A Multi-station Independent Electromechanically Driven Knee Simulator for the Investigation of Wear of Total Knee Replacements, a Comparison to Pneumatically Controlled Simulators

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INTRODUCTION

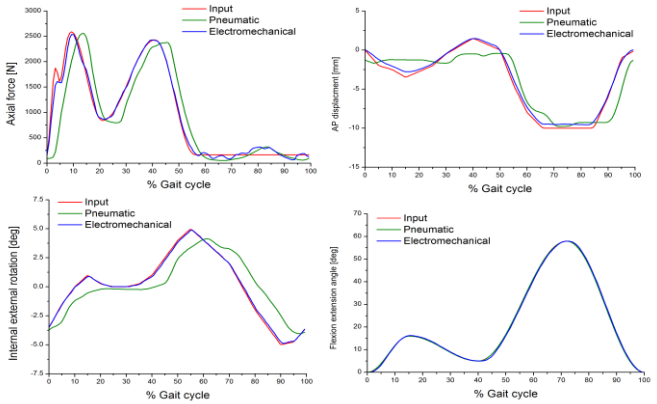
- New electromechanically driven knee simulator (SimSol, UK).
- 5 fully independently controlled axes of articulation for each station.
- Enhanced capability.
- Wear and kinematics were investigated using a fixed bearing total knee replacement (TKR).
- Data compared to previous data from a predominantly pneumatically controlled simulator that was not fully independently controlled.

MATERIALS & METHODS

- Six Sigma CR fixed bearing TKR (DePuy, UK) with curved moderately cross-linked polyethylene inserts.
- Displacement controlled kinematics.
- A maximum anterior-posterior displacement of 10mm (high kinematics) or 5mm (intermediate kinematics) [1].
- 3 million cycles (MC) each of high and intermediate kinematics.
- 25% new-born calf serum.
- Output kinematics and gravimetrical wear were determined.
- Data compared to data from pneumatic knee simulators to investigate the simulator performance.

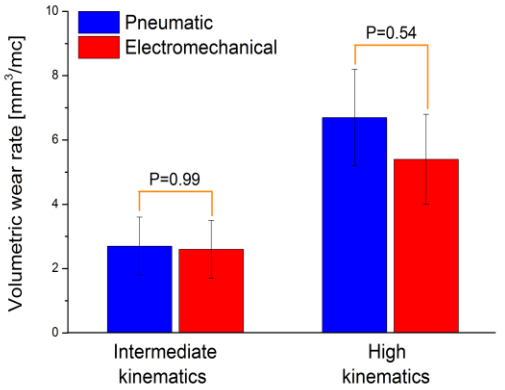
Capability	Electromechanical knee simulator	Pneumatic knee simulator
Independent axes	5	3
Operating frequency	up to 2.0 Hz	up to 2.0 Hz
Flexion extension	Up to +/-90°	Up to +/-90°
Anterior posterior	Up to +/-25mm	Up to +/-13mm
Tibial rotation	Up to +/- 25°	Up to +/- 10°
Adduction abduction	Up to +/-10°	Up to +/-10°
Medial lateral	Up to +/-10mm	Up to +/-10mm
Axial loading	up to 5kN	up to 5kN
Force / displacement	√	√

RESULTS



Input and average output kinematic profiles from the electromechanical and pneumatic knee simulators under high kinematic inputs.

Volumetric wear rates (mean ± 95% CI, n=6) under intermediate and high kinematic conditions measured from pneumatic [2] and electromechanical knee simulators.



DISCUSSION

- The actual delivered loading and kinematic profiles followed the input loading and kinematic profiles more closely on the electromechanical simulator.
- The wear rates from the two simulators were similar under standard gait conditions.
- Inter-station variability in terms of varying wear rates still existed in the electromechanical simulator.
- Suggests that other factors such as alignment of the TKRs and station set up played a role.

SIGNIFICANCE

- The second generation fully independent electromechanically driven knee simulator showed improved performance and capability compared to the previous generation of predominantly pneumatically driven knee simulator.
- Therefore the second generation fully independent electromechanically driven knee simulator can be applied in our SAFER® pre-clinical wear simulation approach to investigate a wider range of conditions.

References

[1] McEwen et al. J BioMech, 2005.
[2] Brockett et al. ORS, 2014.

Acknowledgments

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