Increased Torque in Hip Replacement Bearings due to Translational Surgical Mal-Positioning

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SAFER® Stratified Approach For Enhanced Reliability

Introduction and Aim

- Steep inclination angle and mismatch in centres of rotations of the femoral head and acetabular cup [1] can potentially lead to edge loading in total hip replacement. Edge loading has been shown to cause increased wear or deformation in hip replacement bearings.
- The aim of this study was to develop an in vitro methodology for measuring torques under a wider envelope of surgical positioning including steep cup inclination angles and mismatch in the centres of rotation of the head and cup.

Steep cup inclination angle

Mismatch in the centres of rotation of head and cup

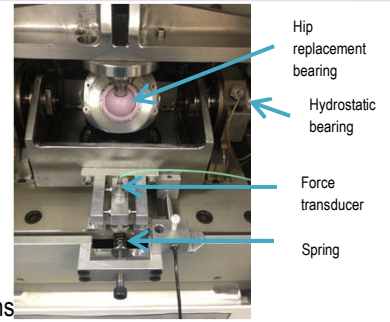
Method

Materials: 36mm CoC (BIOLOX® delta), CoP (BIOLOX® delta and Marathon™) and MoP (Marathon™) bearings (Pinnacle®, DePuy Synthes, Leeds, UK)

Conditions: 2kN peak load and one axis of rotation

1. Well positioned with 45° in vivo equivalent inclination angles
2. Steep inclination angles with 55° and 65°
3. Mismatch in the centres of rotation of the head and cup resulting in microseparation mechanisms during the swing phase which was controlled at 0.5mm.

Lubrication: 25% (v/v) new-born calf serum



ProSim pendulum friction simulator. The force transducer is used to measure the frictional torque and the spring to provide microseparation conditions.

The mean frictional torques and 95% confidence limits were determined.

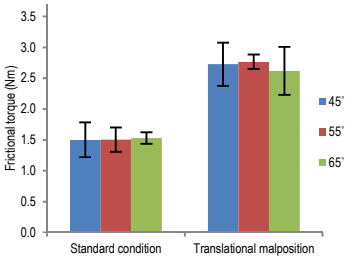
Statistical analysis was carried out using one way ANOVA with significance at $p<0.05$.

Discussion

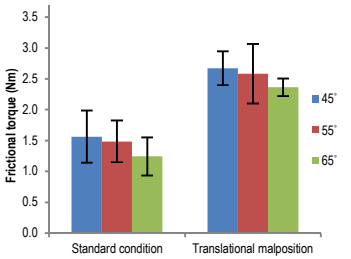
- In this study, it was shown that variations in translational surgical positioning resulting in edge loading conditions due to microseparation conditions can lead to increased torque in ceramic-on-ceramic, metal-on-polyethylene and ceramic-on-polyethylene bearing combinations in total hip replacement.
- These increased levels of torque are important to consider for establishing robust preclinical testing for cup fixation, taper stability, fatigue and corrosion studies, and will form part of our stratified approach for enhanced reliability 'SAFER' pre-clinical simulation testing.

Results

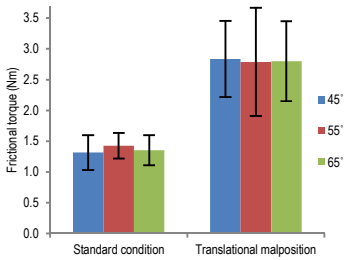
- Steep cup inclination angles did not increase ($p=0.2$) the frictional torque.
- Mismatch in the centres of rotation of head and cup resulted in a significant increase in frictional torque ($p<0.01$ for all bearing combinations and inclination angles).



Mean Frictional Torque (± 95% confidence limit, n=4) of **metal-on-polyethylene** under well-positioned, steep cup inclination angle and microseparation conditions.



Mean Frictional Torque (± 95% confidence limit, n=4) of **ceramic-on-polyethylene** under well-positioned, steep cup inclination angle and microseparation conditions.



Mean Frictional Torque (± 95% confidence limit, n=4) of **ceramic-on-ceramic** under well-positioned, steep cup inclination angle and microseparation conditions.

Significance

- Microseparation conditions, which may occur as a result of many clinical factors such as medialised acetabular cup, head offset deficiency, or soft tissue laxity, may result in increased frictional torques in ceramic-on-ceramic, ceramic-on-polyethylene and metal-on-polyethylene hip replacement bearings.
- Introducing in vitro conditions that simulate variations in surgical positioning is essential during pre-clinical assessment of hip replacement bearings.

References

1. Fisher, J., J Bone Joint Surg Br, 2011. 93(8): p. 1001-4.

Disclosure

J. Fisher is an NIHR senior investigator, a paid consultant to DePuy Synthes, Invibio, Tissue Regenix Group plc and a share holder of Tissue Regenix Group plc; E. Ingham is a paid consultant to DePuy Synthes, Stryker, Tissue Regenix Group plc and a share holder of Tissue Regenix Group plc; S. Williams is a paid consultant to DePuy Synthes; Jonathan Thompson and Graham H. Isaac are employees at DePuy Synthes

Acknowledgement

This study was supported by DePuy Synthes Joint Reconstruction (Leeds, UK) and in part supported by EPSRC Centre for Innovative Manufacturing in Medical Devices and partially funded through WELMEC, a Centre of Excellence in Medical Engineering funded by the Wellcome Trust and EPSRC, under grant number WT 088908/Z/09/Z.

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