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CORR Insights®: Retrieval Analysis of Sequentially Annealed Highly Crosslinked Polyethylene Used in Total Hip Arthroplasty

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Where Are We Now?

In vivo oxidation of highly cross-linked polyethylene (HXLPE) components, particularly among annealed polyethylenes, resulted in the development of the so-called “second-generation HXLPEs” (defined as

HXLPEs that incorporate manufacturing modifications to improve minor deficiencies with unclear consequences). Among those, sequentially annealed polyethylenes were designed to decrease the detected in vivo oxidation that could adversely affect the durability of these components in vivo. Radiostereometric analysis of THAs using sequentially annealed second-generation HXLPE liners suggested that head penetration and three-dimensional wear remained low at 5 years [1]. However, recent retrieval studies [2, 3] stressed the persistence of oxidation in the HXLPE in the face of remelting, annealing, or sequential annealing. While in vivo oxidation was higher in the tibial retrievals than in the acetabular liners, the debate regarding this topic continues. The location and mechanical effects of residual oxidation that develops in vivo may influence the risk of

component failure, in particular in THAs.

Where Do We Need To Go?

More retrieval information is required to evaluate the risks associated with residual in vivo oxidation among sequentially annealed HXLPEs in THAs. It is important to gather chemical information about the retrieved parts including oxidation index, free radicals, and crosslink density inside the component. We can only evaluate the topographical distribution of oxidation within the liner and mechanical information regarding how this material may resist the contact stresses during in vivo service using the destructive methods in retrieved parts. This information is crucial in order to advance the failure-risk evaluation.

In their study, Kurtz and colleagues study the mechanical behavior, linear penetration, and rim damage from 122 sequentially annealed HXLPE acetabular liners that could be compared with 63 annealed HXLPE liners (three annealing cycles versus single

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annealing). Interestingly, Kurtz and colleagues did not find any mechanical differences between the liners in these two categories, with similar penetration rates and similar ultimate strength at the bearing surface. Oxidation was lower in the sequentially annealed cups and the authors did not detect delamination or internal cracking of the rim. These results are noteworthy considering that the material proved to be as resistant as in the previous generation, while lower rim oxidation was less concerning. The expected short-term benefits of this material can therefore be considered proven. However, future increases in the penetration rate may occur when the material ages during its in vivo life. This is a possibility even if higher patient activity may concentrate shortly after implantation, especially in younger population. Therefore, the controversy remains. Is this second-generation HXLPE the best choice for use in THAs?

How Do We Get There?

A combination of comparative clinical long-term studies and retrieval studies on acetabular liners after aseptic failure are necessary to help us decide

whether HXLPE should become the new standard. As in so many areas of arthroplasty research, only longer followup and additional retrieval analyses will offer the information we need about second generation HXLPEs, particularly in terms of oxidation and clinical performance. The trend of decreased oxidation, maintained mechanical properties, and low penetration rate could be expected, which would support this material in use with 32 mm metal heads, as for most retrieved liners in this study. Future studies might compare metal-on-HXLPE and ceramic-on-HXLPE during longer periods of time, which could eventually detect long-term differences. The issue of larger heads (32 mm versus 36 mm) is also interesting, as thinner liners may push these HXLPEs closer to their mechanical limits and risk fatigue fractures. Retrieval studies in the short- and mid-term usually show failures unrelated to wear, and long-term retrievals should permit the eventual association of material failure with clinical failure. Mechanical failure in the long-term could be evaluated in those hips undergoing revision due to aseptic loosening, and comparison of retrieved HXLPE materials from different systems (whether sequentially annealed or

remelted, or even doped with vitamin E) may also clarify the strengths and shortcomings of these solutions. The question of the best possible polyethylene remains open, although data like those in the current study allow us to conclude that innovations such as sequential annealing indeed represent improvements compared with earlier HXLPE materials that may be confirmed in long-term clinical studies.

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