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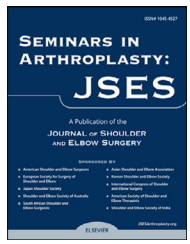

Comparison of complication rates in reverse total shoulder arthroplasty performed for degenerative conditions versus proximal humerus fractures

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ABSTRACT

Background: Indications for reverse total shoulder arthroplasty (RTSA) have been expanding. In addition to degenerative joint disease (DJD), RTSA is now being used to treat proximal humerus fractures (PHF). The purpose of this study was to compare postoperative complications in RTSA performed for DJD versus PHF.

Methods: A retrospective analysis of the PearlDiver National Database was performed. International Classification of Diseases 10 codes were used to identify RTSA patients from 2015-2018 and separate them into DJD and PHF cohorts. Demographics, comorbidities, and hospital data were identified and compared using a two-sample t-test and chi-squared test. Systemic complications at 90 days and surgical complications at 90 days, 1 year, and 2 years were compared using multivariable logistic regression.

Results: Fifteen thousand six hundred seventy eight patients (92.6% DJD, 7.4% PHF) were identified. PHF patients were more likely to be older (70.3 vs. 69.7 years, $P = .026$), female (83.5% vs. 62.2%, $P < .001$), and have more medical comorbidities (Charlson Comorbidity Index 3.42 vs. 3.17, $P = .006$) than DJD patients. After controlling for patient factors, PHF patients were more likely than DJD patients to develop urinary tract infection (odds ratio [OR] 1.65, $P < .001$), deep vein thrombosis (OR 1.76, $P = .024$), and hematoma (OR 3.83, $P < .001$) within 90 days of RTSA. At 90 days, 1 year, and 2 years postoperatively, RTSA for PHF patients were also more likely than RTSA for DJD patients to sustain a periprosthetic fracture (OR 2.57, $P < .001$) and instability (OR 2.02, $P < .001$).

Conclusions: Patients with DJD and PHF undergoing RTSA represent different patient populations with distinct postoperative clinical outcomes. RTSA for PHF has inferior outcomes, which is significant in an era of bundled payments.

Level of evidence: Level III; Large Database Analysis

Institutional review board approval was exempt.

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Reverse total shoulder arthroplasty (RTSA) was originally developed by Grammont in 1985 and its use has steadily increased since that time to more than 36,000 cases annually, comprising 46% of all shoulder arthroplasties performed.[9,16] RTSA was initially indicated for elderly, low-demand patients with end-stage rotator cuff tear arthropathy (CTA), but indications have recently been expanding and RTSA is now being used to treat a variety of conditions including proximal humerus fractures (PHFs),[14] glenohumeral osteoarthritis (GHOA) with intact rotator cuff, inflammatory arthropathy (IA), failed anatomic total shoulder arthroplasty (TSA)/hemiarthroplasty (HA), massive cuff tears, and proximal humerus neoplasms. Reverse prostheses have been shown to have advantages with regards to range of motion, pain relief, and functional improvement compared to HA and TSA with more reliable outcomes. This has been found particularly true for use in PHF.[4,7] Since its approval for use in the United States in 2004 by the Food and Drug Administration, RTSA has become the most common form of shoulder arthroplasty.[8,15] Degenerative conditions comprise the most frequent indication for RTSA, with GHOA, CTA, and post-traumatic arthritis (PTA) recorded as primary diagnostic codes in 45%, 21%, and 15% of RTSA, respectively.[8] As per previously published studies, the proportion of RTSA performed for PHF is 12%-15%.[8,15] RTSA for degenerative conditions has shown satisfactory outcomes in both short-term and long-term follow-up.[1,5,25,29] It has also been shown to be successfully used for PHF, with significantly increased utilization over the past decade.[3,10,17,19,20,28] In the existing literature, there have been several prior small series comparing RTSA outcomes by surgical indication,[2,11,23,26,27] with mixed results. There have been three medium/large sample studies that compare postoperative clinical outcomes in shoulder arthroplasty patients with PHF versus degenerative conditions.[6,12,13] Two of these studies used the National Surgical Quality Improvement Program (NSQIP) database, which restricts outcomes to within 30 days of surgery; the study by Malik et al did not isolate RTSA from TSA and the study by Liu et al only examined RTSA performed for CTA.[12,13] To date, there are no large-sample studies comparing RTSA outcomes in degenerative conditions versus PHF with follow-up beyond 30 days postoperatively. The purpose of this study is to compare short-term postoperative clinical outcomes for RTSA in DJD versus PHF patients.

Methods

This retrospective study used the PearlDiver Patient Record Database (PearlDiver [www.pearldiver.inc], Fort Wayne, IN, USA), a commercially available repository of 41 billion Health Insurance Portability and Accountability Act-compliant patient records. Specifically, the "MUExtr" dataset within Pearl Diver was used, which is comprised of medical records for privately insured, Medicare, and Medicaid patients across the United States who have undergone upper extremity procedures. International Classification of Diseases, 10th revision diagnosis (ICD 10) procedure codes were used to identify all adult patients who underwent primary RTSA from 2015-2019. ICD 10 codes were then used to stratify RTSA cases into two groups based on indication, degenerative joint disease (DJD) or fracture (PHF) (Supplementary Appendix S1). Patients with a history of shoulder infection or previous shoulder arthroplasty besides the index procedure were excluded. DJD was defined to include the diagnoses of CTA, GHOA, PTA, IA, and avascular necrosis. All collected data were deidentified and exempt from the institutional review board requirements.

The primary study outcomes evaluated were systemic complications at 90 days and prosthesis complications at 90 days, 1 year, and 2 years post-RTSA. Systemic complications included cardiac arrest, deep vein thrombosis (DVT), pneumonia, transfusion, pulmonary embolism, urinary tract infection (UTI), sepsis, reintubation, wound disruption, and hematoma. Prosthesis complications included periprosthetic fracture (PPF), prosthetic joint infection, stiffness, instability, and aseptic loosening (AL).

All data analysis was performed using the R statistical software package (R Foundation, Vienna, Austria) integrated within PearlDiver. Patient demographics, comorbidities (defined as diagnoses occurring within 1 year of index RTSA), and hospital factor data were compared between patient groups using Welch's two-sample *t*-test for continuous variables and the chi-squared test for categorical variables. Categorical variables are displayed as frequency and % of the cohort, while continuous variables are shown as means with standard error. Multivariable logistic regression was performed for systemic complications and prosthesis outcomes of interest while controlling for age, gender, Charlson Comorbidity Index (CCI), and all other comorbidities found to be significantly different in the univariate analysis (Tables I and II). Significance was determined with a two-tailed *P* value of .05 with a Bonferroni correction of 27 for baseline patient comorbidities, yielding a significance threshold of $P < .002$ (Table II). A Bonferroni correction was not used for analysis of systemic and surgical complications (Tables III–VI).

Results

A total of 15,678 patients undergoing RTSA for DJD or PHF were identified during the study period. There were 14,515 patients with DJD (92.6%) and 1163 patients with PHF (7.4%).

Table I – Baseline patient characteristics.

	DJD, n = 14,515 (92.6%)	PHF, n = 1163 (7.4%)	P value
Age			
<40	32 (0.2)	2 (0.2)	.988
40-49	169 (1.2)	9 (0.8)	.287
50-59	1378 (9.5)	119 (10.23)	.44
60-69	4817 (33.2)	346 (29.8)	**.018**
70-79	7859 (54.1)	657 (56.5)	.13
≥ 80	307 (2.1)	32 (2.8)	.18
Gender			
Male	5491 (37.8)	192 (16.5)	**<.001**
Female	9024 (62.2)	971 (83.5)	**<.001**
Charlson			
Comorbidity Index			
0	2067 (14.2)	166 (14.3)	1
1	2629 (18.1)	189 (16.3)	.121
2	2688 (18.5)	198 (17)	.22
3	2059 (14.2)	156 (13.4)	.49
4	1550 (10.7)	113 (9.7)	.33
≥5	3522 (24.3)	341 (29.3)	**<.001**

DJD, degenerative joint disease; *PHF*, proximal humerus fracture.
P values <.05 are indicated in bold.

Table II – Baseline patient comorbidities.

	DJD N (%)	PHF N (%)	P value
DM	3092 (21.3)	301 (25.9)	**<.001**
HTN	10186 (70.2)	808 (69.4)	.639
Liver Disease	716 (4.9)	69 (5.9)	.151
Obesity	2849 (19.6)	63 (5.4)	.632
Weight Loss	450 (3.1)	49 (4.2)	.046
Hypothyroidism	2769 (19.1)	273 (23.5)	**<.001**
CVD	1307 (9)	128 (11)	.026
MI	748 (5.2)	60 (5.2)	1
CAD	3026 (20.9)	205 (17.6)	.01
CHF	332 (2.3)	32 (2.8)	.363
PVD	1487 (10.2)	127 (10.9)	.497
Pulmonary Heart Disease	475 (3.3)	51 (4.4)	.052
Ischemic Heart Disease	860 (5.9)	60 (5.2)	.315
Valvular Disease	1437 (9.9)	127 (10.9)	.286
Arrhythmias	2449 (16.9)	225 (19.4)	.034
Coagulopathy	570 (3.9)	72 (6.2)	**<.001**
Deficiency Anemia	1081 (7.5)	105 (9)	.057
Asthma	1512 (10.4)	130 (11.2)	.444
Solid Tumor	1008 (6.9)	80 (6.9)	.98
Cancer	1103 (7.6)	89 (7.7)	.993
Metastatic Cancer	102 (0.7)	8 (0.7)	1
RA	564 (3.9)	26 (2.2)	.006
Tobacco Use	632 (4.3)	49 (4.2)	.7
Alcohol Use	423 (2.9)	69 (5.9)	**<.001**
Drug Abuse	588 (4.1)	39 (3.4)	.276
Depression	3322 (22.9)	289 (24.9)	.135
Dementia	241 (1.7)	35 (3)	**.001**

DJD, degenerative joint disease; *PHF*, proximal humerus fracture; *HTN*, hypertension; *CHF*, congestive heart failure; *CAD*, coronary artery disease; *PVD*, peripheral vascular disease; *CVD*, cardiovascular disease; *DM*, diabetes mellitus; *RA*, rheumatoid arthritis; *MI*, myocardial infarction.
P values <.05 are indicated in bold.

Table III – Systemic complications at 90 days.

	DJD N (%)	PHF N (%)	OR (95% CI)	P value
Cardiac Arrest	5 (0.03)	1 (0.1)	3.63 (0.18-24.1)	.251
Pneumonia	279 (1.9)	33 (2.8)	1.45 (0.98-2.08)	.051
UTI	604 (4.2)	90 (7.7)	1.65 (1.29-2.08)	**<.001**
Sepsis	109 (0.8)	14 (1.2)	1.58 (0.85-2.7)	.119
Reintubation	17 (0.1)	3 (0.3)	1.96 (0.45-6.02)	.291
DVT	145 (1)	19 (1.6)	1.76 (1.04-2.82)	**.024**
PE	9 (0.06)	0	N/A	N/A
Wound Disruption	53 (0.4)	4 (0.3)	1.49 (0.57-3.25)	.365
Hematoma	88 (0.6)	18 (1.6)	3.83 (2.18-6.41)	**<.001**
Transfusion	106 (0.7)	14 (1.2)	1.36 (0.74-2.32)	.289

DJD, degenerative joint disease; *PHF*, proximal humerus fracture; *DVT*, deep vein thrombosis; *PE*, pulmonary embolism; *UTI*, urinary tract infection; *OR*, odds ratio; *N/A*, not applicable.
P values <.05 are indicated in bold.

Patient characteristics

Male patients made up a larger proportion of the DJD cohort (37.8%) than the PHF cohort (16.5%) ($P < .001$) (Table I). DJD patients undergoing RTSA were younger than PHF patients (69.7 vs. 70.3 years old, $P = .026$), with patients aged 60-69 years making up a larger proportion of the DJD cohort than the PHF cohort (33.2% vs. 29.8%) ($P = .018$) (Table I). The mean CCI index was higher in the PHF cohort compared to the DJD cohort (3.42 vs. 3.17) ($P = .006$), with the patient subgroup with 5 or more CCIs making up a larger proportion of the PHF cohort (29.3%) than the DJD cohort (24.3%) ($P < .001$) (Table I).

Baseline medical comorbidities

PHF patients were more likely to have alcohol use (5.93% vs. 2.91%, $P < .001$), coagulopathy (6.19% vs. 3.93%, $P < .001$), diabetes (25.88% vs. 21.3%, $P < .001$), dementia (3% vs. 1.7%, $P = .001$), and hypothyroidism (23.47% vs. 19.085, $P < .001$) within 1 year of index RTSA compared to DJD patients (Table II).

Systemic and surgical complications

After controlling for age, gender, CCI, and other index comorbidities identified as significantly different in univariate analysis, PHF patients were more likely to develop UTI (odds ratio [OR] 1.65, 95% confidence interval [CI] 1.26-2.08, $P < .001$), DVT (OR 1.76, 95% CI 1.04-2.82, $P = .024$), and hematoma (OR 3.83, 95% CI 2.18-6.41, $P < .001$) compared to DJD patients within 90 days of RTSA (Table III). In terms of prosthesis complications, PHF patients were more likely to develop PPF at 90 days (OR 3.66, 95% CI 1.69-7.3, $P < .001$) (Table IV), 1 year (OR 3.07, 95% CI 1.81-4.98, $P < .001$) (Table V), and 2 years (OR 2.57, 95% CI 1.64-3.88, $P < .001$) (Table VI) compared to DJD patients. PHF patients were also more likely to develop instability at 90 days (OR 2.26, 95% CI 1.65-3.04, $P < .001$) (Table IV), 1 year (OR 2.30, 95% CI 1.74-3, $P < .001$) (Table V), and 2 years (OR 2.02, 95% CI 1.53-2.62, $P < .001$) (Table VI) compared to DJD patients. Finally, PHF patients were more likely to develop stiffness (OR 0.176, 95% CI 0.09-2.08, $P = .038$) compared to DJD patients at 2 years post-RTSA (Table VI).

Table IV – Surgical complications at 90 days.

	DJD N (%)	PHF N (%)	OR (95% CI)	*P* value
PPFX	41 (0.3)	10 (0.9)	3.66 (1.69-7.3)	**<.001**
PJI	16 (0.1)	2 (0.2)	1.23 (0.23-1.98)	.59
Stiffness	1605 (11.1)	119 (10.2)	0.94 (0.76-1.14)	.51
Instability	340 (2.3)	52 (4.5)	2.26 (1.65-3.04)	**<.001**
Aseptic Loosening	0	0	N/A	N/A

DJD, degenerative joint disease; *PHF*, proximal humerus fracture; *PPFX*, periprosthetic fracture; *PJI*, prosthetic joint infection; *OR*, odds ratio; N/A, not applicable.
P values <.05 are indicated in bold.

Table V – Surgical complications at 1 year.

	DJD N (%)	PHF N (%)	OR (95% CI)	*P* value
PPFX	93 (0.6)	20 (1.7)	3.07 (1.81-4.98)	**<.001**
PJI	45 (0.3)	4 (0.3)	1.23 (0.93-1.99)	.99
Stiffness	1921 (13.2)	171 (14.7)	1.15 (0.97-1.36)	.11
Instability	443 (3.1)	67 (5.8)	2.3 (1.74-3)	**<.001**
Aseptic Loosening	6 (0.04)	0	N/A	N/A

DJD, degenerative joint disease; *PHF*, proximal humerus fracture; *PPFX*, periprosthetic fracture; *PJI*, prosthetic joint infection; *OR*, odds ratio; N/A, not applicable.
P values <.05 are indicated in bold.

Table VI – Surgical complications at 2 years.

	DJD N (%)	PHF N (%)	OR (95% CI)	*P* value
PPFX	135 (0.9)	27 (2.3)	2.57 (1.64-3.88)	**<.001**
PJI	55 (0.4)	4 (0.3)	1.09 (0.23-1.39)	.99
Stiffness	2009 (13.8)	184 (15.8)	0.18 (0.08-2.08)	**.038**
Instability	504 (3.5)	68 (5.9)	2.02 (1.53-2.62)	**<.001**
Aseptic Loosening	11 (0.1)	0	N/A	N/A

DJD, Degenerative Joint Disease; *PHF*, Proximal Humerus Fracture; *PPFX*, periprosthetic fracture; *PJI*, prosthetic joint infection; *OR*, odds ratio; N/A, not applicable.
P values <.05 are indicated in bold.

Discussion

The expanded indications for the use of RTSA continue to change the expectations and outcomes of patients undergoing the procedure.

Several prior small sample size studies and two systematic reviews have demonstrated improvement in clinical outcomes for all indications of RTSA; however, the many of these studies do not examine RTSA specifically performed for PHF.[2,11,26,27] These studies identify CTA and GHOA as the most common indications for RTSA with the most predictable results occurring for these indications over those performed for PTA or revision arthroplasty.[26]

In the present study, all degenerative conditions were combined into a single cohort. The notion that this population is a relatively homogenous group is supported by results in a previous study demonstrating no significant difference in clinical outcomes in RTSA performed for CTA versus GHOA or other degenerative conditions.[27] Two prior studies found that RTSA for fracture required greater resource utilization and recommended that risk adjustment be considered as the US Healthcare landscape moves toward bundled payment models.[12,13] Although the characteristics of both groups in the present study were slightly different, when controlling for variables, there were similar findings to these prior studies that those patients who underwent RTSA for PHF had a higher rate of various postoperative complications. However, this study was not only the largest population analyzed but also demonstrated that such complication rates exist beyond the initial 30 days postoperatively.

Specifically, our study demonstrated an increased risk for medical complications in PHF patients within 90 days of surgery. This is reflected in the study by Malik et al[13] which found a higher rate of 30-day medical complications in PHF patients, including UTI. Liu et al[12] found no significant differences between cohorts in terms of UTI, DVT, sepsis, pneumonia, reintubation, myocardial infarction, and wound complications.

There was an increased rate of hematoma formation at 90 days postoperatively in PHF patients in our study compared to DJD patients. This finding is somewhat corroborated by results of Crespo et al[6] where PHF had a higher hematoma rate than DJD patients, but this did not reach significance in their study. Interestingly, there was no significant difference in transfusion rates between PHF and DJD patients after accounting for differences in patient characteristics. This is in opposition to results from the NSQIP database studies which report increased transfusion rates at 30 days postoperatively in RTSA performed for PHF.[12,13] The divergent results in these studies may be able to be explained by the decreased sample size and shorter follow-up.

We found no difference in rates of prosthetic joint infection or AL between cohorts with a very low rate of AL in both cohorts up to 2 years postoperatively. This is also reflected in the analogous total hip arthroplasty (THA) literature comparing OA to femoral neck fracture and expected given AL is predominantly a long-term complication.[22] Crespo et al showed a higher rate of radiolucent lines in serial radiographs in the PHF cohort, which may suggest RTSA implants in PHF patients could be predisposed to loosening at longer term follow-up.[6] The two NSQIP studies did not report on any specific surgical complications, but Malik et al found a higher overall rate of surgical complications in PHF patients. In contrast, Crespo et al found no difference in rates of specific surgical complications.[6,13]

Our study consistently demonstrated an increased risk for instability in PHF compared to DJD at all time points up to 2 years. A previous study by Seidel et al found that dislocation in RTSA for PHF was more likely in those cases that were performed in a delayed fashion more than 4 weeks after injury.[24] Our study did not define the timing of the PHF date of injury to the time of RTSA, but clearly the impact of bone loss and difficulty in recreating proper soft tissue tension following RTSA for fracture is likely to lead to an increased risk of instability. Rates of PPF were also shown to be higher in the

PHF cohort in our study. This is in contrast to Crespo et al who did not identify different rates of PPF or dislocation between the two cohorts in their study.[6]

Multiple large database studies have demonstrated higher healthcare resource utilization in PHF patients undergoing RTSA in the form of higher rates of extended hospital length of stay, readmission, and nonhome discharge.[12,13] The findings of the present study are important because they identify specific medical and surgical complications in the PHF population which should help inform risk stratification in RTSA based on preoperative diagnosis. As healthcare reimbursement models continue to shift toward bundled payments to increase quality in an episode of care, risk stratification based on patient factors and indication for surgery will be vital. Risk stratification should be performed so that hospitals treating disproportionately more PHF patients are not unfairly penalized economically, thus disincentivizing hospitals from transferring nonelective PHFs to larger tertiary care centers in populations with known increased healthcare utilization and complications. Reimbursement models should provide additional resources for PHF to ensure the success of value-based approaches so that the target episode price by insurances is sufficient to meet the healthcare needs of these patients. In the analogous THA literature, there has been demonstrated to be increased resource utilization and risk of complications in hip fractures compared to osteoarthritis[18,21,22] which has resulted in the Centers for Medicare and Medicaid Services altering reimbursement for THA to reflect this.

This study is the largest to date comparing postoperative outcomes of RTSA for DJD versus PHF. ICD 10 procedure codes distinguishing RTSA from TSA were initially used in 2015 which is why we chose this as the beginning of our study period. This time point also allowed us to examine all degenerative conditions as opposed to only CTA.[12,13] The large, nationally representative sample size in this database is likely to accurately represent the true RTSA patient population and be able to identify significant differences in relatively rare complications. It is the first large study to examine complications beyond 30 days from surgery, encompassing the entire 90-day global period up to 2 years postsurgery, which is significant because prior studies have demonstrated that 80%-90% of complications occurred beyond 30 days.[6,12,13] The nature of the database used in our study allows for granular data on specific surgical complications.

There are several limitations to this study. First, there are inherent shortcomings associated with the use of large administrative databases, namely inconsistencies in coding and potential errors in data entry meant for billing purposes. There are also certain limitations in the PearlDiver database itself including a lack of detail on implant selection and surgical technique including humeral offset and subscapularis repair. In addition, while the 2-year follow-up period in our study is the longest for a database study in the current literature, we are unable to comment on long-term complication rates. Potential confounding exists despite multivariate analysis, given possible differences in DVT prophylaxis and perioperative antibiotic protocols, postoperative rehab regimens, and surgical indications that may be used by individual institutions and surgeons. This study is retrospective and thus conclusions of causality cannot be made from the present data. Given the nature of the data collected, we do not have information on postoperative function, patient satisfaction, or radiographic outcomes.

Conclusion

The present study demonstrates that PHF and DJD patients undergoing RTSA represent distinct populations where PHF patients have an increased risk for medical and surgical complications persisting up to 2 years postoperatively. Accordingly, the episode of care for RTSA in PHF appears to require higher healthcare utilization than DJD. This highlights the need for appropriate risk stratification in RTSA by surgical indication to determine proper resource allocation.

Disclaimers:

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Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1053/j.sart.2022.10.001.

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