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

Mazen Al-Hajjar, Oscar O’Dwyer Lancaster-Jones, Sophie Williams, Louise M. Jennings, Jonathan Thompson, Graham H. Isaac, Eileen Ingham, John Fisher

Institute of Medical and Biological Engineering, School of Mechanical Engineering, University of Leeds, Leeds, LS2 9JT; DePuy Synthes Joint Reconstruction, Leeds, UK

j.fisher@leeds.ac.uk

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 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].

Materials and Method

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

Translational surgical mismatch

Cup centre vs Head centre

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

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

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


Disclosure

J. Fisher is an NHR senior investigator, a paid consultant to DePuy Synthes, Stryker, 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 Joint Reconstruction, Leeds, UK and a paid consultant to 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 098332/Z/09/Z.

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