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SkinSafe: Comparing Staphylococcus aureus Growth Across Liner Types in Kenya

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Introduction

The interface between an amputee's residual limb and prosthetic liner is at risk for high levels of bacterial growth which can lead to skin breakdown and in the worst cases, infection. This is particularly a concern in low-resource settings, such as Kijabe, Kenya, in which a lack of clean water can result in poor hygiene. It is believed that silicone prosthetic liners have a sealing effect that could heighten this issue. However, research on this topic is minimal. The SkinSafe team is working to provide this research by studying whether or not silicone liners are associated with elevated levels of bacteria growth at the interface between the residual limb and the prosthetic liner of amputees in low-resource settings. To accomplish this goal, the team is conducting a prosthetic liner study to compare the level of bacterial growth associated with silicone liners to that associated with the EVA liners currently used in Kijabe, Kenya.

Fig 1. Prosthesis developed by CURE Kenya
www.curekenya.org/prosthesis-fabrication

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SkinSafe Bacterial Skin Model

Traditional cell culture procedures incubate bacterial plates at a constant environmental temperature. However, the skin–liner interface on an amputee's residual limb is a dynamic environment, as the human body provides heat and water to the surface of the skin. Therefore, the SkinSafe team has developed a bacterial skin model (Fig 1 and 3) that captures this dynamic behavior by incorporating a localized water and heat source (Fig 2) that mimics the human body. The SkinSafe self-regulating heat source utilizes a DS18B20 temperature sensor to monitor the temperature of the water source and a Peltier Tile controlled by an Arduino to heat that water source. The model suspends a layer of agar representing the patient's skin above this water and heat source to allow for the movement of heat and water to the "skin–liner interface".

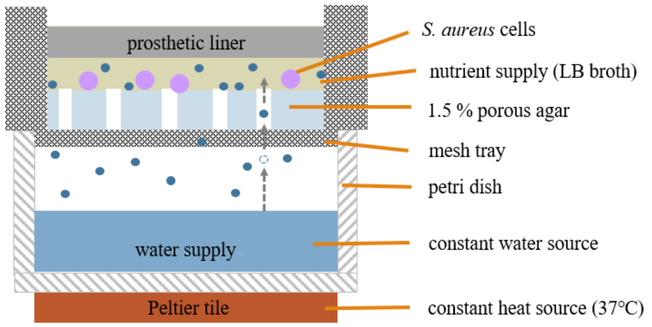

Fig 2. SkinSafe bacterial skin model schematic

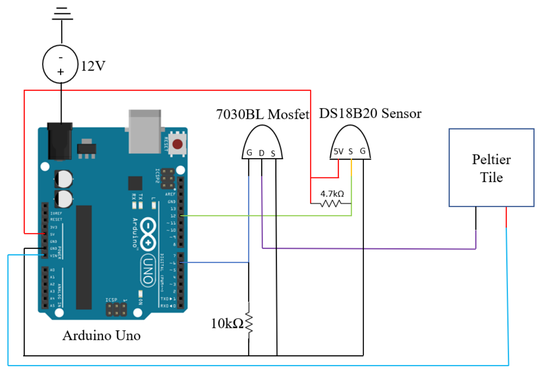

Fig 3. SkinSafe self-regulating heat source

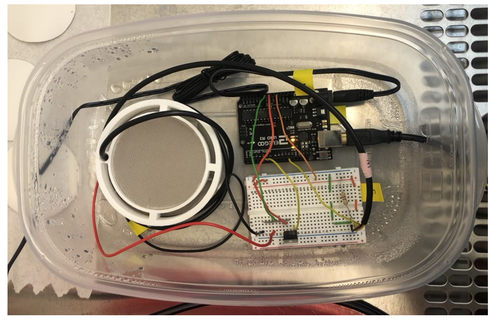

Fig 4. Physical SkinSafe bacterial skin model

Experimental Setup

Bacterial testing was conducted on three different types of liners (Figure 4): a prosthetic sock–EVA liner that is representative of liners currently used by patients in Kijabe, Kenya, a medical grade Ossur Iceross Silicone Liner, and a more affordable Namaste Silicone Liner. *Staphylococcus aureus* cells, a common bacteria found on human skin, are grown on three SkinSafe bacterial skin models each equipped with a different type of prosthetic liner. After a 24-hour period of bacterial growth, the bacteria are collected in a Lysogeny Broth solution. The absorbance of this collected solution is found using a spectrophotometer. The absorbance value is converted to a *S. aureus* cell density value using a known *S. aureus* absorbance–concentration calibration curve (Fig. 5). These densities are then used to compare the bacterial growth associated with the different types of prosthetic liners.

Fig 5. Prosthetic liners for bacterial testing

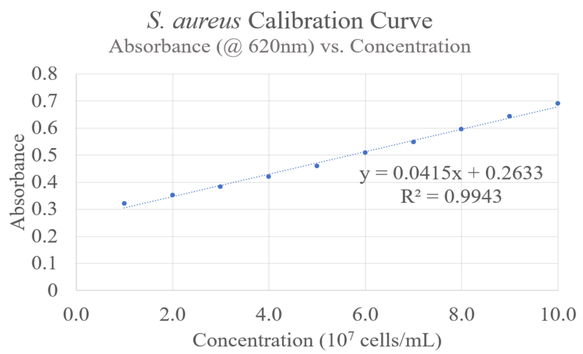

Fig 6. *S. aureus* calibration curve

Results

A two-factor ANOVA test was conducted on 9 cycles of final *S. aureus* growth concentration data collected for the three types of liners.

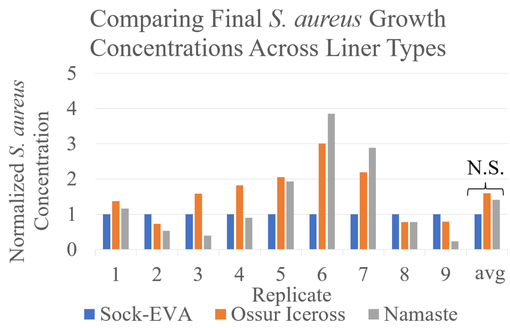

Fig 7. Final *S. aureus* growth concentration data

Table 1. Two-factor ANOVA test results

Source of Variation	Liner Type	Cycle
SS	$6.96*10^{17}$	$1.22*10^{19}$
df	2	8
MS	$3.48*10^{17}$	$1.53*10^{18}$
F	0.839	3.687
P-value	0.450	0.013
F crit	3.634	2.591

Conclusions

The data does not provide sufficient evidence to suggest a significant difference in the bacterial growth associated with using the three different types of liners with the SkinSafe bacterial skin model. Based on this study, it appears that there are not increased risks of bacterial growth when actively wearing silicone liners in comparison to sock–EVA liners in low-resource settings such as Kijabe, Kenya. However, SkinSafe acknowledges that the model used for this study does not encompass all factors that could contribute to elevated bacterial growth. Moving forward, our team will continue looking for ways to safely and sustainably provide CURE Kenya with the silicone liners they are hoping for.

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