Institute of Medical & Biological Engineering

Computational and Experimental Study on the Effect of Centre of Rotation on Wear Performance in TKR

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Introduction

- The combination of flexion-extension, anterior-posterior displacement and internal-external rotation that occur during walking is different from what would occur during deep squatting or passive flexion-extension motion (1, 2).
- The direction and phasing between these three primary motions determine the location of the centre of rotation (COR) of the knee joint (3).
- In-vivo and in-vitro studies suggested that the knee centre of rotation might have a significant effect on the motion and contact at the tibio-femoral joint (4, 5).

Aims & Objectives

- The objective of the present study was to investigate, both computationally and experimentally, the effect of knee centre of rotation on wear performance of a total knee replacement (TKR).
- The computational study was based on a previously validated non-dimensional wear coefficient based, contact area dependent computational wear model (6)

Materials & Methods

- The DePuy Sigma femoral component was run against the PFC Sigma fixed insert, size 3 (DePuy, UK), with conventional UHMWPE material.
- The test was run using the Leeds COR, based on the distal radius of the femoral bearing, and the ISO COR (ISO 14243-3) (Figure 1).
- The loading inputs were adopted from McEwen *et al*. (7) (Figure 2), with reversed AP direction for the ISO setup.

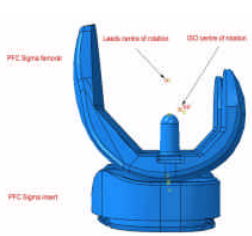

Figure 1: Leeds and ISO centre of rotation for size 3 PFC Sigma fixed TKR, DePuy, UK.

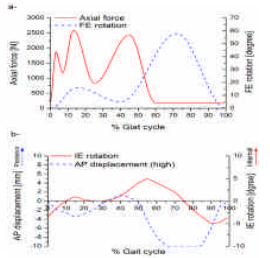

Figure 2: Loading inputs: Axial load and flexion-extension (a), anterior-posterior displacement and internal-external rotation (b) (6).

Results

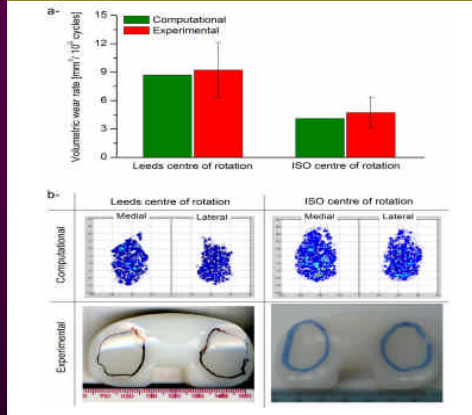

Figure 3: PFC Sigma fixed bearing computational and experimental (mean ±95% confidence interval) wear rates [mm³/million cycles] (a), and wear scars (b).

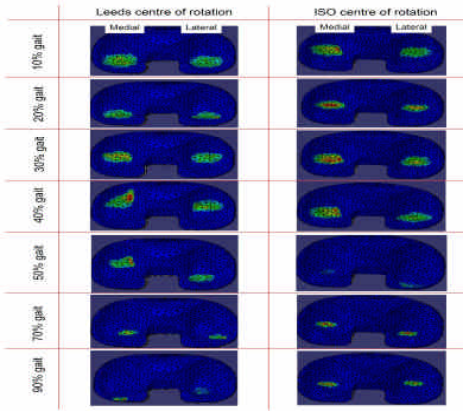

Figure 4: PFC Sigma fixed computationally predicted contact stress [MPa] (contact area [mm²]) at different % gait cycle, for Leeds and ISO CORs.

Discussion

- The predicted wear rate for the ISO COR was approximately half that for Leeds COR, in agreement with the experimental data.
- Although the ISO COR had larger computational wear scars, compared to Leeds COR, it had a lower predicted and experimentally confirmed wear rate (Figure 3).
- The predicted lower wear rate for the ISO COR, compared to Leeds COR, can be explained by the change in contact area.
- The contact stresses (contact areas) plots at different % gait cycle, showed that the Leeds COR had larger contact areas compared to the ISO COR (Figure 4).
- The good agreement found between the computational and the experimental results supports this theory, strengthens the current study and suggests that computational wear modelling is a reliable pre-clinical test method.

Conclusions

The femoral centre of rotation had a significant effect on wear performance in TKR. In addition, the results suggested that activities with high levels of flexion might be accompanied by smaller contact areas and hence lower wear rates.

References

[1] Dyrby and Andriacchi 2004 J Orthopaedic Research 22 794-800.
[2] Koo and Andriacchi 2008 J Biomechanics 41 1269-1273.
[3] Banks and Hodge 2004 J Arthroplasty 19 809-816.
[4] Freeman and Pinskerova 2005 J Biomechanics 38 197-208.
[5] Iwakiet *et al.* 2000 J Bone & Joint Surgery (Br) 82 1189-1195.
[6] Abdelgaied *et al.* 2011 J Biomechanics 44 1108-1116.
[7] McEwen *et al.* 2005 J Biomechanics 38 357-365.

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