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Management of infected shoulder arthroplasty: a comparison of treatment strategies

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Background: The study purpose was to determine whether 2-stage revision procedures result in superior outcomes and whether reverse shoulder arthroplasty produced superior outcomes to hemiarthroplasty or anatomic total shoulder arthroplasty at the time of reimplantation.

Methods: Our prospectively collected database was retrospectively reviewed for all surgically treated infected shoulder arthroplasties between 2006 and 2014. We included 47 patients in this study: 27 underwent a 2-stage revision, and 20 were treated with an antibiotic spacer as definitive treatment. Preoperative laboratory results, intraoperative cultures and pathology findings, recurrence of infection, complications, and outcome measures were compared between treatment groups.

Results: A recurrent infection developed in 3 patients in the antibiotic spacer group and 2 patients in the 2-stage revision group ($P = .25$). A total of 20 procedure-related complications and 11 medical complications occurred between the 2 groups; however, there was no statistically significant difference between groups. The 2-stage group had statistically significantly better Constant scores (58.1 vs. 33.3, $P = .04$) and elevation (94.4° vs. 48.6°, $P = .02$) than the antibiotic spacer group. Subanalysis of the 2-stage revision group showed that reverse total shoulder arthroplasties had statistically superior Shoulder Pain and Disability Index, Simple Shoulder Test, American Shoulder and Elbow Surgeons, University of California at Los Angeles, and Constant scores; elevation; and abduction compared with hemiarthroplasties or anatomic total shoulder arthroplasties.

Conclusion: Two-stage revision procedures and use of an antibiotic spacer for definitive management of periprosthetic shoulder infections appear to be similar and effective in eradicating infections. Two-stage revisions using a reverse total shoulder arthroplasty at the time of reimplantation generate superior range of motion and functional outcome scores.

Level of evidence: Level III; Retrospective Cohort Comparison; Treatment Study

Keywords: Antibiotic articulating spacer; periprosthetic shoulder infection; retrospective review; reverse total shoulder arthroplasty; revision shoulder arthroplasty; 2-stage shoulder arthroplasty revision

Periprosthetic infection after primary shoulder arthroplasty is relatively uncommon, with rates ranging from 1% to 5%; however, infection rates after revision shoulder arthroplasty as high as 15% have been reported.[2-4,16-18,20] An infected shoulder arthroplasty is a complication resulting in significant patient morbidity and expenditure of health care resources.[14] Historically, 2-stage reimplantation

Institutional review board approval (No. 20091701) was obtained for this study.

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has been used for the management of chronically infected shoulder arthroplasties; however, studies on the management technique are limited to a few small series.[5,8,10,15,20-22] As a result, there are conflicting results.

Because of the unpredictable outcomes of 2-stage revision surgery and/or patient host factors, an antibiotic spacer has also been reported as a form of definitive management in the setting of an infected shoulder arthroplasty. Several case series have evaluated the outcomes with an antibiotic spacer for definitive management.[9,12,19] These studies reported that this intervention seemed effective in eradicating infection but the patients had marginal functional outcomes.

The purpose of this study was to compare the outcomes of patients undergoing 2-stage revision for an infected shoulder arthroplasty with the outcomes of patients who elected to keep their antibiotic spacer as definitive management. We also performed a subanalysis of the 2-stage group, comparing outcomes with nonconstrained arthroplasties (hemiarthroplasty [HA] or anatomic total shoulder arthroplasty [aTSA]) and with constrained arthroplasties (reverse total shoulder arthroplasty [rTSA]). We hypothesized that the 2-stage revision group would have improved outcomes compared with the patients who were definitively treated with an articulating antibiotic spacer and that rTSA would produce improved outcomes compared with HA or aTSA on subanalysis.

Materials and methods

Patient selection

Our institution's prospectively collected shoulder arthroplasty database was retrospectively reviewed for all surgically treated infected shoulder arthroplasties from 2006 to 2014 with a minimum of 1 year of clinical follow-up. The identified patients' electronic medical records were then reviewed. The surgical history of the affected shoulder was documented, recording all previous surgical procedures, the dates of previous surgical procedures, and the original diagnosis leading to the shoulder arthroplasty. The patients' serologic laboratory results (white blood cell count, C-reactive protein [CRP], and erythrocyte sedimentation rate [ESR]), radiographs, intraoperative histologic and pathologic results, intraoperative findings, and culture results were reviewed and documented. These findings were used to confirm the diagnosis of infection. Standard patient demographic information was collected in addition to known risk factors for infection (diabetes, tobacco use, liver disease, renal failure, and immunomodulating medications).

Diagnosis of infection and recurrence of infection

A prosthetic joint infection (PJI) was defined using our institution's criteria. A definite PJI existed when 1 of the following 3 factors was present: a sinus tract communicating with the prosthesis, a pathogen isolated by culture from at least 2 fluid or tissue samples from the affected joint, and purulent fluid present within the joint space or directly adjacent to the joint. A PJI was also diagnosed if the patient met 3 or more of the following 5 criteria: elevated serologic laboratory findings (white blood cell count, ESR, and/or CRP level); a pathogen isolated by culture from only 1 fluid or tissue sample from the affected joint; greater than 5 neutrophils per high-power field in 5 high-power fields on histologic analysis; a loose humeral stem on radiographs; and clinical examination findings such as cellulitis, stiffness, and resting pain.

Recurrence of infection and the date on which the diagnosis of recurrence was made were recorded for each patient. A recurrent infection was defined by clinical symptoms, laboratory findings consistent with infection, intraoperative histologic findings consistent with infection, or reoperation for infection.

Surgical technique and medical management of infection

All patients were treated for infection by the same protocol. Patients were diagnosed with infection by use of a combination of clinical findings, laboratory studies, and intraoperative culture and pathology results. The initial treatment began with the removal of all implants, as well as polymethyl methacrylate (PMMA) if present. Aggressive and methodical irrigation and débridement were then performed. After débridement was completed, a prefabricated gentamicin-impregnated PMMA articulating spacer (Interspace; Exactech, Gainesville, FL, USA) was implanted and secured with a mixture of 1 g of vancomycin and PMMA. Patients were then prescribed 6 weeks of intravenous (IV) antibiotics. Antibiotic therapy was determined by culture antibiotic susceptibility results. If cultures did not yield microbial speciation, the patient was empirically treated with 6 weeks of IV vancomycin. Vancomycin was used because of the increasing prevalence of methicillin-resistant organisms according to the antibiotic sensitivity profile of bacterial pathogens at our institution. Once therapy was completed, patients were evaluated clinically and with serologic studies 6 weeks after completion of antibiotics. If there were no signs of infection, patients were offered a second-stage reimplantation shoulder arthroplasty. During the second-stage surgical procedure, intraoperative frozen sections were obtained and clinical inspection of the joint was performed to confirm elimination of infection.

Complications and outcome measures

Postoperative complications, procedurally related and medical, were documented and categorized accordingly. The patients' most recent clinical evaluation findings were reviewed to determine the patients' shoulder range of motion (ROM) and visual analog scale (VAS), Shoulder Pain and Disability Index (SPADI), Simple Shoulder Test (SST), American Shoulder and Elbow Surgeons (ASES), University of California at Los Angeles (UCLA), Constant, and Short Form 12 functional metric scores. In addition, a general patient satisfaction score was included. Internal rotation was measured by vertebral segments and was scored by the following discrete assignment: 0°, 0; hip, 1; buttocks, 2; sacrum, 3; L5-L4, 4; L3-L1, 5; T12-T8, 6; and T7 or higher, 7. The general satisfaction score was determined based on patients' subjective outcome of treatment on a scale from 1 to 5, where 1 indicates much better; 2, better; 3, unchanged; 4, worse; and 5, much worse.

Table I Patient demographic information

	Total	Antibiotic spacer	2-Stage revision	*P* value
No. of patients	47	20	27	
Sex, n				.82
Male	27	9	18	
Female	20	11	9	
Average age, yr	65.9 ± 9.5	63.6 ± 11.2	67.8 ± 7.6	.14
Average BMI	30.5 ± 6.5	29.6 ± 6.4	31.4 ± 6.7	.40
Tobacco use, %	14.8	20	11.1	.29
Diabetes, %	26.6	30	24	.66
Immunocompromised, %	36.2	30	41	.34
Average No. of previous surgical procedures	1.6 ± 1.0	1.85 ± 1.3	1.4 ± 0.7	.15
Index diagnosis, %				.23
Fracture	31.1	50	16	
DJD	22.2	5	36	
RTCA	42.2	40	44	
AVN	4.4	5	4	

BMI, body mass index; *DJD*, degenerative joint disease; *RTCA*, rotator cuff arthropathy; *AVN*, avascular necrosis.

Statistical analysis

All statistical procedures were performed using SPSS software (version 24; IBM, Armonk, NY, USA). Descriptive statistics (means and standard deviations for continuous variables or frequencies and percentages for categorical variables) were calculated for all study variables and demographic characteristics. Normality of the data was first confirmed using Shapiro-Wilk tests. Homogeneity of variance was verified for the study variables using the Levene test. Because of kurtosis and skewness, the follow-up time was log transformed before analysis. Only Mann-Whitney *U* tests were performed on categorical data (patient characteristics, index diagnosis, surgery number, and recurrence of infections). One-way analyses of variance were used to determine whether differences existed for preoperative hematologic variables.

Univariate analyses of variance were performed on patient-reported outcomes and quality-of-life measures, with age and sex as covariates. The dependent variables were the outcome measures (SPADI, ASES, SST, UCLA, and Constant scores; Short Form 12 total scores and subscores; and ROM), and the independent variable was the patient group (2-stage surgical procedures or spacer). Secondary analyses were performed. First, we compared outcome differences between the spacer subgroup, all 2-stage subgroups (HA, aTSA, and rTSA), nonconstrained 2-stage arthroplasty (HA and aTSA), and rTSA. Finally, we determined whether there were outcome differences between the subgroups of the 2-stage group. The 2-stage group was stratified into patients who underwent 2-stage HA or aTSA and those who underwent 2-stage rTSA. The same analyses were repeated as described earlier for the patient outcomes.

Results

Patient selection and demographic characteristics

From the database, we identified 68 patients who had been treated surgically for an infected shoulder arthroplasty. Three patients were excluded because they had been treated with a resection arthroplasty. Three patients were excluded because they had been treated with a single-stage revision. One patient was excluded for having undergone antibiotic spacer placement for a reason other than infection. Six patients had antibiotic spacers placed for primary infection of a native shoulder. Finally, 8 patients were excluded because they did not have a minimum of 1-year follow-up. Thus, 47 patients remained for evaluation. There were 2 deaths that occurred prior to the 1-year follow-up. As a result, no functional data were available for comparison; however, the patients' demographic information, preoperative findings, intraoperative findings, and complications were included.

The patient demographic characteristics are presented in Table I. No difference concerning sex, age, or number of previous surgical procedures was found between study groups. In addition to basic demographic information, common risk factors for infection are presented in Table I. Five patients in the antibiotic spacer cohort were found to have a diagnosis of diabetes mellitus. Six patients also had comorbidities that adversely affect the immune response. Of these 6 patients, 4 had autoimmune diseases being treated with immunomodulating medications, 1 was taking corticosteroids for chronic pulmonary disease, and 2 were dependent on dialysis because of renal disease. Six patients in the 2-stage cohort had a diagnosis of diabetes mellitus. Eleven patients in the 2-stage cohort were also found to have comorbidities that affect the immune response. Of these 11 patients, 2 had chronic liver disease due to hepatitis C, 1 had chronic kidney disease, 3 had severe peripheral vascular disease, and 1 had lymphedema due to axillary node resection and external beam radiation therapy for cancer. In addition, 4 patients were taking immunomodulating medications for pre-existing medical conditions (rheumatoid arthritis in 1, heart transplant in 1, and chronic obstructive pulmonary disease in 2). Of the 47 patients

Table II Preoperative laboratory values and intraoperative culture results and pathology findings

	Total	Antibiotic spacer	2-Stage revision	*P* value
Elevated WBC count (normal WBC count < 10 $\times 10^3$/mL^3), %	15	15	10	.40
Average WBC count, $\times 10^3$/mL^3	7.5 ± 2.1	8.0 ± 1.8	7.0 ± 2.3	.14
Elevated ESR (normal ESR < 20 mm/h), %	88	90	86	.59
Average ESR, mm/h	43.1 ± 24.8	45.1 ± 25.7	41.2 ± 24.5	.63
Elevated CRP level (normal CRP level < 3 mg/L), %	74	85	68	.31
Average CRP level, mg/L	20.6 ± 24.6	25.7 ± 28.3	16.2 ± 20.6	.22
Clinical findings, %				
Purulent fluid	36	40	33.3	.79
Loose implants	42.6	45	40.7	.93
Pathology results, %				
Acute inflammation	80.4	75	84.6	.37
Positive culture, %	65.9	70	62.5	.86
Cutibacterium acnes	9	4	5	
Methicillin-sensitive *Staphylococcus aureus*	5	2	3	
Methicillin-resistant *Staphylococcus aureus*	2	2	0	
S epidermidis	5	2	3	
Other	8	4	4	

WBC, white blood cell; *ESR*, erythrocyte sedimentation rate; *CRP*, C-reactive protein.

included in the study, 18 underwent HA, 13 underwent aTSA, and 16 underwent rTSA at the time of infection. There was no difference between the 2 study groups.

Laboratory, pathology, and culture results

Preoperative serologic laboratory findings are presented in Table II. Overall, 88% of patients had elevated ESR values and 73% of patients had elevated CRP laboratory values. No concerning comorbidities was found between the 2 study groups. Intraoperative clinical findings, pathology results, and culture results are also presented in Table II. No difference in intraoperative frozen section findings was noted between the study groups. Sixty-six percent of the patients had positive intraoperative culture results. The most common infectious organism was *Cutibacterium acnes* (31%), followed by *Staphylococcus aureus* and *Staphylococcus epidermidis*.

Table III Patient-reported outcomes in patients treated with antibiotic spacers compared with 2-stage revision

Outcome measure	Antibiotic spacer	2-Stage revision					
		HA, aTSA, and rTSA	*P* value for HA, aTSA, and rTSA	HA and aTSA	*P* value for HA and aTSA	rTSA	*P* value for rTSA
SPADI score	65.3 ± 18.6	43.2 ± 27.5	.069	63.3 ± 23.2	.306	35.7 ± 17.9	.005
SST score	4.3 ± 3.4	7.3 ± 3.9	.093	5.2 ± 4.0	.866	8.1 ± 3.7	.024
ASES score	45.5 ± 19.3	61.1 ± 22.2	.125	45.3 ± 15.6	.507	67.1 ± 21.8	.027
UCLA shoulder score	15.0 ± 4.2	22.5 ± 8.6	.056	15.2 ± 6.7	.805	24.7 ± 8.1	.027
Constant score	33.3 ± 16.4	58.1 ± 20.5	.037	36.8 ± 19.2	.753	64.6 ± 16.4	.003
SF-12 total score	28.6 ± 6.3	31.6 ± 8.4	.615	28.1 ± 7.0	.733	32.9 ± 8.7	.302
VAS score	4.5 ± 2.7	3.1 ± 2.2	.440	5 ± 1.5	.230	2.1 ± 1.8	.210
Satisfaction score	2.3 ± 1.2	2.5 ± 1.2	.460	3.2 ± 0.75	.520	1.9 ± 1.2	.490
Active ROM							
External rotation, °	−3.6 ± 21.5	21.1 ± 25.9	.075	24.1 ± 33.1	.090	19.6 ± 23.4	.019
Elevation, °	48.6 ± 33.7	94.4 ± 38.4	.023	55.8 ± 28.3	.610	112.3 ± 28.1	.001
Abduction, °	52.1 ± 25.3	84.8 ± 36.2	.083	55.0 ± 33.3	.880	98.6 ± 29.3	.036
Internal rotation	2.4 ± 1.7	3.9 ± 1.9	.112	3.3 ± 2.5	.160	4.2 ± 1.7	.079

HA, hemiarthroplasty; *aTSA*, anatomic total shoulder arthroplasty; *rTSA*, reverse total shoulder arthroplasty; *SPADI*, Shoulder Pain and Disability Index; *SST*, Simple Shoulder Test; *ASES*, American Shoulder and Elbow Surgeons; *UCLA*, University of California at Los Angeles; *SF-12*, Short Form 12; *VAS*, visual analog scale; *ROM*, range of motion.

Table IV Secondary analysis of patient-reported outcomes comparing 2-stage revision subgroups

Outcome measure	2-Stage revision		P value
	HA and aTSA	rTSA	
SPADI score	63.3 ± 23.2	35.7 ± 17.9	.009
SST score	5.2 ± 4.0	8.1 ± 3.7	.038
ASES score	45.3 ± 15.6	67.1 ± 21.8	.009
UCLA shoulder score	15.2 ± 6.7	24.7 ± 8.1	.018
Constant score	36.8 ± 19.2	64.6 ± 16.4	.002
SF-12 total score	28.1 ± 7.0	32.9 ± 8.7	.095
VAS score	5 ± 1.5	2.1 ± 1.8	.770
Satisfaction score	3.2 ± 0.75	1.9 ± 1.2	.300
Active ROM			
External rotation, °	24.1 ± 33.1	19.6 ± 23.4	.616
Elevation, °	55.8 ± 28.3	112.3 ± 28.1	.002
Abduction, °	55.0 ± 33.3	98.6 ± 29.3	.007
Internal rotation	3.3 ± 2.5	4.2 ± 1.7	.304

HA, hemiarthroplasty; *aTSA*, anatomic total shoulder arthroplasty; *rTSA*, reverse total shoulder arthroplasty; *SPADI*, Shoulder Pain and Disability Index; *SST*, Simple Shoulder Test; *ASES*, American Shoulder and Elbow Surgeons; *UCLA*, University of California at Los Angeles; *SF-12*, Short Form 12; *VAS*, visual analog scale; *ROM*, range of motion.

Infection recurrence

A recurrent infection developed in 5 patients (11%): 3 in the spacer group and 2 in the 2-stage group. No significant difference was noted between the 2 study groups. In the 2 patients in the 2-stage group, a recurrent infection developed 5 weeks and 7 months after reimplantation. The patients were treated with implant resection and a definitive antibiotic spacer. As a result, these 2 patients' functional outcomes were not used in the analysis. No further recurrent infections occurred. In addition, 1 patient in the 2-stage group was noted to have acute inflammation and an elevated CRP level after the initial antibiotic spacer was placed. This patient underwent additional irrigation and débridement, antibiotic spacer placement, and 6 additional weeks of IV antibiotic therapy and subsequently had a successful reimplantation with no recurrent infection. All 3 patients in the antibiotic spacer group in whom a recurrent infection developed were treated with irrigation and débridement and a new antibiotic spacer placement. The recurrent infections occurred at 5 weeks, 7 months, and 2 years after placement of the initial antibiotic spacer. No further infections occurred.

Functional outcomes

Functional outcomes between the antibiotic spacer and 2-stage group (HA, aTSA, and rTSA) and 2-stage subgroups (HA or aTSA and rTSA) are summarized in Table III. The 2-stage group had significantly better Constant scores and active elevation than the antibiotic spacer group. When the antibiotic spacer group was compared with the HA-aTSA subgroup, there was no significant difference in functional outcomes or ROM. However, when compared with the rTSA subgroup, the rTSA had significantly better outcomes for all scoring systems and ROM values except internal rotation. A subanalysis of the 2-stage group was also performed comparing rTSA and HA-aTSA outcomes. The results are summarized in Table IV. The rTSA subgroup had significantly better outcomes for all functional outcome scores, active elevation, and active abduction than the HA-aTSA subgroup. The HA-aTSA subgroup had a significantly longer follow-up period: 6.6 years compared with 2.1 years in the rTSA group.

Table V Procedure-related and medical complications

	Antibiotic spacer	2-Stage revision	P value
Procedure-related complications			
Total	7	13	.40
Complication requiring reoperation	3	4	.73
Infection recurrence	3	2	.25
Wound healing	1	0	
Hematoma	2	1	
Iatrogenic fracture	1	5	
Postoperative fracture	2	0	
Neurologic	0	1	
Dislocation	0	1	
Implant loosening	1	1	
Medical complications			
Total	8	3	.13
Death	1	1	
Antibiotic reaction	1	1	
Pneumonia	1	1	
Other	5	0	

Complications

There were 20 total procedure-related complications in 19 patients between the 2 study groups. No statistically significant difference in complication rates was noted between the 2 study groups. A summary of the complications can be found in Table V. A complication that required reoperation occurred in 3 patients in the antibiotic spacer group and 4 patients in the 2-stage revision group. All 3 reoperations in the spacer group were due to recurrent infections. Of the 4 reoperations in the 2-stage group, 2 were due to recurrent infections; the other reoperations were due to a wound-healing complication and humeral stem loosening after reimplantation of the final shoulder arthroplasty. In addition, 11 medical complications occurred in 10 patients between the 2 study groups. There was no significant difference between the 2 study groups. Adverse reactions to IV vancomycin developed in 1 patient from each study group. In the patient in the 2-stage group, Stevens-Johnson syndrome developed, requiring admission to the hospital. In the other patient, an allergic response to the medication developed after 2 weeks of treatment, requiring a change in medication. Additional complications in the spacer group included deep vein thrombosis, myocardial infarction, hip fracture, acute renal failure, and a suicide attempt from an opioid overdose. Two deaths occurred within the first year of surgery. One death occurred as a result of a suicide approximately 9 months after the second-stage reimplantation. The other death occurred owing to sepsis from pneumonia; the patient had undergone antibiotic spacer placement approximately 5 months earlier.

Discussion

In this study, 47 patients underwent management of an infected shoulder arthroplasty via the same treatment protocol for a planned 2-stage revision. However, 18 patients (38%) elected to forgo the second-stage reimplantation procedure, instead choosing to keep the antibiotic spacer as definitive management. Jawa et al[9] and Stine et al[19] reported similar proportions of patients electing to keep the antibiotic spacer as definitive treatment. In addition, 2 patients (4%) were not offered a second-stage reimplantation because of deficient glenoid bone stock. The decision to forgo the second-stage reimplantation was likely multifactorial. The patients' condition appeared to be more medically fragile, as seen by the increased number of medically related complications in this study group. In addition, most of the patients were in their seventh or eighth decade of life and invariably had lower physical demands and were accepting of lower functional outcomes. As a result, this likely introduces some degree of selection bias for whom was definitively treated with an articulating antibiotic spacer.

A total of 5 recurrent infections (11%) occurred in this study: 2 (9%) in the 2-stage group and 3 (15%) in the spacer group. Of note, 1 of the recurrent infections in the 2-stage revision group occurred in a patient who was an IV drug user. The patient's drug abuse was not discovered until after the second-stage revision and likely contributed to his recurrent infection. Two of the recurrent infections in the antibiotic spacer group occurred in patients who were in an immunocompromised state. One patient had poorly controlled type 1 diabetes with hemoglobin A_{1c} levels greater than 10%; the other patient had nutritional malabsorption due to previous gastric bypass surgery, as well as chronic obstructive pulmonary disease treated with corticosteroids. Definitive management with an antibiotic spacer and 2-stage revision were both effective in eliminating infection, with no statistically significant difference in the recurrent infection rate. The infection recurrence rate was similar to what has been reported in the literature.[4,15,19,20-22]

The 2-stage group had significantly better Constant functional outcome scores and abduction and elevation ROM measurements than the antibiotic spacer group. However, on subanalysis, the HA-aTSA group showed no significant difference in functional outcome scores or ROM compared with the antibiotic spacer, whereas the rTSA group showed significantly improved outcomes for all functional outcome scores and ROM. An interesting finding was that there was no difference in patient satisfaction scores between the spacer and 2-stage revision groups despite the obvious difference in functional scores and ROM. There was also no difference in VAS pain scores between the groups. These last 2 findings offer additional support as to why such a large portion of the study group may have elected to forgo the second-stage reimplantation and highlight a certain subset of low-demand patients who are more accepting of poorer functional outcomes.

One of the major principles of treating a prosthetic infection is to perform thorough and aggressive débridement.[13,15,23] The shoulder presents with a unique set of challenges owing to the presence of the rotator cuff and limited bone stock. Because of multiple previous surgical procedures and débridement procedures for infection, the proximal humerus and rotator cuff may become deficient and/or nonfunctional and thus adversely affect the functional outcomes of nonconstrained shoulder arthroplasties. Older studies evaluated the effectiveness of 2-stage revision using either HA or total shoulder arthroplasty during reimplantation.[4,7,18] These studies showed marginal success in restoring function, which is likely a result of inadequate rotator cuff function after débridement. However, rTSA does not primarily rely on the rotator cuff to determine function but, rather, the deltoid.[1,6] In the setting of a periprosthetic shoulder infection after débridement, a reverse shoulder arthroplasty may better restore function and improve pain.[1,15,20] This concept was further supported in our study when a subanalysis of the 2-stage group was performed comparing outcomes of nonconstrained implants (HA and aTSA) vs. rTSA implants. The rTSA group had superior elevation and abduction ROM and SPADI, SST, ASES, UCLA, and Constant functional outcome measures compared with patients who underwent reimplantation with either an aTSA or HA.

A high rate of complications was noted in this series. A total of 25 patients (53%) experienced 31 medical or procedure-related complications. Nineteen patients (40%) experienced 20 procedure-related complications. However, similar complication rates have been reported in the literature. Complication rates of 29% to 35% have been reported after 2-stage revisions for infected shoulder arthroplasties.[8,9,20-22] The high complication rate in this patient population can be attributed to the complexity of the procedure, multiple previous surgical procedures, and poor bone quality.

This study also evaluated the number of reported medical complications that occurred in the perioperative period. Ten patients (21%) experienced 11 major medical complications. To our knowledge, these data have not been reported in detail in previous studies. General medical complications in the treatment of infected hip and knee arthroplasty have been reported in up to 46% of patients.[11] This highlights the fact that many of the patients in this population are in a medically frail condition, and the diagnosis and treatment of an infected shoulder arthroplasty place a substantial physiological burden on these patients. Patients should be evaluated and their condition should be medically optimized prior to undergoing treatment, and patients should maintain routine follow-up during the postoperative course with a primary care provider.

There were 2 deaths within 1 year of surgery in this study, with 1 death in each study group. The patient in the antibiotic spacer group died as a result of pneumonia complicated by sepsis. The patient died approximately 6 months after antibiotic spacer placement. The second patient died of suicide. The patient died approximately 9 months after the second-stage reimplantation. Of note, another patient also attempted suicide shortly after discharge from the hospital after antibiotic spacer placement. This finding may point to the substantial psychosocial burden that management of a prosthetic infection can place on a patient. If a patient is showing or expressing symptoms of depression, screening for depression should be considered and the patient should be referred to a primary care provider or psychiatrist for therapy and routine surveillance or management.

We acknowledge that there are several limitations in this study. This was a retrospective review of a prospectively collected database. In addition, although the average follow-up time was more than 3 years, patients with a minimum follow-up period of 1 year were included (9 patients), and it is possible that these patients could still experience a recurrent infection. Substantial selection bias was also likely present, where a significant number of patients who elected to forgo second-stage revision and to keep an articulating antibiotic spacer as definitive treatment were typically older and in a more medically fragile state. Finally, this study involved a small number of patients and was likely underpowered to make definitive conclusions. However, to our knowledge, this is one of the larger series reporting outcomes on treatment of infected shoulder arthroplasty and comparing outcomes between 2-stage revision and definitive management with an antibiotic spacer.

Conclusion

Two-stage revision procedures and use of an antibiotic spacer for definitive management of periprosthetic shoulder infections appear to be similar and effective in eradicating infections. Two-stage revisions using either an HA or aTSA produce similar functional outcomes to antibiotic spacers used as definitive treatment, whereas 2-stage revisions using an rTSA produce superior functional outcome scores and ROM when compared with antibiotic spacers used as definitive treatment. VAS pain scores and patient satisfaction scores are similar among all the groups, indicating that in certain patient populations, definitive management with an antibiotic spacer may yield acceptable outcomes. In addition, rTSA has significantly better functional outcome scores and ROM when compared with nonconstrained shoulder implants after a 2-stage revision. Finally, patients should be counseled about the potential risk of perioperative surgical and medically related complications prior to undergoing treatment.

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