Relationship of scapular neck length to scapular notching after reverse total shoulder arthroplasty by use of plain radiographs

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Background: Scapular notching in reverse shoulder arthroplasty appears to be a multifactorial problem related to both implant and patient factors. There are well-established guidelines for implant position. Recent cadaveric studies have illustrated anatomic factors that need further consideration. Scapular neck length and inferior glenoid tubercle morphology may be major factors predicting scapular notching.

Methods: From 2 institutions, we reviewed 3 years of patient radiographs for reverse shoulder arthroplasty, including all reverse shoulder arthroplasties at least 12 months from surgery. We used true anterior-posterior radiographs, both preoperatively and postoperatively, and focused on the “ideal” positioning of the glenosphere: at or below the inferior margin of the glenoid, and neutral or slight inferior tilt. Radiographs were reviewed by 2 independent surgeons. Glenoid articular surface height was measured along with scapular neck length and notching presence.

Results: Of 64 sets of radiographs reviewed, 50 met inclusion criteria. Notching was present in only 25 (50%) of the sets. The mean scapular neck length was 8.9 mm with a neck:surface ratio of 0.23 in the notching present group and 12.1 mm with a neck:surface ratio of 0.32 in the notching absent group. Significance was reached with both scapular neck length and neck:surface ratio (P = .0012 and P = .0006, respectively).

Conclusions: There is a high degree of significance that patient anatomy does play a role in the occurrence of notching. Surgeons may consider lateralizing the glenosphere in patients with a scapular neck length of less than 9 mm measured on a true anteroposterior radiograph.


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Reverse total shoulder arthroplasty has a proven track record of improving pain and function, most notably in rotator cuff tear arthropathy, with indications continually expanding. One of the most commonly used reverse prostheses today is the semiconstrained Grammont prosthesis.
style prosthesis. This prosthesis medializes and lowers the glenohumeral center of rotation to reduce the torque of the glenoid-implant interface and concomitantly recruits additional anterior and posterior deltoid fibers to act as abductors.

This medialization has been associated with notching of the inferior aspect of the scapular neck, presumably because of contact of the humeral component with the lateral scapular margin in adduction. Radiographic findings of notching are common after reverse total shoulder arthroplasty, ranging from 44% to 96%. This prosthesis has undergone extensive evaluation since its inception by Paul Grammont in 1985, with the first report of scapular notching 12 years later by Sirveaux in 1997. Scapular notching is believed to be due to mechanical impingement of the medial rim of the humeral cup against the scapular neck in adduction and the local osteolysis from polyethylene wear created from this impingement. Although the radiologic evidence of scapular notching is apparent, the clinical significance is still debated. It has been postulated that scapular notching may ultimately lead to glenoid component loosening; some studies have been able to show poorer clinical outcomes, whereas others have not.

Patient-specific issues must also be considered. Recent cadaveric studies have illustrated anatomic factors that should be considered further. Scapular neck anatomy and inferior glenoid tubercle morphology as well as body mass index and glenoid inclination may be major factors in predicting scapular notching. The aim of this study was to evaluate the distance between the lateral scapular body and the articular surface (scapular neck length) and to determine its relationship to the radiographic incidence of notching in reverse total shoulder arthroplasty.

Materials and methods

This is a retrospective review of plain radiographs of shoulders treated with the Grammont style reverse total shoulder arthroplasty during 2 years. In all cases reviewed, the neck-shaft angle of the humeral prosthesis used was 155°. Standard anterior-posterior shoulder radiographs were collected from 2 institutions on consecutive patients returning to clinic for routine follow-up. Two of the investigators independently reviewed 64 shoulder sets in all. After 14 shoulders were excluded, 50 shoulders were included in this investigation. Inclusion criteria were optimal radiographs, a minimum of 12 months after implantation when notching was not present or sooner once notching was present, appropriate glenosphere positioning, preoperative Grashey view radiographs including a native glenoid, and postoperative Grashey view radiographs to assess positioning of the glenosphere and notching. Grashey view is defined as an anterior-posterior radiograph taken in neutral rotation (tangential to glenohumeral joint). Radiographs were excluded on the basis of quality of radiographs leading to inability to identify critical landmarks or suboptimal glenosphere placement defined by lack of neutral or downward slope and glenosphere not at or below the inferior glenoid.

Results

In total, the included 50 sets of radiographs were analyzed for scapular neck length as well as for glenoid height for all radiographs and determined if notching was present. Scapular neck length was defined by the distance between the lateral column of the scapula and the articular surface (scapular neck length) and to determine its relationship to the radiographic incidence of notching in reverse total shoulder arthroplasty.
and was not present with respect to the 3 obtained variables. Notching was present in 25 (50%) of the radiograph sets, whereas notching was absent in the remaining 25. In the group in which notching was present, the mean scapular neck length was 8.9 mm (range, 5.6-14.4 mm), with a neck:height ratio of 0.23 (0.13-0.32). In the group absent of notching, the mean neck length was 12.1 mm (5.1-18.7 mm), with a neck:height ratio of 0.32 (0.14-0.54) (Fig. 3). Significance was reached with both scapular neck length and neck:height ratio ($P = .0012$ and $P = .0006$, respectively) (Fig. 4; Tables I and II). The measurement of glenoid height did not reach significance ($P = .415$), with the average glenoid height measurement of 38.9 mm (27.7-58.7 mm) without notching present and 40.1 mm (32.3-52.5 mm) with notching. For Figures 3 and 4, the left and right sides of each box denote the 25th and 75th percentiles, respectively. The bar across the box is placed at the median value (50th percentile), and the diamond shape is positioned at the mean.

Of the 50 sets that were included, the diagnoses included rotator cuff tear arthropathy in 27 (54%), fracture in 10 (20%), massive rotator cuff tear with pseudoparalysis in 9 (18%), shoulder hemiarthroplasty conversion to reverse total shoulder arthroplasty in 3 (6%), and failed open reduction–internal fixation conversion to reverse total shoulder arthroplasty in 1 (2%).

The incidence of notching was also evaluated on the basis of the diagnosis precipitating the implantation of the reverse prosthesis. The incidence of notching for rotator cuff tear arthropathy was 15 of the 27 cases; for fracture, 4 of 10 cases; for the massive rotator cuff tear with pseudoparalysis, 5 of 9 cases; for failed open reduction–internal fixation conversion to reverse total shoulder arthroplasty, 1 of 1; and none of the shoulder hemiarthroplasty conversions to reverse total shoulder arthroplasty (0 of the 3 cases).

In addition, Sirveaux grade was performed in the cases in which notching was determined to be present. Of the 25 cases in which notching was present, 18 were grade 1, 5 were grade 2, and 2 were grade 3.

Interobserver reliability as measured by a concordance correlation coefficient was found to be high, with 0.87 for the neck length and 0.91 for the ratio. For concordance correlation, the closer the number is to 1.0 correlates with a higher degree of interobserver reliability. The agreement of notching between the 2 observers was 92% as there were only 4 cases of the 50 for which the observers disagreed about notching.

In running a post hoc power analysis, we determined that our study with the obtained values (mean, standard deviation) is powered to 0.927. We reviewed the data to determine that the number needed to obtain a $\beta$ value of the standard 0.80 would have been 18 in each group or 23 in each group if we used 0.90.

**Discussion**

The reverse shoulder prosthesis has been an important advance in shoulder reconstruction. New designs and understanding of implants have allowed predictable outcomes in primary rotator cuff arthropathy and difficult revision surgery. Scapular notching, however, remains a clinical concern for both implant longevity and patient satisfaction. Thus, it would be a valuable tool to have the ability to predict when notching may occur on the basis of a simple radiographic evaluation.

Several authors have proposed and implemented recommendations to reduce notching. These recommendations include lowering the position of the glenosphere on the glenoid face originally proposed by Nyffeler and further evaluated by Kelly et al with the 12-mm rule and providing a slight inferior tilt to the glenoid component.\textsuperscript{2,7,13,14,19,21} Design changes, such as eccentric glenospheres and lateralization of the center of rotation, have helped decrease the incidence of notching\textsuperscript{11}; techniques described by Boileau, such as bone increased-offset reverse shoulder arthroplasty (BIO-RSA), have also been proposed.\textsuperscript{1}

Other implant features, such as neck-shaft angle and glenosphere size, may contribute to the presence or absence of notching. There are two current major design philosophies that dominate the implant market. Many implants are designed on the basic principles of the Grammont reverse,
with approximately 155° neck-shaft angle and a center of rotation centered on the glenoid surface. Other available systems are based on lateralizing the center of rotation and a lower neck-shaft angle of 135°. Neck-shaft angles closer to 135° produce greater adduction before bone impingement and may reduce notching.10 However, even with stepping outside of the traditional Grammont paradigm with lateralizing the center of rotation by prosthetic means (metallic lateralizing), notching has still been reported.16,18 In addition, metallic lateralization has the risk of glenoid component loosening by increasing the torque or shear force on the glenoid component–bone interface.10,12

Notching, although a concern, was originally thought to stabilize after 1 year without signs of progression,27 although some studies have shown progression of notching for up to 4 years.14,15 The ultimate fear of notch progression is aseptic loosening of the glenoid component leading to catastrophic failure, which has previously been reported in the literature.3,14,17

In the evaluation of our data, we were able to note the incidence of notching to be 50%. More profoundly, we were able to find significance between notching and absence of notching in regard to scapular neck length as well as with the scapular neck length to glenoid height ratio (P = .0012 and P = .0006, respectively). We were able to demonstrate consistency with the interobserver measurements as demonstrated with a high degree of concordance correlation coefficient.

There are some limitations associated with this study. First, this is a retrospective study and thus carries with it the inherent limitations of any retrospective study. Notching has been associated with preoperative diagnosis.14,21 However, the incidence of notching did not appear to correlate with clinical use of the prosthesis. It should again be noted that the glenoid had not been surgically altered in any of the pre-reverse radiographs included for analysis. Second, whereas there was an institution-specific radiographic protocol in place when these shoulder radiographs were obtained, protocol between sites varied. The incidence of notching may have been underestimated, depending on the direction of the x-ray beam as demonstrated by Favard.9 Last, the glensphere size, polyethylene thickness, and humeral version were not standardized, which may have led to altering of the incidence of notching.

This study does have several strengths. Although authors have previously evaluated scapular neck length and glenoid height,3,4,17 we believe this to be the first study to measure radiographically the length of the scapular neck as well as the scapular neck length to glenoid height ratio in relation to documented notching. We were also able to account for ideal glensphere positioning in the attempt to reduce variables in the occurrence of notching as determined by Nyffeler.19 We were able to demonstrate strong interobserver reliability between the 2 independent measurements of scapular neck length and scapular neck length to glenoid height ratio as well as to measure multiple preoperative films for consistency and reliability; we believe these means of measuring to be consistent and repeatable.

### Conclusion

Scapular notching appears to be a multifactorial problem related to prosthesis design, implant technique, and patient factors. In this study, we attempted to evaluate patient-specific factors and whether scapular notching could be predicted on the basis of scapular anatomy. In our analysis of scapular neck length and the ratio of scapular neck length to glenoid height, we were able to reproducibly demonstrate with a high degree of significance that patient anatomy contributes to the occurrence of notching. This is in spite of the surgeon’s best effort to minimize the incidence of notching by use of the techniques described earlier.
There may be a “worst case scenario” in patients whose scapular anatomy has very little offset between the lateral scapular border and the articular surface. In light of the statistical significance in this study, surgeons may consider lateralizing or increasing offset of the glenosphere by bone (BIO-RSA) or prosthetic means in patients with a scapular neck length of less than 9 mm measured on a true anteroposterior radiograph.

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References


