Taper Corrosion in Metal-on-Polyethylene and Metal-on-Metal Total Hip Arthroplasty: A Matched Blinded Observer Retrieval Analysis

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INTRODUCTION: After the clinical introduction of highly-cross-linked polyethylene (HXLPE) nearly two decades ago, it has become the most common acetabular liner material, usually paired with a CoCr or ceramic femoral head[1]. Metal-on-polyethylene (MoP) THA systems have been consistently used with low revision risk compared to other CoCr pairings such as metal-on-metal (MoM) or ceramic-on-metal (CoM). While MoM THA promised success early on due to low bearing surface wear and mitigated risk for dislocation, registries later reported unacceptably high revision rates leading to the recall or withdrawal of almost all MoM systems. The modular interface between the CoCr femoral head and Ti6Al4V stem has been investigated as a significant source of metal debris and metal ions in these systems. While modular designs allow for flexibility during surgery to accommodate patient anatomy, they have been reported to contribute to metal sensitivity in both MoM and MoP systems[2]. While MoM systems have been largely superseded, contemporary MoP systems utilize similar taper designs. Risk factors for taper corrosion including increased taper flexibility, decreased taper diameter, and roughened taper texture have been characterized in both MoM and MoP systems. Therefore, we present a comparison of taper corrosion between MoM and MoP THA modular interfaces by pairing retrieved MoM and MoP components based on time-in-vivo, head diameter, taper geometry, and head offset.

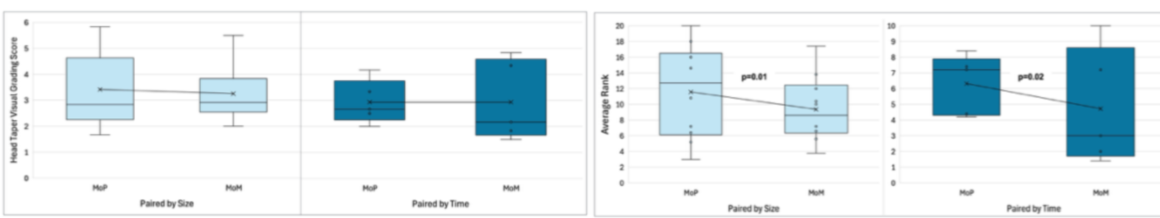
METHODS: Ten retrieved MoP THA components were identified and matched with ten retrieved MoM THA components based on femoral head diameter, taper geometry (11/13 or 12/14), and head offset when available. Five of these MoP THA components were then matched with five additional MoM components based on time in vivo for a total of n=10 MoP CoCr heads and n=15 MoM CoCr heads included. Taper damage was scored by an experienced observer using the visual grading score (VGS) described by McCarty et al.[3] All twenty five femoral heads were assessed and the maximum engaged diameter, contact length, taper texture, and geometry were determined for each component. Each femoral head was measured using a Mitutoyo Legex 322 coordinate measuring machine (CMM) (Mitutoyo America Corp, Aurora, IL, USA). The data were processed to produce wear maps, determine the maximum wear depth, and calculate the volume of material lost. The ten pairs of CoCr femoral heads paired by size and the five pairs of femoral heads paired by time-in-vivo were presented to five observers blinded to the material of the acetabular liner and clinical context. Observers then assigned each head taper a VGS score according to the criteria detailed by McCarty et al. Then, based on their VGS scores, observers ranked each of the components based on severity of corrosion with lower rankings representing less corrosion. Statistical analysis was performed using SPSS Statistics software (SPSS 29.0, IBM, Armonk, NY, USA).

RESULTS: For femoral heads paired by size, maximum engaged taper diameter for MoM was median 13.34 mm (range, 10.16 – 13.36) while the median for MoP was 13.22 mm (range, 11.04 – 13.86). For femoral heads paired by time, maximum engaged taper diameter for MoM was 12.83 mm (range, 12.45 – 13.55) while the median for MoP components was 12.86 mm (range, 12.68 – 13.79). For the femoral heads paired by size, the MoM components had a median volumetric wear of 5.35 mm^3 (range, 0.81 – 119.66) while the MoP components had a median volumetric wear of 2.58 mm^3 (range, 0.01 – 7.72). For the femoral heads paired by time in service, the MoM components had a median of 3.76mm^3 (range, 1.71 – 17.45) while the MoP components had a median of 2.69 mm^3 (range, 0.53 – 7.72). For components paired by size, the MoM components had an average VGS score of 3.3 while the MoP components had an average VGS of 3.4. There was no significant difference in VGS corrosion scoring for MoM or MoP head tapers (p=0.25). However, the MoM components had an average rank of 9.4 out of 20 compared to the MoP components which ranked significantly higher on average at 11.6 out of 20 (p=0.01). For components paired by time, the MoM and MoP groups each had an average VGS of 2.9. Therefore, there was no difference in corrosion scoring between MoM and MoP components. However, the MoM components had an average rank of 4.72 out of 10 compared to the MoP components which ranked significantly higher at 6.32 out of 10 (p=0.02).

DISCUSSION: Despite similar average VGS scores for both MoM and MoP components, the MoP tapers ranked significantly higher whether paired by size or by time. This finding contradicted previous investigations which compared MoM and MoP taper corrosion and generally found that MoP tapers produced less metal debris. However, these studies did not consider service time as a confounding variable for their results when directly comparing MoM and MoP components, and only one previous study paired the components based on size and taper design[4]. Recent registry data has reported an increased risk of ARMD-related revision of non-MoM THAs indicating that modular interface corrosion in MoP THAs is a growing concern. This suggests that taper corrosion in MoP THAs may have been previously underestimated. Finally, the discrepancy between the VGS scoring and corrosion ranking highlights the potential limitations of semiquantitative grading scales especially when comparing corrosion across textures.

CLINCIAL SIGNIFICANCE: These findings indicate that corrosion at the head-neck interface may be a significant, underappreciated source of metal debris in contemporary MoP implants. MoP systems are still widely used and are reportedly demonstrating increased revision risk related to ARMD. This underscores the importance of vigilant postoperative monitoring and careful evaluation of the clinical tradeoffs that accompany metal-on-metal modular interfaces.

FIGURES:



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