J Shoulder Elbow Surg (2016) ■■, ■■–■■

ELSEVIER

Journal of Shoulder and Elbow Surgery

www.elsevier.com/locate/ymse

ORIGINAL ARTICLE

Two-stage revision for infected shoulder arthroplasty

Daniel B. Buchalter, BA*, Siddharth A. Mahure, MD, MBA, Brent Mollon, MD, FRCSC, Stephen Yu, MD, Young W. Kwon, MD, PhD, Joseph D. Zuckerman, MD

Department of Orthopaedic Surgery, New York University Langone Medical Center, NYU Hospital for Joint Diseases, New York, NY, USA

Background: Periprosthetic shoulder infections (PSIs) are challenging to treat and often result in significant patient morbidity. Without a standardized treatment protocol, PSIs are often managed similarly to periprosthetic hip and knee infections. Because 2-stage revision is the gold standard for treating periprosthetic hip and knee infections, we performed a case series and literature review to determine its effectiveness in PSIs.

Methods: We identified 19 patients (14 men) from our institution who were treated with a 2-stage revision after presenting with a PSI. Mean patient age was 63 ± 9 years, and average body mass index was 30.8 ± 5.8. The average time from the index arthroplasty to treatment was 40 months, 8 of 13 positive cultures were *Propionibacterium acnes*, and 9 of 19 patients had multiple shoulder operations before presenting with infection. Minimum follow-up for all patients was 2 years.

Results: After a mean follow-up of 63 months (range, 25-184 months), 15 of 19 patients in our study were successfully treated for PSI. Average postoperative American Shoulder and Elbow Surgeons (ASES) Shoulder Assessment score was 69 (range, 32-98) and average postoperative forward elevation was significantly increased from 58° to 119° ($P < .001$). The incidence of recurrent infection was 26%. The rate of noninfection complications was 16%, for a total complication rate of 42%.

Conclusion: In patients with PSIs, especially those with intractable, chronic infections, a 2-stage revision represents a viable treatment option for eradicating infection and restoring function. However, it is important to recognize the risk of recurrent infection and postoperative complications in this challenging patient population.

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

Keywords: Total shoulder arthroplasty; periprosthetic infection; two-stage revision; reimplantation; medical comorbidities; literature review

Periprosthetic shoulder infections (PSIs) after primary total shoulder arthroplasty (TSA) have a reported incidence of 0.4% to 2.9%, and increase in incidence with every subsequent revision.[3,6,30,37] Literature on the optimal management of the infected shoulder arthroplasty is limited.[21,36,38] As a result, treatment options for PSIs have been modeled on the management of periprosthetic hip and knee infections and include chronic antibiotic suppression, irrigation and débridement, 1- or 2-stage revisions, definitive articulating antibiotic spacer, and

The New York University School of Medicine Institutional Review Board approved the study (Study No.: il4-01618).

*Reprint requests: Daniel B. Buchalter, NYU Hospital for Joint Diseases, 301 E 17th St., New York, NY 10003, USA.

E-mail address: Daniel.Buchalter@nyumc.org (D.B. Buchalter).

1058-2746/$ - see front matter © 2016 Journal of Shoulder and Elbow Surgery Board of Trustees. All rights reserved.
http://dx.doi.org/10.1016/j.jse.2016.09.056

excision arthroplasty.[2,19,25,33] Despite the variety of options available for PSIs, the specific indications for each treatment and their expected clinical outcomes remain unclear.[19,38]

Two-stage revision is the standard of care for treating chronic periprosthetic hip and knee infections[15,22,23] and has consequently become a procedure of interest in the management of PSIs. Directly translating 2-stage revision protocols from the hip and knee to the shoulder has been difficult, however. Compared with the hip and knee, the shoulder joint has limited weight-bearing demands and a greater reliance on the periarticular soft tissues to maintain function.[3,6,7,25] In addition, when aligned with realistic functional expectations, patients may better tolerate reduced shoulder range of motion compared with hip and knee motion because of the ability to compensate with use of the contralateral upper extremity.[6]

Prior series have demonstrated inconsistent postoperative results when applying 2-stage revision protocols to the infected shoulder prosthesis.[7,21,34,36] Weber et al[36] and Ortmaier et al[21] reported only modest improvements in functional outcomes after both 1- and 2-stage revisions for PSI. Strickland et al[34] reported marginal success in eradicating PSI in a series of 17 patients treated with 2-stage revision, with low patient satisfaction scores and high complication rates. Alternatively, Cuff et al[7] reported that 1- and 2-stage revisions for PSI can effectively eradicate infection and provide significant improvement in shoulder range of motion.

Successful management of the infected shoulder arthroplasty should eradicate infection, relieve pain, correct functional limitations, and ultimately, improve quality of life. Because the current literature regarding the optimal treatment of PSIs remains controversial, we conducted a retrospective case series to report our experience and outcomes treating PSIs using a 2-stage revision protocol. We hypothesized that in patients with chronic PSIs, treatment with a 2-stage revision protocol would be an effective approach to eradicate infection, relieve pain, and restore function to the involved shoulder.

Materials and methods

We retrospectively identified patients who underwent 2-stage revision for PSI between 2000 and 2014 by the senior authors (Y.W.K. and J.D.Z.). Minimum follow-up after the second-stage revision (ie, reimplantation of the definitive shoulder arthroplasty) was 2 years. Data extracted from the record review included patient age, gender, medical comorbidities, initial diagnosis, prior surgical management, diagnostic imaging, infection evaluation (eg, culture results, inflammatory serology), and range of motion. Postoperative American Shoulder and Elbow (ASES) Shoulder Assessment scores were collected as the primary functional outcome measure.

Patient sample

We identified 19 patients (14 men [74%]) who underwent a 2-stage revision for the treatment of an infected shoulder arthroplasty. Mean age at presentation with PSI was 63 ± 9 years (range, 47-78 years), and the mean time from the index procedure to suspected infection was 40 months (range, 1.9-94 years). Average body mass index was 30.8 ± 5.8 kg/m^2 (range, 20.5-47.3 kg/m^2). The operative side was right in 12 of 19 patients (63%), and all but 2 patients were right-hand dominant. The most common indication for the index arthroplasty in the 19 patients was degenerative arthritis of the glenohumeral joint in 13, followed by fracture in 3, chronic dislocation in 2, and rotator cuff arthropathy in 1. The PSI involved anatomic TSA (aTSA) most commonly (13 of 19), followed by hemiarthroplasty in 4, and reverse TSA (rTSA) in 2. Two of the 19 patients were diabetic, 2 were active smokers, and 10 were former smokers who quit before presentation with infection. Six of 19 patients had undergone surgery on the involved shoulder before the index arthroplasty as follows: patient 1 underwent 2 open reduction and internal fixations for a glenoid fracture, arthroscopic removal of a displaced screw, and hemiarthroplasty, followed by 2 revisions; patient 2 underwent a staple capsulorrhaphy, followed by aTSA; patient 3 underwent arthroscopic rotator cuff repair, followed by hemiarthroplasty and subsequent conversion to aTSA; patient 6 underwent an open reduction and internal fixation, followed by hemiarthroplasty and subsequent conversion to rTSA; patient 7 underwent an arthroscopic anterior shoulder repair, followed by hemiarthroplasty and subsequent repeat arthroscopic rotator cuff repair; and patient 16 underwent 2 arthroscopic shaving chondroplasties before aTSA.

In addition, 3 patients underwent surgery on the involved shoulder after the index arthroplasty but before the diagnosis of infection as follows: patient 5 underwent a revision aTSA, followed by irrigation and débridement for suspected infection at another hospital; patient 14 underwent an arthroscopic release of soft tissues; and patient 19 underwent diagnostic arthroscopy for suspected infection. Therefore, 9 of 19 patients underwent additional operative procedures before the diagnosis of infection: 6 before the index arthroplasty and 3 after the index arthroplasty.

The pretreatment workup for infection included clinical, laboratory, radiographic, and operative evaluations (Table I). Infection eradication was defined as the absence of any clinical signs of infection, the normalization of inflammatory markers, and the absence of progressive radiolucency on radiographs or evidence of osteolysis consistent with infection. Humeral component radiolucency was classified using the systems developed by Sperling et al[31] for aTSA and Gilot et al[11] for rTSA. In these systems, zones 1 to 3 correspond to the lateral aspect of the stem extending from proximal to distal, zone 4 represents the tip of the stem, zones 5 to 7 extend from distal to proximal on the medial aspect of the stem, and zone 8 is directly underneath the humeral head or cup.

Glenoid component radiolucency was classified using the system developed by Molé et al.[18] In this system, zones 1, 5, and 6 represent the upper, lower, and middle parts of the tray, respectively, and zones 2, 3, and 4 represent the upper, middle, and lower periphery of the keel.

Failed infection management was defined as the need for chronic suppression with oral antibiotics or resection arthroplasty as definitive treatment. Of note, the laboratory at our institution did not use serum interleukin 6 analysis, so this information is not included in our preoperative workup or postoperative follow-up.

Two-stage revision

A standardized 2-stage protocol was used to treat all patients included in this cohort. The first stage consisted of resection arthroplasty