Impingement Performance of a Moderately Cross-Linked UHMWPE Acetabular Liner

Edmund Loftus.
Exactech, Inc., Gainesville, FL, USA.

Disclosures:  
E. Loftus: 3A; Employee of Exactech.

Introduction: Rim fracture of acetabular liners used in total hip arthroplasty (THA) has been documented in the literature and may be associated with design characteristics such as rim geometry overhanging the acetabular shell, thin section geometry of the rim, and reduction of mechanical properties due to cross-linking of the UHMWPE. In particular, a clinical preference for larger-diameter heads to reduce the likelihood of dislocation may necessitate use of thinner liners in a given shell size, which also results in reduced thickness of the liner rim. Therefore, the objective of this study was to compare the rim structural integrity of two moderately cross-linked UHMWPE liner designs, one with a 6mm rim thickness and one with a 4mm rim thickness, by conducting impingement testing per ASTM F2582. Our hypothesis was that since the subject liner design does not overhang the shell and is not highly cross-linked, the 4mm-thick liner would perform equivalently to the 6mm-thick liner and not experience rim fracture during the testing.

Methods: The two acetabular liner designs evaluated were made from the same 5 Mrad moderately cross-linked UHMWPE material and had the same shell interface geometry. Both sets of liners were accelerated aged per ASTM F1980, simulating a 5-year shelf life. One design had a 36mm articulation with a nominal rim thickness of 6mm, while the other design had a 40mm articulation with a nominal rim thickness of 4mm. Impingement testing was performed against titanium test spigots that replicated the neck geometry of the femoral implant. The use of +7mm femoral heads maximized the resultant impingement stresses by focusing impingement on the smallest test spigot contact area. All specimens were preconditioned for 24 hours in the laboratory environment and 48 hours in distilled water at 37 +/-2°C. Peak dislocation moments and associated angular displacements were determined per F2582, which were 8.23 N-m @ 70.30° for the 36mm specimens and 8.74 N-m @ 72.77° for the 40mm specimens. The impingement torque applied during the testing was 70% of the dislocation torque. Peak angular displacements and impingement torques were recorded every 1000 cycles. The impingement testing was unidirectional and conducted using the following parameters:

- Number of Specimens: 5 per design
- Impingement Torque: 36mm specimen = 5.76 N-m, 40mm specimen = 6.12 N-m
- Liner/Head Interface Load: 1000N
- Test Frequency: 10Hz
- Test Duration: 5 million cycles
- Test Medium: Distilled water at 37 +/-2°C

Figure 1 shows an example of the impingement testing configuration.

Results: The impingement areas of both sets of specimens experienced polishing and plastic deformation, the extent of which is represented by the blue outlines in Figure 2 for the 36mm specimens and Figure 3 for the 40mm specimens. No evidence of liner fracture was observed in any of the specimens. The average peak angular displacement obtained at the end of the test was 0.31° (SD .08) for the 36mm specimens and 0.31° (SD .17) for the 40mm specimens.

Discussion: In conclusion, the results of this study demonstrate equivalent impingement performance, with no occurrence of rim fracture, between acetabular liner designs of 4mm and 6mm rim thickness. This equivalent performance may be attributable to the liner rim design, which does not overhang the shell and therefore does not have a stress-concentrating corner in the vicinity of the rim, and the moderately cross-linked UHMWPE, which allowed retention of mechanical properties sufficient to inhibit material fracture.

Significance: The clinical application of thinner UHMWPE acetabular liners in THA may contribute to an increased risk of rim fracture. The results of this study suggest that thinner liners may provide rim fracture resistance equivalent to thicker liners in the presence of other fracture-mitigating design characteristics.

Acknowledgments: None

References:  

5. ASTM F2582-08 Standard Test Method for Impingement of Acetabular Prostheses
