Low-Level Light Therapy for Improvement of Diabetic Foot Ulcer Infection Outcomes

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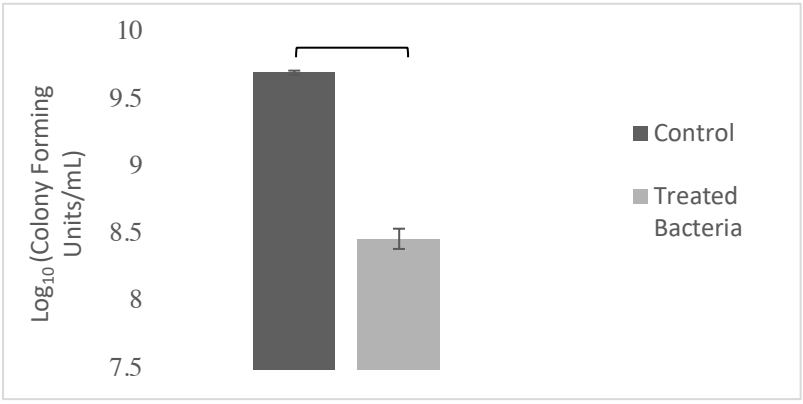
Introduction: It is estimated that 15-25% of diabetics will develop a diabetic foot ulcer (DFU) in their lifetime. Furthermore, every 30 seconds, a lower extremity amputation is performed due to diabetes complications such as diabetic foot ulcers. The current treatment for a DFU relies entirely on passive methods such as standard wound dressings and off-loading casts. As a result, DFUs are notoriously prone to infection leading to costly amputation procedures. To this end, we have created a light therapy device that utilizes blue/green wavelengths to kill bacteria and reduce the risk of infection.

Materials and Methods: The device contains two key components: light control unit (LCU) and light delivery unit (LDU). The light control unit was developed to power 4 mA of current through the 6 LEDs in the light delivery unit. The light delivery included the six 505 nm LEDs wired through a 3D printed scaffold coated in biocompatible silicon.
Bacterial efficacy tests were conducted with the light delivery unit prototype. Patient derived methicillin-resistant *Staphylococcus Aureus* USA 300 was used for the efficacy test. *S. Aureus* was plated on LB agar plates and cultured in LB agar broth. The bacteria was incubated for 5 hours before diluting to an appropriate concentration for light exposure testing. The initial concentration values were determined using absorbance spectroscopy. After diluting the bacteria, the control and treatment solutions were separated. The control in this experiment was the unexposed diluted solution. The treatment solution was prepared by placing 4 mL of bacteria solution in a petri dish. This petri dish was placed under the light delivery unit for 13 hours. After 13 hours, both the control and treated solutions were diluted $1{:}10^6$. Two hundred microliters were plated on LB agar plates (n=4 for both experimental groups). The following morning the colonies were counted for both the control and treated groups. The log reduction in colony forming units per milliliter (CFU/mL) was calculated. A paired t-test was used to determine significance (p-value <0.05).

Results and Discussion: After 13 hours of light exposure from the prototype, there was a significant reduction in bacteria concentration. The control (no light exposure) had a mean Log_{10}(CFU/mL) concentration of 9.7, while the light treated bacteria had a concentration of 8.47. The 1.2 log reduction correlates to approximately 94% reduction in bacteria. These preliminary results indicated promising reduction efficacy for the future treatment cycle of 7-10 days. After only 7% of our allotted treatment time, the 505 nm wavelength LEDs in our prototype were able to significantly reduce the bacteria concentration in vitro.



Conclusions: The 505 nm LEDs and light delivery unit prototype significantly decreased the presence of methicillin-resistant *Staphylococcus Aureus* USA 300. Furthermore, physician and technician feedback regarding the implementation, profile, and usefulness of the device has verified the appropriateness of our design decisions. Noting this, the team will proceed with development of the device.

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