IN VITRO WEAR OF UHMWPE ARTICULATING AGAINST EXPLANTED AND NEW Co-Cr-Mo FEMORAL COMPONENTS

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Introduction
The wear of ultra high molecular weight polyethylene (UHMWPE) tibial inserts used in total knee arthroplasty depends on their material properties, degree of crosslinking, applied kinematics and the surface topography of the counterface femoral components. Artificially scratched femoral components have been shown to produce more wear than smooth ones when articulated against polyethylene inserts in vitro (1). Muratoglu et al. (2) generated in-vitro wear data using explanted (in-vivo roughened) femoral components and established that the wear benefits of e-beam crosslinked implants over conventional materials were preserved. The counterface scratch characteristics that could affect the wear of polyethylene inserts include their orientation relative to articulation direction, presence of built-up edges, the built-up edge apex angle (α) and height of the built-up edge (h). Cutting or ploughing of polyethylene surfaces may occur depending on acute or obtuse built-up edge apex angle of the counterface scratches. This study was undertaken to further investigate the effect of in-vivo generated scratches on the wear of polyethylene inserts.

Materials and methods
Seventeen cruciate-retaining and posterior-stabilized explanted femoral components (NexGen® CR, size E, Zimmer Inc., Warsaw, Indiana) were used in this study. To characterize the explant surfaces, the average surface roughness (R_a) and geometrical parameters (α and h) of three hundred scratches were measured using a Zygo optical interferometer and analyzed using Buttery and Archard’s method (3). Three representative CR knees from the explants and three new ones were articulated against unaged 37 kGy gamma irradiated (conventional) and 65 kGy electron beam crosslinked polyethylene tibial inserts at 1.1 Hz on an AMTI (Watertown, MA) simulator under normal walking gait for 2.5 million cycles with undiluted bovine calf serum lubricant. The conventional inserts were first articulated against the femoral components for two million cycles. The femoral components were then cleaned and articulated against the crosslinked inserts. The wear of the articular surfaces was determined gravimetrically with polyethylene fluid absorption correction. The wear results were statistically analyzed using a Student’s t-test with a confidence level set at 95%.

Results and Discussion
Figure 1 shows the surface features of the new and explanted femoral components. Scratches on the explants were grouped into several domains that were randomly distributed on the articular surfaces. The scratches were mostly oriented along the anterior-posterior direction. Figure 2a, which shows a photograph of an explanted polyethylene insert that was mated against one of the analyzed explanted femoral components clearly reveals the presence of embedded bone cement particles. The minimum (gray), average (white) and maximum (black) R_a of the new and explanted femoral components is shown in Figure 2b. The explanted femoral components were not significantly rougher than the new ones even after 54 months in vivo. Figure 3 shows typical interferometer traces across the scratches and the built up edge apex angle distribution on the explanted femoral components. Sixty six percent (66%) of the analyzed scratches had no built up edges (Figure 3a). These would likely not participate significantly in any material removal during articulation. The built-up edge (Fig. 3b) apex angle distribution on the remaining 34%, reveal that they are mostly obtuse (Fig. 3d). The depth of the scratches ranged from 0.05 μm to 1 μm in agreement with the results of Levesque et al. (4). Figure 4 shows the evolution of weight loss of conventional (Gamma sterilized in nitrogen) and crosslinked polyethylene tibial inserts articulated against new and explanted femoral components after 2.5 million cycles. Both types of femoral components produced statistically significant less wear on the crosslinked inserts than on the conventional ones (p < 0.0005) in disagreement with the results of Widding et al. (5). There was no statistically significant difference between the wear produced on crosslinked polyethylene inserts articulated against the explanted and new femoral components.

Conclusion
These studies show that the explanted Co-Cr-Mo femoral components were not severely damaged after 54 months in vivo. The clinically relevant in vivo generated scratches on the femoral components were mostly oriented in the anterior-posterior directions and were not detrimental to the wear performance of these implants when tested in vitro. Both new and retrieved femoral components produced statistically significant less wear on crosslinked polyethylene inserts than on conventional ones.