Anatomic shoulder arthroplasty for treatment of proximal humerus malunions

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Background: Malunion of proximal humeral fractures complicated by damage to the glenohumeral cartilage and injury to the joint capsule and rotator cuff can include treatment requiring anatomic shoulder arthroplasty. This study defines results and complications of this procedure and identifies factors associated with success or failure.

Methods: From 1976 to 2007, 109 patients underwent shoulder arthroplasty for proximal humerus malunions. Ninety-five met the criteria for analysis with a mean follow-up period of 9.2 years. Fracture types according to the Neer classification were two part in 20, three part in 37, four part in 31, and head splitting in 2, with 16 fracture-dislocations. Hemiarthroplasty was performed in 45 patients, with 50 undergoing total arthroplasty.

Results: Pain scores improved from 7.8 to 3.1 (P < .001). The mean active elevation and external rotation improved from 69° to 109° and from 8° and 39°, respectively (P = .001). Of 31 patients with available radiographs, 20 had healed tuberosity osteotomies. Sixteen complications required 10 reoperations, including 6 of 9 patients with severe postoperative instability. There were 57 excellent or satisfactory results by use of the Neer rating. No patient, injury pattern, previous treatment, surgical, or radiologic variation was significantly associated with an increased risk of an unsatisfactory result, except for severe postoperative instability. Kaplan-Meier survivorship for reoperation, in 109 shoulders, was 94.8% (95% confidence interval, 90.5%-99.4%) at 5 years and 90.1% (95% confidence interval, 83.6%-97.1%) at 10 and 15 years.

Conclusion: Anatomic shoulder arthroplasty improves pain and motion. Surgery is complex. Tuberosity osteotomies often heal. Postoperative instability is the most common complication leading to reoperation and is usually associated with rotator cuff and shoulder capsule injury.

Level of evidence: Level IV, Case Series, Treatment Study.
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Keywords: Proximal humerus malunion; shoulder arthroplasty

Malunions can result from nonoperative management of displaced fractures of the proximal humerus, nonanatomic reduction, or loss of fixation during the healing period. These malunions can be associated with abnormal positioning of the humeral tuberosities, angulation, rotation or offset at the head-shaft junction, rotator cuff tearing, glenohumeral joint issues including stiffness, articular surface step-offs at the fracture site, osteonecrosis of the humeral head, subluxation or dislocation, and cartilage loss with traumatic arthritis. With the potential for all these changes, it seems unlikely that correction of
bony position alone will be effective in treating many of these patients.\(^2\)

In 2002, we published information on the treatment of 50 shoulders using prosthetic shoulder arthroplasty for malunion of a proximal humeral fracture.\(^1\) There was reasonable pain relief and modest improvement in motion. The outcome was adversely affected if there was initial fracture treatment with internal fixation, if arthroplasty was required less than 2 years after the initial fracture, if there was associated osteonecrosis, or if greater tuberosity osteotomy needed to be performed. Other reports have reaffirmed that greater tuberosity osteotomy compromises the results.\(^3,4,6,9,10,13,16\) It has been suggested that reverse shoulder arthroplasty be considered in this circumstance.\(^3,4,6,18,19\)

Since the 2002 report, more cases have been treated, doubling the patient population. Our experience may have improved the operative techniques and outcomes. We believed that it would be useful to restudy the application of anatomic shoulder arthroplasty to the treatment of the proximal humerus malunions with articular surface damage in this larger patient group, having a rather long follow-up, not only to learn of the results but also to perform a complex factor analysis, potentially identifying patients who would most benefit from this form of treatment or those who might be directed to other treatments for this complicated problem, such as reverse shoulder arthroplasty.

Materials and methods

The Department of Orthopedic Surgery joint registry at Mayo Clinic, Rochester, Minnesota, was assessed for patients who underwent anatomic shoulder arthroplasty for the diagnosis of proximal humerus malunion between the years 1976 and 2007. These criteria were met by 109 patients with 109 involved shoulders. Fourteen patients were excluded, 8 because of death and 6 because the length of follow-up was less than 2 years. Thus, 95 patients with 95 injured shoulders were included in the study group. Multiple parameters defining this study group are shown in Table I. The patient-related indications for shoulder arthroplasty were moderate to severe pain and loss of motion and function. Structurally, all patients had joint incongruity, often with loss of glenohumeral cartilage.

Operative technique

The surgical findings and the operative techniques are shown in Table II. The subacromial, subdeltoid, and subconjoined group spaces were freed of scar with care taken to protect the axillary nerve. The positions of the segments of the upper humerus were then evaluated. Preparation of the proximal humerus was the most difficult part of the procedure. Ideally, the prosthetic humeral head would sit on the bone of the proximal humerus at the junction of the anatomic humeral head and the proximal humerus, would extend for 5 to 10 mm above the superior aspect of the greater tuberosity, and would rest in approximately 30° of retroversion. However, the position often needed to be adjusted to maintain the integrity of the greater tuberosity and to optimize the tuberosity–prosthetic humeral head relationship by altering the entry point for the humeral stem laterally, medially, anteriorly, or posteriorly by increasing or decreasing the resting height of the prosthesis or by slightly decreasing the amount of humeral prosthetic retroversion. When tuberosity osteotomies were performed, the tuberosities were repositioned around the humeral head component and repaired with either 20-gauge wire or No. 5 nonabsorbable suture. Bone graft was applied to the tuberosity–proximal humerus junction in 10 cases. In addition, we wished to position the prosthetic humeral head so that it would rest against the central part of the glenoid. Moreover, in 8 cases, the humeral stems were bent to accommodate the head-shaft deformity (Fig. 1). The humeral implants used included the Cofield implant (Smith & Nephew, Memphis, TN, USA) in 46 shoulders, Neer II in 42, Biomodular in 3, Comprehensive in 1, Copeland resurfacing (all from Biomet) in 2, and Aequalis Fracture Stem (Tornier, Stafford, TX, USA) in 1. The glenoid implant types were Cofield in 27 shoulders, Neer II in 19, Biomodular in 3, and Comprehensive in 1. Of the 19 shoulders with torn or severely thinned rotator cuffs, 13 underwent hemiarthroplasty.

Clinical assessment

The patients were followed up clinically with a shoulder analysis sheet to record pain, satisfaction, and range of motion. If the patient was unable to return for a late, final visit and radiographs, he or she was asked to complete the evaluation sheet in the form of a questionnaire and have radiographs taken and sent to us. In an earlier study, the physician-completed and patient self-administered questionnaires were assessed for agreement, with almost perfect agreement by use of intraclass correlations for pain and motion.\(^14\)

Pain was assessed on a 10-point scale, with 1 representing no pain and 10 representing severe pain. Patient satisfaction was graded as much better, better, the same, or worse. Active elevation and active external rotation with the arm at the side were measured in degrees, and internal rotation was measured as the highest spinal level that the patient could reach behind the trunk with the thumb extended. A modified Neer result rating was also used,\(^8,12\) categorizing the outcomes as excellent, satisfactory, or unsatisfactory if specified levels of pain, patient satisfaction, or motion were not achieved or if reoperation was necessary.

Radiographic assessment

Preoperative radiographs, radiographs obtained at 1 to 2 months postoperatively, and final radiographs were evaluated by 2 authors, and a consensus was reached. Radiographic projections included 40° posterior oblique radiographs in internal and external rotation and an axillary view. In hemiarthroplasty cases, the glenoid was evaluated for cartilage wear and bony erosion. Wear was categorized as absent or present if no joint space was visible on the axillary view with the prosthetic humeral head against or eroded through the glenoid subchondral bone plate. For total shoulder arthroplasties, the glenoid component was evaluated for radiolucent lines. These were categorized as none, 1 mm incomplete, 1 mm complete, 1.5 mm incomplete, 1.5 mm complete, or 2 mm complete or greater. The glenoid component was also evaluated for a shift in the component position between

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Table I. The patient-related indications for shoulder arthroplasty were moderate to severe pain and loss of motion and function. Structurally, all patients had joint incongruity, often with loss of glenohumeral cartilage.

Table II. The subacromial, subdeltoid, and subconjoined group spaces were freed of scar with care taken to protect the axillary nerve. The positions of the segments of the upper humerus were then evaluated. Preparation of the proximal humerus was the most difficult part of the procedure. Ideally, the prosthetic humeral head would sit on the bone of the proximal humerus at the junction of the anatomic humeral head and the proximal humerus, would extend for 5 to 10 mm above the superior aspect of the greater tuberosity, and would rest in approximately 30° of retroversion.

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the early postoperative and final radiographs. The humeral component was evaluated for its position in the humeral shaft; for the presence or absence of radiolucent lines, categorized similar to the glenoid component; and for a shift in position between the early postoperative and final radiographs.15 The tuberosities were categorized as anatomic and healed, nonanatomic (>10 mm of displacement) and healed, nonunited, or resorbed. Glenohumeral subluxation was evaluated according to direction and degree and graded as none, mild (center of prothetic humeral head translated <25% relative to center of glenoid), moderate (translation of 25%-50%), or severe (translation >50%).15

Statistical methods

Descriptive statistics are reported as mean (range) for continuous measures and number (percentage) for discrete variables. A paired t test was used to compare preoperative versus postoperative changes. Postoperative assessments were made at the last clinical contact (and with the latest radiograph) and, among shoulders that underwent reoperation, at the last contact before the reoperation. Analyses were performed to identify differences in outcomes related to patient characteristics (age, gender), injury patterns and previous treatment (Neer fracture classification, fractures or fracture-dislocations, previous fracture fixation, rotator cuff tearing, osteonecrosis), surgical issues (time from fracture to arthroplasty, surgical approach, tuberosity osteotomy, variation in humeral stem positioning, bending of humeral stem, hemiarthroplasty vs total shoulder arthroplasty, early or more recent surgery), and radiographic findings (tuberosity osteotomy healing, glenoid cartilage loss, joint subluxation). Each of the factors underwent analysis for differences between preoperative values for pain, active elevation, active external rotation, and internal rotation; for differences between most recent follow-up values; and for differences between preoperative and most recent follow-up values. Differences among the Neer result ratings were also assessed.

### Table I  Patient group and injury characteristics

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study group</td>
<td>95 patients (95 shoulders)</td>
</tr>
<tr>
<td>Age (y)</td>
<td>Mean, 65 (range, 34-83)</td>
</tr>
<tr>
<td>Gender</td>
<td>68 women and 27 men</td>
</tr>
<tr>
<td>Injury event</td>
<td>Fall in 68, vehicular in 16, miscellaneous in 4, and unknown in 7</td>
</tr>
<tr>
<td>Fracture type (Neer11) *</td>
<td>20 two part, 37 three part, 31 four part, 2 head splitting, and 16 with dislocations</td>
</tr>
<tr>
<td>Initial treatment</td>
<td>64 closed and 2 open fractures debrided, internal or pin fixation in 29</td>
</tr>
<tr>
<td>Additional procedures</td>
<td>20 shoulders</td>
</tr>
<tr>
<td>Time to arthroplasty (y)</td>
<td>Mean, 7.6 (range, 0.2-44)</td>
</tr>
<tr>
<td>Time of clinical follow-up (y)</td>
<td>Mean, 9.2 (range, 1-31)</td>
</tr>
<tr>
<td>Time of radiographic follow-up (y)</td>
<td>Mean, 6.2 (range, 0.1-28)</td>
</tr>
</tbody>
</table>

* Ninety were classifiable.
1 Lysis of adhesions in 7, rotator cuff/tuberosity repair in 5, removal of internal fixation in 5, manipulation in 2, and debridement and removal of internal fixation in 1.
2 Known for 91 shoulders.
3 Five reoperations with less than 2 years.
4 Films available for 78 shoulders.

### Table II  Surgical findings and techniques

<table>
<thead>
<tr>
<th>Parameter</th>
<th>No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Approach</td>
<td>53 deltopectoral and 42 anteromedial</td>
</tr>
<tr>
<td>Arthrotomy</td>
<td>63 tenotomy, 24 release from bone, and 8 lesser tuberosity osteotomy</td>
</tr>
<tr>
<td>Tuberosity osteotomy for deformity</td>
<td>29 greater, 7 greater and lesser, and 1 lesser</td>
</tr>
<tr>
<td>Rotator cuff tear/repair</td>
<td>16 (plus 3 severely thinned)</td>
</tr>
<tr>
<td>Humeral head osteonecrosis with collapse</td>
<td>16</td>
</tr>
<tr>
<td>Glenoid surface cartilage/bone loss</td>
<td>43</td>
</tr>
<tr>
<td>Procedure</td>
<td>45 humeral head replacement and 50 total arthroplasty</td>
</tr>
<tr>
<td>Stem fixation</td>
<td>80 press fit and 15 cemented</td>
</tr>
<tr>
<td>Added procedural steps</td>
<td>47 *</td>
</tr>
<tr>
<td>Postoperative arm support</td>
<td>Sling/shoulder immobilizer for 6 wk</td>
</tr>
<tr>
<td>Physical therapy</td>
<td>Perform passive motion for 6-8 wk and then active motion; begin strengthening at 8-12 wk</td>
</tr>
</tbody>
</table>

* Removal of fixation in 18, acromioplasty in 11, biceps tenodesis in 6, trimming of greater tuberosity in 5, glenoidplasty in 4, humeral diaphyseal osteotomy in 1, posterior capsule plication in 1, and lengthening of pectoralis major in 1.
In the assessment of reoperation and timing to reoperation, 109 patients were evaluated, including 14 patients who did not have the required clinical follow-up for the primary outcomes. The shoulders were followed from the date of surgery to either reoperation or last follow-up. Survival free of reoperation was estimated with the Kaplan-Meier method, reporting the estimate and 95% confidence interval (CI). The \( \alpha \) level for all tests was set at .05 for statistical significance.

Results

Clinical and radiographic outcomes

The results are shown in Table III. Postoperatively, 10 patients had moderate pain (11%); no patients complained of severe pain. Of those with moderate pain, 5 had glenoid wear, 2 had postoperative rotator cuff tears, and 1 had a tuberosity osteotomy nonunion and a loosened humeral component; in 2 patients, there was no apparent reason for the pain.

Postoperative active elevation was less than 90° in 26 shoulders, between 90° and 120° in 30 shoulders, and greater than 120° in 38 shoulders. In 1 shoulder, the final range of motion was not recorded. Of the 78 shoulders with preoperative elevation of 90° or less, 38 (49%) had postoperative elevation of 90° or less.

Eleven shoulders had tuberosity nonunion or resorption. The fracture types were classifiable in 10 and comprised 1 two-part fracture, 4 three-part fractures, 2 four-part fractures, and 3 four-part fracture-dislocations. On the most recent radiographs, the tuberosity position was defined as anatomic in 66 shoulders, as displaced in 13, and as resorbed in 3. Moderate or severe glenohumeral subluxation was associated with greater tuberosity nonunion in 1 and resorption in 1.

Complications, reoperations, and survivorship

A postoperative brachial plexopathy developed in 1 patient, and hematomas developed in 2 patients. Heterotopic ossification developed in 1 patient. A deep infection developed in 1 patient. Subsequent periprosthetic humeral fractures developed in 2 patients. Nine patients had moderate or severe postoperative instability.

Subsequent surgery was required for the deep infection, for 1 of the periprosthetic humeral fractures, for 2 shoulders with painful glenoid erosion, and for 6 shoulders to treat glenohumeral instability. Two of those with instability were revised to reverse total shoulder arthroplasties. One shoulder with anterosuperior instability was treated with anterior capsule and rotator cuff reconstruction. Two that were revised for instability also had painful glenoid wear, 2 had humeral component loosening, and 1 had a greater tuberosity nonunion. The 5-, 10-, 15-, and 20-year survivorship rates for the 109 shoulders were 94.8% (95% CI, 90.5%-99.4%), 90.1% (95% CI, 83.6%-97.1%), 90.1% (95% CI, 83.6%-97.1%), and 85.1% (95% CI, 74.4%-97.4%), respectively.
Result rating

Among the 36 patients with an unsatisfactory rating (19 hemiarthroplasties and 17 total arthroplasties), this was because of the need for further surgery in 10. In the remaining 26 cases, the unsatisfactory rating was because of motion deficiencies in 15; pain, dissatisfaction, and lack of motion in 9; and pain and dissatisfaction in 2.

Risk factor analysis and associations

There were no significant associations of age (≤65 years vs >65 years) or gender with any of the clinical outcomes examined: pain, motion, or Neer rating.

When we assessed the injury patterns and previous treatment, there were no differences among the fracture malunion types. Mean preoperative external rotation was less in fracture-dislocations (−3° vs 11°) (P = .009), fractures with previous fixation (3° vs 11°) (P = .02), and fractures with osteonecrosis (−1° vs 10°) (P = .006). The mean postoperative values and changes between preoperative and postoperative values were not significantly different for each of these variables. Rotator cuff tearing or severe thinning of the rotator cuff had no significant association with pain, elevation, external rotation, internal rotation, or Neer rating, nor did the time from fracture to arthroplasty (≤5 years or >5 years) (P > .05).

There were no significant differences in pain, elevation, external rotation, internal rotation, or Neer rating between the deltopectoral and anteromedial surgical approaches.
Shoulders that underwent tuberosity osteotomies for malunion versus shoulders without an osteotomy did not show any significant association with pain, elevation, external rotation, internal rotation, or Neer rating. There was a nonsignificant trend for greater postoperative active elevation (115° vs 101°) and external rotation (42° vs 34°) and fewer unsatisfactory Neer result ratings (34% vs 46%) in patients who did not undergo osteotomy. Positioning the humeral stem in varus or valgus alignment or bending the stem to adjust to the tuberosity position or accommodate head-shaft malalignment had no significant association with outcomes except for greater improvement in external rotation for those with orthogonal stem placement (35° vs 19°, \( P = .05 \)). Hemiarthroplasty and total shoulder arthroplasty responded similarly except for greater improvement in pain scores for shoulders with total shoulder arthroplasty (−5.2 points vs −4.0 points, \( P = .02 \)). We did not find that the postoperative outcomes of surgical treatment had significantly improved over time (\( P > .05 \)). Patients who underwent surgery between 1976 and 1997 had similar outcomes to those who underwent surgery between 1998 and 2007.

Radiographically, of the 31 shoulders with tuberosity osteotomies for malunion and radiographs available for analysis, 11 did not heal or resorb. These 11 shoulders had surprisingly similar outcome measures compared with the shoulders without an osteotomy and those with a healed osteotomy; however, 6 had unsatisfactory Neer result ratings when compared with 29 of the other 78 shoulders (\( P = .16 \)). In analyzing those patients in whom the tuberosities healed or did not heal, we found no trends or significant differences in age, gender, fracture classification, presence of a dislocation, rotator cuff tearing, preoperative active elevation, osteonecrosis, hemiarthroplasty or total shoulder arthroplasty, or time from fracture to arthroplasty. On final follow-up films, 28 hemiarthroplasties had evidence of cartilage loss. However, this glenoid wear had no overall effect on outcome measures, although 5 of the 10 shoulders with moderate postoperative pain exhibited glenoid wear. When we assessed instability radiographically, 9 shoulders had severe humeral head translation (the same 9 shoulders with clinical evidence of severe instability) and had much poorer outcomes than those shoulders without subluxation. This was most pronounced for range of motion (mean active elevation, 94° vs 131°; mean external rotation, 10° vs 47°), and the result ratings for 7 of the 9 shoulders were unsatisfactory. Preoperatively, these 9 patients were, on average, slightly younger (mean age, 60 years); in addition, more were women (8 patients), 5 had 3-part and 2 had 4-part fractures, a dislocation was present in 3, a rotator cuff tear was present in 3, and there was no moderate or severe subluxation present in those who did have dislocations. Osteonecrosis was present in 2. A tuberosity osteotomy was needed in 4, with healing occurring in 2.

**Discussion**

In 1983, we reported on 28 shoulders that underwent prosthetic arthroplasty for chronic fracture problems.\(^{16}\) Sixteen underwent treatment because of malunion with damage to the glenohumeral articular surface. In 2002, we reported on 50 shoulders with this problem.\(^1\) Surgery did result in substantial pain relief. Postoperative pain was more intense in patients who had initial operative treatment of their fracture, who had osteonecrosis, or who required arthroplasty less than 2 years after their fracture. Active elevation was improved, but less postoperative motion was achieved in patients who underwent initial operative treatment of their fracture or a tuberosity osteotomy. Among the 24 shoulders requiring tuberosity osteotomy, nonunion developed in 4 and the tuberosity resorbed in 3.

In this study, pain was again reduced, and if moderate pain persisted, it was generally associated with a complication, notably painful glenoid wear after hemiarthroplasty, postoperative rotator cuff tearing, or tuberosity osteotomy nonunion. Motion improvements were usually dramatic because patients started with such poor movement. However, mean postoperative active elevation and external rotation were only between one-half and two-thirds of those in a normal shoulder. Postoperative motion was worst in patients in whom instability developed in an anterosuperior or anterior direction, usually associated with rotator cuff and shoulder capsule stretching or tearing and occasionally with tuberosity osteotomy nonunion. Many of the bony abnormalities could be addressed surgically by altering the humeral prosthetic position. Thirty-seven patients, however, did require correction of bone deformity by tuberosity osteotomy. Of those requiring tuberosity osteotomy and in whom late radiographs were available for analysis, 20 had healing whereas 11 did not. This is similar to the frequency of healing in 2 other studies on malunion\(^{1,13}\) but a lesser healing rate than that reported in 2 other studies.\(^{2,16}\) Surprisingly, of the 11 shoulders that did not heal, only 6 had an unsatisfactory result, with the others having a fibrous union creating the ability to obtain at least one-half of normal active movement. Importantly, with this larger patient group, we could perform a more extensive risk factor analysis. This allowed us to understand that older patients did not fare more poorly, men and women responded in a similar fashion, the initial fracture pattern had a mild effect on outcome, previous fracture fixation had little effect, osteonecrosis had a limited effect, rotator cuff tearing had no effect on outcome, and the time from fracture to surgery did not alter the outcome appreciably. Among the operative parameters, the anteromedial approach did not compromise outcome. Tuberosity osteotomy did have an effect on regaining less active movement, but the differences were not statistically validated. Altering the humeral stem position or bending the stem to accommodate tuberosity head or head-shaft malalignment did not alter outcome.
improvement in pain was greater with total shoulder arthroplasty than hemiarthroplasty, but the other measured parameters were not different. Comparing the patients treated in the earlier years versus those treated more recently, we found no clinical improvement. A dramatic finding was the adverse effect of anterior or anterosuperior instability: It was associated with tuberosity nonunion or greater tuberosity resorption in 2 of the 9 cases with incompetent soft tissues, the rotator cuff or shoulder capsule, involved in the remainder.

Over the past few decades, authors have offered insight into the treatment of malunions of proximal humeral fractures, often associated with destruction of the glenohumeral joint. The results are rather uniform, with most patients having pain relief and variable motion return, with between one-half to two-thirds of normal on average.1-3,5,7,9,10,13,16,17 In these studies, associations that were identified included the following: age had no effect1 or younger patients fared better,9 gender had no effect,3 previous surgery was without an effect,2 earlier surgery was better2,5 or had no effect,1 rotator cuff tearing10 or tuberosity osteotomy3,9,10 was detrimental to outcome, and tenodesis of the long head of the biceps had no effect.4 All studies commented on the complexity, or technical difficulty, of the surgery, with the implied recommendation to correct the multiple problems encountered.2

Several authors have recommended reverse shoulder arthroplasty for patients with severe tuberosity malunions who require tuberosity osteotomy.3,4,18 Willis et al19 reported on 16 patients treated with reverse shoulder arthroplasties for the sequelae of proximal humeral fractures with malunion. The patients in this series required alteration of the humeral preparation to place the implant. Pain was reduced, and mean forward elevation was 105° postoperatively. No major complications occurred. However, the mean clinical follow-up was only 3.1 years. Additional complications after reverse shoulder arthroplasty may become apparent with longer follow-up.

Our study has strengths and weaknesses. The strengths include the long-term nature of the study. This has allowed collection of a large number of cases. The planning for data collection over time has remained consistent, so there is a rather complete set of follow-up information, including images saved over time. This material was collected from 1 institution with a limited number of surgeons involved, so there is some homogeneity and consistency. The longer-term collection period allows one to understand implant survival better. Moreover, the consistency of the data collection allows better analysis of risk factors. The limitations are apparent. This is a retrospective analysis of prospectively collected data, and although there were a limited number of surgeons, there were several different individuals collecting the data. In addition, several different implants were used; however, the Neer and Cofield implants are similar, with these stems being implanted in 88 of 95 shoulders and glenoid implants from these 2 systems being inserted in 46 of 50 cases. With the application of a similar inclusive philosophy, the variety of malunions requiring implants was studied, but after analysis, the outcomes among fracture types were similar and all were included in the study group.

**Conclusion**

Many types of proximal humeral fractures can result in malunion with damage to the glenohumeral joint surfaces and surrounding soft tissues. These injuries usually require treatment of multiple problems. Pain is often relieved; regaining motion is less certain but, on average, is between one-half and two-thirds of normal; and tuberosity osteotomies often heal, but the need for postoperative protection will compromise motion. If glenoid cartilage is affected, total arthroplasty should be considered to improve pain relief. Severe postoperative instability, though infrequent (9 cases), is the most detrimental complication. It is usually due to soft tissue incompetency, with most of these patients having an unsatisfactory result. In shoulders with substantial stretching or tearing of the rotator cuff (usually associated with tuberosity displacement) or those with only partially correctable instability, we would currently strongly consider reverse arthroplasty. Many other patient, injury pattern, previous treatment, surgical, or radiologic factors that could affect outcome have little or no influence in determining prognosis.

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