The Influence of Design on the Wear of Mobile Bearing Total Knee Replacements
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Introduction: There remain long term concerns that the accumulation of polyethylene wear particles from the surface wear of Total Knee Replacements (TKRs) will cause osteolysis and loosening. Previous in vitro knee simulation studies have shown the generation of wear particles to be highly dependent on the kinematics and design of the prosthesis [1]. Currently there are considerable variations in designs to meet diverse biomechanical demands for fixation, stability and mobility.

The aim of this study was to investigate the influence of design on the wear of mobile bearing TKRs. In particular this study compared TKRs in which the posterior cruciate ligament is retained and the mobile bearing allows both antero-posterior (AP) and rotational movement; and a rotating platform (RP) design in which the posterior cruciate ligament is sacrificed.

Materials and Methods: The commercially available LCS AP Glide and LCS RP mobile bearing TKRs (DePuy) were investigated in this study. The LCS AP Glide permits both antero-posterior and rotational movement, whereas the LCS RP allows rotational movement only. Standard LCS Co-Cr-Mo alloy femoral components and cobalt chrome tibial trays were used for all testing. All tibial inserts were GUR 1020 UHMWPE which had been sterilised in foil pouches by gamma irradiation in a vacuum (GVF). The LCS RP insert was positioned directly into the cobalt chrome tray, whereas the LCS AP Glide incorporated a guide arm which allowed movement in both the AP and rotational directions. All components were size 3.

The testing was performed on six station knee simulators (Simulation Solutions, Manchester, UK) using femoral axial loading (max. 2600N) and flexion-extension (0 - 58°) profiles taken from ISO 14243 (2002). The internal-external rotation was ±5°. The AP force profile adopted from ISO 14243 (2002) (-262 to 110 N) was used for the LCS RP, as this design restricts AP motion. An AP displacement of 0-10 mm was used for the LCS AP Glide. All TKRs were tested for a minimum of 5 million cycles. The movement of the tibial insert relative to the tibial tray was quantified for the LCS AP Glide under these kinematic conditions using a ceramic bead embedded in the inferior surface of the tibial insert.

The simulator was run at 1 Hz and the lubricant used was 25% (v/v) newborn calf serum with 0.1% (w/v) sodium azide solution in deionised water. Wear of the tibial inserts was determined gravimetrically, using unloaded soak controls to compensate for moisture uptake. Volumetric wear was calculated from the weight loss of the inserts using a density of 0.934 mg/mm³. Statistical analysis was performed using One way ANOVA.

Results: The mean wear rates with 95% confidence limits are shown in Figure 1. The LCS AP Glide had a mean wear rate of 12.14 ± 4.20 mm³/million cycles (mm³/MC) and the LCS RP had a significantly lower mean wear rate of 5.18 ± 1.67 mm³/MC (p < 0.01). For comparison purposes, the PFC Σ cruciate retaining fixed bearing TKR with a cobalt chrome tray and tested under the same kinematic conditions as the LCS AP Glide, had a wear rate of 15.93 ± 2.93 mm³/MC. Although higher than the LCS AP Glide, this was not significant (p > 0.08).

Discussion: The low wear rate of the LCS RP has been attributed to the decoupling of the rotation motion from the femoral interface to the inferior surface of the tibial insert, thus reducing cross-shear on the superior femoral articulating interface, as well as a reduction in antero-posterior sliding [2]. The increased wear rate of the LCS AP Glide in comparison to the RP was likely due to the increased antero-posterior sliding and more multi-directional motion observed at the tibial interface, which resulted in higher cross-shear.


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