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Complications after reverse shoulder arthroplasty for proximal humerus nonunion

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Background: Proximal humerus nonunion is a challenging complication of fractures that can be treated surgically with either open reduction internal fixation (ORIF) or reverse total shoulder arthroplasty (RTSA). The few studies published on this subject have shown high rates of complications and revision surgery when RTSA has been performed for proximal humerus nonunion. The purpose of this study was to determine the rates of complications and revision of this procedure at our institution, as well as to identify any variables that may impact risks of complications and reoperations.

Methods: A single-institution retrospective review of all patients who underwent RTSA for proximal humerus nonunion between 2005 and 2021 was performed. Nonunion was defined as imaging evidence of lack of union, at least 90 days after the index fracture. Patients with less than 1 year of clinical follow-up were excluded. Fifty patients were included, with the majority being female (78%). The mean age at time of RTSA was 71 (range: 54-86) years and most patients were initially treated nonoperatively (74%). Mean total follow-up was 49 (range: 11-130) months. Demographic and surgical variables were recorded. Primary outcomes were complications and reoperations. Complications were divided into surgical (those directly related to RTSA), or other (those unrelated to RTSA). Secondary outcomes included visual analog scale pain scores and range of motion.

Results: A total of 17 shoulders (34%) sustained complications after revision shoulder arthroplasty, with 10 (20%) requiring reoperation. Six patients (12%) sustained dislocations and 5 (10%) had radiographic evidence of humeral loosening. No variables examined, including nonoperative vs. surgical management of the index fracture, prosthesis type, or management of tuberosities, influenced the risk of dislocation. Survivorship free from reoperation at 2 years was 73%. Younger age at time of RTSA and the presence of diabetes mellitus both increased the risk of reoperation significantly ($P = .013$ and $P = .037$, respectively). There was a trend towards increased risk of reoperation in patients who were treated with initial ORIF (hazard ratio = 2.95); however, this did not reach statistical significance ($P = .088$). Three patients (6%) sustained a periprosthetic fracture after a fall.

Conclusion: RTSA provides improved pain and function for properly selected patients with proximal humerus nonunion. Dislocation, humeral loosening, and reoperation rates remain high when RTSA is performed for nonunion compared to other diagnoses. In this study, younger age and diabetes mellitus increased the odds of reoperation. Every effort must be made to optimize implant stability and humeral component fixation when RTSA is performed for proximal humerus nonunion.

Level of evidence: Level IV; Case Series; Treatment Study

Keywords: Proximal humerus nonunion; ORIF; RTSA; complications; revisions

Mayo Clinic Institutional Review Board approved this study (Mayo IRB #21-004343).

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Previous studies have shown that approximately 75% of proximal humerus fractures can be treated nonoperatively with good functional outcomes.[13,22,29,31,32,35] However, fracture union does not always occur. One study reported that nonoperative treatment increases the risk of nonunion compared to internal fixation.[12,35] However, nonunion can still occur after open reduction internal fixation (ORIF). Previous studies have reported anywhere from 0% to 27% nonunion rates after ORIF.[3,12] Furthermore, Goudie et al documented a 10% overall rate of nonunion and identified other risk factors for nonunion, including translation of the humeral shaft, varus displacement, and smoking.[18]

While the overall rate of nonunion after proximal humerus fractures remains relatively small, surgical management of these nonunions can be challenging.[20,35] Most surgeons consider either ORIF or reverse total shoulder arthroplasty (RTSA). Surgical decision making is dependent on a variety of patient and surgeon factors, and there is no clear consensus on what is the ideal treatment.[10] Currently, many surgeons favor RTSA, given the technical difficulties and relatively high rates of reoperation after ORIF.[17]

Unfortunately, reverse arthroplasty performed for proximal humerus nonunion has been associated with an increased rate of complications as well.[34,41] Dislocation is the most commonly reported complication, with rates varying between 17% and 38%.[34,41] Interestingly, most studies on the subject have included a relatively small number of shoulders, with the two largest current studies reporting on 32 and 35 patients, respectively.[34,41] Other similar studies examining RTSA after proximal humerus fracture sequelae have examined more heterogenous cohorts, including malunions and varying types of nonunions. This makes it challenging to draw conclusions given the substantial variability amongst these groups. Our study aimed to examine a more uniform cohort, only including surgical neck nonunions, with or without greater tuberosity nonunion.

At our institution, we have made an effort to reconstruct the tuberosities when RTSA is performed for nonunion. Additionally, we selectively use metallic proximal replacement implants or allograft prosthetic composites (APCs) for those nonunions with poor proximal humerus bone quality or substantial proximal humerus bone loss. The purpose of this study was to determine our complication and revision rates after RTSA for proximal humerus nonunion. Secondarily, patient and surgical variables were examined to determine whether any features could be identified to correlate with complications and reoperations.

Material and methods

Patient cohort

After Institutional Review Board approval, a single-institution retrospective case-series review was undertaken. All patients who underwent reverse shoulder arthroplasty for proximal humerus nonunion between 2005 and 2021 were considered potentially eligible for inclusion in this study. Nonunion was defined as imaging evidence of lack of union (on radiographs and/or computed tomography scan) at least 90 days after the index fracture. Patients with less than one year of clinical follow-up were excluded.

A total of 50 patients met inclusion criteria and form the basis of this study, with 78% (n = 39) being females. Forty-two shoulders (84%) presented with isolated nonunions of the surgical neck of the humerus. whereas the remaining 8 (16%) had nonunion of both the surgical neck and the greater tuberosity. The average age at time of arthroplasty was 71 (range: 54-86) years. A total of 46% (n = 23) had surgery performed on their dominant arm. Most patients underwent initial conservative management of their index proximal humerus fracture (74%, n = 37), whereas 13 patients (26%) had undergone previous ORIF to treat their proximal humerus fracture. The average time between fracture and arthroplasty was 17.3 months (range: 3.2-89.5 months). Of those who underwent previous ORIF, the average time between initial fracture and ORIF was 13.5 days (range: 0-82 days). The average follow-up for the entire cohort was 5 years (range: 12 months-13 years).

Surgical technique

All procedures were performed by fellowship-trained shoulder and elbow surgeons. Surgeries were performed under interscalene blockade and general anesthesia in the beach chair position. The implants used varied throughout the duration of the study. An effort was made to repair both the greater and the lesser tuberosity whenever possible. Fixation of the humeral component was performed with cement in 21 shoulders and without cement in 29 shoulders. In 8 shoulders, the quality of proximal humerus bone stock or the severity of the proximal humerus bone loss was substantial, and shoulders were reconstructed using a metallic proximal humerus replacement (SRS, Zimmer-Biomet, Warsaw, IN, 4 shoulders) or an APC (4 shoulders), respectively. The mean length of bone loss reconstructed using an APC was 4.5 cm (range: 3.5-6 cm). All 4 APC reconstructions were secured utilizing a plate and screws, with 1 reconstruction having a cerclage wire added.

Data collection

The electronic medical records of all 50 patients were reviewed for demographic data, including gender, hand dominance, age at time of surgery, body mass index, presence of certain comorbid conditions (diabetes mellitus, rheumatoid arthritis, or osteoporosis), history of smoking, and alcohol use disorder. Initial treatment and time from proximal humerus fracture to arthroplasty were recorded. For patients who underwent initial ORIF prior to union, time from that surgery to arthroplasty was also recorded. Operative reports were reviewed for type of prosthesis utilized, size of glenosphere, as well how the tuberosities were managed. Postoperative radiographs were reviewed to classify tuberosity management as anatomic reduction, malreduction, or resection. Most recent radiographs, prior to any revision surgery, were also reviewed for signs of humeral loosening.

Primary outcomes included postoperative complications and need for revision surgery. Complications were classified as either surgical or other. Surgical complications included those that were

considered directly related to the arthroplasty (such as dislocation, humeral loosening, and deep infection). Periprosthetic fracture after trauma, hematoma, and superficial infection not requiring reoperation were considered as other complications. Secondary outcomes included preoperative range of motion that was recorded by the performing surgeon at their preoperative visit, as well as postoperative range of motion, either at latest follow-up or most recent visit prior to revision surgery, if applicable. Active elevation and active external rotation were recorded in degrees. Internal rotation was graded based on classification system previously described by Levy et al.[25] Preoperative and postoperative VAS pain scores were also recorded.

Statistical analysis

BlueSky Software was utilized for statistical analysis (BlueSky Statistics LLC, Chicago, IL, USA). Descriptive statistics were used to describe the demographic variables and overall complication profile. A Kaplan-Meier curve was calculated for survivorship free of reoperation. The hazard ratio (HR) with 95% confidence interval (CI) was calculated for demographic and operative factors affecting dislocation event and reoperation separately. Alpha-level was set at 0.05. A nonparametric *t*-test was used to differences between preoperative and postoperative variables.

Results

The overall complication rate in this cohort was 34% (n = 17), with 10 patients (20%) requiring reoperation. A total of 13 patients (26%) had surgical complications directly related to RTSA and 5 patients (10%) had other complications. All complications are summarized in Table 1. There was a 14% risk of a surgical complication at 1 year (CI: 3.9%-23.3%) and a 26% risk of a surgical complication at 2 years and beyond (CI: 12.0%-37.8%).

Dislocation was the most frequently reported complication (12%). Details regarding the six patients who sustained RTSA dislocation are summarized in Table 2. Of these, 5 patients required reoperation, 4 of which required more than 1 surgery. One patient who underwent arthroplasty with an SRS implant and 1 patient who had an APC reconstruction sustained postoperative dislocations. Demographic and operative characteristics were examined to determine factors affecting risk of dislocation. These are detailed in Table 3. Alcohol use disorder trended towards an increased risk of dislocation, which approached but did not reach statistical significance (HR = 4.25, $P = .095$). When SRS and APC were grouped together and compared against standard RTSA, differences in dislocation rates did not reach statistical significance ($P = .251$). None of the remaining factors examined statistically increased the risk of dislocation event.

A total of 9 patients required reoperation secondary to surgical complications (Table 4). The aforementioned variables were also examined to determine risk of reoperation (Table 5). Younger age was associated with a significantly increased risk of reoperation (HR = 0.90, $P = .013$). The presence of diabetes was associated also with a significantly increased risk of reoperation (HR = 3.80, $P = .037$). There was a trend towards an increased risk of reoperation with initial treatment of ORIF compared to nonoperative management as well as with alcohol use disorder, but these differences did not reach statistical significance (HR = 2.95, $P = .088$ and HR = 3.76, $P = .056$, respectively). When SRS and APC were grouped together and compared against standard RTSA, differences in reoperation rates did not reach statistical significance ($P = .774$). Figure 1 graphically represents the Kaplan-Meier curve for survivorship free of reoperation. Survivorship free of reoperation was 80% at 1 year (CI: 64.8%-99.7%), 73% at 2 years (CI: 54.9%-97.2%), and a 49% at 10 years (CI: 20.8%-100.0%).

Table I Complications

	n
Implant-related complications	
Dislocation	6
Loose humeral component	5
Deep infection	2
Acromion fracture	1
Total*	13
Nonimplant related and minor complications	
Periprosthetic fracture	3
Hematoma	1
Superficial infection	1
Total	5

* 1 patient had concomitant dislocation and deep infection.

RTSA led to significant improvements in active elevation, from an average of 45° (range: 0-140) preoperatively to 101° (range: 30-160) postoperatively ($P < .005$). Active external rotation also improved significantly, from an average 15° (range: 0-60) to 26° (range: 0-80) postoperatively ($P = .034$). There was an increase in active internal rotation, however this was not statistically significant, average grade 3.6 (range: 0-10) to a grade 4.1 (range: 0-8) postoperatively ($P = .470$). This is approximately equivalent to preoperative internal rotation to between the level greater trochanter and sacrum and postoperative internal rotation to the level of L4. There was also a significant improvement in VAS pain postoperatively from 6.1 (range: 0-10) to 1.4 (range: 0-9) ($P < .005$).

Radiographically, 77% of shoulders (24 out of 31) had evidence of tuberosity union at final follow-up. There were 5 shoulders (10%) with radiographic evidence of humeral loosening, 6 (12%) with humeral stress shielding, 4 (8%) with scapular notching, and (12%) with ectopic bone formation. All patients with evidence of humeral loosening had RTSA performed with standard implant components. One of the 5 stems with evidence of humeral loosening was after implantation of a cemented stem, while the remainder

Table II Dislocation events

Patient (age/sex)	Initial treatment	Implant type	Time to first dislocation, days	Total no. of dislocations	Treatment
82F	Nonop	SRS	688	1	Closed reduction
66M	Nonop	Standard	18	2	Closed reduction; open reduction; 2 periprosthetic fractures after
70M	Nonop	Standard	28	4*	Open reduction x2; revision RSA; revision to hemiarthroplasty
61F	Nonop	Standard	42	2	Open reduction; ORIF for periprosthetic fracture; postop dislocation requiring closed reduction
58M	ORIF	Standard	23	4*	Closed reduction; open reduction; revision to hemiarthroplasty
72F	ORIF	APC	55	1	Open reduction

Nonop, nonoperative; *ORIF*, open reduction internal fixation; *RSA*, revision shoulder arthroplasty; *SRS*, Zimmer-Biomet Comprehensive Segmental Revision System.
* Continued instability at most recent follow-up.

Table III Factors affecting risk of dislocation event

	Hazard ratio	CI	*P* value
Age	0.98	(0.90-1.07)	.607
BMI	1.00	(0.90-1.13)	.932
Diabetes	1.76	(0.32-9.61)	.517
Rheumatoid arthritis	0.97	(0.11-8.35)	.981
Osteoporosis	5.22	(0.95-28.51)	.057
Smoking history	1.62	(0.30-8.89)	.576
Alcohol use disorder	4.25	(0.78-23.30)	.095
Initial treatment			
Nonoperative	REF	-	-
ORIF	1.57	(0.29-8.60)	.601
Prosthesis type			
Standard RSA	REF	-	-
APC	2.98	(0.33-26.78)	.330
SRS	2.48	(0.28-22.21)	.417
Glenosphere size			
36 mm	REF		
>36 mm	1.12	(0.83-1.15)	.459
Management of tuberosities			
Anatomic reduction	REF	-	-
Malreduced	0	-	.999
Resected	3.85	(0.35-42.49)	.271

BMI, body mass index; *CI*, confidence interval; *ORIF*, open reduction internal fixation; *RSA*, reverse shoulder arthroplasty; *APC*, allograft prosthetic composites; *SRS*, Zimmer-Biomet Comprehensive Segmental Revision System.

complicated noncemented stems. Only 1 of these patients referred a history of torsional injury to the shoulder and 3 of these 5 shoulders underwent revision surgery. Of note, none of the patients with humeral loosening had concomitant infection or any history of infection in the ipsilateral shoulder.

Discussion

This study indicates that RTSA provides adequate pain relief and improvements in motion and function when performed for proximal humerus nonunion. This is in agreement with previous literature and the results of our study confirm the high rate of complications and reoperations reported by others. In particular, our study found a high rate of dislocation and humeral loosening. In our cohort, younger age and a history of diabetes mellitus were associated with an increased risk of reoperation.

Our study found a high overall complication rate (34%) and specifically a 26% rate of complications directly related to RTSA. The rate of overall complications in previous studies has been quite variable. One early study examined 18 patients who underwent RTSA for proximal

Table IV Indications for reoperation

	n
Major complications	
Dislocation	5
Loose humeral component	3
Deep infection	2
Total*	9
Minor complications	
Periprosthetic fracture	3
Total	3

* 1 patient had concomitant dislocation and deep infection.

humerus nonunion and found a 27% complication rate (n = 5).[30] The most commonly cited article by Raiss et al reported a 41% complication rate[34] A more recent study by Dezfuli et al reported only 1 complication in their cohort of 13 patients (8%) who underwent RTSA for proximal humerus nonunion or malunion.[15] They did not clarify whether this complication affected a patient with a prior nonunion or malunion.

Other studies with lower complication rates have lumped together various post-traumatic indications for RTSA. With heterogeneous patient cohorts, it is difficult to draw conclusions and prognostic factors for specific diagnoses and patients. As one can imagine, surgical intervention after nonunion can pose much different challenges as compared to that after malunion. One could hypothesize that nonunions may be more prone to instability due to bone loss and subsequent difficulty restoring humeral length. The soft tissue environment in nonunions may also predispose patients to instability. These nuances suggest that nonunions will have much different outcomes and complication profiles as compared to malunions and should therefore not be grouped together as the majority of previous studies have done. For example, in the study by Shannon et al, the 26 patients included underwent salvage RTSA after failure of prior ORIF, with an 8% (n = 3) complication rate, which included 1 dislocation and 1 humeral loosening, although neither of these patients underwent revision surgery.[37] However, it is important to note that only 4 of the 26 shoulders included in that study had undergone RTSA for nonunion. Sebastia-Forcada et al reported a complication rate of 20%, but only one-third of the patients included had proximal humerus nonunions, and they did not delineate which patients had complications or reoperations.[36] Similarly, the study by Hattrup et al which reported on 26 patients who underwent RTSA after traumatic sequela, only included 6 patients with surgical neck nonunions.[21] These studies, while important, limit surgeons' abilities to draw conclusions about outcomes or complication profile in patients with proximal humerus nonunions. To the authors' knowledge, there are currently only two studies that examine only proximal humerus nonunions. This includes a study by Zafra et al which examined 35 patients and reported a 17% complication rate.[41] Even within their cohort, they noted variability in nonunion pattern, with only 8 being classified as surgical neck nonunions, also known as Checchia Group II.[8,41] The other study by Raiss et al examined 32 patients, all with surgical neck nonunions, and reported a similar complication rate to our study at 41%.[34] Our study is therefore the largest series of a cohesive cohort of proximal humerus nonunions to date.

Dislocation was the most common surgical complication after RTSA for proximal humerus nonunion, occurring in 12% of patients. This is similar to the previously reported dislocation rate of 11% (2 out of 18) in a study by Martinez.[30] One study reported a dislocation rate of 38% in this patient population.[34] These figures are much larger than the previously reported incidence of instability after RTSA for other nontraumatic etiologies, which are typically less than a 10% rate[9,23,26-28,38] and oftentimes under 2%.[9,23,26-28,38] One study examining overall risk factors for dislocation, found that preoperative diagnosis of fracture sequelae placed patients at higher risk.[9] This study also found an increased rate of dislocation with prior shoulder surgery in allcomers.[9] With the numbers available, we could not demonstrate a difference in dislocation rates when for patients with or without prior ORIF of their proximal humerus nonunion compared to these treated nonoperatively. We were also unable to identify any other demographic or surgical factors, including management of the tuberosities or APC reconstruction that contributed to an increased risk of dislocations. This is despite 1 previous study showing that intraoperative resection of the tuberosities increased risk of dislocation.[34] Our study did show an increased HR with resection of the tuberosities (HR = 3.85); however this did not reach statistical significance ($P = .271$). Another previous study noted instability in 6 out of 25 patients (24%) who underwent RTSA with APC reconstruction.[5] Our study did not corroborate these findings, noting no differences in dislocation rate based on type of RTSA performed. Again, while the HRs were increased for APC or SRS (HR = 2.98 and 2.48, respectively), these did not reach statistical significance ($P = .330$ and $P = .417$, respectively). It is possible that this is secondary to type II error and that our sample size was not large enough to reach proper statistical power in order to capture these differences.

Interestingly, our study found a high rate of aseptic humeral loosening, which has not previously been reported in the literature. We reported a 10% humeral loosening rate, of which 3 of the 5 patients (60%) went on to revision surgery. In a previous study by Shannon et al, 1 out of 26 patients was noted to have aseptic humeral loosening, which did not go on to require revision surgery during the study period.[37] While aseptic humeral loosening is a rare occurrence in primary shoulder arthroplasty performed for arthritis, it has

Table V Factors affecting risk of reoperation

	Hazard ratio	CI	*P* value
Age	0.90	(0.83-0.98)	**.013**
BMI	1.05	(0.97-1.14)	.190
Diabetes	3.80	(1.09-13.31)	**.037**
Rheumatoid arthritis	0.51	(0.06-4.00)	.519
Osteoporosis	2.95	(0.85-10.30)	.090
Smoking history	2.04	(0.52-7.91)	.304
Alcohol use disorder	3.76	(0.97-14.62)	.056
Initial treatment			
Nonoperative	REF	-	-
ORIF	2.95	(0.85-10.21)	.088
Prosthesis type			
Standard RSA	REF	-	-
APC	1.40	(0.17-11.32)	.753
SRS	1.14	(0.14-9.14)	.903
Glenosphere size			
36 mm	REF		
>36 mm	1.98	(0.57-6.88)	.280
Management of tuberosities			
Anatomic reduction	REF	-	-
Malreduced	1.32s	(0.14-12.70)	.810
Resected	2.22	(0.45-11.03)	.331

BMI, body mass index; *CI*, confidence interval; *ORIF*, open reduction internal fixation; *RSA*, reverse shoulder arthroplasty; *APC*, allograft prosthetic composites.
Bold values are those that are statistically significant ($P < .05$).

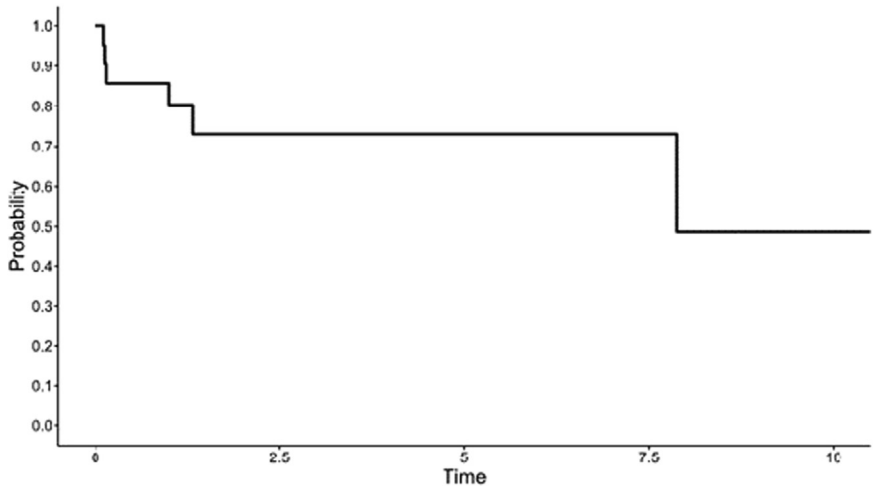

Figure 1 Survivorship free of reoperation.

previously been reported in the literature in the setting of revision shoulder arthroplasty. Boileau et al noted aseptic humeral loosening in 5 out of 37 (14%) of patients undergoing revision shoulder arthroplasty.[4] They suggest that this is secondary to proximal humerus bone loss. This is supported by a previous biomechanical study which found that proximal humerus bone loss led to increased micromotion and subsequent implant failure after reverse shoulder arthroplasty.[14] One can reason that all patients with a surgical neck nonunion have some component of proximal humerus bone loss and are subject to an increased rate of humeral loosening. A previous study by Chacon et al suggests that patients with substantial proximal humerus bone loss should be treated with APC, which may help decrease the risk of humeral loosening.[7] Our study supports this, as there was no evidence of

humeral loosening in any of the patients who underwent APC reconstruction at the time of RTSA, despite them having significant proximal humerus bone loss.

Our study found a 20% reoperation rate after RTSA for proximal humerus nonunion, which is similar to previous studies examining revision after RTSA for proximal humerus nonunion.[34] Again, this is higher than traditional reoperation rates after primary RTSA.[26] This study also found an increased risk of reoperation for patients with younger age as well as diabetes. A previous international database study found that younger patients were at higher risk of postoperative complications and need for revision surgery.[26] One additional national database study found that diabetes predisposes patients to complications and readmissions, including infection, respiratory complications, and deep vein thromboses after shoulder arthroplasty.[16] Interestingly, in our study body mass index was not associated with increased risk of reoperation, which is in agreement with previous studies examining obesity as a risk factor for surgical complications after shoulder arthroplasty.[1,11] In the current study, there was also a trend towards increased risk of reoperation with prior ORIF compared to nonoperative management (HR = 2.95), although it did not reach statistical significance ($P = .088$). Previous shoulder surgery has been shown to be a risk factor for increased complications and reoperations in other studies.[2] One study that specifically examined RTSA for failed ORIF of proximal humerus fractures found that 7% of patients required revision surgery, with reasons including infection, instability, and periprosthetic fracture.[19] Another study by Bois et al found that 19% of patients undergoing RTSA after ORIF sustained complications.[6] While the exact numbers are variable, the literature suggests that we should expect an increased risk of reoperations in patients who underwent previous ORIF for their proximal humerus fracture as compared to those who were treated nonoperatively. It is possible that overall small numbers or patient factors in our cohort, such as younger age of those undergoing ORIF previously, skewed the results seen in our study.

Three patients did require reoperation for periprosthetic fracture in this study. There is recent evidence suggesting that a fragility fracture occurring within 3 years of shoulder arthroplasty places the patient at increased risk of periprosthetic fracture and subsequent revision surgery in the first 2 years postoperatively.[39] Proximal humerus fractures are often seen in elderly patients after low energy trauma with underlying osteopenia/osteoporosis, and therefore, likely places this cohort at an innately higher risk of periprosthetic fractures.

When complications did not occur, patients included in our study experienced improved pain and functional outcomes after RTSA. Similar studies have also shown improved postoperative clinical outcome variables in this cohort. Specifically, Sebastia-Forcada et al found that patients experienced improved pain scores and functional outcome scores after RTSA for failed proximal humeral locking plate fixation.[36] Hattrup et al also demonstrated improved pain along with increased forward flexion and external rotation when RTSA was performed for posttraumatic sequelae of proximal humerus fractures.[21] However, there are multiple studies that have shown that RTSA for fracture sequelae have inferior results as compared to the outcomes of RTSA for other indications. A previous study by Wall et al found that while all etiologies had improvement in functional scores postoperatively, those with previous trauma had significantly worse scores.[40] Kilic et al reported that clinical outcomes of RTSA for fracture sequelae were somewhere in between the outcomes of RTSA for rotator cuff arthropathy and revision surgeries.[24] While the aforementioned study by Sebastia-Forcada found improved postoperative outcomes after RTSA for failed proximal humerus fixation, these functional outcomes were significantly worse when compared to patients who underwent acute RTSA after proximal humerus fracture.[36] Additionally, a systematic review comparing the outcomes of primary RTSA for acute proximal humerus fracture versus salvage RTSA for failed treatment of proximal humerus fracture by Nelson et al demonstrated that primary RTSA had improved range of motion, patient-reported outcomes and complications as compared to salvage RTSA.[33] These studies do not correlate the complication rates to clinical outcomes, however, one could hypothesize that the decreased functional outcomes are directly related to the increased complication rate in this cohort compared to those who undergo RTSA for nontraumatic etiologies. The current study would support this hypothesis, with patients reporting significantly decreased pain and increased range of motion, despite the relatively high complication rate.

Our study is not without limitations. While this study is the largest to date on this topic, the overall numbers of patients and subsequent complications remain relatively low. A multicenter study would be necessary to obtain a substantially larger sample size. Additionally, this study was performed at a tertiary care center, meaning patient follow-up may be variable, however any follow-up within the health system was reviewed and used as last visit to better capture all complications. There also may be selection bias due to the retrospective nature of this study, for instance those patients who underwent initial ORIF versus those who were initially treated nonoperatively. Finally, multiple surgeons were involved in this study; therefore, surgical techniques may vary and have an unrecognized impact on patient outcomes.

Conclusion

RTSA provides improved pain and function for properly selected patients with proximal humerus nonunion.

However, dislocation, humeral loosening, and reoperation rates remained relatively high when RTSA is performed for nonunion. In this study, younger age and diabetes mellitus increased the odds of reoperation. Every effort must be made to optimize implant stability and humeral component fixation when RTSA is performed for proximal humerus nonunion.

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