Bearing Surface Damage Analysis of Coupled Total Shoulder Replacement Retrievals

L. Malito, BS[1], F. Ansari, MS[1], A. Mehdizadeh, BS[1], J. Koller[1], S. Gunther, MD[2], T. Norris, MD[3], M. Ries, MD[4], L. Pruitt, PhD[1]

[1]University of California, Berkeley, [2]Martha Jefferson Hospital, [3]San Francisco Shoulder, Elbow & Hand Clinic, [4]University of California, San Francisco

Statement of Purpose: Characterizing *in vivo* damage of total shoulder replacements (TSR) is important for improving arthroplasty outcomes, modeling damage modalities, and validating simulator studies. The limited TSR retrieval studies primarily focus on ultrahigh molecular weight polyethylene (UHMWPE) wear associated with osteolysis and implant loosening.[1] However, counterbearing metallic damage may significantly increase UHMWPE wear.[2] This work presents a methodology that classifies the mode, geometric extent and severity of surface damage in TSR retrievals. This work also correlates trends in UHMWPE gleniod damage with mated cobalt chrome (CoCr) humeral head components[3] and clinical factors.

Methods: Six TSR bearing couples (n=5: Depuy, Warsaw, IN) were evaluated (Figure 1). Average *in vivo* duration was 66 ± 46 months. A grid placed on glenoid components divided the bearing surface into 17 regions of equal area. Each region was photographed at 249 dpi (16-20x) using a Nikon 1 J1 camera and Infinivar Video Microscope lens under an AmScope LED ring light. Observers noted the presence, severity and geometric extent of 13 UHMWPE damage modes: scratching, striations, pitting, abrasion, adhesion, fracture, burnishing, wear-through, surface deformation, rim erosion, delamination, subsurface cracking, and embedded debris.[4-6] Trends in glenoid damage were characterized to track frequency, average coverage and location of damage modes. A damage index (DI) value was calculated by summing the regional scores for each damage mode (product of the severity and geometric extent scores) across all 17 regions and dividing by a maximum score of 1683 for UHMWPE components. Similarly, CoCr humeral head component scores were translated into a maximum DI value out of 3000.[3]

The total geometric extent of each severity level for all damage modes were correlated with corresponding humeral head values using a non-parametric Spearman's rank correlation coefficient (ρ) in Matlab. The same correlation method was used to reveal trends between clinical data (time *in vivo* and patient age) and damage mode occurrence for glenoids and humeral heads.

Results: All six glenoids demonstrated instances of scratching, striations, pits and surface deformation in at least 75% of the regions. On average, striations and pitting had a slight tendency to occur in the central 9 regions; a single instance of embedded debris was also present in the center. Abrasion, delamination, fracture and surface deformation were preferentially located in the outer eight regions of the glenoids.

There was no correlation of Spearman coefficients comparing DI values on the coupled bearing surfaces. However, several significant ($p < 0.05$) correlations were observed between specific damage modes and severity levels, shown in Table 1. No significant correlations were found when comparing total damage scores or specific damage mode presence for humeral heads with clinical inputs of time *in vivo* and patient age. Significant ($p < 0.05$) positive correlations were revealed for mild striations with patient age (ρ = 0.88) and mild pitting with time *in vivo* (ρ = 0.89).

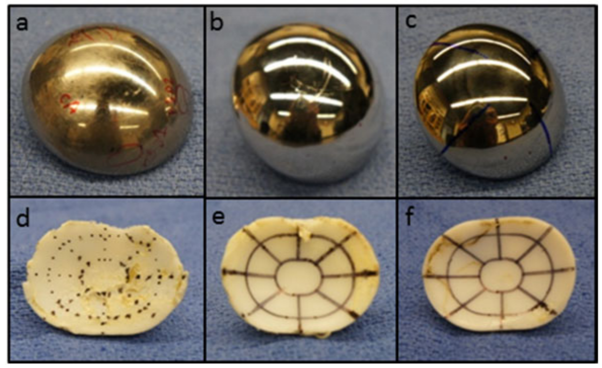

Figure 1. Photographs of a subset of retrievals evaluated, including (a-c) humeral heads (DI = 0.13, 0.03, 0.09) and (d-f) glenoids (DI = 0.27, 0.18, 0.15).

Correlated Damage Modes		Spearman Rank Coefficient (ρ), p < 0.05
CoCr Humeral Head	UHMWPE Glenoid	
Pitting	Mild Scratching	0.91
	Moderate Scratching	0.92
	Mild Surface Deformation	0.91
Curvilinear Abrasion	Severe Surface Deformation	-0.89
	Moderate Fracture	0.88
Moderate Striated Scratching	Mild Scratching	0.94
	Moderate Scratching	0.84
Mild Striated Scratching	Mild Pitting	-0.9

Table 1. Summary of significant (p<0.05) Spearman rank correlation data for damage modalities.

Conclusions: Our findings show that damage to UHMWPE and CoCr surfaces occurs *in vivo*. Damage modes and frequency on UHMWPE glenoids are similar to those observed in hip and knee components with longer implantation times.[3-6] Damage in TSR is distributed over a smaller area and accumulates at a faster rate than hip and knee arthroplasties. This greater severity in UHMWPE damage suggests that increased metal bearing damage plays an important role in TSR wear *in vivo*.

References: [1]Willert HG. J Bio Mat Res. 1977; 11:157-46; [2]Saikko V. J. Biomed. Mater. Res. 2005; 57: 506-12; 3. [3]Ansari F. 58th ORS Ann. Mtg. Feb 4-7, 2012; Poster # 1209; [4]McKellop HA. Biomat. 2007; 28: 5049-57; [5]Harman M. J Mat Sci: Mat in Med. 2011; 22: 1132-46; [6]Gunther, SB. J Arthro. 2002; 17: 95-100.