Institute of Medical & Biological Engineering

WEAR OF A TOTAL ANKLE REPLACMENT

UNIVERSITY OF LEEDS

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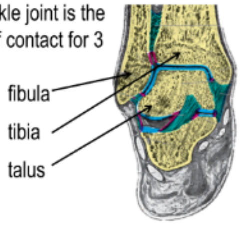
Introduction

The ankle joint is the point of contact for 3 bones



Ankle injuries can lead to **post-traumatic ankle arthritis** often needing surgical intervention.

The only motion preserving end stage treatment is **Total Ankle Replacement** (TAR) which aims to regain a pain free range of motion by replacing the tibial and talar surfaces with a mechanical bearing [1]

The Problem

- Ankle replacements were introduced in the 1970s but its clinical success is far inferior to that of hip and knee replacements
- Of new generations the average survivorship is approximately **89% at 10 years**, varying for specific designs [2]
- Osteolysis is cited as the biggest cause of failure after infection, which, in other joints has been attributed to presence of wear particles [3]
- Limited understanding of TAR failure
- As class II devices in-vitro testing has been limited

The Aim

The aim is to develop a method of evaluating the wear performance of a TAR used clinically.

The tribology and wear effects of the ankle replacement system can be quantified through mechanical simulation of the ankle gait cycle.

This method can be used to understand the implications of a variety of gait combinations on the Corin Zenith TAR

Materials and Methods

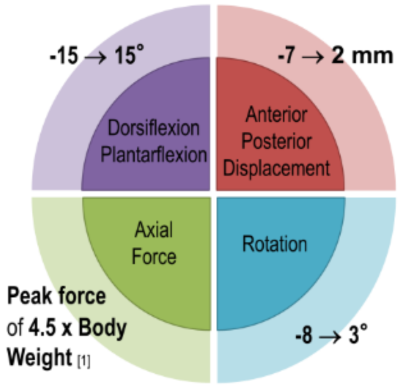
A knee simulator was altered to be able to run smaller TAR components →

Driven Parameters
- Axial Force
- Plantar/Dorsiflexion
- Rotation
- Anterior/Posterior Displacement

Passive Parameters
- Inversion/Eversion

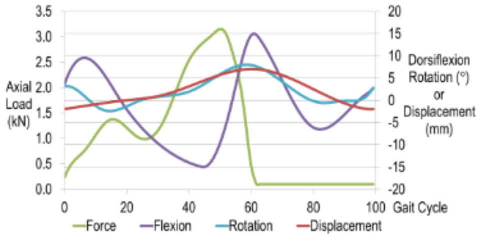
Fixed Parameters
- Medial/Lateral Displacement

A range of motion during gait which can be driven in the simulator was defined from literature →

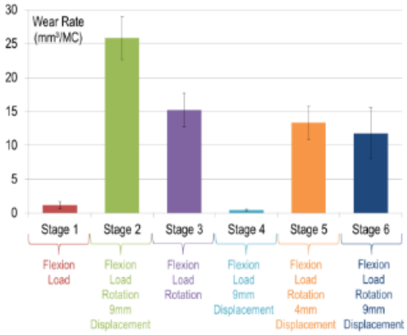


A gait profile was defined. Five combinations of inputs were tested for 2 million cycles (MC) with Stage 2 inputs repeated. Wear was quantified gravimetrically every MC.

	Stratification Stage					
	1	2	3	4	5	6
Force	✓	✓	✓	✓	✓	✓
Flexion	✓	✓	✓	✓	✓	✓
Rotation	✗	✓	✗	✓	✓	✓
Displacement	✗	9mm	9mm	✗	4mm	9mm



Results



The measured polyethylene wear rate depended on the gait inputs applied to through the simulator

- Linear inputs of Stage 1 and 4 produced significantly lower wear independent of displacement
- The combination of high displacement and rotation in Stage 2 the wear rate was significantly higher at 25.8±3.1 mm³/MC
- For stages 3,5 and 6 there is no significant difference in the measured wear rate despite varying displacement

Discussion

- Rotation and displacement were observed to occur at the tibial interface whereas the talar wear scratches were linear
- Stages involving rotation increased the TAR wear rate tenfold a similar trend to Johnson seen in knees [4]
- Initially displacement appeared to increase wear rate but later in testing the effect of displacement was no longer significant
- The AP displacement trend contrasted with McEwen et al. who found the wear to be dependent on the AP magnitude in knee replacements [5] thought to be due to the tibial interface remaining a surface with multidirectional wear even with no AP
- Significantly increased wear in first MC after unidirectional stages as a result of strain softening effects [6]
- Wear rate comparable to similar unconstrained designs

References

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[5] McEwan et al. Journal of Biomechanics, 2005. 38: p. 357-365
[6] Wang et al. Wear, 1997. 204: p.230-241

Financial Disclosure: AS is funded by an EPSRC CASE studentship, supported by Corin Ltd. AT is an employee of Corin Ltd. JF a consultant to DePuy International Ltd, UK, a Director and share holder of Tissue Regenix plc.
Acknowledgements JF is an NIHR senior investigator. This research work is supported by EPSRC, the Leeds Centre of Excellence in Medical Engineering, WELMEC, funded by the Wellcome Trust and EPSRC, WT088908/Z/09/Z and the Leeds Musculoskeletal Biomedical Research Unit (LMBRU), funded by NIHR.

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