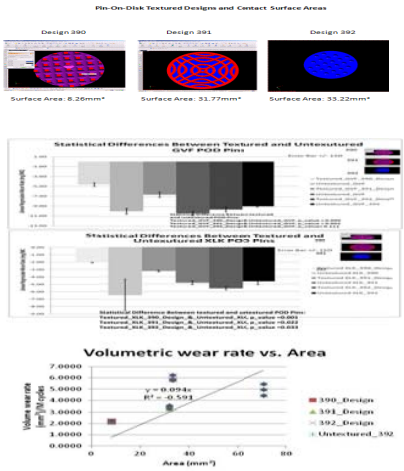
Wear Rates of Ultra High Molecular Weight Polyethylene (UHMWPE) uncorrelated to Contact Area

Sherrod A. Woods, Michelle A. Ross, Chase Maag and Adam Schlachter
Materials Research, DePuy Orthopaedics, Warsaw, IN 46581 USA

Statement of Purpose: The wear rate of Ultra High Molecular Weight Polyethylene (UHMWPE) in joint replacements has been correlated to both contact area and contact stress in the literature, [1], [2]. In both publications and our 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 the Mazzuco and Spector [1] publication, volumetric wear was found to be independent of normal load and dependent upon increasing contact area. However, the Mazzuco and Spector results also demonstrated that an increase in contact stress brought about a twofold *decrease* in wear rates. The Ernsberger, et. al. publication [2], found that at maximum cross-shear, wear is proportional to nominal contact area and wear factors normalized to area are more appropriate than load based wear factors. In both of the aforementioned studies, the contact surface areas of the POD pins were reduced by decreasing the diameters of the POD Pins. For the purposes of this experiment, the contact area was dependent upon different POD Pin design types, hereafter referred to as "textured" POD Pin designs. There were three (3) textured POD Pin designs. The textured POD Pins did not involve the reduction of the POD Pin's diameter as was done in both publications. But, rather the contact surface area of the textured POD Pins involved intricate design patterns while maintaining the *original* diameter of the POD Pins.

Methods: Two different polyethylene materials were evaluated. Both were comprised of GUR 1020 resin. The GVF group was gamma irradiated to 40kGY in a vacuum package. The XLK group was gamma irradiated to 50kGy in a vacuum package and then remelted. Nine (9) textured (XLK) POD Pins and nine (9) untextured GVF POD Pins were used in six (6) tests. Three (3) untextured GVF and XLK POD pins were tested against three (3) textured GVF and XLK POD pins respectively for each of the textured designs, i.e.390, 391 and 392 The other nine (9) untextured XLK and GVF POD pins were used as soak controls for each textured XLK and GVF POD Pin design. Textured POD Pin designs 390, 391 and 392 reduced the normal POD contact surface area of 71mm² to 8.26 mm², 31.77 mm² and 33.22 mm² respectively. 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.

Results: The three different textured POD Pin designs are illustrated in Figure 1. In Figure 2 designs 390 and 391 textured GVF POD Pin wear rates were statistically significant as compared to the untextured GVF POD Pin, while design 392 was not statistically significant (p_value =0.111). In Figure 3 the textured XLK POD Pin wear rates were statistically significant for all three textured POD Pin designs as compared to the untextured XLK POD Pin wear rates. Figure 4 illustrates the volumetric wear rates vs. the contact surface areas of each textured POD Pin Design as well as the untextured POD Pin.



Conclusions: Three textured POD Pin designs; designated as design 390, 391and 392 had contact surface areas of 8.26mm², 31.77 mm² and 33.22 mm² respectively. The untextured POD Pins had a contact surface area equal to 71mm². The wear rates of both the GVF and XLK textured 390 and 391 designed POD Pins were statistically significant in terms of a reduction in wear as compared to the untextured GVF and XLK POD Pins. The wear rates of the GVF and XLK textured 392 POD pins were greater than the untextured GVF and XLK POD Pins. The wear rates between the untextured GVF POD Pins and the textured 392 POD Pins was not statistically significant.

However, the wear rates between the textured XLK POD Pins and the textured 392 design POD Pins were statistically significant. The reduction of contact surface area for POD Pin designs 390 and 391 correlated with a reduction in wear rates. The reduction of contact surface area for POD Pin design 392 did not correlate with a reduction in wear rates.

References:

[1].D. Mazzuco, M. Spector, Wear 254(2003) 514-522
[2].C N, Ernsberger, D, Whitaker, J, Chavarria, 53rd Annual Meeting of the Orthopaedic Research Society, Poster No: 1801

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