Evaluating the Mechanisms of Cobalt Chromium Damage in Total Knee Replacement

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INTRODUCTION: Biological reactions caused by the presence of wear particles can play a crucial role in driving the need for revisions in total knee arthroplasty (TKA). The tribocorrosion mechanisms governing the release of metals in TKA may result from wear, electrochemical dissolution, or a synergistic interplay between these two processes. Damage caused by electrocautery may also contribute to metal release. The primary goal of this study is to determine incidence of metal release mechanisms in contemporary total knee arthroplasty and patient – related factors associated with the release.

METHODS: 48 TKA retrievals were collected from aseptic revisions after a mean implantation time of 7.4 ± 5.8 y. Reasons for revision included femoral loosening (n = 7), instability (n = 15), tibial loosening (n = 11), stiffness (n = 3), implant loosening (n = 2), and other (n = 10). None were revised specifically due to a reaction to metal debris or metal hypersensitivity. The cohort mainly comprised devices from Zimmer Biomet (n=17), Stryker and Howmedica (n=15), Depuy Synthes (n=12), and others (n=4). The average body mass index (BMI) was 34.1 ± 7.3, and the mean age was 60 ± 9 years, and the patients were 48%F. For examination of femoral components four predominant damages that could result in the production of metal debris, or the release of metal ions were assessed. Abrasive wear mechanisms included scratching due to third-body wear debris and complete wear or fracture of the polyethylene component resulting in metal-on-metal articulation between the femoral condyle and the tibial baseplate. Corrosive damage mechanisms that were noted included inflammatory cell induced corrosion (ICIC) and discoloration of the backside of the femoral component at the interface with the cement mantle. The bearing surface of each femoral condyle was divided into four zones. For each zone and each type of damage, a score ranging from 1 to 4 was assigned, depending on the severities of damage of each damage mode. A score of 1 indicated minimal damage, a score of 2 indicated damage that covered less than 10% of available area, a score of 3 was given when a damage mode covered between 10% and 50% of the surface, and a score of 4 was given when a damage mode covered more than 50% of the surface. A total scratching score was calculated as the sum of the 4 zones.

RESULTS: All of the femoral condyles had at least minimal abrasion on the bearing surface. One implant had the posterior area of the polyethylene fracture and that resulted in direct metal on metal articulation between the femoral condyle and the tibial tray (Figure 1). The median total scratching score was a 6.5 (Range: 4 -11). There was no difference in scores between the medial and lateral portions of the implant (p=0.993). Similarly, we did not observe a difference in scores between the anterior and posterior portions of the implant (p=0.413). Scratching was positively correlated with implantation time (Rho=0.36, p=0.021). Scratching was not correlated with patient age (p=0.590) or BMI (p=0.468). Of the 20 implants that we could evaluate the backside, 6 had evidence of discoloration.

DISCUSSION: In this study, we analyzed the articulating surfaces of CoCr femoral condyles from aseptic revision for the presence of abrasive wear or corrosion. The most common damage mechanism that we observed was scratching. This is similar to previous research in which scratching was observed in 98% of CoCr femoral condyles in a study of long-term retrieved femoral components. The clinical significance of these findings is unclear at this point as none of the retrievals in this study were revised for a reaction to metal debris. We focused on aseptic revisions in this study because future analyses are being planned to analyze blood and tissue samples associated with these retrievals to help elucidate the role of CoCr debris on peri-implant biology and metal hypersensitivity reactions.

SIGNIFICANCE/CLINICAL RELEVANCE: Although TKA components have been fabricated from CoCr for decades, comparatively little research has been performed on metal release in TKA as compared with THA. This study adds to the understanding of the mechanisms of CoCr damage and metal release in aseptic revision TKA.

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Figure 1: An example of severe scratching (orange oval) as result of metal-on-metal articulation.