EFFECT OF FEMORAL HEAD SIZE AND MATERIAL AND SERUM CONCENTRATION ON THE WEAR OF 5 MRAD CROSSLINKED- REMELTED UHMWPE ACETABULAR CUPS

Introduction: Acetabular cups fabricated from moderately crosslinked-remelted UHMW polyethylene (PE) have shown a substantial improvement in wear resistance over historical polyethylenes, both in laboratory wear tests (1) and in early clinical follow-up (2,3). To date, the majority of clinical use has involved cobalt-chromium alloy femoral heads of 32 mm or smaller. However, the use of 36 mm heads can improve the range of motion and help to reduce the incidence of dislocation, and the introduction of high-strength, scratch resistant ceramic heads may reduce the wear rate of the crosslinked polyethylene, particularly in the presence of third-body abrasives. This study evaluated the wear resistance of Marathon™ moderately crosslinked-remelted cups as a function of ball material, ball diameter, and lubricant concentration.

Materials and Methods: Extruded bars of GUR 1050 UHMW polyethylene (Poly Hi – Solidur, Ft. Wayne, IN) were placed in foil bags, flushed with inert gas, evacuated, crosslinked using 5 Mrads of gamma radiation, remelted to extinguish free radicals, and then machined into acetabular cups of 28 or 36 mm I.D. Final sterilization was by gas plasma.

The PE cups were placed in Pinnacle® titanium alloy shells (DePuy Orthopaedics, Warsaw, IN), mounted in an OBMP-type hip simulator (Shore Western, Monrovia, CA) in the inverted position using urethane molds, and then were tested against femoral balls of ASTM F-1537 CoCrMo or Delta® ceramic (DePuy Orthopaedics), under a Paul-type load (2000 N max.) at 1 Hz. The lubricant was bovine serum (HyClone, Logan, UT). Three cups were tested with each of the four combinations of diameter and ball material. The protein concentration was 63 mg/ml (~ 90%) from zero to 5 million cycles, and then diluted with distilled water to 17.5 mg/ml (~ 25%) from 5 to 7 million cycles. At both protein concentrations, the serum contained 0.2% sodium azide and 20mM EDTA. At 500K cycle intervals, the cups were cleaned ultrasonically, vacuum desiccated and then weighed to determine the weight loss. Desiccated samples were ground to a 35-mesh powder and the volume loss was converted to volumetric wear using a linear regression, and the mean values were compared using a t-test.

Results: Comparing ceramic and CoCr heads, the mean PE wear rate was slightly higher with 36 mm ceramic in 90% serum, but was lower with ceramic in the other three combinations of ball diameter and serum (Table.). However, due to the overall low wear rates with the moderately crosslinked PE, combined with the overlap among the individual wear rates (S.D.), these differences had low statistical certainty (p-values from 0.15 to 0.77, Table.) Comparing low and high concentration serum, in 25% serum, the mean wear rates of the cups were higher by 47% for 28mm CoCr, by 50% for 36mm ceramic, by 71% for 28 mm ceramic and by 136% for 36 mm CoCr (p=0.03, 0.01, 0.30 and 0.03, respectively). For both concentrations of serum, the mean wear rates were higher with the larger ball diameters, i.e., by 64% for CoCr and by 17% for ceramic in the 90% serum, and by 87% for CoCr and by 44% for ceramic in the 25% serum (p = 0.45, 0.05 and 0.28, respectively).

Discussion: In general, the magnitudes of the wear rates in this study were comparable to the range that has been reported for 5 Mrad-remelted PE in prior tests (1). The higher wear rates in the lower concentration serum may reflect the function of protein as a boundary lubricant (4). Although there was the confounding variable that the higher concentration of serum was used earlier in the test, in previous studies, the mean wear rates of 5 Mrad-remelted poly cups have remained relatively stable after initial wear-in, suggesting that the increase after 5 million cycles in the present study was primarily due to the change from 90% to 25% serum.

The wear rates exhibited by 5 Mrad-remelted polyethylene in this study represent a substantial improvement over historical polyethylenes (i.e., either non-irradiated, or gamma-sterilized in a low oxygen atmosphere.) Continued testing will include the effects of third-body abrasion, in which the advantage of the harder ceramic heads over the CoCr alloy will likely be greater than that exhibited under the clean conditions of the present study (5).

We acknowledge in part the financial support provided by DePuy Orthopaedics, Inc. and the Los Angeles Orthopaedic Hospital Foundation.