The Effect of Femoral Head Size on the Wear Performance of Sequentially Crosslinked Polyethylene

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INTRODUCTION

Prosthetic dislocation is one of the major complications following a total hip arthroplasty (THA) [1]. The incidence of dislocation has been shown to be reduced by the use of larger femoral head sizes [2,3]. This is due to the decreased component-on-component impingement and increased range of motion (ROM) provided by large femoral head size [2]. It has been shown however, that acetal liner wear is a function of contact area and thusly head size [4].

Larger head size leads to the reduction of the thickness of the complimentary acetaliner. This decrease in acetal thickness has been of general concern as a factor involved in increased wear [5,6]. In a previous study, it was shown that sequentially crosslinked material maintains its low wear characteristics regardless of thickness or head size [7]. However, that study was a combination of head size and thickness and the effect of head size alone was not evaluated. Therefore, the objective of this study is to evaluate the effect of femoral head size on the wear characteristics of sequentially crosslinked and annealed polyethylene (SXL).

MATERIALS AND METHODS

A total of four sets of test samples were used for evaluation in this study. Trident® design (Stryker Orthopaedics, Mahwah, NJ) liners with internal diameters ranging from 28mm to 40mm were used. Liner thickness was held as consistently as possible as would be allowed by commercial availability, with all liners being 7.9mm thick except the 40mm liner which had a thickness of 7.4mm. These polyethylene liners were manufactured from GUR 1020 UHMWPE that was sequentially annealed and irradiated three times and then gas plasma sterilized (X3™, Stryker Orthopaedics, Mahwah, NJ) [8]. Appropriate diameter cobalt chrome femoral heads ranging from 28mm to 40mm (n=3) were matched with the inserts.

A twelve stations hip joint simulator (MTS, Eden Prairie, MN) was used with cups positioned at 50° to abduction. Three sets of each size liner (28mm, 32mm, 26mm, 40mm) were tested (n=12). Testing was run at 1 Hz with cyclic Paul curve physiological loading applied axially, at a maximum of 2450 N [9]. The twelve chambers were filled with Alpha Call Fraction serum (Hyclone Labs, Logan, UT) diluted to 50% with de-ionized water and 20mMole EDTA.

The serum solution was replaced and inserts were weighed for gravimetric wear at least every 0.5 million cycles (Mc). Tested samples were compared against soaked samples to negate weight changes due to fluid absorption. Volumetric wear data for each acetabular liner was calculated from the weight change of the liner and the known density of the conventional UHMWPE. This data was also compared to the historical wear data of a conventional UHMWPE liner with a thickness of 7.9mm and an inner diameter of 32mm [7]. Statistical analysis was performed using the Student’s t-test (p<0.05). Testing ran for 2 million cycles.

RESULTS

Results are shown in figure 1 and table 1. No statistical difference in wear rate was seen between any of the head sizes (p>0.07 for all cases) for the sequentially crosslinked material. Linear correlation coefficient (R²=0.4) for all head sizes indicates poor correlation between head size and wear. Additionally, an average of all sequentially crosslinked liner wear rates (all head sizes) showed a 95% (p=0.009) reduction compared to published [7] conventional liners with equivalent thickness.

![Figure 1: Volume loss as a function of cycle count, including published [7] conventional data.](image)

<table>
<thead>
<tr>
<th>Head Size (mm)</th>
<th>Wear Rate (mm³/10⁶cycles)</th>
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<tbody>
<tr>
<td>28 mm</td>
<td>1.8 ± 0.8</td>
</tr>
<tr>
<td>32 mm</td>
<td>1.5 ± 0.8</td>
</tr>
<tr>
<td>36 mm</td>
<td>1.9 ± 0.5</td>
</tr>
<tr>
<td>40 mm</td>
<td>4.3 ± 1.5</td>
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Table 1: Cumulative wear rate at 2 million cycles.

DISCUSSION

Wear is a function of sliding distance and consequently head size, therefore larger heads are expected to show higher wear than smaller heads. The results in this study show that in fact the largest head tested exhibited the highest amount of wear; however, there was no statistical difference in wear rate between any of the head sizes tested. These results indicate that modern crosslinked materials, such as sequentially crosslinked polyethylene, provide the opportunity of increasing the head size and therefore increasing ROM and decreasing the incidence of impingement. Additionally, all sizes evaluated here demonstrated significantly lower wear than conventional materials.

These results support previous work showing that increase in head size, despite increasing contact area, does not statistically affect the wear of equivalent thickness sequentially crosslinked acetabular liners.

REFERENCES