Shoulder Arthroplasty for the Treatment of Postinfectious Glenohumeral Arthritis

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Investigation performed at the Mayo Clinic, Rochester, Minnesota

Background: Currently, no studies on shoulder arthroplasty after a previous infection of the shoulder have been published, as far as we know. The purpose of this study was to evaluate the rates of reinfection and the clinical results after shoulder arthroplasty for the treatment of postinfectious glenohumeral arthritis.

Methods: Between 1975 and 2000, thirteen patients with a history of infection of the shoulder that resulted in severe glenohumeral arthritis underwent shoulder arthroplasty. One patient who had been followed for less than two years was excluded. Therefore, twelve shoulders that had been followed for a minimum of two years (mean, 9.7 years) or until the time of revision surgery were included in the study. Complications, clinical results (pain, satisfaction, and range of motion), and radiographic results were documented at the time of the latest follow-up.

Results: No patient in this study had had a known reinfection at the time of the latest follow-up. Overall pain scores improved from 4.8 to 2.5 points after implantation of a prosthesis. Eight of the twelve patients had no pain or mild or moderate pain only after vigorous activity. The mean shoulder abduction improved from 75° to 117°, and the mean external rotation improved from 13° to 36°. Subjectively, only six of the twelve patients rated the result as much better or better. The results in the eight patients who underwent a full rehabilitation program were better than those in the four patients who underwent a limited-goals rehabilitation program.

Conclusion: Shoulder arthroplasty for the treatment of the sequelae of an infected shoulder can be performed with a low risk of reinfection. While overall pain and motion can be expected to improve, unsatisfactory clinical results that are related to the destructive effects of the initial infection are not uncommon.

Level of Evidence: Therapeutic study, Level IV (case series [no, or historical, control group]). See Instructions to Authors for a complete description of levels of evidence.

Infection of the shoulder is a devastating event that can lead to early degenerative changes, pain, and poor function. Total joint arthroplasty for the treatment of the sequelae of infected joints has been addressed with respect to the hip, knee, and elbow[1-8]. However, little has been published with regard to the role of arthroplasty in the treatment of a previously infected shoulder[9,10]. The purpose of the present study was to evaluate the rates of reinfection and the clinical results after shoulder arthroplasty for the treatment of postinfectious glenohumeral arthritis.

Materials and Methods

Between 1975 and 2000, 2568 patients underwent primary shoulder arthroplasty at the Mayo Clinic. Thirteen patients had a history of infection of the shoulder that resulted in severe glenohumeral arthritis. The senior author (R.H.C.) performed each of the arthroplasties in these patients. One patient who had been followed for less than two years was excluded. Therefore, twelve shoulders that had complete preoperative evaluation and operative records and had been followed for a minimum of two years or until the time of revision surgery were included in the study.

There were eight men and four women with an average age of fifty-six years (range, forty-two to seventy-eight years). All patients had a history of infection of the shoulder with subsequent surgical débridement and treatment with courses of antibiotics of various durations. Five patients had had a hematogenous infection (two had the infection in childhood and three had it as adults), three patients had had an infection from a shoulder aspiration, and four patients had had a postoperative infection (two after open reduction and internal fixation of a proximal humeral fracture, one after an acromionectomy, and one after a rotator cuff repair (see Appendix). All patients had degenerative disease of the glenohumeral joint that was unresponsive to nonoperative management. A total shoulder arthroplasty was performed in six patients, and a hemiarthroplasty was done in the other six. The decision to resurface the glenoid was made on the basis of the condition of the glenoid

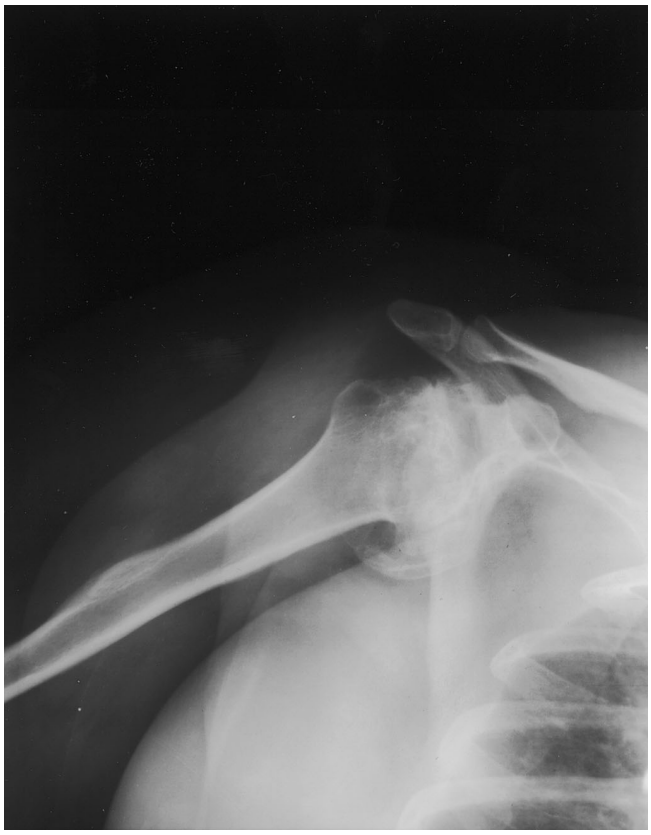

Fig. 1-A

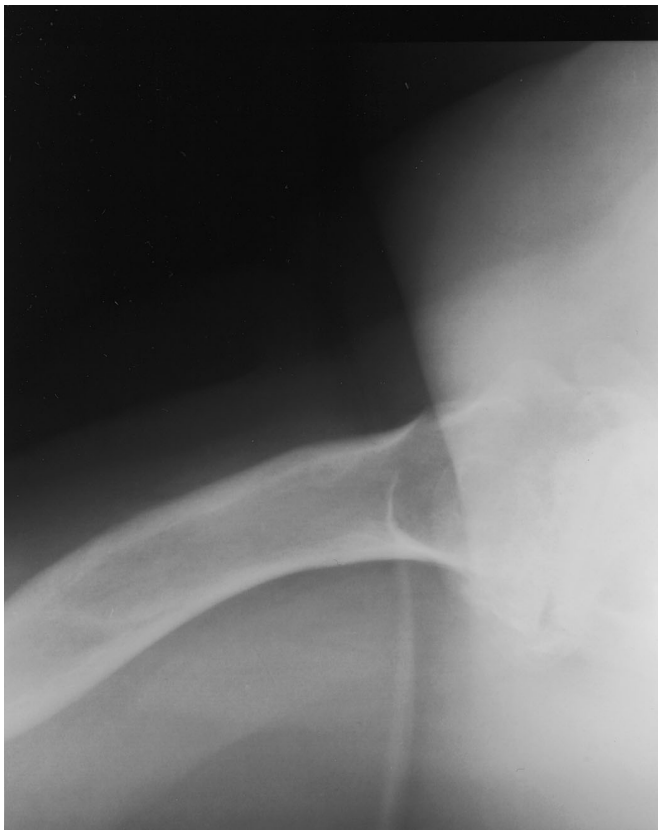

Fig. 1-B

Figs. 1-A and 1-B Radiographs demonstrating proximal humeral bone loss and dysplasia with medial erosion of the glenoid as a result of glenohumeral infection during childhood.

articular surface, the glenoid bone stock, and the rotator cuff integrity. The average time from the infection to the arthroplasty was 15.4 years (range, seven months to fifty-one years).

The patients were identified with the use of the Total Joint Registry at our institution, which has prospectively followed patients since 1969. Patients were asked to return for clinical and radiographic evaluation by the senior author at regular follow-up intervals. Those who were unable to return completed a standard questionnaire to evaluate function and satisfaction, and they also had radiographs made locally and sent to our institution for interpretation. The average duration of follow-up was 9.7 years (range, 2.7 to nineteen years).

Evaluation for Infection

Prior to joint arthroplasty, the patients underwent a laboratory workup to rule out active infection. A complete blood-cell count with differential was determined for all patients, and the erythrocyte sedimentation rate was measured in nine patients. Six of the twelve patients underwent aspiration of the shoulder joint. All aspirations were negative. Tissue for culture and pathologic examination was obtained intraoperatively in all patients.

Clinical Evaluation

The results of the clinical assessment of all patients were recorded on a standard shoulder-analysis form. Pain was recorded 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, moderate pain; and 5 points, severe pain. Satisfaction was assessed, with use of a 4-point scale, by asking the patients how they had felt when seen at the time of the follow-up examination compared with how they had felt preoperatively: 1 point was given if they felt much better; 2 points, if they felt better; 3 points, if they felt the same; and 4 points, if they felt worse. The range of motion in abduction and external rotation was recorded in degrees, whereas internal rotation was measured by the most cephalad posterior vertebral segment that could be reached by the thumb.

The overall results for eight patients in a full rehabilitation program were also graded according to a modification of the rating system of Neer et al.[11,12]. The result was considered to be excellent if the patient had no or slight pain, had active abduction to 140°, had external rotation to 45°, and was satisfied with the result. The result was satisfactory if the patient had no or slight pain or moderate pain only with vigorous activity, had active abduction to 90°, had external rotation to 20°, and was satisfied with the result. A result was graded unsatisfactory if the satisfactory criteria were not met or if the patient needed a revision procedure.

A subgroup of four patients who had limited rehabilitative goals because of an irreparable rotator cuff tear was evaluated separately. These patients participated in an exercise program that was directed at maintaining stability with a smaller range of motion. The result was considered to be successful if 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°[12,13].

Radiographic Evaluation

Routine radiographic evaluation consisted of 40° posterior oblique radiographs, with internal and external humeral rotation, in addition to an axillary radiograph of the shoulder. Glenohumeral subluxation was determined by the amount and direction of translation of the humeral head in relation to the center of the glenoid or the glenoid component. Subluxation was recorded as none when no translation was observed, mild if there was <25% translation, moderate if there was 25% to 50% translation, or severe if there was >50% translation.

Periprosthetic radiolucency was graded according to a previously published scale[13,14]. Grade 0 was given if there was no line; grade 1, if the line was 1 mm wide and incomplete; grade 2, if the line was 1 mm wide and complete; grade 3, if the line was 1.5 mm wide and incomplete; grade 4, if the line was 1.5 mm wide and complete; and grade 5, if the line was 2 mm wide and complete. Any shift in the position of the glenoid as well as subsidence or tilt of the humeral component was also recorded.

Operative Technique

Shoulder arthroplasty was performed through a deltopectoral approach with the cephalic vein preserved and retracted medially. The subdeltoid-subacromial space and the interval between the conjoint tendon and the subscapularis muscle were freed of adhesions and scar tissue. In shoulders with ≥30° of external rotation, the subscapularis was divided through the tendon 1 cm medial to its insertion on the lesser tuberosity. If the patient had <30° of external rotation, the subscapularis was taken off the lesser tuberosity and later reattached through drill holes along the humeral neck. The subscapularis and capsule were taken off together as one structure. The inferior aspect of the capsule was released from the humeral neck with electrocautery with careful protection of the axillary nerve. The proximal part of the humerus was then carefully dislocated anteriorly. Capsular tissue and the rotator cuff tendons were critically assessed, and any abnormalities were recorded. One patient had a thin but intact rotator cuff, a second patient had a rotator cuff tear that was repaired, and four patients had a massive, irreparable rotator cuff tear. In each patient, intraoperative specimens of soft tissue and bone were obtained for frozen-section analysis to detect signs of infection and they were also sent for culture. Once the intraoperative frozen sections were read as negative for active infection, the proximal part of the humerus was osteotomized at the anatomic neck in the appropriate retroversion to match the glenoid and to counteract any preoperative tendencies for subluxation. The osteotomies ranged from 15° to 60°, with the majority between 20° and 40°. The glenoid was then inspected. All patients had degenerative changes of the glenoid surface. Patients with a severe deficiency of the rotator cuff or inadequate glenoid bone stock were treated with contouring and bone-grafting of the glenoid as needed but without placement of a glenoid component. Six patients underwent placement of a glenoid component. In three of them, there was a question as to whether the glenoid bone stock was sufficient to support a cemented keeled glenoid component. Therefore, a metal-backed tissue-ingrowth component was used in order

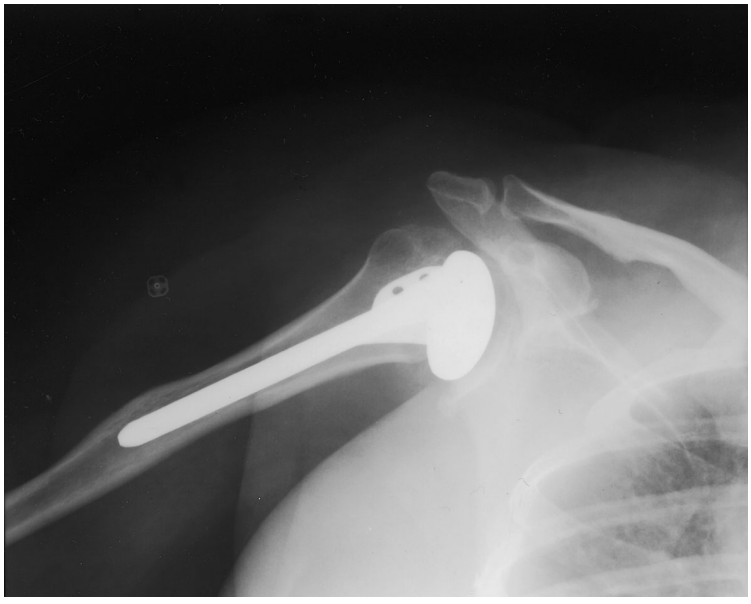

Fig. 1-C

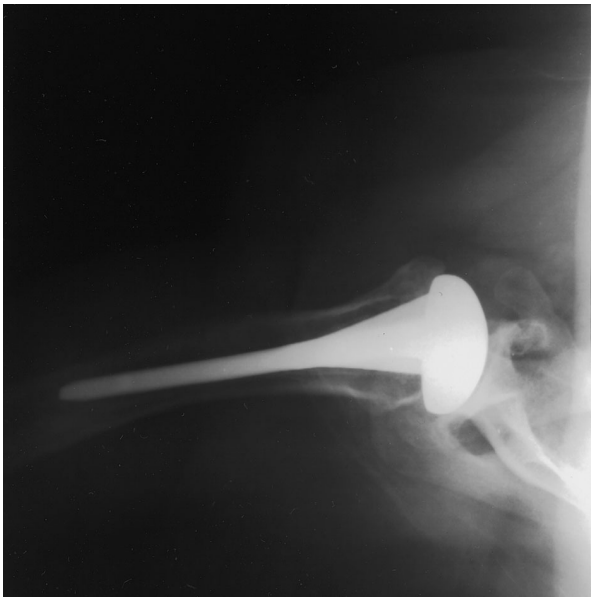

Fig. 1-D

Figs. 1-C and 1-D Hemiarthroplasty of the proximal part of the humerus.

to obtain immediate screw fixation of the component. The remaining three patients had a keeled glenoid component inserted with cement, and only one of those components was inserted with antibiotic-impregnated cement.

Six patients in this group did not have glenoid resurfacing. Two of them 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 a third patient had a massive, irreparable rotator cuff tear and a dysplastic glenoid. The fourth patient had medial erosion of the glenoid that precluded glenoid placement. Another patient had paraplegia and relied heavily upon his upper extremities for operating a wheelchair and had a thin but intact rotator cuff. It was thought that this patient had a high risk for glenoid loosening. The final patient was a physiologically young fifty-four-year-old woman with a concentrically shaped glenoid covered with fibrocartilage.

Following management of the glenoid, the humeral component was inserted and the subscapularis was repaired. None of the humeral components were inserted with cement. Neer humeral and glenoid components (Kirschner Medical, Fairlawn, New Jersey) were used in eight patients, and Cofield-1 components (Smith and Nephew Richards, Memphis, Tennessee) were used in four.

The patients received perioperative administration of cefazolin for a period that varied from one to seven days. The only exception was one patient who had intraoperative cultures that were positive for Pseudomonas, and he was treated with three weeks of intravenous administration of tobramycin.

Postoperatively, a shoulder immobilizer was used at all times for one week. Thereafter, a sling was used during the day. However, the shoulder immobilizer was continued at night for another month. Vigorous rehabilitation, beginning with passive range-of-motion exercises, was started on the first postoperative day in eight patients. At four to five weeks, active-assisted range-of-motion exercises and isometric strengthening were begun. At two to three months, stretching and strengthening exercises with use of an elastic strap were added. The limited-goals rehabilitation program, emphasizing maintenance of joint stability through a longer period of immobilization and a smaller range of motion, was followed in four patients.

Results

Complications and Reoperations

Five complications occurred in four patients, three of whom needed a reoperation. One patient sustained a postoperative hematoma that required serial aspirations. All cultures were negative, and the hematoma resolved without the need for surgical intervention. 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. Fortunately, the patient had no pain but did have very poor function. No additional surgery was performed.

Three patients had a revision operation; two of them had the revision because of component loosening and one, because of glenoid arthrosis after hemiarthroplasty. An extensive workup including appropriate laboratory studies, bone and indium scans, and cultures did not indicate infection in any of the three patients. Three years after total shoulder arthroplasty, one patient underwent revision to a hemiarthroplasty because of loosening of a metal-backed ingrowth glenoid component. He had an excellent clinical result after the revision. A second patient who had had a total shoulder arthroplasty five years earlier underwent revision to a hemiarthroplasty because of loosening of both the humeral and keeled glenoid components and had a poor clinical result. The third revision was performed because of glenoid arthrosis five years after a hemiarthroplasty. At the time of the initial surgery, the surgeon elected not to place a glenoid component because of the patient's physiologically young age and concentric, smooth glenoid surface. The patient had a satisfactory result after the revision.

Intraoperative Pathology and Cultures

All intraoperative frozen sections were negative for signs of acute inflammation. In one patient, intraoperative cultures grew Pseudomonas several days after a hemiarthroplasty. The patient was treated with three weeks of intravenous administration of tobramycin. At the time of the latest follow-up examination, the patient had a good clinical result with no signs of recurrent infection.

Clinical Results

The mean score for pain decreased from 4.8 points preoperatively to 2.5 points after the arthroplasty. Eight of the twelve patients had no or mild pain or moderate pain only with vigorous activity (Table I).

The mean abduction improved from 75° to 117°. The mean external rotation improved from 13° to 36°. Six patients subjectively rated the shoulder as much better; five, as the same; and one, as worse after arthroplasty. Among the eight patients who underwent the full rehabilitation program, two patients had an excellent result, according to a modification of the rating system of Neer et al.[11,12]; three patients, a satisfactory result; and three patients, an unsatisfactory result. The unsatisfactory results were due to pain in two patients and to poor motion alone in another. Both patients with pain underwent revision surgery.

In the limited-goals subgroup, one patient had a successful result and three patients had an unsuccessful result. The unsuccessful results were due to pain in one patient, to pain and poor motion in one patient, and to poor motion and instability despite good pain relief in the third patient. One of them, who had pain and poor motion, underwent revision surgery because of loose components.

Radiographs

Preoperatively, several patients had radiographic abnormalities. Three patients had a mottled, moth-eaten appearance of the proximal part of the humerus that raised a concern about the possibility of chronic osteomyelitis. Three patients had a

TABLE I Results at the Latest Follow-up Examination

Case	Abduction *(deg)*		External Rotation *(deg)*		Pain *(points)*		Satisfaction *(points)*	Overall Rating*
	Preop.	Postop.	Preop.	Postop.	Preop.	Postop.		
Full rehabilitation group								
1	70	90	–15	0	5	3	3	Unsatisfactory
3	80	165	10	75	4	2	1	Excellent
4	160	175	15	30	5	2	1	Satisfactory
5	135	180	0	45	5	1	1	Excellent
6	80	135	30	35	5	4	3	Unsatisfactory
7	30	180	0	30	5	1	1	Satisfactory
8	90	130	10	55	5	4	3	Unsatisfactory
11	65	100	10	30	5	3	1	Satisfactory
Limited-goals rehabilitation group								
2	80	80	0	20	5	4	3	Unsuccessful
9	30	20	0	0	4	1	4	Unsuccessful
10	20	35	100	45	4	4	3	Unsuccessful
12	60	110	0	70	5	1	1	Successful

*The patients in the full rehabilitation group were evaluated according to the system of Neer et al.[11,12], 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°.

history of an infectious process of the glenohumeral joint in childhood and, subsequently, had dysplastic changes of the proximal part of the humerus (Figs. 1-A through 1-D).

Complete radiographic follow-up was available for seven patients (four who had a total shoulder arthroplasty and three who had a hemiarthroplasty). Of the four patients who had a total shoulder arthroplasty, one had no radiolucency in the glenoid, one had a grade-1 radiolucency, and two had a grade-5 radiolucency. One of the patients with a grade-5 radiolucency had medial migration of the glenoid component and underwent revision arthroplasty. Two of the three patients who had a hemiarthroplasty demonstrated mild central glenoid erosion. One of the two patients had symptoms severe enough to warrant revision surgery to resurface the glenoid.

Of the seven humeral components, three demonstrated no periprosthetic radiolucency; one, grade-1 radiolucency; one, grade-3 radiolucency; and two, grade-5 radiolucency. The two patients with grade-5 radiolucency had subsidence of the humeral component. One of the two patients underwent revision of the humeral component. Three patients demonstrated subluxation. One patient had severe anterior-superior subluxation. A second patient had moderate superior subluxation, and the third had moderate superior and mild anterior subluxation.

Discussion

Intra-articular infection can lead to substantial morbidity including early degenerative change, poor function, and pain. Surgical options in these patients include arthrodesis, resection arthroplasty, and prosthetic arthroplasty. While prosthetic arthroplasty in this setting has been studied in the hip, knee, and elbow, little has been published with regard to shoulder arthroplasty in patients with a history of joint infection[1-10,15-19].

Numerous studies have demonstrated the safety and efficacy of hip and knee arthroplasty for the treatment of degenerative joints with a history of infection[1-7]. Reinfection rates have ranged from 0% to 9.5%, with clinical results approaching but not equal to those after arthroplasty in joints without a history of infection[1-8]. In these series, the preoperative evaluation varied and included clinical evaluation, aspiration and cultures, laboratory assessment with use of white blood-cell counts and the erythrocyte sedimentation rate, and nuclear scans. Intraoperative histological examination and cultures were also included. It is of note that many of these series have documented intraoperative cultures that became positive after placement of the prosthesis[1-4]. Most frequently, this situation was managed with retention of the prosthesis, a course of antibiotics, and close clinical follow up. The reinfection rate in our series was comparable with that described in the hip and knee literature. None of the patients in the present series had an obvious clinical infection at the time of the latest follow-up examination. One patient had had an intraoperative culture at the time of the revision that was positive for *Staphylococcus aureus*. It was treated with two weeks of intravenous administration of vancomycin, and the patient subsequently had an excellent clinical outcome without signs of infection at the time of the latest follow-up.

While this series of patients did well with regard to rein-

fection, the clinical outcomes were more varied. Overall, the pain scores as well as abduction and external rotation improved. Subjectively, however, only six of the twelve patients rated their results as much better or better. Finally, objective ratings of outcome demonstrated that five of eight patients in the full rehabilitation program had an excellent or satisfactory outcome, whereas only one of four patients in the limited-goals program had a successful result. Of the unsatisfactory results in the two groups, four were due to pain, one was due to poor motion and instability, and the last was due to poor motion alone.

There are many possible explanations for the suboptimal clinical outcomes in these patients. All of the patients in both groups had undergone several procedures prior to the arthroplasty, including at least one, and often several, débridements. In addition, patients with childhood infection had dysplastic changes and bone loss that could be attributed to growth disturbances in addition to the effects of surgical débridement. Finally, the combination of the destructive effects of the initial infection and débridement to treat the infection left many patients with severely compromised soft tissues, likely affecting both function and stability.

Our recommendations for the management 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 delineating the anatomic factors that influence the surgery. Laboratory screening tests for infection should be performed, and any abnormalities in the studies should be an indication for a bone or indium scan as well as for aspiration of the joint. Plain radiographs and a computed tomography scan provide valuable information with regard to osseous abnormalities. Intraoperatively, specimens should be sent for histologic evaluation and cultures should be obtained to confirm that an active infectious process is not present. In addition to the radiographic evaluation, the rotator cuff and glenoid bone stock must be critically assessed intraoperatively to determine whether glenoid resurfacing should be performed. If questions arise in either the preoperative or the intraoperative assessment with regard to possible ongoing infection or the ability to place a stable implant, the surgeon must consider other options such as nonoperative management, débridement, or arthrodesis.

In summary, arthroplasty after infection of the shoulder can be performed with a low risk of reinfection in properly selected patients. However, arthroplasty in this setting is especially challenging because of the potential for substantial bone and soft-tissue deficits. These challenges can lead to variable clinical results, a number of which are likely to be inferior to those seen following standard shoulder arthroplasty.

Appendix

eA A table showing the specific data on all twelve patients is available with the electronic versions of this article, on our web site at www.jbjs.org (go to the article citation and click on "Supplementary Material") and on our quarterly CD-ROM (call our subscription department, at 781-449-9780, to order the CD-ROM). ■

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