Comparison of complication types and rates associated with anatomic and reverse total shoulder arthroplasty

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Abstract

Introduction

Complications after anatomic (aTSA) and reverse (rTSA) total shoulder arthroplasty can be devasting to a patient's quality of life and require revisions which are costly to both the patient and the health care system. The purpose of this study is to the determine the types, incidence and timing of complications following aTSA and rTSA using an international database of patients who received a single platform total shoulder arthroplasty system in order to quantify the types of failures modes and the differences that occur between aTSA and rTSA.

Methods

2224 aTSA (1090M/1134F) and 4158 rTSA (1478M/2680F) patients were enrolled in an international database of primary shoulder arthroplasty performed by 40 different surgeons in the US/Europe. Adverse events and revisions reported for these 6382 patients were analyzed to identify the most common failure modes associated for both aTSA and rTSA.

Results

Of 2224 aTSA patients, 239 adverse events were reported for a complication rate of 10.7% and 124 revisions for a revision rate of 5.6%. The top three complications for aTSA were rotator cuff tear/subscapularis failure (n=69, complication rate=3.1%, revision rate=1.9%), aseptic glenoid

loosening (n=55, complication rate=2.5%, revision rate=1.9%) and infection (n=28, complication rate=1.3%, revision rate=0.8%)

Of 4158 rTSA patients, 372 adverse events were reported for a complication rate of 8.9% and 104 revisions for a revision rate of 2.5%. The top three complications for rTSA were acromial/scapular fracture/pain (n=102, complication rate=2.5%, revision rate=0.0%), instability (n=60, complication rate=1.4%, revision rate=1.0%) and pain (n=49, complication rate=1.2%, revision rate=0.2%).

Conclusions

This large database analysis quantified complication and revision rates for aTSA and rTSA. We found aTSA and rTSA complication rates of 10.7% and 8.9%, respectively; with revision surgery rates of 5.6% and 2.5%, respectively. The two most common complications for each prosthesis type (aTSA: subscapularis/rotator cuff tears; rTSA: acromial/scapular fractures) were unique to each device. The rate of infection was similar for both. Future prosthesis and technique development should work to mitigate these common complication types in order to reduce their rate of occurrence.

Level of Evidence: Level III, Retrospective Cohort Design; Treatment Study

Keywords: shoulder arthroplasty; complications in arthroplasty

Introduction

Complications after anatomic (aTSA) and reverse (rTSA) total shoulder arthroplasty can be devasting to a patient's quality of life, resulting in recurring pain and impaired function that compromises their ability to perform activities of daily living. Complications can sometimes require revisions which are often costly to both the patient and the health care system, and also subject the patient to additional health risks. Furthermore, the risks of future revisions and complications increase with revision arthroplasty[12].

In recent years, there has been a dramatic increase in the utilization of rTSA, along with a smaller increase in the use of aTSA[7]; as previously described by Routman et al., since 2015, rTSA is more commonly performed in the US than aTSA[16]. There are numerous potential reasons for this change in market utilization, including: 1) an increased usage of rTSA for complex humeral fractures in the elderly, 2) an increased usage of rTSA for revision arthroplasty, 3) population-based changes related to an aging baby-boomer population and the associated increased occurrence of rotator cuff tears with age, 4) a real-perception that rTSA is a more forgiving procedure relative to aTSA, which can be successful irrespective of the quality of a patient's rotator cuff, which deteriorates with age, and 5) substantial improvement in rTSA prosthesis and technique design since the Grammont prosthesis was introduced into the US market in 2003, which has reduced the initially high complication and revision rates associated with rTSA as reported by Werner et al.[19] and Guery et al.[11]. These initially high complication rates prompted recommendations to only use rTSA as an end-stage salvage procedure for patients greater than 70 years of age[11, 19].

More recent studies with contemporary implant designs and techniques have demonstrated that the complication and revision rates are less than those previously published for both aTSA and rTSA, though the relative differences between the two procedures are not well-defined[2, 8]. Some have

reported increases in complications with rTSA relative to aTSA[2, 11, 19], whereas others have reported similar complication and revision rates between procedures[8]. Additionally, differences in complication and revision rates can be different between different aTSA prostheses and can be different between different rTSA prostheses. The purpose of this study is to the determine the types, incidence and timing of complications following aTSA and rTSA using an international database of patients who received a single platform total shoulder arthroplasty system in order to quantify the types of failures modes and the differences that occur between aTSA and rTSA.

Materials and Methods

2224 primary aTSA (1090M/1134F) and 4158 primary rTSA (1478M/2680F) patients were prospectively enrolled in an international database consisting of one platform total shoulder arthroplasty prosthesis (Equinoxe, Exactech, Inc, Gainesville, FL) utilized by 40 fellowship trained shoulder surgeons in the US and Europe. Patients with revision of a previously placed hemiarthroplasty or total shoulder arthroplasty, or a diagnosis of proximal humerus fracture were excluded. All patients enrolled in this study had data collected using standardized forms; all data collection forms were completed at each surgical site and uploaded onto a secure database. The mean age of the aTSA patient cohort at the time of surgery was 66 years with a mean BMI of 30 and a mean follow-up of 34 months. The mean age of the rTSA patient cohort at the time of surgery was 72 years with a mean BMI of 29 and a mean follow-up of 22 months. The mean follow-up for the combined group of 6,382 patients is 26 months. Adverse events and revisions reported for any of these 6382 patients were documented and analyzed to identify the most common failure modes associated with each prosthesis type. Complications and revisions were separately analyzed and the time after surgery in which the complication or revision occurred was reported for aTSA and rTSA. A two-tailed unpaired students t-test was used to compare the complication and revision rates for the different failure modes between aTSA and rTSA patients, where $p<0.05$ defined significance.

Results

For the 2224 aTSA patients, 239 adverse events were reported for a complication rate of 10.7%, which resulted in 124 revisions, for a revision rate of 5.6%. Table 1 describes the detailed break-out of complication and revision information for aTSA patients. The most commonly reported complication for aTSA was rotator cuff tear and/or subscapularis failure, which occurred in 69 patients (3.1%), of which 42 were revised (1.9%), at a mean follow-up of 23 months. Rotator cuff tear and/or subscapularis failure accounted for 28.9% of all aTSA complications and 33.9% of all revisions. Aseptic glenoid loosening was the 2nd most common aTSA complication, occurring in 55 patients (2.5%), of which 43 were revised (1.9%) at a mean follow-up of 56 months. Aseptic glenoid loosening accounted for 23.0% of all aTSA complications and 34.7% of all revisions. Infection was the 3rd most common aTSA complication and was reported in 28 patients (1.3%), of which 18 were revised (0.8%) at a mean follow-up of 19 months. Infection accounted for 11.7% of all aTSA complications and 14.5% of all revisions. Pain was the 4th most common aTSA complication and was reported in 25 patients (1.1%), of which 2 were revised (0.1%), at a mean follow-up of 39 months. Pain accounted for 10.5% of all aTSA complications and 1.6% of all revisions. Other notable complication types and rates were nerve injury (n = 15; complication rate = 0.7%, revision rate = 0.1%), instability (n = 14; complication rate = 0.6%, revision rate = 0.5%), aseptic humeral loosening (n = 8; complication rate = 0.4%, revision rate = 0.2%), and humeral fractures (n = 8; complication rate = 0.4%, revision rate = 0.1%).

For the 4158 rTSA patients, 372 adverse events were reported for a complication rate of 8.9%, which resulted in 104 revisions for a revision rate of 2.5%. Table 2 describes the detailed break-out of complication and revision information for rTSA patients. The most commonly reported

complication for rTSA was acromial & scapula fracture 69 patients (2.5%), of which 0 were revised (0%), at a mean follow-up of 11 months. It should be noted that there were an additional 33 patients who reported acromial pain but had no documented fracture on radiographic studies. Since there was no documentation of a fracture, they were not included in the count of 69 patients. Acromial fracture/scapular fracture accounted for 18.5% of all rTSA complications and 0.0% of all revisions. Instability was the 2nd most common rTSA complication occurring in 60 patients (1.4%), of which 40 were revised (1.0%), at a mean follow-up of 16 months. Instability accounted for 16.1% of all rTSA complications and 38.5% of all revisions. Pain was the 3rd most common rTSA complication and was reported in 49 patients (1.2%), of which 7 were revised (0.2%), at a mean follow-up of 11 months. Pain accounted for 13.2% of all rTSA complications and 6.7% of all revisions. Infection was the 4th most common rTSA complication and was reported in 36 patients (0.9%), of which 28 were revised (0.7%), at a mean follow-up of 17 months. Infection accounted for 9.7% of all rTSA complications and 26.9% of all revisions. Humeral fracture was the 5th most common rTSA complication and was reported in 36 patients (2.5%), of which 2 were revised (0.9%), at a mean follow-up of 21 months. Humeral fracture accounted for 9.7% of all rTSA complications and 1.9% of all revisions. Aseptic glenoid baseplate loosening was the 6th most common rTSA complication and was reported in 24 patients (0.6%), of which 13 were revised (0.3%), at a mean follow-up of 35 months. Aseptic glenoid loosening accounted for 6.5% of all rTSA complications and 12.5% of all revisions. Other notable complication types and rates were nerve injury (n = 15; complication rate = 0.4%, revision rate = 0%) and aseptic humeral loosening (n = 6; complication rate = 0.1%, revision rate = 0.1%).

The complication (Table 3) and revision (Table 4) rates for the most common failure modes between aTSA and rTSA patients are presented in Tables 3 and 4, respectively. Regarding differences in complication rates as described in Table 3, aTSA patients had a significant greater overall complication rate (aTSA = 10.7% vs. rTSA = 8.9%, p=0.0434) and a significantly greater aseptic glenoid loosening rate (aTSA = 2.5% vs. rTSA = 0.6%, p<0.0001) compared to rTSA patients. However, rTSA patients had a significant greater incidence of instability (aTSA = 0.6% vs. rTSA = 1.4%, p=0.0029) and a significantly greater humeral fracture rate (aTSA = 0.4% vs. rTSA = 2.5%, p=0.0165) than aTSA patients. Regarding differences in revision rates as described in Table 4, aTSA patients had a significant greater overall revision rate than rTSA patients (aTSA = 5.6% vs. rTSA = 2.5%, p<0.0001) and a significantly greater rate of revisions caused by aseptic glenoid loosening (aTSA = 1.9% vs. rTSA = 0.3%, p<0.0001) as compared to rTSA patients. However, rTSA patients had a significantly greater rate of revisions caused by instability (aTSA = 0.5% vs. rTSA = 1.0%, p=0.0222) as compared to aTSA patients.

The relative ranking of complications (Table 5) and revisions (Table 6) between aTSA and rTSA is presented in Tables 5 and 6, respectively. As described, causes of complications and revisions were similar between aTSA and rTSA, though a few differences were unique to each procedure. Specifically, rotator cuff failure was the most common complication for aTSA patients and the 2nd most common reason for revision for aTSA patients; however, this failure mode was understandably not observed for any rTSA patients. Conversely, acromial and scapular fractures were the most common complication for rTSA patients, though it was not observed in any aTSA patients. Additionally, the most common cause for revisions was different between aTSA and rTSA patients. Aseptic glenoid loosening was the most common cause for revision of aTSA

patients (by comparison, it was the #3 reason for revisions of rTSA patients), and instability was the most common reason for revision in rTSA patients (by comparison, it was the #4 most common reason for revision of aTSA patients).

Discussion

This large prospective database analysis of 6,382 patients documents the complication and revision rates associated with aTSA and rTSA using a contemporary single platform total shoulder arthroplasty system utilized for a variety of underlying indications and diagnoses, and quantifies the time to occurrence for the different complications and failure modes. The results of this study demonstrate aTSA is associated with a significant greater overall complication rate compared to rTSA (aTSA = 10.7% vs. rTSA = 8.9%, p=0.0434) and a significant greater overall revision rate (aTSA = 5.6% vs. rTSA = 2.5%, p<0.0001) compared to rTSA patients. Additionally, the failure modes between aTSA and rTSA were similar in type, though their relative rates were different. Aseptic glenoid loosening was significantly more common with aTSA (2.5%) than rTSA (0.6%) and was the most common cause of aTSA revisions (34.7% of all aTSA revisions). Conversely, instability was significantly more common with rTSA (1.4%) than aTSA (0.6%) and was the most common cause of rTSA revisions (38.5% of all rTSA revisions). Interestingly, the most common complication for each prosthesis type (aTSA: subscapularis/rotator cuff tears; rTSA: acromial/scapular fractures) were unique to each device. Of note, the rate of infection was similar for both aTSA (1.3%) and rTSA (0.9%).

Early reports of rTSA demonstrated high rates of complications compared to aTSA[6, 9, 19]. As implant designed changed and surgeon experience increased, complication rates have decreased substantially. Specifically, complications such as infection (4.0-6.7%[6, 18]), hematoma (21%[19]), instability (7.5%[18]) and need for revision surgery (13-33%[9, 19]) have all decreased in occurrence from these early reports. The implant in this current study has been previously evaluated as it

pertains to post-operative instability and found to have a very low dislocation rate (<1.5%), whether or not the subscapularis was repaired[10].

In 2006, Bohsali et al[3] conducted a meta-analysis on literature from 1995 to 2006 and reported 414 complications after 2,810 aTSA shoulders for a rate of 14.7%, in which loosening accounted for 39% of all complications reported. In 2017, Bohsali et al.[2] conducted a new meta-analysis on the literature from 2006 to 2015 and reported 2,122 complications in 19,262 aTSA and rTSA, for a rate of 7.4%. Comparing the first to the second meta-analysis, the overall complication rate was reduced by half; however, the length of follow-up was also observed to be less. The 7.4% complication rate was similar to the rate reported by Flurin et al.[8], who compared the outcomes of 528 aTSA patients and 617 rTSA patients at a mean follow-up of 40 months (and implanted during the same time-window of Bohsali et al. [2]) and found that aTSA patients (35 complications in 528 shoulders for a rate of 6.6%) had a slightly lower complication rate than rTSA patients (45 complications in 617 shoulders for a rate of 7.3%). In our study, at a shorter mean follow-up, we found that rTSA patients had a significantly lower complication rate (aTSA = 10.7% vs. rTSA = 8.9%, p=0.0434) and revision rate (aTSA = 5.6% vs. rTSA = 2.5%, p<0.0001) than aTSA patients. Comparing complication frequency for aTSA and rTSA, Bohsali et al. [2] reported that the complications are different and occur with different frequency, which aligns with our own findings. However, our ranking of complication frequency was different for both aTSA and rTSA from what was reported by Bohsali et al.[2]. They reported that the most common complications after aTSA in order of decreasing frequency were component loosening, glenoid wear, instability, rotator cuff tear, periprosthetic fracture, neural injury, infection, while the most common complications after rTSA in order of decreasing frequency were instability, periprosthetic fracture,

infection, component loosening, nerve injury, acromial and/or scapular spine fracture, and hematoma.

Kiet et al compared outcomes between 47 aTSA and 53 rTSA patients in a prospectively gathered study[13]. They found similar rates of complications and revisions between the two surgeries with 7 complications (13.2%) and 5 revisions (9.4%) in the rTSA group and 7 complications (14.9%) and 5 revisions (10.6%) in the aTSA group at two years. Complications varied by operation type with the complications in order of decreasing frequency for aTSA being rotator cuff tear, glenoid loosening and infection compared to those following rTSA being fracture, infection and instability. Fractures in the rTSA group included 2 traumatic glenoid fractures after falls and 1 coracoid and 1 acromial fracture deemed to be insufficiency or stress fractures.

Boileau has also reported on his experience with over 800 rTSA with 84 reinterventions and 60 revision surgeries in 54 patients[4, 5]. He found that the most common complications in order of decreasing frequency were instability, infection, humeral complications, fracture and bone defect, glenoid complications and glenoid component loosening and other complications. Scapular fractures were not reported in this series. This contrasts somewhat with the findings by Zumstein et al in a systematic review that identified a problem rate of 44% and a complication rate of 24%[20]. The review by Zumstein et al included a majority of articles published in 2005 or earlier and accordingly found the most common problem to be scapular notching on radiographs and the most common complication of instability (4.7%) followed by infection (4.0%). Barco et al discussed the definitions of "problem" *versus* "complication" to define events that have a negative effect on outcome after total shoulder arthroplasty[1]. The authors point out the variability in articles when

defining criteria for a complication. They found acromion and scapular fractures in 0 – 4% in the articles they reviewed with an overall complication rate of primary rTSA to be approximately 15%.

A recent complication profile was reported by Kennon et al, analyzing 90-day complications, reoperations and readmission rates of 636 primary aTSA and 1081 primary rTSA cases over a five-year period[12]. Two surgeons performed all cases. They found a 90-day complication rate, reoperation rate and readmission rate of 2.3%, 0.6% and 1.8%, respectively. Most readmissions were for medical and not surgical complications.

A strength of the current study is the large number of patients included in the analysis. To date, this is the largest study examining complications and revision surgery after aTSA and rTSA. Previous studies of smaller patient cohorts may have been subject to sampling errors, which may explain the difference in results from this study compared to previous ones. This study is also the first of this magnitude that demonstrated the most common complications varied by surgery type.

This study has several limitations. First, we did not analyze complications or revisions by patient diagnosis or perform any sub-analysis by patient comorbidities. Second, we did not attempt to quantify risk factors associated with complications or revisions for either aTSA or rTSA, similar to what was previously conducted by Leschinger et al.[14] and Lu et al.[15] Third, the mean follow-up of our complication analysis is relatively short at 26.0 months and the mean follow-up between aTSA and rTSA patients was different, with aTSA patients having longer follow-up than rTSA patients. We observed that aTSA patients had a greater revision rate than rTSA patients, and this may be due in part to the longer follow-up. Additional and longer follow-up is necessary to better

quantify how these complication and revision rates compare between aTSA and rTSA procedures and also quantify how these rates change with longer-term follow-up. Also, we did not analyze scapular notching as a complication in this study as has been performed in smaller studies. Once thought to be an asymptomatic radiographic finding, scapular notching is now known to lead to decreased clinical outcomes over time[17]. Finally, this is not a survivorship study, and future work should conduct a survivorship analysis to compare aTSA and rTSA at equivalent post-surgical timepoints.

Conclusion

This study of 2224 primary aTSA patients and 4,158 primary rTSA patients demonstrates that aTSA is associated with a significantly greater complication and revision rate than rTSA. Numerous rates and times of occurrences were documented for each failure type, along with a relative ranking of failure mode by prosthesis type. This analysis provides the orthopedic surgeon with valuable information related to the relative rates of complications and revisions associated with a modern platform total shoulder arthroplasty system and also their post-surgical time of occurrence. This knowledge is valuable to the surgeon for shared decision making and when obtaining informed consent for this elective procedure, and this knowledge can help establish appropriate patient expectations of risk for aTSA and rTSA. Furthermore, this knowledge is valuable to those involved in the design and development of shoulder implants so that they may direct resources to design better prostheses and improve surgical techniques to mitigate these complications and reduce their rates of occurrence.

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346 **Table Legends:**

347 Table 1. Detailed breakout of Complication & Revision Information for aTSA patients

348 Table 2. Detailed breakout of Complication & Revision Information for rTSA patients

349 Table 3. Comparison of complication rates between aTSA and rTSA

350 Table 4. Comparison of revision rates between aTSA and rTSA

351 Table 5. Ranked comparison of relative complication occurrences between aTSA and rTSA

352 Table 6. Ranked comparison of relative revision occurrences between aTSA and rTSA

Table 1. Detailed breakout of Complication & Revision Information for aTSA patients

aTSA Patients, n = 2224	Qty	AE Time after Surgery	Number Revised	% Complications of n=2224	Relative % of Complications, n=239	% Revisions of n=2224	Relative % of Revisions, n=124
RC tears and & subscap failure combined	69	22.5 ± 30.5	42	3.1%	28.9%	1.9%	33.9%
Aseptic glenoid loosening	55	55.8 ± 45.1	43	2.5%	23.0%	1.9%	34.7%
Subscapularis failure	35	13.3 ± 17.1	20	1.6%	14.6%	0.9%	16.1%
Rotator cuff tear	34	32.6 ± 38.2	22	1.5%	14.2%	1.0%	17.7%
Infection	28	18.9 ± 26.1	18	1.3%	11.7%	0.8%	14.5%
Pain - Combined	25	38.7 ± 47.3	2	1.1%	10.5%	0.1%	1.6%
Nerve injury	15	1.1 ± 2.9	1	0.7%	6.3%	0.0%	0.8%
Pain, persistent	15	51.6 ± 56.2	2	0.7%	6.3%	0.1%	1.6%
Instability	14	19.5 ± 36.4	10	0.6%	5.9%	0.5%	8.1%
Pain after fall	10	19.3 ± 18.8	0	0.4%	4.2%	0.0%	0.0%
Aseptic humeral loosening	8	41.5 ± 21.3	5	0.4%	3.3%	0.2%	4.0%
Humeral fracture, intraoperative	4	NA	0	0.2%	1.7%	0.0%	0.0%
Humeral Fracture, Periprosthetic	4	49.0 ± 25.5	1	0.2%	1.7%	0.1%	0.8%

aTSA = anatomic total shoulder arthroplasty; RC = rotator cuff; subscap = subscapularis; Qty = quantity; AE = adverse events

Table 2. Detailed breakout of Complication & Revision Information for rTSA patients

rTSA Patients, n = 4158	Qty	AE Time after Surgery	Number Revised	% Complication of n=4158	Relative % Complications, n = 372	% Revisions of n=4158	Relative % Revisions, n = 104
Acromial and Scapular Fx	69	11.3 ± 14.2	0	1.7%	18.5%	0.0%	0.0%
Instability	60	15.6 ± 23.1	40	1.4%	16.1%	1.0%	38.5%
Pain combined	49	10.5 ± 12.9	7	1.2%	13.2%	0.2%	6.7%
Acromial Fracture	48	9.8 ± 11.8	0	1.2%	12.9%	0.0%	0.0%
Infection	36	16.6 ± 19.2	28	0.9%	9.7%	0.7%	26.9%
Pain, persistent	33	8.8 ± 9.7	4	0.8%	8.9%	0.1%	3.9%
Aseptic glenoid loosening	24	34.6 ± 32.8	13	0.6%	6.5%	0.3%	12.5%
Scapular fracture	21	14.9 ± 18.5	0	0.5%	5.6%	0.0%	0.0%
Humeral Fracture, Periprosthetic	17	33.9 ± 29.2	1	0.4%	4.6%	0.0%	1.0%
Pain after fall	16	14.2 ± 17.7	3	0.4%	4.3%	0.1%	2.9%
Nerve injury	15	2.1 ± 3.7	0	0.4%	4.0%	0.0%	0.0%
Humeral fracture, intraoperative	13	NA	0	0.3%	3.5%	0.0%	0.0%
Aseptic humeral loosening	6	27.4 ± 21.4	4	0.1%	1.6%	0.1%	3.9%
Humeral Fractures, nonspecific	6	29.4 ± 28.2	1	0.1%	1.6%	0.0%	1.0%
Acromial Pain	5	3.0 ± 1.8	0	0.1%	1.3%	0.0%	0.0%
Coracoid Fracture	5	17.8 ± 33.9	0	0.1%	1.3%	0.0%	0.0%
Humeral Liner and/or Tray Disassociation	5	46.4 ± 19.2	5	0.1%	1.3%	0.1%	4.8%
Clavicle fracture	2	10.0 ± 12.5	0	0.0%	0.5%	0.0%	0.0%
Glenosphere Disengagement	2	0.3 ± 0.4	1	0.0%	0.5%	0.0%	1.0%

rTSA = reverse total shoulder arthroplasty; Fx = fracture; Qty = quantity; AE = adverse events

Table 3. Comparison of complication rates between aTSA and rTSA

Complication Name	aTSA Complication Rate	rTSA Complication Rate	P Value
Overall Complication Rate	10.7%	8.9%	**0.0434***
Aseptic Glenoid Loosening	2.5%	0.6%	**<0.0001***
Instability	0.6%	1.4%	**0.0029***
Pain	1.1%	1.2%	0.7696
Infection	1.3%	0.9%	0.1605
Humeral Fracture	0.4%	2.5%	**0.0165***
Aseptic humeral loosening	0.4%	0.1%	0.0886

* = denotes $P < 0.05$

aTSA = anatomic total shoulder arthroplasty; rTSA = reverse total shoulder arthroplasty

Table 4. Comparison of revision rates between aTSA and rTSA

Revision Name	aTSA Revision Rate	rTSA Revision Rate	P Value
Overall Revision Rate	5.6%	2.5%	**<0.0001***
Aseptic Glenoid Loosening	1.9%	0.3%	**<0.0001***
Instability	0.5%	1.0%	**0.0222***
Pain	0.1%	0.2%	0.4081
Infection	0.8%	0.7%	0.5958
Humeral Fracture	0.1%	0.9%	0.9403
Aseptic humeral loosening	0.2%	0.1%	0.2059

* = denotes $P < 0.05$

aTSA = anatomic total shoulder arthroplasty; rTSA = reverse total shoulder arthroplasty

Table 5. Ranked comparison of relative complication occurrences between aTSA and rTSA

Complication Name	aTSA Complication Rank	rTSA Complication Rank
Rotator Cuff Failure	1	NA
Acromial & Scapular Fractures	NA	1
Instability	6	2
Pain	4	3
Infection	3	4
Humeral Fracture	8	5
Aseptic Glenoid Loosening	2	6
Nerve Injury	5	7
Aseptic humeral loosening	7	8

aTSA = anatomic total shoulder arthroplasty; rTSA = reverse total shoulder arthroplasty; NA = not applicable

Table 6. Ranked comparison of relative revision occurrences between aTSA and rTSA

Cause of Revision	**aTSA Revision Rank**	**rTSA Revision Rank**
Rotator Cuff Failure	2	NA
Humeral Liner Disassociation	NA	5
Instability	4	1
Pain	6	4
Infection	3	2
Humeral Fracture	7	7
Aseptic Glenoid Loosening	1	3
Nerve Injury	7	NA
Aseptic humeral loosening	5	6

aTSA = anatomic total shoulder arthroplasty; rTSA = reverse total shoulder arthroplasty; NA = not applicable