Metal Bearing Surfaces in Total Joint Arthroplasty: Do different joints display similar damage modes?

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Statement of Purpose: The historical use of metal-on polyethylene (MoP) bearings and descriptions of accumulated surface damage modes that exist at retrieval have led to a basic understanding of wear performance during *in vivo* function. [1,2] However, with the recent introduction of modern metal-on-metal (MoM) bearing couples, there remains the question of whether damage modes observed on MoM bearings should be interpreted to have the same wear mechanism as similar modes observed on MoP bearings. This study uses characteristic visual features to categorize surface damage modes that exist on retrieved metal components from MoP shoulder, knee, and hip implants along with MoM hip implants.

Methods: Retrieved components archived at three different university retrieval labs included 72 MoP total shoulder replacements (TSR), 53 MoP total knee replacements (TKR), 74 MoP total hip replacements (THR), and 170 MoM THR. Hard bearing materials included cobalt-chrome alloys, oxidized zirconium, and titanium alloys. All bearing surfaces were formalin disinfected, cleaned according to the laboratories' standard protocols and stored in padded containers. Characterization methods applied to all devices included digital optical microscopy and visual damage scoring based on scale, shape, distribution and reflectivity. Quantitative surface analysis was performed on selected components using white light interferometry or a coordinate measurement machine.

Results: Damage features were identified and catalogued by each laboratory based on size scale, spatial density, recurrence, and orientation (Figures 1 and 2). Damage modes common to all joint bearings in this study include scratching, pitting, abrasion, and material transfer. For all bearings, scratches tended to align with typical motion paths for the various joints and were visualized as single or grouped features. Some damage features, including scratching and pitting, were identified at different scales for different joints under investigation (Figure 3).

Conclusions: Although these bearings from different joints showed some feature similarities, differences in the damage modes within the MoP, and between MoP and MoM bearings were observed. The different modes are consistent with the different materials, lubrication regimes and loaded motion patterns that exist in the MoM THR compared to the MoP TSR, TKR, and THR.[3,4] Illustrated descriptions of damage modes enabled uniform assessments among the three laboratories. Damage assessment tools originally developed for polyethylene analysis might be applicable to metal bearings at revision; however, distinctions in the conditions leading to damage will be the key in translating such methods for clinical use.[5] Orthopaedic surgeons should anticipate seeing some differences in damage mode appearance during routine inspection of metal bearing surfaces at revision surgery.

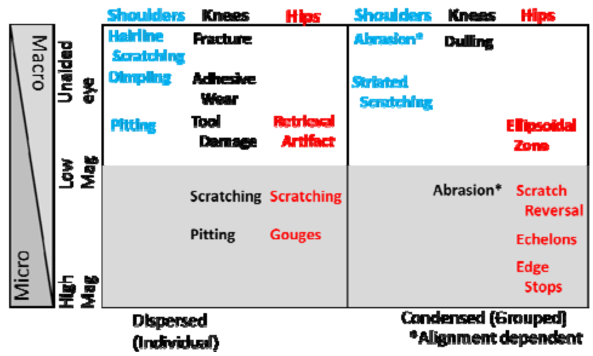

Fig.1: Damage modes on TSR, TKR and MoM THR can be distinguished macroscopically and microscopically.

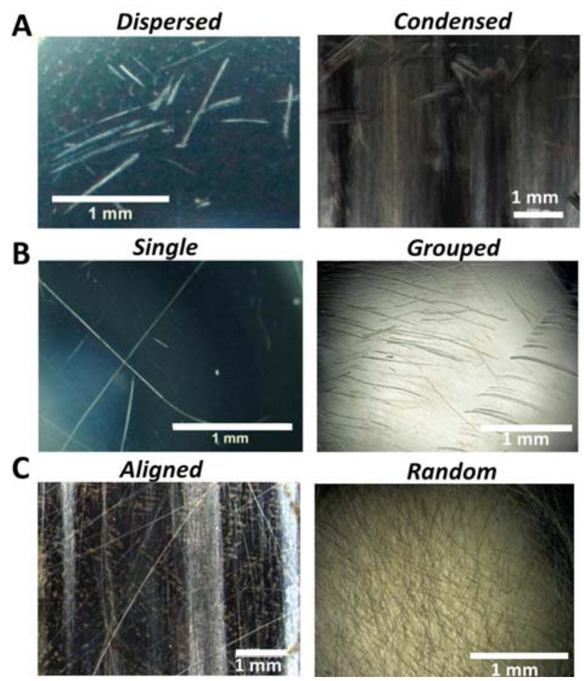

Fig. 2: Characteristics features included A) spatial density, B) recurrence and C) orientation.

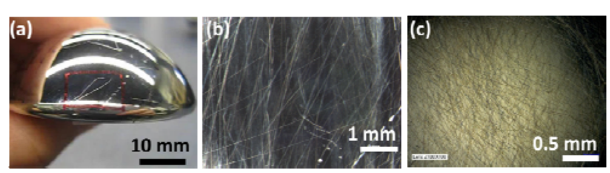

Fig. 3: Scratching damage on (a) TSR, (b) TKR and (c) THR bearing surfaces exist on different size scales.

References: [1]Hood RW. J Bio Mat Res, 1983; 17:829-49; [2]Harman M. J Mat Sci: Mat in Med, 2011; 22: 1137-46; [3]Ansari F. ASME-SBC 2012; P80839; [4]Alvarez E. 58th ORS Ann Mtg. 2012; P1949; [5]Currier JH. AAOS 2012; SE03.