Micro-Patterned Polyurethane Surfaces for Reducing Bacterial Attachment Associated with Catheter-Associated Blood Stream Infections

Rhea M. May PhD, Matthew G. Hoffman BA, Dipankar Manna PhD, and Shravanthi T. Reddy PhD
Sharklet Technologies, Inc., Aurora, Colorado, USA

Background

Central venous catheters (CVCs) are responsible for approximately 90% of all catheter-related bloodstream infections (CRBSIs). These CRBSIs, commonly caused by *Staphylococcus aureus* and *Staphylococcus epidermidis*, are associated with 28,000 deaths per year in the U.S. as well as prolonged hospital stays and increased healthcare costs. A common strategy used to prevent CRBSIs has been to impregnate CVCs with antimicrobial agents, which can be limited by the short duration of efficacy and the potential for contributing to antimicrobial resistance. A novel micro-topography may provide an alternative strategy as it has been shown to reduce bacterial attachment and biofilm formation without the use of antimicrobial agents (Figure 1). This micro-pattern also inhibits bacterial migration, offering the possibility of reducing bacterial access into the bloodstream via the CVC (Figure 2). The objective of this study was to determine the performance of the Sharklet micro-pattern in reducing *S. aureus* attachment to samples made in the same material as CVCs after whole blood pre-conditioning.

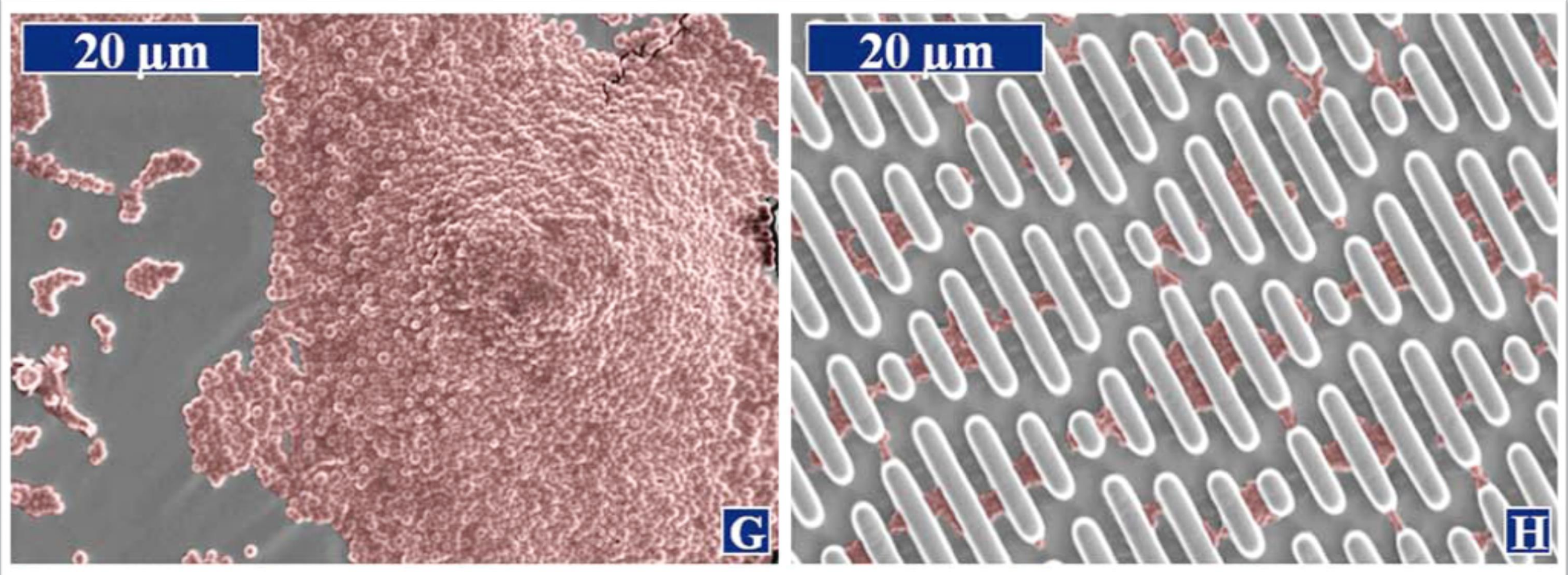

Figure 1. The Sharklet micro-pattern (right) reduces S. aureus *biofilm formation over 14 days when compared to an un-patterned surface (left). Representative Scanning electron micrographs from Chung* et al. *(Biointerphases, 2007, 2(2):89-94)*

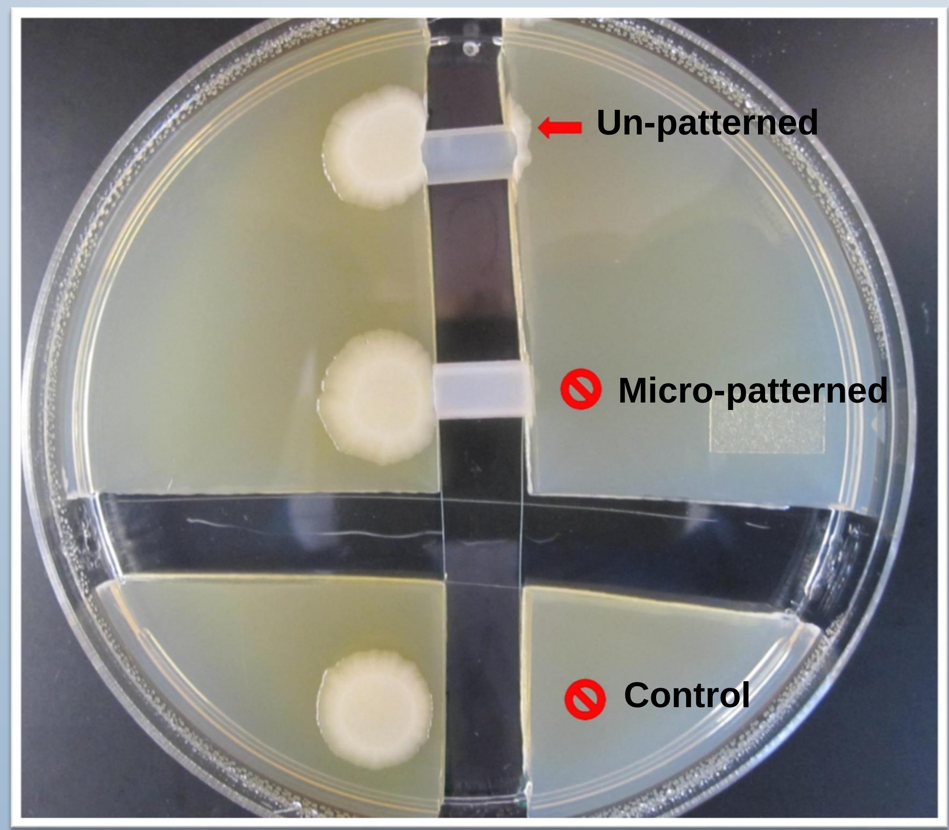

Figure 2. The Sharklet micro-pattern decreases bacterial migration. A model adapted from Sabbuba et. al. *(BJU Int. 2002, 89, 55-60) has shown a 81% (p=0.03) and 92% (p=0.003) reduction in* Escherichia coli *and* Serratia marcescens *migration, respectively.*

Sharklet patterned polyurethane surfaces reduce *Staphylococcus aureus* attachment after pre-treatment with whole blood under two shear conditions

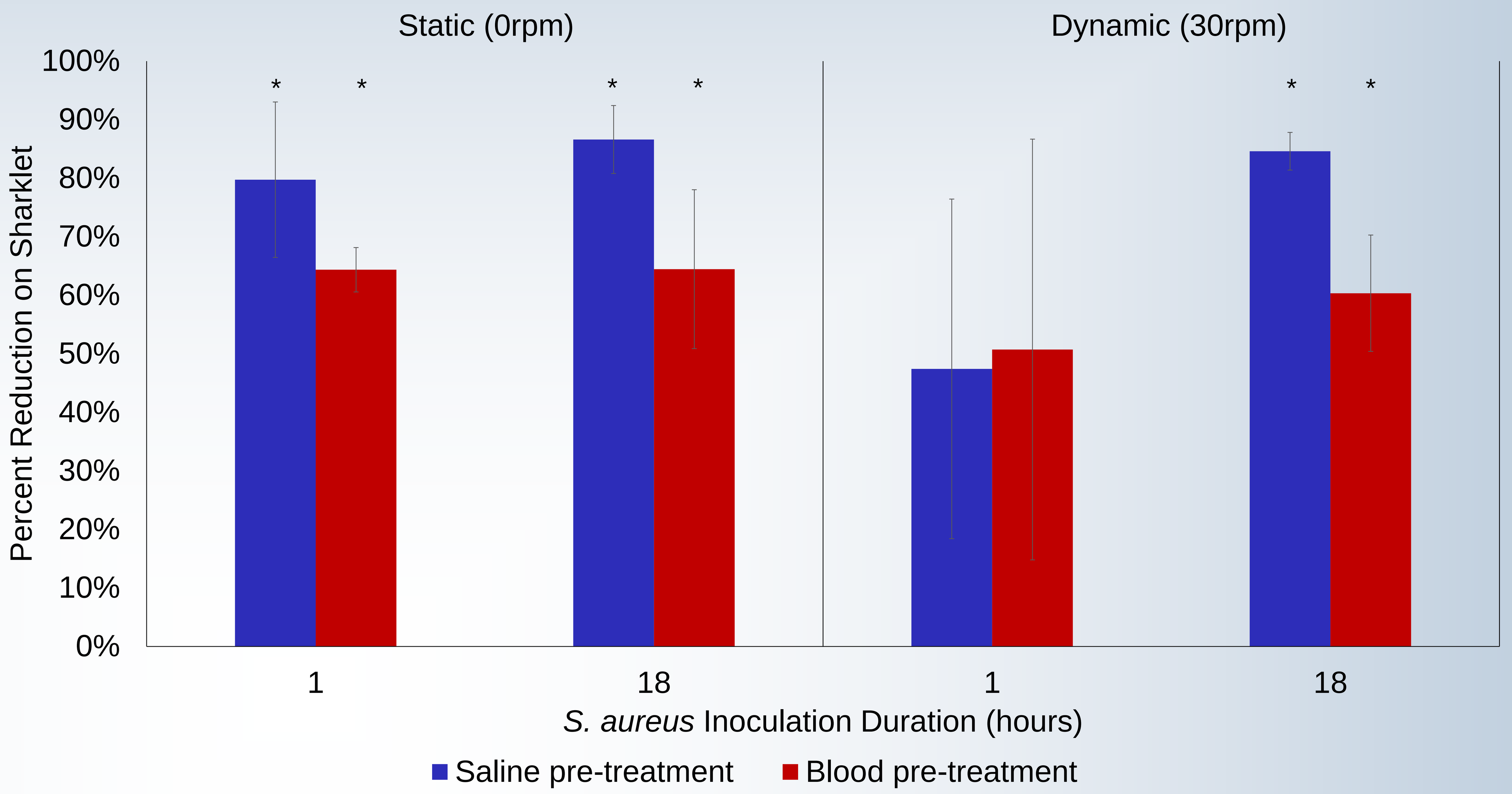

*Figure 3. The Sharklet micro-pattern, in polyurethane, significantly reduces S. aureus attachment under two shear environments even after blood pre-treatment (*p<0.05 over three experiments) when compared to an un-patterned control surface. The difference in pre-treatment media (blood vs. saline) or time point did not significantly alter the performance results. The dynamic 1 hour condition yielded variable results and was not significant (p ≤ 0.1)*

Methods

Patterned and un-patterned (control) thermoplastic polyurethane samples (n=4) were immersed statically or dynamically (30rpm) in either whole blood or saline for 2 hours at 37°C, followed by a saline rinse, and inoculation with 10^7 - 10^8 CFU/mL *S. aureus* (ATCC6538) in saline. The samples were incubated statically or dynamically (30rpm) for 1 and 18 hours at 37°C before rinsing with saline and enumerating the attached cells by ultrasonication and dilution plating. Statistical analysis was conducted through t-test and ANOVA models.

Results

After preconditioning surfaces with blood, the micro-patterned surfaces reduced *S. aureus* colonization to a clinically relevant material by 65% (p≤0.05) after 1 & 18hrs static incubation and 51% (p≤0.1) after 1hr & 60% (p≤0.05) after 18hrs dynamic incubation when compared to preconditioned un-patterned surfaces. There was no significant difference in micro-patterned surface performance across time points and preconditioning fluids (i.e. blood vs. saline).

Conclusions

The surface modification afforded by the micro-texture significantly inhibits the colonization of *S. aureus* after blood preconditioning on a clinically relevant material under clinically relevant shear conditions.

Introduction of this micro-pattern on central venous catheters may be useful for controlling CRBSIs while not contributing to the rise in antimicrobial resistance.

Acknowledgements

Sharklet would like to thank Dr. Christopher Siedlecki for providing his expertise as well as Melinda Sogo and Trevor Hostetter for helping to carry out these studies.

This work was financially supported by award number 1R43HL112410-01 from the National Institutes of Heart Lung and Blood

For inquiries/questions, please e-mail rmay@sharklet.com