Institute of Medical & Biological Engineering

The Effect of Insert Conformity on Total Knee Replacement Wear

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Aims & Objective

Demand for joint replacements in young patients is increasing, and therefore there is a need to increase the lifetime of the prostheses.

One of the design parameters that may affect the predicted lifetime of TKRs is the insert conformity (Fisher et al 2010).

The objective of the present study was to investigate the effect of insert conformity on wear in TKR.

Materials & Methods

Using a previously validated non-dimensional wear coefficient (*C*) based computational wear model (Abdelgaied et al., 2011).

The volumetric wear (*W*) was defined as a function of contact area (*A*) and sliding distance (*S*) from the formulation:

$$W = C\,A\,S \qquad (1)$$

The conventional UHMWPE wear coefficients were independently measured from experimental Pin-on-Plate wear tests (Kang et al., 2008), for the same TKR material combination.

Four different insert designs, with different conformity (Figure 1), were tested against the Sigma fixed femoral (DePuy, UK).

Two different kinematic inputs, intermediate and high kinematic inputs (McEwen et al., 2005).

UHMWPE was modelled as an elastic–plastic material (Godest et al. 2002), with a modulus of elasticity of 463 MPa and a Poisson's ratio of 0.46 (Bartel et al., 1995, Kurtz et al., 2002).

Materials & Methods

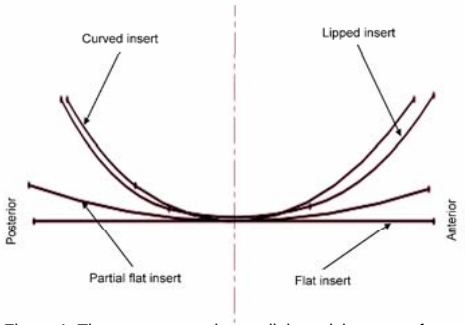

Figure 1: The curvature at the medial condyle centre, for different insert types.

Results

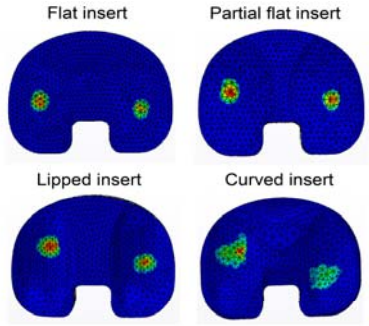

Figure 2: Contact pressure [MPa] (contact area [mm^2]), for different inserts, at 50% gait cycle, under intermediate kinematic inputs.

Results

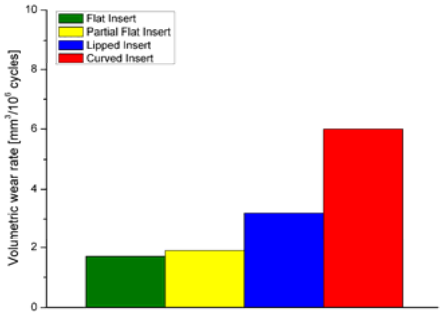

Figure 3: Predicted volumetric wear rate for different inserts, under intermediate kinematic inputs.

Results

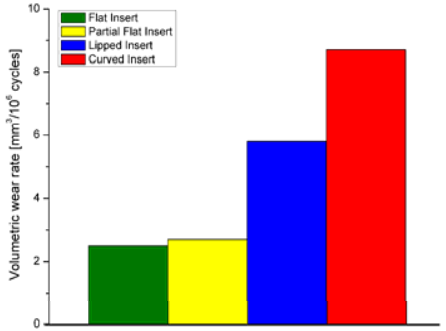

Figure 4: Predicted volumetric wear rate for different inserts, under high kinematic inputs.

Discussion

The computational wear model was based on the contact area (Figure 2) and an independent experimentally determined non-dimensional wear coefficient.

Under both intermediate and high kinematics, the less conforming geometries had the lower predicted wear (Figures 3 and 4).

The predicted wear rate for the curved insert was more than three times that for the flat insert, under both intermediate and high kinematic inputs (Figures 3 and 4).

The predicted wear rates under high kinematics were approximately 1.5 times the corresponding predicted wear rate under intermediate kinematics, for the same insert.

Conclusions

The current study showed that a potential method for increasing the expected total knee replacement lifetime may be to introduce less conforming knee replacements.

Acknowledgments

A. Abdelgaied is supported by The Egyptian Ministry of Higher Education & Scientific Research (Helwan University).

J. Fisher is an NIHR senior investigator.

This research work is supported by EPSRC, the Leeds Centre of Excellence in Medical Engineering, WELMEC ,funded by the Wellcome Trust and EPSRC, WT088908/Z/09/Z and the Leeds Musculoskeletal Biomedical Research Unit (LMBRU), funded by NIHR.

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Conflict of interest statement

J. Fisher is a consultant to DePuy International Ltd, UK, a Director and share holder of Tissue Regenix plc and BITECIC Ltd and a Director of Medilink.
C. Brockett is a consultant to DePuy International Ltd, UK.