Effect of Acetabular Cup Version angle on the Wear of BIOLOX® Delta Ceramic-on-Ceramic Bearings under standard and Edge Loading Conditions

Mazen Al-Hajjar, Silvia Carbone, Sophie Williams, Louise M. Jennings, John Fisher.
Institute of Medical and Biological Engineering, University of Leeds, Leeds, United Kingdom.

Disclosures:
M. Al-Hajjar: None. S. Carbone: None. S. Williams: 3B; DePuy Synthes Joint Reconstruction. L.M. Jennings: 5; Mathys Orthopadie GmbH, DePuy Synthes Joint Reconstruction, Invibio, Biocomposites. J. Fisher: 1; DePuy Synthes Joint Reconstruction. 2; DePuy Synthes Joint Reconstruction. 3A; Tissue Regenix plc. 3B; DePuy Synthes Joint Reconstruction, Tissue Regenix plc, Invibio. 4; Tissue Regenix plc. 5; DePuy Synthes Joint Reconstruction, Invibio, Mathys Medical.

Introduction: Some hip replacement failures have been associated with component mal-positioning. Mal-positioning of the implant can lead to edge loading hence excessive wear of the bearing surfaces. There are two elements to mal-positioning; rotational and translational. Rotational mal-positioning can include steep inclination angle or excessive version/ante-version of the acetabular cup, and translational mal-positioning is a mismatch between the centres of rotations of the femoral head and the acetabular cup. The effect of ante-version of the acetabular cup on the wear of ceramic-on-ceramic bearings.

Methods: Six 36mm ceramic-on-ceramic bearings (BIOLOX® Delta, CeramTec, Germany) were tested using the Leeds II Physiological Anatomical Hip Joint Simulator. In this study, all six cups were mounted with an ante-version angle of 30°; two cup inclination angles were considered; in vivo equivalence of 45° (n=3) and 65° (n=3). Two million cycles were run under standard gait conditions with a twin peak load (peak load of 3000N), extension/flexion (−15°/+30°) and internal/external rotation (±10°). Then three million cycles were run under edge loading conditions associated with translational mal-positioning by applying microseparation conditions to the gait cycle. This was achieved by introducing a 0.5mm medial/lateral displacement between the head and the cup during the swing phase of the standard gait cycle resulting in edge loading at heel strike [2]. The results were directly compared to previous study completed on the same machine with no ante-version of the acetabular cup [3].

Results: The wear rates of ceramic-on-ceramic bearings under standard gait conditions with ante-version angle of 30°, under both cup inclination angle conditions (45° and 65°), were very low (<0.05mm³/million cycles) and similar in magnitude to that with no ante-version angle of the cup (p=0.36, Figure 1). Stripe wear and increased wear rates occurred only under edge loading due to microseparation conditions associated with translational mal-positioning. Increasing the ante-version angle of the cup from 0° to 30° resulted in a decrease in the wear rates under both cup inclination angle conditions (Figure 1) but the decrease was not significant (p=0.14). The wear stripe formed on the femoral head had different orientations and positions depending on the acetabular cup inclination and version angle (Table 1).

Discussion: Optimum positioning of total hip replacement bearings is very difficult to achieve during surgeries hence preclinical simulation of hip replacement bearings should include conditions that include mal-positioning of implant in order to assess their safety and reliability under the adverse conditions that might exist in vivo. In this experimental simulation study, an increased ante-version angle was introduced as another parameter representing rotational mal-positioning of the prosthesis. It was found that increased ante-version angle of 30° did not increase the wear rate of BIOLOX® delta ceramic-on-ceramic bearings, under standard gait conditions, indicating the resistance of this material combination to rotational mal-positioning. Stripe wear and increased wear rates, however, still formed under microseparation conditions representing translational mal-positioning.

Significance: Rotational mal-positioning, including both steep cup inclination and increased version/ante-version angles, did not influence the wear rates of BIOLOX® delta ceramic-on-ceramic bearings but changed the position and orientation of the wear stripe formed due to edge loading under microseparation conditions associated with translational mal-positioning. This helps to explains variations in stripe wear orientation reported in different clinical studies of retrieved components.

Acknowledgments: This study was supported by Orthopaedic Research UK (ORUK) and partially funded through WELMEC, a Centre of Excellence in Medical Engineering funded by the Wellcome Trust and EPSRC, under grant number WT 088908/Z/09/Z.

Means and 95% confidence limits were calculated and statistical analysis was performed using one-way ANOVA (significance taken at p<0.05).

Statistical analysis was performed using one-way ANOVA (significance taken at p<0.05).

Means and 95% confidence limits were calculated and statistical analysis was performed using one-way ANOVA (significance taken at p<0.05).
JF is an NIHR Senior Investigator and his research is supported through The NIHR Leeds Musculoskeletal Biomedical Research Unit.

References:
Figure 1: Mean wear rates of BIOLOX® delta ceramic-on-ceramic bearings with no version/anteversion of the cup [3] and 30° cup ante-version angle under standard and edge loading conditions associated with both rotational and translational mal-positioning. Error bars represent ± 95% confidence limits.
Table 1: Orientations and positions of the wear stripe formed on the femoral heads under edge loading conditioning associated with translational mal-positioning with different acetabular cup inclination and version angles. The arrows show how the orientations of the stripe areas change.

<table>
<thead>
<tr>
<th>No version/ante-version</th>
<th>30 degrees ante-version</th>
</tr>
</thead>
<tbody>
<tr>
<td>45° inclination</td>
<td></td>
</tr>
<tr>
<td>65° inclination</td>
<td></td>
</tr>
</tbody>
</table>

ORS 2014 Annual Meeting
Poster No: 1826