The Effect of the Swing Phase Load under Head and Cup Centre Mismatch on the Severity of Edge Loading and Wear of Ceramic-on-Ceramic Hip Joint Replacements

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Significance

Patient and surgical variability should be taken into account during pre-clinical testing of hip replacement bearings. This study has shown that the level of swing phase load in hip simulator testing associated clinically with soft tissue tensioning affects the occurrence and severity of edge loading under conditions where a mismatch between the centres of rotation of the femoral head and acetabular cup exists.

Introduction

Pre-clinical testing of hip joint replacements is important for the evaluation of the performance, safety and reliability of existing and new devices. Patient and surgical variability need to be accounted for, as they may lead to scenarios which affect the occurrence and severity of edge loading conditions. Clinically, edge loading has been associated with increased wear and revision of hip replacements [1]. Clinical biomechanical studies show a variation in the swing phase load applied to hip prosthesis [2]. Thus, it is important to widen the set of conditions to be considered for pre-clinical testing.

Aim

The aim of this study was to determine the effect of varying the swing phase load on the occurrence and severity of edge loading and the wear of ceramic-on-ceramic bearings when a medial-lateral translational mismatch (offset deficiency) of the centres of the head and cup was present under different cup inclination angles in a hip joint simulator.

Method

Edge loading was replicated in a hip joint simulator by applying a translational mismatch between the centre of the head and the centre of the cup during the set-up of components. Different levels of swing phase loads were applied along with different levels of mismatches and cup inclination angles to determine the dynamic separation and severity of edge loading, and wear (study A and B).

The severity of edge loading is the time during the cycle where the head is in contact with the rim (duration of separation) and the magnitude of the forces applied [3].

<table>
<thead>
<tr>
<th>Test study</th>
<th>Translational mismatch between the head and cup centres</th>
<th>Swing phase load</th>
<th>Inclination angle (in vivo equivalent)</th>
<th>Study output assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>[A] Biomechanical study (96 combinations), n=3 per combination</td>
<td>1, 2, 3 and 4 mm</td>
<td>50, 70, 100, 150, 200, 250, 300, and 450 N</td>
<td>45°, 55° and 65°</td>
<td>Dynamic separation, severity of edge loading</td>
</tr>
<tr>
<td>[B] Wear study (n=6)</td>
<td>4 mm</td>
<td>70, 150 and 300 N</td>
<td>65°</td>
<td>Wear rate (determined gravimetrically)</td>
</tr>
</tbody>
</table>

• Leeds Mark II Physiological Anatomical Hip Joint Simulator
• Test conditions:
  • Walking gait cycle kinematics
  • Lubrication: 2% new-born calf serum + 0.03% sodium azide

Statistical analysis was performed using one way ANOVA (significance at 0.05).

Results and Discussion

The magnitude of dynamic separation decreased as the swing phase load increased for all the cup inclinations.

The severity of edge loading also decreased under different level of mismatches as the swing phase load increased. This led to lower wear rates at higher swing phase loads.

Acknowledgement

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References


Disclosure

J. Fisher is an MHR senior investigator, a paid consultant to DePuy Synthes, Invibio, Tissue Regenix Group plc and a share holder of Tissue Regenix Group plc; E. Ingham is a paid consultant to DePuy Synthes, Stryker, Tissue Regenix Group plc and a share holder of Tissue Regenix Group plc; G. Williams is a paid consultant to DePuy Synthes, Jonathan Thompson, Oscar O’Dwyer Lancaster-Jones and Graham H. Isaac are employees at DePuy Synthes.