Mechanically Assisted Taper Corrosion In Modular Total Knee Arthroplasty

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Disclosures:

Introduction: Little is known about mechanically-assisted crevice corrosion of modular tapers in TKA. Recently, a case of adverse local tissue reaction (ALTR) has been reported at a TKA taper [1]. The purpose of this study was to characterize the prevalence of taper damage in modular components for TKA. Historically, factors such as mixed alloy combinations and taper design have been identified as characteristics leading to an increase in the prevalence of fretting corrosion in THA [2], leading researchers to question if these factors influenced corrosion in TKA. We hypothesized that similar to THA, mechanically-assisted crevice corrosion occurs at modular junctions in TKA. Additionally, we hypothesized that factors that contribute to increased fretting corrosion in THA (e.g., mixed alloy combinations, flexural rigidity) would also be associated with fretting corrosion in modular TKA.

Methods: Overall, 1873 retrieved TKA components were collected from 2002 to 2013 as part of a multi-institution, IRB-approved retrieval program. There were 218 modular components from 159 revised TKAs implanted for an average of 3.7±4.0 years (range: 0.0-17.5y). The TKAs were predominantly revised for loosening, infection, and instability. Medical records were reviewed for observations of ALTRs. Modular components were disassembled and evaluated for fretting corrosion using a semi-quantitative 4-point scoring system (1 being little-to-no fretting corrosion and 4 being extensive fretting corrosion) [3]. Flexural rigidity, stem diameter, alloy coupling, patient weight, age and implantation time were assessed as predictors of fretting corrosion damage. Selected components were further inspected using a high resolution digital microscope (Hirox KH 8700). Images of corrosion regions were documented and used to identify the corrosion mechanism. A JEOL JSM-5600 scanning electron microscope was used to further inspect the fretting and corrosion sites at higher magnification. The components selected for further inspection had a score of 4, with the exception of one threaded tibial component that had a score of 3. They were chosen based on identified correlated criteria. The implants were inspected for signs of pitting, fretting and extensive corrosion on the surface.

Results: Mild to severe fretting corrosion (score ≥ 2) of at least one component was observed in 106/111 (95.5%) of the tapers on the modular femoral components and 98/107 (91.6%) of the modular tibial components. Damage was more prevalent in mixed alloy pairs (Ti Alloy and CoCr) when compared to same alloy pairs (Figures 1 A and B). Clinical factors (e.g., age, weight, implantation time) did not correlate with fretting corrosion damage scores (p>0.05). Threaded tapers (n=102) had a lower damage score compared with conical tapers (n=116) (p<0.0001). Femoral components exhibited significantly greater fretting and corrosion damage when compared with tibial components (p<0.02). Femoral conical and threaded taper junction components with mixed alloy combinations had evidence of fretting and pitting corrosion (Figure 2 A and B, respectively). On the tibial side,
conical tapers with similar alloy combinations also showed evidence of pitting, fretting and corrosion, as did threaded tibial taper junctions (Figure 2 C and D respectively). Specifically, the threaded components exhibited corrosion on the raised threaded regions, while the conical components displayed corrosion throughout the taper. 5/159 revised knee components had intraoperative evidence of metallosis; however none of the modular knees were revised for reactions with metallic debris.

Figure 1: A) Male conical taper titanium exhibiting a fretting/corrosion score of 4. B) Female conical taper CoCr exhibiting a fretting corrosion score of 4.

Figure 2: A) Pitting and fretting scars (Black Arrow) were visible in a tibial conical taper with similar alloys using SEM. B) Threaded taper connections had evidence of fretting (B; White Arrow) and in more severe cases, evidence of pitting and corrosion scars (C; Black Arrow). D) In one conical taper (femoral component), there was evidence of rotating and pistoning in the form of a scar.

Discussion: The observations of this study confirm the hypothesis that mechanically-assisted crevice corrosion occurs in TKA. The decreased elastic modulus of Ti-Al-V alloys relative to CoCr alloys likely allows for more micromotion, which can damage the passivation layer and lead to galvanic corrosion [2]. This leads to mixed alloy pairs having a higher corrosion scores compared with similar alloy couplings. Likewise, the threaded modular connection possibly decreases micromotion between the interfaces, resulting in threaded cohorts having lower damage scores compared to their conical counterparts. The increase in femoral
component damage score compared to tibial component damage score is hypothesized to result from the majority of this cohort having a mixed alloy pair and potential differences in the biomechanics at the taper interface. The clinical implications of fretting and corrosion for TKA remain unclear, because modularity in TKA is typically reserved for unstable or revised knees. Additionally, the majority of TKAs were cemented, which may also limit the diffusion of corrosion products. Although mechanically-assisted crevice corrosion was confirmed in TKA the biomechanics at the taper and resulting corrosion mechanisms are still unclear.

**Significance:** Mechanically-assisted crevice corrosion has recently been identified as a clinical concern in large head MoM total hip arthroplasty, however, little is known about this mechanism of corrosion in modular TKA. In this study we found that moderate to severe fretting and corrosion was prevalent in modular taper junctions for TKA.

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**References:**

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