Different levels of Rotational and Translational Surgical Mal-Positioning Affects the Occurrence and Severity of Edge Loading and Wear in Total Hip Replacements

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SAFER

Stratified Approach For Enhanced Reliability (SAFER)

Introduction

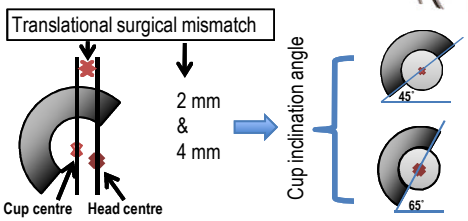
- Increased wear rates [1, 2] and acetabular rim fracture [3] of hip replacement bearings reported clinically have been associated with edge loading, which could occur due to steep cup inclination angle or mismatch in centres of rotation of the head and cup leading to microseparation conditions [4].
- Stripe wear has been observed on retrievals and has been associated with edge loading [1].
- Steep cup inclination angle alone did not reproduce stripe wear in ceramic-on-ceramic bearings in vitro, however, microseparation have replicated stripe wear and the bi-modal wear debris distribution observed clinically [5, 6].

Aim

The aim of this study was to determine the influence of cup inclination angle on the magnitude of dynamic microseparation, severity of edge loading, and the resulting wear rate of a ceramic-on-ceramic bearing, under different levels of rotational and translational surgical positioning.

Materials and Method

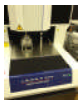
36 mm BIOLOX® delta ceramic-on-ceramic (DePuy Synthes, UK)



Six-station Leeds Mark II Physiological Anatomical Hip Joint simulator

Gait input: 3 kN twin peak load, ±10˚ internal/external rotation & -15˚/+30˚ extension/flexion
Lubricant: 25% new-born calf serum
Total number of cycles: three million
No. of samples: 6 samples per condition

Gravimetric measurements every one million cycles using microbalance (XP205, Mettler Toledo, UK)

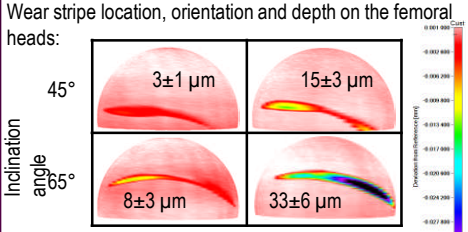


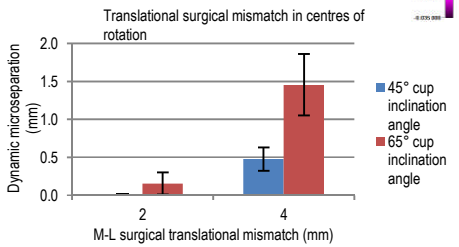
Geometric measurements to reconstruct three dimensional representation of wear area using CMM (Legex 322, Mitutoyo, Japan)

Statistical analysis was performed using one way ANOVA (significance at 0.05)

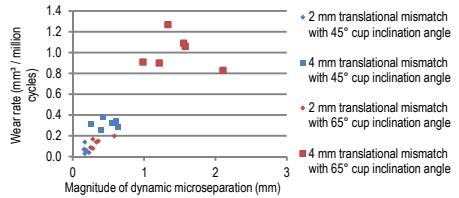
Results

Wear stripe location, orientation and depth on the femoral heads:





Mean (±95% confidence limit) magnitude of dynamic microseparation under 2 & 4 mm medial lateral surgical translational mismatch with two cup inclination angles conditions; 45˚ & 65˚, for ceramic-on-ceramic bearings.



Wear of ceramic-on-ceramic bearing versus dynamic microseparation displacement under the four testing conditions.

Discussion

- Surgical variations, such as steep inclination angle, medialised cups, head offset deficiencies, stem subsidence, and joint laxity can lead to edge loading and increased wear in hip replacement bearings.
- This study showed that both increased surgical translational mismatch between the centres of rotation of the cup and head combined with increased cup inclination compounded the increase in the level of dynamic microseparation conditions, severe edge loading condition and increased wear rates.

Significance

An advanced physiological in vitro simulator method, that can predict the occurrence and severity of edge loading and the wear of different hip bearings materials and designs due to variations in surgical positioning, was developed in this study, and used as a preclinical testing technique to better predict the efficacy and reliability of new hip replacement bearings.

References

1. *Nevelos, J.E., et al., Biomaterials, 1999.* ***2***. *De Haan, R., et al., J Bone Joint Surg Br, 2008.* ***3***. *Waewsawangwong, W. and S.B. Goodman, J Arthroplasty, 2012.* ***4***. *Fisher, J., J Bone Joint Surg Br, 2011.* ***5***. *Nevelos, J., et al., J Arthroplasty, 2000.* ***6***. *Tipper, J.L., et al., Biomaterials, 2002.*

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

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