HIP SIMULATOR EVALUATION OF THE EFFECT OF FEMORAL HEAD SIZE AND LINER THICKNESS ON THE WEAR OF SEQUENTIALLY CROSSLINKED ACETABULAR LINERS.

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INTRODUCTION:
A larger femoral head size reduces the incidence of hip dislocation [1-6] and impingement [7-8]. However, the general concern in the use of larger femoral heads is increased wear [4]. Previous clinical studies of large diameter femoral heads [7] show very low polyethylene wear, which appears to be independent of head size when using highly cross-linked polyethylene. Larger heads are accompanied by a concomitant reduction in liner thickness. A sequential crosslinking and annealing process for treating ultra-high molecular weight polyethylene (UHMWPE) has been developed and previously described [9]. Wear performance combined with functional fatigue characteristics [10] suggest that this material may be applied to larger articular diameter, and thinner acetabular liners. The purpose of this study is to evaluate the influence of polyethylene thickness and femoral head size on the wear performance of the sequentially crosslinked acetabular inserts.

MATERIALS AND METHODS:
A total of 5 sets of test samples were evaluated. Trident® design (Stryker Orthopaedics, Mahwah, NJ) liners with internal diameters ranging from 32mm to 52mm and wall thicknesses from 3.8mm to 7.9mm evaluated here. These liners were machined from compression molded GUR1020 UHMWPE that had been γ-irradiated to 30 kGy followed by annealing 3 times (total dose=90 kGy, X3™). After machining inserts were gas plasma sterilized. A set of control samples (n=12) was machined from GUR 1050 UHMWPE, packaged in a nitrogen environment and then γ-radiation sterilized (30 kGy). The control liners had an internal diameter of 32mm, with a wall thickness of 7.9mm. Appropriate diameter CoCr femoral heads were mated against the inserts. See Table 1 for sample details.

A hip joint simulator (MTS, Eden Prairie, MN) was used for testing with the cups positioned anatomically (superior) and uncannulated and an 50° of abduction. Testing was run at 1 Hz with cyclic Paul curve physiologic loading applied axially, at a maximum of 2450 N [11]. Component assemblies were lubricated using Alpha Calf Fraction serum (Hyclone Labs, Logan UT) diluted to 50% with a pH-balanced 20-mMole solution of deionized water and EDTA (protein level ≈ 20 g/l). The serum solution was replaced and inserts were weighed for gravimetric wear at least every 0.5 million cycles. Dynamically loaded soak control specimens were used to correct for fluid absorption with weight loss data converted to volumetric data (by material density). Statistical analysis was performed using the Student’s t-test (p<0.05). Testing ran for 5 million cycles.

RESULTS:
Results are shown in Figure 1, and Table 1. Statistically significant wear rate reductions of more than 90% were seen for all X3™ inserts compared to the control samples (p<0.009 for all). There was no statistical difference in wear rate between any of the X3™ inserts regardless of size and thickness (p=0.1 for all). Additionally, an average of all X3™ liner wear rates (all sizes) showed a 96% (p=0.00001) reduction compared to the 32mm diameter control liners. Figure 2 and 3 show wear rates plotted against both head size and liner thickness. These plots shows poor correlation between wear rate and head size (R²=0.0251) and poor correlation between wear rate and liner thickness (R²=0.0055). Visual examination of worn inserts revealed typical wear scars and features on the articular surfaces of all sizes/material, including polishing and some scratching.

DISCUSSION AND CONCLUSION:
Wear results demonstrate that during this test, head size or liner thickness did not statistically change wear rate or volume loss for the X3™ liners. These results suggest that this material may be applied to larger articular diameter, thinner acetabular liners. All sizes and thicknesses evaluated here demonstrated significantly lower wear than 32mm controls. Sequentially cross-linked liners up to 52mm in inner diameter and down to 3.8mm in wall thickness are anticipated to clinically outperform predicate control liners.

REFERENCES