# The complex characteristics of 282 unsatisfactory shoulder arthroplasties

Amy K. Franta, MD,[a] Tim R. Lenters, MD,[a] Doug Mounce, MSc,[a] Blazej Neradilek, MSc,[b] and Frederick A. Matsen, III, MD,[a] *Seattle, WA*

*The purpose of our study is to augment the knowledge of patient dissatisfaction after a shoulder arthroplasty. A total of 353 shoulders were prospectively enrolled into the Shoulder Arthroplasty Failure Experience (SAFE) project. Of these, 282 patients had complete data for the final analysis, including demographic information, medical history, physical examination, standard radiographs, and the Simple Shoulder Test (SST) scores. These data were analyzed to determine the frequency of 17 possible characteristics of an unsatisfactory arthroplasty. Pain was the most common reason for patients to seek an evaluation (241 of 282 shoulders). Shoulder function was substantially reduced at presentation, with patients only able to perform an average of 2.6 of 12 SST functions. Overall, technical factors such as component malpositioning and glenohumeral malalignment were the most common characteristics identified among all the shoulders. Loosening of glenoid components was noted in 85 of the 136 total shoulder arthroplasties, and glenoid erosion was found in 51 of 80 hemiarthroplasties performed for degenerative conditions. Patients with an unsatisfactory outcome after shoulder arthroplasty present with poor shoulder function and pain. Component malposition, glenohumeral malalignment, and glenoid failure are all prevalent features among patients with an unsatisfactory outcome. (J Shoulder Elbow Surg 2007;16:555-562.)*

Despite many enthusiastic reports on the results of shoulder arthroplasty, the published literature does not completely represent the conditions in which the outcome is unsatisfactory for the patient.[20] This is because there has been a focus on outcomes from the perspective of the surgeon, rather than of the patient. The literature largely presents the results achieved by high-volume surgeons, even though it is recognized that most of these procedures are done by surgeons who do less than 3 shoulder arthroplasties per year, that the results for low-volume surgeons are poorer,[13,16] and that patients with unsatisfactory results may tend to be lost to follow-up and thus be underrepresented in the published series.

The purpose of this study is to augment the knowledge of shoulder arthroplasties having outcomes that were unsatisfactory from the standpoint of the patient. A prospective registry was established to collect data on all patients presenting to us for consultation because of dissatisfaction with their result from a previous shoulder arthroplasty. We termed this the Shoulder Arthroplasty Failure Experience (SAFE).

We recognize that this type of observational study is different than prospective studies in which a group of patients treated by one or a few surgeons is followed up to determine the rate of failure, yet prospective studies cannot include the failures that arise in the practices of occasional shoulder arthroplasty surgeons. Although most studies of shoulder arthroplasty present good and excellent results, to our knowledge, this article presents the largest series of failures to be reported.

We recognize that failure of a shoulder arthroplasty is likely to be multifactorial. For example, some surgeons may be relatively less skillful in patient selection, soft-tissue management, prosthesis placement, and aftercare; thus, sorting out the cause of a given failure is often difficult because some of these factors are more visible than others. Specifically, excessive humeral retroversion may be associated with failure, but it is not necessarily the cause of failure of arthroplasties with this finding.

Although it is tempting to attribute failure to surgeon error, many of the factors under consideration cannot be judged as right or wrong; for example, we know that neither an excessively high humeral head placement nor glenoid lucent lines are inconsistent with an excellent functional result. Thus, our approach was to discern features that were common to patients

From the [a]Department of Orthopaedics and Sports Medicine, University of Washington Medical Center; and [b]Mountain-Whisper-Light Statistical Consulting.

Reprint requests: Frederick A. Matsen, III, MD, Professor and Chairman, Department of Orthopaedics and Sports Medicine, University of Washington Medical Center, 1959 NE Pacific St, Box 356500, Seattle, WA 98195 (E-mail: *matsen@u.washington.edu*).



1058-2746/2007/$32.00
doi:10.1016/j.jse.2006.11.004

with a failed shoulder arthroplasty. By pointing out these common features, we could create new insight among shoulder surgeons of elements of this practice that deserve particular attention.

Against this background and based on our prior experience, we hypothesized that:

1. patients who were dissatisfied with their shoulder arthroplasty would have poor shoulder function;
2. patients would predominantly express concern about shoulder pain and stiffness rather than complications of the surgery, such as fracture or instability;
3. factors related to surgical technique, such as component placement and fixation and subscapularis failure, would emerge as prominent features;
4. glenoid failure would be a common feature of both; and
5. tuberosity failure would be a common feature of unsatisfactory arthroplasties performed for fracture.

We were unable to test hypotheses relating to the prevalence of these causes of failure because we cannot know the total number of arthroplasties from which this population of failures presented, and the rate with which different types of failures might present to us may have been affected by selection or referral bias.

## MATERIALS AND METHODS

We obtained approval from our Human Subjects Review Committee. From 1994 to 2004, 353 shoulders were evaluated by our shoulder consultation service because of patients' dissatisfaction with the result of a shoulder arthroplasty. The data collected at the time of presentation included (1) demographic information, (2) medical history, (3) physical examination, (4) a standard set of radiographs consisting of true anteroposterior and axillary views of the glenohumeral joint and a full-length anteroposterior radiograph of the humerus, and (5) the results of the Simple Shoulder Test (SST)[2,19] inventory of shoulder functions. Information gathered from the medical history included the patient's chief complaints, diagnosis at the time of primary arthroplasty, surgical history, medical history, and the hospital at which the primary shoulder arthroplasty was performed. Additional data not initially recorded were collected by chart review using paper-based, microfiche, and electronic medical records.

A total of 296 radiographic examinations met our standards of quality for inclusion in this analysis. Radiographs were reviewed simultaneously by two orthopaedic surgeons. If the reviewers disagreed about the radiographic findings, the senior author was consulted. These films were assessed for evidence of glenoid or humeral component loosening, tuberosity nonunion or malunion, humeral component malposition, dislocation, subluxation, glenoid erosion or polyethylene wear, periprosthetic fracture, and the presence of heterotopic bone.

Humeral components were evaluated to determine malpositioning in varus, valgus, flexion, and extension. Although there is no commonly accepted guideline for the determination of excessively high placement, we defined high placement as one in which the articular surface was more than 1 cm above the greater tuberosity. The relative position of the center of the prosthetic humeral head to the glenoid center was recorded for each shoulder. The humeral head was considered centered in the glenoid if the distance between the center of the humeral head and the center of the glenoid was within 25% of the humeral head diameter. If the distance exceeded 25% of the humeral head diameter, components were considered to have glenohumeral malalignment.[15] Although these criteria were quite broad, we selected them for ease of use by other surgeons.

Glenoid erosion was characterized by using previously described methods.[14] An adaptation of the Gruen classification was used to document radiolucent lines about the humeral prosthesis.[11] In patients with a glenoid component, radiolucency and seating scores were recorded according to the classification described by Lazarus et al.[17] The glenoid and humeral components were judged to be loose radiographically according to the criteria described by Sanchez-Sotelo et al.[30,31] Computerized tomography scans were not used in this analysis because the mentioned benchmark studies were based on plain films, the presence of a humeral component can make the analysis of the glenoid component difficult, and we did not believe that the cost was offset by their benefit.

For the 237 shoulders that underwent revision surgery, intraoperative findings were collected from operative notes and used to support or augment the findings identified on clinical and radiographic examination. Antibiotics were withheld preoperatively until 3 cultures and a frozen section were obtained.

Although it would be of value to know if different categories of disease and different implant systems had different characteristics, the noncontrolled nature of this study did not allow for this determination. This fact, however, did not preclude us from identifying the common features within this large population of failed arthroplasties.

We considered 17 possible characteristics of an unsatisfactory shoulder arthroplasty (Tables I and II). The presence of these characteristics was determined by using clinical, radiographic, and operative data. The presence of stiffness, instability, deltoid dysfunction, or nerve injury was noted on the physical examination. Glenoid and humeral loosening were identified on radiographs or intraoperative findings, or both. Patients with polyethylene wear, humeral component malposition, glenohumeral malalignment, tuberosity nonunion, tuberosity malunion, periprosthetic fracture, and glenoid erosion were similarly identified by a combination of radiographic and operative findings. Rotator cuff tears and subscapularis incompetence was based on operative findings only. A shoulder was considered infected if results of intraoperative cultures were positive, if they had evidence of infection on examination or at the time of surgery, or if outside records documented the presence of

**Table I** Attributes of unsatisfactory shoulder arthroplasties by initial diagnosis

| Attribute | All shoulders, N (%) | Primary, n (%) | Fracture, n (%) | AVN, n (%) | Posttrauma DJD, n (%) | CA, n (%) |
|---|---|---|---|---|---|---|
| Totals | 282 | 93 (33) | 39 (14) | 25 (9) | 29 (10) | 30 (11) |
| Component malalignment | 189 (67) | 56 (60) | 27 (69) | 15 (60) | 21 (72) | 17 (57) |
| Stiffness | 184 (65) | 57 (61) | 32 (82) | 20 (80) | 23 (79) | 15 (50) |
| Component malposition | 184 (65) | 57 (61) | 26 (67) | 17 (68) | 21 (72) | 22 (73) |
| Glenoid loosening | 94 (33) | 54 (58) | 1 (3) | 4 (16) | 11 (38) | 2 (17) |
| Polyethylene wear | 84 (30) | 48 (52) | 1 (3) | 3 (12) | 9 (31) | 5 (17) |
| Glenoid erosion | 79 (28) | 11 (12) | 17 (44) | 13 (52) | 9 (31) | 8 (27) |
| Heterotopic bone | 77 (27) | 24 (26) | 16 (41) | 2 (8) | 9 (31) | 8 (27) |
| Instability | 67 (24) | 57 (61) | 4 (10) | 3 (12) | 5 (17.2) | 9 (30) |
| Subscapularis failure | 55 (20) | 16 (17) | 6 (15) | 5 (20) | 5 (17) | 7 (23) |
| Rotator cuff tear | 54 (19) | 13 (14) | 14 (36) | 4 (16) | 5 (17) | 2 (7) |
| Tuberosity nonunion | 35 (12) | 1 (1) | 16 (41) | 0 (0) | 3 (10) | 0 (0) |
| Humeral loosening | 31 (11) | 9 (10) | 5 (13) | 0 (0) | 5 (17) | 4 (13) |
| Tuberosity malunion | 31 (11) | 1 (1) | 20 (51) | 1 (4) | 4 (14) | 0 (0) |
| Infection | 31 (11) | 15 (16) | 4 (10) | 1 (4) | 3 (10) | 3 (10) |
| Deltoid dysfunction | 28 (10) | 5 (5) | 4 (10) | 2 (8) | 3 (10) | 4 (13) |
| Periprosthetic fracture | 6 (2) | 4 (4) | 1 (3) | 0 (0) | 0 (0) | 0 (0) |
| Nerve injury | 3 (1) | 1 (1) | 1 (3) | 0 (0) | 1 (3) | 0 (0) |

*DJD,* Degenerative joint disease; *AVN,* avascular necrosis; *CA,* capsulorrhaphy arthropathy.

**Table II** Attributes of unsatisfactory arthroplasties by index procedure

| Attribute | TSA, n (%) | Hemiarthroplasty | | |
|---|---|---|---|---|
| | | Total | For fx, n (%) | For nonunion, n (%) |
| Total | 136 (48) | 80 (28) | 37 (13) | 17 (6) |
| Component problem | | | | |
| Malalignment | 87 (64) | 59 (74) | 25 (68) | 12 (71) |
| Malposition | 87 (64) | 58 (73) | 24 (65) | 8 (47) |
| Glenoid loosening | 85 (63) | | | |
| Stiffness | 79 (58) | 59 (74) | 30 (81) | 11 (65) |
| Polyethylene wear | 79 (58) | | | |
| Heterotopic bone | 37 (27) | 13 (16) | 15 (41) | 8 (47) |
| Instability | 36 (27) | 16 (20) | 3 (8) | 9 (53) |
| Subscapularis failure | 28 (21) | 15 (19) | 6 (16) | 3 (18) |
| Humeral loosening | 17 (13) | 4 (5) | 5 (14) | 2 (12) |
| Infection | 16 (12) | 6 (8) | 4 (11) | 5 (30) |
| Rotator cuff tear | 15 (11) | 19 (24) | 13 (35) | 4 (24) |
| Deltoid dysfunction | 5 (4) | 13 (16) | 4 (11) | 3 (18) |
| Tuberosity nonunion | 4 (3) | 2 (3) | 15 (41) | 11 (65) |
| Periprosthetic fracture | 4 (3) | 0 (0) | 1 (3) | 1 (6) |
| Tuberosity malunion | 2 (2) | 3 (4) | 19 (51) | 6 (35) |
| Nerve injury | 0 (0) | 2 (3) | 1 (3) | 0 (0) |
| Glenoid erosion | | 51 (64) | 17 (46) | 5 (29) |

*TSA,* Total shoulder arthroplasty; *fx,* fracture.

infection. The presence of heterotopic bone was reported based on radiographic findings.

### *Data analysis*

Only the 282 shoulders with complete information were used for the analysis. Differences in quantitative measures between and among groups were tested using 1-way analysis of variance or 2-sample *t* tests assuming unequal variances. The nonparametric Mann-Whitney test and Kruskal-Wallis test were used instead of the *t* test or analysis of variance, respectively, when the data suggested that the measures being compared were not normally distributed. Equalities of proportions of events in 2 or more groups were tested using the $\chi^2$ test or the Fisher exact test. Multiple logistic regressions were used to compare proportions of events involving 2 or more groups when adjustments for

**Table III** Demographic data

| Characteristic* | All shoulders, n (%) | Patients with complete data, n (%) |
|---|---|---|
| Totals | 353 | 282 |
| Age, years ± SD | 63 ± 13.1 | 63 ± 12.9 |
| Men | 195 (55) | 155 (55) |
| Women | 158 (45) | 127 (45) |
| Left shoulder | 155 (44) | 124 (44) |
| Right shoulder | 197 (56) | 158 (56) |
| Dominant extremity (%) | 188 (53) | 155 (55) |
| Primary osteoarthritis | 114 (32) | 93 (33) |
| Secondary arthritis | 30 (9) | 24 (9) |
| Osteonecrosis/AVN | 31 (9) | 25 (9) |
| Rheumatoid arthritis | 20 (6) | 16 (6) |
| Cuff tear arthropathy | 20 (6) | 12 (4) |
| Capsulorrhaphy arthropathy | 34 (10) | 30 (11) |
| Posttraumatic arthropathy | 33 (9) | 29 (10) |
| Fracture | 52 (15) | 39 (14) |
| Fracture nonunion | 19 (5) | 17 (6) |
| Postseptic arthropathy | 3 (0.9) | 1 (0.4) |
| Neoplasia | 1 (0.3) | 0 |
| Previous surgeries | 253 | — |
| Previous revisions | 156 | — |

*AVN,* Avascular necrosis; *SD,* standard deviation.
*Values are number (percentage) unless otherwise indicated.

**Table IV** Factors influencing Simple Shoulder Test score

| Factor | Mean ± SD |
|---|---|
| All patients | 2.6 ± 2.5 |
| Gender* | |
| Male | 3.2 ± 2.5 |
| Female | 1.9 ± 1.9 |
| Implant† | |
| Hemiarthroplasties | 2.1 ± 2.0 |
| TSA | 3.1 ± 2.5 |
| Previous surgery | |
| Yes | 2.6 ± 2.4 |
| No | 2.6 ± 2.3 |
| Prior revision‡ | |
| Yes | 2.3 ± 2.0 |
| No | 3.0 ± 2.5 |
| Diagnosis§ | |
| Primary DJD | 3.3 ± 2.7 |
| Secondary DJD | 2.8 ± 2.5 |
| Fracture | 1.8 ± 1.8 |
| Nonunion | 1.5 ± 1.5 |
| Capsulorrhaphy | 2.7 ± 2.4 |
| Cuff tear arthropathy | 1.6 ± 1.7 |
| Rheumatoid arthritis | 1.6 ± 1.2 |
| Avascular necrosis | 2.8 ± 2.1 |
| Posttraumatic arthritis | 2.6 ± 2.3 |

*SD,* Standard deviation; *TSA,* Total shoulder arthroplasty; *DJD,* degenerative joint disease.
*$P < .0001$ (*t* test with unequal variance).
†$P < .0001$ (*t* test with unequal variance).
‡$P = .05$ (*t* test with unequal variance).
§$P < .01$ (Kruskal-Wallis test with $\chi^2$).

other covariates were required. Odds ratios, with their 95% confidence intervals, and Wald test values of *P* are reported for the logistic regression models. Statistical significance was defined as $P < .05$. Data were analyzed using Stata 8.0 statistical software (StataCorp, College Station, TX).

## RESULTS

### *Demographic data*

We initially enrolled 309 patients with 353 unsatisfactory shoulder arthroplasties, including 161 total shoulder replacements, 181 hemiarthroplasties, 3 bipolar prostheses, 4 constrained prostheses, 1 cuff tear arthropathy head, 1 tumor prosthesis, and 1 resurfacing-type of prosthesis. Of these, 282 records were complete and were included in the final analysis. There was a slight male predominance. The predominant diagnosis was primary degenerative joint disease. The mean time from index arthroplasty or latest revision to presentation was 48.7 months (range, 0-336 months); 103 of the 353 shoulders presented within the first year after surgery. The basic demographic data for the initial and final analysis groups are listed in Table III.

### *Shoulder function*

At presentation, the patients indicated that their shoulders could perform an average of 2.6 of the 12 functions of the SST. The worst shoulder function was found in women and in shoulders that had a hemiarthroplasty, previous revision arthroplasty, and with initial diagnoses such as fracture nonunion, cuff tear arthropathy, rheumatoid arthritis, and fracture (Table IV). Nonarthroplasty surgery before the index arthroplasty did not seem to affect initial SST scores nor did the patient's age at presentation.

Shoulder function at presentation was also affected by the general health status of the patient ($P = .0001$). Patients who were considered healthy had the highest function and were able to perform 3.9 of 12 functions. Those with poor health and very poor health were only able to perform 1.9 and 2.7 functions, respectively.

### *Presenting complaints*

The most common presenting complaints were pain and stiffness. At the initial evaluation, 241 of 282 shoulders were painful and 121 were stiff. Other presenting complaints included weakness in 82 shoulders, instability in 48, and crepitus in 17. Fewer patients presented with complications such as fracture (3 shoulders) and infection (14 shoulders). A total of 144 presented with more than 1 chief complaint.

*Objective factors associated with unsatisfactory arthroplasties*

The attributes of unsatisfactory arthroplasties are summarized by index diagnosis in Table I and by procedure performed in Table II. Stiffness was the most prevalent finding in 184 of the 282 shoulders. Shoulders treated for an acute fracture of the proximal humerus were stiff significantly more often than those treated for other diagnoses and with other types of arthroplasties ($P = .009$). No difference was found in the number of stiff shoulders between men and women or younger and older patients.

Weakness (grade 4 or less) was a common finding, occurring in 155 shoulders. Rotator cuff tears were documented intraoperatively in 54 shoulders. Failure of the subscapularis repair was documented intraoperatively in 55, and 26 of these occurred among the 99 shoulders that had undergone a prior revision arthroplasty ($P = .035$). No difference was seen in the rate of subscapularis failure when patients were evaluated by gender, diagnosis, and type of arthroplasty. Additional findings included instability in 67 shoulders, deltoid dysfunction in 28, infection in 11, fracture in 3, and peripheral nerve or brachial plexus injury in 3.

*Technical factors*

Humeral component malposition (184 shoulders) and glenohumeral malalignment (189 shoulders) were the most common technical problems seen. Patients treated for secondary degenerative joint disease and cuff tear arthropathy were noted to have the highest percentage of humeral component malposition, whereas patients treated for posttraumatic degenerative joint disease had the highest percentage of glenohumeral malalignment. Problems with humeral component positioning also tended to be higher in patients treated with a hemiarthroplasty compared with a total shoulder arthroplasty. Superior placement of the humeral component in relation to the greater tuberosity was the most common problem with humeral component positioning.

Glenoid failure was a common feature of both hemiarthroplasties and total shoulder arthroplasties. Glenoid component loosening was noted in 85 of 136 total shoulder arthroplasties; of these, 72 were identified radiographically, and the remaining 13 were found to be loose at the time of revision surgery. Surgical technique, instability, rotator cuff tears, and heavy use have all been implicated in glenoid component loosening, but our study did not reveal the relative importance of the different factors in these cases of glenoid loosening. However, the data published by Lazarus et al[17] indicate that proper seating and cementing of the glenoid component is technically difficult. Humeral component malposition and glenohumeral malalignment was noted in more than half of the patients with glenoid loosening, but this relationship was not found to be statistically significant.

Glenoid erosion was noted in 51 of the 80 hemiarthroplasties performed for degenerative conditions, but was less commonly seen in patients treated for an acute proximal humeral fracture (17/37) or proximal humeral nonunion (5/17). Erosion of the superior portion of the glenoid was the most common. The presence of glenoid erosion among all hemiarthroplasties was significantly related to humeral component malposition ($P < .0001$) and glenohumeral malalignment ($P < .0001$).

*Tuberosity failure*

Tuberosity failure, including nonunion and malunion, occurred in 50 of the 282 shoulders, 35 of which had evidence of tuberosity nonunion and 31 had evidence of tuberosity malunion. The highest percentage of tuberosity nonunions occurred in patients treated for nonunion of a proximal humeral fracture (11/17 shoulders). Conversely, tuberosity malunion was most common in shoulders treated for an acute proximal humeral fracture (20/39). Overall, tuberosity failure was significantly higher in shoulders treated for a nonunion of a proximal humerus fracture ($P < .0001$) than those treated for an acute fracture or posttraumatic arthritis. Shoulders treated for a fracture nonunion were at 20 times greater risk for tuberosity failure than those treated for other diagnoses (95% CI, 6.2-64.7). The relationship between tuberosity failure and humeral loosening was also found to be significant ($P = .001$). Tuberosity failure was more common in women than in men; however, after controlling for diagnosis using logistic regression analysis, this difference was not found to be significant.

*Culture data*

One of the most interesting findings in our study was that 31 of the shoulders had evidence of infection. These included shoulders with active septic arthritis, persistent wound drainage, or erythema, and shoulders with positive intraoperative cultures. Positive intraoperative cultures were found in 23 shoulders at the time of revision surgery: 20 were monomicrobial and 3 were polymicrobial. The most common organisms identified were coagulase-negative staphylococcus in 9 patients, followed by *Propionibacterium acnes* in 4 and *Staphylococcus aureus* in 3. Eighteen of the 23 positive cultures occurred in men.

## DISCUSSION

Previous studies have shown that patients with an unsatisfactory shoulder arthroplasty have substantial

deficits in shoulder function.[12] Our data confirm the severe functional limitation of an unsatisfactory arthroplasty: the typical patient could perform only 2 to 3 of the 12 SST functions. This is in marked contrast to the 9 functions typically performable by patients after hemiarthroplasty or total shoulder arthroplasty for osteoarthritis.[8,10,25] Diagnosis, gender, previous arthroplasty revision, type of arthroplasty, and general health status all affected the patient's functional status at presentation.

Problems with humeral component positioning and alignment were prominent among unsatisfactory arthroplasties. Neer recognized component position as a potential cause for failure of a shoulder arthroplasty[22,23]; however, few subsequent studies have specifically looked at the impact of component positioning and its relationship to arthroplasty failure. A high position of the humeral component relative to the greater tuberosity was the most common problem with humeral component positioning. Recent studies have also stressed the need for anatomic reconstruction the proximal humeral geometry at the time of shoulder arthroplasty.[27] In conventional shoulder arthroplasty, the goal of surgery is a near-anatomic reconstruction.

Problems with component alignment and instability have been well documented.[6,23,25,34,38,39] Prior studies have shown that glenohumeral instability is one of the most common complications of shoulder arthroplasty.[6,25,38,39] Glenohumeral malalignment was the most common technical problem in our series. Commonly, the humeral head center was superior to the glenoid center. Despite previous reports noting the association between superior humeral migration after total shoulder arthroplasty and glenoid loosening, we did not find a significant relationship between the two.[1,7,9,39] However, a significant relationship was noted between glenohumeral malalignment and erosion of the glenoid.

Glenoid loosening has been associated with declining patient satisfaction and increasing shoulder pain in long-term studies.[3] It is also cited as the most common prosthesis-related cause for revision surgery, with rates of 0% to 12.5%.[3,4,29,38] Our study indicates that glenoid component loosening, which was present in 63% of the unsatisfactory total shoulder arthroplasties, remains a problem in total shoulder arthroplasty.

Glenoid erosion is a recognized sequela of proximal humerus replacement, especially in young active individuals.[26,34,35] The incidence of radiographic glenoid wear has been estimated up to 100% in young patients.[26] Symptomatic glenoid erosion has been associated with unsatisfactory results and the need for conversion to total shoulder arthroplasty in some studies.[18,26,33] The data from our study support the idea that glenoid erosion is a prominent feature among unsatisfactory shoulder arthroplasties. It is also in agreement with previous studies that have noted a relationship between glenoid erosion and humeral component malposition.[5]

Tuberosity malunion and nonunion after treatment for an acute proximal humerus fracture have been associated with worse functional results.[3,21,28] In our series, tuberosity failure was a prevalent finding among unsatisfactory shoulder arthroplasties performed for fracture or trauma-related conditions. What was particularly surprising was the high rate of tuberosity failure among shoulders treated with prostheses for a nonunion of a proximal humerus fracture. Patients with a proximal humerus nonunion were at 20 times greater risk for tuberosity failure than all other diagnoses. In addition, tuberosity failure was found to be significantly associated with humeral component loosening.

The frequency of positive cultures and the number of cultures that grew *P acnes* are interesting findings in this study. During the last 5 years, more attention has focused on *Propionibacterium* as a potential infecting organism in the shoulder[32,36,37,40] In our series, *P acnes* was the second most common organism isolated after coagulase-negative staphylococcus. The index of suspicion of identifying *P acnes* should be elevated when evaluating possible infections after shoulder arthroplasty. A recent report questioned whether aseptic loosening was truly aseptic.[24] The authors pointed out that some cases of failed orthopedic implants were considered aseptic loosening based on the absence of clinical signs of infection, but the failure may actually have had infectious etiology even though no bacteria were isolated.

The results of our study should be interpreted in light of certain limitations:

- The data were derived from only one practice and, as such, may not be generalizable to all practices.
- Only 80% of the cases had complete data. Many of the shoulders lost to follow-up were enrolled early in the study, and medical records had been destroyed by the time of our review.
- No attempt was made to correlate our data with objective findings such as range of motion and strength.
- The population from which these cases were drawn is unknown, so that the rate of unsatisfactory arthroplasty and the prevalence of specific findings cannot be calculated.
- The observation that a given attribute was present in an unsatisfactory shoulder arthroplasty did not establish that this attribute contributed to the arthroplasty being unsatisfactory. Other attributes, such as socioeconomic factors, may have played an important role.

## CONCLUSION

Despite these limitations, the following conclusions are supported by this study. Patients dissatisfied with their shoulder arthroplasty report very poor shoulder function. They commonly present with pain and stiffness rather than with surgical complications. Technical problems, such as component placement and fixation, are prominent features among unsatisfactory arthroplasties. Glenoid failure remains a problem for both total shoulder and hemiarthroplasties. Tuberosity failure is common among unsatisfactory arthroplasties performed for fracture, especially those treated for a proximal humeral fracture nonunion. Positive cultures are relatively common among unsatisfactory arthroplasties with high rates of infection with *P acnes*.

In each case, we were able to identify at least 1 factor that may have contributed to the failure. The data in Table IV indicate that the average patient with a failed total shoulder arthroplasty had 4.3 such factors, the average patient with a failed hemiarthroplasty had 4.0, the average patient with a hemiarthroplasty for fracture had 4.9, and the average patient with a hemiarthroplasty for nonunion had 5.3 factors.

This study illustrates the need for both surgeons and patients to be aware of the potential for an unsatisfactory result after shoulder arthroplasty. Our data suggest that shoulder arthroplasty surgeons, whether high-volume or occasional, need to understand the importance of a surgical technique that includes anatomic and secure positioning of the implants along with precise soft-tissue balancing to minimize the risk of stiffness and instability. Tuberosity fixation must be optimized for healing in facture-related cases. Surgeons need to exercise vigilance for the possibility of low-grade infection, especially in revision of previous surgery. Implant designers need to focus on better methods for glenoid component fixation.

Although much of the published literature has focused on the complications of shoulder arthroplasty performed in major centers, this study clearly demonstrates that failure of a shoulder arthroplasty in the general population often occurs from factors such as stiffness rather than from surgical complications. Thus, a good result appears to require attention not only to avoiding complications but also to optimizing patient selection, component positioning, soft-tissue balance, and rehabilitation.

Failures can be a complex combination of multiple factors, including patient selection, patient expectation, patient motivation, technical factors, and postoperative care. Expanded and continued documentation of the shoulder arthroplasty failure experience (SAFE) will be important to improving the results of this procedure in the future.[20,22]

## REFERENCES

1. Barrett WP, Franklin JL, Jackins SE, Wyss CR, Matsen FA III. Total shoulder arthroplasty. J Bone Joint Surg Am 1987;69:865-72.
2. Beaton DE, Richards RR. Measuring function of the shoulder. J Bone Joint Surg Am 1996;78:882-90.
3. Boileau P, Krishnan SG, Tinsi L, Walch G, Coste JS, Mole D. Tuberosity malposition and migration: reasons for poor outcomes after hemiarthroplasty for displaced fractures of the proximal humerus. J Shoulder Elbow Surg 2002;11:401-12.
4. Brems J. The glenoid component in total shoulder arthroplasty. J Shoulder Elbow Surg 1993;2:47-54.
5. Carroll RM, Izquierdo R, Vazquez M, Blaine TA, Levine WN, Bigliani LU. Conversion of painful hemiarthroplasty to total shoulder arthroplasty: long-term results. J Shoulder Elbow Surg 2004; 13:599-603.
6. Cofield R. Complications of shoulder arthroplasty. Instructional Course Lecture No. 317. Presented at: American Academy of Orthopaedic Surgeons Annual Meeting, San Francisco, CA; 1993.
7. Collins D, Tencer A, Sidles J, Matsen F III. Edge displacement and deformation of glenoid components in response to eccentric loading. The effect of preparation of the glenoid bone. J Bone Joint Surg Am 1992;74:501-7.
8. Fehringer EV, Kopjar B, Boorman RS, Churchill RS, Smith KL, Matsen FA III. Characterizing the functional improvement after total shoulder arthroplasty for osteoarthritis. J Bone Joint Surg Am 2002;84:1349-53.
9. Franklin JL, Barrett WP, Jackins SE, Matsen FA 3rd. Glenoid loosening in total shoulder arthroplasty. Association with rotator cuff deficiency. J Arthroplasty 1988;3:39-46.
10. Goldberg BA, Smith K, Jackins S, Campbell B, Matsen FA, 3rd. The magnitude and durability of functional improvement after total shoulder arthroplasty for degenerative joint disease. J Shoulder Elbow Surg 2001;10:464-9.
11. Gruen TA, McNeice GM, Amstutz HC. "Modes of failure" of cemented stem-type femoral components: a radiographic analysis of loosening. Clin Orthop Relat Res 1979:17-27.
12. Hasan SS, Leith JM, Campbell B, Kapil R, Smith KL, Matsen FA III. Characteristics of unsatisfactory shoulder arthroplasties. J Shoulder Elbow Surg 2002;11:431-41.
13. Hasan SS, Leith JM, Smith KL, Matsen FA III. The distribution of shoulder replacement among surgeons and hospitals is significantly different than that of hip or knee replacement. J Shoulder Elbow Surg 2003;12:164-9.
14. Hettrich CM, Weldon E 3rd, Boorman RS, Parsons IM, Matsen FA III. Preoperative factors associated with improvements in shoulder function after humeral hemiarthroplasty. J Bone Joint Surg Am 2004;86:1446-51.
15. Iannotti JP, Norris TR. Influence of preoperative factors on outcome of shoulder arthroplasty for glenohumeral osteoarthritis. J Bone Joint Surg Am 2003;85:251-8.
16. Jain N, Pietrobon R, Hocker S, Guller U, Shankar A, Higgins L. The relationship between surgeon and hospital volume and outcomes for shoulder arthroplasty. J Bone Joint Surg Am 2004;86: 496-505.
17. Lazarus MD, Jensen KL, Southworth C, Matsen FA III. The radiographic evaluation of keeled and pegged glenoid component insertion. J Bone Joint Surg Am 2002;84:1174-82.
18. Levine WN, Djurasovic M, Glasson JM, Pollock RG, Flatow EL, Bigliani LU. Hemiarthroplasty for glenohumeral osteoarthritis: results correlated to degree of glenoid wear. J Shoulder Elbow Surg 1997;6:449-54.
19. Lippitt SB, Harryman DT II, Matsen FA III. A practical tool for evaluating function. The Simple Shoulder Test. In: Matsen FA III, Fu FH, Hawkins RJ, editors. The shoulder a balance of mobility and stability. Rosemont, IL: American Academy of Orthopaedic Surgeons; 1993. p. 501-18.

20. Matsen FA III, Rockwood CA Jr, Wirth MA, Lippit SB. Glenohumeral arthritis and its management. In: Rockwood CA Jr, Matsen FA III, editors. The shoulder. Philadelphia, PA: Saunders; 1998. p. 840-964.
21. Mighell MA, Kolm GP, Collinge CA, Frankle MA. Outcomes of hemiarthroplasty for fractures of the proximal humerus. J Shoulder Elbow Surg 2003;12:569-77.
22. Neer CS II, Watson KC, Stanton FJ. Recent experience in total shoulder replacement. J Bone Joint Surg Am 1982;64:319-37.
23. Neer CS 2nd, Kirby RM. Revision of humeral head and total shoulder arthroplasties. Clin Orthop Relat Res 1982:189-95.
24. Nelson CL, McLaren AC, McLaren SG, Johnson JW, Smeltzer MS. Is aseptic loosening truly aseptic? Clin Orthop Relat Res 2005:25-30.
25. Norris TR, Iannotti JP. Functional outcome after shoulder arthroplasty for primary osteoarthritis: a multicenter study. J Shoulder Elbow Surg 2002;11:130-5.
26. Parsons IM, Millett PJ, Warner JJ. Glenoid wear after shoulder hemiarthroplasty: quantitative radiographic analysis. Clin Orthop Relat Res 2004:120-5.
27. Pearl ML. Proximal humeral anatomy in shoulder arthroplasty: implications for prosthetic design and surgical technique. J Shoulder Elbow Surg 2005;14:99S-104S.
28. Plausinis D, Kwon YW, Zuckerman JD. Complications of humeral head replacement for proximal humeral fractures. Instr Course Lect 2005;54:417-80.
29. Rodosky MW, Bigliani LU. Indications for glenoid resurfacing in shoulder arthroplasty. J Shoulder Elbow Surg 1996;5:231-48.
30. Sanchez-Sotelo J, O'Driscoll SW, Torchia ME, Cofield RH, Rowland CM. Radiographic assessment of cemented humeral components in shoulder arthroplasty. J Shoulder Elbow Surg 2001;10:526-31.
31. Sanchez-Sotelo J, Wright TW, O'Driscoll SW, Cofield RH, Rowland CM. Radiographic assessment of uncemented humeral components in total shoulder arthroplasty. J Arthroplasty 2001;16:180-7.
32. Settecerri JJ, Pitner MA, Rock MG, Hanssen AD, Cofield RH. Infection after rotator cuff repair. J Shoulder Elbow Surg 1999;8:1-5.
33. Sperling JW, Cofield RH. Revision total shoulder arthroplasty for the treatment of glenoid arthrosis. J Bone Joint Surg Am 1998;80:860-7.
34. Sperling JW, Cofield RH, Rowland CM. Minimum fifteen-year follow-up of Neer hemiarthroplasty and total shoulder arthroplasty in patients aged fifty years or younger. J Shoulder Elbow Surg 2004;13:604-13.
35. Sperling JW, Cofield RH, Rowland CM. Neer hemiarthroplasty and Neer total shoulder arthroplasty in patients fifty years old or less. Long-term results. J Bone Joint Surg Am 1998;80:464-73.
36. Sperling JW, Kozak TK, Hanssen AD, Cofield RH. Infection after shoulder arthroplasty. Clin Orthop Relat Res 2001:206-16.
37. Topolsk MS, Chin P, Sperling JW, Cofield RH. The fate of revision arthroplasty with positive intraoperative cultures. American Academy of Orthopaedic Surgeons Annual Meeting, San Francisco, CA; 2004. p. 518.
38. Wirth MA, Rockwood CA Jr. Complications of shoulder arthroplasty. Clin Orthop Relat Res 1994:47-69.
39. Wirth MA, Rockwood CA Jr. Complications of total shoulder-replacement arthroplasty. J Bone Joint Surg Am 1996;78:603-16.
40. Zimmerli W. Prosthetic joint infection: diagnosis and treatment. Curr Infect Dis Rep 2000;2:377-9.