Wear of moderately cross-linked polyethylene fixed bearing knee replacements
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Introduction

Cross-linked polyethylene has been explored as an alternative to conventional polyethylene in total joint replacement in order to reduce wear volume and decrease failure through polyethylene wear debris induced osteolysis [1]. Due to the demands of a total knee replacement, moderately cross-linked polyethylene is recommended to retain mechanical properties [2]. This study aims to investigate the wear performance of a new moderately cross-linked polyethylene in a fixed-bearing knee configuration through experimental wear simulation.

Materials and Methodology

The wear of a novel cross-linked polyethylene bearing was investigated using a physiological six station Prosim knee wear simulator (Simulator Solutions, UK). Six size 3 fixed bearing Sigma total knee replacements (DePuy International, UK) were studied for a period of 6 million cycles (Mc). The bearing inserts were XLK, a moderately cross-linked (4MRad irradiated and remelted) 1020 GUR polyethylene, with a curved geometry, which clipped into a polished cobalt-chrome tray. The central axis of the implant was offset from the aligned axes of applied load and tibial rotation to replicate a right knee.

Two kinematic conditions were used for this study, both under anterior-posterior (AP) displacement control; intermediate kinematics for 3Mc and high kinematics for 3Mc. Intermediate kinematics were defined as a maximum femoral axial loading of 2600N, flexion-extension of 0 to 58º, an anterior-posterior displacement of 0-5mm, and an internal-external rotation of ±5º. High kinematics used the same profiles for loading, rotation and flexion-extension, but used an increased anterior-posterior displacement of 0-10mm [3].

The lubricant was 25% (v/v) calf serum supplemented with 0.03% (w/v) sodium azide solution in deionised water, as an antibacterial agent, and was changed approximately every 0.33Mc. Wear was assessed gravimetrically at 1 and 3 Mc for each kinematic condition, and moisture uptake was assessed using unloaded soak. Volumetric wear was calculated using a density of 0.934mg/mm³, and statistical analysis was performed using one-way ANOVA, comparing the data with a previously tested conventional polyethylene in total joint replacement in order to reduce wear rate and could be considered to significantly extend the osteolysis free lifetime of a total knee replacement patient. A moderately cross-linked polyethylene fixed bearing total knee replacement provides a low wearing solution for the knee replacement patient.

Results

The mean wear as a function of cycles, under intermediate and high kinematics is indicated in Figure 1. There was a significant increase in wear observed when the kinematics were increased to the high kinematic condition (p<0.05).

Discussion and Conclusions

This study investigated the in-vitro wear performance of a new moderately cross-linked polyethylene through experimental wear studies, and contrasted it with a previously tested conventional polyethylene in an identical bearing configuration, tested under the same conditions. There was a significant increase in wear rate when the kinematics were increased to high, increasing the anterior-posterior translation by 5mm.

The mean wear rates of the XLK bearing throughout the study were significantly lower than a conventional GVF polyethylene, with rates between 2.5 – 7mm³/Mc. This is a substantial reduction in wear rate, and could be considered to significantly extend the osteolysis free lifetime of a total knee replacement patient. A moderately cross-linked polyethylene fixed bearing total knee replacement provides a low wearing solution for the knee replacement patient.

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References

[1] Ingham and Fisher 2005