Low-Cost, 3D-Printed, Universal-Fit, Transradial Socket for Amputees in Developing Countries

PROBLEM AND SOLUTION

Problem: Need for Prosthetics Globally

As of 2017, there were **57.7 million** people with upper and lower limb amputation globally.

An estimated **40 million** of these amputees live in the developing world, and **only 5%** have access to prosthetic devices

- The heightened rates are due to a high prevalence of injuries and illnesses and a lack of medical services.
- *Why the shortage?* Current prosthetics are:
  (1) Very expensive, ranging from **$4,000 - $8,000** for body-powered prosthetics;
  (2) Hard to produce in volume;
  (3) Easy to damage
  (4) Require prosthetists or healthcare professionals to fabricate, fit, and manage them

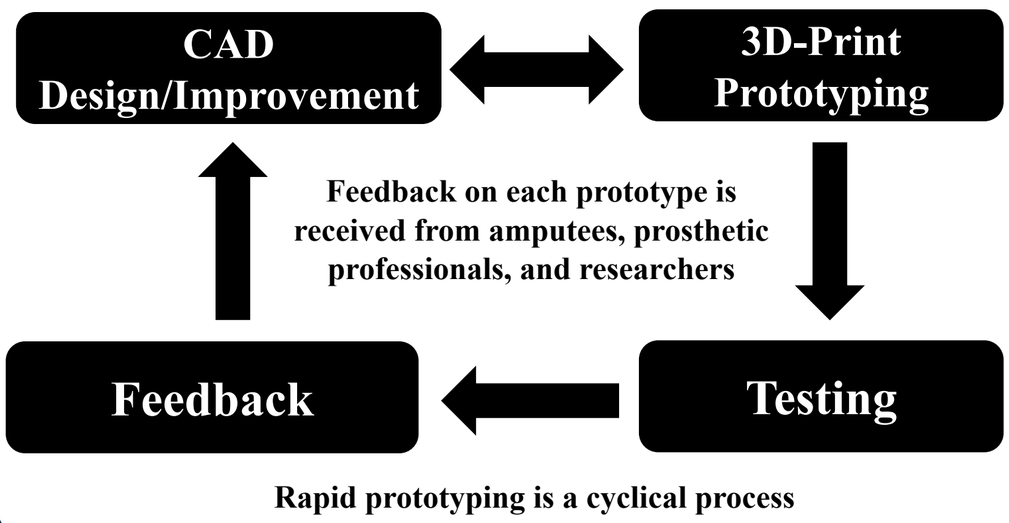
Solution: Low-Cost, Universal-fit Prosthetic

Goal: Use 3D-printing to develop a functional transradial (below-elbow) socket at a cost of <$40.

The device must be universal-fit and fully size-adjustable, so it does not require a fit from a healthcare professional and can accommodate any transradial amputee, considering disparities in length and circumference sizes.

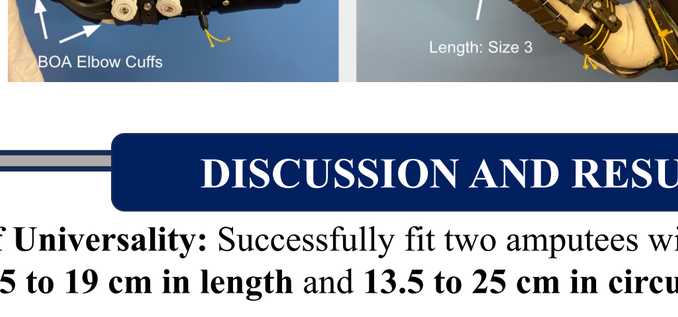
Future: The fully developed product would be able to be distributed efficiently to the **millions of amputee**s globally at a low cost.

EXPERIMENTAL PROCEDURE

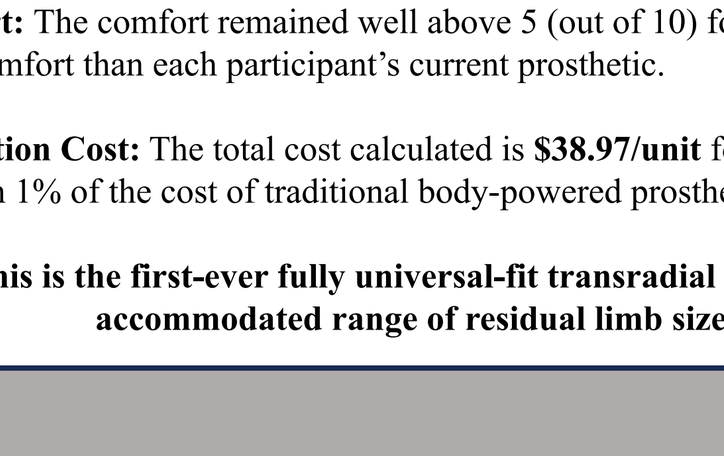


Rapid prototyping is a cyclical process

AMPUTEE FITTING

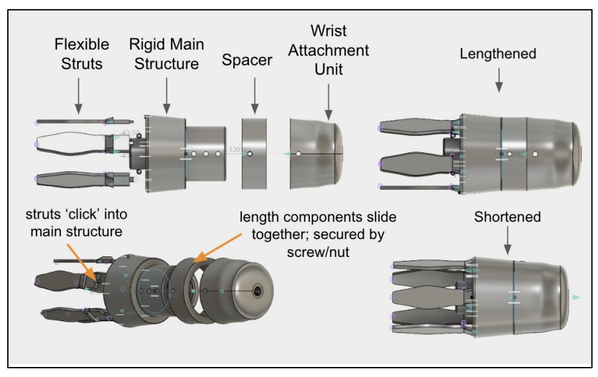


Two amputees (1 and 2) of **disparate length (10.5 cm and 19 cm) and circumference (13.5-23 cm)** amputations were fit with the same device. Comfort was rated on a Likert scale from 1-10 at different loads (1kg increments up to 8kg).

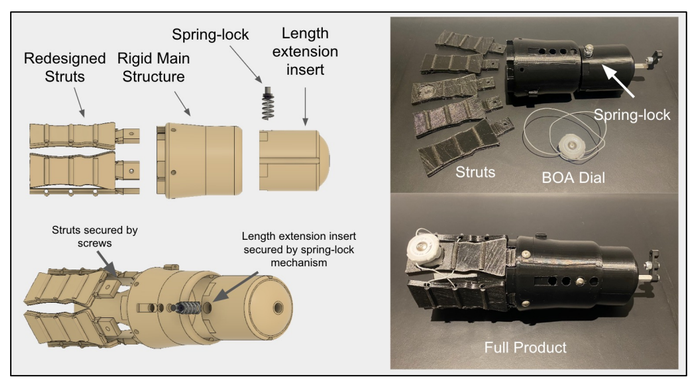


PROTOTYPING

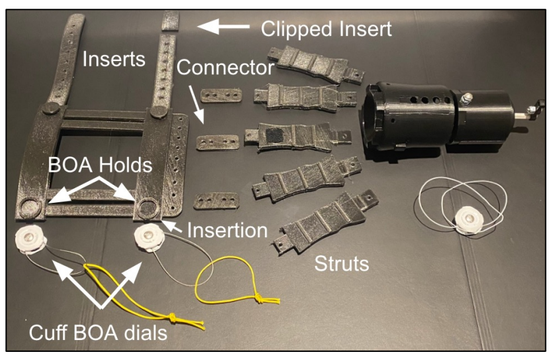
Prototype 1: Conceptual Design



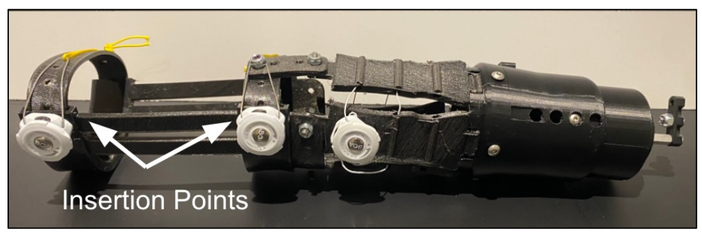
Prototype 2: Revised Design



Prototype 3: Tested Design with Elbow Cuff

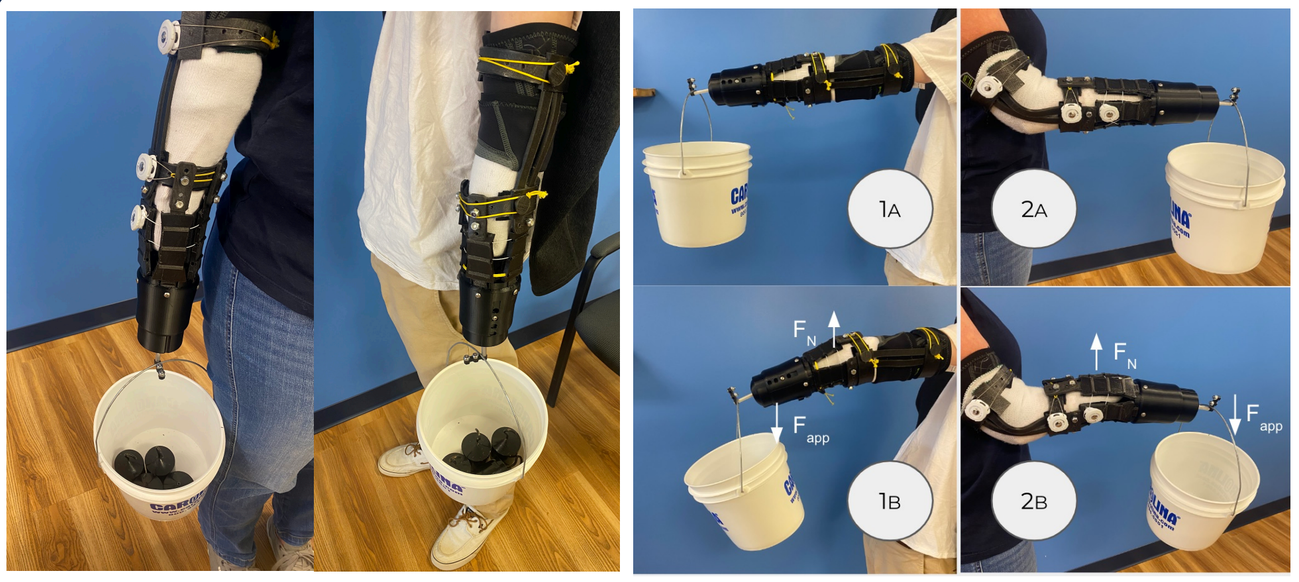


Prototype 3: Full Assembled Device



Prototypes 1-3 display major designs within the 300 iterations of the device. Prototype 2 was tested with an amputee, and the feedback was incorporated into the design of Prototype 3.

TESTING



Participants 1 and 2 (as shown in "Amputee Fitting" section) undergoing vertical (left) and horizontal (right) load-bearing tests to ensure that the socket can be used in activities of daily living (ADLs). With greater loads, minimal flex of the material occurs.

DISCUSSION AND RESULTS

Proof of Universality: Successfully fit two amputees with a wide range of residual limb size: **10.5 to 19 cm in length** and **13.5 to 25 cm in circumference**.

Socket functionality and Load-Bearing Capabilities: The device passed vertical loading socket standards for transradial sockets.

Comfort: The comfort remained well above 5 (out of 10) for all loads and had a higher rated comfort than each participant's current prosthetic.

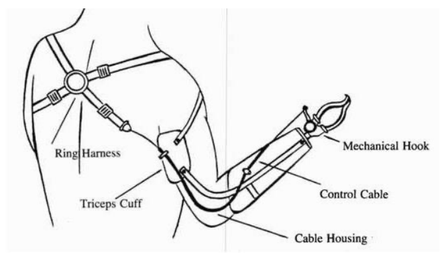
Production Cost: The total cost calculated is **$38.97/unit** for 1 unit produced which is less than 1% of the cost of traditional body-powered prosthetics.

This is the first-ever fully universal-fit transradial socket with the largest accommodated range of residual limb sizes for a socket.

FUTURE GOALS

1. Continue to develop and transform the socket into the full **body-powered transradial prosthetic** (bottom left)

2. Adapt the socket into comprehensive prosthetic kits to be **distributed to millions of amputees worldwide** through partnerships and connections with global nonprofit organizations such as e-NABLE.



https://www.orthobullets.com/basic-science/9072/rehab-and-prosthetics

e-NABLE Logo Courtesy of e-NABLE

All figures created by Arav Bhargava unless otherwise noted with a citation.