Climbing Axe Prosthetic for Adaptive Rock Climbing

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Introduction and Motivation

Climbing tools on the market require users to be able-bodied, and do not account for the needs of disabled climbers. The customer, Jared, is an avid rock climber who has been enjoying the sport for more than five years, but has been unable to climb pain-free due to an injury to his right hand. To resolve this obstacle in climbing, our group designed an adaptive climbing tool to function as a climbing axe and prosthetic hybrid.

Based on Jared's arm anatomy, CAD drawings were created as a basis for the bodily attachment, and the Tech Machine Ice-Vario by Grivel® climbing axe was utilized as a template for the axe head. This device provided Jared with a new climbing method that did not require using his injured hand.

Figure 1: Jared climbing for Team USA.

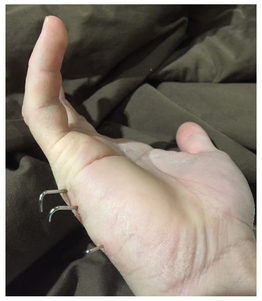

Figure 2: Pins to correct broken bones in right hand.

Design

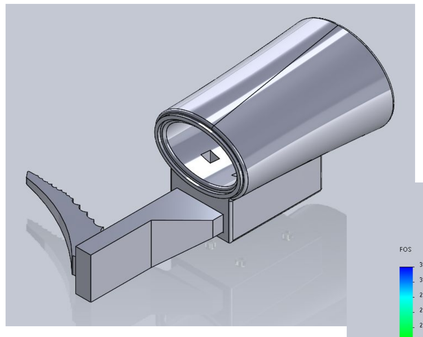

Figure 3: CAD drawing of final device.

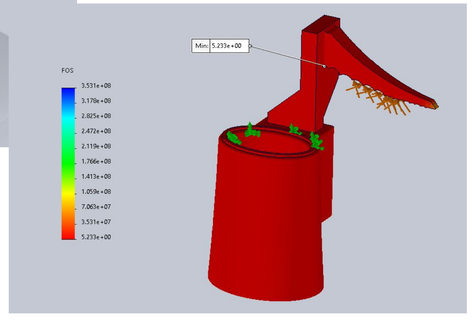

Figure 4: FEA of final device.

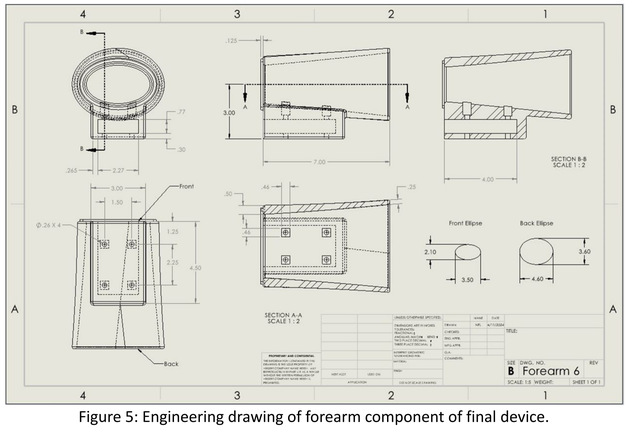

Figure 5: Engineering drawing of forearm component of final device.

Method

A design iteration methodology was utilized to create a balance of device functionality and comfortability.

Design Requirements

- Climb without utilization of injured hand
- Minimize climbing route damage
- Unassisted dressing
- Comfortability
- Resilience to fracture
- Resistance to rotation about arm
- Resistant to water absorbance
- Uncompromised arm mobility

Manufacturing

Figure 6: Forearm piece produced with PLA+ using a Prusa i3 MK3S+ 3D printer.

Figure 7: 6065-T6 aluminum axe head produced by CNC machine operations.

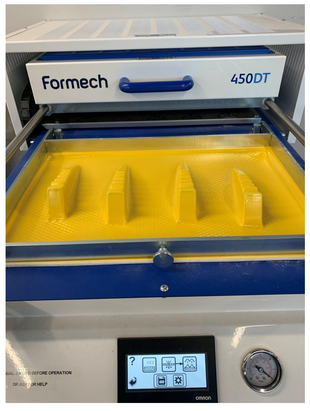

Figure 8: HIPS axe head covers produced by vacuform.

Figure 9: Safety strap made out a glove, silicone, fabric, and a Velcro strap.

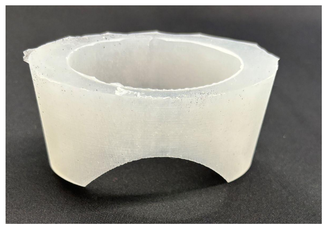

Figure 10: Device liner made out of silicone and fabric. This lies inside the forearm piece at the wrist to fill the space around the wrist.

Figure 11: Final device assembly. Includes wrist/safety strap, forearm component, and axe head. Axe head covers not shown.

Conclusions

The climbing axe prosthetic design allows for an alternative and adaptive method of rock climbing for our customer who is unable to utilize his injured hand. Axe head covers enable the user to climb both indoors and outdoors with the device, while minimizing damage to climbing routes.

The climbing axe prosthetic provided several achievements, of which include customer satisfaction, comfortability, allowance of full mobility, and an adaptive method to continue rock climbing without pain.

Future Work

The following are ideas to further improve the climbing axe prosthetic project:

- Outsource forearm component
- Identify alternate material for axe head that minimizes weight profile
- 3D scans of forearm to allow for custom sizing

The device created by the Climbing Axe Prosthetic Team has room for growth and endless potential. Design modifications is the largest area for future directions.

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