Investigating the mechanical behaviour of 3D printed prosthetic socket under gait loading conditions: Numerical and experimental assessment

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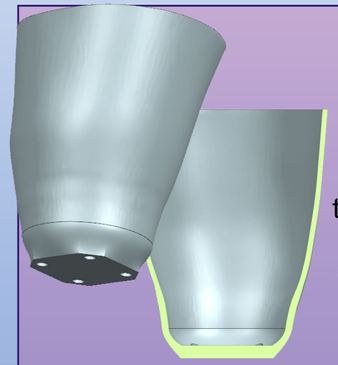
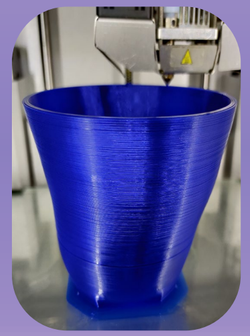
Introduction. Due to the unique geometrical characteristics of the prosthetic socket and the complex loading mechanism during walking, there is no standard procedure to assess the mechanical behaviour of such a component. This research aims to assess the loading capacity of the prosthetic socket using experimental and numerical framework. ISO 10328 load requirements, modified for paediatric application, were used to address the structural compliance of the sockets tested with a custom, in-house developed testing rig. Finite Element Modelling is used to simulate static loading of a transfemoral socket to understand the stress distribution inside the socket.



A socket CAD model was developed with approximately 3 mm thickness at the vertical walls and a thickened 7 mm at the distal end. Distal end was square shaped to be safely attached on the pyramid

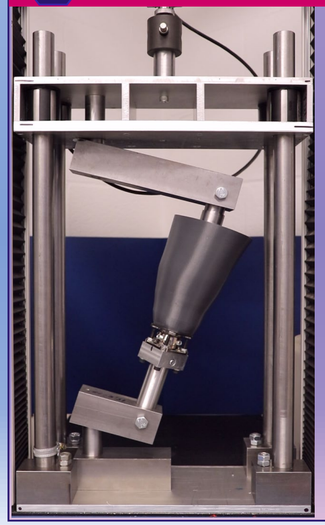
1 Socket Design – 3D printing

PLA was used to 3D print the socket with 100% infill throughout the product. The produced socket was weighted at 220 grams. For the printing an Ultimaker 2+ was used at a printing speed of 70 mm/s.

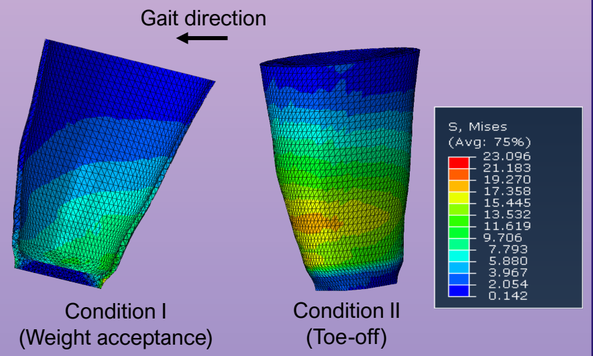


BS EN ISO 10328 guidelines were modified to represent a paediatric application. A new weight class was introduced and the loading conditions were adjusted to the new requirements. Loading conditions simulated the “heel-strike” stance of the gait cycle.
To achieve realistic loading of the socket, a residual limb mannequin was used with mechanical properties similar to soft-tissue. A steel mandrel was used to simulate the internal bone structure.

2 Prosthetic Socket Testing



Testing configuration for Condition I of paediatric prosthetic sockets

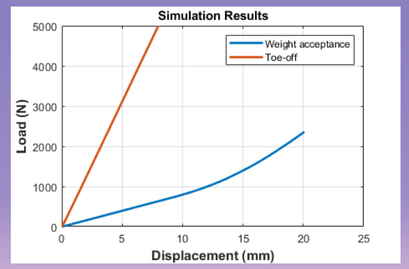


Condition I
(Weight acceptance)

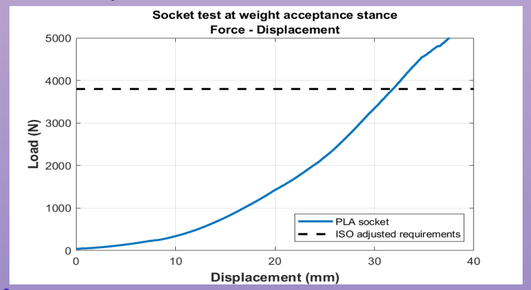
Condition II
(Toe-off)

2 Numerical Simulations

Finite element modelling was used to identify the stress distribution on the socket during the static compressive loading tests



Results from Condition I indicate that the socket can withstand approximately 5000 N without failing easily surpassing 3890 N that was the required level.



4 Results - Conclusions

A paediatric transfemoral socket was 3D printed and mechanically tested. The socket was tested using an in-house developed loading apparatus, in accordance with modified standard from BS EN ISO 1032.

The findings of this study, demonstrate the potentials of 3D printing in prosthetic socket manufacturing supported by encouraging results from thorough mechanical testing.