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Posterior augmented glenoid designs preserve more bone in biconcave glenoids

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Background and hypothesis: Total shoulder arthroplasty is recommended treatment for severe osteoarthritis of the glenohumeral joint, which often results in excessive posterior wear. Two recent glenoid components with posterior augments have been designed to correct excessive posterior wear and retroversion. Our primary hypothesis was that posterior augmented glenoid designs require less bone removal than a standard glenoid design.

Methods: Ten arthritic scapulae classified as Walch B2 glenoids were virtually implanted with standard, stepped, and wedged components. The volume of surgical bone removal, the maximum reaming depth, and the portion of the implant surface in contact with cancellous vs. cortical bone were calculated for each implant.

Results: The neoglenoid made up an average of 65% ± 12% of the glenoid width. Mean surgical bone volume removed was least for the wedged (2857 ± 1618 mm^3) compared with the stepped (4307 ± 1485 mm^3; $P < .001$) and standard (5385 ± 2348 mm^3; $P < .001$) designs. Maximum bone depth removed for the wedged (4.2 ± 2.0 mm) was less than for the stepped (7.6 ± 1.2 mm; $P < .001$) and standard (9.9 ± 3.2 mm; $P < .001$). The mean percentage of the implant's back surface supported by cancellous bone was 18.2% for the standard, 8.8% for the stepped ($P = .02$), and 4.3% for the wedged ($P = .01$).

Discussion: Both augmented components corrected glenoid version to neutral and required less bone removal, required less reaming depth, and were supported by more cortical bone than in the standard implant. The least amount of bone removed was with the wedged design.

Level of evidence: Basic Science, Computer Modeling.

Keywords: Shoulder arthroplasty; glenoid design; glenohumeral arthritis; retroversion; augmented implant

Total shoulder arthroplasty (TSA) is the ''gold standard'' for severe shoulder arthritis,[27] and the incidence of these procedures is increasing at rates far greater than those of hip and knee arthroplasty.[14] With greater numbers of TSAs being performed, the incidence of revision surgeries to address TSA failures is increasing as well: 288% since

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1993.[1] The reasons for TSA failures are many, but they are most commonly related to component malposition or glenoid failure.[7]

Measurement of glenoid version is an important part of preoperative planning for a TSA and is typically done with computed tomography (CT) imaging.[8,16] Normal glenoid version is within 5° of neutral, but studies have shown that arthritic shoulders tend to have, on average, 11° of retroversion.[8,12] Several studies suggest that excessive retroversion in TSA is associated with an increase in glenoid loosening.[2,4,6,13,17,18,21] Clavert et al,[4] in a cadaveric model, suggested that more than 5° of retroversion may lead to instability, supporting the importance of achieving neutral version when placing the glenoid component.

Various surgical techniques have been used to address excessively retroverted glenoids. Bone grafting of the posterior glenoid is well described, but it also has a high complication rate.[9] Asymmetric reaming of the retroverted glenoid, wherein the intact anterior bone is reamed down to create a neutral glenoid base, is also a viable option that allows correction of approximately 15° to 20° of retroversion.[4,23] Asymmetric reaming to correct glenoid retroversion may result in a reduction of the width and depth of the glenoid vault, removal of cortical bone resulting in reduced support for the implant: all compromising the fixation of the glenoid implant. The greater the magnitude of retroversion being corrected, the more likely that significant medialization of the implant will occur, therefore increasing the risk of penetration of the peripheral or central pegs outside the bone.[10,19,20,24]

With the objective of long-term fixation of the glenoid, several designs have been marketed to improve glenoid fixation or to accommodate excessive retroversion. Metal-backed glenoids have been recommended in an attempt to enhance bone ingrowth into the implant. A 2013 study by Clement et al[5] with medium-term follow-up showed 93% survivorship of metal-backed implants at 10 years, although other studies have shown unacceptably high failure rates with metal-backed implants.[3] A more recent trend in glenoid implant design is posteriorly augmented glenoid components incorporating either a wedged or a stepped design. Both designs are indicated for use in posteriorly eroded or excessively retroverted glenoids.[15,22]

One subset of retroverted arthritic glenoid morphology is the biconcave glenoid, classified as B2 by Walch.[25] B2 glenoids have excessive wear in the posterior aspect of the glenoid. The humeral head articulates with the worn portion of the glenoid (also called the neoglenoid) and tends to sublux posteriorly. Our primary hypothesis was that posterior augmented glenoid designs (wedged or stepped designs) would require less bone removal than a standard design implanted in biconcave B2 glenoids and that a greater portion of the back surface of posterior augmented glenoid implants would be supported by cortical bone. Our secondary hypothesis was that the stepped glenoid design would require less bone removal than the wedged glenoid design because the stepped design is likely to be more effective at filling defects localized to the posterior aspect of the glenoid. We tested our hypotheses by analyzing the CT scans of 10 B2 glenoids.

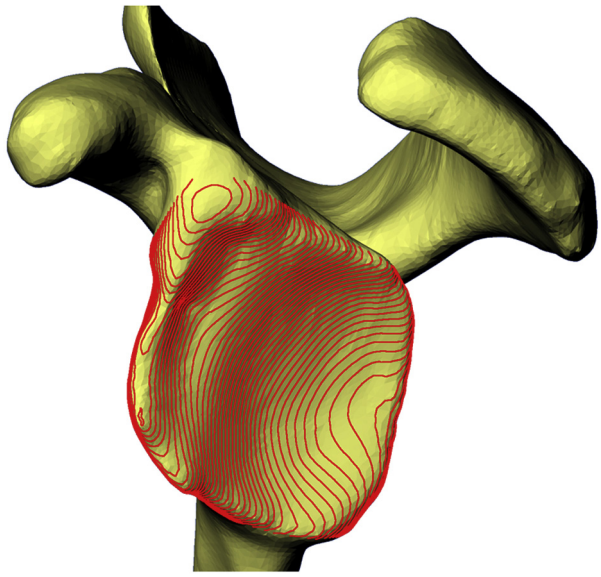

Figure 1 The 3D CT image with contour lines showing posteroinferior wear and the large neoglenoid.

Materials and methods

Preoperative high-resolution axial CT scans of the shoulder taken from 121 consecutive patients with osteoarthritis scheduled for TSA were initially screened. CT was performed in a GE LightSpeed RT 16 scanner (GE Healthcare, Waukesha, WI, USA) with a 0.625-mm slice thickness. The glenoid morphology of these CT scans was then classified by the Walch classification.[25] Ten glenoids that were classified as B2 biconcave were chosen for this study. The mean age of patients was 71 ± 12 years (range, 53-85). There were 5 men and 5 women.

The commercially available software program Mimics (Materialise, Leuven, Belgium) was used to generate three-dimensional (3D) surface reconstructions of the scapula from the CT scans (Fig. 1). We have previously reported on the accuracy of segmentation and reproducibility of the resulting reconstructed geometry.[10] Each glenoid was then virtually implanted with a standard (nonaugmented) component, a stepped component, and a wedged glenoid component (Fig. 2). The 3D models of the glenoid components were constructed in SolidWorks 2012 (Dassault Systèmes Americas Corp., Waltham, MA, USA) and Rhino 3D 4.0 (Robert McNeel and Associates, Seattle, WA, USA). The standard design was constructed from measurements of glenoid components used in our surgical practice. The 2 posterior augmented designs, wedged and stepped, were derived from the standard design as follows. The wedged implant was generated by rotating the spherical back surface of the standard implant in the axial plane passing through its center such that a line joining its anterior and posterior edges forms a correction angle of 8°, 12°, or 16° with a line joining its articular surface's anterior and posterior edges. The stepped design was generated by bisecting the standard