P < .0001$) scores. Nonetheless, the most recent PROM scores (SST, ASES, and VAS pain) were not different between the cohorts differentiated by baseline pain level. However, overall patient satisfaction was significantly different ($P = .035$), with 10.8% of patients in the function cohort being unsatisfied compared with only 3.6% in the function-pain cohort.

Specifically, within the function cohort, patients with elevation $< 90^\circ$ and a rotator cuff tear prior to surgery (ie, pseudoparesis) reported less pain (VAS pain score, 1.2 vs. 2.7; $P = .034$) and greater improvements in active motion (excluding internal rotation) but showed no differences in satisfaction when compared with the rest of the cohort (Table IV). However, when relating these results to the function-pain cohort, overall satisfaction was much lower for patients with characteristics of pseudoparesis, with 13.3% reporting being unsatisfied ($P < .0001$).

Discussion

RSA has expanded indications for a variety of shoulder pathology and has become one of the few arthroplasty procedures being performed primarily for function rather than pain in specific cases. With the increasing utilization of RSA, it is important to define expectations for improvement following the procedure. This is the first study to specifically address the impact of minimal pain scores on the outcome of RSA. Our study found that patients with minimal preoperative pain achieve the same functional outcome scores (ASES and SST) and range of motion as patients with moderate and severe baseline pain. However, patients with lower baseline pain are more unsatisfied and less likely to exceed the maximal improvement threshold for excellent satisfaction. The results of this study highlight that RSA remains a successful procedure for restoring function but patients with less baseline pain should be carefully counseled regarding expectations for functional improvement and pain relief prior to undergoing surgery.

As highlighted in previous studies, preoperative patient expectation can influence postoperative outcomes. Swarup et al[25] examined 67 patients undergoing anatomic total shoulder arthroplasty and reported that patients with

Table II Preoperative to most recent postoperative improvement in PROMs and active range of motion

	Function group: VAS score ≤ 3			Function-pain group: VAS score > 3		
	Preoperative	Postoperative	*P* value	Preoperative	Postoperative	*P* value
PROM						
SST score	3.14 ± 2.27	7.46 ± 3.25	<.0001*	2.32 ± 1.78	7.90 ± 3.32	<.0001*
ASES score	56.12 ± 13.92	69.66 ± 24.20	.001*	27.49 ± 14.00	74.02 ± 24.62	<.0001*
VAS pain score	1.71 ± 1.15	2.02 ± 3.01	.488	7.11 ± 1.80	1.85 ± 2.78	<.0001*
Active range of motion						
External rotation, °	19.82 ± 24.23	33.31 ± 19.95	.001*	17.31 ± 22.85	36.17 ± 17.92	<.0001*
Forward elevation, °	66.23 ± 34.40	114.62 ± 35.09	<.0001*	71.18 ± 31.31	126.41 ± 28.65	<.0001*
Internal rotation†	4.98 ± 2.98	4.98 ± 2.43	.996	4.25 ± 2.59	5.45 ± 2.77	<.0001*

PROM, patient-reported outcome measure; *VAS*, visual analog scale; *SST*, Simple Shoulder Test; *ASES*, American Shoulder and Elbow Surgeons.
* Statistically significant ($P < .05$).
† Internal rotation conversion scale: buttock to greater trochanter, 2 points; sacrum to L4, 4 points; L3 to L1, 6 points; T12 to T8, 8 points; and T7 to T1, 10 points.

Table III Comparison of patient-reported outcome measures, maximal improvement, range of motion, and satisfaction

	Function group (n = 65)	Function-pain group (n = 195)	*P* value
% of maximal improvement			
SST score	47.63 ± 36.67	58.16 ± 33.62	.034*
ASES score	34.35 ± 59.63	62.78 ± 37.13	<.0001*
% of patients exceeding threshold for maximal predictability of excellent satisfaction			
SST score	43.08	55.38	<.0001*
ASES score	28.42	57.44	<.0001*
PROM			
SST score	7.46 ± 3.25	7.90 ± 3.32	.829
ASES score	69.66 ± 24.20	74.02 ± 24.62	.215
VAS pain score	2.02 ± 3.01	1.85 ± 2.78	.687
Active range of motion			
External rotation, °	33.31 ± 19.95	36.17 ± 17.92	.279
Forward elevation, °	114.62 ± 35.09	126.41 ± 28.65	.007*
Internal rotation†	4.98 ± 2.43	5.45 ± 2.77	.231
Patient satisfaction, n (%)			.035*
Excellent	35 (53.8)	140 (71.8)	
Good	16 (24.5)	30 (15.4)	
Satisfactory	7 (10.8)	18 (6.1)	
Unsatisfactory	7 (10.8)	7 (3.6)	

SST, Simple Shoulder Test; *ASES*, American Shoulder and Elbow Surgeons; *PROM*, patient-reported outcome measures; *VAS*, visual analog scale.
* Statistically significant ($P < .05$).
† Internal rotation conversion scale: buttock to greater trochanter, 2 points; sacrum to L4, 4 points; L3 to L1, 6 points; T12 to T8, 8 points; and T7 to T1, 10 points.

greater expectations for pain relief, functional improvement, and well-being had better outcome scores following the procedure. Henn et al[11] and Tashjian et al[26] similarly demonstrated improved postoperative outcomes with better patient preoperative expectations after rotator cuff surgery. These results have been replicated in studies of other non–shoulder-related procedures as well.[9,24,32] Although patients' high expectations were associated with better objective outcomes, improvements were less than what patients expected. As a result, patients often have unrealistic expectations of their arthroplasty outcomes, and these patient expectations were the major contributing factor in patient discontentment.[17,31] In these studies, physicians were able to influence patients' expectations and ultimately change hip and knee patients' outcomes.

Table IV Stratification of patients with minimal preoperative pain by baseline elevation and presence of rotator cuff tear as characterized by pseudoparesis

	Function group		*P* value
	Preoperative elevation $< 90°$ with cuff tear (n = 30)	Preoperative elevation $\geq 90°$ or intact cuff (n = 35)	
Final PROM			
SST score	7.3 ± 3.0	7.6 ± 3.5	.658
ASES score	74.8 ± 18.5	65.3 ± 27.7	.115
VAS pain score	1.2 ± 1.8	2.7 ± 3.6	.034*
Final active range of motion			
Forward elevation, °	113 ± 35	116 ± 36	.787
Improvement, °	63 ± 40	31 ± 42	.005*
External rotation, °	38 ± 18	29 ± 21	.079
Improvement, °	22 ± 23	8 ± 24	.036*
Internal rotation†	5.3 ± 2.4	4.7 ± 2.5	.287
Improvement	−0.4 ± 3.6	1.0 ± 3.4	.151
Patient satisfaction, n (%)			.337
Excellent	17 (56.7)	18 (51.4)	
Good	8 (26.7)	8 (22.9)	
Satisfactory	1 (3.3)	6 (17.1)	
Unsatisfactory	4 (13.3)	3 (8.6)	

PROM, patient-reported outcome measure; *SST*, Simple Shoulder Test; *ASES*, American Shoulder and Elbow Surgeons; *VAS*, visual analog scale.

* Statistically significant ($P < .05$).

† Internal rotation conversion scale: buttock to greater trochanter, 2 points; sacrum to L4, 4 points; L3 to L1, 6 points; T12 to T8, 8 points; and T7 to T1, 10 points.

Although RSA has demonstrated reliable and predictable improvements in pain and function in patients with expanding indications, these improvements are not universal for all patients. Hartzler et al[10] found patients with higher preoperative function, higher ASES scores, and younger age to be at risk of achieving worse results after RSA for massive rotator cuff tears. Rauck et al[20] found that patients with worse physical and mental health before surgery have higher rates of dissatisfaction following the procedure. The same study determined that patients with better-functioning shoulders preoperatively (higher ASES scores) had lower satisfaction rates. Boileau et al[3] examined only patients receiving RSA following failed rotator cuff surgery and found that the results were predicated on preoperative active anterior elevation. Patients with active anterior elevation $< 90°$, with or without arthritis, achieved good subjective results and functional outcomes, which contrasted with the patient group with pain but normal mobility. The authors suggested RSA to be a contraindication in painful shoulders after cuff surgery if active anterior elevation was preserved. These studies highlight the importance of preoperative function and pain in terms of postoperative outcomes and patient expectations.

Our study demonstrates that patients electing to undergo RSA with similar baseline function but minimal pain have significantly lower satisfaction scores and are less likely to achieve excellent satisfaction. Improvement in pain after RSA can translate into major improvements in functional ability. In a previous study, the researchers determined that patients treated with shoulder arthroplasty typically require a 1.4-point improvement in the VAS pain score, a 2.4-point improvement in the SST score, and a 21-point improvement in the ASES score to achieve the minimal clinically importance difference after the procedure.[27] These data help explain how fewer patients in the cohort with lower baseline VAS pain scores, which improved only 0.32 points, were satisfied and achieved an excellent outcome.

It is very relevant for the treating physician and patient to understand improvements following RSA, particularly for a patient with lower baseline pain. As patient satisfaction and achievement of quality metrics become increasingly important for health care reimbursement, surgeons must be adept at patient selection, education, and setting of expectations. It is often the surgeon's role to recommend against surgical intervention or properly counsel patients on realistic expectations. Specific to patient populations, a systematic review from Tokish et al[28] differentiated between 2 diseased states: pseudoparesis, characterized as loss of active elevation to $<90°$ with maintained passive elevation in the presence of a massive irreparable rotator cuff tear, and pseudoparalysis, characterized as complete loss of active elevation and neutral external rotation with a massive cuff tear, occasionally with instability from anterior-superior escape. Although both groups may experience pain relief with a local anesthetic injection, only patients with symptoms of pseudoparesis tend to experience improved motion with treatments including nonoperative procedures, rotator cuff repair, or patch augmentation.[5,6,18,19] RSA is the only reliable treatment option for pseudoparalysis and for a select group of pseudoparesis, representing a unique patient cohort to study because the decision for surgery relates to a functional indication more so than pain.[1,3,8,29] Although our study demonstrates that patients with less preoperative pain and fewer characteristics of pseudoparesis show improvement in outcomes, they tend to be less satisfied. Furthermore, because our study was not designed to specifically identify pseudoparalysis, a focused outcome analysis of patients with and without pseudoparalysis remains a future research interest.

The strengths of this study relate to the study design with well-matched cohorts and the use of the same implant systems and surgical technique in all patients. However, this study is not without limitations. As a single-surgeon series, the results of this study may not be extrapolated to practitioners with lower-volume experience treating patients with RSA. Another limitation is that the patient satisfaction survey is limited to broad terminology such as

how satisfied the patient is with his or her ability to perform activities after surgery. As a result, this assessment makes it difficult to reach conclusions about what exactly led to the patients' dissatisfaction. Moreover, there is subjectivity in what defines an excellent result for each patient, and the use of the SST and ASES scores may not be clinically representative of what matters to a patient. However, Hsu et al[12] previously demonstrated that the SST score correlates well with patient satisfaction, and thresholds have been previously defined to predict achievement of excellent satisfaction for both SST and ASES score improvements.[7]

Conclusion

RSA patients with minimal pain scores achieve significant improvements in function and active motion similar to those who choose to undergo the surgical procedure for both pain and function. However, those with minimal baseline pain have higher rates of unsatisfactory outcomes and are less likely to achieve excellent satisfaction. As a result, patients with low preoperative pain levels should be carefully counseled regarding expectations of improvement following RSA.

Disclaimer

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