Design of 3D Printed Orthotics and Bacterial Testing on Silicone Liners for CURE Kenya

MESSIAH COLLEGE

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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. They desire to replace their current ethylene vinyl acetate prosthetic liners with silicone liners and have asked us to determine if this is feasible. Additionally, a 3D printing system training manual to create ankle-foot orthotics (AFO) will allow employees in the orthopedics department to see and treat a greater volume of patients as well as potentially cut long term costs.

Current Need

There are 40 million amputees globally, but only 5% of these have access to prosthetic assistive devices (World Health Organization, Fig. 1).

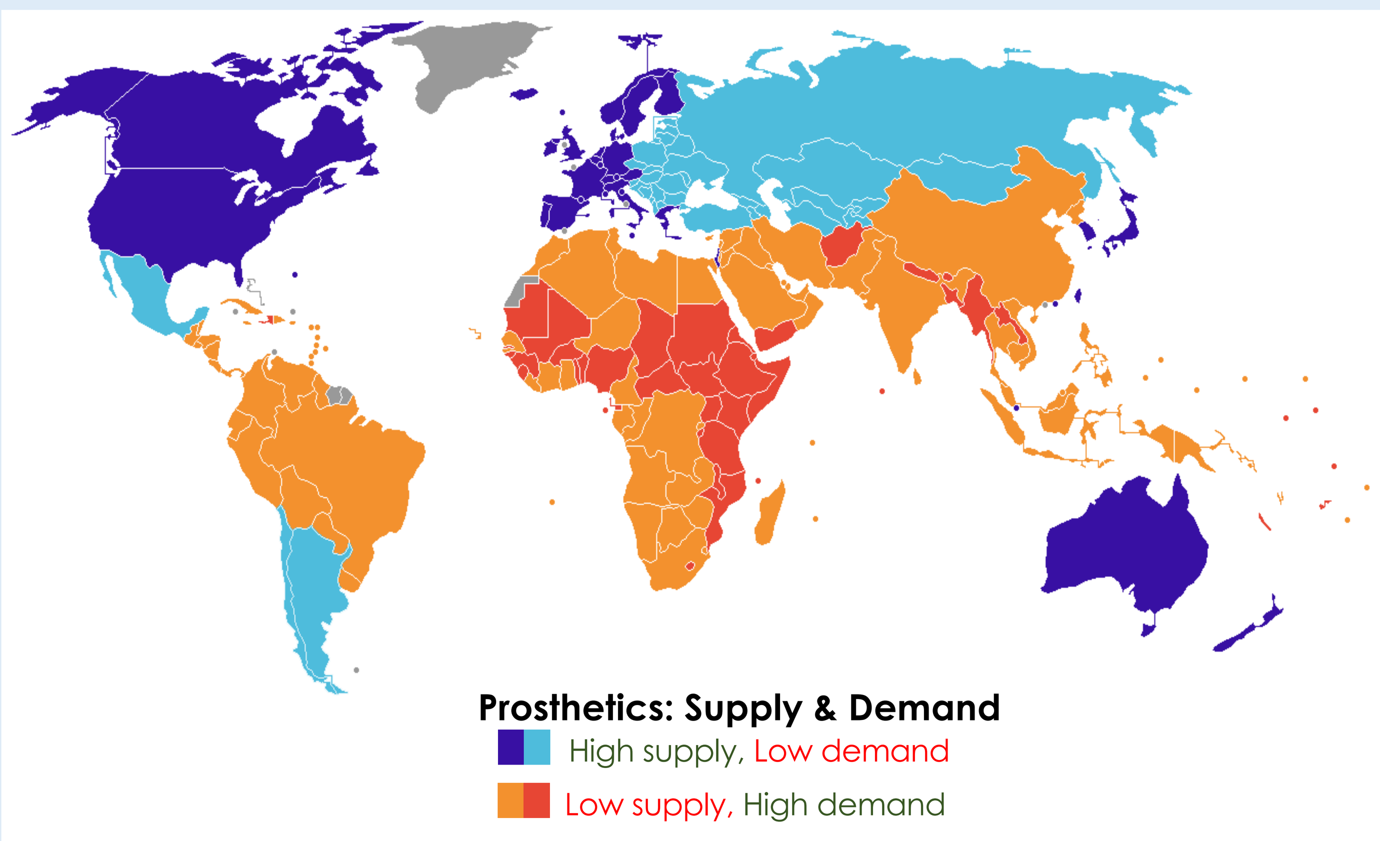

Figure 1 – The gap between global supply and demand of prosthetic devices.

CURE International works to fill this gap 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, and 2018 (Fig. 2)

Figure 2 – The orthopedic workshop in Kijabe, Kenya and the ROCK team together during the 2018 site team trip

System Design

In summer 2017 and 2018, the technicians in Kenya learned how to make prosthetic leg sockets and static AFOs using a structure sensor and iPad, Omega, MeshMixer, Simplify 3D and a DeltaWasp 3D printer. Figure 3 shows the design process with our current process, as delivered in 2017. In 2018 and 2019, we have worked on expanding the workshop's capabilities with using this system

Figure 3– Current process of 3D printing system

Design Criteria	
Unit Cost	< $25 USD
System Cost	< $5000 USD
Manufacturing Time	< three days (current standard)
Compatibility	Must be compatible with current prosthetic and orthotic parts used in Kenya
Comfort	Must be customized to the patients limb

Table 1. Design Criteria as given by CURE's workshop

Table 1 shows our design criteria for the orthotics and prosthetics. This also includes any silicone liner, if deemed feasible in the future.

Bacteria Testing for Silicone Liners

Now that CURE has a 3D printing system in Kenya, our task is to expand their system to meet all the needs of the orthopedic workshop and better serve their patients. Our main objective in determining the feasibility of using silicone liners (Fig. 4) in a low resource setting is to determine if they are safe to use with regards to bacterial growth.

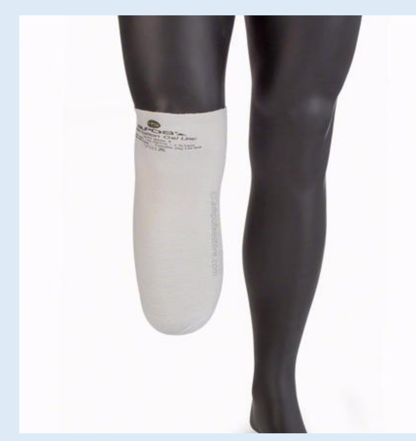

Figure 4– Silicone liner as seen on an example patient

Currently, our goal is to develop a procedure that allows us to quantifiably compare bacterial growth across different samples. In order to do this, we have been designing and editing a procedure that allows us to determine growth of *Staphylococcus aureus* in contact with medical grade silicone (Fig. 5, 6, and 7).

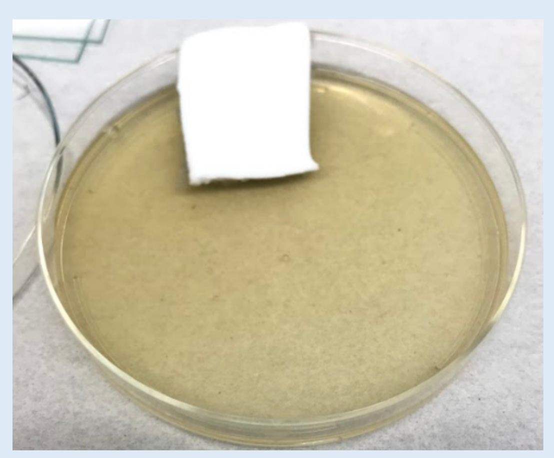

Figure 5– Silicone and agar plates used for bacteria testing

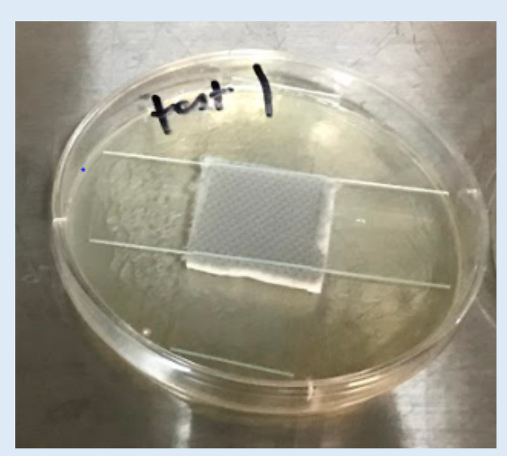

Figure 6– Samples before inoculation

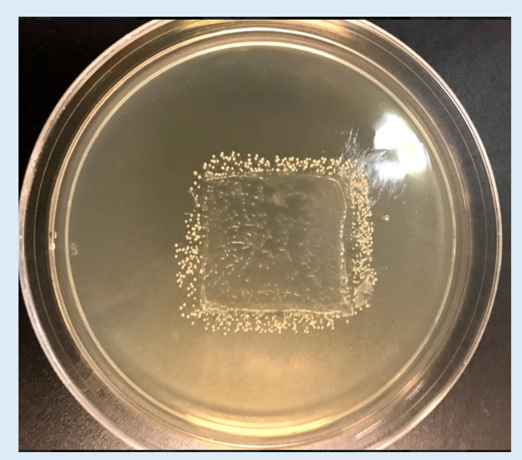

Figure 7– Bacterial growth on agar after 24 hours

After 3 rounds of testing, we have found a procedure that we believe will allow us to quantifiably compare bacterial growth on silicone over time. Moving forward, we will do another test to seek to promote colony growth under the silicone rather than around it and to use this procedure to compare bacterial growth on silicone with that on ethylene vinyl acetate, the material currently used for prosthetic liners by CURE Kijabe's orthopedic workshop.

Dynamic Ankle-Foot Orthotic (AFO)

On the 2018 site team trip, the workshop expressed interest with manufacturing dynamic AFO's using the 3D printing system. With the addition of the Tamarack joint housing pieces (Fig. 8) and the stopper pieces (Fig. 9) to the static AFO (Fig. 10) given in May 2018 to the workshop, we have successfully made a dynamic AFO.

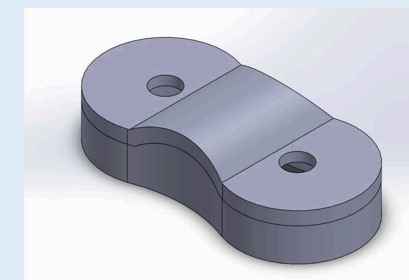

Figure 8– Tamarack housing piece in SolidWorks

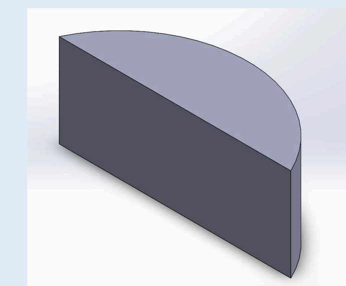

Figure 9– Stopper piece in SolidWorks

Figure 10– Static ankle-foot orthotic

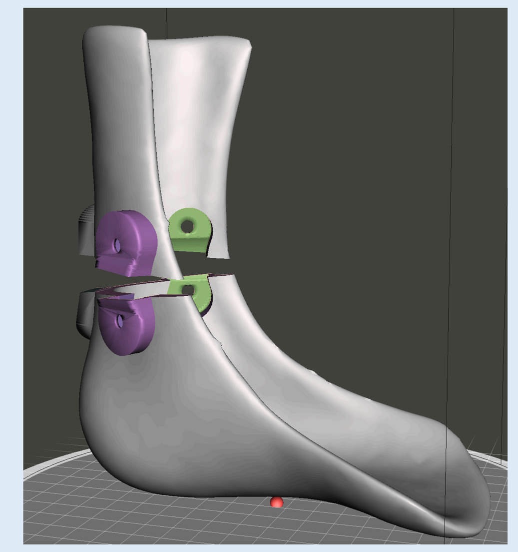

Figure 11– Dynamic AFO in MeshMixer

The top and bottom pieces shown in Figure 11 will be printed separately, and the tamarack joints will be screwed into place after the AFO is printed.

After printing, the technicians add the Tamarack joints and attach a small piece of rubber to the top and bottom of the stopper piece in the back. All steps needed to create the dynamic AFO will be compiled into our training manual.

Upcoming Site Team Trip

From May 24 to June 8, 2019, most of our team will be travelling to Kenya to expand their 3D printing system and continue to build relationships with CURE Kijabe's orthopedic workshop. Our work will include training the technicians to create dynamic AFO's as well as prosthetic hands from the project management team

Figure 12– ROCK team

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More Information

Project Report: https://bit.ly/2KfR3ip
CURE: www.cure.org

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