What Biomechanical and Patient Factors Influence Fretting Corrosion in Total Shoulder Replacement?

Judd Day, Ph. D.¹, Daniel MacDonald, M.S.¹, Christina Arnholt¹, Gerald R. Williams, M.D.², Clare M. Rimnac, Ph. D.³, Steven M. Kurtz, Ph. D.⁴.

¹Drexel University, Philadelphia, PA, USA, ²Rothman Institute, Philadelphia, PA, USA, ³University Hospitals Case Medical Center, Case Western Reserve University, Cleveland, OH, USA, ⁴Drexel University and Exponent, Philadelphia, PA, USA.

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Introduction: Mechanically assisted crevice corrosion of taper interfaces was raised as a concern in total hip arthroplasty (THA) approximately 20 years ago (Gilbert 1993). In total shoulder replacement, however, comparatively little is known about the prevalence of fretting assisted crevice corrosion or the biomechanical and patient factors that influence this phenomenon. Given the comparatively lower loading experienced in the shoulder compared to the hip, we asked: (1) What is the prevalence of fretting assisted corrosion in modular total shoulder replacements, and (2) What patient and implant factors are associated with corrosion?

Methods: Modular components were collected from 48 revision shoulder arthroplasties as part of a multi-center, IRB approved retrieval program. For anatomic shoulders, this included 40 humeral heads, 32 stems and 4 taper adapters from 7 manufacturers. For reverse shoulders, there were 8 complete sets of retrieved components from 3 manufacturers. The components were predominantly revised for instability, loosening, and pain. Anatomical shoulders were implanted for an average of 3.1 years (st dev 3.8; range 0.1-14.5). Reverse shoulders were implanted for an average of 2.2 years (st dev 0.7; range 1.3-3.3).

Modular components were disassembled and examined for taper damage. The modular junctions were scored for fretting corrosion using a semi-quantitative 4-point scoring system adapted from Goldberg, et al. (Goldberg, 2002, Higgs 2013). The scoring system was criteria was adapted from Goldberg and Higgs which is comprised of a one to four grading system (with 1 indicating little-to-no fretting/corrosion and 4 indicating extensive fretting/corrosion).

The component alloy composition was determined using the manufacturer’s laser markings and verified by x-ray fluorescence (Niton XL3t GOLDD+; Thermo Scientific, Waltham, MA). Patient age, gender, hand dominance, alloy, flexural rigidity of the trunnion and taper geometry were assessed independently as predictors for fretting corrosion.

Results: Moderate to severe fretting corrosion (score > 2) was observed in 23% of the anatomic modular components (Figure 1) and 22% of the reverse shoulder components. There was no significant relation between corrosion scores and any of the assessed factors.

Figure 1: Photographs of taper surfaces with fretting corrosion in anatomical (left) and reverse (right) total shoulder
arthroplasty.

Figure 2. Counts of taper corrosion scores for humeral heads (left) and stems (right) stratified by female (bore) and male (trunnion) taper geometry and material type. A score of 1 corresponded to little or no taper corrosion while a score of 4 indicated severe corrosion.

**Discussion:** It has been suggested that fretting assisted crevice corrosion may be a concern in THA, particularly with large head metal-on-metal articulations. We have identified the presence of moderate to severe corrosion on approximately one quarter of all retrieved shoulder arthroplasties. This is similar to the proportion observed in retrieved modular hips (Goldberg, 2002). While the expected loading of the shoulder is less than that in the hip (Westerhoff, 2009), the offset between the effective center of the prosthetic humeral head and the taper connector is often larger. This can increase the effect of bearing surface loading on the taper. We were unable to detect significant associated biomechanical or patient factors. This may have been due to the limited sample size of our population. At the present time, the clinical effects of taper corrosion in shoulder arthroplasty remain unknown.

**Significance:** Clinically significant taper damage has been identified in total hip arthroplasty, but little is known about this phenomenon in total shoulder arthroplasty. This study highlights the incidence of taper damage in 48 retrieved systems.

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**References:**

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