Shoulder arthroplasty for the treatment of postinfectious glenohumeral arthritis

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**Background:** Shoulder arthroplasty after native shoulder infection is an uncommon problem with limited outcomes data. The purpose of this study was to evaluate the rates of reinfection and clinical outcomes after shoulder arthroplasty for the treatment of postinfectious glenohumeral arthritis.

**Methods:** Between 1977 and 2009, 24 shoulders underwent shoulder arthroplasty for postinfectious glenohumeral arthritis. Twenty-three were monitored for a minimum of 2 years (mean, 8.3 years) or until reoperation. Complications and clinical and radiographic results were documented at the most recent follow-up.

**Results:** Of the 23 shoulders, 23 had no pain or mild or moderate pain after vigorous activity. Pain scores improved from 4.5 to 2.1 points after shoulder arthroplasty ($P < .001$). The mean shoulder abduction improved from $62^\circ$ to $110^\circ$ ($P < .001$), and the mean external rotation improved from $14^\circ$ to $47^\circ$ ($P < .001$). Subjectively, the result in 16 of the 23 shoulders was rated as much better or better. Five shoulders required reoperation, with 2 having an infectious cause. The Neer rating was excellent in 2 shoulders, satisfactory or successful in 9, and unsatisfactory or unsuccessful in 12. Radiographic follow-up showed 3 glenoids and 3 humeral components were at risk for loosening.

**Conclusions:** Shoulder arthroplasty for the treatment of the sequelae of an infected shoulder can be performed with a low risk of reinfection. The higher-than-expected rate of clinical or radiographic loosening remains concerning for culture negative infection. Although overall pain and motion can be expected to improve, unsatisfactory clinical results are not uncommon and may be secondary to the initial insult of infection.

**Level of evidence:** Level IV, Case Series, Treatment Study.

As demonstrated in our previous study, infection of the shoulder is a significant problem that can lead to early degeneration, pain, and poor function. Shoulder arthroplasty for the resultant arthritis of infected joints has been studied with respect to the other major joints. However, little has been published with regard to the role of arthroplasty in the treatment of a previously infected shoulder. The aim of this study was to analyze the rates of reinfection and the clinical outcomes after shoulder arthroplasty for the treatment of postinfectious glenohumeral arthritis. We thought it prudent to update our previous study by assessing the variation in outcomes with...
increased clinical follow-up and an increased number of patients.

Materials and methods

The mean time from infection to shoulder arthroplasty in the study group was 8.2 years (range, 0.25-48 years). All shoulders were identified by the Total Joint Registry at our institution, which has prospectively enrolled all arthroplasty patients since 1969. Patients are asked to return for clinical and radiographic evaluation at regular follow-up intervals, when possible. For those unable to return for an in-person evaluation, standardized questionnaires are used to evaluate function and satisfaction. Radiographs performed at other institutions are mailed for surgeon interpretation.

Our joint registry identified 24 shoulders with a history of a native shoulder infection that resulted in severe glenohumeral arthritis requiring shoulder arthroplasty. Shoulders treated for their initial infection at our institution or at another hospital were included in the study. The study included 23 shoulders for which complete records were available, including preoperative evaluation, operative records, and a minimum of 2 years of clinical follow-up or to the time of revision surgery. The study excluded 1 patient who was lost to follow-up before 2 years. The average duration of follow-up was 8.3 years (range, 2.216 years).

The study group consisted of 14 men and 9 women with an average age of 56 years (range, 38-75 years). All shoulders had a history of infection that was treated with irrigation and debridement or intravenous antibiotics, or both, before shoulder arthroplasty. Ten shoulders had a hematogenous infection (3 developed the infection in childhood and 7 occurred as adults), 4 shoulders developed an infection from a shoulder aspiration/injection, and 9 shoulders sustained a postoperative infection (2 after open reduction and internal fixation of a proximal humeral fracture, 1 after an acromiectomy, 1 after an acromioplasty, 1 after a capsule tightening, 2 after a rotator cuff repair, and 2 after arthroscopic procedures). All shoulders had degenerative disease of the glenohumeral joint that was nonresponsive to nonoperative treatment. Eleven shoulders underwent an anatomic total shoulder arthroplasty (TSA) and 12 underwent hemiarthroplasty. The decision to resurface the glenoid was determined by the condition of the glenoid articular surface, bone stock, and rotator cuff integrity.

Evaluation for infection

Before shoulder arthroplasty, all patients underwent routine blood work to assess for signs of active infection. A complete blood count with differential was obtained for all shoulders, and an erythrocyte sedimentation rate was measured in 21 shoulders. None of the white blood cell count results were concerning for active infection. Three shoulders had elevated erythrocyte sedimentation rates. Nine of the 23 shoulders underwent aspiration of the shoulder joint. All aspirations were negative for infection.

Operative technique and postoperative care

The same operative technique and postoperative course was followed as in our previous study.14 Shoulder arthroplasties were performed through an anteromedial or deltopectoral approach with the cephalic vein preserved and retracted medially. Four shoulders required an anteromedial approach due to severe scarring of the deltopectoral interval. For the 19 shoulders undergoing a deltopectoral approach, adhesions were removed from the subdeltoid-subacromial and conjoint tendon-subscapularis interval. In shoulders with at least 30° of external rotation, the subscapularis was divided through the tendinous portion 1 cm medial to its insertion on the lesser tuberosity. For shoulders with external rotation limited to less than 30°, the subscapularis was released from the lesser tuberosity and then reattached at the end of the case with drill holes in the neck of the humerus. The subscapularis and capsule were taken down as one structure. The inferior capsule was released from the neck of the humerus with electrocautery while protecting the axillary nerve.

The rotator cuff and capsule were carefully evaluated. Torn rotator cuffs were noted in 7 shoulders at the time of the index arthroplasty. One was repaired and underwent TSA. Six had irreparable rotator cuff tears, and 5 of these underwent hemiarthroplasty. Two additional shoulders had thin, but intact rotator cuff tears.

Intraoperative specimens of bone and soft tissue were sent for frozen section pathologic analysis and culture. Once the intraoperative frozen sections were determined to be negative for acute inflammation, the humeral head was osteotomized at the anatomic neck in retroversion to match the glenoid and to counteract any preoperative tendencies for subluxation. The osteotomies ranged from 15° to 60°, with most between 20° and 40°.

The glenoid was then evaluated. All shoulders had some level of glenoid surface degeneration. Shoulders with a severe deficiency of the rotator cuff or insufficient glenoid bone stock were treated with contouring and bone grafting of the glenoid as needed, but a glenoid component was not placed. Eleven shoulders underwent glenoid replacement. Eight shoulders received a cemented keeled or pegged glenoid, 4 of which used antibiotic-impregnated cement. A metal-backed tissue-ingrowth component was used in 3 shoulders to obtain immediate screw fixation of the component because deficient bone stock precluded placement of an all poly component.

Twelve shoulders in this group did not undergo glenoid resurfacing. Two of these had a previous resection of the proximal part of the humerus distal to the level of the surgical neck and, therefore, had no capsular or rotator cuff tissue attachments, whereas 3 patients had a massive irreparable rotator cuff tear. A sixth patient had medial erosion of the glenoid that precluded glenoid placement. Another patient, who was paraplegic and relied heavily on his upper extremities for operating a wheelchair, had a thin but intact rotator cuff. This patient was believed to be at an elevated risk for glenoid loosening. Another patient had a concentrically shaped glenoid covered with fibrocartilage. It was decided that the other 4 shoulders did not have adequate bone stock for the placement of glenoid prosthesis.

After glenoid treatment, the humeral component was inserted and the subscapularis repaired. All humeral components were uncemented. Neer humeral and glenoid components (Kirschner Medical, Fairlawn, NJ, USA) were used in 10 shoulders, Cofield components (Smith & Nephew Richards, Memphis, TN, USA) were used in 9 shoulders, and Biomet components (Biomet, Warsaw, IN, USA) were used in 4 shoulders.

Twenty-one shoulders received perioperative cefazolin for a period that varied from 1 to 7 days. The only exceptions were 1 patient whose intraoperative cultures were positive for...
Pseudomonas and who was treated with 3 weeks of intravenous tobramycin, and another patient who received clindamycin until final cultures came back negative.

The patients used an immobilizer at all times for the first week and at night for 1 month. A sling was used thereafter in the daytime for 1 month. In the full rehabilitation program, passive exercises were started on postoperative day 2, and patients were advanced to active exercises at 4 to 6 weeks. In the limited goals rehabilitation program, passive motion was started at 4 to 6 weeks with active motion at 8 to 12 weeks. Isometric strengthening was begun at 4 to 6 weeks for both groups.

**Clinical evaluation**

All shoulders were monitored for pain, function, and range of motion according to our joint registry protocol.1 Patients are contacted for follow-up evaluation at 1, 2, and 5 years, and every 5 years thereafter. Those patients unable to return for an in-person evaluation are monitored by a mailed questionnaire or telephone interview, with radiographs performed locally. Pain was assessed on a 5-point scale, with 1 point indicating no pain; 2 points, mild pain; 3 points, moderate pain after unusually vigorous activity; 4 points, moderated pain; and 5 points, severe pain. Satisfaction was assessed by asking the patients at follow-up how they felt compared with before surgery and was scored using a 4-point scale: much better (1 point), better (2 points); same (3 points), or worse (4 points). Range of motion was recorded in degrees for abduction and external rotation. Internal rotation was determined by the most cephalad posterior vertebral segment that could be reached by the thumb.

Overall, shoulders were graded according to a modified rating system of Neer et al.3,15 In the full rehabilitation group, ratings were considered excellent for shoulders with no or slight pain, active abduction to 140°, external rotation to 45°, and patient satisfaction. A satisfactory rating required no pain or slight or moderate pain only with vigorous activity, active abduction to 90°, external rotation to 20°, and patient satisfaction. Unsatisfactory ratings were given to shoulders failing to meet these criteria or if the shoulder underwent a reoperation.

The Neer ratings in a subgroup of 6 shoulders, with limited rehabilitative goals, were evaluated separately. These shoulders were determined to have an irreparable rotator cuff tear at the time of arthroplasty, with 3 having had previous proximal humerus resections. Postoperative rehabilitation for these shoulders was designed to maintain joint stability within a smaller range of motion. Successful ratings were given to shoulders with no, slight, or moderate pain only with vigorous activity, external rotation to 20°, and active abduction to greater than 70°.3,15 (Table I).

**Radiographic evaluation**

Standardized radiographs included anteroposterior internal and external rotation views plus an axillary radiograph (Fig. 1). Glenohumeral subluxation was assessed as a percentage of humeral head translation on the glenoid. Subluxation was recorded as none, mild (less than 25% translation), moderate (25% to 50% translation), or severe (greater than 50% translation).

Periprosthetic radiolucency was graded according to a previously published 5-point scale.17,18 No visible lucent lines received a grade 0. A 1-mm line was graded as 1 if incomplete and 2 if complete. A 1.5-mm-wide lucent line was graded as 3 if incomplete and 4 if complete. Grade 5 lacencies were reserved for shoulders with 2-mm-wide and complete lucent lines. Humeral and glenoid shift in the position, subsidence, or tilt was also recorded.

**Statistical methods**

Descriptive statistics are detailed as mean (standard deviation) for continuous measures and number (%) for discrete variables. Included in the clinical outcomes were 18 shoulders with a minimum of 2 years of clinical follow-up and 5 shoulders undergoing reoperation for any cause (total of 23 shoulders). Shoulders undergoing reoperation were monitored from the date of surgery to the last follow-up immediately before reoperation. A paired t test was used to compare preoperative vs postoperative changes. The z level for all tests was set at 0.05 for statistical significance.

**Results**

**Complications and reoperations**

Eight complications (5 loosening, 2 hematomas, 1 anterior subluxation) occurred in 7 shoulders, 5 of which required reoperation. One patient developed a hematoma postoperatively that required serial aspirations. All cultures were negative, and the hematoma resolved without the need for surgery. The same patient had severe anterior-superior instability of the prosthesis in addition to postoperative detachment of the anterior deltoid repair. As a result, the prosthesis sat in a subcutaneous position. The patient had no pain but did have very poor function. No additional surgery was performed.

Of the 23 shoulders treated for postinfectious arthritis, 5 required reoperation at a mean of 5 years (range, 1.6-9.5 years) after the initial arthroplasty procedure. Two of the 5 shoulders required reoperation for culture-positive infections after the index arthroplasty. One shoulder developed humeral and glenoid loosening 6.5 years postoperatively and underwent removal of both implants and conversion to a hemiarthroplasty. Intraoperative cultures grew Staphylococcus aureus, and the patient was treated with 2 weeks of vancomycin. At 9.5 years after revision, the patient remained satisfied with his revision arthroplasty, with an excellent Neer rating. It is unknown whether the pathogen identified at the revision matched his original pathogen that was identified 40 years before his index arthroplasty. The second shoulder developed a subcutaneous abscess 1.6 years postoperatively that failed to heal after irrigation and debridement. Ultimately, the patient required a resection arthroplasty. Intraoperative cultures grew coagulase-negative Staphylococcus, which did not match his original pathogen, methicillin-sensitive S aureus.

Three additional patients were treated for component loosening; however, intraoperative cultures remained negative without evidence of recurrent infection. Two patients were revised for loosening of TSA components. The first developed loosening of the humeral and glenoid components and was treated with a conversion to a hemiarthroplasty. At
3.5 years after revision, the patient had an unsatisfactory Neer rating secondary to pain and limited motion. The second patient developed a loose glenoid that was treated with arthroscopic removal of the all-poly glenoid component 10 years after the index arthroplasty. No follow-up was available for this patient. The last aseptic revision was performed for loosening of the humeral component in a patient treated with a hemiarthroplasty. The patient was converted to a TSA 5 years after the index arthroplasty. At 2 years after revision, the patient had an unsatisfactory Neer rating secondary to pain.

<table>
<thead>
<tr>
<th>Table I</th>
<th>Results at the latest follow-up examination</th>
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<tbody>
<tr>
<td>Patient</td>
<td>Type of surgery</td>
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<tr>
<td>1</td>
<td>Hemi</td>
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<td>3</td>
<td>TSA</td>
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<td>5</td>
<td>Hemi</td>
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<td>Hemi</td>
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</table>

Hemi, hemiarthroplasty; TSA, total shoulder arthroplasty.
* The patients in the full rehabilitation group were evaluated according to the system of Neer et al. and those in the limited-goals rehabilitation group were evaluated separately, with a result considered to be successful when the patient had no or slight pain or moderate pain only with vigorous activity, had external rotation to 20°, and had active abduction to >70°.

Figure 1  (A) Preoperative internal rotation view of shoulder demonstrating severe glenohumeral arthritis. (B) Internal rotation view showing the same patient after hemiarthroplasty. (C) Axillary view showing the same patient after hemiarthroplasty.
subsequently developed positive intraoperative cultures in
the days after surgery. In 1 patient, intraoperative cultures
grew *Pseudomonas* several days after a hemiarthroplasty,
matching his original infectious organism. The patient
was treated with 14 days of minocycline and had an unsatis-
factory Neer rating at the time of latest follow-up secondary
to limited abduction and external rotation. The second
shoulder with positive *Propionibacterium* cultures was
treated with lifelong amoxicillin suppression and had a
satisfactory Neer rating at the latest follow-up with
a functioning prosthesis.

Intraoperative cultures from 2 shoulders grew *Propio-
nibacterium*, which represented different pathogens than
the original infectious organisms. One of the shoulders was
treated with 14 days of minocycline and had an unsatis-
factory Neer rating at the time of latest follow-up secondary
to limited abduction and external rotation. The second
shoulder with positive *Propionibacterium* cultures was
treated with lifelong amoxicillin suppression and had a
satisfactory Neer rating at the latest follow-up with a
functioning prosthesis.

Two other shoulders grew coagulase-negative *S aureus*
in 1 of 3 cultures. These were believed to be contaminants,
and the patients were not treated with additional antibiotics.
Neither patient showed any signs of infection at the latest
follow-up. One had an unsatisfactory Neer rating at the
latest follow-up secondary to subjective dissatisfaction.
The second shoulder had a satisfactory Neer rating at the
latest follow-up, and the patient was satisfied with his outcome.

**Clinical results**

The mean score for pain decreased from 4.5 points pre-
operatively to 2.1 points at the latest follow-up (*P < .001*).
Of the 23 shoulders, 20 had no or mild pain or moderate
pain only with vigorous activity (Table I).

The mean abduction improved from 62° to 110° (*P =
.002*). The mean external rotation improved from 14° to 47°
(*P < .001*). Ten shoulders were subjectively rated as much
better; 6 as better; 5 as the same, and 2 as worse after
arthroplasty.

In the normal rehabilitation group, 2 shoulders had
an excellent rating, according to a modification of the
rating system of Neer et al. Ratings were satisfactory in 6
shoulders and unsatisfactory in 9. The unsatisfactory rat-
ings were due to poor motion in 1, pain in 1, a combination
of pain and loss of motion in 2, and patient satisfaction in 3.
Two additional patients underwent reoperation, resulting in
an unsatisfactory Neer rating.

In the limited goals rehabilitation group, outcomes were
successful in 3 patients and unsuccessful in 3 patients. The
unsuccessful outcomes were due to range of motion in 1
patient and revision secondary to pain in 2.

When isolating out patients qualifying for the limited
goals rehabilitation, there was no significant difference in
postoperative range of motion, improvements in range of
motion, or postoperative pain compared with the full
rehabilitation group. When the 3 patients with thin or
repaired rotator cuffs were added to the limited goals group,
In these series, the preoperative evaluation varied and included clinical evaluation, aspiration, and cultures, and laboratory assessments, which included white blood cell counts, erythrocyte sedimentation rate, and nuclear scans. Intraoperative histology and cultures were also included in the decision to proceed with arthroplasty. Many of these series have documented intraoperative cultures that later became positive after the arthroplasty procedure. Most commonly, this situation was managed with retention of the prosthesis, a course of antibiotics, and close clinical follow-up.

Although the patients in our series had low rates of reinfection, the clinical outcomes were more heterogeneous. Overall, pain scores as well as abduction and external rotation improved. Subjectively, the outcomes of 69.5% of the shoulders were rated as much better or better. However, objective outcome ratings demonstrated that only 47.8% of shoulders had a successful result. In part, the unsatisfactory results may be due to the presence or development of postoperative rotator cuff tears or anterior-superior escape, or both, leading to worsening shoulder functionality. At the time of arthroplasty, 9 patients were noted to have compromised rotator cuffs. Today, a portion of these would surely have been best treated with a reverse TSA.

Improvements in pain and range of motion were similar to those patients treated for osteoarthritis. However, patients treated for osteoarthritis had better motion and fewer unsatisfactory results than the postinfectious population. Again, this is similar to the hip and knee literature, where clinical results approach but are not equal to those after arthroplasty in joints without previous infection.

Radiographically identifiable glenoid lucencies developed in 8 of the 11 TSAs (72.7%), and 3 underwent reoperation for a loose glenoid (27.2%). Interestingly, only 2 of 3 revised glenoids showed radiographic signs of loosening preoperatively. The rate of radiographic glenoid loosening after TSA for postinfectious arthritis is higher than the rate for the osteoarthritic population but similar to the rheumatoid population. However, the rate of revision for symptomatic glenoid loosening was higher than in the osteoarthritic and rheumatoid populations. Given the high rate of glenoid loosening, consideration could be given to treating this population with a reverse TSA with the goal of securing stronger glenoid fixation. Reverse TSA should routinely be considered for patients with a previously resected proximal humerus, inadequate bone to support a glenoid component, or a deficient rotator cuff.

Of the 23 humeral components placed, 3 (13%) underwent revision operations for loose components. However, only 2 of the 3 components had radiographic evidence of preoperative loosening. The rate of radiographic humeral loosening after TSA for postinfectious arthritis is much higher than that for the osteoarthritic population and slightly higher than that of the rheumatoid population (13% vs 7%).

Our recommendations for the treatment of postinfectious arthritis of the shoulder include appropriate preoperative and intraoperative assessment together with standard decision making with regard to placement of the prosthesis. Preoperative assessment should be aimed at ruling out active infection as well as defining the anatomic considerations that influence the surgery. Laboratory evaluation for infection should be performed, and any abnormalities in the tests should be an indication for joint aspiration. Plain radiographs and a computed tomography scan provide helpful information with regard to bony abnormalities and evaluation of glenoid bone stock. A magnetic resonance image should be considered to evaluate the rotator cuff when there are any concerns clinically. Intraoperatively, specimens should be sent for histologic evaluation, and cultures should be obtained to verify that active infection is not present. In addition to the radiographic evaluation, the rotator cuff and glenoid bone stock must be critically evaluated intraoperatively to determine whether a glenoid component should be placed.

### Table II Subgroup clinical analysis

<table>
<thead>
<tr>
<th>Variable</th>
<th>Hemi (n = 12)</th>
<th>TSA (n = 11)</th>
<th>Hemi vs TSA</th>
<th>Full rehab (n = 17)</th>
<th>Hemi vs TSA</th>
<th>Limited goals rehab (n = 6)</th>
<th>P*</th>
<th>Full vs limited goals rehab (n = 14)</th>
<th>P*</th>
<th>Deficient rotator cuff (n = 9)</th>
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<td>Pain</td>
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<td>.69</td>
<td>2.1 (1.0)</td>
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<td>.85</td>
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<td>117 (47.6)</td>
<td>.62</td>
<td>121 (41.1)</td>
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<td>.88</td>
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<td>6 (50)</td>
<td>5 (45)</td>
<td>.88</td>
<td>8 (47)</td>
<td>3 (50)</td>
<td>.91</td>
<td></td>
<td>6 (43)</td>
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<td>5 (56)</td>
<td>.56</td>
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</table>

Hemi, hemiarthroplasty; TSA, total shoulder arthroplasty.

* Comparison using a 2-sample t test assuming unequal variances.

† Limited goals rehabilitation group includes patients with massive rotator cuff tears or proximal humerus resection, or both, before arthroplasty.
If concerns arise in the preoperative or the intraoperative assessment regarding ongoing infection or the ability to place a stable implant, the surgeon must weigh other options such as nonoperative management, debridement, or arthrodesis. When the decision is made to proceed with arthroplasty, consideration should be given to the use of antibiotic-impregnated cement. Our current practice involves using 1 g of vancomycin and 1.2 g of gentamicin per batch of cement when cementing the glenoid component. However, our preference remains to use uncemented implants for the humeral component.

Conclusions

Arthroplasty after infection of the glenohumeral joint can be performed with a low risk of reinfection, with appropriate patient selection. However, arthroplasty in the setting of a previous infection can be extraordinarily difficult due to resultant bone loss and soft-tissue deficits. These challenges lead to variable clinical results, with a significant number of shoulders doing worse than those receiving primary shoulder arthroplasty for osteoarthritis.

Disclaimer

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References