Rim Damage in Retrieved 1st and 2nd Generation Annealed HXLPE Hip Liners

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INTRODUCTION: Highly crosslinked polyethylene (HXLPE) was clinically introduced in total hip arthroplasty in 1998 with a goal to reduce wear and wear debris induced osteolysis. Clinical and retrieval studies have shown increased wear performance of the HXLPE articulating surface as compared to conventional and historical controls. However, wear particles can also be produced via different mechanisms, particularly at the rim of the HXLPE liner (e.g., dislocation or impingement. The purpose of this study was to compare the rim damage of 1st Generation Annealed (single dose) and 2nd Generation Annealed (sequentially annealed) HXLPE THA acetabular liners.

METHODS: Eight-nine (89) annealed and sequentially annealed THA liners implanted for ≥5 years were collected at routine revision THA surgery as part of a multi-institutional orthopaedic implant retrieval program. Fifty-seven (57) of the liners were fabricated from Single Dose Annealed HXLPE while 32 were fabricated with Sequentially Annealed HXLPE. For the Single Dose liners, 32 were the Omnifit design, while the rest were the Trident design. All of the Sequentially Annealed liners were of the Trident design. The liners were revised predominantly for: loosening, infection, instability, head disassociation, and ceramic head fracture (albeit in different proportions between the cohorts) (Figure 1). Patient demographics (gender, age, BMI, and activity level) were similar between the two cohorts. The Single Dose Annealed liners were implanted for a longer duration than the Sequentially Annealed liners (Mean Difference=2.5 years, $p<0.001$).

The retrieved liners were inspected for the 7 damage mechanisms first described by Hood. In addition, we noted instances of subsurface whitening that is likely a precursor to delamination. The extent of damage was described as the percentage of the rim exhibited each damage mode. A high-resolution photograph was taken of each liner. Damage was assessed as the extent damage that was present on the hip liner rim. Straight lines were drawn from the edges of each damage mechanism to the center of the hip liner. The angle that was formed by the 2 intersecting lines was measured using publicly available software (ImageJ). A percentage of rim damage was calculated by dividing that angle by 360 degrees.

RESULTS: Rim damage was observed on 46% of Single Dose Annealed liners and 25% of Sequentially Annealed liners Delamination (observed in 33% of Single Dose liners and 6% of Sequentially Annealed liners), subsurface whitening (observed in 16% of Single Dose liners and 3% of Sequentially Annealed liners), burnishing (observed in 19% of Single Dose liners and 6% of Sequentially Annealed liners), and abrasion (observed in 11% of Single Dose liners and 3% of Sequentially Annealed liners) were the damage mechanisms seen in both cohorts. We observed some instances of scratching, however it appeared to be iatrogenic nature. The extent of subsurface whitening, abrasion, and burnishing was similar between the two cohorts ($p>0.07$). The extent of delamination was greater in the Single Dose HXLPE liners than the Sequentially Annealed HXLPE liners ($p = 0.015$). We did not observe any correlation between the extent of any damage mechanism and implantation time, femoral head size, maximum rim oxidation, or implant design ($p> 0.05$).

DISCUSSION: In this study, we analyzed the rim damage mechanisms of retrieved 1st and 2nd generation annealed HXLPE THA liners. Delamination, subsurface whitening, burnishing, and abrasion were the damage mechanisms we observed in these retrieved THA liners. The wear debris generated at the rim by these wear modes are expected to be higher than the wear of the expected articulating surfaces. We did see that the Sequentially Annealed liners had lower levels of damage as compared to Single Dose HXLPE liners, particularly with delamination. The clinical significance of these findings is unclear at this point as the biological response to HXLPE particles is multifactored (e.g., particle size, particle load, etc.).

SIGNIFICANCE/CLINICAL RELEVANCE: Although wear of HXLPE THA liners has been studied for decades, there is considerably less known about the prevalence of wear mechanisms occurring at the rim of THA liners. This study adds to the understanding of damage mechanisms that occur unintendingly at the rim of annealed HXLPE liners used in total hip arthroplasty.

IMAGES AND TABLES:

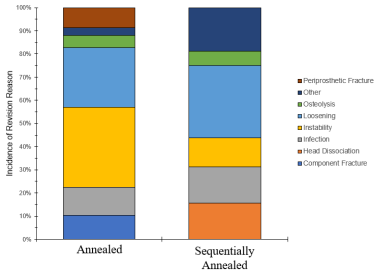

Figure 1: Revision reasons for the two Annealed HXLPE cohorts.

Table 1: Patient Demographics for the 2 Annealed HXLPE cohorts.

	Annealed (n=57)	Sequentially Annealed (n=32)	p-Value
Gender (% Female)	52	44	0.490
Age at Insertion (years)			
Mean ± SD	56 ± 16	54 ± 16	0.452
Median	58	56	
BMI ($^{kg}/_{m^2}$)			0.704
Mean ± SD	30.1 ± 6.2	29.8 ± 7.5	
Median	28.7	30.1	
Implantation Time (years)			
Mean ± SD	9.8 ± 3.2	7.3 ± 1.8	<0.001
Median	9.8	7.3	
Maximum UCLA Score			
Mean ± SD	5 ± 3	5 ± 2	0.452
Median	5.5	5	

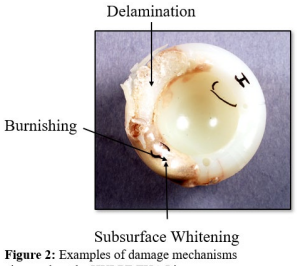

Figure 2: Examples of damage mechanisms observed on the HXLPE THA Liners.