

Retrospective Study of Scapular Notches in Reverse Shoulder Arthroplasties

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Abstract

We conducted a retrospective study of 36 patients with reverse shoulder prostheses to assess whether placement of the glenoid component affected development of scapular notches. Minimum follow-up was 2 years. Glenosphere position and its relation to scapular notching was analyzed radiographically.

The glenosphere overhung the inferior glenoid rim in 19 cases (52.8%) and was flush with the rim in the other 17 cases (47.2%). A scapular notch developed in 13 (36.1%) of the 36 cases. The notch developed in 8 (42.1%) of the 19 cases in which the glenosphere overhung the inferior rim, and in 5 (29.4%) of the 17 cases in which the glenosphere was flush with the rim. There were no significant differences ($P = .601$) between the 2 groups (overhanging vs flush glenoid component) with respect to development of scapular notching. Preoperative and postoperative Constant-Murley Shoulder Outcome scores were 19.42 and 49.21 for the group with scapular notches, and 25.09 and 51.96 for the group without notches.

From a clinical viewpoint, there were no significant differences in scapular notch development and functional Constant-Murley Shoulder Outcome scores between glenospheres overhanging the glenoid rim and glenospheres flush with the glenoid rim.

Reverse shoulder arthroplasty follows the biomechanical concept of Grammont, which provides a fixed pivot point that allows patients with a rotator cuff deficiency to actively abduct and forward-flex. Over short- and mid-term follow-up, reverse shoulder arthroplasties have proved to be an effective surgical method for relieving pain and improving function in patients with massive irreparable cuff tears and arthrosis.¹⁻⁵

However, there is some concern about development of a

notch at the inferior pole of the scapular neck. Two explanations for notching have been proposed: (1) The notch is a result of impingement of the medial border of the humeral implant against the inferior rim of the glenoid; and (2) Mechanical impingement between the polyethylene of the epiphyseal implant and the glenoid during adduction of the arm results in polyethylene wear, causing chronic inflammation of the joint capsule and local osteolysis.^{2,6-12}

The clinical relevance of scapular notching has been disputed, though it has been associated with poorer clinical outcome, polyethylene wear, chronic inflammation of the joint capsule, and local osteolysis. Furthermore, scapular notching can progress and lead to glenoid loosening. Simovitch and colleagues¹² concluded that craniocaudal position of glenosphere, angular relationship between glenosphere and scapular neck, and peg-glenoid rim distance predict inferior scapular notch development.

Nyffeler and colleagues¹⁰ biomechanically determined that when the glenoid component is placed flush with the inferior glenoid rim, the glenosphere extends beyond the scapular neck. This results in better clearance and complete adduction of the arm without abutment of the polyethylene cup against the bone of the scapula.

We conducted a study of patients with reverse shoulder prostheses to assess whether placement of the glenoid component affected development of scapular notches. We also evaluated the effect of scapular notch development on clinical and quality-of-life (QOL) outcomes.

Materials and Methods

This retrospective study included 54 consecutive patients treated with a reverse shoulder arthroplasty (Delta III or Delta Xtend; DePuy Orthopaedics Inc, Warsaw, Indiana). Patients with less than 2 years of complete, strictly standardized radiographic and clinical follow-up were excluded ($n = 18$). Thirty-six patients (29 with a Delta III implant, 7 with a Delta Xtend implant) were suitable for further evaluation and were included in the study.

The study group consisted of 35 women and 1 man. Mean age was 75.12 years (range, 66-84 years). There were no sex or age differences between patients who had a Delta III implant and patients who had a Delta Xtend implant. Two independent surgeons clinically and radiographically reviewed all pa-

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tients after a mean of 39.8 months (range, 24-72 months). Thirty surgeries involved the right arm and 6 the left arm. Thirty-two shoulders had an irreparable rotator-cuff tear with pseudoparesis and arthrosis; 2 had proximal humerus fracture sequelae; 1 had an acute fracture (treated with a reverse total shoulder arthroplasty); and 1 had a degenerative massive rotator cuff tear without arthrosis.

After surgery, all patients were placed in a simple sling with the arm at the side and the shoulder internally rotated. The sling was to be worn for 3 weeks and patients immediately began passive-assisted exercises.

Clinical Analysis

Standardized clinical assessment was performed before surgery; 3 months, 6 months, and 1 year after surgery; and annually thereafter. Each assessment was coincident with radiographic follow-up by 2 orthopedists. Each assessment consisted of a thorough history and a physical examination, which included scoring on the Constant-Murley test¹³ and the EuroQol-5D (EQ-5D) (EuroQol Group, The Netherlands).^{14,15}

The Constant-Murley Shoulder Outcome score includes subjective and objective data. Subjective data were pain rated from 0 to 15 on an analog scale, and activities of daily living (ADLs) rated from 0 to 20. Objective data were range of motion (ROM), which included forward elevation, abduction, external rotation, and internal rotation (ranging from 0-40), and strength (ranging from 0-25 lb). Active ROM, including forward elevation and abduction, was recorded with a manual goniometer. Strength was measured with a validated electronic dynamometer (Manual Muscle Testing System; Lafayette Instrument Company, Lafayette, Indiana) with the shoulder in neutral rotation and 90° of abduction in the scapular plane.

The EQ-5D is a generic instrument used to measure health-related QOL. On the basis of the utility approach, this instrument is used to calculate quality-adjusted life years. The EQ-5D consists of a descriptive system and a visual analog scale (VAS). In the descriptive system, patients indicate their health status (1, no problems; 2, some problems; 3, extreme problems) on each of 5 dimensions (mobility, self-care, usual activities, pain/discomfort, anxiety/depression). On the VAS, they rate their perceived health status from 0 (worst) to 100 (best). Obtained values are converted to a "health tariff" (1, excellent health; 0, death). For example in the Catalan population Badia and colleagues¹⁴ found that people older than 65 years had a mean VAS score of 60.6 and a mean health tariff of 0.83.



Figure 1. Glenosphere above or flush with inferior glenoid rim.



Figure 2. Glenosphere extending past inferior glenoid rim.

Radiographic Analysis

Radiographic assessment, which included true scapular anteroposterior and scapular Y views, was performed under fluoroscopic guidance 3 months, 6 months, and 1 year after surgery, and annually thereafter, coincident with each clinical evaluation. Final radiographic follow-up was performed at a minimum of 24 months. Radiographs were reviewed by 2 orthopedic surgeons for scapular notching and glenoid component position.

Inferior notching was defined as scapular neck erosion near the glenoid component. Two different settings were established for glenoid component position—glenosphere above or flush with the inferior glenoid rim (Figure 1) and glenosphere extending past the rim (Figure 2). Nyffeler and colleagues¹⁰ described the latter setting as optimal.

Osteophytes were recorded on the anteroposterior radiographs by tracing the scapular neck from medial to lateral and noting any osseous excrescences. An osseous excrescence was judged to be an osteophyte only if it had been absent before surgery and was in continuity with the bone of the scapular neck on postoperative radiographs, thereby differentiating it from heterotopic bone.

Statistical Analysis

One of the authors, in conjunction with a statistical consultant, analyzed the results with SPSS Version 12 (SPSS, Chicago, Illinois). The Pearson χ^2 test was used to analyze outcomes for correlation and association of notching with glenoid component position and for correlation and association of notching with clinical outcome and QOL. Significance level was set at $P < .05$.

Results

We assessed 36 patients in 2 groups. One group had the glenoid component implanted flush with the inferior glenoid rim, and the other had the component implanted overhanging the rim.

Glenoid component position and presence of scapular notching were determined at a minimum 2-year follow-up.

The glenosphere overhung the inferior glenoid rim in 19 cases (52.7%) and was flush with the rim in the other 17 cases (47.2%). Scapular notches were found in 13 cases (36.1%). According to Nerot classification, there were 4 grade 1 notches, 5 grade 2 notches, 3 grade 3 notches, and 1 grade 4 notch. One notch was detected at 6 months, 8 notches at 1 year, and 4 notches at 2 years. A notch developed in 8 (42.1%) of the 19 cases in which the glenosphere overhung the rim and in 5 (29.4%) of the 17 cases in which the glenosphere was flush with the rim. There were no statistically significant differences ($P = .601$) between the 2 groups (overhanging vs flush glenoid component) with respect to development of scapular notching.

Mean distance from glenosphere to rim was 3.7 mm (range, 0.28-7 mm) for the 19 overhanging glenospheres, 2.9 mm (range, 0.28-5.1 mm) for the 8 that developed a scapular notch, and 4.5 mm (range, 1.1-7 mm) for the 11 that did not develop a notch.

Scapular notching developed in 10 (34.48%) of the 29 pa-

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tients in the Delta III group and in 3 (42.85%) of the 7 patients in the Delta Xtend group; however, based on the small number of patients in the group, no conclusions could be drawn from these results.

Constant-Murley Shoulder Outcome score improved from 21.41 to 49.88 in the flush-component group and from 23.66 to 54.83 in the overhanging-component group. These groups showed no statistically significant differences with respect to total Constant-Murley Shoulder Outcomes score ($P = .540$) or Constant-Murley Shoulder Outcome score based on glenoid component position ($P = .701$).

To determine if scapular notching affected clinical outcomes, we compared patients with and without notches. Preoperative and postoperative Constant-Murley Shoulder Outcome scores were 19.42 and 49.21 for the group with notches, and 25.09 and 51.96 for the group without notches. These groups were not statistically significantly different ($P = .601$) with respect to total Constant-Murley Shoulder Outcome scores but were different with respect to separate Constant-Murley Shoulder Outcome scores for ADLs ($P = .023$), forward elevation ($P = .027$), and external rotation ($P = .046$). The patients without notches fared better on these 3 items.

Overall EQ-5D scores were 0.455 (patients with notches) and 0.563 (patients without notches). The difference was not statistically significantly different ($P = .763$).

Neither diagnosis nor laterality made a difference in glenoid component position or development of a scapular notch.

Discussion

The most common radiographically detected complication of reverse shoulder arthroplasties is inferior scapular notching. The constrained design of the reverse shoulder prosthesis causes mechanical impingement between humeral cup and scapula during arm adduction.^{2,6,7,10,12} Results from the present study confirmed the frequency of notch development after reverse shoulder arthroplasty. In addition, though biomechanical studies have shown that placing the glenosphere inferiorly may prevent a notch from developing,¹² our study found that such placement did not completely prevent scapular notching.

The high (36.1%) rate of scapular notching in the present study is consistent with previously reported rates (44%-96%).^{1,3-5,8,9,12} In addition, other investigators have reported that inferior scapular notching developed quickly (by 12-month follow-up), with most notches limited (Nerot classification grade 1 or 2) and none associated with loosening or failure of metaglene and glenosphere.^{1,8-12}

Nyffeler and colleagues¹⁰ conducted an in vitro study and concluded that a glenoid component placed flush with the inferior glenoid rim, with the glenosphere extending past the scapular neck, resulted in complete adduction of the arm without mechanical impingement at the bone of the scapula. From a biomechanical viewpoint, lateralization of the center of the rotation offset affected impingement-free abduction.² Nevertheless, a scapular notch developed in this lateralized design.⁹

Although some authors have recommended slight inferior tilting of the glenosphere to prevent scapular notch development, Nyffeler and colleagues¹⁰ also showed that even though this tilt (compared with the standard technique) improved adduction angles, results were not as good as those obtained when the glenosphere was placed inferior to the glenoid rim. In addition, the oblique osteotomy needed to create the tilt may compromise stable fixation of the glenoid base plate.

Scapular anatomy studies have described different glenoid articular surface-neck angles and the implications for scapular notch development.^{11,16} In addition, the infraglenoid tubercle varies in width and length and can interfere with the humeral part of the reverse prosthesis and contribute to the development of a scapular notch.¹⁷

The clinical implications of scapular notch development are not clear. Some authors have found that patients who developed notching scored lower on functional scores than patients who did not. But other authors have found no clinical differences between patients with and without notches.^{1,4,5,12}

The present study demonstrated that placing the glenosphere past the inferior glenoid rim may not completely prevent scapular notch development. Moreover, there were no significant differences between glenospheres positioned flush with the rim and glenospheres overhanging the rim. As noted earlier, no conclusions can be drawn from these results because of the small number of prostheses analyzed. A study with a larger sample size may be able to confirm a difference between flush and overhanging glenospheres. As patients with overhanging glenospheres can develop scapular notching, it can be concluded that an overhanging glenosphere alone will not prevent notch development.

Since the distance from glenosphere to inferior glenoid rim was slightly larger for overhanging glenospheres without scapular notches than for overhanging glenospheres with notches, a minimum distance may be needed for overhanging glenospheres to obtain a biomechanical benefit and prevent notch development. Surgeons are aware that placing the glenoid component too inferiorly may compromise inferior screw positioning, so there may be a balance between preventing notch development and ensuring proper screw positioning.¹⁶ Several factors seem to be implicated in notch development—including glenosphere position, glenoid morphology, center of rotation offset, and polyethylene disease.

This study did not find any significant clinical or QOL differences between patients who developed scapular notches and patients who did not develop notches. However, the true clinical implications of these notches is yet to be defined, and more studies are needed before more definitive statements can be made. Although biomechanical studies have recommended placing the glenosphere inferiorly to prevent notch development, our data suggest that in cases where the glenosphere position on the glenoid overhangs equal to or less than 2.9 mm, there is no significant difference between patients with and without notches.

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