Addressing Glenoid Erosion in Anatomic Total Shoulder Arthroplasty

Richard B. Jones, M.D.

Abstract

Glenoid wear is common in the setting of shoulder arthritis. Severe glenoid erosion presents a serious challenge to the surgeon performing a shoulder arthroplasty. This paper presents the various classification schemes for glenoid erosion. The results of the six main treatment options for shoulder arthroplasty with an eroded glenoid are reviewed. The six treatment options include: 1. eccentric reaming, 2. bone grafting, 3. use of inset glenoid, 4. use of an augmented (asymmetric) glenoid component, 5. hemiarthroplasty, and 6. reverse shoulder arthroplasty. A treatment algorithm is proposed based on the amount of glenoid erosion.

Severe glenoid wear resulting in the need for shoulder replacement surgery is a challenge; however, new tools for dealing with this complicated entity are rapidly evolving, including the use of augmented anatomic glenoid components and reverse shoulder arthroplasty with augmented baseplates.

Primary total shoulder arthroplasty has over time yielded excellent clinical results. Rates of shoulder arthroplasty have grown tremendously with 20,000 to 25,000 performed annually. This number continues to expand as well. The most common indications for shoulder arthroplasty are osteoarthritis or rheumatoid arthritis; however, more recently indications have expanded to include certain fractures, arthritis associated with recurrent dislocations or trauma, metabolic diseases, tumors, and glenoid dysplasia. Survivorship has been reported to be approximately 85% at 15 years; however, the revision burden has been estimated to be 7%.

Most complications of total shoulder arthroplasty involve glenoid component loosening. Factors affecting loosening of the component include changes in joint reaction forces from the normal state (rotator cuff failure), malposition of the implant, or insufficient glenoid bone stock to support the implant.

Lack of sufficient glenoid bone stock from erosion or dysplasia is one of the most difficult problems shoulder arthroplasty surgeons face. Numerous studies have reported compromised results with total shoulder arthroplasty in the presence of significant posterior glenoid bone loss. Ianotti and Norris found that, compared to other patients with shoulder arthroplasty in their study, patients with posterior subluxation of the humeral head and posterior glenoid erosion had lower final American Shoulder and Elbow Surgeons scores, increased pain, and decreased active external rotation. Levine and coworkers showed only 63% satisfactory results after hemiarthroplasty in patients with type II or posteriorly worn glenoids.

Posterior glenoid erosion can result in significant glenoid component malposition. Shapiro and colleagues found that placement of the glenoid component in 15° of retroversion resulted in decreased contact area of the glenohumeral joint and increased contact pressures in cadavers. This may affect survival of the implant. Moskal and coworkers reported on results of successful and failed total shoulder arthroplasties. They found no glenoid malversion in successful shoulders. However, 46% of unsuccessful shoulders showed malversion of the glenoid. Farron and associates showed increased micro motion at the cement interface of greater than 700% with retroversion over 10°.

Classification

The fact that significant glenoid retroversion should be corrected during total shoulder arthroplasty is well accepted. However, methods to most accurately quantify glenoid ero-
sion or posterior subluxation of the humeral have not been standardized. Walch and coworkers examined CT scans of arthritic shoulders and developed a classification system based on the pattern and severity of wear of the glenoid as well as the version (Fig. 1). Type A glenoids have centered humeral heads with either minor (type A1) or major (type A2) glenoid erosion. This was the most common type at 59% in their series. Type B glenoids, the next most common type, consist of posterior subluxation of the humeral head. Type B1 glenoids contain posterior subluxation with no erosion. Type B2 involves posterior erosion with a biconcave glenoid. Type C glenoids show severe erosion of greater than 25° and are considered hypoplastic.

Preoperative Evaluation

Standard radiographs are often the first step in preoperative evaluation of the shoulder. Common views include the AP Grashey (30° external oblique that shows the glenohumeral joint in profile), scapular lateral, and axillary lateral. Using these radiographs the surgeon can assess bone quality, osteophytes, acromiohumeral space, humeral canal diameter, and in most cases glenoid version. However, the accuracy of the axillary lateral in determining retroversion has been debatable, with a reported 86% overestimation.

CT scans have been a commonly accepted method to evaluate glenoid erosion. Friedman and coworkers introduced a method to calculate glenoid version using a line drawn along the axis of the scapula. This line is from the medial tip of the scapula to the center of the glenoid fossa. The version is defined as the angular difference in a perpendicular to the scapular axis line and a line along the edges of the glenoid fossa (Fig. 2).
Rouleau and colleagues developed an additional way to classify Walch type B glenoids using three reference lines: the paleo-glenoid (original surface), the intermediate glenoid (line from furthest anterior and posterior edges), and the neoglenoid (the posterior eroded surface) (Fig. 3). The investigators determined that combining the Friedman line and the intermediate line provided the best estimation of glenoid version in posteriorly worn glenoids.

More recently, Scalise and associates have published on the use of 3D CT scanning to evaluate glenoid version. This has tremendous potential in evaluating severe deformities to the glenoid, such as determining the amount of vault available or quantifying defects.

Treatment Options

There are numerous treatment options available to address glenoid erosion and deficiency. The choice depends on multiple factors including amount of erosion, bone quality, patient demands, and surgeon experience. In cases of severe glenoid erosion or retroversion too great to place an implant, hemiarthroplasty has been shown to achieve acceptable results. Edwards and coworkers used the criteria of less than 15 mm of glenoid vault for performing hemiarthroplasty. They found significant improvements in pain and function scores. Bonnveialle and colleagues also found significant improvements in pain, function, and outcome scores at 2-year follow-up in patients with severe glenoid deficiency. However, others have found less favorable results. Iannotti and Norris found significantly better passive total elevation and active external rotation with total shoulder arthroplasty verses hemiarthroplasty in patients with significant posterior erosion. Levine and associates also found only 63% satisfactory results with hemiarthroplasty in these patients.

In cases where it is felt a total shoulder replacement is indicated, the glenoid erosion must be addressed. Lack of correction of glenoid version is eccentric reaming. This technique involves asymmetrically reaming the “high” or anterior side of the glenoid back to a more neutral version. Benefits of this technique are relative technical ease and lack of need for specialized implants. The drawbacks include a possibility of only limited correction, potential loss of glenoid vault bone, which may compromise stability, and medialization of the joint possibly affecting biomechanics.

Numerous studies have reported on eccentric reaming and have found that approximately 15° is the maximum amount of retroversion correctable. Nowak and coworkers used 3D models from CT scans to simulate eccentric reaming and resurfacing in various degrees of retroversion. They found that correction greater than 18° consistently caused vault penetration, whereas correction of 12° or less did not.

There have been few reports on the clinical effectiveness of TSA with eccentric reaming. The technique has been shown to result in well maintained centering of the humeral head and correction of posterior subluxation of the humeral head. However, limitations to the amount of correction can limit this technique's usefulness in extreme cases. Eccentric reaming removes subchondral bone (the best bone) and can lead to medial migration of the implant.

In cases where more correction is needed, posterior bone grafting may be useful. This can be done with autograft humeral head, iliac crest, or allograft. Advantages of this technique include maintenance of proper joint lateralization and preservation of glenoid bone stock. Disadvantages include technical difficulty, fixation failure, and graft resorption, which can lead to component loosening.

Various techniques have been reported for glenoid bone grafting. Neer and Morrison reported on 20 patients with autograft humeral head bone grafting at the time of TSA. At 2 years, 16 were found to have excellent results. No glenoid component loosened or migrated. However, two broken screws occurred. Steinmann and Cofield reported somewhat different results in their series of 28 patients with average 5.3 year follow-up. All but one were autologous humeral head grafts, fixed with 3.5 cortical screws. Twenty-
three patients showed excellent or satisfactory results; however, 54% showed incomplete or complete lucencies on radiographs. Three glenoids were felt to be radiographically loose. Hill and Norris\(^2\) reported on bone grafting with either autologous humeral head or iliac crest in 17 patients. Two showed early failure, but the remainder were followed up at an average of 70 months. There were five glenoid failures requiring revision. Eight patients showed unsatisfactory results. Elhassan and coworkers\(^3\) looked at revision shoulder arthroplasty with glenoid bone grafting in 21 patients. They found improvements in Constant-Murley scores and range of motion in all patients. The most improvement occurred in patients with glenoid reimplantation. Patients undergoing revision to a reverse TSA with bone grafting showed increased flexion but decreases in external rotation.

Due to inconsistent results with other techniques, some have looked to implant solutions to solve the posterior erosion problem. The use of posterior augmented implants is not new, but limited reports are available on their use. Neer\(^34\) reported using polyethylene implants with a sloped posterior buildup. However, no results of this technique were published. Rice and colleagues\(^35\) published on the results of using a 4° posterior augmented implant (Cofield 2 keeled polyethylene component, Smith & Nephew, Memphis, TN). Fourteen shoulders were followed for a minimum follow-up of 2 years. Patients showed good early to midterm results, but its use was discontinued due to lack of correction of humeral subluxation. Gunther and coworkers\(^36\) reported a slightly different option using an implant. They used an inset glenoid placed asymmetrically into the high or anterior side allowing at least a partial correction of version. All seven patients showed improvements in ASES scores, range of motion, and pain at average follow-up of 4.3 years. More recently, other augmented implants have been introduced. These include the DePuy Global Steptech APG (DePuy, Warsaw, IN) and the Exactech Posterior Augment Glenoid (Exactech, Gainesville, FL), which comes in a 8°, 12°, or 16° buildup (Fig. 4). Arthrosurface also has an inset glenoid to combine with a resurfacing implant (Arthrosurface, Franklin, MA). The long-term results of these implants are not yet known.

Some patients have such severe retroversion of the glenoid, that placement of any glenoid component may be difficult. Walsh classified these as type C glenoids. This type shows greater than 25° of retroversion and is thought to most commonly be due to congenital dysplasia of the glenoid. Edwards and associates\(^37\) felt this involved about 3.5% of patients undergoing shoulder arthroplasty. They felt that more than 15 mm of glenoid vault was necessary for placement of an implant. Patients not meeting this minimum criterion may be treated with hemiarthroplasty, which has been shown to achieve satisfactory results.\(^24,25\) A small inset glenoid placed in some degree of retroversion may also be acceptable.\(^38\) Attempts to completely correct the severe retroversion with bone graft may result in significant limitations of internal rotation due to excess tightening of the posterior capsule. Elderly patients with severe deformity may be better suited for a primary reverse TSA. This allows more freedom with bone graft options due to the ability to place screw fixation through the graft into the native glenoid vault. It is important in these situations that the central post or cage peg pass through the graft into the native glenoid vault as well. Most systems offer an extended version of the central post or cage for this purpose. Exactech (Gainesville, FL) offers a posterior augmented glenoid baseplate, which can assist in the correction as well.

**Treatment Algorithm**

Although many options are possible, the following treatment algorithm represents my experience with this difficult problem. Patients with only 10° to 15° of retroversion are usually treated with eccentric reaming and use of a standard glenoid implant. Those with approximately 15° to 25° of retroversion can usually be treated with a combination of slight eccentric reaming and a posterior augmented implant to make up the rest of the correction. Patients with over 25° of retroversion present a difficult treatment dilemma. Those aged 65 years or older or low demand patients frequently receive a reverse TSA primarily. I often combine it with an autograft humeral head bone graft. Femoral head allografts are employed in revision surgery where no autograft humeral head is available. A posterior augmented glenoid baseplate may be used in these patients to assist in correction. Younger, high demand patients are the most difficult to treat in this situation. For patients in their 40s to early 50s, I consider arthroplasty with the use of a small inset glenoid to achieve at least partial correction and preserve glenoid bone stock. For patients in their mid-50s to mid-60s, I consider using a posterior glenoid bone graft with autograft humeral head and a standard glenoid implant.

In summary, posterior glenoid bone loss is a challenging problem with total shoulder arthroplasty. Traditional treatments have shown mixed results in severe cases. Progress is being made in the use of augmented implants, but little long-term results are available. Reverse TSA remains a growing option in the most severe cases but further study is necessary.

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**Figure 4** Exactech Posterior Augment Glenoid right and left components. (Exactech, Gainesville, FL).
Disclosure Statement
Richard B. Jones, M.D., is a consultant and design surgeon for Exactech, Inc., Gainesville, Florida.

References