Institute of Medical & Biological Engineering

Experimental Setup and Kinematic Input Conditions Influence the Wear of Total Knee Replacements

UNIVERSITY OF LEEDS

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Introduction

Wear performance of total knee replacements (TKR) can be determined pre-clinically through experimental [1] and computational wear simulation [2].

In experimental wear simulation our philosophy has been to set the centre of rotation of femoral components on their distal radius in order to facilitate femoral rollback [1].

Aim

The aim of this study was to investigate the influence of femoral setup (the position of the centre of rotation) and kinematic inputs (the amplitude and polarity of anterior-posterior displacement) on wear.

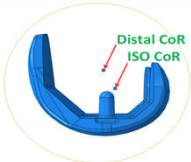
Materials

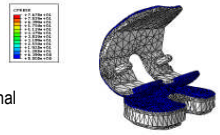
Sigma CR fixed bearing TKRs (DePuy Synthes, Leeds, UK) with curved moderately cross-linked polyethylene inserts (XLK) (n=6)

Experimental & Computational Methods

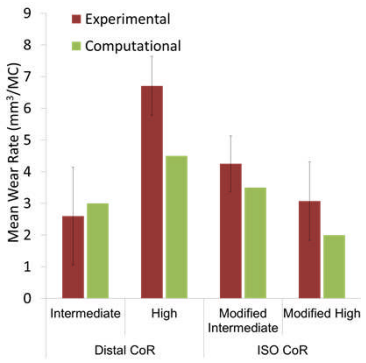
Experimental:
Femoral components set up on either Distal centre of rotation (Distal CoR) or ISO centre of rotation (ISO CoR).
Standard Leeds kinematic input conditions for the TKR's set up on Distal CoR; maximum anterior-posterior (AP) displacement of either 10mm (high) or 5mm (intermediate) [1].
Setting the femoral component on the ISO CoR led to the femoral component rolling back off the tibial insert under (Leeds) high kinematic conditions, necessitating a reversal of direction of the AP displacement in order to maintain contact within the insert.
Lubricant 25% new-born calf serum, wear assessed gravimetrically, 3 million cycles for all test conditions, statistical analysis performed using one way ANOVA (significance at 0.05).

Computational:
Wear model based on the contact area and an independent experimentally determined non-dimensional wear coefficient, previously validated against experimental data [2].

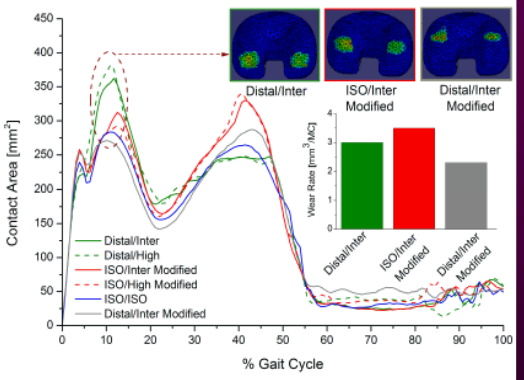




Results



Experimental (with 95% Confidence Limits) and Computational Mean Wear Rates



Computationally Predicted Contact Area, Average Wear Rates Under Different Conditions

Results

The reversal of the AP displacement produced a significantly lower wearing configuration under high kinematic conditions on the ISO CoR ($p<0.05$).
On the distal radius the wear under high kinematic conditions was significantly higher than under intermediate conditions ($p<0.05$). However, for the TKRs on the ISO CoR, the trend was reversed.
Good agreement was found between our computational and

Test Conditions	Average Wear Rate [mm³/MC]	Average Cross-shear Ratio
Distal / Inter	3.0	0.025
Distal / High	4.5	0.05
ISO / Inter Modified	3.5	0.005
ISO / High Modified	2.0	0.004
Distal / Inter Modified	2.3	0.002

Computationally Predicted Average Wear Rates and Cross-shear Ratios Under Different Conditions

Significance

These experimental and computational studies have shown that the most important factor influencing the wear of TKRs was the position of the relative contact point at the femoral component and tibial insert interface.

The changes in centre of rotation and direction of AP motion produced significantly different relative motions and levels of cross-shear, significantly influencing wear.

References

1. *McEwen H.J.M, et al., J Biomechanics, 2005.*
2. *Abdelgaied A, et al., J Biomechanics, 2011.*

Disclosure

John Fisher is an NIHR senior investigator, a director of Tissue Regenix Ltd and a paid consultant to DePuy Synthes;

Acknowledgement

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