Clinical Irrigation Solutions Eradicate *Staphylococcus aureus* Biofilm and Prevent Regrowth on Implant-Grade Surfaces: An *In Vitro* Study

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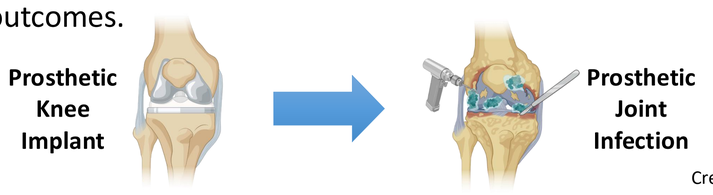
Takeaway: Of five irrigation solutions, BC and PI achieved ≥ 4-log biofilm reduction of MSSA and MRSA with no recovery after reintroduction to growth media; CS and PB showed strain-specific limitations.

Introduction

- Periprosthetic joint infection (PJI) leads to emotional, financial, and physical stress for patients.
- Approximately 1 in 100 joint replacements result in an infection, and *Staphylococcus aureus* (*S. aureus*) is one of the most common causative organisms.
- *S. aureus* readily forms biofilm, leading to increased antibiotic tolerance.
- Irrigation solutions are often used intraoperatively during revision arthroplasties to treat *S. aureus* biofilm.
- However, the efficacy of common, commercially available irrigation solutions remains poorly characterized.
- Identifying the most effective irrigation solution may guide intraoperative decision-making during revision arthroplasties and lead to improvements in treatment outcomes.



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Objective

To evaluate the efficacy of common surgical irrigation solutions against *S. aureus* biofilm on implant-grade surfaces, and to determine if those effects are sustained after reintroduction to growth media.

Methods

Biofilm grown (MSSA/MRSA) on cobalt chromium discs

- 3 discs measured for initial biofilm load (growth control)
- 3 discs were imaged using Scanning Electron Microscopy for biofilm visualization
- Discs exposed to treatments (n=6 per group)

- 3 discs assessed for initial biofilm reduction
- 3 discs assessed for biofilm regrowth after reintroduction to growth media

Treatments	Exposure Times
Benzalkonium Chloride (BC)	5 min, 21°C
Polyhexanide/Betaine (PB)	15 min, 37°C
Citric Acid/Sodium Citrate (CS)	5 h, 37°C
0.5% Povidone-Iodine (PI)	5 min, 21°C
Saline	5 h, 21°C

Bacteria
MSSA ATCC 25923
MRSA ATCC BAA 1717

- Statistical comparisons were performed using Student's t-test, Analysis of Variance, and Tukey's Test. Figures generated using GraphPad Prism.

SEM Biofilm Imaging

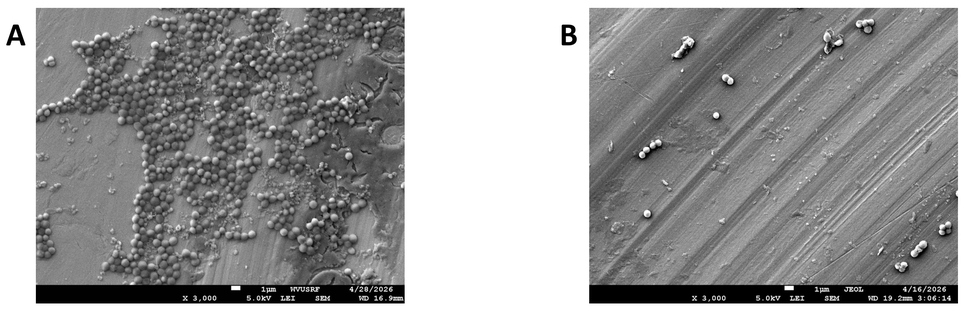

Figure 1: Scanning Electron Microscopy (SEM) images showing MRSA biofilm adhesion to cobalt chromium discs prior to treatment (A) and residual changes after treatment with CS (B).

Results

- All tested irrigation solutions eliminated ≥99.99% of MSSA and MRSA biofilm (≥ 4-log reduction). while saline was ineffective.

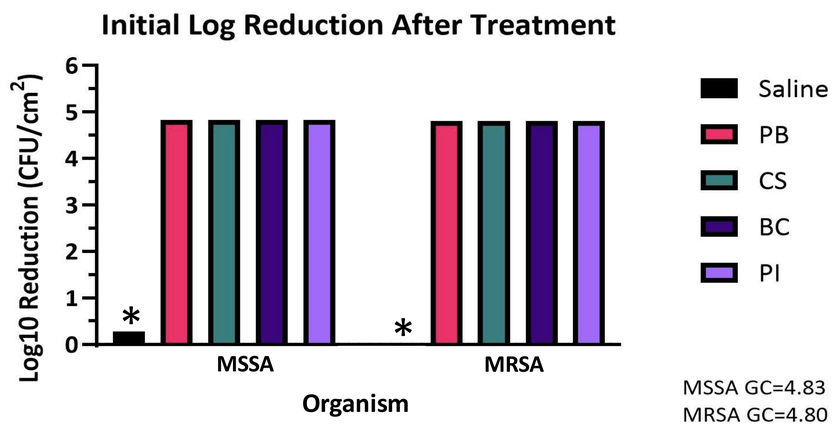

Figure 2: Growth control discs (GC) showed an initial MSSA biofilm load of 4.83 log and MRSA biofilm load of 4.80 log. For both MSSA and MRSA, discs treated with PB, CS, BC, and PI initially showed a ≥ 4-log reduction in CFUs compared to a < 1-log reduction in the saline group ($P < 0.05$). * Indicates significance.

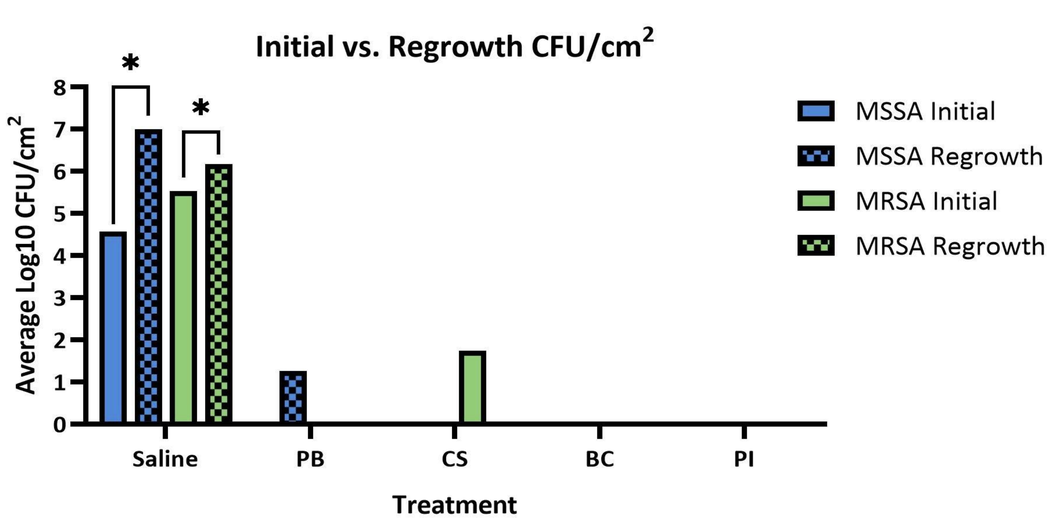

Figure 3: Biofilm burden immediately after treatment (initial) vs. after reintroduction to growth media (regrowth), by strain (n=3). BC, CS, and PI showed no regrowth; saline CFUs increased ($P < 0.05$). PB regrew for MSSA; CS did not fully clear MRSA initially ($P > 0.05$). * Indicates significance.

Conclusions

- BC and PI sustained both MSSA and MRSA biofilm eradication post reintroduction to growth media, indicating that they effectively eliminated initial biofilm and prevented regrowth of any remaining biofilm.
- While not significant, CS did not fully reduce MRSA biofilm initially, and PB showed some regrowth in MSSA biofilm.
- The goal for infection control requires initial eradication without recurrence of the infection. This study shows that BC and PI fully met this standard for both *Staphylococcus aureus* strains, while CS and PB showed strain-specific limitations that warrant further investigation.
- This study provides important insight into the use of commercially available irrigation solutions as potential alternatives or adjuvants to antibiotics for the management of PJI.

References & Acknowledgments

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Images: WVU SEM Imaging Core
Figures: https://BioRender.com