The relationship between glenoid retroversion correction and volume of bone removed in total shoulder arthroplasty

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INTRODUCTION:
Total shoulder arthroplasty (TSA) is an effective treatment for end stage glenohumeral arthritis. Glenoid bone deficiency and posterior wear are common features of advanced shoulder arthritis and can compromise implantation of the glenoid component, making the procedure more difficult. The magnitude of glenoid retroversion that can be surgically corrected and still enable successful implantation of a glenoid component without substantial bone removal has not been established. We simulated glenoid resurfacing on computer models of osteoarthritic glenoids with varying degrees of erosion obtained from patients who were to undergo TSA. In-line three peg glenoid components at various degrees of retroversion were used to determine the amount of glenoid bone removal during reaming.

METHODS:
Eighteen patients with glenohumeral osteoarthritis undergoing TSA were prospectively included in this study. Institutional Review Board approval and informed consent for study patients were obtained. Three-dimensional models of the patients’ scapulae were created digitally from computed tomography (CT) using Materialise’s Interactive Medical Image Control System (Mimics) software (Ann Arbor, MI). The glenoid components and reamers from the Bigliani-Flatow Shoulder System (Zimmer, Warsaw, IN) were digitized with a coordinate measuring machine (Gage 2000 Coordinate Measuring Machine, Brown & Sharpe, North Kingston, RI). These glenoid components consist of three in-line pegs arranged vertically. Glenoid sizes of 40 mm (black), 46 mm (white), and 52 mm (blue) were digitized.

Simulated glenoid resurfacing was attempted on all patients with the 40 mm, 46 mm and 52 mm glenoid components. The neutral axis, representing zero degrees of retroversion, was defined as the line from the center of the glenoid to the medial border of the scapula in a mid-axial CT slice of the glenoid vault. The glenoid components were implanted at neutral version and in five degree increments of increasing retroversion until the component implantation was compromised or up to a maximum of twenty degrees of retroversion. Component implantation was considered compromised if peg penetration of the glenoid vault occurred. Implantation was deemed contained if the pegs did not violate the glenoid vault. The volume of bone removed required to implant the glenoid components at each stage was computed.

SPSS (SPSS Inc., Chicago, IL) was used for statistical analysis. A paired, one-tailed t-test was performed to calculate whether a statistical significant difference existed among each group for bone volume removed at different glenoid component retroversion angles and for bone volume removed for the different glenoid components at the same retroversion. Statistical significance was defined as p<0.05.

RESULTS:
For the 52 mm glenoid component, 5 of 18 patients were able to be resurfaced with a contained component at neutral version, 7 of 18 at five degrees of retroversion, and 8 of 18 at ten degrees of retroversion. For the 46 mm glenoid component, 6 of 18 patients were able to be resurfaced at neutral version, 7 of 18 at five degrees of retroversion, and 8 of 18 at ten degrees of retroversion. For the 40 mm glenoid component, 11 of 18 patients were resurfaced at neutral version, 14 of 18 at five degrees of retroversion and 17 of 18 at ten degrees of retroversion.

The least amount of bone removed was at 10 degrees of retroversion for both the 52 mm and the 46 mm glenoid components (p=0.05). The 52 mm component required more bone removal compared to the 46 mm and 40 mm at neutral, 5 degrees of retroversion, and 10 degrees of retroversion (p<0.05 for all). The 46 mm component required more bone removal than the 40 mm at 5 degrees of retroversion (p<0.05), but statistical significance was not achieved for neutral version (p=0.14) and 10 degrees of retroversion (p=0.11).

For both the 52 mm and 46 mm components, significantly more bone was required to be removed at 0 degrees (neutral version) compared to 5 degrees of retroversion (p<0.05), 0 degrees compared to 10 degrees (p<0.05), and 5 degrees compared to 10 degrees (p<0.05) [Fig 1]. Comparisons to 15 degrees of retroversion were not significant.

For the 40 mm glenoid, resurfacing at 15 degrees of retroversion had the least amount of bone volume removed, although this was not statistically significantly different from the volume removed at 10 degrees (p=0.08). Significantly more bone was required to be removed at 0 degrees compared to 5 degrees of retroversion (p<0.001), 0 degrees compared to 10 degrees (p<0.01), 0 degrees compared to 15 degrees (p<0.05), 5 degrees compared to 10 degrees (p=0.05), and 5 degrees compared to 15 degrees (p<0.05).

DISCUSSION:
TSA is a technically demanding surgery, especially with regard to implantation of the glenoid component when glenoid deformity exists. The ability to resurface the glenoid with a prosthesis and prosthetic loosening are the most frequently encountered complications of TSA. Commonly, the arthritic deformity erodes the glenoid causing eccentric posterior wear which, if uncorrected and resurfaced, may result in posterior instability and glenoid component loosening.

Finite element analyses have shown that a retroverted glenoid component results in eccentric contact forces, especially in situations with greater than 10 degrees of retroversion,[1, 2] that this off-center loading results in increased tensile and shear stresses about the cement/bone interface[1-3]. Clinically, asymmetric load distribution of the humeral head on the glenoid can lead to early loosening of the glenoid component analogous to the “rocking horse” phenomenon that was originally described in a rotator cuff tear model. Therefore, a technical goal for resurfacing the glenoid is to at least partially, if not fully, correct the retroversion.

We have shown through computer simulations that correction of glenoid retroversion to neutral version results in significantly more bone removal than resurfacing the glenoid in retroversion. In addition, larger glenoid components require more glenoid bone removal for contained implantation. The shoulder surgeon needs to weigh the benefits of retroversion correction with glenoid bone loss when resurfacing the glenoid in TSA. In order to preserve glenoid bone, it may be beneficial to not fully correct glenoid version to neutral.

REFERENCES: