Effect of Anatomic and Inverted Test Position on the Wear of Crosslinked UHMWPE Liners in a Hip Simulation Study

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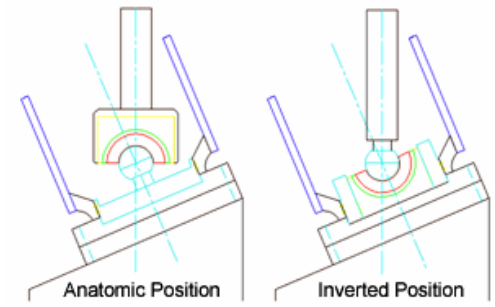
Statement of Purpose: Utilization of multidirectional motion in hip wear simulations is recommended for the production of clinically relevant wear rates [1]. However, the orientation of tested specimens throughout these wear simulations varies between laboratories [2-3]. This study is to compare the wear rates of anatomic and inverted orientations of crosslinked UHMWPE liners on a 12-station orbital bearing motion hip simulator.

Materials & Methods: Crosslinked UHMW polyethylene materials, Gamma Vacuum Foil (GVF) and Marathon, were evaluated. For the GVF, liners were machined from GUR 1020 extruded bars and gamma sterilized at 4 Mrads in vacuum foiled bags. For the Marathon, extruded bars of GUR 1050 UHMWPE were vacuum packaged in foil bags and gamma irradiated at 5 Mrads. The bars were remelted to extinguish free radicals, then, cooled down and machined into acetabular liners of 28 mm ID.

The liners were further divided into four test groups, each of which contained three liners to be tested in either the anatomic (head below liner) or inverted (head above liner) orientation (Figure 1). These liners were tested against CoCr heads with a 28mm nominal diameter.

Figure 1: Test Specimen Orientation

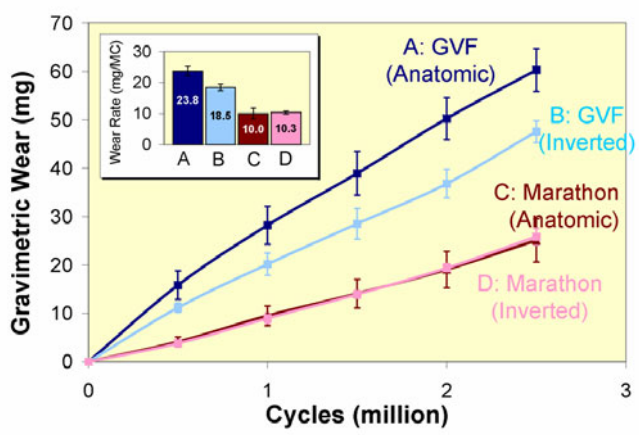


The test was conducted on a 12-station hip simulator (Shore Western, Monrovia, CA). The Paul load curve of gait (max load 2000N) was applied to the specimens, which were seated at a 23° stem angle on the rotary drive system, creating an orbital bearing motion [4]. The test was run at 1 Hz for a total of 2.5 million cycles (M.C.). Each bearing couple was lubricated with bovine serum (HyClone, Logan, UT), which was pre-treated with 2 mM EDTA and Sodium Azide (0.2% w/v), resulting in 90% of original serum concentration. Serum was changed every 0.25 million cycles. Polyethylene wear was calculated from the weight loss of the liners every 0.5 million cycles, with load soak controls to correct for fluid absorption.

A two-tailed equal variance t-test was utilized to analyze differences in wear rates between test groups.

Results/Discussion: The cumulative wear and average wear rates of each test group are shown in Figure 2 and Table 1. The wear rate of the anatomically oriented GVF liners was 29% higher than that of the inverted GVF specimens. In contrast, the wear rate of the Marathon liners did not demonstrate a statistically significant difference in wear rates between the two test positions. The former trend likely indicates that the divergence in wear rates for the two test setups in GVF liners resulted from decreased serum lubrication and increased contact area at the joint interface in the anatomic setup, while the latter trend likely signifies a greater ability of Marathon to withstand adverse loading conditions.

Figure 2: Cumulative Wear



Wear rates of the GVF liners were higher than those of the Marathon liners in both test setups, with anatomic GVF specimens portraying a wear rate 138% higher than that of the anatomically oriented Marathon liners and inverted GVF specimens demonstrating a wear rate 80% higher than that of the inverted Marathon liners. These data suggest that the comparative wear properties between UHMWPE materials remain constant, regardless of specimen orientation.

Table 1: Wear Summary

Group ID	A	B	C	D
Material	GVF	GVF	Marathon	Marathon
Orientation	Anatomic	Inverted	Anatomic	Inverted
Wear Rate (mg/M.C.)	23.8 ± 1.6	18.5 ± 1.0	10.0 ± 1.8	10.3 ± 0.5
p-value	A<B (0.01), B>C (0.005), C<D (0.78)			

Conclusions: The results indicated that GVF liners experienced a higher wear rate than Marathon liners, regardless of specimen orientation. The wear rate of GVF liners also demonstrated a greater sensitivity to the orientation of the test stations than that of the Marathon specimens.

References: [1] Saikko, et al., J Biomech 2002, v35:455-464. [2] McNulty, et al., SFB 2006, p220. [3] Bowsher, et al., SFB 2006, p547. [4] Paul, Proc Inst Mech Eng 1967, v23: 8-15.