AUTODESK UNIVERSITY

Creating Custom Prosthetic Arms Using Fusion 360's Solid and Mesh Modeling

MFG501520

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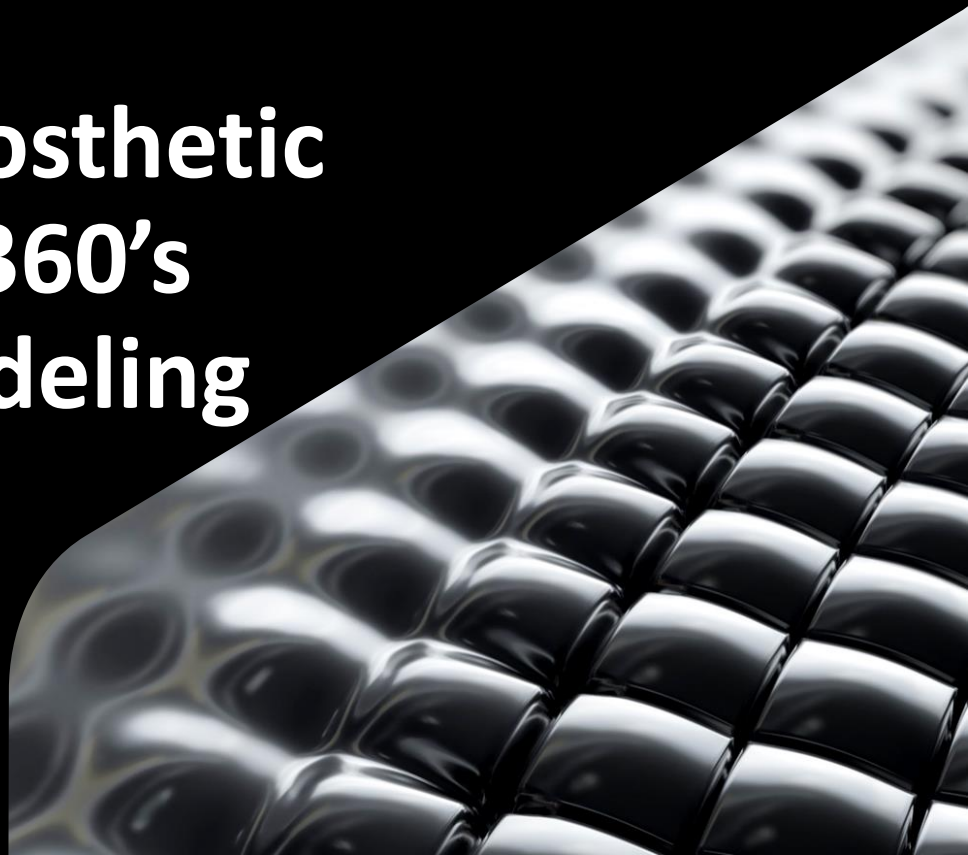


About the Speakers

- Michael Peirone
  - Chief Executive Officer, Victoria Hand Project (VHP)
  - B.Eng. Biomedical Engineering, University of Victoria, 2016
- Kim Arklie
  - Mechanical Systems Designer, Victoria Hand Project (VHP)
  - B.Eng. Mechanical Engineering, University of Victoria, 2021

Class Summary

- The class will cover the following topics:
  - Victoria Hand Project’s international work in the field of prosthetics
  - Issues with creating upper-arm (i.e above elbow) prosthetic devices
  - Combining solid bodies with 3D scan data to produce upper-arm prosthetic devices
  - Patient case study and workflow demonstration
  - How we implement our product workflows in partner clinics around the world

Learning Objectives

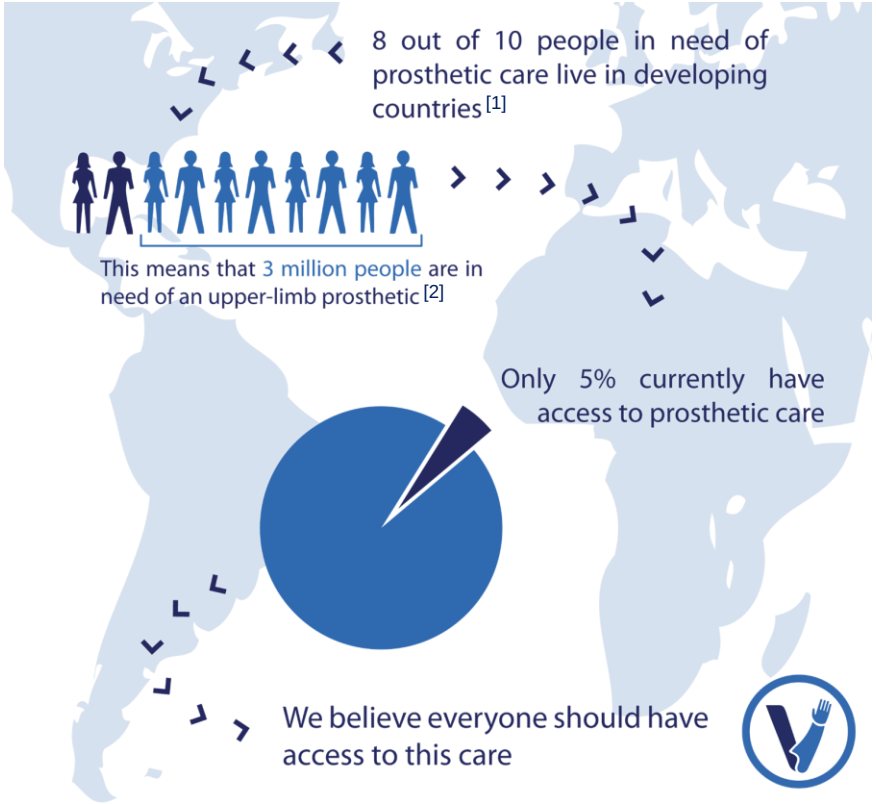
1. Create custom healthcare devices by combining **3D scanning** and **CAD tools**
2. Implement custom product design workflows using the **Fusion 360 API**
3. Combine 3D scans and solid bodies using both **Solid and Mesh Modeling in Fusion 360**
4. Integrate **Fusion 360** in **clinical settings** to improve productivity

Victoria Hand Project

Background

International Work

Victoria Hand Project (VHP) Background




Victoria Hand Project. Haiti, 2016.

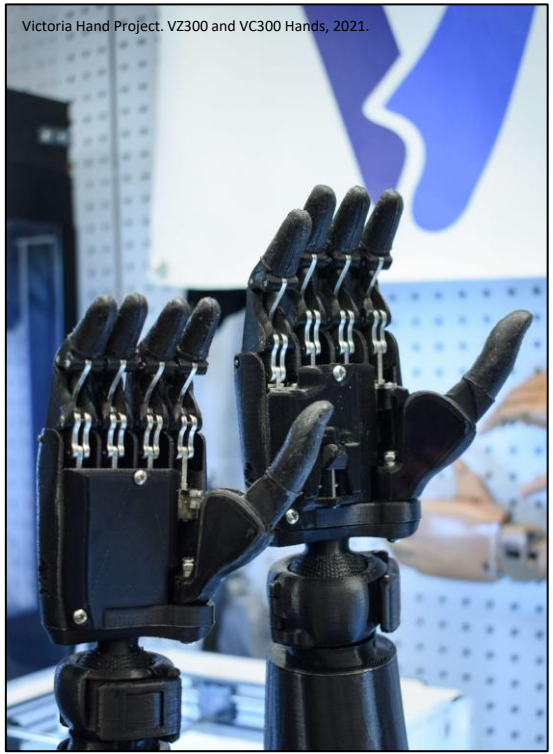
International Work

Victoria Hand Project (VHP) Background

Video: https://www.youtube.com/watch?v=prHm4fRm5q4

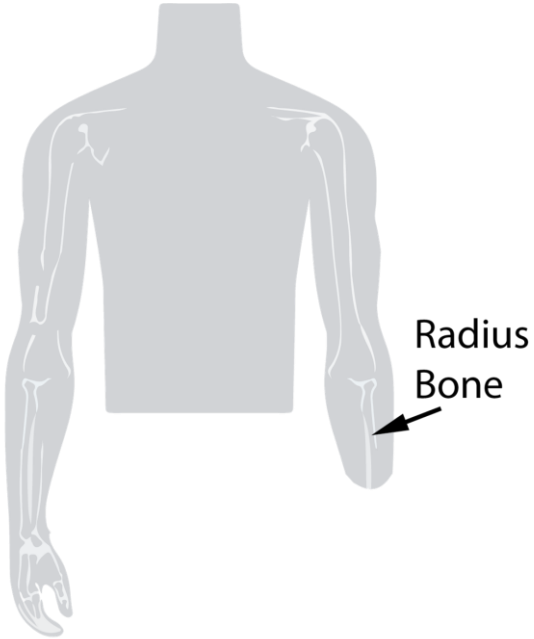
The Victoria Hand

Victoria Hand Project (VHP) Background


Victoria Hand Project. VZ300 and VC300 Hands, 2021.

Creating Upper-Limb Prosthetic Sockets

Victoria Hand Project (VHP) Background



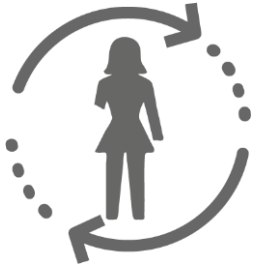
Trans-radial

Below elbow amputation

Victoria Hand Project. Cambodia, 2018.

Creating Upper-Limb Prosthetic Sockets

Victoria Hand Project (VHP) Background



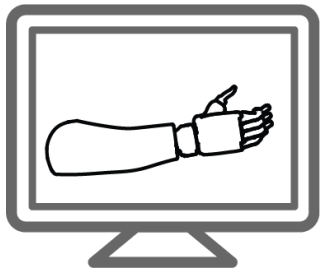
3D-scan the patient's limb shape using **Autodesk Recap Pro** and take anatomical measurements

Casted Limb Impression

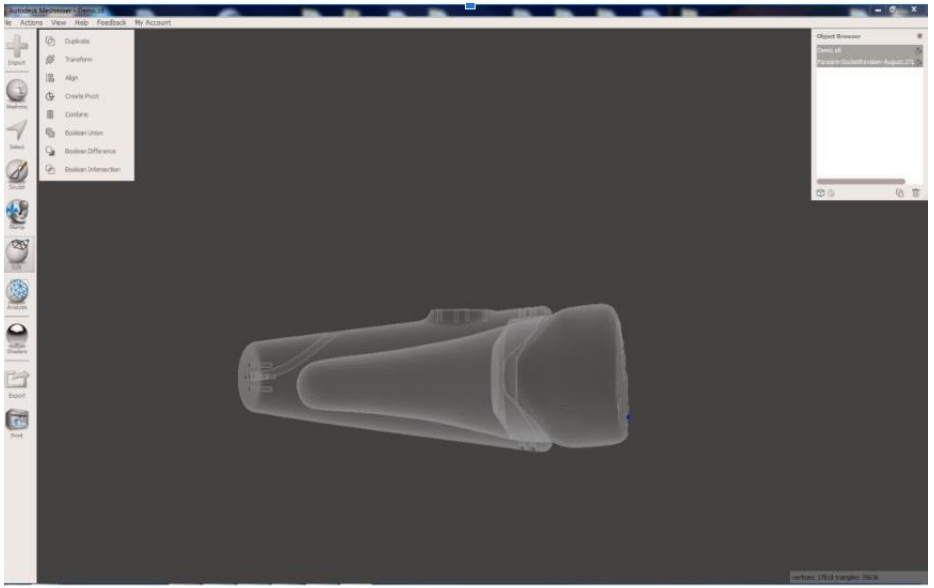
Autodesk Recap Pro

Creating Upper-Limb Prosthetic Sockets

Victoria Hand Project (VHP) Background



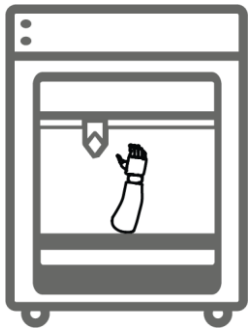
Generate the custom limb socket using **Autodesk Fusion 360** and **Meshmixer**



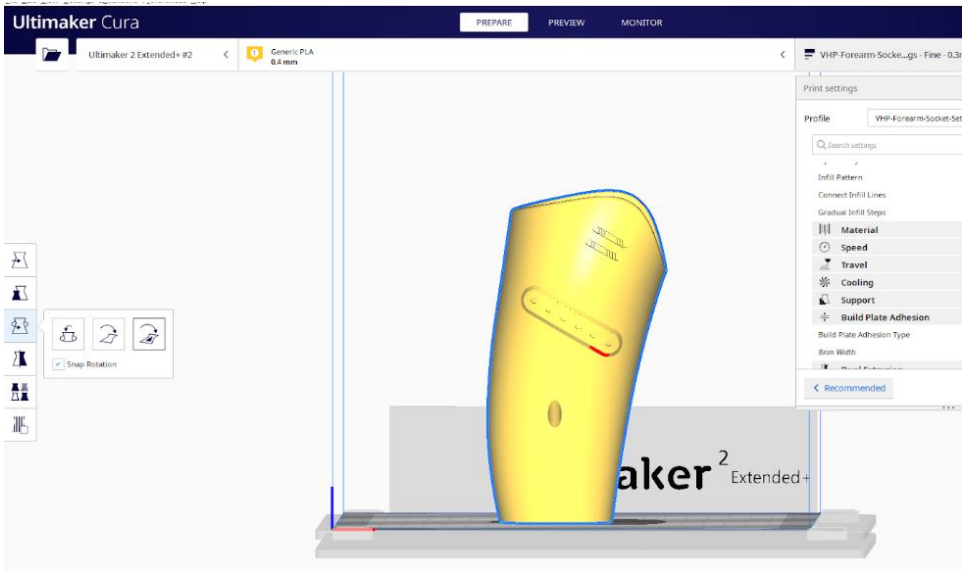
Autodesk Meshmixer

Creating Upper-Limb Prosthetic Sockets

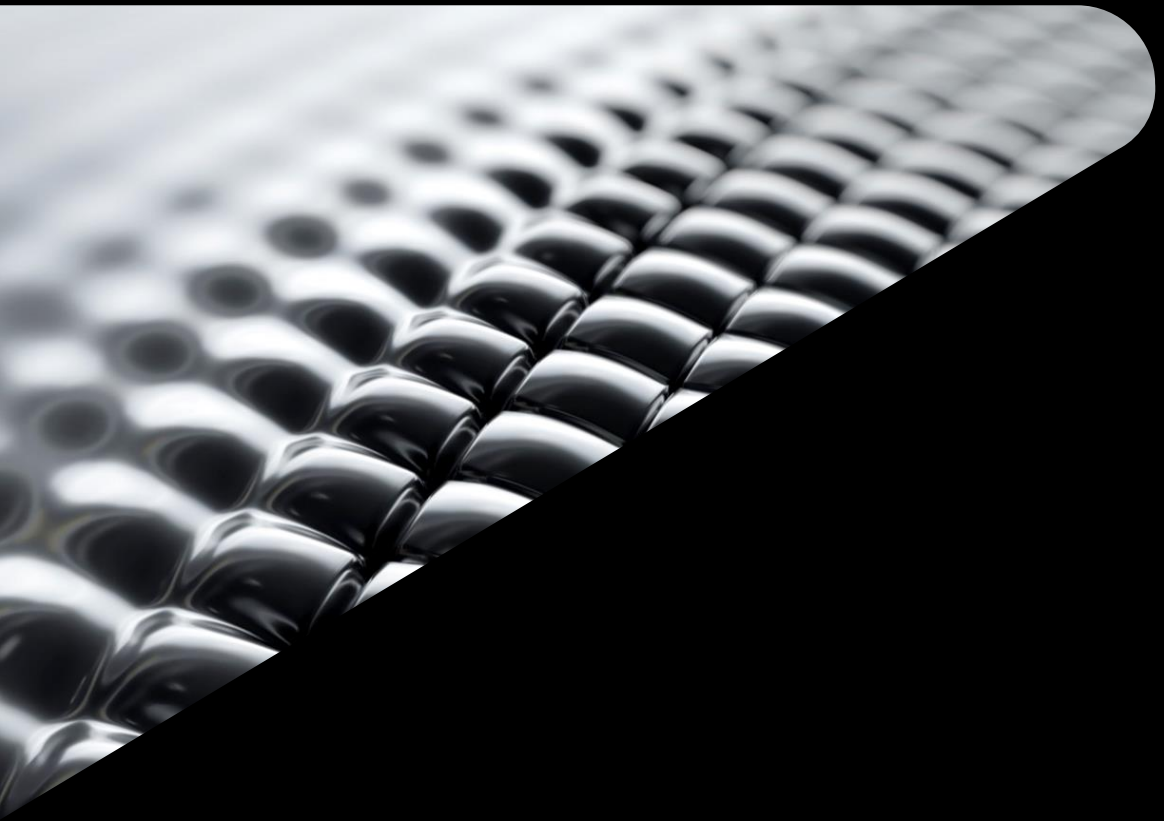
Victoria Hand Project (VHP) Background



3D-print the **custom** limb socket



Ultimaker Cura



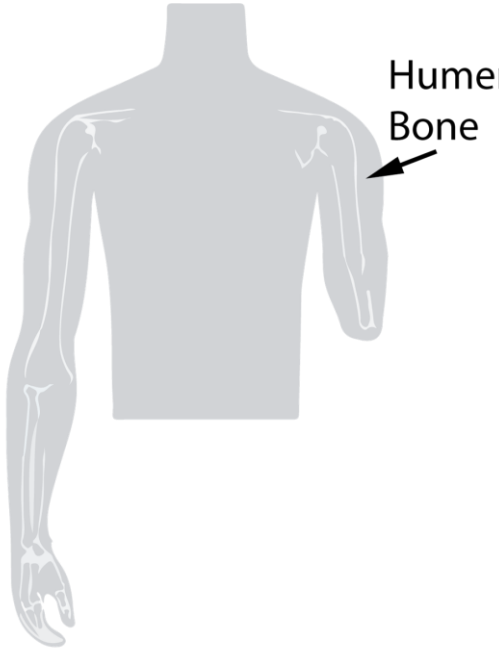
Trans-Humeral Prosthetics

Background and Original Workflow

Development of Trans-Humeral Prosthetics

Trans-Humeral Prosthetics Background

- Help more amputees globally
- More complex scan data
- Design Constraints:
  - Good cosmetic appearance
  - Low weight
  - Appropriate fit and range of mobility
  - Functional elbow
  - Adaptable workflow



Original Trans-Humeral Socket Workflow

Trans-Humeral Prosthetics Background

- Used Autodesk Fusion 360 and Autodesk Meshmixer
- Various pre-sized lower sockets made in Fusion 360
- Patient's scan data smoothed and offset in Meshmixer to produce the upper socket
- Imported the pre-made lower socket into Meshmixer and combined with the upper socket

Fusion 360 Pre-Sized Lower Sockets

Original Trans-Humeral Socket Workflow

Trans-Humeral Prosthetics Background

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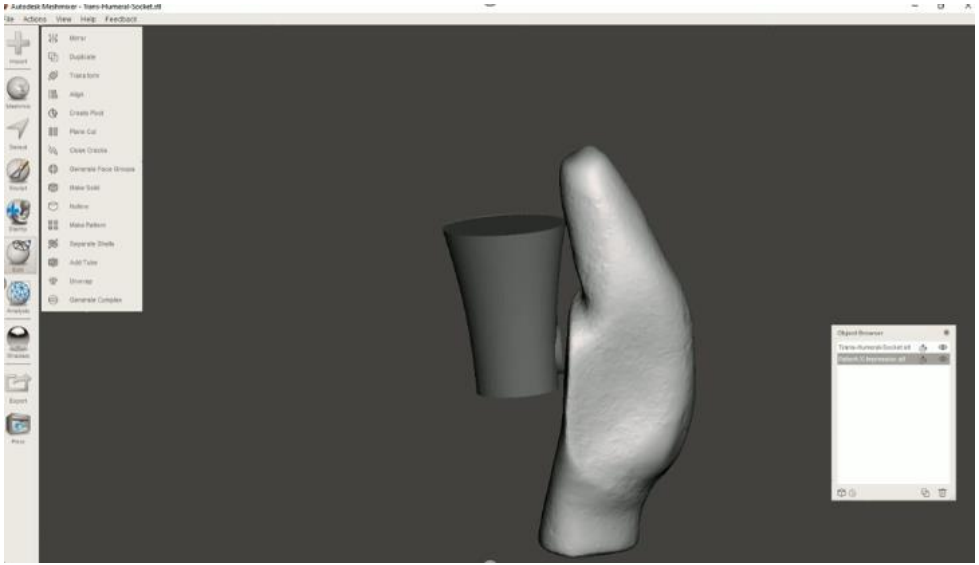


AutoDesk MeshMixer Socket Workflow
Video: https://www.youtube.com/watch?v=Fo0p7GjkJxU

Issues with the Original Trans-Humeral Socket Workflow

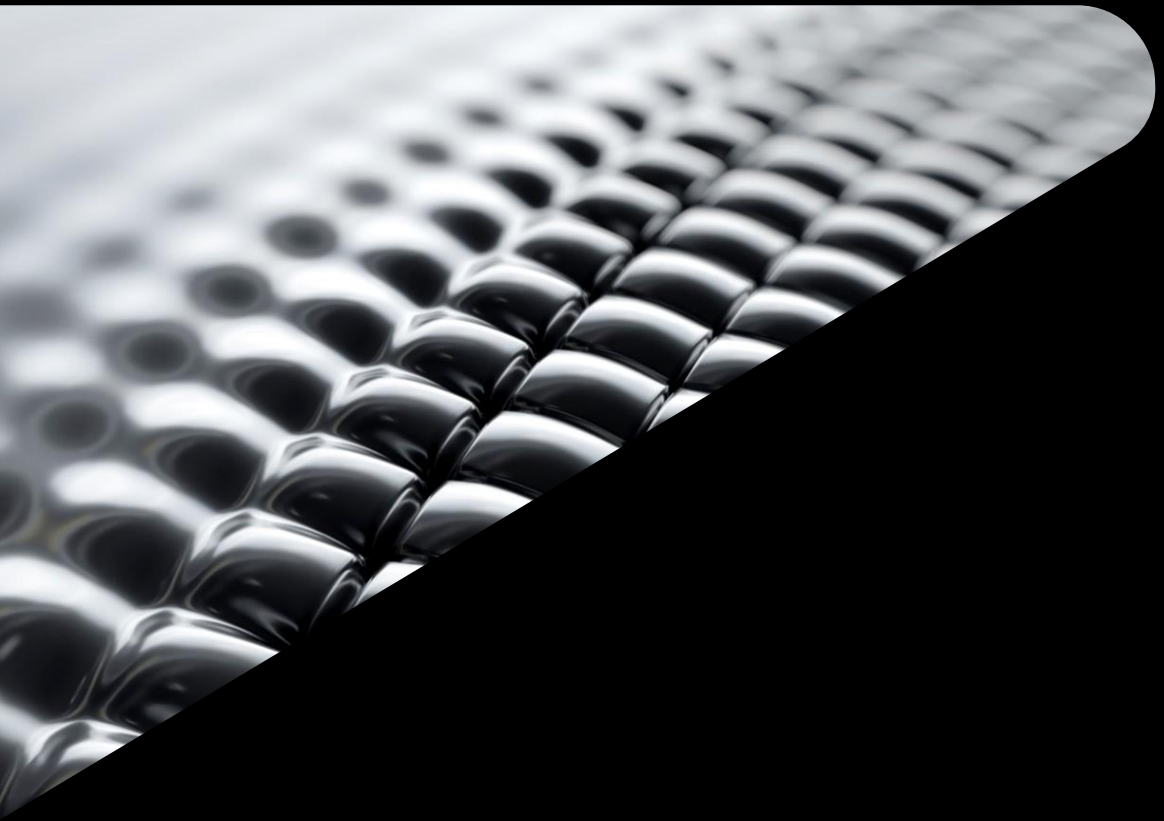
Trans-Humeral Prosthetics Background

1. Not a smooth transition between lower and upper portions of the socket

2. Cannot resize the socket easily due to the cross-platform workflow (i.e. export from Fusion 360, import into Meshmixer)

3. Too many user inputs and commands

Poor Quality Socket Transition



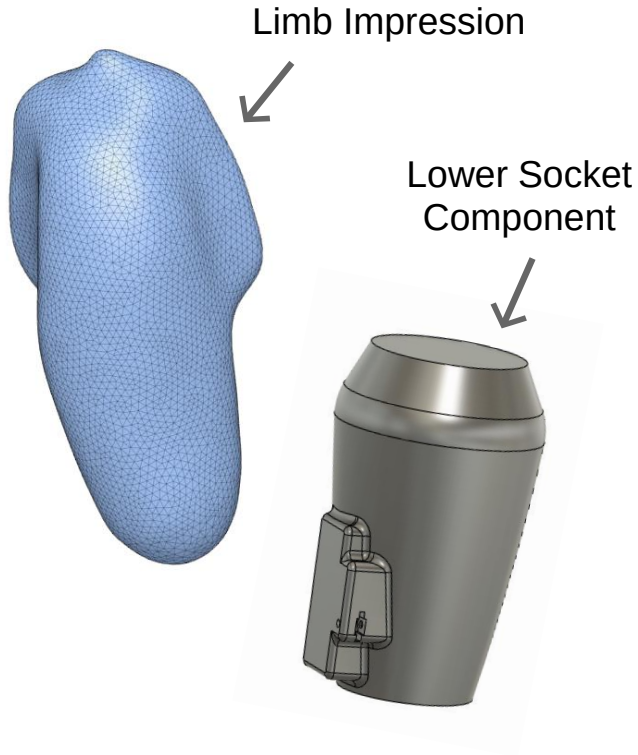
Trans-Humeral Prosthetics

Optimization of Workflow

Workflow Overview

Optimization of Trans-Humeral Socket Workflow

- Utilizes the Mesh Workspace in Autodesk Fusion 360
- Pre-made lower socket was redesigned to be parametrically dimensioned, allowing for more customization
- Limb impression is imported into Fusion 360 as a mesh and kept as a mesh body to be edited

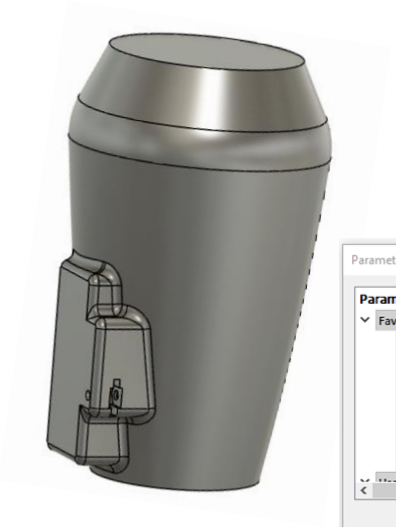


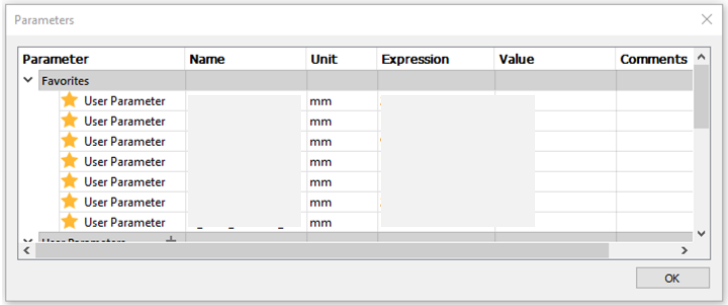
Trans-Humeral Socket Creation

Optimization of Trans-Humeral Socket Workflow

1. Create the Lower Socket

Size the lower socket by inputting the patient's recorded measurements into the solid body design parameters.



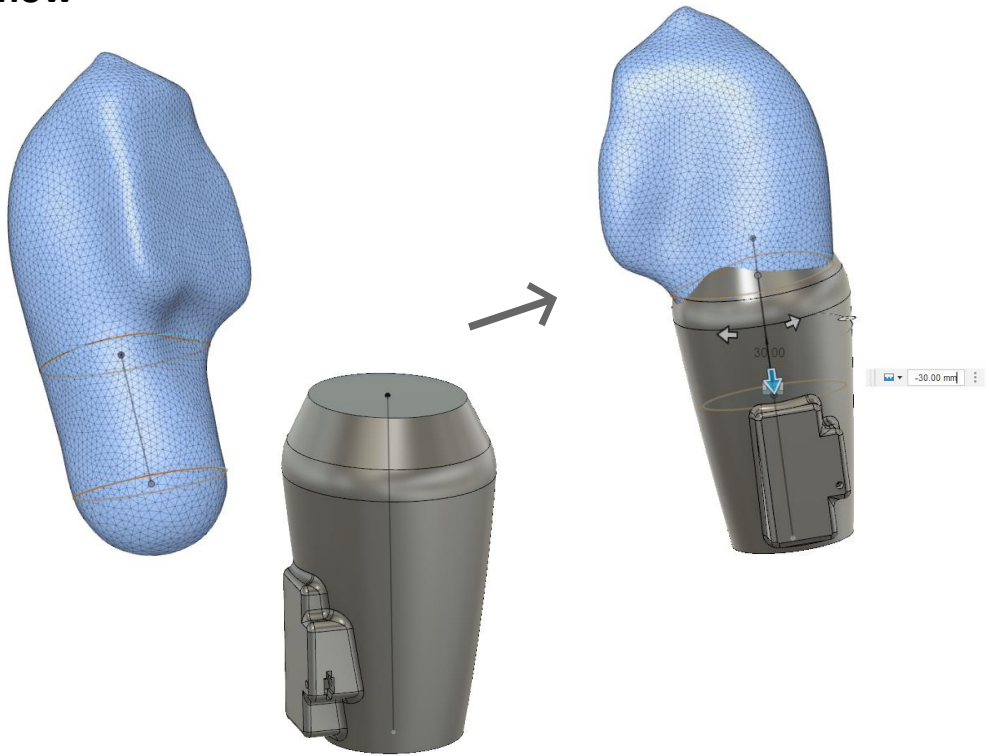


Trans-Humeral Socket Creation

Optimization of Trans-Humeral Socket Workflow

2. Import and Align the Limb Impression

Insert the limb impression into Fusion 360 as a mesh body. Upon insertion, align the limb impression to the lower socket solid body.

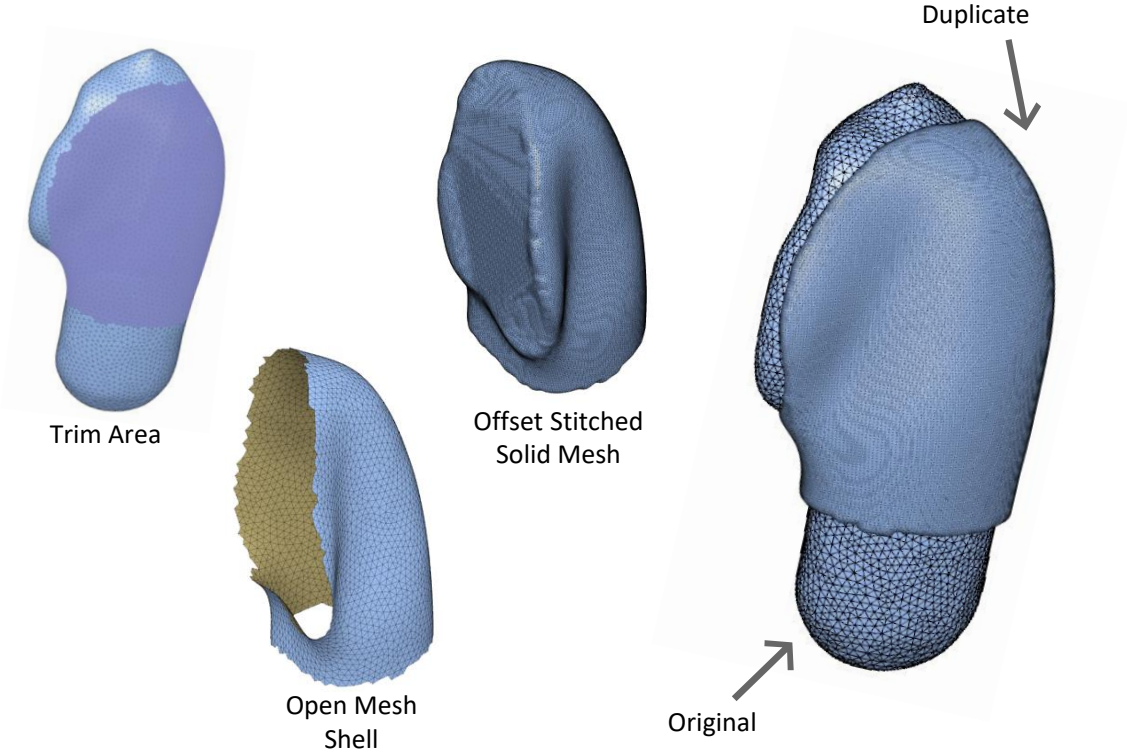


Trans-Humeral Socket Creation

Optimization of Trans-Humeral Socket Workflow

3. Create the Upper Socket

Duplicate, trim, repair, remesh, smooth, and offset the limb impression 5mm outwards to create the basis of the upper socket.

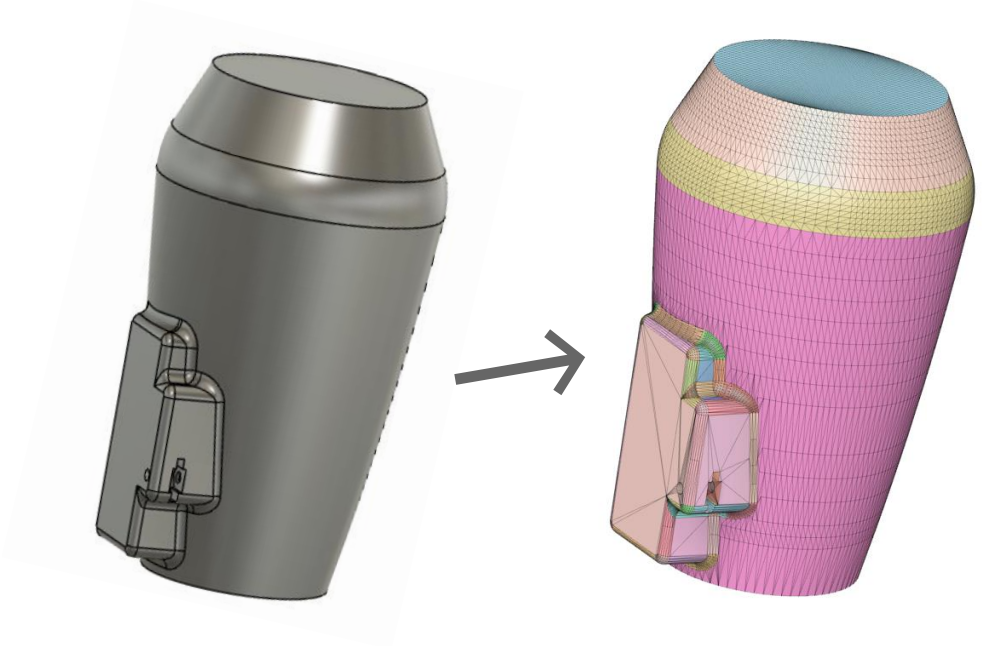


Trans-Humeral Socket Creation

Optimization of Trans-Humeral Socket Workflow

4. Tessellate the Lower Socket

Confirm the alignment of the limb impression, and lower and upper socket. Then tessellate the lower socket into a mesh body.

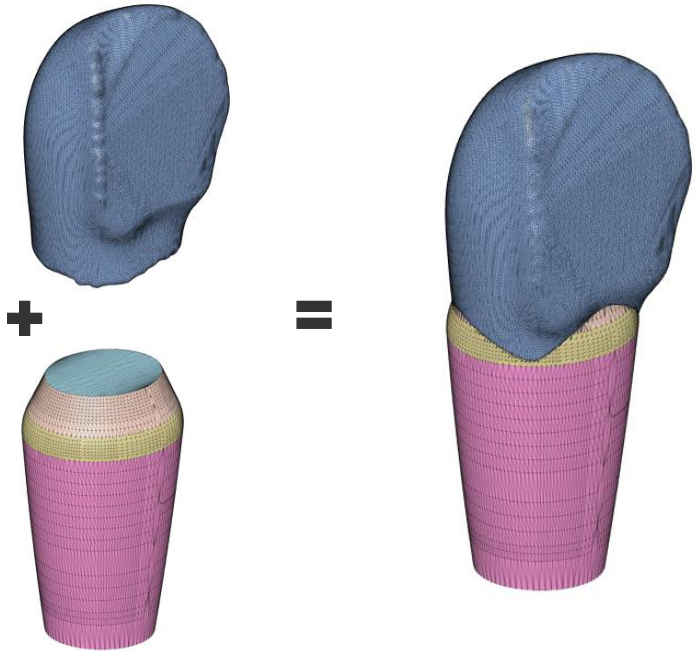


Trans-Humeral Socket Creation

Optimization of Trans-Humeral Socket Workflow

5. Boolean Union the Lower and Upper Socket

Perform a Boolean Union operation to combine the previously prepared lower socket and 5mm offset of the upper socket.

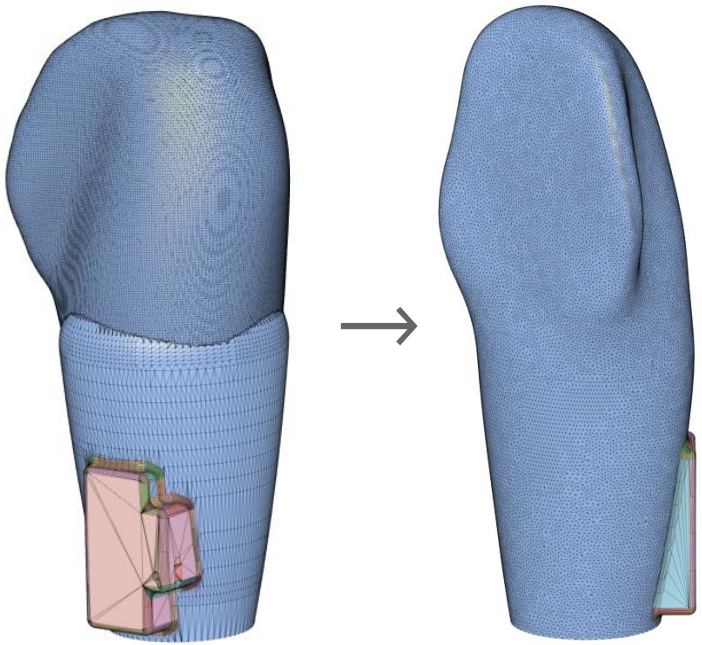


Trans-Humeral Socket Creation

Optimization of Trans-Humeral Socket Workflow

6. Clean Up Socket Transition

Combine the face groups on the main socket body. Erase and fill, remesh, and smooth the socket to achieve a seamless transition between the two socket components (i.e. lower and upper).



Before

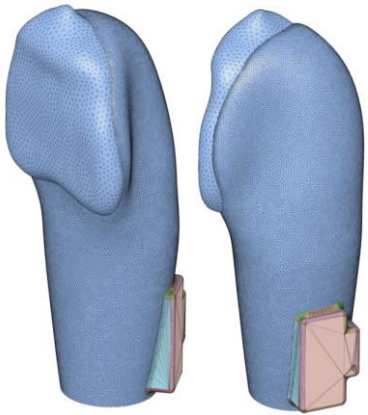
After

Trans-Humeral Socket Creation

Optimization of Trans-Humeral Socket Workflow

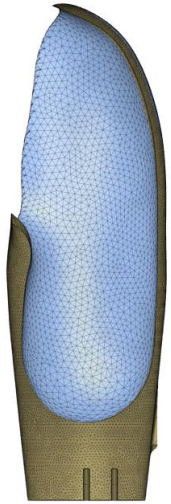
7. Boolean Difference the Limb Impression and Combined Socket

Perform a Boolean Difference operation to cut the limb impression from the combined lower and upper socket. The socket is now complete and ready to be prepared for 3D printing.



Before

After



X-Section

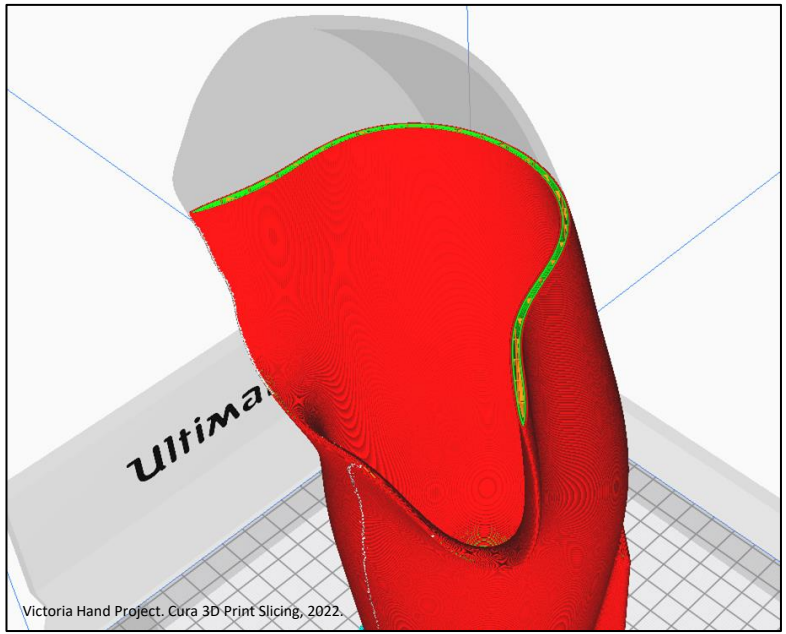
Advantages

Optimization of Trans-Humeral Socket Workflow

- Higher precision model
- Improved socket fit for better usability of the prosthetic device

Advantages

Optimization of Trans-Humeral Socket Workflow



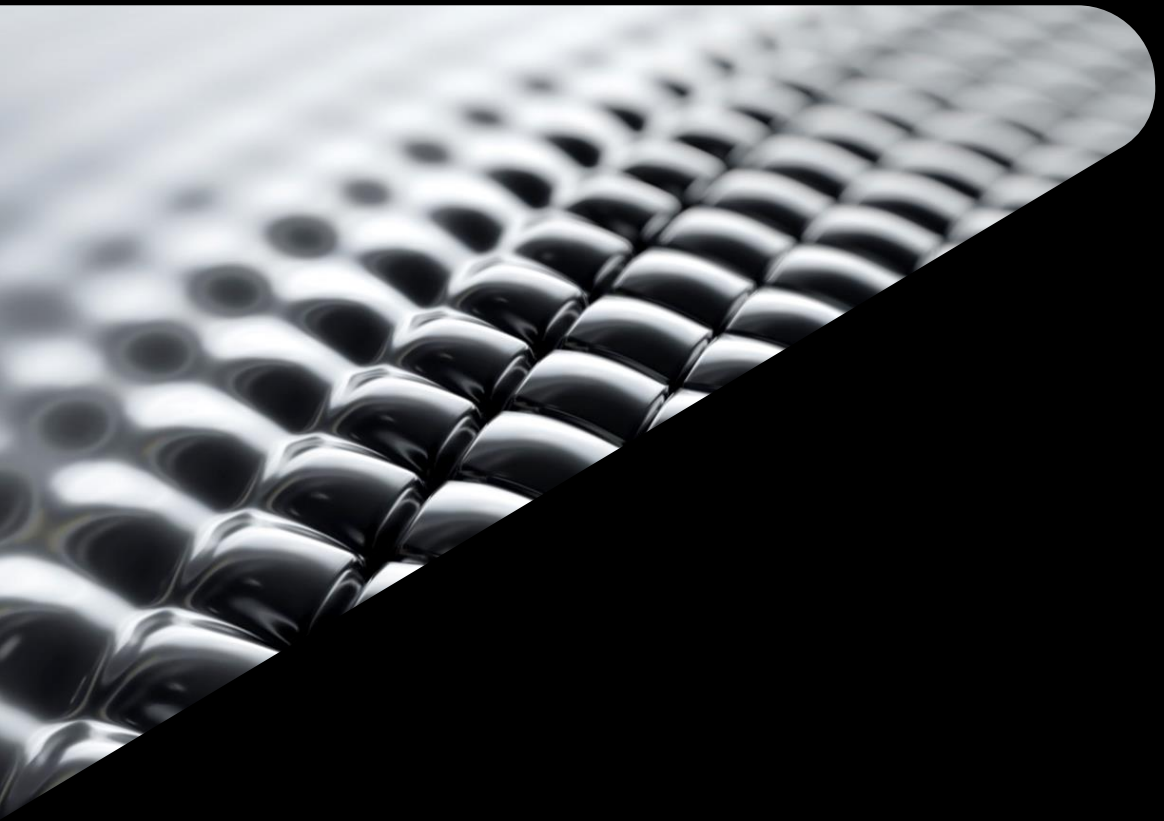
Victoria Hand Project. Cura 3D Print Slicing, 2022.

- Uniform thickness of the upper socket
- Improved socket appearance
- Integration with the Fusion 360 API

Advantages

Optimization of Trans-Humeral Socket Workflow

- Semi-automate alignment process
- More easily modify and realign components throughout workflow
- Simplification of workflow



Case Study Demonstration

Haiti Trans-Humeral Patient

Case Study Demonstration

Haiti Trans-Humeral Patient

- 7.0 magnitude earthquake occurred in Haiti on January 12, 2010 [3]
- Hundreds of thousands were killed or injured in the disaster [3]

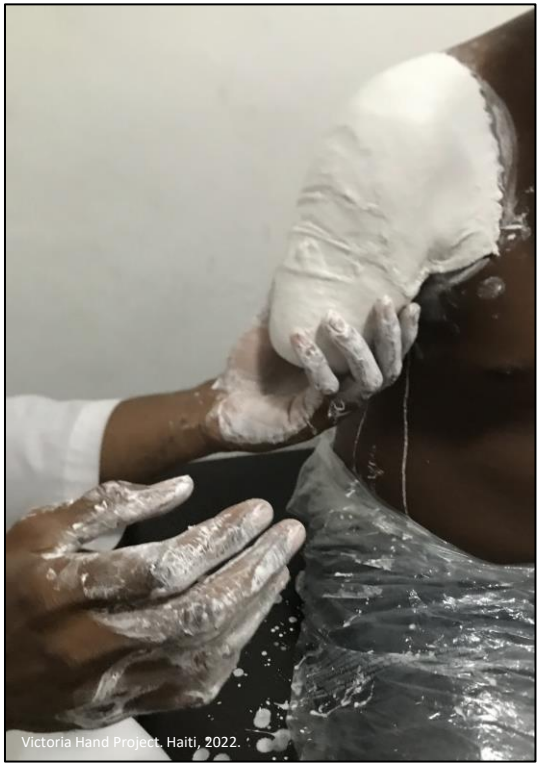
Haiti, 2010. *Getty Images*.

Case Study Demonstration

Haiti Trans-Humeral Patient

- John was injured in the earthquake when his house collapsed on top of him
- Never received a prosthetic arm
- Recently met with VHP in-country partner clinician in Haiti to be fit with a device


Victoria Hand Project. Haiti, 2022.

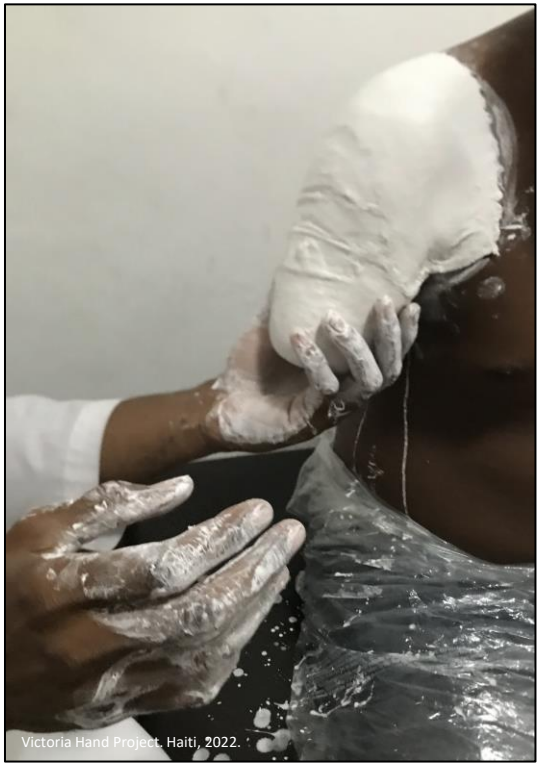

Victoria Hand Project. Haiti, 2022.

Case Study Demonstration

Haiti Trans-Humeral Patient

- In-country clinician completes end-to-end workflow independently
- Plaster limb impression and patient measurements taken

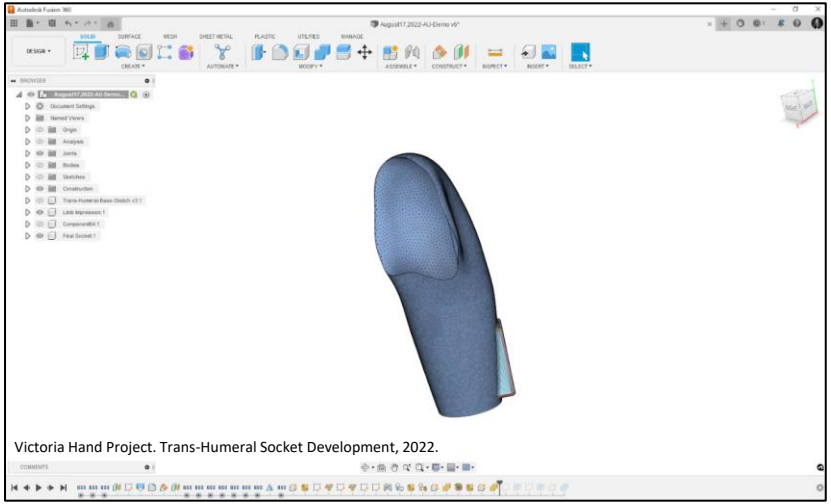

Victoria Hand Project. Haiti, 2022.


Victoria Hand Project. Haiti, 2022.

Case Study Demonstration

Haiti Trans-Humeral Patient

- Limb impression is digitized using photogrammetry methods
- Optimized trans-humeral upper socket workflow is followed to create the upper socket
- Clinician applied their knowledge and expertise to create a proper fitting socket

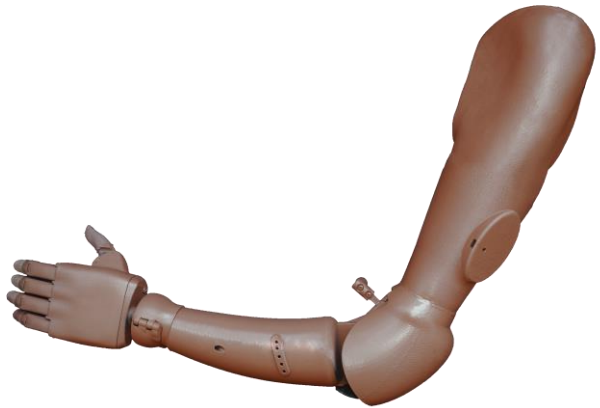


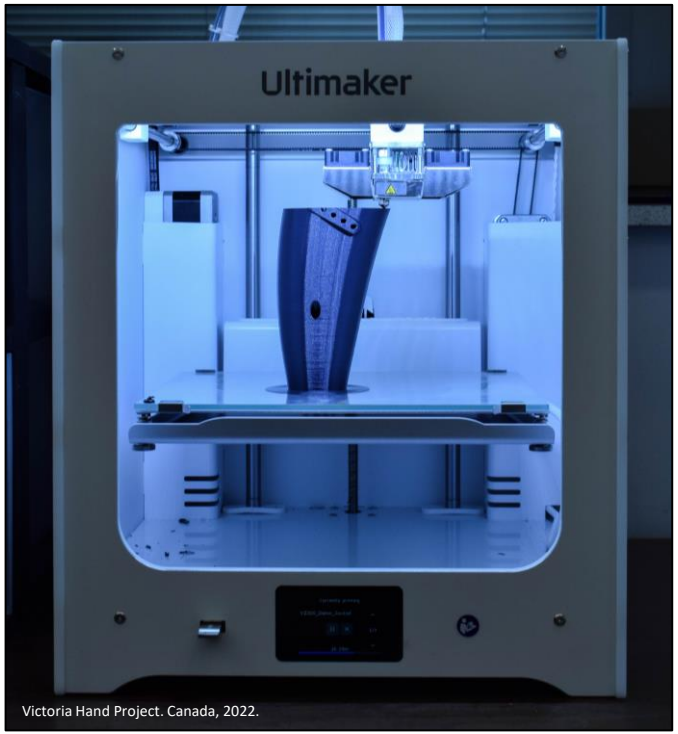
Victoria Hand Project. Trans-Humeral Socket Development, 2022.

Case Study Demonstration

Haiti Trans-Humeral Patient

- Socket is exported from Fusion 360 and 3D printed on an Ultimaker 3D printer
- Victoria Hand and additional trans-humeral components are 3D printed by the local 3D Print Technician





Victoria Hand Project. Canada, 2022.

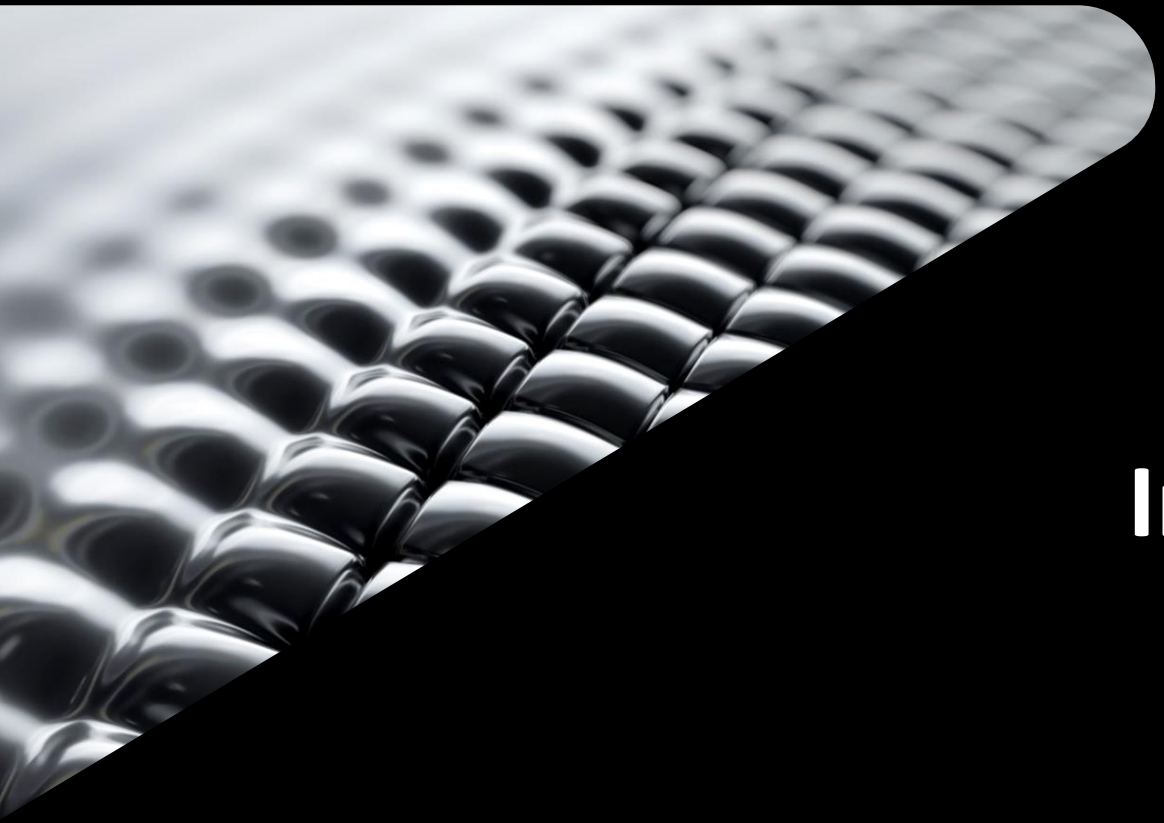
Case Study Demonstration

Haiti Trans-Humeral Patient

- Trans-humeral system is assembled by the local 3D Print Technician
- Clinician fits patient with the upper socket and prosthetic system
- In-country partner team provides feedback to VHP team in Canada

Case Study Socket, 2022.

Victoria Hand Project. Haiti, 2016.



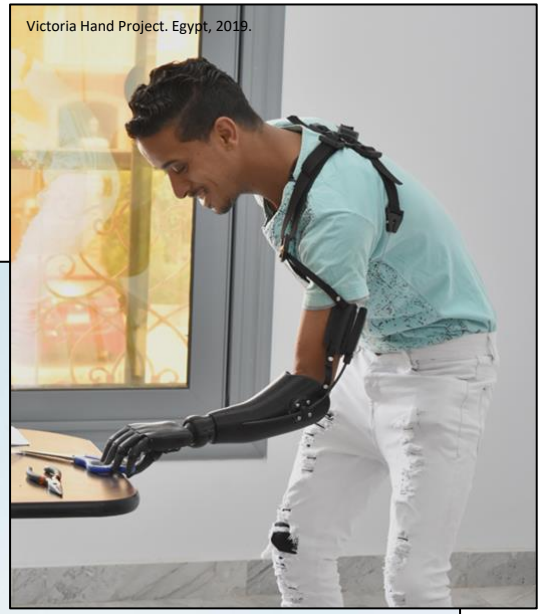
Workflow Implementation

VHP Partner Clinics

Workflow Deployment Model

Workflow Implementation in VHP Partner Clinics

- Workflow provided to VHP’s partners
- Integrated into VHP software
- Easier to produce custom devices



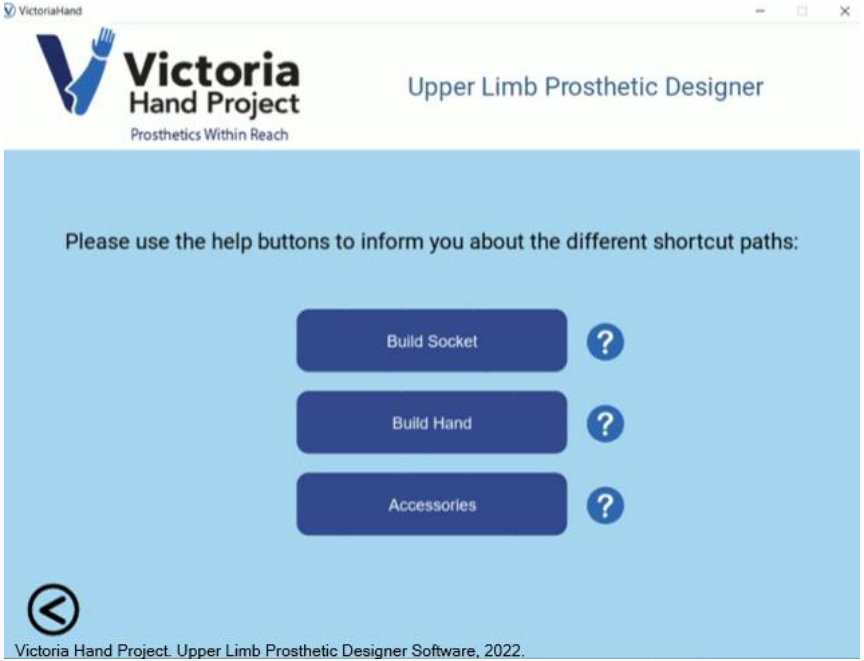
Victoria Hand Project. Egypt, 2019.

Victoria Hand Project. Trans-humeral Prosthetic Device, 2022.

Combining Advanced Technologies with Traditional Workflows

Workflow Implementation in VHP Partner Clinics

- Combine CAD tools and additive manufacturing with traditional prosthetic fitting methodologies
- More efficiently create devices at a lower cost
- Allow clinicians to focus more time on patient care
- Produce better custom fit devices



Victoria Hand Project Software Demo Video: https://www.youtube.com/watch?v=tC7kadLzsJU

Combining Advanced Technologies with Traditional Workflows

Workflow Implementation in VHP Partner Clinics

- Combine CAD tools and additive manufacturing with traditional prosthetic fitting methodologies
- More efficiently create devices at a lower cost
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Victoria Hand Project. Cambodia, 2019.

Future Work

Workflow Implementation in VHP Partner Clinics

- Refining the development of the trans-humeral socket workflow
- Automating the workflow further with VHP software and the Fusion 360 API to make the process of creating the socket easier for the clinician
- Realistic color information for increased accuracy when creating the socket


Victoria Hand Project. Kenya, 2020.

Future Work

Workflow Implementation in VHP Partner Clinics

- Refining the development of the trans-humeral socket workflow
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- Realistic color information for increased accuracy when creating the socket

Socket Shape Sketched on Impression

To Summarize

- Custom 3D printed prosthetic arms
- Previous trans-humeral socket workflows were too tedious and resulted in sockets with a poor appearance
- Use Fusion 360 Mesh Workspace to easily create custom prosthetic sockets
- Easier workflow resulting in a socket with a better cosmetic appearance


Victoria Hand Project. Egypt, 2019.

To Summarize

- Custom 3D printed prosthetic arms
- Previous trans-humeral socket workflows were too tedious and resulted in sockets with a poor appearance
- Use Fusion 360 Mesh Workspace to easily create custom prosthetic sockets
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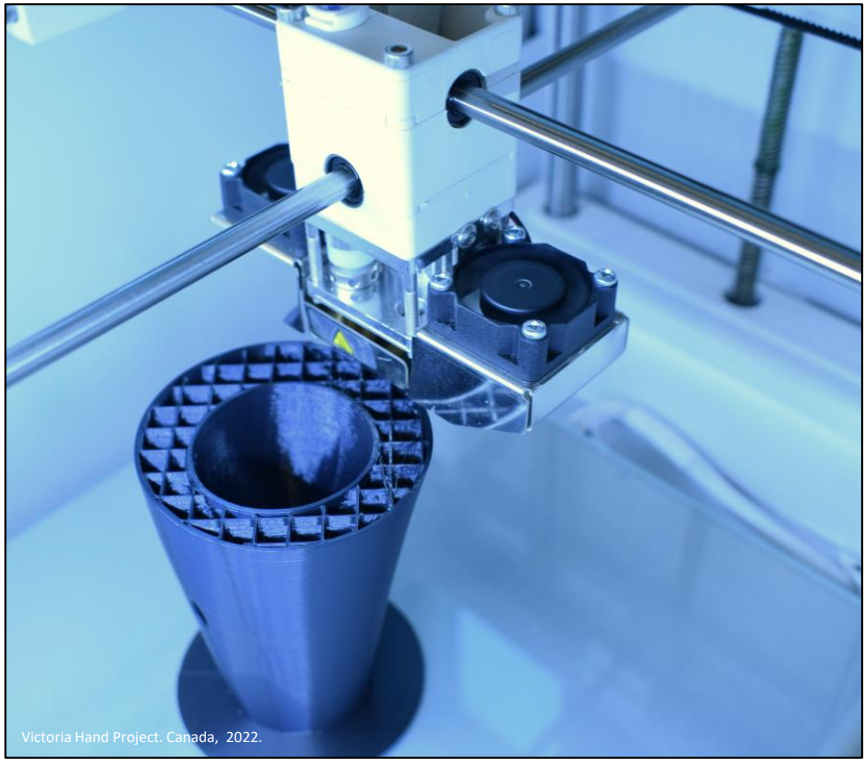

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Victoria Hand Project, 2022.

Victoria Hand Project

Prosthetics Within Reach

Victoria Hand Project

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Victoria Hand Project

www.victoriahandproject.com

References

[1] B. Phillips, G. Zingalis, S. Ritter, and K. Mehta, “A review of current upper-limb prostheses for resource constrained settings,” 2015 IEEE Global Humanitarian Technology Conference (GHTC), 2015.

[2] M. LeBlanc, “Give Hope - Give a Hand - The LN-4 Prosthetic Hand,” November 2008. [Online]. Available: https://web.stanford.edu/class/engr110/2011/LeBlanc-03a.pdf.

[3] “2010 Haiti earthquake,” History.com, 18-Jul-2011. [Online]. Available: https://www.history.com/this-day-in-history/massive-earthquake-strikes-haiti. [Accessed: 19-Aug-2022].