

The Effect of Sterilization Method and Resin Type on the Oxidation of Ultra-High Molecular Weight Polyethylene

Introduction: Understanding the effects of sterilization method and resin type on the oxidation of ultra-high molecular weight polyethylene (UHMWPE) is crucial in developing orthopedic total joint systems with longer outcomes. Oxidative degradation of polyethylene components promotes osteolysis and subsequent aseptic loosening of total joint replacements.^{1,2} Implant loosening is a major cause of premature joint failure. The sterilization of UHMWPE by gamma-radiation has been shown to induce oxidative degradation of the polymer. Calcium stearate additives in the resin have also been reported to promote oxidation.⁴ Oxidative degradation of UHMWPE results in increased density of the polymer, and this relationship allows oxidation levels to be quantified by measuring changes in density.^{1-3,5} The experiment tested the hypothesis that polyethylene sterilized using gamma-radiation in air or in a nitrogen environment would be more oxidized than polyethylene sterilized using ethylene oxide or gas plasma sterilization methods. The study also tested the hypothesis that polyethylene containing calcium stearate would be more oxidized than polyethylene without calcium stearate.

Materials and Methods: Two resin types commonly used for articulating surfaces in total joint arthroplasty were obtained—one

methods: gamma-radiation in air; gamma-radiation in nitrogen, gas plasma and ethylene oxide. The specimens were exposed to oxygen for 10 months and density values were attained using a linear gradient column.

Results: Statistically significant differences ($p < 0.05$) were observed between all sterilization groups with the exception of gamma-radiation in air and gamma-radiation in an inert environment. The data also suggests that after 10 months of oxidation, resin type does not have an effect on UHMWPE density levels and therefore, on oxidation levels.^{1-3,5}

Discussion: The density changes observed in this study could dramatically impact the elastic modulus and wear resistance of UHMWPE components.⁵ The data in this study indicates that ethylene oxide and gas plasma sterilization methods may be less damaging to UHMWPE orthopedic components than sterilization methods using gamma-radiation.

References: 1. Rimnac et al., JBJS, 76A:1052-1056, 1994. 2. Li et al., Clin Orthop 319:54-63, 1995. 3. Kurtz et al., J Orthop Res 15:57-61, 1997. 4. Poggie et al., ASTM, p.120-129, 1998 5. Bostrom et al., Clin Orthop 309:20-28, 1994.

Acknowledgements: The DVA Med. Res Funds VAMC, Dept. Orthop., UUSM, SLC, UT. We also thank Dr. Clare Rimnac.



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