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Research paper

Tradeoffs amongst fatigue, wear, and oxidation resistance of cross-linked ultra-high molecular weight polyethylene

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ABSTRACT

This study evaluated the tradeoffs amongst fatigue crack propagation resistance, wear resistance, and oxidative stability in a wide variety of clinically-relevant cross-linked ultra-high molecular weight polyethylene. *Highly cross-linked re-melted* materials showed good oxidation and wear performance, but diminished fatigue crack propagation resistance. *Highly cross-linked annealed* materials showed good wear and fatigue performance, but poor oxidation resistance. *Moderately cross-linked re-melted* materials showed good oxidation resistance, but moderate wear and fatigue resistance. Increasing radiation dose increased wear resistance but decreased fatigue crack propagation resistance. Annealing reduced fatigue resistance less than re-melting, but left materials susceptible to oxidation. This appears to occur because annealing below the melting temperature after cross-linking increased the volume fraction and size of lamellae, but failed to neutralize all free radicals. Alternately, re-melting after cross-linking appeared to eliminate free radicals, but, restricted by the network of cross-links, the re-formed lamellae were fewer and smaller in size which resulted in poor fatigue crack propagation resistance. This is the first study to simultaneously evaluate fatigue crack propagation, wear, oxidation, and microstructure in a wide variety of clinically-relevant ultra-high. The tradeoff we have shown in fatigue, wear, and oxidation performance is critical to the material's long-term success in total joint replacements.

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