RESEARCH ARTICLE

Surgical Treatment of Shoulder Infection Following Rotator Cuff Repair

Michael A. Stone, MD[1]; Tyler W. Henry, BS[3]; Michael J. Gutman, BA[3]; Jason C. Ho, MD[4]; Surena Namdari, MD[2]

Research performed at the Rothman Orthopaedic Institute, Thomas Jefferson University Hospitals, Philadelphia, PA, USA

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Abstract

Background: Deep infection after rotator cuff repair (RCR) can cause significant morbidity and healthcare burden. Outcomes of surgical treatment of infection following RCR are limited. This study aimed to assess the clinical course and outcomes related to surgical management of deep infection following RCR.

Methods: Patients treated with debridement for infection after RCR at a single institution were included. Postoperative deep infection included the following criteria: persistent drainage more than five days from index surgery, development of a sinus tract to the joint, ≥ 2 positive cultures at the time of revision surgery with the same bacteria, or presence of purulence. Functional outcomes (ASES, SANE, SF-12) were assessed at a minimum of 1-year post-debridement.

Results: Twenty-three patients were included and analyzed at mean six years post-debridement. All were free of infection at the final follow-up. The average age was 55 years; fifteen (65.2%) had infection after primary RCR and eight (34.8%) after revision RCR. Twelve (52.2%) patients required a repeat debridement prior to eradicating infection for an average of 1.9 surgeries before clearance of infection. Statistically significant predictors of need for a repeat debridement included initial open RCR ($P = .02$), open debridement ($P = .002$) and infection requiring IV antibiotics ($P = .014$). Postoperative ASES, SANE, SF-12M, SF-12P, and satisfaction scores were 71.7±25.7, 67.0±28.1, 55.5±6.5, 38.4±14.3 and 3.7±1.3, respectively.

Conclusion: Deep infection after RCR can be treated with open or arthroscopic debridement. However, more than 50% of patients may require multiple debridements. Final functional results after infection control following RCR are satisfactory. However, chronic infection predicts worse functional outcomes.

Level of evidence: IV

Keywords: Arthroscopy, Cutibacterium acnes, Debridement, Propionibacterium acnes, Rotator cuff tear, Shoulder infection

Introduction

Deep infection after rotator cuff repair (RCR) can cause significant morbidity and healthcare burden. The risk of deep infection following arthroscopic RCR is low, but postoperative infection can significantly change the course of recovery. Current reports of outcomes of surgical treatment of infection following RCR are limited. Reported infection rates following open or mini-open rotator cuff repair range from 0.3-1.9%. [1-3] Rates of infection following arthroscopic repair range from 0.3-0.9%.[4, 5] Several studies have shown a lower complication profile of arthroscopic RCR compared to open repair.[6] In one of these studies, Vopat et al. determined that open RCR had an 8.6 times higher risk of developing a deep

Corresponding Author: Surena Namdari, Rothman Orthopaedic Institute, Thomas Jefferson University Hospital, Philadelphia, PA, USA
Email: Surena.Namdari@rothmanortho.com

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postoperative infection than arthroscopic repair.[7] Treatment for confirmed or suspected infections following RCR is also variable. Treatment of infection may involve serial debridement and intravenous (IV) antibiotics, oral antibiotics, or a combination of the above.

This study aimed to assess the clinical course and outcomes associated with the surgical management of deep infection following RCR. The primary outcome of interest was to determine response to treatment as measured by a number of debridements until the infection was successfully eradicated. Secondary outcomes included functional outcome scores, range of motion (ROM), and satisfaction. We hypothesized that successful eradication of infection would commonly require multiple debridements.

Materials and Methods

Our Institutional Review Board approved this study. Patients were retrospectively identified through a database query of all patients surgically treated with an open or arthroscopic debridement for postoperative infection after either open or arthroscopic RCR between 2003-and 2017. Age, demographics, comorbidities, RCR type (arthroscopic or open), debridement type (arthroscopic or open), and the number of reoperations were determined. Patients with a postoperative infection were identified by reviewing the operative report and/or clinic records. Determination of postoperative deep infection included the following criteria: persistent drainage more than five days from index surgery, development of a sinus tract to the joint, ≥ 2 positive cultures at the time of revision surgery with the same bacteria, or presence of purulence. Those with superficial infections or superficial wound dehiscence were excluded. Those deceased during the follow-up period for reasons unrelated to shoulder infection or could not be reached by telephone or email were excluded. Acute infections were classified as those developing symptoms < 6 weeks postoperatively, and chronic infections were classified as those developing symptoms ≥ six weeks postoperatively.

The primary outcomes of interest included eradication of infection and number of debridements. Secondary outcomes included functional outcome scores (American Shoulder and Elbow Surgeons – ASES, Single Assessment Numeric Evaluation – SANE, short-form 12 – SF-12), ROM, and satisfaction. Satisfaction scores ranged from 1 (very unsatisfied) to 5 (very satisfied).

Patient demographics, including age, sex, BMI, Charleson comorbidity index, comorbid health conditions, and smoking status, were recorded. Preoperative (within six months before surgery) and postoperative (within 24 months after surgery), active forward elevation (FE), abduction, and external rotation (ER) measurements were collected from the medical record. All ROM data was collected and recorded by the treating surgeon, and a goniometer was not routinely utilized. Preoperative ASES, SANE, and SF-12 scores were obtained from the medical record, and all patients were contacted at a minimum of two years postoperatively to obtain the same functional scores.

Statistics

Summary statistics, including means and standard deviations, were calculated. The student's t-test was used to compare means between groups with parametric data. Fisher's exact test was used for categorical data, and linear regression was used to assess risk factors for revision. All statistics were performed using Stata software (StataCorp, College Station, TX, USA). Significance was set as $P < .05$.

Results

After the application of inclusion and exclusion criteria, twenty-three patients were included with an average 6-year follow-up (range 14.5-195.8 months). All patients were free of infection at the time of final follow-up (all available culture data were negative for bacterial growth and no clinical signs or symptoms of infection). There were twenty-one (91.3%) men and two (8.7%) women with an average age of 55 years old [Table 1]. Fifteen (65.2%) patients had infection after primary RCR, and eight (34.8%) had infection after revision RCR. Index surgeries included thirteen (56.5%) arthroscopic and ten (43.5%) open RCR. Seven (30.4%) index procedures were performed at an outside facility. The mean time to infection treatment was 96.1 days, with fourteen (60.9%) acute and nine (39.1%) chronic infections. For treatment of infection, nine (40.9%) patients had an arthroscopic debridement, and thirteen (59.1%) had an open debridement surgery [Figure 1]. All patients received antibiotics as part of their infection treatment, with fifteen (68.2%) receiving intravenous (IV), five (22.7%) oral, and two (9.1%) combined with a mean treatment duration of 5.5 weeks [Table 2].

Twelve (52.2%) patients required a repeat debridement prior to eradicating infection for an average of 1.9 surgeries before clearance of

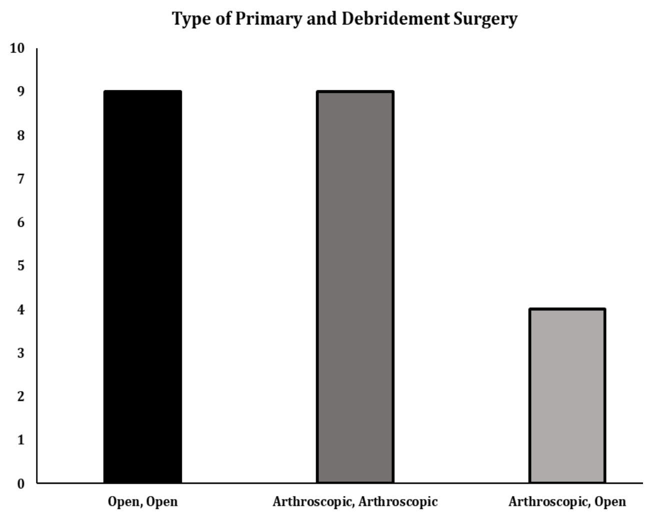


Figure 1. Type of primary and debridement surgery.

infection. Statistically significant predictors of need for a repeat debridement included initial open RCR (*P= .02*), open debridement (*P= .002*) and infection requiring IV antibiotics (*P = .014*). There was no statistically significant association between any comorbidity, smoking, age, sex, or presence of a worker's compensation claim with the need for repeat debridement on regression analysis.

Postoperative ASES, SANE, SF-12M, SF-12P, and satisfaction scores were 71.7, 67.0, 55.5, 38.4, and 3.7, respectively [Table 3]. The presence of a chronic infection compared to acute infection was statistically significant for a lower final ASES score (55.8 vs. 81.4, *P=.02*). When comparing ROM and functional outcomes after open versus arthroscopic debridement, there were no differences in ROM, ASES, SANE, SF-12, or satisfaction at final follow-up. Most cases were culture negative (31%) or polymicrobial (Cutibacterium acnes and Coagulase Negative Staphylococcus) (18%) [Figure 2; Table 4].

Table 1. Patient demographics

Variable	Mean ± SD (range) or No. (%) (n=23)
Age (years)	55 ± 7 (range 38-73)
Sex	M = 21 (91.3%), F = 2 (8.7%)
Follow-up (months)	72.4 ± 43.2 (range 14.5-195.8)
BMI	31.9 ± 7.6 (range 23.5-48.1)
Charleson comorbidity index	2.0 ± 1.3 (range 1-5)
Smoking status	
current	8 (34.8%)
nonsmoker	15 (65.2%)
Surgical indication	
Primary cuff repair	15 (65.2%)
Revision cuff repair	8 (34.8%)
Initial surgery	
Arthroscopic	13 (56.5%)
Open	10 (43.5%)
Debridement surgery	
Arthroscopic	9 (40.9%)
Open	13 (59.1%)
Comorbidities	
HTN	12 (52.2%)
HLD	11 (47.3%)
DM2	6 (26.1%)
CAD	4 (17.4%)
CA	4 (17.4%)
COPD	1 (4.4%)
RA	1 (4.4%)
Worker's compensation claim	10 (43.5%)

M – male, F – female, L – left, R – right, BMI – body mass index, HTN – hypertension, HLD – hyperlipidemia, DM2 – diabetes mellitus type 2, CAD – coronary artery disease, CA – cancer history, COPD – chronic obstructive pulmonary disease, RA – rheumatoid arthritis

Table 2. Infection treatment results

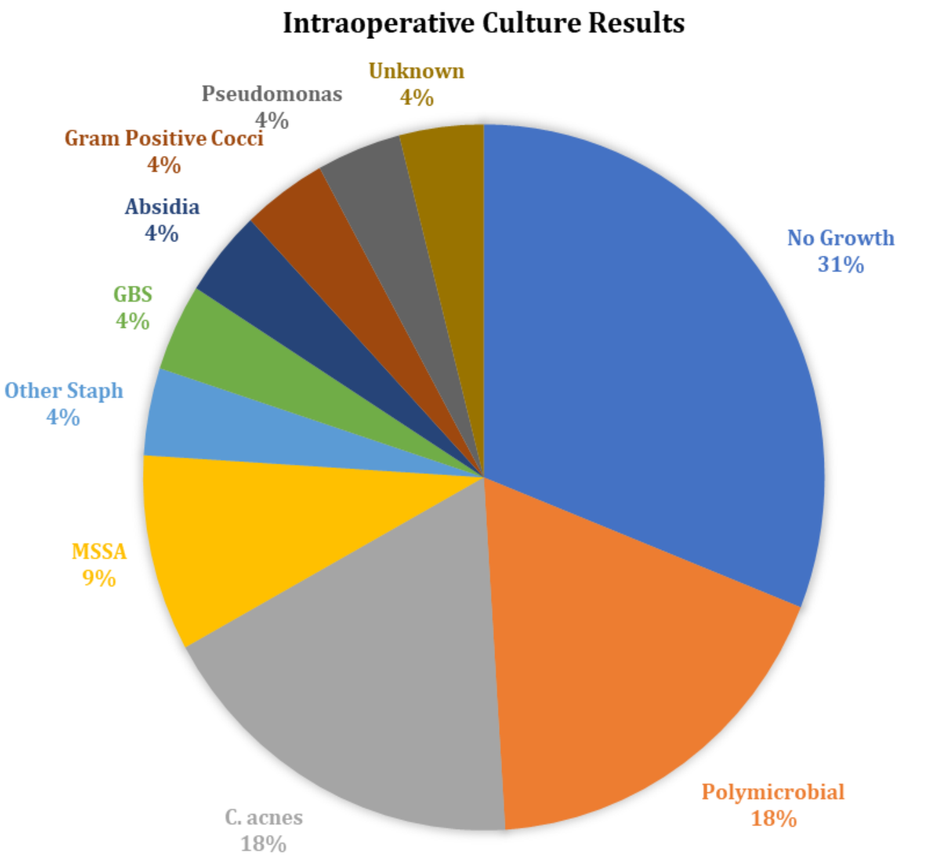
Variable	Mean ± SD (range) or No. (%) (N=23)
Time to infection (days)	96.1 ± 158.4 (range 9-707)
Repeat debridement	12 (52.2%)
Antibiotic delivery	
Intravenous	15 (68.2%)
Oral	5 (22.7%)
Combined	2 (9.1%)
PICC line	17 (77.3%)
Antibiotic duration (weeks)	5.5 ± 1.5 (range 2-8)
Complications	
None	13 (56.2%)
Weakness	7 (30.4%)
Pain	3 (13.0%)
Satisfaction (1-5)	3.7 ± 1.2 (range 1-5)

PICC – Percutaneous Intravenous Cutaneous Catheter

Table 3. Functional outcomes and range of motion

	Preoperative	Postoperative	*P value*
ROM (°)			
Forward elevation	144 ± 41	136 ± 31	.81
External rotation	47 ± 19	45 ± 12	.20
ASES	31.3 ± 13.1	71.1 ± 23.4	.02*
SANE	38.5 ± 9.7	68.0 ± 25.8	.47
SF12-P	35.3 ± 10.6	38.1 ± 13.6	.36
SF12-M	48.4 ± 12.7	56.9 ± 5.7	.11

ROM – range of motion, ASES – American Shoulder and Elbow Society, SANE – single assessment numeric evaluation, SF12-P – Short Form Health Survey Physical Evaluation, SF12-M – Short Form Health Survey Mental Evaluation
*indicates statistically significant difference ($P < .05$)



C. acnes = Cutibacterium acnes; MSSA = Methicillin sensitive staphylococcus aureus; Other Staph = Other

Figure 2. Intraoperative culture results
MSSA – Methicillin Sensitive Staphylococcus Aureus, GBS - Group B Streptococcus, C. acnes – cutibacterium acnes

Table 4. Intraoperative Culture Results

Result	Percentage (%)
No growth	31
Polymicrobial	18
Cutibacterium Acnes	18
MSSA	9
Other Staphylococcus Species	4
GBS	4
Absidia	4
Gram Positive Cocci	4
Pseudomonas	4
Unknown	4

MSSA = Methicillin sensitive staphylococcus aureus, GBS = Group B streptococcus

Discussion

Postoperative infection after RCR can effectively be treated by both open or arthroscopic irrigation and debridement. Initial open RCR, treatment of infection with an open debridement, or presence of an infection requiring IV antibiotics resulted in the need for repeated debridement to clear the infection adequately. Although most infections are culture-negative, C. acnes or polymicrobial infections are responsible for the majority of positive cultures.

A number of studies have demonstrated the superiority of arthroscopic RCR over open repair in terms of lower infection rates, faster recovery, and lower postoperative pain.[7-9] However, other studies have shown no difference in infection rates between arthroscopic and open repair.[6] In a retrospective study by Jenssen et al., the authors reported the outcomes of eleven deep infections following RCR treated with arthroscopic debridement. Six of eleven patients required multiple debridements, with an average of 1.7 surgical debridements needed for clearance of infection.[10] The authors concluded that postoperative infection following RCR could adequately be treated by a combination of arthroscopic debridement and oral antibiotics.[10] We had a similar but slightly higher rate of 1.9 debridements for clearance of infection in our study (open and arthroscopic combined). Comparatively, in a series of 39 deep infections, 30 were treated with open debridement, Athwal et al. reported a considerably higher mean of 3.3 surgical debridements to achieve infection eradication. [1] Kwon et al. also reported on outcomes of open debridement in treating 14 deep infections with a mean of 2.6 debridements. [2] These results were based on the primarily open treatment of infection. This association is further supported by the recent findings of Pauzenberger et al., who reported the outcomes of 28 infections after arthroscopic RCR. Twenty-six patients were treated with open debridement, yet only four required repeat debridement, a substantially lower rate than the aforementioned studies.[4]

Based on the current data, as well as the data in the present study, it is unclear why open debridement may result in the need for repeat debridement for adequate treatment of infection following RCR. It is possible that the infections requiring open treatment were more severe than the infections requiring arthroscopic treatment. Another possibility is that the joint was more easily and thoroughly irrigated by arthroscopic debridement with improved visualization of the potentially concealed nidus. However this speculation has not been proven based on current literature.

Infection following shoulder surgery can lead to debilitating function, and outcomes are worse than an infection-free recovery.[11] Mirzayan et al. previously assessed such functional limitations following chronic infection. They reported outcomes of thirteen patients with chronic infections presenting at a mean of 9.7 months after RCR. All thirteen patients required serial debridements, and most reported a loss of overhead function after treatment.[12] In their series of patients treated with open or open and arthroscopic debridement, Athwal et al. reported an average FE of 120^0 and ER of 45^0. Functional outcomes included an ASES of 67 and an SST of 7.1 Our postoperative outcomes in terms of ROM and functional scores were similar. There were no differences in functional outcomes or ROM between patients who had an arthroscopic versus open debridement in our cohort. Although significant improvements were seen in ASES scores, this number is still lower than expected after RCR, even in the setting of a retear. [13,14]

Intraoperative cultures resulted in negative growth in the majority of cases (31%). Negative cultures are not uncommon throughout the literature on shoulder infections.15 The second most common infection was polymicrobial (Cutibacterium acnes and Coagulase Negative Staphylococcus) (18%). Athwal et al. found a 51% rate of C. acnes and 31% coagulase-negative Staphylococcus.[1] The studies by Kwon, Settecerri, and Jenssen all found C. acnes as the most common organism isolated in culture. [2,3,10]

Finally, patient satisfaction varied considerably, but most patients were satisfied at the final follow up, with an average satisfaction score of 3.7. As mentioned, reported satisfaction rates after infection are generally poor and could potentially be improved through better management of patient expectations. The literature suggests that acceptable functional and patient-reported outcomes can be obtained despite surgically-treated infections after RCR.[2] However, these outcomes are variable, and continued studies on optimal treatment strategies to prevent functional deficits and dissatisfaction are warranted.

This study has limitations, including its retrospective design and population size. Some eligible cases of infection may not have been identified through electronic medical record search queries. Both of these potentially introduced selection bias. Infection severity is among the potential confounders and interactions that may have impacted data analysis. Furthermore, functional outcomes were not compared to a control group, which could have assessed the effect of infection treatment on these measures more accurately.

Deep infection after RCR can be treated with open or arthroscopic debridement. Irrigation and debridement of infection following RCR is effective in the eradication of infection. However, more than 50% of patients may require multiple debridements. Final functional results in patients who sustain infection after RCR can still be good based on ASES and SANE outcome measures; however, chronic infection predicts worse functional results. The end range of motion was similar to preoperative levels within the current study population.

Michael A. Stone MD[1]
Tyler W. Henry BS[3]
Michael J. Gutman BA[3]
Jason C. Ho MD[4]
Surena Namdari MD[2]
1 Cedars-Sinai Medical Center, Los Angeles, CA, USA
2 Rothman Orthopaedic Institute, Thomas Jefferson University Hospital, Philadelphia, PA, USA
3 Sidney Kimmel Medical College, Thomas Jefferson University, Philadelphia, PA, USA
4 Cleveland Clinic, Cleveland, OH, USA

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