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Guidelines for the selection of optimal glenoid augment size for moderate to severe glenohumeral osteoarthritis

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Background: Total shoulder arthroplasty is technically demanding in regard to implantation of the glenoid component, especially in the setting of increased glenoid deformity and posterior glenoid wear. Augmented glenoid implants are an important and innovative option; however, there is little evidence accessible to surgeons to guide in the selection of the appropriate size augmented glenoid.

Methods: Solid computer models of commercially available augmented glenoid components (+3, +5, +7) contained within the software allowed placement of the best fit glenoid component within the three-dimensional reconstruct of each patient's scapula. Peg perforation, amount of bone reamed, and amount of medialization were recorded for each augment size.

Results: There was strong correlation between the medialization of the joint line and the glenoid retroversion for each augmented component at neutral correction and correction to 6° of retroversion. At neutral, the range of retroversion that restored the anatomic joint line was −3° to −17° with use of the +3 augmented glenoid, −5° to −24° with the +5 augmented glenoid, and −9° to −31° with the +7 augmented glenoid. At 6° of retroversion, the range of retroversion that restored the anatomic joint line was −4° to −21° with use of the +3 augmented glenoid, −7° to −27° with the +5 augmented glenoid, and −9° to −34° with the +7 augmented glenoid.

Conclusions: There was a strong correlation between glenoid retroversion and medialization for all augment sizes, supporting the recommendation for glenoid retroversion as the primary guide in selecting the amount of augmentation.

Level of evidence: Anatomy Study, Imaging and Computer Modeling.

Keywords: Augmented glenoid; biomechanics; total shoulder arthroplasty; shoulder osteoarthritis; glenoid bone loss

Glenoid loosening is the leading complication associated with total shoulder arthroplasties, with heightened risk in the setting of increased glenoid deformity and glenoid bone loss.[2,6,19,24,28,31,34,37] Understanding of the biomechanics of initial glenoid retroversion and correction of glenoid deformity can provide insight into glenoid failure mechanisms as well as minimize glenoid loosening.[11,35] Studies have shown that adequate correction of glenoid disease and accurate placement of prosthetic components are necessary to restore

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normal glenohumeral motion.[14,36] Options to address glenoid bone deficiency include asymmetric reaming of the glenoid and glenoid bone grafting, which are both technically demanding with less than optimal outcomes, especially in the setting of increased glenoid retroversion.

The literature demonstrates that glenoid component malposition is associated with early component lucent lines, component loosening, and higher glenoid failure rates.[9,14,16,23] A greater amount of preoperative glenoid retroversion correlates with excessive postoperative glenoid component retroversion, particularly when a standard glenoid is used.[9,16,30,33] The use of simulation software to understand the biomechanics of implant positioning with respect to glenoid vault and version has been well documented in the literature.[4,13,18,20,23,26] The goal of glenoid implantation is to correct the glenoid version and use the glenoid vault anatomy to maximize fixation and minimize medialization.[7,8] Furthermore, preoperative planning with three-dimensional (3D) computed tomography (CT) imaging can clearly provide advantages in accurately assessing glenoid retroversion, guiding surgical technique, and optimizing implant positioning, ultimately improving clinical outcomes and patient satisfaction.[2,5]

The recent development of augmented glenoid components provides an alternative to current shoulder implant techniques.[7,22] Current techniques using commercially available glenoid implants, with bone grafting or asymmetric reaming, have been shown to increase glenoid loosening in severe glenoid bone loss by either technical difficulties or compromise of the keel or peg fixation. Augmented glenoids are an important and innovative option; however, there is little evidence accessible to surgeons to guide in the selection and potential outcomes of these augmented implants.

The purpose of this study was to define clinical guidelines for selection of specific glenoid augment size to restore native glenoid morphology with 3D simulation software.

Methods

The study cohort consisted of 24 men and 5 women, with an average age of 66 years. All patients were indicated for total shoulder arthroplasty for treatment of osteoarthritis. We excluded all patients having a type C Walch classification of glenoid morphology consistent with a developmental hypoplasia.

Preoperative CT scans for each patient in our cohort were used in this study. All CT scans were performed with a Siemens (Sensation 64, Definition DS or AS+) scanner (Siemens Healthcare, Forchheim, Germany) using a single-energy CT protocol with 140 kVp, 300 mAs with dose modulation 0.6 mm collimation, effective pitch 0.9, B40 (medium) reconstruction kernel, reconstructed slice thickness 0.6 mm, and slice increment 0.6 mm.

Three-dimensional modeling of the shoulder

Three-dimensional reconstructions of each patient's preoperative CT images were generated by image analysis software (OrthoVis, Cleveland Clinic, Cleveland, OH, USA). Planes of the scapula and the glenoid fossa were defined to calculate the amount of retroversion. The plane of the scapula was defined by 3 points, one placed at the inferior angle of the scapula body, a second at the scapula trigonum, and the third in the center of the glenoid fossa such that a line from this point to the scapula trigonum was in the center of the glenoid vault.[25,26]

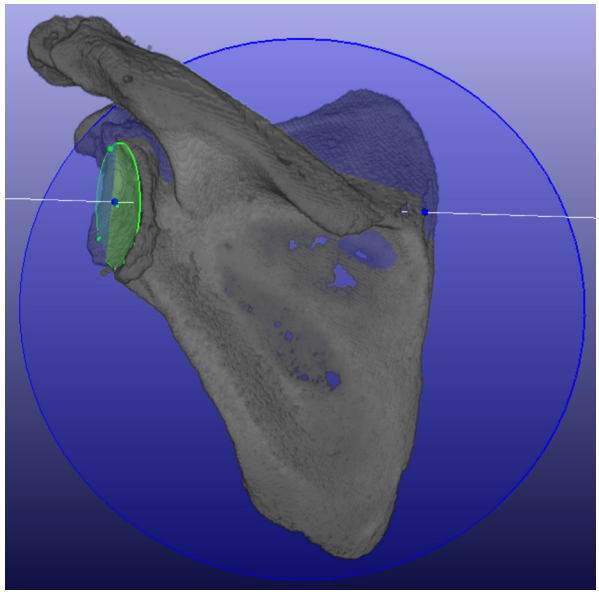

Figure 1 The plane of the scapula is defined by 3 points, one placed at the inferior angle of the scapular body, a second at the scapula trigonum, and the third in the center of the glenoid fossa such that a line from this point to the scapula trigonum is in the center of the glenoid vault and defines the center line of the scapula. The glenoid plane was defined by 3 points placed on the glenoid surface to define a plane that best represented the average version and inclination of the glenoid fossa. These points were approximated to the superior glenoid, the anterior inferior glenoid, and the posterior inferior glenoid in the area of greatest bone loss not including osteophytes.

A plane that best represented the overall version and inclination of the glenoid fossa was defined by placing 3 points on the glenoid articular surface; these points were approximated to the superior glenoid, the anterior inferior glenoid, and the posterior inferior glenoid, in the area of greatest bone loss, to provide the most accurate reflection of glenoid retroversion (Fig. 1). The measured retroversion angle was calculated as the angle between the plane of the scapula and plane of the glenoid.

Estimation of the glenoid joint line was measured by use of the glenoid vault model as previously described.[27,30,32] The native glenoid morphology/native premorbid joint line was calculated in the software with the previously validated vault model.[26] The amount of glenoid bone loss was measured from the most lateral aspect of the vault model (anatomic joint line) to the posterior inferior glenoid plane, which was the area of greatest bone loss (Fig. 2).[26]

Implant modeling

The imaging software contained solid computer models of a commercially available augmented glenoid component (DePuy