Evaluation and Treatment of the Infected Shoulder Arthroplasty

Daniel J. Hackett, Jr., M.D., and Lynn A. Crosby, M.D.

Abstract

Infection after shoulder arthroplasty remains one of the most common postoperative complications. Treatment options range from debridement, appropriate antibiotic regimen, and retaining the implant to resection arthroplasty in the elderly medically challenged patient.

We review the diagnostic challenges and treatment options for periprosthetic infections involving the shoulder. It appears that early detection, isolation of the infecting organism, and aggressive debridement with appropriate antibiotic treatment is the most important component of a successful treatment program designed to eradicate the infection. This early treatment which in most cases is combined with a two-stage approach (with an interim antibiotic spacer) provides the best opportunity to obtain a reasonably painless and functional shoulder arthroplasty.

Infection following shoulder arthroplasty, although infrequent, remains one of the most common postoperative complications encountered and accounts for a large number of failures in both primary and revision shoulder arthroplasty.1-5 The increase in the number of primary shoulder arthroplasties being performed has increased the number of patients requiring revision arthroplasty for the treatment of infection. Infection poses a number of issues for the surgeon with respect to diagnosis, treatment, and revision following eradication of infection. Diagnosis of infection relies upon a high clinical suspicion and appropriate diagnostic studies.1

Due to the low virulence of organisms, such as Propionibacterium acnes (P. acnes), it is our opinion that postoperative pain following shoulder arthroplasty should be considered due to infection, until proven otherwise.1,6-7 There has yet to be a consensus on the optimal treatment for periprosthetic infection after shoulder arthroplasty, and most treatment is based upon surgeons’ past clinical experiences and use of data from infection treatment following hip and knee arthroplasty. The hip and knee literature provide some insight for infection treatment. However, the common infective organisms, the presenting signs and symptoms, laboratory data, and clinical course all prove to be somewhat different in shoulder arthroplasty.8 More studies related to infection following shoulder arthroplasty are published each year; however, these studies have smaller numbers and lack the power analysis that is found in the hip and knee literature.8

Most agree that treatment should involve diagnosis of the infective organism, an adequate debridement followed by one or two stage revision, and species specific IV antibiotic treatment following the initial operation.5,7,9-20 In most cases, elimination of infection requires aggressive debridement of soft tissues, which creates yet another reconstructive problem for the surgeon.21 Debridement creates a larger amount of dead space, providing organisms an opportunity for re-infection. Aggressive soft tissue debridement may also eliminate the amount of soft tissue needed to provide stability and function when considering revision arthroplasty options.10,20-24 Results of revision arthroplasty following infection have also differed in terms of pain improvement, rate of complications, and functional status.5,7,9-20 This review will focus on what we currently understand about revision shoulder arthroplasty with a focus on the results of two stage revision with anatomic and reverse total shoulder arthroplasty.

Patient Evaluation

Infection should be ruled out in any patient with a painful shoulder arthroplasty.1,6-7 A complete history should be taken, with particular attention to the time since the initial
operation, constitutional symptoms, recent hematogenous infections, and recent dental work or other procedures. The patient should be questioned about recent use of oral antibiotics, anti-inflammatory medication, and narcotics, as these may mask symptoms and interfere with prompt diagnosis. Multiple factors can increase the risk of infection including systemic factors, such as malnutrition, diabetes mellitus, chronic hypoxia, obesity, renal or liver failure, intravenous drug use, and immunodeficiency.\(^7,24-27\) Limb specific risk factors include previous shoulder surgery, local corticosteroid injections, chronic lymphedema, venous stasis, vascular compromise, and radiation fibrosis.\(^7,24-28,29\)

Other risk factors for periprosthetic infection include postoperative hematoma formation, revision surgery, initial surgery performed for fracture, cuff tear arthropathy, malignancy, or radiation-induced osteonecrosis.\(^7\)

Physical signs of periprosthetic infection can often be very subtle. Infections are often indolent, especially those involving \(P.\ acnes\), in which pain may be the only presenting symptom.\(^1,6-7\) Worsening results of the physical exam, such as a decreasing range of motion, should warrant further work up for infection.\(^1,6-7\) Obvious signs of infection, such as fever, chills, and certainly drainage and sinus tract formation, obviously warrant further work up.

**Diagnostic Workup, Imaging, and Evaluation**

The diagnostic workup should include standard shoulder radiographs. The laboratory evaluation should include a complete blood count (CBC) with differential, erythrocyte sedimentation rate (ESR), and C-reactive protein (CRP).\(^7,24-28,30\) With early infection, radiographs will usually appear normal. With subacute or late infection, periprosthetic osteopenia or osteolysis might be evident, as well as pseudosubluxation of the humeral head component.\(^31\) Diagnostic radiographic studies, such as MRI and ultrasonography, can be helpful in detecting surrounding osteomyelitis and loculated abscesses but are not routinely utilized. Other studies, which are not routinely obtained, include technetium Tc-99 bone scans and indium \(-111\)-labeled white blood cell scintigraphy as the sensitivity and specificity of these tests make interpretation of the results difficult.\(^7,9-29\) The peripheral leukocyte count is usually within normal range, as is the neutrophil cell distribution. However, if either is elevated, it can be helpful. Patient history should be taken into consideration when evaluating the ESR and CRP, as these are non-specific markers of inflammation and can be normally elevated in the perioperative period. The ESR and CRP are often not elevated in cases of \(P.\ acnes\) infection.\(^10\)

In all cases where there is high clinical suspicion for deep infection, aspiration of the glenohumeral joint should be performed. Synovial fluid analysis should include cell count with differential; gram stain; and cultures for aerobes, anaerobes, fungi, and mycobacteria.\(^25\) Aerobic and anaerobic incubation periods should be specified to the laboratory, as \(P.\ acnes\) can take up to 3 to 4 weeks for positive cultures.\(^1\) The gram stain is positive in 75% of proven cases of infection; cultures are positive in 80% of cases. A negative gram stain or culture from an aspiration, however, does not rule out infection.\(^7,15,24-28,29\)

**Management of Periprosthetic Infection**

Management of periprosthetic infection should take into account multiple factors including timing of infection (acute, subacute, or late), infecting organism(s), overall health of the patient, soft tissue and bony integrity, and patient age and expectations. Ideal management involves successful elimination of infection while minimizing functional compromise and the incidence of complications. In patients with medical comorbidities that may prevent or limit operative management, species directed long-term suppressive antibiotic therapy may be required. Table 1 depicts the classification and treatment recommendations for periprosthetic infections. In acute infections (less than 4 weeks), a thorough irrigation and debridement with polyethylene exchange (if possible) is appropriate.\(^32-33\) There is little data available on the outcomes of this approach but removing the polyethylene liner to expose as much surface area as possible for irrigation is the rationale. In infections that present greater than 4 weeks after the initial operation, complete removal of implants is indicated with the options of resection arthroplasty or revision either in a single or two-staged approach, followed by species directed antibiotic therapy.\(^5,7,9-20\) Patients who are low demand or are not medically appropriate for significant revision operations have shown benefit from placement of an antibiotic impregnated cement spacer or simple resection arthroplasty as their definitive treatment.\(^10,17,19\) Weber and coworkers showed near comparable outcomes with resection arthroplasty versus two-staged revision

| Table 1 Classification and Treatment Options for Periprosthetic Infections |
|-----------------------------|-----------------------------|-----------------------------|
| Type of Infection | Time Period of Infection | Treatment |
| Type I | Positive cultures at time of revision | Organism specific antibiotic treatment with close observation |
| Type II | Acute infection within 30 days of surgery | Surgical debridement with retention of prosthesis |
| Type III | Acute hematogenous infection > 30 days after surgery | Surgical debridement with retention of implants or two-stage treatment with antibiotic spacer |
| Type IV | Chronic infection | Surgical debridement with implant removal, temporary antibiotic spacer placement, and delayed reimplantation |
with reverse total shoulder arthroplasty (rTSA) (Constant scores 32.7 and 40.1, respectively), with the main difference representing differences in range of motion.\textsuperscript{19} There has been some success with single stage revisions. Ince and associates reported on nine patients who underwent a one-stage revision without recurrent infection, and Klatte and colleagues reported eradication in 33 of 35 patients.\textsuperscript{11,12} However, most studies of one-staged revision have reported high reinfection rates. There are more studies reporting successful elimination of infection and better functional results with a two-staged procedure. One-staged procedures have the potential for better functional results and are more cost effective but have a higher risk for re-infection, which is primarily secondary to not having the organism identified prior to the reimplantation.\textsuperscript{19} In medically stable patients with relatively high demand, the two-staged exchange is generally accepted as the treatment of choice.\textsuperscript{10,13,14,19,20} In a two-staged revision, antibiotics should be held until intraoperative cultures are obtained. Broad spectrum intravenous antibiotics can then be initiated, followed by placement of an antibiotic impregnated cement spacer. Placement of a prefabricated

<table>
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<th>Table 2</th>
<th>Overview of the Treatment Results of Infected Shoulder Arthroplasties Utilizing Two-stage Revisions</th>
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<tbody>
<tr>
<td>Study</td>
<td>No. of Patients</td>
</tr>
<tr>
<td>Jawa et al. 2010</td>
<td>15</td>
</tr>
<tr>
<td>Romano et al. 2012</td>
<td>17</td>
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<tr>
<td>Weber et al. 2011</td>
<td>4</td>
</tr>
<tr>
<td>Sabesan et al. 2011</td>
<td>17</td>
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<tr>
<td>Coffey et al. 2010</td>
<td>12</td>
</tr>
<tr>
<td>Coste et al. 2004</td>
<td>10</td>
</tr>
<tr>
<td>Cuff et al. 2008</td>
<td>12</td>
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<tr>
<td>Jerose and Schneppenheim 2003</td>
<td>8</td>
</tr>
<tr>
<td>Mileti et al. 2004</td>
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<td>Sperling et al. 2001</td>
<td>3</td>
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<tr>
<td>Strickland et al. 2008</td>
<td>19</td>
</tr>
<tr>
<td>Seitz and Damacen 2002</td>
<td>8</td>
</tr>
<tr>
<td>Total</td>
<td>129</td>
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spacer has shown parallel results to those spacers made intraoperatively. Figure 1 shows a radiograph and an example of a prefabricated antibiotic spacer. Use of these prefabricated spacers reduces operative time and provides a more anatomic humeral head component, which can reduce glenoid wear; it is required to remain in place for long periods. Prefabricated antibiotic spacers elute antibiotic over a longer period of time, as they have a large surface area. Postoperatively, antibiotics are generally continued for 6 to 8 weeks. Laboratory markers, such as CRP and ESR, as well as Interleukin - 6 (IL-6), have been shown to be reliable indicators to follow serially as markers for eradication of infection. If lab values continue to remain elevated, suspicion for recurrent infection should remain high. A second washout with reinsertion of an antibiotic spacer may be needed if the IL-6 remains high over a long period of time.

Table 2 displays the results of recent two-stage exchanges. Total infection free rates are about 89%. Two studies noted a reinfection rate of 37% and 40%; however, an infecting organism was only obtained in a few patients in both of these studies. Coste and colleagues noted a suspicion of continued infection in two of the four patients at the time of the second stage revision that eventually required repeat revision. Romano and associates noted a decrease in mean visual analog pain score (VAS) from 6.4 to 1.5 and improvement in mean Constant score from 26 to 38.3. There were no re-infections, but a complication rate of 15.9% was reported. Sabesan and coworkers reported a mean improvement in Penn shoulder scores of 24.9 to 66.4 with a 35% complication rate, including one re-infection. Coffey and colleagues found patients to have significant improvement in mean visual analog pain score from 8.4 before spacer placement to 0.5 at final follow up and an increase in Constant score from 16 to 57. Cuff and coworkers reported great improvement in mean abduction from 36° preoperatively to 76° postoperatively, forward flexion from 43° to 80°, and external rotation 10° to 25°. Although Strickland reported a high re-infection rate, patients reported an improvement in pain score and in ROM. As with any revision, the results reported have been inferior compared to those for primary aTSA. Most complications in these studies were related to instability and/or periprosthetic fracture. Particular attention should be paid to soft tissue tensioning, as the incidence of dislocation has been reported to be high. Sabesan and associates and Romano and colleagues both reported laxity and or dislocation in 5 of 17 revisions. As adequate debridement of suspicious soft tissue is required in the initial debridement, second-stage revision with rTSA is supported by many investigators since it allows the initial debridements to be performed with less concern for preservation of soft tissues. Of the 129 two-stage revisions published, over half of revisions utilized rTSA as the implant of choice.
Conclusion

Periprosthetic infection is one of the complications associated with a high morbidity following shoulder arthroplasty. It poses a great burden to the patient, and a significant technical challenge to the surgeon. With the increasing awareness of *P. acnes*, as the organism responsible for periprosthetic infections, shoulder surgeons have become more concerned with patients who present with a painful shoulder following arthroplasty.10 There is currently a lack of consensus of the criteria required for diagnosing periprosthetic infection; however, studies have shown that both the clinical presentation and the diagnostic evaluation both play a role in early diagnosis.1,6-7 Identification of the infective organism prior to initial revision surgery is very helpful in eradicating infection. The initial treatment after the diagnosis of periprosthetic infection remains controversial. While some investigators have reported good results with one-stage revisions, more reproducible results have been shown with the two-stage revision. As diagnostic criteria and identification of organisms prior to explant improves, one-stage revisions may show more promise in the future.19 Irrespective of the revision choice, multiple tissue cultures along with an adequate debridement at time of initial explant are crucial, followed by the need for an interdisciplinary approach utilizing infectious disease consultants.25 Many patients have shown improved functional results with the use of an antibiotic spacer as the definitive treatment.10,17,19 The use of commercially produced spacers appears to provide the patient with a better functional overall result compared to those made by the surgeon intraoperatively.10 The timing of a second-stage revision, by monitoring IL-6 levels may allow earlier implantation and potentially better functional results.10 As with any shoulder arthroplasty, the integrity of the remaining soft tissues following debridement should direct the implant of choice for revision.21 Reverse total shoulder arthroplasty, in most cases, appears to be the implant of choice as it provides more stability and greater potential functional results.10,13,14,19,20 The use of antibiotic impregnated cement is highly recommended when performing the revision procedure.10

Disclosure Statement

Lynn A. Crosby, M.D., is a paid consultant and design surgeon for Exactech, Inc., Gainesville, Florida. Daniel J. Hackett, Jr., M.D., has no financial or proprietary interest in the subject matter or materials discussed in the manuscript, including, but not limited to, employment, consultancies, stock ownership, honoraria, and paid expert testimony.

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