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Introduction

Applying the same standard conditions using different simulators provides the opportunity to compare the wear rates of the same type of hip component; however the expectation of obtaining the same results using different simulators has been challenged. Recently developed electromechanical simulators are able to fully comply with the latest ISO standards [1].

Aim

The aim of this study was to compare the wear rates of metal-on-UHMWPE bearings tested using newly developed electromechanical hip joint simulators and a pre-existing pneumatic hip joint simulator.

Materials and Equipment

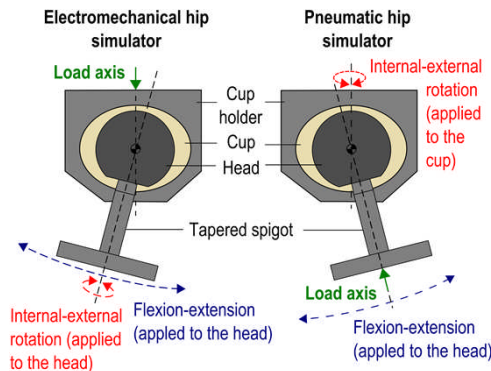
Ten 36mm diameter cobalt chrome on moderately cross-linked UHMWPE (Marathon™, DePuy Synthes Joint Reconstruction, Leeds, UK) hip replacements were tested on simulators, ProSim EM13 (n = 6) and ProSim pneumatic (n = 4) (Simulation Solutions, Stockport, UK).

Methods

The input load profile, angular displacements [2] and lubrication were the same for all tests.

EM13 and pneumatic simulator test conditions

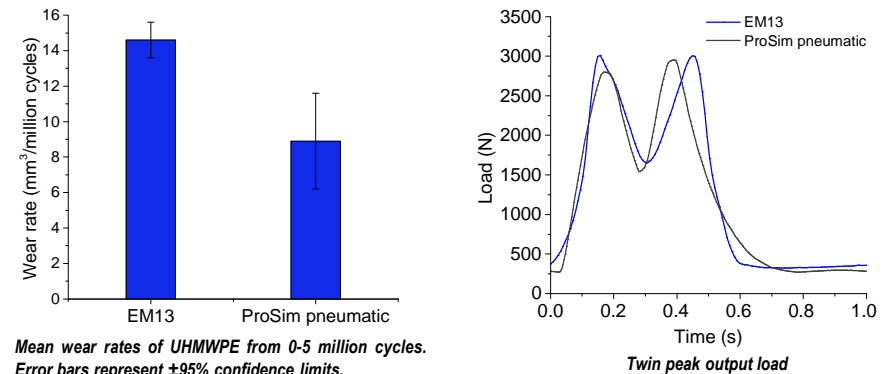
	Test condition
Axial load	3000N twin peak load with 300N swing phase load
Flexion-Extension	+30°/-15°
Internal-External rotation	±10°
Lubrication	25 % new-born calf serum
Test duration	5 million cycles (for each test)



ProSim electromechanical and pneumatic simulator test station schematic (front view)

- Gravimetric analysis was carried out at 1, 2, 3 and 5 million cycle intervals using a microbalance (Mettler Toledo XP205, Greifensee, Switzerland).
- Statistical analysis: One-way ANOVA, significance taken at $p \leq 0.05$.

Results



Mean wear rates of UHMWPE from 0-5 million cycles. Error bars represent ±95% confidence limits. Between 0-5 million cycles: the wear rate (per million cycles) from EM13 was significantly higher ($p < 0.01$) compared with the ProSim pneumatic simulator.

Discussion

- Differences in simulator design, load and kinematics application could contribute to the variation in wear rates in metal-on-polyethylene hip replacement bearings. Different phasing and magnitude of the twin peak loads, and transition rate to the swing phase load was observed between simulators.
- The importance of using control samples for each simulator is confirmed.
- Comparing results from different simulators may offer an initial approach to simulator validation, however, direct comparisons of absolute wear rates between simulators should be avoided.

Significance

This study shows the importance and influence of *in-vitro* simulator design and mechanics on the wear rates of moderately cross-linked polyethylene.

References

- ISO 14242-1:2014
- Barbour PSM et al. Proc. Inst. Mech. Eng. H J. Eng. Med., 213, 455-467, 1999.

Acknowledgements

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