INTRODUCTION
Wear and polyethylene damage continue to be important factors affecting outcomes, and have been implicated in up to 22% of revision surgeries after unicompartmental knee replacement [1]. The design rationale for unicompartmental components include fully congruent mobile bearings with large contact areas and low contact stresses to reduce wear; or moderately conforming fixed bearings to prevent bearing dislocation and reduce backside wear. This study was designed to determine if a highly crosslinked fixed-bearing design would increase wear resistance. A secondary objective was to quantify the relative contribution backside wear in unicompartmental mobile-bearing designs.

METHODS
Gravimetric wear rates were measured for two unicompartmental implant designs: Oxford unicompartmental (Biomet) and Triathlon X3 PKR (Stryker) on a knee wear simulator (AMTI) using the ISO recommended standard. The Oxford design had a highly conforming mobile bearing of compression molded polyethylene (Arcom). The Triathlon PKR had a moderately conforming fixed bearing of sequentially crosslinked polyethylene (X3).

A finite element model of the AMTI wear simulation for both designs was constructed to replicate experimental conditions and to compute wear. This approach was validated using experimental results from previous studies [2,3].

The wear coefficient obtained previously for radiation sterilized low crosslinked polyethylene was used to predict wear in Oxford components [2]. The wear coefficient obtained for highly crosslinked polyethylene was used to predict wear in Triathlon X3 PKR components [3]. To study the effect design and polyethylene crosslinking, wear rates were computed for each design using both wear coefficients.

RESULTS

![Fig 1: FEA predicted wear rates were very close to those measured experimentally for both Oxford and Triathlon X3 PKR designs, validating our model assumptions. Our FEA wear penetration rates (0.024 mm/million cycles) also compare well to in vivo studies, which reported 0.022 mm/year for Oxford bearings [4, 5].](image)

![Table 1: Increasing the crosslinking, significantly reduced the wear coefficient and wear rates](image)

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<tr>
<th></th>
<th>Low Crosslinked</th>
<th>Highly Crosslinked</th>
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<tbody>
<tr>
<td>Oxford</td>
<td>17.64</td>
<td>3.7</td>
</tr>
<tr>
<td>Triathlon X3 PKR</td>
<td>8.08</td>
<td>1.54</td>
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![Table 2: Over 40% of the total wear occurred at the “backside” of the mobile bearing, for low and high crosslinked polyethylene.](image)

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<tr>
<th></th>
<th>Low Crosslinked</th>
<th>Highly Crosslinked</th>
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<tr>
<td></td>
<td>46%</td>
<td>43%</td>
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![Fig 2: Comparison of simulated wear depth (left) with experimental wear scars (right): Top: Frontside; Bottom: Backside](image)

![Fig 3: “Frontside” wear rates in highly crosslinked polyethylene were significantly lower.](image)

DISCUSSION
We used a combined experimental and computational approach to quantify factors contributing to polyethylene wear after unicompartmental knee arthroplasty. Overall, wear in the Triathlon X3 PKR design was 80% less than that in the Oxford design (Fig 1). Major factors that affect wear are the level of crosslinking in polyethylene and the implant design.

To isolate the effect of crosslinking level and mobile-bearing design, we computed wear rates for both designs using wear coefficients obtained for both low and highly crosslinked polyethylene. Wear rate in a highly crosslinked Oxford insert was reduced although still higher than that in a highly crosslinked Triathlon X3 PKR (Fig 3).

While experimental measurements of backside wear are challenging, the FE method provides a convenient method to determine the relative backside to frontside wear. Directly comparing frontside wear, using the same wear coefficient for both designs brought the wear rates even closer 9.6 vs. 8.08 for low crosslinked and 2.1 vs. 1.54 mg/million cycles for highly crosslinked polyethylene (Oxford vs. PKR). This indicates that level of crosslinking and backside wear are major factors contributing to the difference in wear: backside wear (46%) and increased crosslinking (43%).

SIGNIFICANCE
A validated computer model is extremely valuable for efficient evaluation of wear performance and design development. Increasing conformity to increase contact area and reduce contact stress may not be the sole predictor of wear performance.

1) Lidgren, Swedish Knee Arthroplasty Register Annual Report, 2009;
2) Hermida, AAOS, 2003;
3) Hermida, JOR 2000;
4) Kendrick, JBJS, 2011.
5) Price JBJS-B, 2005