GRIFFITH UNIVERSITY

A Mechano-Acoustic Phantom-Twin Of The Post-Amputation Lower-Limb Residuum

Author

Langton, Christian, Perevoshchikova, Nataliya, Feih, Stefanie, Lloyd, David, Barrett, Rodney, Frossard, Laurent

Published

2022

Conference Title

The 13th Australasian Biomechanics Conference (ABC13)

Version

Version of Record (VoR)

Rights statement

© 2022 Australian and New Zealand Society of Biomechanics. The attached file is reproduced here in accordance with the copyright policy of the publisher. Please refer to the conference's website for access to the definitive, published version.

Downloaded from

http://hdl.handle.net/10072/420035

Link to published version

https://www.anzsb.asn.au/abc-13

Griffith Research Online

https://research-repository.griffith.edu.au

A MECHANO-ACOUSTIC PHANTOM-TWIN OF THE POST-AMPUTATION LOWER-LIMB RESIDUUM

Langton CM[1], Perevoshchikova N[1], Feih S[1], Lloyd D[1], Barrett R[1], Frossard LA[1]
[1]Griffith Centre of Biomedical and Rehabilitation Engineering, Australia

INTRODUCTION

We aim to optimise the residuum health of individuals suffering from lower-limb loss, through computational simulations of a '*Digital Twin*' (DT) to facilitate the design of optimized prosthetic attachments. The DT will be informed by 3D medical imaging data, along with triaxial mechanical loading and 4D ultrasound-derived detailed spatial anatomy data. Scientific validation of the *DT* will be performed through development and utility of a bespoke *Mechano-Acoustic Phantom Twin* (MAPT), incorporating replica compartments of soft-tissues and bone-tissue.

METHOD

A simplistic triple-layer cylindrical test sample of 50 mm diameter was created and mechano-acoustically tested. The soft-tissues of skin, fat, and muscle, were replicated by silicone materials with Shore Hardness values of A-20, 00-10 and 00-30 respectively; with corresponding thicknesses of 4, 12, and 24 mm. Noting similar acoustic impedance values for the three silicone materials, thin polymeric discs were incorporated between the two internal interfaces to create detectable ultrasound echoes.

The test sample was placed onto a 3D-printed ultrasound transducer housing. Mechanical load-deformation analysis (Instron) was performed as the test sample was uniaxially compressed at a constant rate of 2.5 %/s to 25 % compression (10 mm), followed by 45 seconds of hold. Dynamic Anatomical Ultrasonography (DAU) analysis was performed utilising a 1 MHz single-element ultrasound transducer connected to an Olympus Omniscan MX device. Digital video was also used to record deformation over time. A corresponding finite element model (FEA) model of the triple-layer sample, with accurately assigned hyperelastic material properties and applied loading matching experimental boundary conditions was developed. Tissue interface depth (mm) versus time was calculated using FEA. A photograph of the triple-layer test sample positioned on the ultrasound housing between Instron platens, incorporating a video calibration frame, is shown in Figure 1a.

RESULTS

Mechanical testing, DAU and FEA results are shown in Figures 1b - 1d.

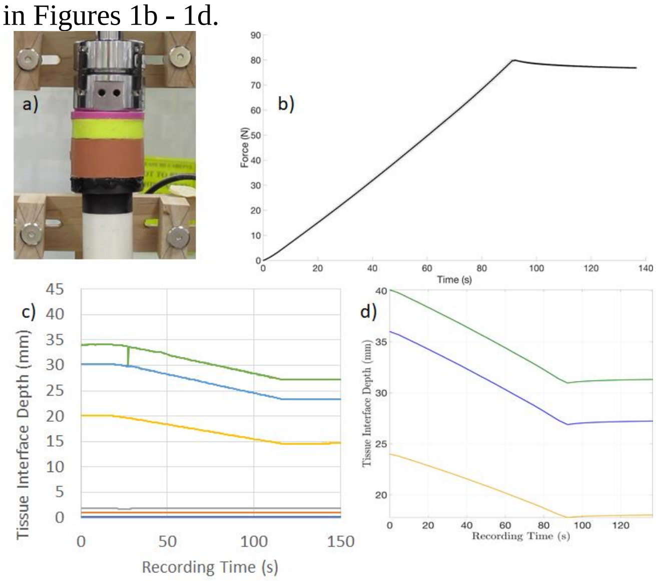

Figure 1. a) Experimental set-up; b) force-time curve; interface-depth vs time plots for c) DAU and d) FEA

CONCLUSIONS

All four analysis techniques demonstrated expected deformation-time relationships. Future MAPT designs will utilise medical imaging data to replicate the detailed spatial anatomy of a given subject.

REFERENCES

Frossard L, Lloyd D. Research Features, 134, 54-7, 2021

FUNDING

DoD RESTORE Award W81XWH2110215-DM190659 and the Bionics Queensland Challenge 2021 Major Prize – Mobility.

ACKNOWLEDGEMENTS

Antonio Grimm and Derek Smith of Griffith University's ADaPT for CAD and 3D-printing support, along with Dr Kevin Moerman of National University of Ireland for FEA support.

Dr Christian M Langton, c.langton@griffith.edu.au