

# WEAR TESTING OF CROSSLINKED AND CONVENTIONAL UHMWPE AGAINST SMOOTH AND ROUGHENED FEMORAL COMPONENTS

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## INTRODUCTION

Various formulations of crosslinked UHMWPE (XPE) have demonstrated improved wear resistance in comparison to non-crosslinked, conventional UHMWPE (CPE) when articulated against pristine CoCr femoral components in-vitro. However, CoCr femoral components are prone to in vivo scratching. Therefore, the sensitivity of XPE to roughened surfaces needs to be evaluated. An option to overcome the effects of in vivo roughening is the use of microabrasion-resistant counterbearing materials, such as surface oxidized Zr-2.5Nb (OXINIUM™) [1]. The objectives of this study were to measure wear of CPE and XPE against smooth CoCr and OXINIUM components, and to evaluate the sensitivity of CPE and XPE to roughened CoCr surfaces.

## METHODS

Tibial inserts were manufactured from compression-molded GUR 1020 UHMWPE (Poly-Hi Solidur, Ft. Wayne, IN). The UHMWPE was either untreated (no crosslinking) or crosslinked by gamma irradiation to 5 Mrad (5-XPE) or 7.5 Mrad (7.5-XPE) and then melt annealed. Tibial inserts were ethylene oxide sterilized.

CoCr femoral components were roughened by tumbling in a centrifugal barrel mass-finisher for approximately 30 seconds in a 25 µm alumina powder and plastic cone media (133g alumina powder, 1274g plastic cones, 500 ml water). Roughness Ra, Rpm, and Rpk were measured after tumbling but before wear testing using a contact profilometer with a 2µm radius stylus tip (Table 1). Roughness measurements were made at ten pre-selected locations from 0 to 45 degrees of flexion on each condyle of each femoral component.

	Smooth CoCr	Roughened CoCr
Ra	0.035 ± 0.004	0.077 ± 0.009
Rpm	0.140 ± 0.013	0.510 ± 0.057
Rpk	0.066 ± 0.008	0.253 ± 0.022

Table 1. Mean roughness values ± standard deviation (µm) of smooth and roughened CoCr femoral components (n=9).

Previously used simulator inputs [2] based on a study of healthy patients [3] were modified for this study (Figure 1). Simulator studies (6-station knee simulator, AMTI, Boston, MA) were conducted at 1 Hz to five million cycles. The lubricant was alpha calf fraction (Hyclone Labs, Logan, UT), with sodium azide and EDTA, diluted to 50% to obtain a protein concentration of approximately 20 mg/ml.

The serum solution was replaced, and the tibial inserts were weighed weekly. Gravimetric measurements were corrected for fluid absorption using soak controls and converted to volumetric measurements using the UHMWPE density (0.93g/cm<sup>3</sup>). Wear rates were determined by linear regression of volume loss vs. cycles. A single factor analysis of variance was used to determine statistical differences.

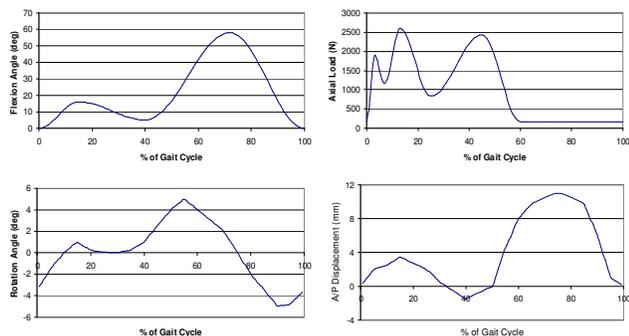


Figure 1. Knee simulator inputs

## RESULTS

The predominant wear feature displayed on the articular surface of the tibial inserts was burnishing. There were no signs of fatigue wear or of delamination. The mean wear rates (± standard deviation) of 7.5-XPE, 5-XPE and conventional UHMWPE (CPE) tibial inserts articulating against smooth CoCr femoral components were 6.4 ± 0.6 mm<sup>3</sup>/Mcycle, 10.9 ± 0.9 mm<sup>3</sup>/Mcycle, and 23.4 ± 2.4 mm<sup>3</sup>/Mcycle, respectively. The mean wear rates of 7.5-XPE, 5-XPE, and CPE articulating against rough CoCr femoral components were 24.0 ± 1.2 mm<sup>3</sup>/Mcycle, 32.5 ± 0.7 mm<sup>3</sup>/Mcycle, and 41.2 ± 2.3 mm<sup>3</sup>/Mcycle, respectively. Statistically significant reductions in polyethylene wear rates were seen with increases in irradiation dose for inserts tested against both smooth and roughened CoCr femoral components (p<0.01). Roughening of the femoral components resulted in 1.8, 3.0, and 3.7 times increases in wear rates for the CPE, 5-XPE, and 7.5 XPE inserts, respectively.

The mean wear rates of 7.5-XPE, 5-XPE, and CPE tibial inserts articulating against smooth OXINIUM components were 1.4 ± 0.2 mm<sup>3</sup>/Mcycle, 5.0 ± 1.3 mm<sup>3</sup>/Mcycle, and 11.7 ± 1.9 mm<sup>3</sup>/Mcycle, respectively. This represents statistically significant wear reductions of 79%, 55%, and 50% in comparison to 7.5-XPE, 5-XPE, and CPE articulated against smooth CoCr, respectively (p<0.01). A comparison of the wear rates appears in Figure 2.

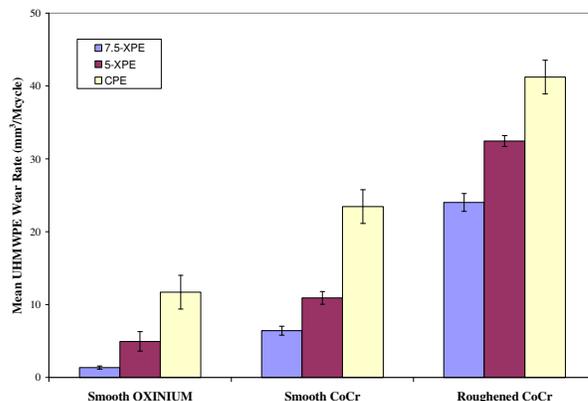


Figure 2. Comparison of volumetric wear rates (± standard deviation)

## DISCUSSION

Against either smooth or roughened CoCr, 7.5-XPE had the lowest wear rate, followed by 5-XPE and CPE. However, against roughened CoCr femoral components, the advantage of crosslinking decreased. The increased sensitivity of XPE to abraded surfaces is likely related to the associated reduction of material and mechanical properties, including toughness, elongation to break, and tensile strength [4,5]. Additionally, the use of micro-abrasion resistant OXINIUM femoral components in conjunction with crosslinked tibial inserts resulted in more than a 50% wear reduction over pristine CoCr components.

This study shows that 5 and 7.5 Mrad crosslinked compression-molded GUR 1020 UHMWPE tibial inserts wear less than their conventional UHMWPE counterparts against smooth and roughened counterfaces. However, device performance under PS post fatigue and posterior edge loading conditions for high flexion designs should also be considered when determining the appropriate irradiation dose.

**REFERENCES:** [1]Spector et al., *J Bone Joint Surg*, 83-A Suppl 2 Pt 2, 2001:80-86 [2]McEwen et al., *Trans Society for Biomaterials*, 2005:98 [3]Lafortune et al., *J Biomechanics*, 25(4), 1992:347-357 [4]Muratoglu et al., *Trans ORS* 1999:77 [5]DiMaio et al., *Trans ORS* 1999:100

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