J Shoulder Elbow Surg (2015) 24, 965-971

ELSEVIER

Journal of Shoulder and Elbow Surgery

www.elsevier.com/locate/ymse

Patient-specific targeting guides compared with traditional instrumentation for glenoid component placement in shoulder arthroplasty: a multi-surgeon study in 70 arthritic cadaver specimens

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Hypothesis and background: The purpose of this study was to compare the accuracy of patient-specific guides for total shoulder arthroplasty (TSA) with traditional instrumentation in arthritic cadaver shoulders. We hypothesized that the patient-specific guides would place components more accurately than standard instrumentation.

Materials and methods: Seventy cadaver shoulders with radiographically confirmed arthritis were randomized in equal groups to 5 surgeons of varying experience levels who were not involved in development of the patient-specific guidance system. Specimens were then randomized to patient-specific guides based off of computed tomography scanning, standard instrumentation, and anatomic TSA or reverse TSA. Variances in version or inclination of more than 10° and more than 4 mm in starting point were considered indications of significant component malposition.

Results: TSA glenoid components placed with patient-specific guides averaged 5° of deviation from the intended position in version and 3° in inclination; those with standard instrumentation averaged 8° of deviation in version and 7° in inclination. These differences were significant for version ($P = .04$) and

Institutional Review Board approval was not required (Basic Science study).

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1058-2746/$ - see front matter
http://dx.doi.org/10.1016/j.jse.2014.10.013

inclination ($P = .01$). Multivariate analysis of variance to compare the overall accuracy for the entire cohort (TSA and reverse TSA) revealed patient-specific guides to be significantly more accurate ($P = .01$) for the combined vectors of version and inclination. Patient-specific guides also had fewer instances of significant component malposition than standard instrumentation did.

Conclusion: Patient-specific targeting guides were more accurate than traditional instrumentation and had fewer instances of component malposition for glenoid component placement in this multi-surgeon cadaver study of arthritic shoulders. Long-term clinical studies are needed to determine if these improvements produce improved functional outcomes.

Level of evidence: Basic Science, Surgical Technique.

Keywords: Total shoulder arthroplasty; patient-specific targeting guides; standard guides; cadaver study; component placement

Accurate glenoid component placement is an important technical goal in shoulder arthroplasty. Multiple biomechanical studies have identified glenoid malposition in either version or inclination to be detrimental to component fixation and stability.[15,21-23,26,28] Malpositioned components have clinically significant implications for function and implant longevity, including potential alterations in impingement-free range of motion and stability.[4,5,10,13,31] Current methods to address glenoid wear patterns and then to place components accurately often are inadequate and can result in aseptic loosening.[7,9,13]

Multiple methods of attempting to correct glenoid wear have been described, including eccentric glenoid reaming, bone grafting, and augmented components.[12,16,24,25] Intraoperative navigation systems to guide component placement have been developed,[1,20,27,30] and 3-dimensional (3D) computed tomography (CT) has been investigated as a preoperative planning and templating tool.[7,14,19] Finally, CT scans also have been used to create patient-specific guides to improve glenoid component placement in some studies[11,17,29]; however, there have been no adequately powered studies to compare the accuracy of these guides with standard preparation techniques. The purpose of this study was to compare the accuracy of glenoid component placement with patient-specific targeting guides and traditional instrumentation using an arthritic cadaver model. We hypothesized that patient-specific guides would place components more accurately than standard instrumentation and with fewer significant instances of component malposition.

This study was supported by Biomet, for whom all authors are consultants.

Materials and methods

To conduct this randomized controlled trial, we conducted a prestudy power analysis. Sample size calculations were implemented in nQuery Advisor 7.0 software (Statistical Solutions, Boston, MA, USA) using a 1:1 ratio of patient-specific guides to traditional instrumentation. The primary objective of this study was to determine differences between patient-specific guides and traditional instrumentation in absolute version of glenoid components relative to the intended neutral version. With a planned 2-sided t test with α of .05 and β of 80% for difference in mean degrees of absolute version, a sample size of 66 shoulders to detect a statistically significant difference between preparation techniques was recommended. To have similar sample sizes among 5 surgeons, a study size of 70 shoulders was chosen. All 70 specimens had pretest radiographic analysis for confirmation of glenohumeral arthritis, typically by identification of an inferior humeral head osteophyte. Specimens were then randomized by random number generator to the use of patient-specific targeting guides (Signature; Biomet, Inc., Warsaw, IN, USA) or standard glenoid preparation (Comprehensive; Biomet, Inc., Warsaw, IN, USA) and anatomic total shoulder arthroplasty (TSA) or reverse total shoulder arthroplasty (RTSA).

The Signature glenoid preoperative planning techniques were used to formulate a plan for each cadaver. Specimens were placed supine in the scanner with the arm externally rotated (palm up). A General Electric LightSpeed 64 CT scanner (GE Healthcare, Fairfield, CT, USA) was used for all scans. CT scans were obtained in accordance with the Signature glenoid CT scanning protocol with soft tissue algorithms and 0.625 × 0.625-mm slices at 120 kVp. Two-dimensional DICOM images were segmented and used to create a 3D representation of the cadaver scapulae; 3D reconstructions were done with ORS Visual (Objects Research Systems, Montreal, QC, Canada), which converted the 2-dimensional DICOM images to a 3D .stl file. These files were converted to .IGES files with Geomagic Studio (Geomagic, Cary, NC, USA). All scapular planning was performed in NX 7.5 (Siemens, Washington, DC, USA).

The Signature planning technique uses 3D CT imaging to plan implantation in neutral version based on the methods of Friedman et al.[6] This method essentially aligns the implant version by aiming toward the medial border of the scapula and is defined as anatomic version. Glenoid inclination was preoperatively planned in neutral inclination based on the methods of Churchill et al[2] and De Wilde et al.[3] By use of these methods to measure anatomic inclination, an average of each author's results (8° inclined from the anatomic axis projecting perpendicular to the medial border of the scapula) was defined as neutral inclination. The starting point for guide pin placement also was defined by the Signature planning techniques. Anatomic TSA implants were placed in the center of the glenoid, which was determined through anterior-