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Designing 3D Printed Transtibial Prosthetic Sockets

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Background

- 95% of amputees in developing countries do not have access to prosthetic care[1]
- Creating a high quality, well-fitted prosthetic socket is a labor-intensive process that takes several months and thousands of dollars to develop
- The shape of the residual limb also undergoes many changes throughout the amputee's lifetime, so the cost of getting an artificial limb is unsustainable

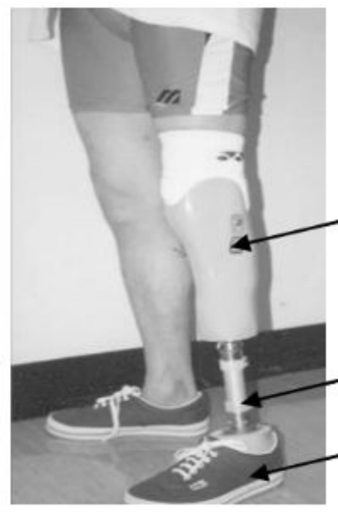

Figure 1. A typical transtibial prosthetic leg[2].


Figure 2. Prosthetist casting a mold of the residual limb[5].

Objectives

- Our aim was to be able to use 3D residual limb models created from cell phone photogrammetry to create an affordable, well-fit prosthetic socket
  - Become familiar with Autodesk Meshmixer
  - Come up with design iterations from literature
  - 3D print and test socket designs
  - Come up with a final design and write a procedure

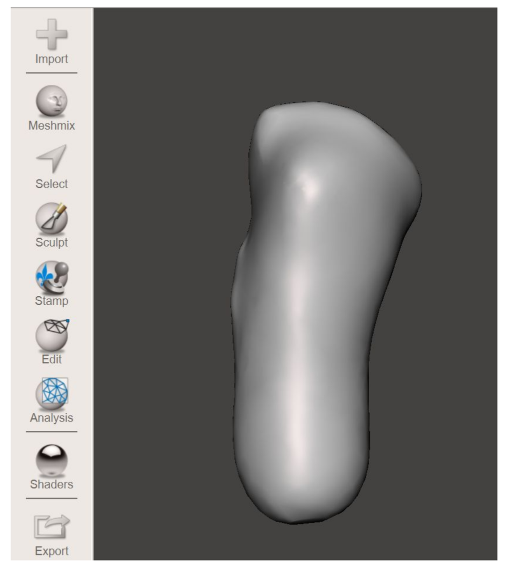
Figure 3. Residual Limb Model Using Autodesk MeshMixer.


Figure 4. Example of 3D printed socket[3].

Acknowledgements

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Design Considerations

- Shape of the socket: Patellar tendon bearing (PTB) vs total surface bearing (TSB)
- Pressure distribution: Loading and unloading zones on the residual limb
- Suspension system: Passive vs active suction, low cost cuffs and belts
- Socket-pylon attachment: Where failure occurs most of the time

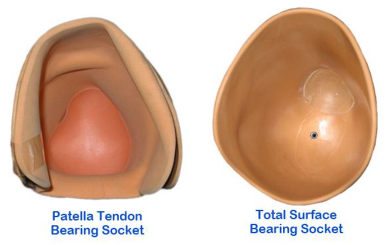

Figure 5. Interior of PTB socket (left) and TSB socket (right)[4].

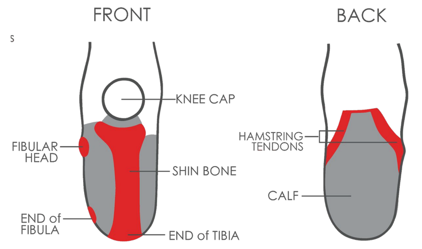

Figure 6. Pressure zones for a transtibial residual limb[2].

Design Iterations

- First and second designs were created by following the procedure written previously
- Cylinder for attachment of a one-way check valve for passive suction suspension
- Created a lip on socket anterior so the back of the knee doesn't hit the socket when bending
- Changed socket-pylon attachment from a rectangular shape to cylindrical for smoother print and more even stress distribution
- Incorporated a supracondylar socket shape for better suspension
- Joined socket bottom and pylon attachment for a smoother print

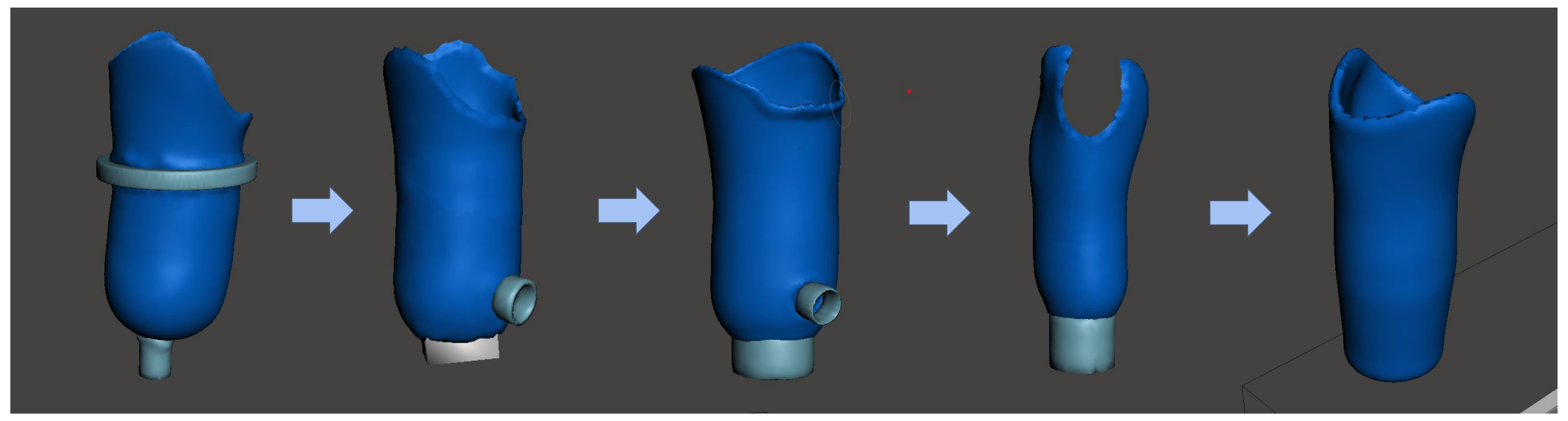
Figure 7. Progression of design iterations.

Final design

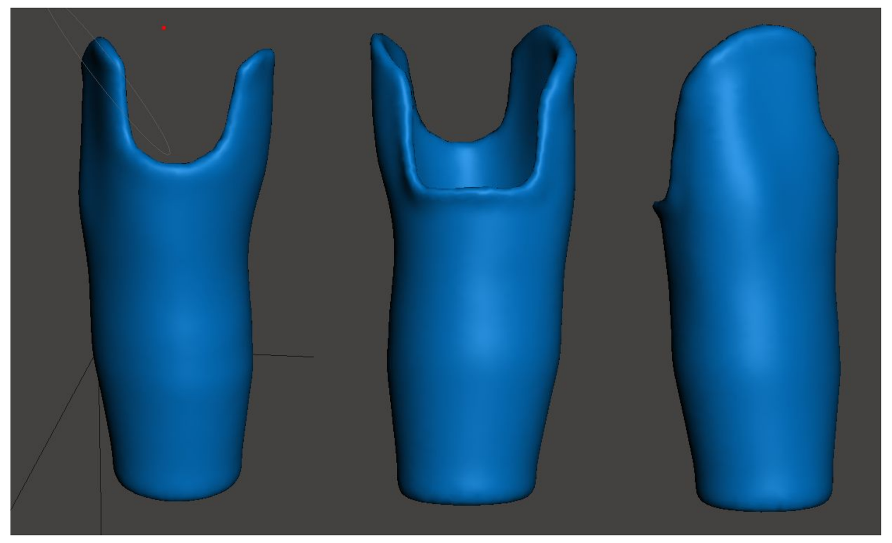
Figure 8. Frontal (left), dorsal (middle) and lateral (right) view of the final socket design.

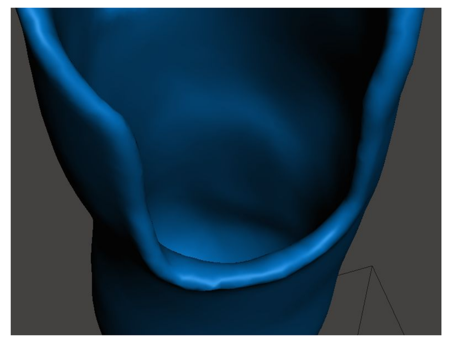
Figure 9. Interior of final socket showing pressure areas.

- Extended sides similar to supracondylar socket and prosthetist's socket
- Smoother and flatter lip for better print quality
- Included raised areas in the interior socket to help with pressure distribution

Results

3D Printed Sockets


Figure 10: Half scale (grey) and Full scale (blue) 3D Printed Sockets.

- Used polyactide (PLA) to 3D print
- Half-scale model took 5 hours (grey)
- Full-scale model took 60 hours (blue)
- Scaling was slightly small
- Extended sides could be more even

Cloudcompare

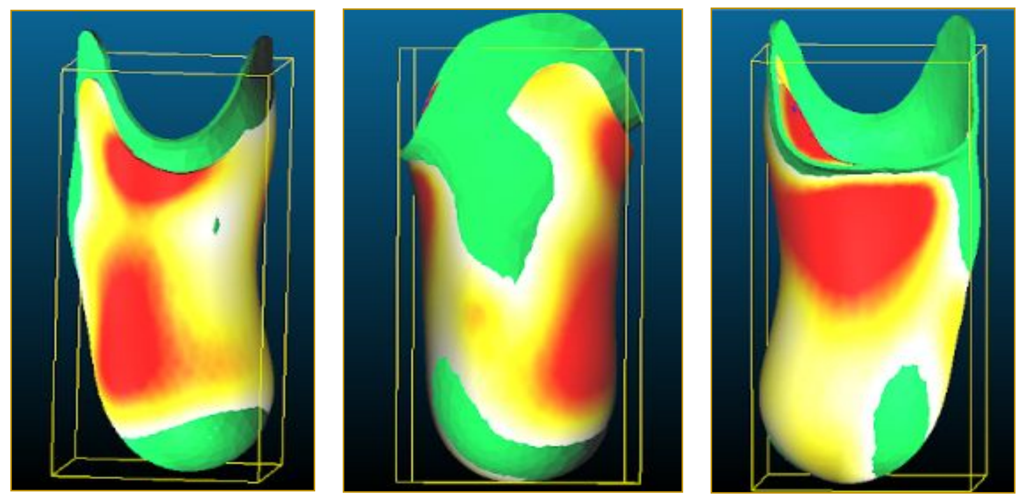
Figure 11: Comparison of Our Socket vs. Prosthetist's Socket.

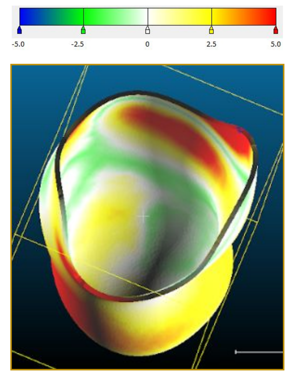
Figure 12: Interior Comparison.

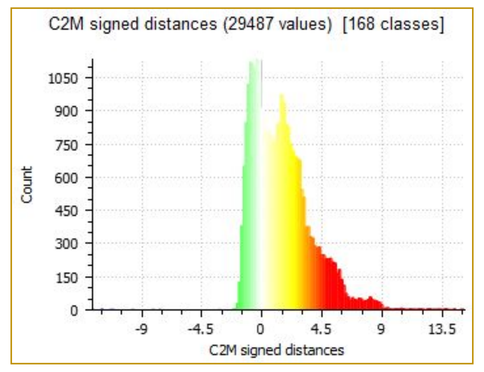

Figure 13: Histogram of Comparison.

- Compared prosthetist's socket to our own
- Interior mostly within 5mm
- Our socket was slightly smaller

Conclusions & Future Work

- Socket design printed well with minimal support material
- The size of our socket model matched close to the professional socket
- In the future, we want to
  - Integrate a suspension system to keep the socket on the limb
  - Test fit and comfort of the socket on the user

References

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