Debris from Combinations of Alumina Versus Alumina Matrix Composite: a Hip Simulator Model with Microseparation Test Mode

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Statement of Purpose: Ceramic-on-ceramic (COC) total hip replacements (THR's) have been used successfully in Europe and Japan for more than twenty years [1-3]. Since 2003 COC THR have been used in the US [3]. It has also been demonstrated that the microseparation test mode (MSX) is important in the wear of all-ceramic THR [3-5]. However, little is known about the wear particles. Alumina matrix composite (AMC) has been tested and shown to have comparable physical properties, yet improved wear compared to alumina [4,5]. Therefore, the objective of this study was to investigate the wear debris from these two combinations of ceramic materials (alumina and AMC) under MSX.

Methods: Femoral balls and liners of alumina (Al) (Biolox-forte, CeramTec, Germany) and alumina matrix composite (AMC) (Biolox-delta, CeramTec, Germany) were run on a commercial hip simulator (Shore Western, Monrovia, CA). Four ceramic combinations were studied (Table 1). A Paul load curve (max load 2kN) was used with alpha-calf serum (Hyclone®, Ogden, UT) as the lubricant (diluted to 10mg/ml of protein). The liner was position at an angle of 50º to the horizontal and 2mm of micro-separation (MSX) was introduced in each cycle. Lubricant samples were collected at 500,000 cycles for wear debris analysis and approximately 90ml was processed. The proteins were digested with HCl acid (2ml HCl to 1ml serum) and washed. The samples for each group were subsequently filtered through a 0.1µm pore polycarbonate filter. The filters were examined with SEM and particle morphology computed with commercial software (Image J, NIH). The equivalent circular diameter (ECD), aspect ratio (AR), and circular shape factor (CSF) were measured. Descriptive statistics were performed (Table 1, Figure 1).

Results / Discussion: Approximately 240 to 600 particles were analyzed for each group (Table 1). There were notable differences in the particle size (ECD) for the four bearing combinations (Figure 1). The Al/Al combination exhibited the smallest size of debris. The AMC/AMC in general demonstrated larger size (>2microns) particles than Al/Al. This resulted in a 2-fold increase in the median ECD for AMC/AMC compared to Al/Al (Table 1). Yet, the AMC/AL distribution overall was comparable to the AMC/AMC (Figure 1). The order from lowest to highest median ECD for the four groups was Al/AL < AMC/AMC, AMC/AL < Al/AMC. The Al/AMC group showed about a 4-fold increase compared to AMC/AMC (Table 1). Very little, if any difference for aspect ratio or CSF was seen between any groups.

Conclusions: The ceramic combination affected the median size of the debris. The order from lowest to highest median ECD for the four groups was Al/Al < AMC/AMC, AMC/Al < Al/AMC. There was little change in particle shape between the four ceramic combinations.

Table 1: Statistics for the morphological data from the four ceramic groups (mean ± std and [median] for each parameter and group).

	ECD	AR	CSF
Al/Al (N=592)	0.79 ± 1.11 [0.49]	1.56 ± 0.38 [1.50]	0.79 ±0.09 [0.80]
AMC/ AMC (N=260)	1.24 ± 1.72 [0.76]	1.61 ± 0.44 [1.51]	0.79 ± 0.10 [0.80]
AMC/Al (N=307)	1.57 ± 3.35 [0.75]	1.56 ± 0.43 [1.45]	0.77 ± 0.10 [0.78]
Al/AMC (N=239)	4.29 ± 4.07 [2.98]	1.69 ± 0.58 [1.58]	0.74 ±0.11 [0.76]

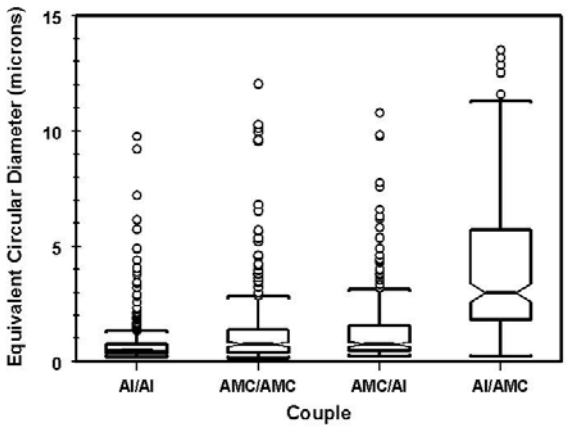

Figure 1: Box plot of the size (ECD) for the four ceramic combinations (500,000 cycles).

References: [1] H. Oonishi et al., *J Biomed Mater Res* **70A**, 523-32, 2004. [2] A. Gustafson, I. C. Clarke, Proc 16th Ann Symp Int Soc Tech Arthroplasty, San Francisco, California, Sept 24-27 2003. [3] T. Shishido *et al.*, *J Biomed Mater Res* **67B**, 638-47, 2003. [4] J. Nevelos *et al.*, *J Arthroplasty* **15**, 793-5, 2000. [5] D. D. Green *et al.*, 51st Ann Meet Ortho Res Soc, Washington D. C., Feb. 20-23, p. 239, 2005.

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