Wear Pattern of Hybrid Ceramic-on-Metal Bearings in Hip Simulator

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Statement of Purpose: A simulator study of hybrid ceramic-on-metal (COM) indicated much reduced wear and metal ion release compared to MOM [1,2]. Thus there is greatly increasing interest in COM performance features such as novel hard-on-hard total hip replacements (THR). However there have been few detailed bearing surface studies of how the hybrid bearings wear between ceramic head and metal cup. Therefore the purpose of our study was to map the extent and types of wear seen on COM compared to MOM bearing in hip simulator according to our previous wear mapping studies [3,4,5].

Methods: Our control THR was a standard 32mm MOM. The femoral heads of 32mm alumina (Biolox-delta^{TM}: CeramTec AG, Plochingen, Germany) and 38mm alumina (Vitox^{TM}: Morgan Advanced Ceramics, UK) were coupled with high-carbon CoCr cups (Biomet Inc., Warsaw, IN). Our orbital simulator used the standard anatomical set up to 1.0 million cycles (Mc) duration. In a previous study, 5 grades of wear were developed to characterize progression in ceramic retrievals [4]. This mapping was fundamental to understand mechanisms and progression of wear. We assessed wear features by reflected light microscopy (RLM) and then characterized these features by scanning electron microscopy (SEM). Progression of abrasion based on scratch length (long; >0.5mm, short; <0.5mm), direction (mono, multiple) and frequency (sparse, dense) of scratch yielded five grades (colors) as follows.

Grade 1 (green): no scratches surface, surface appear perfectly polished .

Grade 2 (yellow): sparse matrix, short and multi-directional scratches.

Grade 3 (pink): sparse matrix, short and mono-directional scratches.

Grade 4 (orange): dense matrix, long and mono-directional scratches.

Grade 5 (red): severe wear, coarsely dense matrix, long and mono-directional scratches.

Results/Discussion: Overall wear rates were 1.58 mm^3/ Mc for MOM, 0.29-0.38 mm^3/ Mc for 32mm COM and 38mm COM. Our studies of 32mm and 38mm COM bearings showed a lower range of wear-rates compared to our control MOM THR. Differential hardness surfaces may lead to reduced adhesive, corrosive wear [2]. In our wear mapping, MOM wear pattern clearly showed larger wear zone and more severe wear grade than COM bearings (Fig.1, 2). Especially, both 32 and 38mm ceramic heads showed less wear zone and grade than CoCr head (Fig. 1) and there was not clearly metal transfer and severe wear such as stripe wear on ceramic heads. Retrievals of COC bearings has shown a certain incidence of stripe wear and from our laboratory studies we know that microseparation test mode create stripe wear and elevated wear rates by an order of magnitude [3,4]. In case with MOM impingement, a more severe stripe wear has been reported [6]. However, in the COM, no stripe wear was seen on ceramic head under microseparation mode due to differential hardness [2]. Overall our study was therefore basically in agreement with prior published COM concepts showing reductions in wear levels and wear performance compared to control MOM bearings.

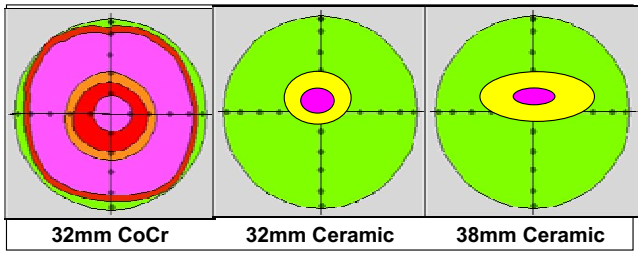

Fig. 1. Comparison of ball wear mapping for 32mm MOM, COM and 38mm COM at 1.0 Mc.

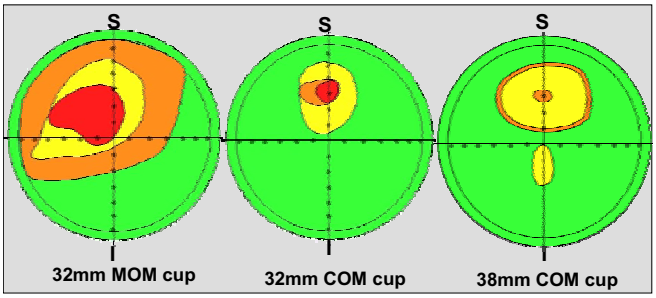

Fig. 2. Comparison of cup wear mapping at 1.0 Mc.

Conclusions: Our study appeared to confirm potential advantages of low wear compared to our control MOM and our mapping provides COM would be a reasonable and compatibility bearing surface for use in THR.

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References:

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