Wear Rate Comparison of Textured Versus Untextured Ultra High Molecular Weight Polyethylene with Hydroxylapatite Particles Simulating Third Body Wear Debris using a 1N HCl Cleaning Technique

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Statement of Purpose: The wear rate of Ultra High Molecular Weight Polyethylene (UHMWPE) has been correlated to both contact area and contact stress in the literature, [1], [2]. In both publications and this experiment, UHMWPE articulating with a polished surface of cobalt-chromium alloy were evaluated using a Pin-on-Disk (POD) apparatus implementing bi-directional movement. In [3], the wear rates of three (3) different Textured XLK POD Pins with contact surface areas of 8.26mm² (T390), 31.77mm² (T391), and 33.22mm² (T392), were compared to the wear rates of three (3) untextured XLK POD Pins each with contact surface areas of 71mm². For the purposes of this experiment, the contact area was dependent on the POD pin design found to have the best wear results, namely T390.

The textured XLK POD pins did not involve the reduction of the POD pin's diameter as was done in both of the aforementioned publications [1] and [2], but rather the contact surface area reduction involved an intricate design pattern while maintaining the original diameter of the POD pins. T390 was found to have the lowest rate of the three textured XLK POD Pins.

In this experiment, Hydroxyapatite (HA) particles were introduced into the serum in order to simulate third body wear debris and its impact on wear performance with the T390 Pod Pin and an untextured POD pin. A 1N HCl cleaning solution was used to clean both the T390 and untextured POD Pins to ensure that the HA particles were completely removed after each test cycle. This was done to make certain that the weight measurements of the POD pins did not include the weight of residual HA particles.

Methods: The GUR 1020 resin XLK POD Pins were gamma irradiated to 50kGy and then remelted. Three (3) T390 POD pins (Figure 1) and six (6) untextured XLK POD Pins were used in this experiment. Three (3) untextured XLK POD Pins were tested against three T390 POD pins. The other three (3) untextured XLK POD Pins were used as soak controls. Each pin articulated against a polished, high carbon wrought CoCr metal alloy counterface (ASTM F1537; diameter = 38.1 mm; thickness =12.7 mm). Wear rate tests were for 1.98 million cycles.

In order to perform the t-test analysis, the wear rates for each pin were given by the slope of the linear regression line through the individual data points (cycle count, cumulative wear), excluding the (0, 0) point.
A measure of 0.14mg of HA particles was used in each 250mL of serum. With the exception of test run 0.66 million cycles, each test cycle included sonication of both textured and untextured POD Pins in 1N HCl for 30 min to remove any remaining HA particles prior to cleaning and weighing. The p- value was calculated using a two-sample T-test utilizing the statistical program Minitab. The p-value calculation assumed a 95% confidence interval and assumed equal variances.

Results: The wear rates means (milligram per million cycles +/- 1 standard deviation) for the T390 and untextured POD pins were 3.3 +/- 0.23 and 7.5 +/- 0.85. The calculated probability p value for the wear rate means was p = 0.015. Therefore, the differences between the wear rate means of both the T390 Pins and untextured XLK POD Pins were statistically significant.

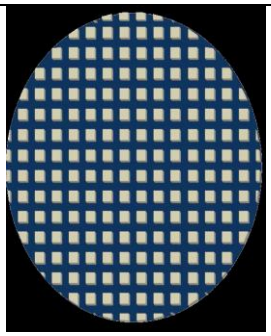

Figure 1: T390 Contact surface area of 8.26mm²

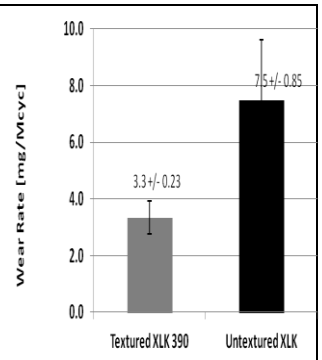

Figure 2: Difference in the wear rate means (Mg/Mcyc +/- 1SD) between the textured and untextured XLK POD pins.

Conclusions: The purpose of this experiment was to determine the impact of HA particles simulating third body wear debris on the wear rate performance of both low-wear textured XLK and untextured XLK POD Pins. The wear rate means were found to be 3.3 +/0.23 and 7.5 +/- 0.85 for T390 and the untextured POD pins respectively. The p-value calculated was 0.015 and therefore less than the predetermined alpha value of 0.05. Therefore, the statistical significance calculated is unlikely to have occurred by chance alone.

References:

[1] Mazzuco, M. Spector, Wear 254(2003) 514-522
[2] C N, Ernsberger, D.Whitaker, J. Chavarria, 2007 53rd Annual Meeting of the Orthopaedic Research Society, Poster No: 1801
[3]. S.A, Woods, M. Ross, C. Maag, A. Schlachter, 2013 Society for Biomaterials Conference, Poster No: 723