BIOMECHANICAL COMPARISON OF ANATOMIC HUMERAL HEAD RESURFACING VERSUS HEMIARTHROPLASTY FOR FUNCTIONAL GLENOHUMERAL POSITIONS

Gareth Hammond1,2, James E. Tibone1,2, Michelle H. McGarry1, Bong-Jae Jun1, Thay Q. Lee1
1Orthopaedic Biomechanics Laboratory, Long Beach VA Healthcare System and University of California, Irvine, Long Beach, CA; 2Department of Orthopaedic Surgery, University of Southern California, Los Angeles, CA
tqllee@med.va.gov

Introduction: Hemiarthroplasty is performed for the relief of pain from conditions which damage the congruity of the humeral articular surface, most commonly arthritis, avascular necrosis, and large defects due to trauma or metabolic insults. Recently, proximal humeral implant design has focused on restoring the intact humeral head anatomy based on the hypothesis that such designs may limit eccentric loading and restore physiologic motion. The objective of this study was to quantitatively assess the biomechanical characteristics of the glenohumeral joint for normal, humeral head resurfacing, and hemiarthroplasty.

Materials and Methods: Seven cadaveric shoulders were used to test the normal, humeral resurfacing, and hemiarthroplasty conditions on a custom shoulder testing system (Fig 1). The supraspinatus, infraspinatus/teres minor, subscapularis, pectoralis, and latissimus were loaded with 20N and the deltoid was loaded with 40N. The articular surface of the normal humeral head, resurfacing, and hemiarthroplasty was digitized with a Microscribe 3DLX. A three dimensional mathematical spherical fit was used to calculate the geometric center of the humeral head and the total distance from the normal geometric center was calculated following arthrosurface and hemiarthroplasty. Glenohumeral contact area and pressure were measured with a Tekscan pressure sensor. Each specimen was tested in 20°, 40°, and 60° of glenohumeral abduction in neutral, 30° internal, and 30° external rotation. Fifteen degrees of external rotation and neutral rotation was tested at 80° of abduction. All abduction angles were tested in the scapular plane and 45° of horizontal abduction. The Microscribe 3DLX was used to measure the position of the humeral head relative to the glenoid at all testing positions.

Results: The distance from the geometric center of the normal humeral head was 2.2(0.3)mm and 4.7(0.3)mm for humeral resurfacing and hemiarthroplasty, respectively [mean(SEM)]. The resurfacing condition was closer to the normal humeral geometric center. Representative contact patterns are shown for the scapula plane and neutral rotation position in Figure 2. Both humeral head resurfacing and hemiarthroplasty decreased the glenohumeral contact area. For the humeral head resurfacing condition significant differences were noted at 40° of abduction in the scapular plane and 20° of abduction in forward flexion. The contact area for the hemiarthroplasty condition was less than the intact specimen at 40° and 60° of abduction in the scapular plane. Peak pressure was higher for both humeral head resurfacing and hemiarthroplasty. There was no difference between the resurfacing and hemiarthroplasty groups for contact area and pressure.

Discussion: To restore glenohumeral joint biomechanics after humeral arthroplasty, it is necessary to restore the glenohumeral joint anatomy. Although the humeral head resurfacing has contact characteristics similar to those of hemiarthroplasty, the position of the humeral head apex on the glenoid surface during neutral rotation in both the scapular plane (Fig 3) and 45° horizontally abducted position from intact condition and the arthrosurface condition varied from the position of the intact specimen at 60° abduction, neutral rotation, and 45° forward flexion but was not significantly different from intact condition.

Figure 1: Shoulder testing system.

Figure 2: Glenohumeral contact patterns.

Figure 3: Humeral head apex position.

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