COMPARISON OF VOLUMETRIC POLYETHYLENE WEAR RATES ACROSS REVERSE TOTAL SHOULDER ARTHROPLASTY DESIGNS

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Introduction: Nearly all modern reverse total shoulder arthroplasty (rTSA) systems have been documented to experience both articular surface wear and extra-articular rim wear. The resulting wear particles have been hypothesized to contribute to mechanical notching, osteolysis, and possibly implant loosening. Consequently, several manufacturers have taken different approaches to the designs of their rTSA systems' construct geometry to decrease mechanical impingement and to improve polyethylene wear characteristics, including irradiation crosslinking in conjunction with thermal stabilization or antioxidant additive— all which may affect how the bearings handle long-term cyclic loading. However, despite these efforts towards wear particle reduction, few studies have been able to volumetrically quantify *in-vivo* wear with sufficient power to adequately evaluate their progress, or even further, the effect of specific design decisions. Thus, this study aims to understand the potential difference in average liner wear rates between manufacturers in hopes of elucidating the device characteristics that most optimally mitigate polyethylene wear particle production.

Methods: Thirty-eight retrieved polyethylene liners across five manufacturers' rTSA systems (n = 10, n = 10, n = 9, n = 7, n = 2) were scanned and processed using a validated, coordinate measuring machine and interpolation-based protocol. Devices were selected from an IRB-approved retrieval database by including at least ten liners when ten or more were available from the manufacturer, and if not, all eligible liners instead. Each device was assessed for rim, articular surface, and total volumetric wear rates. To determine whether wear rates significantly differed, a one-way analysis of variance (ANOVA) was performed. Subsequently, Welch's t-test was utilized to evaluate a potential wear difference between crosslinked versus non-crosslinked ultra-high-molecular-weight polyethylene (UHMWPE).

Results: The ANOVA revealed no significant difference in average rim, articular surface, or total wear rates between manufacturers ($p = 0.5299$). This implies that, despite deviations in liner rim geometry and placement, differences in general wear behavior are either undetectable by the applied method or largely equivalent for the liner designs tested. For the comparison between crosslinked and non-crosslinked total polyethylene wear rates, Welch's t-test was chosen because of unequal variances between the groups, as confirmed using an F-test. Disregarding outliers further than three standard deviations from each group's mean (n = 2 for both groups), the test resulted in null hypothesis rejection ($p = 0.0328$), implying a statistically significant difference in mean wear rates; the average non-crosslinked polyethylene liner wear rate was more than double that of the crosslinked liners' (3.2063 mm^3/month vs. 1.3479 mm^3/month). Collapsing the groups and separating by wear location instead, overall average articular surface and rim wear rates were found to be 1.5434 mm^3/month and 2.0279 mm^3/month, respectively.

Conclusions: Herein we present the first comparative study of articular and nonarticular surface wear for a group of reverse shoulder arthroplasty retrievals. As documented for knee and hip arthroplasty, larger crosslinking doses in the shoulder are shown to decrease material loss rate by a factor of two in the present study. Clinicians are encouraged to consider this material choice for patient treatment. Additional design characteristics specific to different manufacturers do not appear to have the same influence on UHMWPE liner wear rate. Alternatively, given these relatively small sample sizes, the influence of these design strategies may exist below the resolution of the employed technique when patient-to-patient variability is included. Ultimately, a larger cohort analyzed in the same manner may allow for the isolation of more nuanced design decisions— including the morphological differences listed before— with objective benefits over their alternatives.

Figure 1: Wear rates for crosslinked vs not crosslinked polyethylene

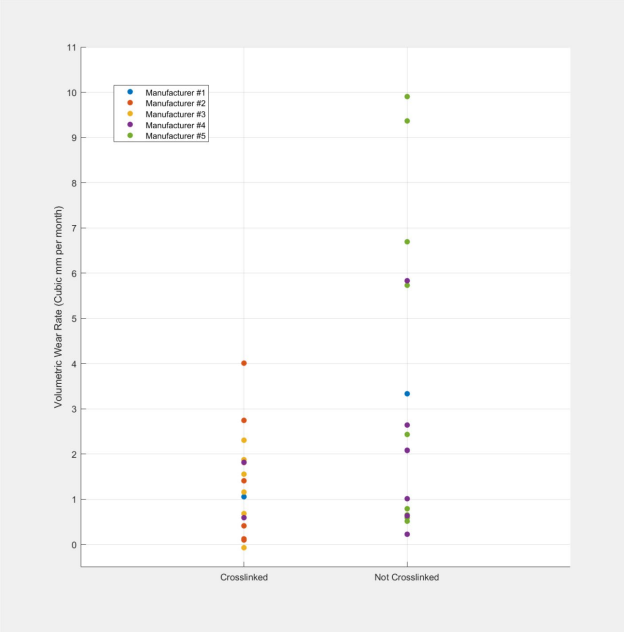

Figure 2 (A,B): Wear rates by manufacturer