Effect of Head Size on the Wear of GUR 1050 5-Mrad and GUR 1020 7.5-Mrad Crosslinked-Remelted Polyethylene

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INTRODUCTION:
The benefits of using larger heads in hip arthroplasty include increased range of motion and enhanced stability from hip joint dislocation, while the concern is increased polyethylene wear as the head size increases. Marathon™ polyethylene has shown 85% lower wear than non-crosslinked polyethylene in a simulation test [1]. In addition, AltrX™ polyethylene showed 92% lower wear than non-crosslinked polyethylene while maintaining mechanical properties similar to Marathon™ [2]. Both materials were crosslinked-remelted polyethylene and were tested using 28 mm diameter heads. The objective would be to combine the low wear advantage of the materials with the benefits of larger head size. This study evaluates the wear of Marathon™ and AltrX™ using 48 mm heads of cobalt-chrome alloy and compares it to a previous study using 28 mm heads.

MATERIALS AND METHODS:
Three groups of femoral heads and acetabular inserts were evaluated in this study (Table 1). For Group A, the acetabular inserts were machined from GUR 1050 ram extruded bar (REB), with nominal inner diameter of 28 mm (Enduron™, DePuy, Warsaw, IN). Group B used GUR 1050 REB that was vacuum-packaged in a foil bag and crosslinked with gamma radiation at a dose of 5 Mrad followed by remelting at 155°C in an oxygen-free environment to eliminate free radicals (Marathon™, DePuy, Warsaw, IN). Group C used GUR 1020 REB that was vacuum-packaged in a foil bag and crosslinked with gamma radiation at a dose of 7.5 Mrad followed by remelting at 155°C in an oxygen-free environment to eliminate free radicals (AltrX™, DePuy, Warsaw, IN). The nominal inner diameter of the acetabular inserts was 48 mm for both Groups B and C. All polyethylene bars were from the same vendor (MediTECH, Ft. Wayne, IN).

Table 1. Insert Materials for Each Group

<table>
<thead>
<tr>
<th>ID</th>
<th>Description</th>
<th>Size (mm)</th>
<th>Resin</th>
<th>Gamma-Dose (Mrad)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Enduron™</td>
<td>28</td>
<td>GUR 1050</td>
<td>No</td>
</tr>
<tr>
<td>B</td>
<td>Marathon™</td>
<td>48</td>
<td>GUR 1050</td>
<td>5.0</td>
</tr>
<tr>
<td>C</td>
<td>AltrX™</td>
<td>48</td>
<td>GUR 1020</td>
<td>7.5</td>
</tr>
</tbody>
</table>

The test was performed on an OBM-type hip simulator (Shore Western, Monrovia, CA). The inserts were assembled into metal shells that were attached to urethane molds, and then worn against ASTM F1537 CoCrMo heads (Articul/eze™, DePuy, Warsaw, IN) of the corresponding sizes, under a Paul-type load (2000 N max) at 1 Hz. The implants were tested in an inverted position in 90% bovine calf serum (HyClone, Logan, UT) with 0.2% sodium azide added as a preservative and 20 mM EDTA to prevent calcium phosphate precipitation. Serum volume was 400 ml for each station. The test length was five million cycles (MC).

The specimens were cleaned and weighed every 500K cycles. Wear was determined from the weight loss of each cup with compensation for fluid uptake assessed using control test inserts that were cyclically loaded and soaked in the same solution but not rotated. Wear rates were determined by linear regression. A two-tailed equal variance t-test was utilized to analyze differences in wear rates between test groups.

RESULTS:
The results are summarized in Figure 1 and Table 2. The wear rates of the polyethylene inserts were primarily affected by the gamma-irradiation dose used for crosslinking of the polyethylene. The samples in Group A were not crosslinked and, as expected, generated the highest wear rates of any of the four groups; followed by Group B at 5 Mrad and Group C at 7.5 Mrad. The wear rate of Group A (38.0 ± 3.4 mg/MC) generated in this study was consistent with that of previous studies [2,3].

DISCUSSION:
Comparing Groups B (48-mm Marathon™) and C (48-mm AltrX™) to the non-crosslinked polyethylene in Group A (28-mm Enduron™) gave wear reductions of 59% and 79%, respectively. In contrast to the higher wear reduction of 85% and 92% for Marathon™ and AltrX™ that was previously reported for 28 mm heads [1,2], the current test showed the effect of using a larger head size.

CONCLUSION:
The wear of crosslinked-remelted polyethylene materials against 48 mm femoral heads was evaluated. AltrX™ polyethylene has about 50% of lower wear than Marathon™ polyethylene, while maintaining comparable mechanical properties as shown previously [2]. Using AltrX™ polyethylene allows the dual benefits of lower wear and large head size in hip arthroplasty.

REFERENCES: