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Radiographic assessment of prosthetic humeral head size after anatomic shoulder arthroplasty

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Background: Restoring the premorbid proximal humeral anatomy during shoulder arthroplasty is critical yet can be difficult because of the deformity of the arthritic head. The purpose of this study was to measure the variation between surgeons and between types of prosthetics in reproducing the anatomic center of rotation (COR) of the humeral head after anatomic shoulder arthroplasty.

Methods: The anteroposterior radiographs of 125 stemmed and 43 resurfacing shoulder arthroplasties, performed by 5 experienced surgeons, were analyzed. All patients had primary replacement for treatment of end-stage glenohumeral arthritis. A best-fit circle to preserved nonarticular humeral landmarks was used to define the difference between the anatomic COR and the prosthetic COR. A difference in COR of >3.0 mm was considered clinically significant and analyzed for the cause of this deviation.

Results: The average deviation of the postoperative COR from the anatomic COR was 2.5 ± 1.6 mm for stemmed cases and 3.8 ± 2.1 mm for resurfacings. Thirty-nine stemmed cases (31.2%) and 28 resurfacings (65.1%) were beyond 3.0 mm of deviation and regarded as outliers. The majority of the stemmed outliers and all resurfacing outliers were overstuffed. An improper humeral head size selection and inadequate reaming were the main reasons for the deviation in stemmed and resurfacing outliers, respectively.

Conclusion: A large percentage of shoulder replacements demonstrated significant deviations from an anatomic reconstruction. Resurfacing arthroplasty exhibited significantly greater deviations compared with stemmed arthroplasty ($P < .001$), indicating that surgeons have more difficulty in restoring the anatomy with resurfacings. Further studies are needed to assess the clinical impact of these deviations.

Level of evidence: Basic Science, Anatomy, Imaging.

Keywords: Anatomic shoulder arthroplasty; humeral head arthroplasty; resurfacing; humeral head size; glenohumeral arthritis; shoulder replacement

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The articular surface of the humeral head is spherical in its center,[1,6,10-12] with the peripheral contour being more elliptical.[6] In addition, the entire proximal humerus can be represented by a sphere.[17] The goal of anatomic humeral head arthroplasty is to restore these anatomic relationships, specifically with regard to the center of rotation (COR) of the articular surface. Accurate sizing of the implants,

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especially the humeral head, is critical, as component malpositioning can result in pain, clinical symptoms, worse outcomes, and increased complication and failure rates.[3,5,7,9,16]

Sizing of the humeral head during shoulder arthroplasty is often performed at the time of surgery with a combination of dimensions of the prepared bone surface, the resected head, the size of the glenoid component (when present), and soft tissue balancing. This is usually accomplished with the use of trial implants and sizing templates provided by commercial implant vendors. These methods focus only on the articular surface and do not use the anatomic concept of the sphericity of the proximal humerus. However, because the articular surface is generally deformed from the arthritic process, it is often difficult to accurately assess the correct size of the premorbid humeral head.

We have previously demonstrated that premorbid humeral head size and COR in the arthritic shoulder can be accurately predicted from preserved nonarticular bone landmarks by a best-fit sphere or circle fitted to the proximal humerus. Sphere placement requires use of 3-dimensional computed tomography; circle placement can be performed in the mid–coronal plane of the proximal humerus, obtained from either a 2-dimensional computed tomography scan or a true anteroposterior (AP) radiograph of the shoulder.[17] The goal of the current radiographic study, therefore, was to apply this method to assess the ability to accurately restore humeral head anatomy in shoulder arthroplasty. We used the best-fit circle technique to measure the deviation of the COR of the prosthetic humeral head from native anatomy after both stemmed and resurfacing humeral head arthroplasty. We hypothesized that there would be variation between surgeons in the restoration of the anatomic COR after shoulder arthroplasty and that the magnitude of the deviation would be greater after resurfacing arthroplasty compared with stemmed arthroplasty.

Materials and methods

Patient selection

The AP radiographs of 275 consecutive stemmed anatomic humeral head arthroplasties performed for end-stage glenohumeral arthritis between April 2008 and July 2012 by 1 of 5 academic fellowship-trained shoulder surgeons were identified. The radiographs of 125 arthroplasties (117 patients) met the study inclusion criteria; the rest were excluded because of inadequate radiographs. Cases were evenly distributed among the 5 surgeons, totaling 25 cases per surgeon. AP radiographs of 53 consecutive humeral head resurfacings performed for end-stage glenohumeral arthritis or avascular necrosis between June 2007 and July 2008 by 4 of the 5 shoulder surgeons performing the stemmed arthroplasties were also identified. The radiographs of 43 resurfacings (40 patients) met the study inclusion criteria; the rest were excluded because of inadequate radiographs. Inclusion criteria for both groups included primary cases performed for either hemiarthroplasty or total shoulder arthroplasty with a postoperative AP radiograph having a near-perfect profile of the implant and the proximal humerus (Fig. 1), as described later. Exclusion criteria included revision cases, patients with evidence of a previous proximal humerus fracture or proximal humeral deformity, and cases in which the surgeon stated in the operative note that the sizing of the humeral head was adjusted from the expected anatomic size to account for other intraoperative concerns (e.g., soft tissue balancing, medialization of glenoid, bone loss).

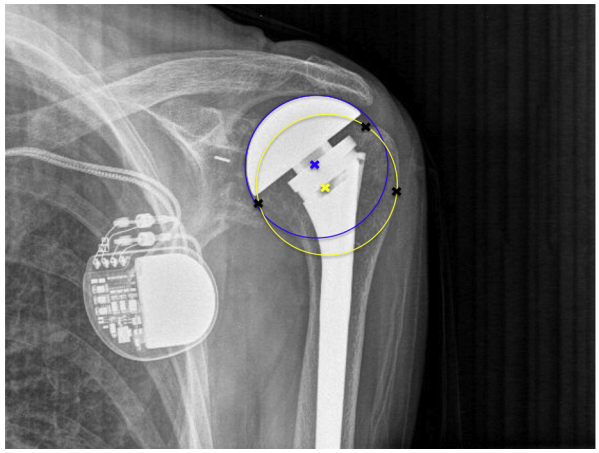

Figure 1 A postoperative AP radiograph of a patient demonstrating the anatomic circle with its COR (*yellow circle*) and the postoperative implant circle and its COR (*blue circle*). The three preserved bone landmarks (*black x*) used to generate the anatomic circle are also depicted.

The average age of patients with a stemmed humeral head arthroplasty was 64.8 ± 11.5 years (range, 30-88 years), and 58 patients (46%) were men. Ninety-one percent of the cases (114 cases) were total shoulder arthroplasties, and 9% of cases (11 cases) were hemiarthroplasties. The average age of patients with a resurfacing humeral head arthroplasty was 46.7 ± 10.1 years (range, 26-69 years), and 33 patients (76.7%) were men. Only one case had a glenoid component inserted at the same time of the resurfacing.

Surgical technique

All cases were performed by a standard deltopectoral approach. The subscapularis was managed with a lesser tuberosity osteotomy or a tenotomy. For all cases, the humeral head size was chosen at the discretion of the treating surgeon, with the goal of restoring the anatomic relationships of the proximal humerus and soft tissue balancing. For stemmed humeral head arthroplasty, the Global AP (DePuy Johnson & Johnson, Warsaw, IN, USA) implant was used in 74 cases, the Aequalis (Tornier, Bloomington, MN, USA) in 25 cases, the Affiniti (Tornier) in 25 cases, and the Equinoxe (Exactech, Gainesville, FL, USA) in 1 case. Among all implants, a fixed-angle prosthesis was used in 118 cases, whereas a variable-neck prosthesis was used in 7 cases. Use of a fixed-angle or variable-neck prosthesis was at the discretion of the treating surgeon, again with the goal of restoring the anatomic relationships of the proximal humerus and soft tissue balancing. For resurfacings, the Global CAP (DePuy Johnson & Johnson) implant was used in 39 cases, the Aequalis Resurfacing (Tornier) in 2 cases, the Copeland resurfacing (Biomet, Warsaw, IN, USA) in 1 case, and the HemiCAP (Arthrosurface, Franklin, MA, USA) full resurfacing in 1 case.