A Comparison of Electromechanical versus Pneumatic-Controlled Knee Simulators for the Wear Performance of a Total Ankle Replacement

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Objectives:

Implant loosening remains a common cause of total ankle replacement (TAR) revision, and has been associated with wear-mediated osteolysis. Relatively few pre-clinical testing studies for TARs have been reported and the variety of experiment settings used make it difficult to directly compare wear rates. Factors such as simulator control mechanism; whether pneumatic or electromechanical, may influence the integrity of the simulator outputs with respect to input profiles. This study compares the wear of a TAR tested in electromechanical and pneumatic experimental simulators under identical input conditions.

Methods:

Twelve medium BOX® (MatOrtho Ltd) TARs (n=6 for each simulator) were tested in an electromechanical and pneumatic knee simulator (Simulation Solutions, UK) for 3 million cycles (Mc). Standard displacement-controlled motion and loading profiles were used [1]. Kinematic performance was investigated by comparing the output profiles against the maximum demanded input values. The lubricant used was 25% new-born calf serum and wear was determined gravimetrically.

Results:

There was no significant difference ($P = 0.66$) in wear rate between simulators (electromechanical = 15.96±6.37mm^3/Mc; pneumatic =14.51±5.27mm^3/Mc). The electromechanical simulator (3157.06±1.52N) achieved the maximum axial load (3150N), but the pneumatic simulator was unable to attain the demand (2542.34±86.52N). The maximum delivered AP displacement from the electromechanical simulator was 3.27±0.07mm (3.1mm input) compared to 3.62±0.95mm from the pneumatic simulator. The internal/external rotation angle was 7.97°±0.00N (8° input) and 7.24°±0.12N from the electromechanical and pneumatic simulators respectively. Both simulators achieved the demanded flexion angles (±15°).

Conclusions:

The outputs from the electromechanical simulator followed the input profiles more closely than the pneumatic simulator. Despite these differences, there was no significant influence on wear rate. The variation in kinematics between simulators was not sufficient to significantly change the tribological conditions of the TAR. However, the authors recommend the use of electromechanical simulators for future studies where more demanding and adverse conditions may be applied.

References

[1] Smyth A, Fisher J, Suñer S, Brockett, C. Influence of kinematics on the wear of a total ankle replacement. J Biomech. 2017; 53:105-110.

Objectives: Implant loosening remains a common cause of total ankle replacement (TAR) revision, and has been associated with wear-mediated osteolysis. Limited pre-clinical studies for TARs have been reported and the variety of experiment settings make it difficult to compare wear rates. Factors such as simulator control mechanism; whether pneumatic or electromechanical, may influence the integrity of the simulator outputs with respect to input profiles. This study compares the wear of a TAR, tested in electromechanical and pneumatic experimental simulators under identical input conditions. Methods: Twelve medium BOX® (MatOrtho Ltd) TARs (n=6 for each simulator) were tested in an electromechanical and pneumatic knee simulator (Simulation Solutions, UK) for 3 million cycles (Mc). Standard 'Leeds' displacement-controlled inputs were used. Kinematic performance was investigated by comparing the output profiles against the maximum demanded input values. The lubricant used was 25% new-born calf serum and wear was determined gravimetrically. Results: There was no significant difference (P=0.66) in wear rate between simulators (electromechanical = 15.96 ± 6.37mm^3/Mc; pneumatic = 14.51 ± 5.27mm^3/Mc). The electromechanical simulator (3157.06 ± 1.52N) achieved the maximum load (3150N), but the pneumatic simulator was unable to attain the demand (2542.34 ± 86.52N). Maximum AP displacement from the electromechanical simulator was 3.27 ± 0.07mm (3.1mm input), compared to 3.62 ± 0.95mm from the pneumatic simulator. Internal/external rotation angle was 7.97° ± 0.00N (8° input) and 7.24° ± 0.12N from the electromechanical and pneumatic simulators respectively. Both simulators achieved the demanded flexion angle (±15°). Conclusions: The outputs from the electromechanical simulator followed the input profiles more closely than the pneumatic simulator. Despite these differences, there was no significant influence on wear rate. The variation in kinematics between simulators was not sufficient to significantly change the tribological conditions of the TAR. The authors recommend the use of electromechanical simulators for future studies where more demanding and adverse conditions may be applied.