IN-VITRO WEAR OF AL2O3 / AL2O3 IMPLANT COMBINATION WITH OVER 10 MILLION CYCLES DURATION

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INTRODUCTION: Rigid-on-rigid ceramic bearings have been in continuous use since 1970. With the increased concerns over polyethylene (PE) wear debris promoting osteolysis, there has been a renewed interest in rigid-on-rigid combinations. Interest in the USA has focused on CoCr/CoCr THR bearings and contemporary simulator studies have been conducted with bovine serum as the lubricant. Gravimetric wear assessments were used to predict the actual volume of wear debris created. These in-vitro studies examined the effects of implant parameters such as CoCr alloy type, sphericity, surface finish and diametrical tolerances. Diametrical clearance proved to be a very important parameter for optimizing wear performance. Too much clearance created very high contact stresses between rigid femoral head and rigid cup and led to massive wear[1]. On the other extreme, near total-conformity could exacerbate wear problems by making a) sphericity and surface roughness criteria critical, b)difficult for wear debris to exit the wear zone and c)could exclude the lubricant to some extent and exacerbate wear. Chann et al demonstrated that wear of CoCr/CoCr systems increased by 4 times for diametrical clearances increased from 30 to 100 um[2]. There have been no comparably detailed studies of all-ceramic bearings.
The objective of this study was to compare the wear rates of Al_2O_3 / Al_2O_3 bearings. using bovine serum as the lubricant. Three groups with increasing diametrical tolerances were selected to examine the effects of conformity on wear-rates of Al_2O_3 / Al_2O_3 implants.

MATERIALS AND METHODS: Nine 28mm Al_2O_3 / Al_2O_3 acetabular cups with matching femoral heads (Bioceram Div., Kyocera Inc.) were run in a multi-channel hip simulator (Shore Western Manuf. Inc.). The cups were grouped according to diametrical clearance (Grp 1 = 20-30 µm; Grp 2 = 60-70 µm and Grp 3 = 90-100 µm). The cups were run non-anatomically with a Paul load profile (max = 2000N) at 1Hz and 90% bovine serum (Hyclone Laboratories) with additives (Sodium Azide and EDTA) as the lubricant. Wear was determined by the weight-loss method for both cups and heads. The heads were weighed with the taper cone to avoid metal transfer during the removal process. The test duration was 10.3 million cycles and volumetric wear-rates (linear regression) were calculated using the specific density (Al_2O_3 = 3.97 mg/mm^3).

RESULTS: Wear of the acetabular cups was minimal with a weight loss of 0.03mg/10^6cycles for groups 1 & 2 and 0.02mg/10^6cycles for group 3. These weight losses corresponded to a volumetric wear rate of 0.007mm^3/10^6cycles (groups 1 &2) and group 3 was 0.006mm^3/10^6cycles (Fig. 1 & 2). Conversely, the heads gained weight at a rate of 0.02, 0.04 and 0.05 mg/10^6cycles for groups 1, 2 and 3 respectively. Equivalent volumetric wear–rates were 0.006, 0.012, and 0.14 mm^3/10^6cycles respectively. The wear was so minimal that there was no significant difference between the three diametrical clearances for either the cups or heads.

DISCUSSION: This appeared to be the first simulator wear study of 28 mm diameter Al_2O_3 / Al_2O_3 combinations run with serum lubrication with a duration of over 10 million cycles. Previous simulator tests have been conducted with water, saline or Plasmion™ as the lubricant[3]. The diametrical clearance did not seem to have an effect on the wear rate of the Al_2O_3 / Al_2O_3 combination. The weight gain of the femoral heads could be due to contaminants that may have penetrated the interface between taper-cone and head during the wear tests. The risk was that removal of the taper cones could have resulted in the intermittent transfer of cone material and thus affected the wear assessment. The weigh process for the heads will be modified in the next phase from 10 to 15 million cycles.

The acetabular cups exhibited extremely low wear-rates corresponding to a volumetric loss of 0.006 to 0.007 mm^3/10^6cycles. This is an 8 to 10 thousand difference in wear when compared to UHMWPE on ceramic. This study will be continuing with further emphasis on the wear of the ceramic heads.

	Group 1		Group 2		Group 3	
	Cup	Ball	Cup	Ball	Cup	Ball
Wear Rate	-0.007	0.006	-0.007	0.012	-0.006	0.014
Precision	56%	85%	65%	63%	75%	43%

Table 1 Al_2O_3 volumetric wear rates (mm^3/10^6cycles) and precision for the three diametrical clearance groups (Grp 1 = 20-30 um; Grp 2 = 60-70 um and Grp 3 = 90-100 um).

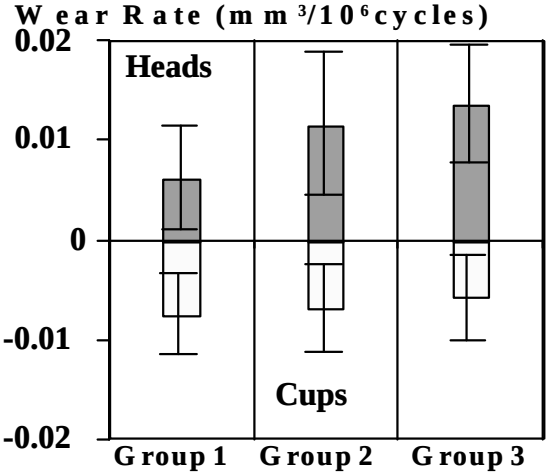

Fig. 1. Volumetric wear rates for Al_2O_3 acetabular cups (weight loss) and femoral heads (weight gain) for the three groups of diametrical clearances (Grp 1 = 20-30 um; Grp 2 = 60-70 um and Grp 3 = 90-100 um).

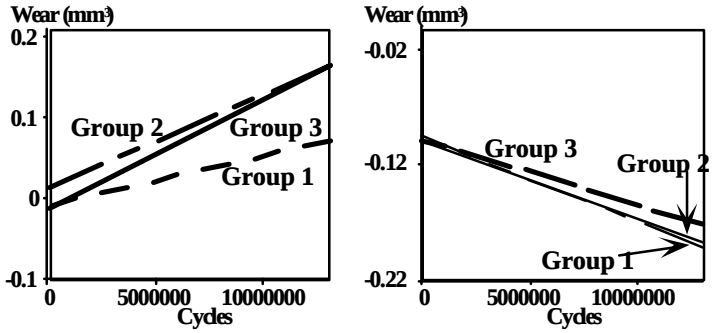

Fig2 A) Al_2O_3 Femoral heads showing wear trends (gain) for 10.3 million cycles. B) Matching Al_2O_3 Acetabular Cups showing wear (loss) for the 3 groups at 10.3 million cycles.

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