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

**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 amputees globally at a low cost.

**EXPERIMENTAL PROCEDURE**

- **CAD Design/Improvement**
- **3D-Print Prototyping**
- **Feedback**
- **Testing**

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).

**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 prosthesis.
- **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.

**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.

**FUTURE GOALS**

1. Continue to develop and transform the socket into the full body-powered transradial prosthesis (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.

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