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SYMPOSIUM: REVERSE TOTAL SHOULDER ARTHROPLASTY

Two-stage Reimplantation for Treating Prosthetic Shoulder Infections

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Abstract

Background Two-stage reimplantation for prosthetic joint infection reportedly has the lowest risk for recurrent infection. Most studies to date have evaluated revision surgery for infection using an anatomic prosthetic. As compared with anatomic prostheses, reverse total shoulder arthroplasty is reported to have a higher rate of infection.

Questions/purposes We determined reinfection rates, functional improvement, types and rates of complications, and influence of rotator cuff tissue on function for two-stage reimplantation for prosthetic joint infection treated with reverse shoulder arthroplasty.

Patients and Methods We retrospectively reviewed 27 patients treated with a two-stage reimplantation for prosthetic shoulder infection using a uniform protocol for management of infection; of these, 17 had reverse shoulder arthroplasty at second-stage surgery. Types of organisms cultured, recurrence rates, complications, function, and radiographic followup were reviewed for all patients.

Results One of the 17 patients had recurrence of infection. The mean (± SD) Penn shoulder scores for patients treated with reverse shoulder arthroplasty improved from 24.9 ± 22.3 to 66.4 ± 20.8. The average motion at last followup was 123° ± 33° of forward flexion and 26° ± 8° of external rotation in patients treated with a reverse shoulder arthroplasty. The major complication rate was 35% in reverse shoulder arthroplasty, with five dislocations and one reinfection. There was no difference in final Penn score between patients with and without external rotation weakness.

Conclusions Shoulder function and pain improved in patients treated with a second-stage reimplantation of a reverse prosthesis and the reinfection rate was low.

Level of Evidence Level IV, case series. See Guidelines for Authors for a complete description of levels of evidence.

Introduction

Infection after shoulder arthroplasty is a devastating complication. In many patients, the diagnosis is delayed because of the indolent nature of common shoulder pathogens, such as Propionibacterium acnes [5, 8]. Early diagnosis and effective treatment can prevent chronic infections and serious damage to bone and soft tissue.

The treatment options for an infected shoulder arthroplasty are similar to those for other prosthetic joint infections: débridement and intravenous (IV) antibiotic treatment, single-stage reimplantation, resection arthroplasty, and staged prosthetic reimplantation. Most reports [3, 7, 13, 14] are retrospective and limited by small sample size, variation in surgical technique, and inclusion of multiple treating surgeons, thus restricting the conclusions that

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can be drawn. Studies evaluating resection arthroplasty and one-stage reimplantation have reported infection recurrence rates from 0% to 46% with continued pain, poor function, and low patient satisfaction rates [2, 3, 7, 14]. Two-stage surgical protocols calling for component explantation and placement of a polymethylmethacrylate (PMMA) antibiotic-impregnated cement spacer, followed by reimplantation after a course of IV antibiotics, reportedly have a risk for recurrent infection of 38% [14]. However, few studies report function, particularly when the second-stage reconstruction used a reverse total shoulder arthroplasty. Two case series report function after two-stage reimplantation [4, 14] but used different functional scores and reported differing reinfection rates. Strickland et al. [14] reported 17 patients treated with two-stage reimplantation for infected shoulder arthroplasty and found 37% had persistent infection. Of the 17 patients, 13 had average pain score improvement of 2.4 of 5; mean elevation improved from 42° to 89° and mean external rotation from 30° to 43°; and 14 had complications. The overall mean elevation, external rotation, and internal rotation did improve for the cohort. They concluded two-stage reimplantation for infected shoulder arthroplasty provided marginal success in controlling infection and low patient satisfaction with high complication rates. Cuff et al. [4] reported substantially different findings, with no recurrence of infection for patients treated with a single- or two-stage revision. They reported major improvements in postoperative shoulder ROM when compared to preoperative levels (abduction, 36.1° preoperatively to 75.7° postoperatively; forward flexion, 43.1° to 79.5°; mean external rotation, 10.2° to 25.4°). The literature therefore presents contradictory evidence.

Accordingly, we determined (1) the reinfection rate for two-stage reimplantation with a reverse total shoulder arthroplasty, (2) the functional improvement that could be expected for reverse total shoulder arthroplasty after second-stage revision, (3) the rate and effect of complications for reverse total shoulder arthroplasty after second-stage revision, and (4) whether residual weakness from severe rotator cuff deficiency would influence patient-reported outcomes after second-stage reimplantation.

Patients and Materials

We retrospectively reviewed the records of 706 arthroplasty cases performed from 2001 to 2009 and identified 27 patients treated with a two-stage reimplantation for prosthetic shoulder infection. Seventeen of the 27 patients were revised to a reverse total shoulder arthroplasty in the second-stage surgery and are the focus of this study. The diagnosis of infection was based on a combination of clinical suspicion, positive intraoperative frozen sections, positive culture treated at an outside referring institution, positive preoperative aspiration cultures, or positive intraoperative tissue cultures (Table 1) [4]. Fourteen patients had their initial diagnosis and treatment at our institution, while three were initially diagnosed and treated for infection at an outside hospital and then referred to our institution for treatment. Specific organisms cultured were not available for these three patients. The patients included 10 men and seven women with a mean (± SD) age at the time of initial diagnosis of 67.6 ± 10.3 years. Primary surgery was performed due to fracture in nine (53%) patients, rotator cuff arthropathy in five (29%), and osteoarthritis in two (12%). One patient had an unknown initial diagnosis. The minimum followup was 22 months (mean, 46.2 months; range, 22–80 months). All patients were contacted via telephone at a minimum of 2 years postoperatively to verify any suspicion for recurrent infection, complications, or revision surgery. No patients were lost to followup.

Table 1. List of microorganisms for each patient

Patient	Culture organism
1	Enterococcus
2	Serratia marcescens
3	Pseudomonas and Staphylococcus epidermidis
4	Staphylococcus epidermidis and Propionibacterium acnes
5	Coagulase-negative Staphylococcus
6	Staphylococcus epidermidis and Propionibacterium acnes
7	Propionibacterium acnes
8	Unavailable from outside hospital
9	Propionibacterium acnes
10	Enterococcus
11	Unavailable from outside hospital
12	Coagulase-negative Staphylococcus
13	Coagulase-negative Staphylococcus
14	Coagulase-negative Staphylococcus
15	Propionibacterium acnes
16	Unavailable from outside hospital
17	Providencia and Enteroccocus faecalis

Eight patients (47%) presented with subacute infections (1 week to 3 months), seven (41%) with chronic infections (> 3 months), and two were intraoperatively diagnosed with an infection at the time of the first-stage revision surgery (Table 2). The preoperative erythrocyte sedimentation rate (ESR) (mean, 28.8; 95% confidence interval [CI], 18.8–38.9) and the C-reactive protein (CRP) (mean, 2.22; 95% CI, 1.27–3.16) were above normal values in 11 of the 13 patients for which these tests were obtained. Four of 17 patients did not have preoperative ESR or CRP tests performed due to low suspicion of infection or previous

Table 2. Stage 1 preoperative data and demographics (n = 17)

Variable	Value
Age at Stage 2 (years)	67.6 [63.5–71.7]
Gender	
Male	10/17 (59) [36–78]
Female	7/17 (41) [22–64]
Initial diagnosis	
Fracture	9/16 (56) [33–77]
Rotator cuff	5/16 (31) [14–56]
Arthritis	2/16 (12) [3–36]
Initial procedure	
Hemiarthroplasty	10/17 (59) [36–78]
TSA	4/17 (24) [10–47]
Reverse TSA	3/17 (18) [6–41]
Infection class	
Acute	2/17 (12) [3–34]
Subacute	8/17 (47) [26–69]
Chronic	7/17 (41) [22–64]
WBC count (k/μL) (n = 14)	6.93 [5.60–8.27]
ESR (mm/hour) (n = 13)	28.8 [18.8–38.9]
CRP (mg/dL) (n = 13)	2.22 [1.27–3.16]
Aspirate	
No fluid	2/12 (17) [5–45]
Negative	1/12 (8) [1–35]
+ poly, − org	3/12 (25) [9–53]
+ org	6/12 (50) [25–75]

Values are expressed as mean, with 95% confidence interval in brackets, or as number/total number of patients, with percentage in parentheses and 95% confidence intervals in brackets; TSA = total shoulder arthroplasty; WBC = white blood cell; ESR = erythrocyte sedimentation rate; CRP = C-reactive protein; poly = polymorphonuclear leukocytes; org = organisms.

preoperative studies performed at a different institution. The average white blood cell (WBC) count was within normal limits (mean, 6.93; 95% CI, 5.60–8.27) in the 14 patients for which this test was obtained. Nine of the 17 patients had intraoperative tissue samples obtained for frozen histopathology. Preoperative aspirates were performed by the senior author (JPI) in an office setting without image guidance. An aspirate was performed in 12 patients, and fluid was available in 10 of the 12 patients. In the other patients, the shoulder aspirate did not yield fluid (two of 12) or an aspirate was not performed (five of 17). Six of the 12 patients (50%) had positive preoperative aspirates, and an organism was isolated with culture before the surgery. The most common organisms cultured were Staphylococcus spp (seven of 15, 47%) and P acnes (five of 15, 33%). A majority (10 of 17, 59%) of patients presented with an infected hemiarthroplasty, four with an infected total shoulder arthroplasty (24%), and three with an infected reverse shoulder arthroplasty (18%) (Table 2). All patients had severe functional disability preoperatively with a mean Penn shoulder score of 24.9 (of 100 points; range, 3–89).

All shoulder procedures were performed through a standard deltopectoral approach. The subdeltoid/subacromial space and the interval between the conjoined tendon and subscapularis were freed of adhesions and scar tissue. Subscapularis release was performed either off bone or with a lesser tuberosity osteotomy, based on preoperative external rotation. The anterior capsule was carefully separated off the subscapularis tendon and resected. The rotator cuff tendons were critically assessed intraoperatively in each stage of treatment. A thorough débridement of all nonviable and possibly infected tissues was performed in all patients. Both tissue and bone were sent to microbiology for cultures. An antibiotic-impregnated PMMA spacer was placed in all patients. When the subscapularis was available, the tissue was reattached to the anterior proximal humerus with monofilament absorbable suture [11]. During the second-stage reimplantation, the cement spacer was removed if reverse shoulder arthroplasty was performed. If the subscapularis was present, it was repaired with bone tunnels and Number 2 FiberWire® (Arthrex, Inc, Naples, FL).

All surgery was performed by a single surgeon (JPI). Intraoperative frozen-section histopathology was positive for acute or chronic inflammation consistent with infection in eight of nine patients with available pathology specimens (89%). Intraoperative cultures were positive in 14 of 17 (82%) cases, and previous preoperative cultures had been positive for infection in the three negative intraoperative cultures.

After first-stage surgery, all patients received 6 weeks of IV antibiotic therapy specifically tailored for the identified microorganism in either the preoperative or intraoperative cultures. Patients were placed in an immobilizer and, starting on Postoperative Day 1, began pendulum exercises to tolerance. Patients were instructed to return to waist level activities of daily living with no strenuous, active exercises. Patients then had a period off after antibiotic treatment for a median of 6.3 weeks (range, 4–54 weeks) and were re-evaluated for infection. Before second-stage reimplantation, patients were ruled out for persistent infection using preoperative ESR, CRP, WBC, and a negative preoperative aspirate. Intraoperative frozen sections were sent to pathology to verify no acute inflammation, indicative of infection control, to undergo second-stage reinsertion of arthroplasty components. One patient had a negative preoperative workup for infection but intraoperatively had positive frozen pathology specimens for acute inflammation. This was treated with a repeat irrigation, débridement, and reimplantation after a second 6-week course of IV antibiotics. Patients had a median of

4.0 months (range, 1.8–61 months) between explant of the infected prosthetic to second-stage reconstruction. All patients who underwent second-stage reverse total shoulder arthroplasty had major damage to the rotator cuff at the time of second-stage reconstruction. Eleven of the 17 patients treated with a reverse shoulder arthroplasty had a prior hemiarthroplasty and the glenoid did not have a prior implant. Two of the 17 patients treated with a reverse shoulder arthroplasty had a structural femoral head allograft to treat a massive cavitary glenoid defect (Fig. 1). These two patients had an additional bone graft after an index procedure of a hemiarthroplasty with bone graft.

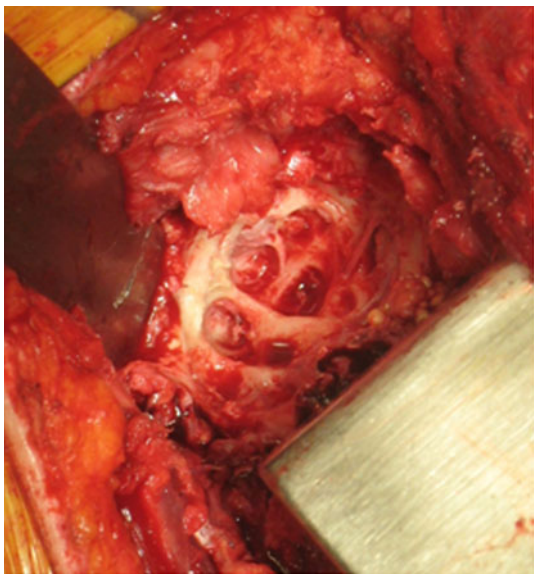

Fig. 1 A photograph shows Stage 2 reimplantation with severe glenoid bone loss.

The allograft was compressed and fixed using the standard baseplate screws for the metaglene component (Fig. 2).

After second-stage reconstruction, patients were placed in a shoulder immobilizer postoperatively. Rehabilitation was started on Postoperative Day 1, beginning with passive ROM exercises. At 4 to 5 weeks, active assist and then active ROM exercises were integrated into the rehabilitation, with the final goal of strengthening exercises using rubber bands at 3 months postoperatively.

Patients were then scheduled for postoperative followup visits at 2 weeks, 6 weeks, 3 months, 6 months, and 1 year. Routine radiographs, clinical examination, and Penn shoulder scores were obtained at each visit. No followup aspirations or serology were performed unless there was suspicion for recurrent infection based on history, clinical examination, or characteristic radiographic findings. Shoulder function was evaluated preoperatively and at last followup using the Penn shoulder score [9]. All patients were contacted at a minimum of 2 years postoperatively to assess whether there was any recurrence of infection or any further treatment for infection or revision surgery. All charts were reviewed for major complications (death related to surgical procedure, recurrence of infection, revision surgeries) and minor complications (eg, superficial wound problems), substantial (> 50%) radiographic graft resorption, chronic instability managed nonoperatively, and other persistent problems related directly to this surgical procedure. Additionally, patient charts were reviewed for most recent clinical followup, physical examinations, and last radiographic followup.

We determined differences in Stage 2 preoperative and postoperative Penn score using a paired t test. We determined differences of followup Penn scores between

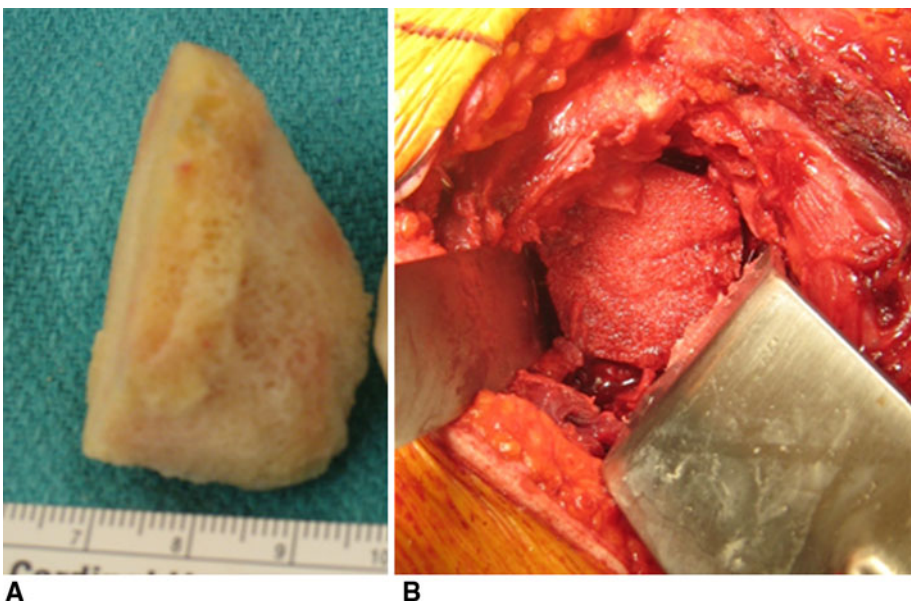

Fig. 2A–B Photographs of Stage 2 reconstruction show (**A**) a contoured femoral head bone allograft used for massive glenoid bone loss and (**B**) placement of the glenoid bone allograft for severe glenoid bone deficiency into the existing glenoid vault.

patients with complications and those without and between those with external rotation weakness and those without using a Student's t test. All statistical analyses were performed using JMP® software (Version 8.0; SAS Institute Inc, Cary, NC).

Results

The recurrence rate of infection for all patients was 6% (one of 17). One patient had persistent signs for infection at Stage 2 and had a second débridement procedure and proceeded to a second-stage reimplantation at a third operation. This patient's laboratory values were negative for infection before the third operative procedure, and positive cultures were only evident 5 days after surgery (P acnes). Attempts to treat the reoccurrence with an oral antibiotic regimen after the third operation failed, and the patient ultimately underwent a second explantation and IV antibiotic treatment that was ultimately successful. A repeat second-stage reimplantation was performed and the patient was infection-free 24 months after the last procedure.

Patients undergoing reverse shoulder arthroplasty had substantial preoperative dysfunction and pain, with an average preoperative total Penn score of 24.9 (range, 3–89), which improved ($p = 0.007$) to a mean postoperative Penn score of 66.4 (range, 37–93) (Table 3). The average postoperative motion was 123° ± 33° (range, 80°–180°) of forward flexion and 26° ± 8° (range, 15°–40°) of external rotation, and five patients had a positive external rotation lag sign. The five patients with residual external rotation weakness at last followup had a similar ($p = 0.26$) average Penn score of 78.3 ± 22.0 (range, 53–93) compared to those with no sign of external rotation weakness (average Penn score, 58.6 ± 18.2; range, 37–91).

We observed a 35% (six of 17) major complication rate and a 6% (one of 17) minor complication rate. There were no surgery-related mortalities. There were six reoperations for instability or dislocations (five) and recurrent infection (one). All five patients with recurrent instability underwent a revision surgery with polyethylene exchange or revision glenosphere component. No patient remained unstable after revision surgery, and their mean final followup Penn score was 66.2 ± 21.1, similar to ($p = 0.40$) patients without complications. All patients achieved good stability and no continued problems with infection at final followup. The recurrent infection case was successfully treated as mentioned earlier. The minor complication included one case of a hematoma with delayed wound healing, which required surgical débridement but healed without problems or recurrence of infection.

Table 3. Stage 2 followup outcomes (n = 17)

Variable	Value
Major complications	6/17 (35)
Postoperative forward flexion (°)	123 ± 33 (80–180)
Postoperative external rotation (°)	26 ± 8 (15–40)
Baseline Penn score	24.9 ± 22.3 (3.3–89.0)
Last followup Penn score	66.4 ± 20.8 (36.5–92.9)

Values are expressed as number/total number, with percentage in parentheses, or as mean ± SD, with range in parentheses.

Discussion

Periprosthetic shoulder joint infection is a devastating complication that remains both a diagnostic and treatment challenge. Control of infection continues to be the primary goal, and various treatment options have been reported in the literature, including long-term antibiotics, débridement with retention of prosthesis, resection arthroplasty, single-stage exchange, and delayed reimplantation [1, 3, 7, 11, 13, 14]. The high rates of recurrent infection with IV antibiotics alone or débridement with retention of components (up to 65% [1, 10]) have led surgeons to explore alternative treatment options, such as resection arthroplasty, which however is associated with substantial functional limitations [1, 4, 10]. Both single-stage and two-stage exchange arthroplasty demonstrate high rates of infection control; however, the most reproducible rates of infection control have been obtained with two-stage reimplantation procedures [3, 4, 13, 14]. Our objectives were to determine the reinfection rate for a patient cohort treated with a similar two-stage exchange arthroplasty. We sought to evaluate functional improvement and patient-reported outcomes and the rate and effect of complications for reverse shoulder arthroplasty after second-stage revision.

We acknowledge limitations of our study. First, while we had a minimum followup of 2 years from the last surgery with a minimum clinical followup of 22 months (range, 22–80 months), the last followup was by telephone and we had no laboratory studies excluding infection. Recurrence of infection may reoccur in some of these patients even followed for 2 or more years, particularly if the pathogen is of low virulence (P acne). Second, our series was too small to control for all potentially confounding variables in our statistical analysis. On the other hand, this is a relatively rare event, and compared to the literature, our series had relatively large number of cases with the same reverse arthroplasty using a standardized treatment algorithm.

Control of infection has been reported in a number of studies of two-stage exchange procedures [3, 11, 12, 14].

Sperling et al. [13] reported patients treated various ways and found recurrent infection in 50% of patients who underwent a single-stage revision compared to 0% with two-stage exchange group at a mean followup of 6.5 years. Cuff et al. [4] reported no recurrence of infection and good function in patients treated with reverse shoulder arthroplasty in a single- or two-stage reimplantation. We found a comparably low recurrence rate in patients after two-stage exchange procedure. Quality of soft tissue and bone débridement in infection cases is considered an important factor for control of infection. With reverse total shoulder arthroplasty, aggressive débridement of suspicious soft tissue and bone can be performed with less concern for decreased functional improvement. The ability for shoulder surgeons to successfully restore function, even with major bone deficits and loss of the rotator cuff tissue, using a reverse shoulder arthroplasty was demonstrated in this series.

In previous reports [3, 4, 7, 14], expectation for postoperative function after periprosthetic shoulder joint infection always focused on quality of the rotator cuff tissues. Clearly a reverse shoulder arthroplasty provides a possible solution in this clinical setting as it relies primarily on deltoid muscle function to determine function [6]. This, of course, is not without consequences of increased surgical complexity and postoperative complications. Our results demonstrated improvements in postoperative ROM and Penn scores in all patients treated with reverse shoulder arthroplasty even with the occurrence of major postoperative complications.

The major complication rate (35%) in this series and types of complications were comparable to those previously reported in the literature [4, 7, 14]. The majority of complications in this reverse shoulder arthroplasty group were due to dislocation (83% of all major complications). Although successful treatment of these complications was achieved with revision surgery in all cases, the need for additional surgeries adds to increased risk and costs that must be considered when selecting a reverse shoulder arthroplasty at second-stage revision. Careful understanding of soft tissue tensioning and surgical technique when performing a reverse shoulder arthroplasty at second-stage reimplantation may decrease the rates of instability and overall complications.

Our data suggest low recurrence rates after a staged exchange procedure. Reimplantation with a reverse shoulder arthroplasty can adequately restore function, substantially improve pain, and provide patient satisfaction, even with major bone deficits and loss of the rotator cuff tissue, as demonstrated in this series. Thorough débridement and careful assessment of soft tissue tensioning and stability may decrease complication rates for reverse shoulder arthroplasty at second-stage reimplantation.

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