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The Effect of Prosthetic Socket Texturing on Suspension

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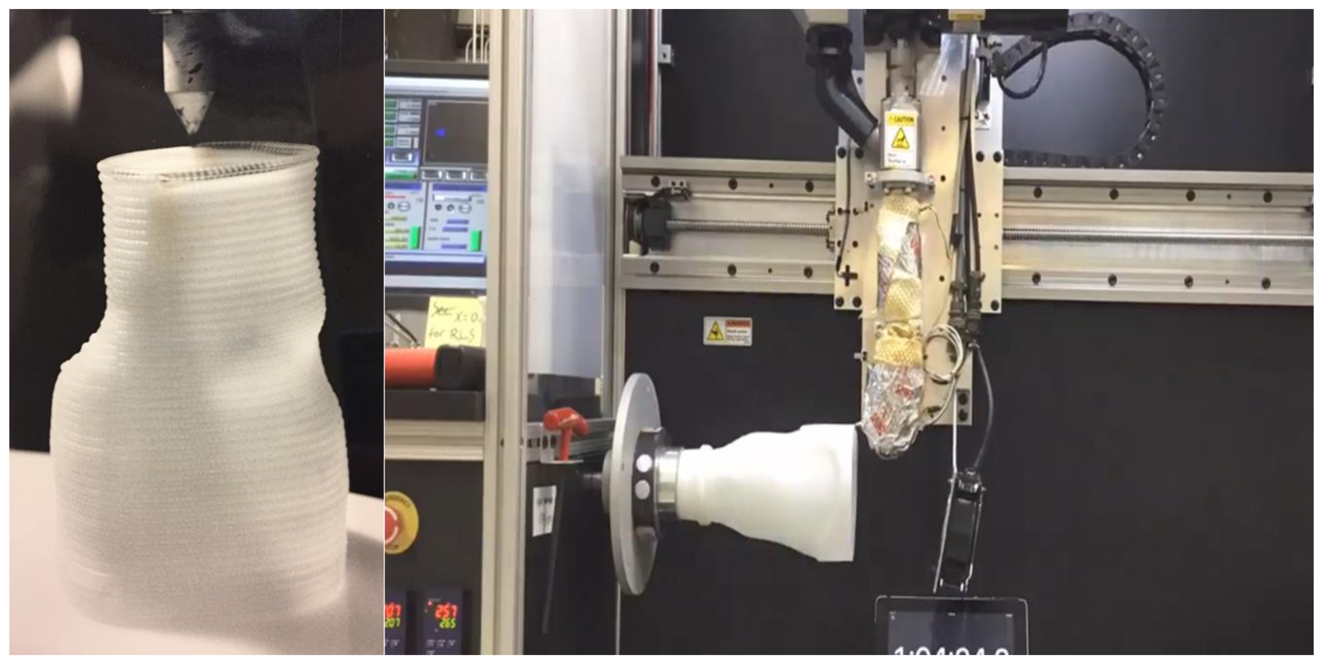
PROSTHETIC DESIGN.

Introduction

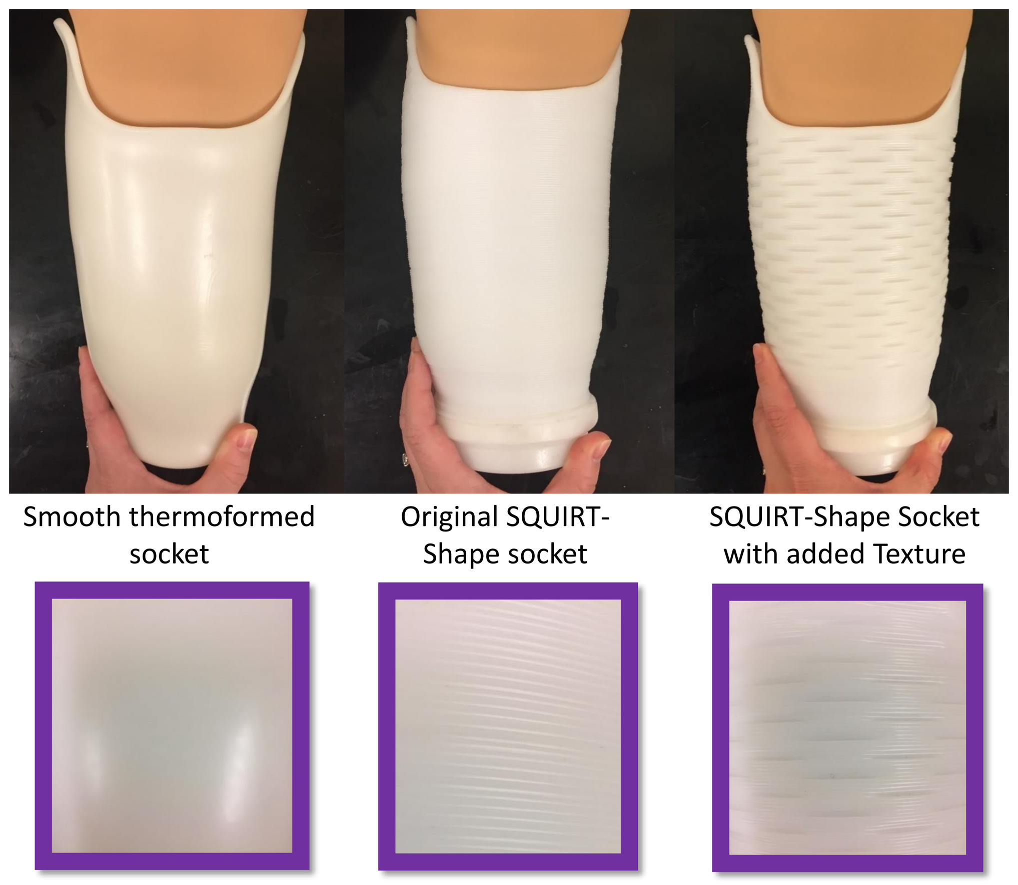
Fused deposition modelling of prosthetic sockets, such as with the SQUIRT-Shape Rapid Prototyping System [1], results in a textured surface as compared to conventionally smooth sockets. Texturing sockets may improve suspension by increasing the coefficient of sliding friction between the socket and liner. This serves to minimizing the lower limb prosthesis slipping off the residual limb during activities.



Original SQUIRT-Shape socket with horizontal striations and socket fabrication.

Aim

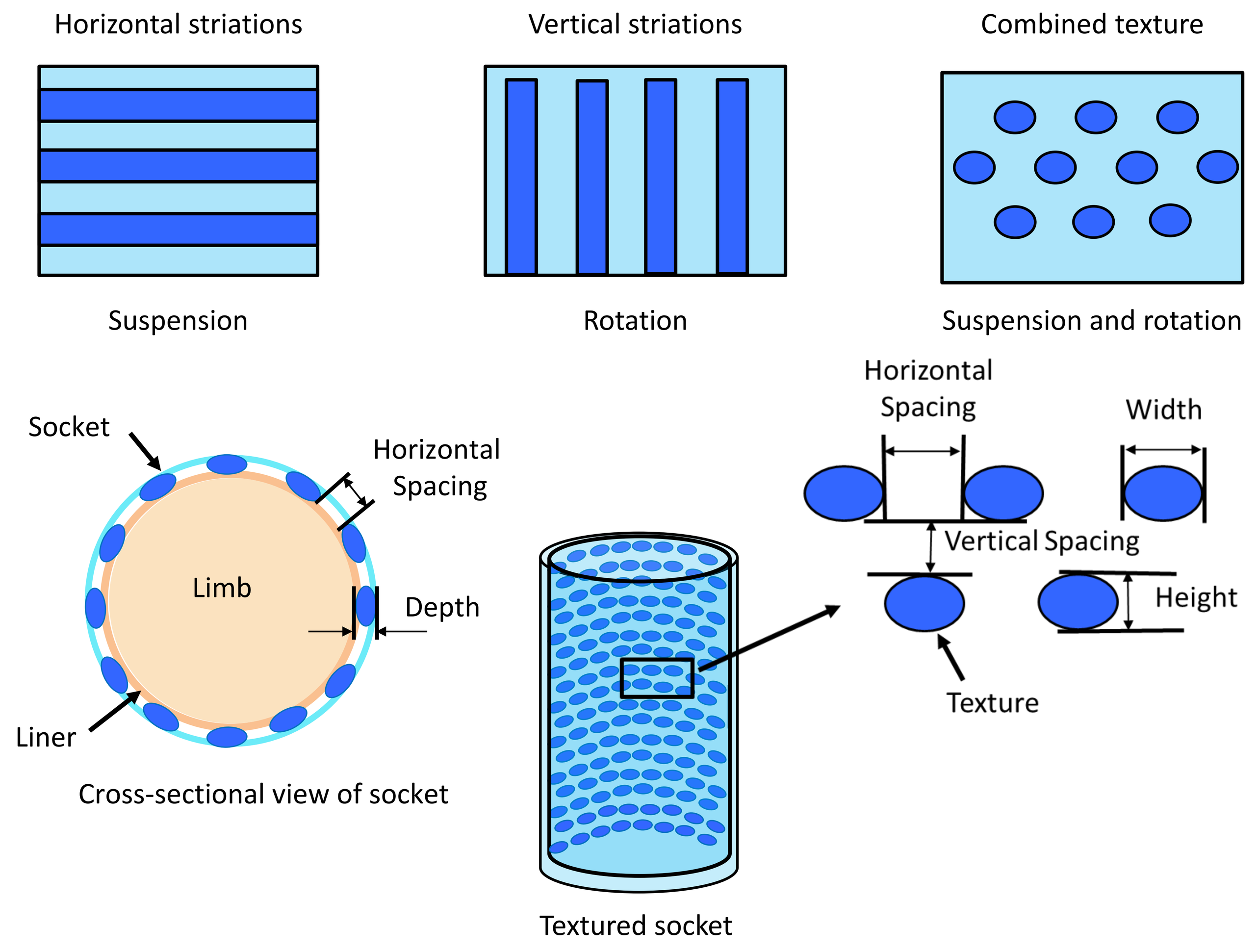
To evaluate the effect of socket texturing on socket suspension using mechanical testing.



Smooth socket, original SQUIRT-Shape Socket texture, and SQUIRT-Shape socket with added texture.

Hypothesis

Socket texturing will decrease longitudinal displacement.



Dimensions of socket textures that can be programmed for 3D-printing.

Methods and Results

Sockets

A selection of different texture patterns were programmed and 3D printed using the SQUIRT-Shape System [1]. A smooth thermoformed socket and a SQUIRT-Shape socket with original texturing consisting of horizontal striations approximately 1.2 mm in depth were used as controls.

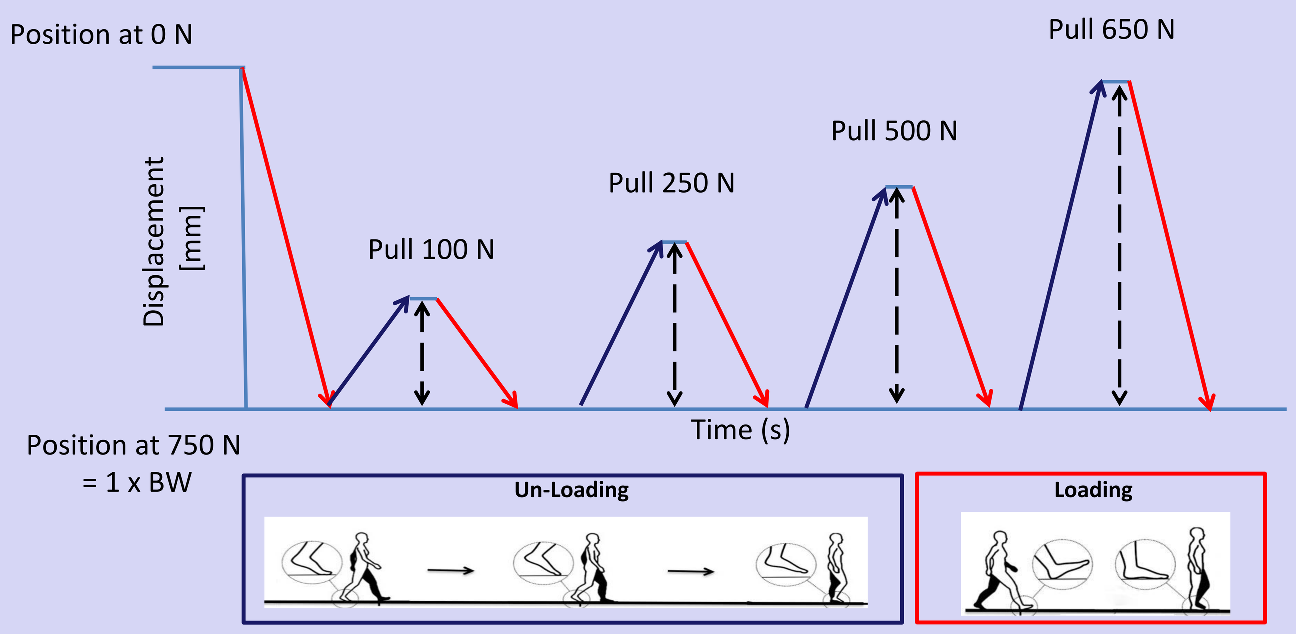
Reference Sockets	
Smooth thermoformed socket	Original squirt-shape socket

Textured Sockets	
Horizontal line	Vertical line
Hemisphere	Half-hemisphere
Diamond	Checkerboard
Horizontal rectangle	Vertical rectangle

Black represents heavy/dense texturing. Green represents light/sparse texturing.

Testing Protocol

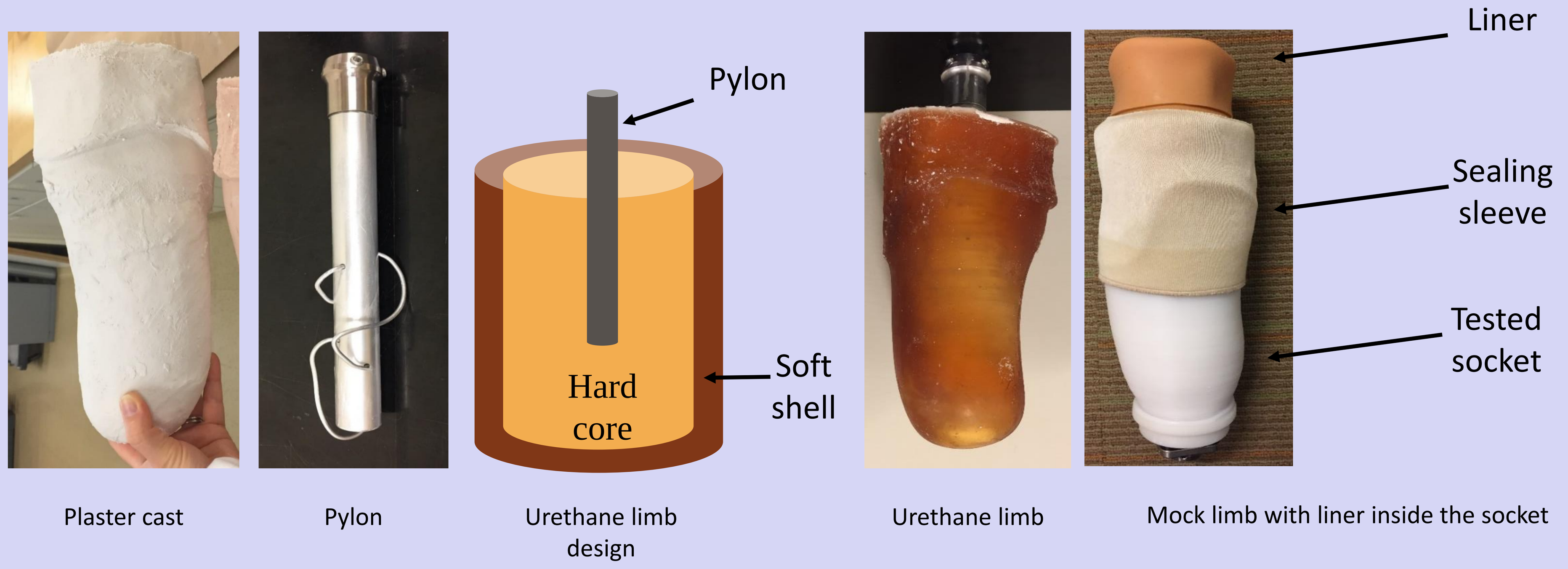
During longitudinal testing, pre-compression of 750 N was applied to the mock limb and socket to mimic the load experienced by a prosthesis user. All sockets were then subjected to preselected distraction force magnitudes of 100N, 250N, 500N and 650N, with 10 cycles at each force magnitude.



Testing protocol.

Mock Limb Fabrication

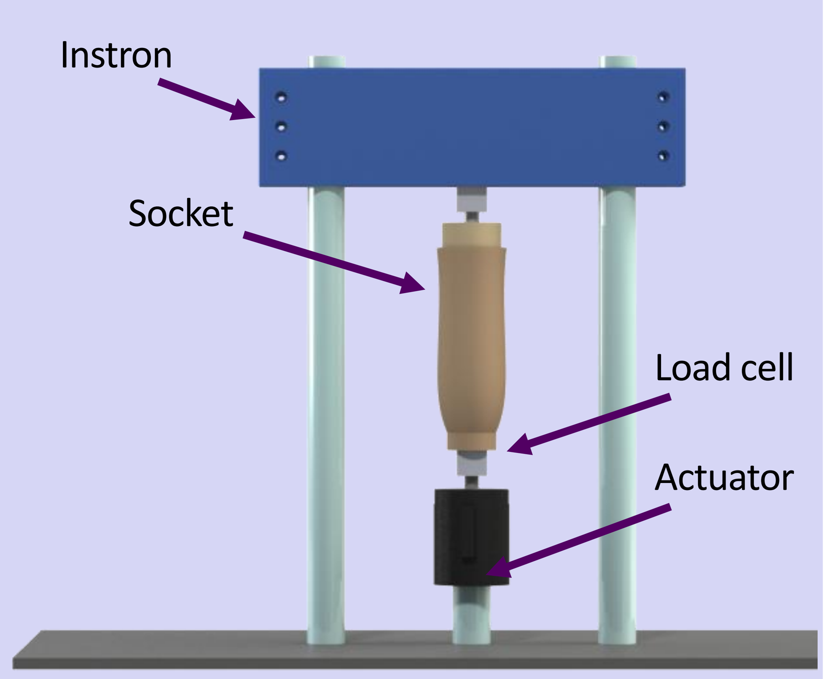
Transtibial plaster cast was used to create a dual durometer polyurethane mock limb wherein a harder core mimicked muscle and bone tissue and a softer outer shell mimicked skin and subcutaneous tissue. A stainless steel pylon threaded with wire was used to create an attachment point between the mock limb and materials testing system. All sockets were made to fit the same mock limb.



Components of transtibial mock limb.

Apparatus

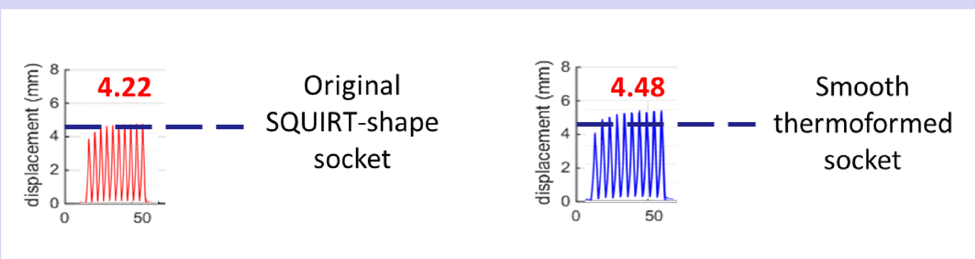
A hydraulic materials testing system (Instron, Norwood, MA) was used to test socket displacement in the longitudinal direction.



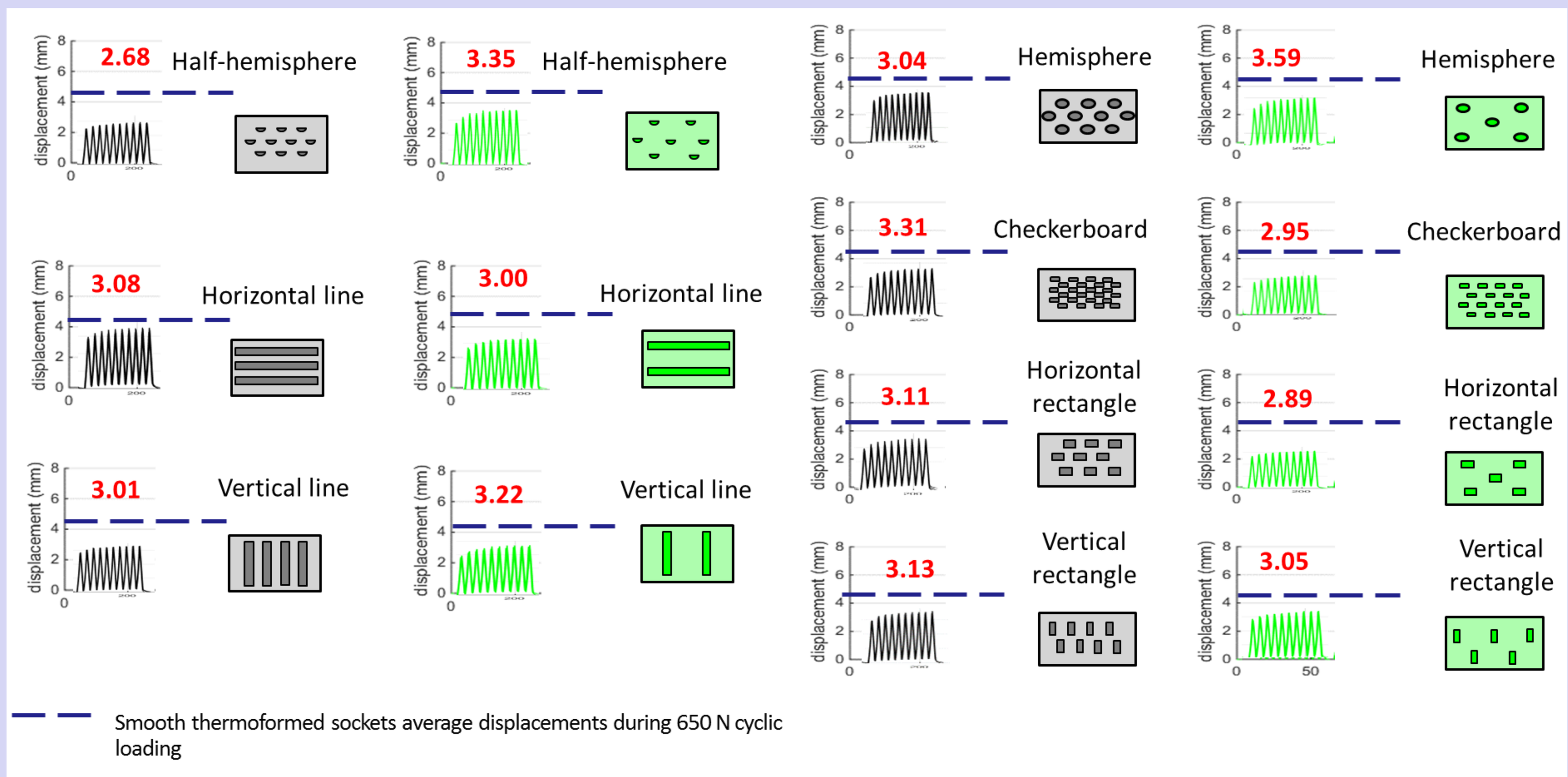
Longitudinal testing set up.

Results

- The smooth thermoformed socket displayed slightly more longitudinal displacement than the original SQUIRT-Shape Socket.
- All textured sockets displayed less longitudinal displacement than the smooth thermoformed socket and original SQUIRT-Shape Socket.
- The half-hemisphere heavy/dense texture pattern resulted in the least longitudinal displacement of all textured patterns.



Reference socket displacements.



Textured socket displacements.

Discussion

Mechanical testing demonstrated that textured sockets improved socket suspension by minimizing longitudinal displacement of the socket relative to the liner clad mock limb. While certain textures appeared to minimize longitudinal displacement the most, the best texture pattern for clinical use will ultimately be one that also minimizes rotational motion without undue wear on the liner and sufficient socket durability for everyday use. Additional mechanical testing of rotational displacement for the same set of socket textures is currently underway.

Conclusions

Mechanical testing of sockets serves as pre-clinical research on the feasibility of texturing to improve suspension. For texture patterns that improve suspension, further work is needed to assess the coefficient of friction and strength to ensure that textured sockets are sufficiently durable for testing on human subjects.

References

[1] Rovick J. Automated Fabrication of Sockets for Artificial Limbs. PhD Dissertation, Northwestern University, 1993.

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