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Rapid Orthotics for Cure Kenya: Mechanical Design and Modeling of 3D Printed Sockets

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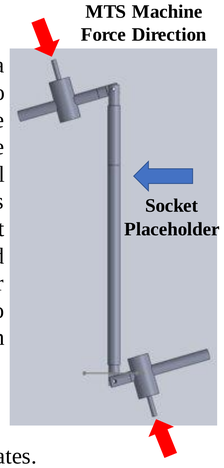
Our Mission

ROCK works with CURE International Hospital, a non-profit orthopedic workshop in Kjabe, Kenya, to implement a 3D printing system for manufacturing custom prosthetics and orthotics.

The system will:

- Assist technicians with high volume of seeking care for prosthetic leg sockets.
- Reduce the production time and cost for transtibial sockets being manufactured.
- Give patients a way to integrate into society and reduce stigma from their communities.

Design of MTS Testing Adaptors

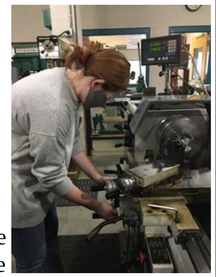


To determine the safety of the sockets, tests must be run where a compressive force is applied at an angle through the socket to replicate the loads felt during a step. This was a big challenge because the testing hardware at Messiah University is only able to apply loads in a vertical direction. The ISO 10328 International Standard defines an alternate coordinate system and specifies certain offset distances from the socket that the force load must be applied to replicate the force angle. However, the Standard offers no direction on how to achieve this practically. After several initial designs were scrapped due to their inability to accommodate the complex geometry that was needed, the team developed a novel rig, called the MTS Testing Adaptors.

Key features of MTS Testing Adaptors:

- The socket takes on the angle specified by the Standard.
- Adjustable components accommodating varying offset coordinates.
- Pin grips at the ends of the rig for MTS machine to apply a compressive force that flows through the center of the adjacent cylinders.

Manufacturing of MTS Testing Adaptors



MTS Testing Adaptors:

Manufacturing of the MTS Adaptors began in Fall 2020 after finalizing the initial design. The MTS Adaptors were built under the mentorship of John Meyer, Messiah University's Mechanical Engineering Technician who oversees the Machine Shop, where the team used the Lathe, Horizontal band saw, drill press and milling machine.

The lathe was used to decrease the diameter of the cylindrical body of the MTS Testing Adaptor so the force could flow from the grips of the MTS Machine. The hole cutting feature on the lathe was used to fine tune a hole just smaller than the diameter of the Pin Grip so it could be pressed into place. The hole was chamfered to allow the option of welding the pin into place in case the hole was accidentally cut too large.

Wooden Jigs:

Designed to interface Angle Joint to the bottom of the socket. Both a Short and Long Jig were manufactured for Type I or II tests and were machined using the horizontal and circular bandsaw.

Metal Shim:

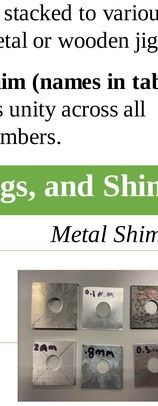
The distances between the knee and the Angle Joints must vary by several millimeters for each testing condition to accommodate the ISO 10328 geometry. The Shim spacers can be stacked to various distances and loaded between the Angle Joints and the metal or wooden jig.

Naming Convention for MTS Adaptors, Jigs and Shim (names in table)

➡ *Why Establish a Naming Convention?* It creates unity across all documentation and increases clarity for future team members.

MTS Testing Adaptors, Wooden Jigs, and Shim

MTS Testing Adaptors	*Wood Jigs*	*Metal Shim*
Upper	*Long-Type I*	
Lower	*Short-Type II*	



Full Assembly of Testing Rig in MTS Machine

Our Goal

3D Printed Transtibial Socket

The team has developed a transtibial socket for below-the-knee amputees produced by a 3D printing system that converts a scan of the residual limb to a model that takes a third of the time to print versus the current manufacturing method. The current focus of the team is to develop a rigorous testing procedure adhering to the requirements set by the ISO 10328 Standard, an internationally recognized testing method.

In order to ensure the safety of the sockets, differing types of tests must be run demonstrating that the product can withstand the different forces experienced during the gait cycle for patients with varying masses.

Finite Element Analysis of 3-D Printed Socket

Finite Element Analysis (FEA) is a computer-based simulation, run in the 3D modeling software called SolidWorks, to determine how components will behave under certain environmental and loading conditions.

The ROCK Team uses FEA to:

- Ensure that the designed testing equipment will function as expected while staying in accordance with the 10328 Standard.
- To ensure that the connection between the socket and the equipment does not fail under loading conditions.
- To compare results with the Ultimate and Static Proof tests being run on the MTS machine.

In the future, the ROCK Team will begin transitioning FEA towards cyclic testing to determine if test methods are appropriate before spending time and money conducting tests.

Conclusion

The team is currently on the verge of completing the design and manufacturing of the MTS Testing Adaptors and has been successful in developing a testing procedure for the socket according to the ISO 10328 Standard. The focus of the next year will be to use the novel rig to collect valid data using the procedure to determine the safety of the 3D printed socket, using both ultimate strength and cyclic tests. Once data is collected, additional design changes can be considered for both the socket and the method of printing to move towards being able to implement a safe and functional transtibial socket into the orthopedic workshop at CURE Kenya.

Acknowledgments

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