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Observations on retrieved glenoid components from total shoulder arthroplasty

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Hypothesis: Polyethylene components retrieved at revision of total knee and hip replacements have been analyzed to study the effect of design, patient, and surgical factors on initial implant performance, but few studies have reported similar types of findings in retrieved glenoids.
Materials and methods: From 1979 to 2006, 78 glenoid components were retrieved from revision surgery in 73 patients at a single institution. Each glenoid component was analyzed for 9 modes of damage in each of 4 quadrants into which the bearing surface was divided. For each glenoid, the most recent radiographs before removal were scored using an adapted radiolucency score.
Results: Scratching, pitting, and burnishing were the most common and most severe types of polyethylene wear. In addition, the modes of damage observed were not uniformly distributed across the bearing surface, but commonly focused in the inferior quadrant of the glenoid, suggesting a propensity for a humeral impingement mechanism leading to glenoid loosening. The radiographic analysis performed was found to severely underestimate the presence of clinical glenoid loosening.
Conclusion: Impingement of the glenoid with bone at the edge of the humeral component and edge deformation secondary to eccentric forces of the humeral head on the glenoid rim are highly associated with glenoid loosening. Analysis of retrieved glenoid components, along with patient, design, and surgical factors, provide important information on the causes of component failure.
Level of evidence: Basic science study.

Keywords: Polyethylene wear; glenoid loosening; glenoid component failure; total shoulder arthroplasty revision

Analysis of polyethylene components retrieved at revision of total knee and total hip arthroplasties has been effective for defining the effect of design, patient, and surgical factors on implant performance, but few such studies have reported similar findings in retrieved total shoulder arthroplasty (TSA) glenoid components.[10,11,23,25] Scarlat and Matsen[23] reported 39 glenoid components retrieved after a mean implantation length of 2.5 years. The most frequent finding was erosion of the rim of polyethylene glenoid components, which occurred in 28 cases, followed by surface irregularities in 27, fractured glenoid components in 11, and central wear in 9. Hertel and

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Ballmer[10] also noted the presence of central wear in their report of 7 components. In all of the glenoids, a new conforming articular facet had been worn, with a radius of curvature matching that of the humeral head. Gunther et al[9] described the wear mechanisms in 10 all-polyethylene glenoid components, adopting a previously described classification system[11] for total knee arthroplasty tibial polyethylene inserts. Scratching, abrasion, pitting, and delamination were the most common damage modes, implying that these components sustained a combination of abrasive and fatigue wear similar to that observed in total knee arthroplasty.

These studies demonstrated the potential for wear and surface damage in glenoid components but were limited by the numbers of retrieved components, the different designs, and the lack of complete radiographic and clinical data from which to explore relationships between implant performance and clinical, surgical, and design factors. The purpose of the present study, therefore, was to determine the wear damage and examine these relations using a large collection of retrieved components with multiple designs.

Materials and methods

From 1979 to 2006, 78 retrieved TSA glenoid components were collected from removal and revision surgeries of 73 patients as part of an ongoing, Investigational Review Board-approved implant retrieval system at a single hospital. The implants were from 4 manufacturers: 52 Biomet (Warsaw, IN), 17 Smith and Nephew (Memphis, TN), 6 Custom HSS (Hospital for Special Surgery, New York, NY), and 2 DePuy (Warsaw, IN); the manufacturer of 1 glenoid implant could not be determined. Polymethylmethacrylate cement was used to implant 74 glenoids, and adjuvant screw fixation was used for the remaining 4. Backings were keeled in 43 glenoids and pegged in 35. The articulation of the glenoid implants was nonconforming in 54% and conforming in 46%. A conforming surface was one in which the glenoid radius matched the radius of the humeral head component vs the presence of a greater radius mismatch in nonconforming surfaces. In 55 of the 73 patients, the glenoid was removed and the TSA was converted to a hemiarthroplasty.

Retrospective review of the medical records and radiographs were available for 71 of the 73 patients. The clinical information included patient demographics, medical comorbidities, shoulder history, clinical assessment (pain and range of motion), intraoperative findings, implant information, and postoperative complications. The primary arthroplasty in 57 patients occurred at our institution, from 17 orthopedic surgeons, and 14 patients received their initial surgeries at other hospitals. The revision surgeries were performed by 15 different orthopedic surgeons at our institution. Glenoid components were removed from both shoulders in 3 patients, and 2 patients underwent revision of a glenoid component that was subsequently removed at a second surgery. Average patient age was 60.8 $\pm$ 11.7 years at the time of revision surgery. The mean length of implantation was 4.0 $\pm$ 4.4 years (range, 0.1-19.2 years). The primary diagnosis was osteoarthritis in 54 patients, rheumatoid arthritis in 12, avascular necrosis in 3, fracture in 1, and systemic lupus erythematosus in 1. The revision diagnosis was aseptic glenoid loosening in 60 patients, septic loosening in 6, and instability in 5. Additional pathology determined intraoperatively at revision surgery included glenoid osseous defects after component removal in 61%, adhesions in 55%, rotator cuff tendinopathy in 52%, humeral head subluxation or dislocation in 37%, and deltoid atrophy in 20%. The average forward elevation was 56° (range, 0° to 170°), and external rotation was 18° (range, −40° to 80°) for patients just before revision surgery (Table I).

The polyethylene-bearing surfaces of the components were examined microscopically using ×31 magnification in a light stereomicroscope. For each surface, 9 modes of damage were subjectively scored: burnishing, abrasion, scratching, pitting, delamination, focal wear, surface deformation, embedded third body debris, and fracture, based on previously developed scoring systems for polyethylene joint replacement components.[10,11] The surface was divided into anterior, posterior, superior, and inferior quadrants and given a subjective damage score of 0 to 3 for each damage mode in each quadrant[10] (Figure 1).

The most recent plain anteroposterior (AP) and axillary shoulder radiographs before removal of the glenoid were examined. The extent and amount of radiolucency in the AP view was measured with digital calipers according to the system described by Molé,[19] in which the area surrounding the glenoid fixation keel is separated into 6 zones. Radiolucent lines were assigned a numeric value by the thickness of the radiolucency for all 6 zones, and the values were summed to give the radiolucency score. A score between 0 and 6 points corresponded to no loosening, between 7 and 12 points represented possible loosening, and between 13 and 18 points represented definite loosening.[19] The same method was adapted to the axillary radiographs, with radiolucencies measured in 3 zones corresponding to the anterior rim (zone 1), around the fixation keel or pegs (zone 2), and the posterior rim (zone 3) of the glenoid. The amounts of subluxation in the coronal (AP view) and sagittal (axillary view) planes were measured as the percentage of translation and graded as mild (<25%), moderate (25% to 50%), or severe (>50%).[23] The glenoid wear measurements and radiographic analysis were performed by a senior orthopedic resident experienced with wear analysis from prior total knee arthroplasty retrievals.

Results

Glenoid component wear analysis

Scratching was the most common damage mode, involving all 78 glenoids that were retrieved, closely followed by pitting in 73 glenoids (Figure 2, *A* and *B*). Both modes were most prevalent on the inferior aspect of the retrieved components. Next were burnishing in 54 glenoids and abrasion in 53 (Figure 2, *A* and *C*). Specifically, abrasion on the edge of the component, consistent with glenoid impingement with the humerus, was evident in 29 of 78 glenoid components (Figure 2, *C*). In two-thirds of these cases, the abraded area occurred on the anterior and inferior quadrants. Surface deformation occurred in 48 of the retrieved glenoids, with edge deformation evident in 18