Effect of High Cup Angle and Neck-Liner Impingement on Moderately Crosslinked, Thermally Treated UHMWPE Hip Liners

Yen-Shuo Liao1, Dustin Whitaker2, Takayuki Nakamura1, Catherine Hardaker2.
1DePuy Orthopaedics, Inc., Warsaw, IN, USA, 2DePuy International, Leeds, United Kingdom.

Disclosures:

Introduction: Polyethylene wear, aseptic loosening and osteolysis are considered as dominant causes for revisions in total hip surgeries. Cross-linking of polyethylene liners has been shown, in short to mid-term, to reduce the poly wear. The apparent benefit of cross-linking, however, comes with consequential reduction in mechanical properties. DePuy’s moderately crosslinked polyethylene has to date demonstrated a good balance of wear resistance and mechanical properties. MARATHON™ Polyethylene was among the first FDA-cleared cross-linked polyethylenes which used a re-melting treatment for oxidative stability. It is made from polyethylene resin GUR 1050, gamma-irradiated at a dose of 5.0 Mrads, and thermally treated above the melting temperature to eliminate free radicals which helps maintaining important physical and mechanical properties. Using polyethylene wear as an endpoint, a 10-year clinical follow-up study showed 100% MARATHON survivorship versus 93.3% for conventional polyethylene [1], in addition to a wear reduction comparable to that reported in laboratory wear simulation tests [2-3].

There is an increasing demand for improved head-to-shell ratio acetabular systems because larger head sizes have the benefits of increased stability and range of motion. The increased head-to-shell ratio is often times achieved by using a reduced liner thickness. The clinical concern of thinner poly liners is the potential for rim fracture, particularly in the occurrences of rim loading or impingement at high cup angles [4-7].

This study investigated the performance of thinner poly liners to the challenge of high angle loading and neck-to-liner impingement.

Methods: Three groups of MARATHON polyethylene liners were paired with matching femoral heads that were manufactured from CoCrMo (ASTM F1537) with diameters of 28, 32, and 36 mm (Table 1). The inserts were chosen to have similar thickness at the dome. The liners were ethylene oxide (ETO) sterilized. This study included two parts: (1) the implants were rim-loaded without neck-liner impingement; (2) impingement was tested using simulated gait cycles.

The high angle fatigue test was performed on a MTS frame (MTS Corp, Eden Prairie, MN). Each liner was assembled in a metal shell that was potted in a stainless steel block tilted at 64° with PMMA dental acrylic (Figure 1) to create an edge loading scenario. Axial loading (sinusoidal wave form) was applied from minimum controllable load, 0 N, to maximum 5000 N (1124 lbf) in a circulating pH buffered saline bath (37 ±2 °C) at a frequency of 3 Hz for 5-million cycles or until component failure, whichever occurred first. Definition of failure is initiation of crack or liner fracture. The sample number was 6 for each group. The impingement testing was performed on a 12-station hip simulator (AMTI, Watertown, MA) per ISO 14242-1 standard [8] with some modification: The metal shells were potted at 54° (in the abduction/adduction plane) with cement while the femoral heads were mounted on a vertical stem taper support (Figure 2). The maximum impingement angle was 64° which was controlled by varying the abduction/adduction angle (54±10°) during the simulated gait cycle (Figure 3). The physiological loading cycle was applied with a maximum load of 3000 N at 1 gait cycle per second for 3-million cycles. The interface was lubricated with synthetic grease (Mobilith AW3, Exxon Mobil, Buffalo, NY) with an open chamber to enable constant visual monitoring of the test specimen. The sample number was 4 for each group.

The components were cleaned for visual inspection every million cycles. A high intensity light was used to monitor for any signs of crack initiation, fractures, and/or deformation. Both test methods were validated to be able to replicate liner fractures.

Results: All Marathon ETO liners passed 5-million cycles of high angle fatigue testing without failure, and, all liners passed 3-million cycles of impingement testing without failure.

Discussion: Causes of liner fractures can be multi-factorial: poly material, locking designs, implant orientations, and impingement may contribute to the clinical failures. In this study, we developed adverse testing conditions of rim-loading and neck-liner impingement, in order to evaluate the performance of thin polyethylene liner due to the improved head-to-shell ratio.

Significance: MARATHON ETO liners did not fracture in high angle fatigue and impingement testing.

Acknowledgments:
References: [1] Engh et al, J Arthroplasty, 2012, v27 n8 s1, p1
<table>
<thead>
<tr>
<th>Group</th>
<th>Material</th>
<th>Liner ID (mm)</th>
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<tbody>
<tr>
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<tr>
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<td>32</td>
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