Assessment of Residual Bone Movement in Transtibial Prosthetic Sockets Using B-Mode Ultrasound

Dominique Babin[1], Lina Fessi[1], Assel Nemerenova[1], Pierre-Yves Rohan[1]

1) Arts et Metiers, 151 Boulevard de L'hospital, 75013,Paris, FRANCE

Abstract

Challenge:
Improper prosthetic socket fit can lead to bone displacement, discomfort, and long-term complications for transtibial amputees

Literature gap:
Current research only rely on static measurements, ignoring dynamic bone movement

Our study:
B-mode ultrasound evaluation of the bone movement during walking tasks to indicate the optimal socket fit

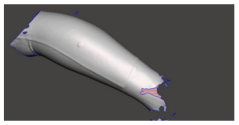
Project Aim and Hypothesis

Aim:
Designing a 3D-printed socket with windows for real-time imaging, validating it on healthy individuals

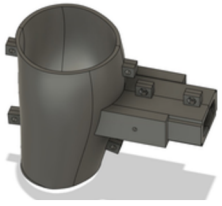
Hypothesis:
B-mode ultrasound can assess residual bone movement in a transtibial socket during dynamic tasks, improving prosthetic fitting with enhanced probes, fit, and measurement techniques.

Methods

1. 3D-Scanning of the calf with a HandySCAN

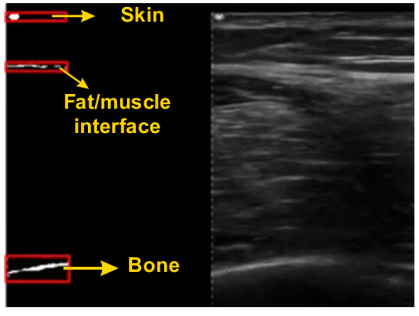


2. Socket design on Meshmixer and Fusion360 around the scanned calf



3. 3D-Printing of the prototype using the Ultimaker S5 3D printer

4. Testing : Loading of an ultrasound probe into the socket and recording calf movement during walking tasks



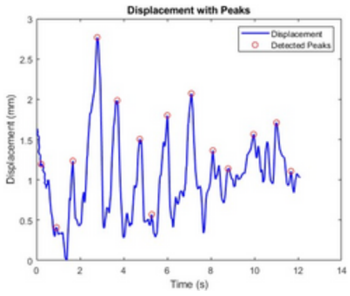
5. Ultrasound video analysis:

Peak detection and decomposition of the cycles on MATLAB to quantify bone movement relative to socket

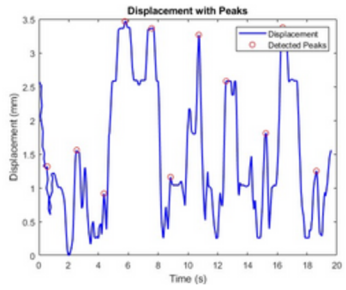
Results

Soft tissue displacement

Anterior

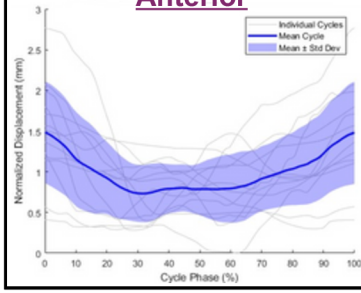


Lateral

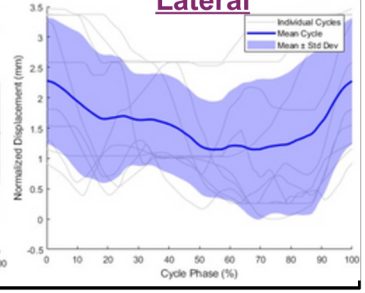


Normalized displacement of the tibia over the walking cycle phase (0% - 100%)

Anterior



Lateral



Conclusions

- B-mode ultrasound enables real-time assessment of bone movement within a prosthetic socket
- Results highlight the influence of probe positioning and soft tissues on measurement accuracy
- This research paves the way for personalized prosthetic design, improving comfort and mobility for transtibial amputees
- Results are comparable to what is seen in the literature

Next Steps

- Expanding testing to amputees (subject to ethical approval)
- Add multiple windows to the socket to find the optimal probe location
- Combining ultrasound data with gait analysis to identify key movement phases