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Mechanical Testing of 3D Printed Prosthetics

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Mechanical Testing of 3D Printed Prosthetics

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Intro & Problem Statement

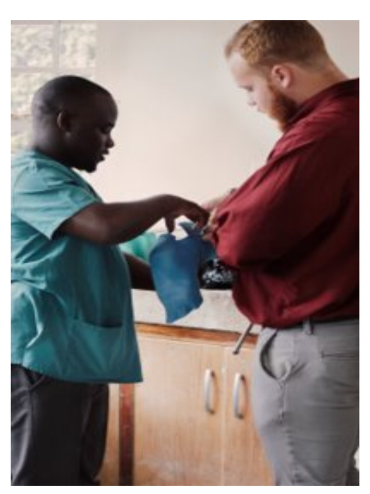
The ROCK team is working in collaboration with CURE International in Kijabe, Kenya to implement a 3D printing system in the orthopedics department. The department asked for this system to help handle the high volume of patients seeking care for prosthetic leg sockets. A dynamic prosthetic arm was also requested to be incorporated into this 3D printing system. The safety and functionality of the prosthetics are a high priority and a focus of the ROCK team.

Partner

CURE International works by supplying charitable health care services to high-need communities. Their orthopedic workshop supplies prosthetic and orthotic devices to approximately 100 patients per month.

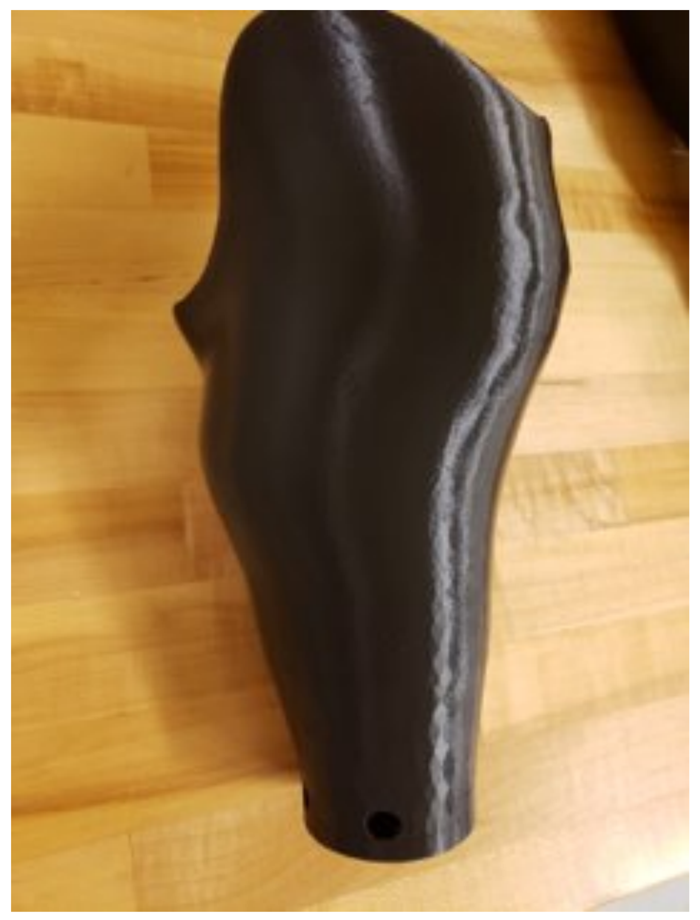
Our team has witnessed this amazing work CURE is doing during our site team trips in 2016, 2017, 2018, and 2019. As shown below our team members have been able to work hands on with technicians in Kenya.

With the implementation of the 3D printing system, the orthopedic workshop will be able to treat a greater volume of patients, potentially cut long term costs, and reduce the amount of waste generated by their current production system.



Safety Testing of 3D Printed Transtibial Socket

Previous teams have sought to verify the safety of the ROCK team's 3D printed socket through using a variety of mechanical tests. These included compressive axial tests and pure bending tests. Unfortunately, it was rather difficult to show that the sockets were safe with the results from these tests as there was no official standard associated with these tests for transtibial sockets. During the Fall of 2019 semester, it was decided that the International Standard ISO-10328 would be used to verify the safety of all of ROCK's 3D printed prosthetic transtibial sockets. One such socket can be seen in the left image. The ISO-10328 provides a verified method for determining whether any transtibial socket is safe and can be used.



The ISO-10238 specifies many types of tests that can be done on the socket. These tests simulate either the heel strike or the toe-off portion of a typical step taken by people of different masses. Each test makes use of a compressive load that is to be applied off-axis with respect to the socket. The loading geometry varies significantly among different tests, as does the magnitude of the applied force. Since the standard is still being understood by the team, it was decided that a "pilot" run would be conducted on a few of the sockets to gain better insight on carrying out a test. For reference, the team decided to use the P5 Type I test, which simulates a 100kg (220 lbs.) person undergoing the heel strike. Messiah College's MTS machine is capable of providing the correct magnitude of the compressive load for this test; however, the load must not be purely axial. Instead, the load must be applied at different offsets with respect to the socket. This can be achieved by constructing additional hardware that will interface with the MTS machine and the socket while providing the correct offsets as dictated by the standard. The socket, along with the additional hardware placed in the MTS machine as shown in the figure above on the right. The hardware that has been produced is only compatible with the P5 Type I test, current efforts are currently being undertaken to design and produce adjustable, universal, plates that will work for every test.

3D Prosthetic Arm

Upper limb prosthetics are cost between $1,000-$5,000 to manufacture and are thus too expensive for the vast majority of Kenyans that need them. During the 2019 site team trip to CURE in Kijabe, Kenya, ROCK was asked for a prosthetic arm design that could be implemented into the 3D printing system.

The design criteria are as follows:

- Compatible with a mid-forearm amputation
- Be able to support a weight of 10kg (22lbs)
- Fingers should be free to move independently from each other
- Cost effective so CURE's patients can purchase the prosthetic
- Simple to assemble and operate.
- Realistic

Very few options currently exist for 3D printable prosthetic arms and of them, the Unlimbited arm satisfied most of the design criteria listed above. The dimensions of the prosthetic arm can be customized to the patient using scaling software available throughthingiverse (https://www.thingiverse.com/thing:1672381). Only three dimensions are needed, forearm length, bicep circumference, and length from the wrist to the tip of the third digit (middle finger). Once printed and fully assembled, the patient can strap the prosthetic to their upper extremity using the Velcro straps along the forearm and bicep. The straps can be adjusted to the length of the amputated extremity.

The dynamic action of the fingers is accomplished through elbow flexion. When the elbow flexes, tension is put on the string running through the forearm and each finger. The tension enable the fingers to flex and grasp objects. From our testing and observation, grasping, holding, and picking up small everyday objects such as water bottles, a phone, or keys. Most amputees learn how to do everything they need, so this prosthetic will only serve as a tool for them to make certain tasks easier.

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cure KENYA

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