Reverse Shoulder Arthroplasty for Management of Postinfectious Arthropathy With Rotator Cuff Deficiency

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abstract

Treatment of patients with rotator cuff deficiency and arthritis in the setting of a prior glenohumeral infection (postinfectious arthropathy) is complex, with little evidence to guide treatment. The current authors present their approach to management of these patients and clinical outcomes after reverse shoulder arthroplasty (RSA). All primary RSAs performed for postinfectious arthropathy and rotator cuff deficiency with native glenohumeral joints were identified in a prospective shoulder arthroplasty registry. Eight patients with a minimum of 2-year follow-up were included in the analysis. Clinical outcomes, including the Constant score, the American Shoulder and Elbow Surgeons (ASES) score, the Western Ontario Osteoarthritis Shoulder (WOOS) index, the Single Assessment Numeric Evaluation (SANE) score, and range of motion measurements, were assessed preoperatively and at final follow-up. At an average follow-up of 4.4 years, no patient had a clinically detectable recurrence of infection. Significant improvements were noted in all outcome scores from preoperative evaluation to final follow-up after RSA, including Constant score (P=.003), ASES score (P<.001), WOOS index (P=.002), SANE score (P=.025), forward flexion (P<.001), abduction (P<.001), and external rotation (P=.020). Seven of 8 patients reported they were satisfied or very satisfied at final follow-up. Reverse shoulder arthroplasty can be performed in patients without significant medical comorbidities in the setting of postinfectious arthropathy and rotator cuff deficiency with a low risk of recurrence of infection. Significant clinical improvements were noted at short-term follow-up. [*Orthopedics*. 2015; 38(8):e701-e707.]

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Rotator cuff deficiency and arthritis in the setting of a prior glenohumeral infection (postinfectious arthropathy) is a devastating problem often associated with severely diminished function, debilitating pain, and few treatment options. Shoulder arthroplasty has been reported to provide improved pain and function in patients with postinfectious glenohumeral arthritis[1]; however, anatomic shoulder arthroplasty relies on a functional rotator cuff for optimal results. Reverse shoulder arthroplasty (RSA) can be used as an alternative treatment in the setting of postinfectious arthropathy with rotator cuff deficiency. Reverse shoulder arthroplasty is classically used for glenohumeral arthritis with a deficient rotator cuff,[2,3] but promising results have been described for other pathologies.[4-10] Reverse shoulder arthroplasty for postinfectious arthropathy has been reported in a single series of patients[11]; however, the majority of the shoulders (17 of 22) reported had infection in the setting of a prior hemiarthroplasty, whereas only 5 shoulders had an intact, native glenohumeral joint.

The purpose of the current study was to present the authors' approach to management and clinical outcomes in patients following RSA for postinfectious arthropathy with rotator cuff deficiency and a native glenohumeral joint. The primary hypothesis was that patients with a history of postinfectious arthropathy would have improved clinical outcome scores following RSA. The secondary hypothesis was that patients with a history of postinfectious arthropathy would have a low risk of recurrent infection following RSA when following the authors' treatment algorithm.

Materials and Methods

Patient Inclusion Criteria and Demographics

The authors identified all primary RSAs completed for postinfectious arthropathy from 2004 to 2011 in a prospectively collected shoulder arthroplasty registry. Eleven patients were identified, and 3 patients were excluded due to inadequate follow-up (less than 2-year follow-up). Eight patients with a minimum of 2-year follow-up were included in the analysis.

Six of the 8 patients had a history of deep infection following rotator cuff repair, and 1 patient had an infection following open reduction and internal fixation (ORIF) of a proximal humeral fracture. One patient did not have prior surgery, and the etiology of infection was unknown. All patients had native glenohumeral joints, and none had a prior history of hemiarthroplasty or total shoulder arthroplasty. All patients had positive cultures or clear documentation of infection treated at outside facilities.

All cases were performed at a single, high-volume shoulder arthroplasty center by a single surgeon (T.B.E.). All patients had rotator cuff deficiency and end-stage arthritis documented with preoperative computed tomography arthrogram or magnetic resonance imaging and noted intraoperatively. Seven of the 8 patients had massive irreparable supraspinatus, infraspinatus, and subscapularis tears, and 1 patient had massive irreparable supraspinatus and infraspinatus tears with an intact subscapularis.

Specific patient demographic and clinical characteristics reviewed included age, sex, duration of follow-up, smoking status, history of chronic back pain, depression, diabetes mellitus, heart disease, and body mass index (BMI). Clinical outcome scores evaluated preoperatively and at final follow-up included the Constant score,[12] the American Shoulder and Elbow Surgeons (ASES) score,[13-15] the Western Ontario Osteoarthritis Shoulder (WOOS) index,[16] the Single Assessment Numeric Evaluation (SANE) score,[17] and range of motion (ROM) measurements. Final follow-up for 3 of the 8 patients was obtained via telephone. These 3 patients had ASES, SANE, and Constant pain scores.

Treatment Algorithm

All patients were treated according to an algorithm developed by the surgeon (**Figure**). All patients with a remote history of deep infection or an acute deep infection in the operative shoulder completed a preoperative infection workup, which included complete blood count with differential, erythrocyte sedimentation rate (ESR), C-reactive protein (CRP), and an image-guided glenohumeral joint aspiration by a musculoskeletal radiologist. Patients were taken off antibiotics at least 2 weeks prior to aspiration, and the aspirate was sent for aerobic, anaerobic, fungal, and acid-fast bacteria (AFB) cultures. Cultures were held for a minimum of 21 days to detect bacteria such a *Propionibacterium acnes* and *Staphylococcus epidermidis*, which have longer incubation periods.[18,19]

Patients with a clinical presentation of an acute infection (eg, fluctuance, open draining wound) or positive cultures from joint aspiration were initially treated with open irrigation and debridement procedures. Two to 3 open irrigation and debridement procedures were completed with antibiotic spacer placement, typically 2 to 3 days apart during the same hospitalization. The number of debridement procedures performed was dictated by clinical assessment at the time of surgery as determined by the surgeon, but the minimum number of irrigation and debridement procedures for actively infected patients was 2. Infectious disease consultation was obtained during hospitalization, and patients were treated with a minimum of 6 weeks of intravenous antibiotic therapy. Once infection eradication was achieved, as demonstrated by improving clinical examination and normalization of infectious markers (ESR and CRP), definitive treatment with RSA was commenced. Repeat aspiration or biopsy is not routine following irrigation and debridement procedures completed at the authors' institution by the senior surgeon (T.B.E.).

Patients with a remote history of infection in the operative shoulder and negative joint aspiration cultures underwent an arthroscopic biopsy. A minimum of 5 separate biopsy specimens were sent for aerobic, anaerobic, fungal, and AFB cultures. De-

finitive RSA was completed if all cultures were negative. A positive culture following arthroscopic biopsy required at least 2 open irrigation and debridement procedures with antibiotic spacer placement and 6 weeks of antibiotics prior to RSA.

Surgical Technique

The operative shoulder was cleaned with isopropyl alcohol and prepped with povidone iodine scrub and iodine paint solution (Medline Industries, Inc, Mundelein, Illinois). Ioban 2 (3M, St Paul, Minnesota) surgical drapes were applied to cover all exposed skin on the operative shoulder. Surgical helmets were not used.

The Aequalis reverse shoulder arthroplasty system (Tornier, Edina, Minnesota) was used for all patients. The RSA technique used during the study period is well described.[20,21] All patients had antibiotic-loaded bone cement with 1.0 g of vancomycin or 1.0 g of tobramycin per 40 g of bone cement based on culture results and antibiotic sensitivity data. All patients received preoperative intravenous (IV) antibiotics within 30 minutes of incision and 24 hours of IV antibiotics postoperatively for the definitive RSA procedure. The antibiotic regimen for the 6 patients who underwent surgery between 2004 and 2009 was 1 g of IV cefazolin infused within 30 minutes of incision and 1 g of IV cefazolin every 8 hours postoperatively for 3 additional doses. The antibiotic regimen was changed in 2010, and 2 patients underwent surgery during this time period. The antibiotic regimen after 2010 was 1 g of vancomycin infused prior to incision and 1 g of vancomycin every 12 hours postoperatively for 2 additional doses. Furthermore, these patients also received 300 mg of oral clindamycin postoperatively every 8 hours for a total of 12 doses as an additional precaution against *P acnes*.

Sequential compression devices were used for deep venous thrombosis (DVT) prophylaxis, and chemical DVT prophylaxis was not used. All patients were placed in a neutral rotation brace for 3 to 4 weeks before initiating a standardized postoperative rehabilitation protocol.[20,22]

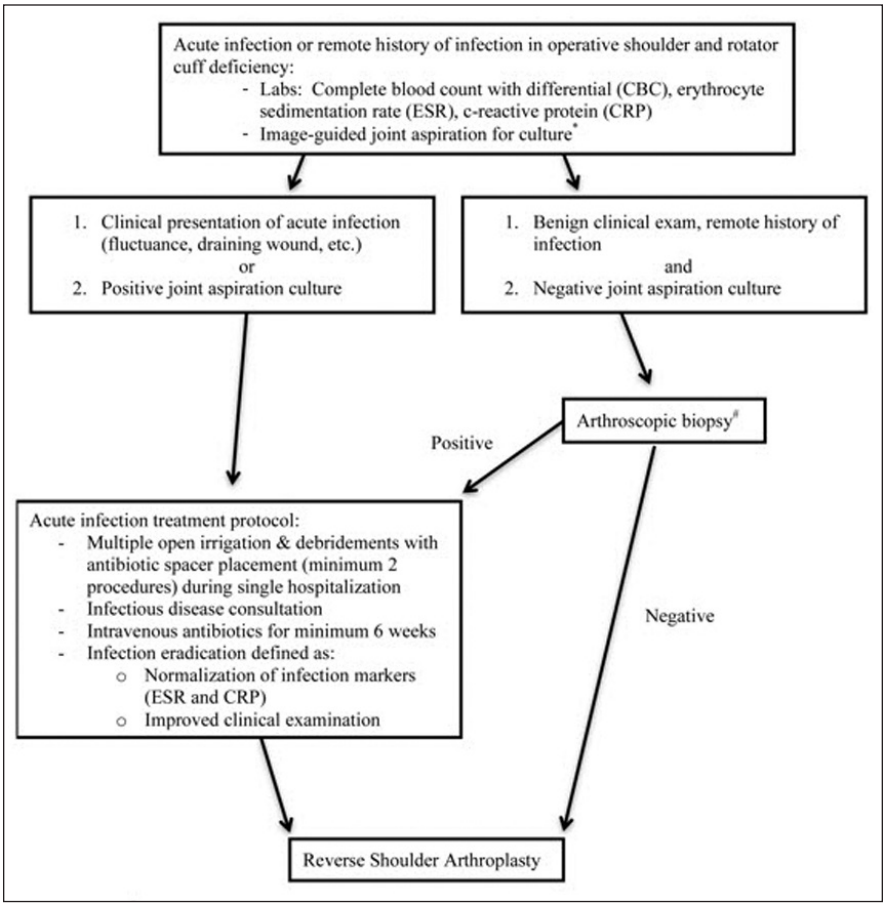

Figure: Treatment algorithm for postinfectious arthropathy with rotator cuff deficiency. *Patients were kept off of antibiotics for at least 2 weeks prior to aspiration. Cultures were sent for aerobic, anaerobic, fungal, and acid-fact bacteria and held for a minimum of 21 days to detect *Propionibacterium acnes* and *Staphylococcus epidermidis*. #A minimum of 5 arthroscopic specimens were obtained for cultures.

Clinical Assessment

Patients were prospectively enrolled in a shoulder arthroplasty registry and followed clinically. Patients were examined preoperatively by the surgeon, and repeat examinations were completed postoperatively at 1 and 6 weeks; 3, 6, and 12 months; and annually thereafter. Radiographs were obtained at each clinic appointment and included anteroposterior (AP) in the plane of the scapula, scapular Y, and axillary views. Radiographs were evaluated for glenoid component and humeral component loosening.[23] Range of motion was measured at each visit, and outcome scores were collected annually.

Statistical Analysis

Means and SDs were calculated for patient demographic data, outcome scores, and ROM measurements, and comorbidities are presented as percentages. One-tailed, paired-sample *t* tests were used to test pre- to postoperative (final follow-up) changes (improvement) in outcomes and ROM measurements. *P* values less than .05 were considered statistically significant.

Results

Patient demographic data are shown in **Table 1**. The majority of the patients were male (n=6; 75%), with an aver-

Table 1

Patient Demographics

Demographic	Value
Patients, male/female, No.	6/2
Age at surgery, mean±SD (range), y	64.1±11.2 (45-77)
Follow-up, mean±SD (range), y	4.4±1.7 (2-7)
Smoker, No. (%)	1 (12.5)
History of chronic back pain, No. (%)	3 (37.5)
Depression, No. (%)	1 (12.5)
Diabetes mellitus, No. (%)	0 (0)
Heart disease, No. (%)	0 (0)
Body mass index, mean±SD, kg/m^2	30.6±4.5

age age of 64.1±12.0 years (range, 45-77 years) and average BMI of 30.6±4.5 kg/m^2. Average clinical follow-up time was 4.4 years (range, 2-7 years).

Average radiographic follow-up was 3.0 years. There was no radiographic evidence of glenoid component loosening or humeral component subsidence for any patient. No patient had humeral component loosening as noted by radiolucent lines of 2 mm or larger in more than 3 of the 7 zones as described by Melis et al.[23] Six patients had no radiolucent lines. One patient had radiolucent lines smaller than 2 mm in 2 zones (zones 3 and 5), and another patient had radiolucent lines of 2 mm and larger in 1 zone (zone 4).

The diagnosis of infection and complications are noted in **Table 2**. Three of the 8 patients presented with an acute infection and required open irrigation and debridement procedures to eradicate infection prior to definitive RSA. One patient was already a candidate for RSA for rotator cuff tear arthropathy prior to presenting with an acute infection. This patient had definitive treatment 8 weeks after 2 staged irrigation and debridement procedures. The other 2 patients with acute infections had a known history of infections 1 year prior to presentation and had multiple irrigation and debridement procedures at outside hospitals. Both patients subsequently presented to the authors' institution with active infections and were considered as acute infections. Both patients underwent 3 irrigation and debridement procedures followed by definitive treatment at 11 weeks and 16 weeks, respectively, following initial presentation.

The remaining 5 patients had a remote history of infection in the operative shoulder with irrigation and debridement procedures performed at outside hospitals. One of these patients with a remote history of an infection had a positive aspirate culture and required open irrigation and debridement procedures. The other 4 patients with a history of a remote infection and negative aspirate cultures had arthroscopic biopsies performed. One of the 4 arthroscopic biopsies revealed a positive

Table 2

Diagnosis of Deep Infection and Complications

Patient No.	Presentation of Deep Infection[a]	Operation Before Infection	Diagnosis of Infection and Initial Treatment at Outside Hospital	Outside Hospital Culture Results	Aspiration Results at Authors' Facility	Arthroscopic Biopsy Culture Results at Authors' Facility	Culture Results at Authors' Facility at Time of Irrigation/ Debridement	Complication
1	Acute	None	No	N/A	Negative	N/A	MSSA	None
2	Acute	RCR	Yes	U/A	Negative	N/A	Negative	None
3	Acute	Revision RCR	Yes	U/A	Negative	N/A	Negative	Acromial stress fracture
4	Remote	RCR	Yes	U/A	Negative	Negative	N/A	None
5	Remote	Revision RCR	Yes	MSSA	Negative	Negative	N/A	Acromial stress fracture
6	Remote	ORIF proximal humerus	Yes	U/A	Negative	Negative	N/A	None
7	Remote	RCR	Yes	MRSA	Negative	Positive: MRSA	MRSA	Humeral fracture
8	Remote	RCR	Yes	MRSA	Positive: MRSA	N/A	MRSA	None

Abbreviations: MRSA, methicillin-resistant Staphylococcus aureus*; MSSA, methicillin-sensitive* Staphylococcus aureus*; N/A, not applicable; ORIF, open reduction and internal fixation; RCR, rotator cuff repair; U/A, unavailable.*

[a]*Acute means presentation of an acute deep infection. Remote means remote history of deep infection treated at an outside facility.*

culture (methicillin-resistant *Staphylococcus aureus*) that was not identified on aspiration (culture negative).

Cultures were positive for methicillin-sensitive *S aureus* (2 patients) and methicillin-resistant *S aureus* (2 patients). Four patients with a remote infection diagnosed and treated at outside hospitals did not have culture data available. Outside hospital records confirmed the diagnosis and treatment of an infection in all 4 cases; however, the culture results were not available.

Three patients had complications. One patient had an intraoperative complication with a humeral fracture requiring cerclage cabling. Two patients had postoperative acromial stress fractures that were treated nonoperatively and resolved. No patient had a recurrence of infection postoperatively.

Three patients were excluded due to short-term follow-up (less than 2 years). One patient had 6-month follow-up, and a second patient had 1-year follow-up. These 2 patients had clinical and radiographic follow-up at their final clinic visit, with no signs or symptoms of infection and no radiographic signs of glenoid or humeral loosening. The third excluded patient had significant glenoid bone loss secondary to infection and required autogenous iliac crest bone grafting at the time of definitive RSA. The bone graft construct failed, and loss of fixation on the glenoid side occurred at 4 months postoperatively. The patient subsequently required resection arthroplasty, and no infection was noted on intraoperative cultures at the final operation. The patient was last evaluated at 6 months after resection arthroplasty, with no signs or symptoms of infection.

Overall, significant improvements were noted for all outcome scores and ROM measurements at final follow-up. Three patients were only available for follow-up via telephone and were only included in the analysis for Constant pain, ASES, ASES pain, and SANE scores (**Table 3**). Subjective pain scores (Constant pain and ASES pain) were obtained for all 8 patients, and significant improvements were noted from preoperatively to final follow-up. American Shoulder and Elbow Surgeons and SANE scores significantly improved for all patients.

Table 3

Outcome Scores and Range of Motion Measurements

Parameter	Mean±SD		*P*[a]
	Preoperative	Final Follow-up	
Outcome score			
Constant pain	6.6±3.9	11.8±5.0	.006
Constant activity (n=5)	5.5±1.9	11.2±4.1	.025
Constant mobility (n=5)	2.3±2.9	26.0±7.1	.001
Constant strength (n=5)	0±0	9.2±5.2	.009
Constant total (n=5)	14.4±6.0	56.2±19.4	.002
Constant adjusted (n=5)	17.8±6.8	77.2±29.7	.003
ASES	38.0±14.8	78.4±15.2	<.001
ASES pain	3.8±2.3	0.6±0.5	.002
WOOS (n=5)	72.8±13.9	33.6±16.3	<.001
SANE	24.3±27.2	59.9±34.5	.025
Range of motion			
Forward flexion (n=5)	7.5°±13.9°	143.3°±21.3°	<.001
Abduction (n=5)	7.5°±13.9°	135.0°±22.6°	<.001
External rotation (n=5)	3.8°±7.4°	20.0°±14.6°	.020

Abbreviations: ASES, American Shoulder and Elbow Surgeons; SANE, Single Assessment Numeric Evaluation; WOOS, Western Ontario Osteoarthritis of the Shoulder index.
[a]*One-tailed, paired-sample* t *test was used to test pre- to postoperative changes (improvement) in outcome and range of motion measures.* P *values less than .05 were considered statistically significant.*

Five patients were available for clinical evaluation allowing for Constant score, WOOS index, and ROM measurements (**Table 3**). The total and adjusted Constant scores significantly improved in all sections (pain, activity, mobility, and strength). The WOOS index, an osteoarthritis disease-specific clinical outcome measure, similarly improved significantly ($P<.001$). Range of motion measurements also significantly improved (forward flexion, abduction, and external rotation).

Preoperatively, 7 of 8 patients were very dissatisfied, and 1 patient was dissatisfied. At final follow-up, 7 of 8 patients were satisfied or very satisfied, and 1 patient was dissatisfied.

Discussion

This investigation demonstrates that RSA can be a viable treatment option for patients with rotator cuff deficiency and arthritis in the setting of a prior glenohumeral infection (postinfectious arthropathy). Improvements in pain and outcome scores can be attained with a low risk of recurrent infection.

Mileti et al[1] reported 12 patients treated for postinfectious glenohumeral arthritis with shoulder arthroplasty from 1975 to 2000 with at least 2-year follow-up. Six patients with deficiency of the rotator cuff were treated with hemiarthroplasty, whereas the remaining 6 patients had an intact rotator cuff and were treated with

total shoulder arthroplasty. Although overall pain score and ROM improved with no recurrence of infection, only half of the patients rated their result as better or much better.

Cuff et al[11] retrospectively evaluated 21 patients with deep infection and rotator cuff deficiency treated with RSA in either a single- or 2-staged procedure. All pain and functional outcome scores showed statistically significant improvement, with no recurrence of infection. Seventeen shoulders were previously treated with hemiarthroplasty, and 5 shoulders had native glenohumeral joints following failed open rotator cuff repair.

All 8 patients in the current study had native glenohumeral joints prior to definitive treatment. Statistically significant improvement occurred in all pain and functional outcome scores and ROM measurements. There was no recurrence of clinically detectable infection.

Oral clindamycin was added to the authors' postoperative antibiotic regimen in 2010 as an additional precaution against *P acnes*. It is unclear whether the addition of oral clindamycin has affected the postoperative infection rate. Antibiotic-loaded cement has been shown to be effective in the prevention of deep infection following primary RSA at a minimum 1-year follow-up.[24] However, the retrospective investigation did not include a multivariable analysis and was unable to account for other important patient variables, such as smoking, diabetes mellitus, rheumatoid arthritis, or BMI, which may contribute to infection. Antibiotic-loaded cement was used for all patients in the current study because these patients had a history of infection. However, antibiotic-loaded cement is not routinely used in the authors' practice for cemented primary RSAs without a history of infection.

The addition of an arthroscopic biopsy has been useful prior to RSA in patients with a remote history of glenohumeral joint infection. One patient in the study had a negative preoperative infection workup, including a negative aspirate, and a positive culture was noted following arthroscopic biopsy. An arthroscopic biopsy can be particularly helpful given the poor sensitivity of ESR,[25-27] CRP,[25-27] and intraoperative histology in shoulder surgery.[27] The number of biopsy specimens sent for culture during the arthroscopic biopsy is also important because the rate of positive cultures increases with the number of culture specimens obtained.[28] The authors obtain a minimum of 5 biopsy specimens for culture during arthroscopic biopsy.

Limitations of this study include its retrospective nature and short-term follow-up. The minimum follow-up time of 2 years is relatively short; however, a minimum 12-month follow-up has been used for postoperative infection surveillance following RSA,[24] and a minimum 2-year follow-up is typical for shoulder arthroplasty. Average follow-up time for the entire study population was 4.4 years. The study was also limited by having a small number of patients, which is not entirely unexpected given the uncommon diagnosis. Furthermore, the authors were limited by an inability to obtain culture information from outside hospitals. Four of the patients had an infection documented in outside hospital notes; however, the authors were unable to obtain the culture results.

The study also has some notable strengths, including use of a standardized infection workup and treatment protocol and the fact that a single surgeon used the same operative technique, implant, postoperative protocol, and postoperative rehabilitation. Furthermore, multiple validated shoulder outcome scores were used.

No recurrence of clinically detectable infection was noted in the patient cohort, and this has also been reported in a similar cohort[11]; however, this should be viewed with caution in light of the fact that the current cohort had few comorbidities. Although the authors feel that their treatment algorithm helps to diagnose and treat infections in this setting, patient comorbidities also contribute to the ability to eradicate infection. Other variables such as diabetes mellitus, smoking, morbid obesity, and rheumatoid arthritis have been associated with an increased risk of infection in various orthopedic procedures.[29-32] No patient in the current study had diabetes mellitus, heart disease, or rheumatoid arthritis; only 1 patient was a smoker; and the average BMI was 30.6 kg/m^2.

Conclusion

Reverse shoulder arthroplasty can be performed in patients without significant medical comorbidities in the setting of postinfectious arthropathy and rotator cuff deficiency with a low risk of recurrence of infection. Significant clinical improvements were noted at short-term follow-up.

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