



Efficacy of Contact Lens Care Solutions Against Neutrophil Enhanced Biofilms

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INTRODUCTION

Contact lenses (CTL) are one of the most commonly used medical devices, with more than 40 million contact lens users in the United States alone. Microbial keratitis is the most severe and visually devastating complication associated with contact lens wear.^{1,2} Studies in our laboratory have shown that invasive corneal isolates of *Pseudomonas aeruginosa* (PA) have enhanced adhesion to CTL surfaces in the presence of dying neutrophils.³ This occurs through the development of neutrophil-derived extracellular scaffolds that facilitate lens colonization by PA and potentiates the development of biofilms.⁴ Prior studies have shown reduced disinfection efficacy of lens care solutions against bacterial and fungal biofilms formed on CTL surfaces.^{5,6} Following two recent outbreaks of microbial keratitis associated with the use of specific contact lens care solutions, the FDA is currently re-evaluating disinfection guidelines and establishing new “real world” testing requirements.⁷

PURPOSE

To evaluate the antimicrobial efficacies of four currently available chemically preserved and peroxide-based lens care products (LCPs) against neutrophil enhanced bacterial biofilms formed on CTL surfaces.

MATERIALS AND METHODS

Bacteria: Four strains of bacteria commonly encountered during contact lens use were selected for this study: *Pseudomonas aeruginosa* (PA, ATCC 9027), *Staphylococcus aureus* (SA, ATCC 6538), *Stenotrophomonas maltophilia* (ST, ATCC 13637), and *Serratia marcescens* (SM, ATCC 13880).

Neutrophil Isolation: Human neutrophils (PMN) were harvested by Ficoll gradient separation and stimulated with phorbol 12-myristate 13-acetate.

Lens Disinfection: Unworn Lotrafilcon A silicone hydrogel contact lenses (Alcon Laboratories, Ft. Worth, TX) were incubated overnight with bacteria and PMNs at a 1:0.1 bacteria:PMN ratio. Lenses were then disinfected with one of four commercially available contact lens care solutions: Biotrue (BT), PureMoist (PM), ClearCare (CC) and PeroxiClear (PC, Table 1). Digital cleaning and disinfection time were performed according to specific manufacturer guidelines.

Bacterial Viability: Contact lenses were stained using a BacLight Bacterial Viability assay and imaged using laser scanning confocal microscopy. Image stacks were reconstructed three-dimensionally using IMARIS software. Viable bacteria were quantified using standard colony counts.

RESULTS

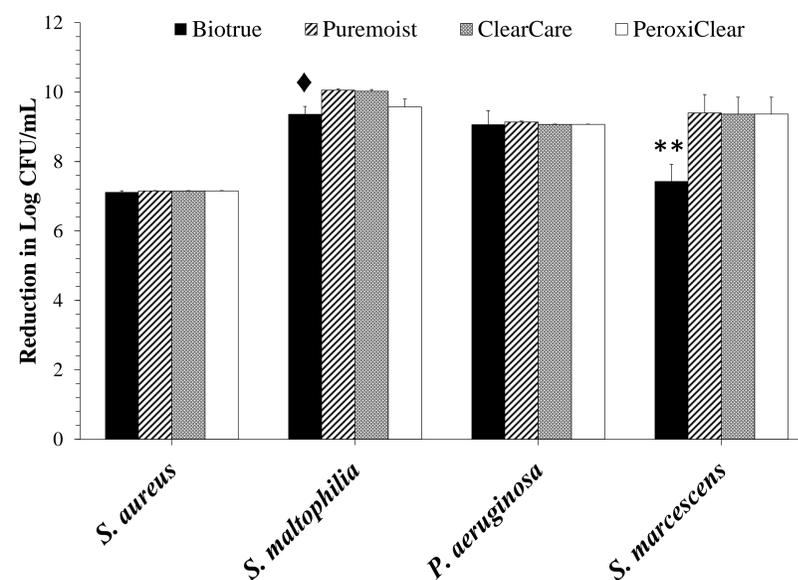
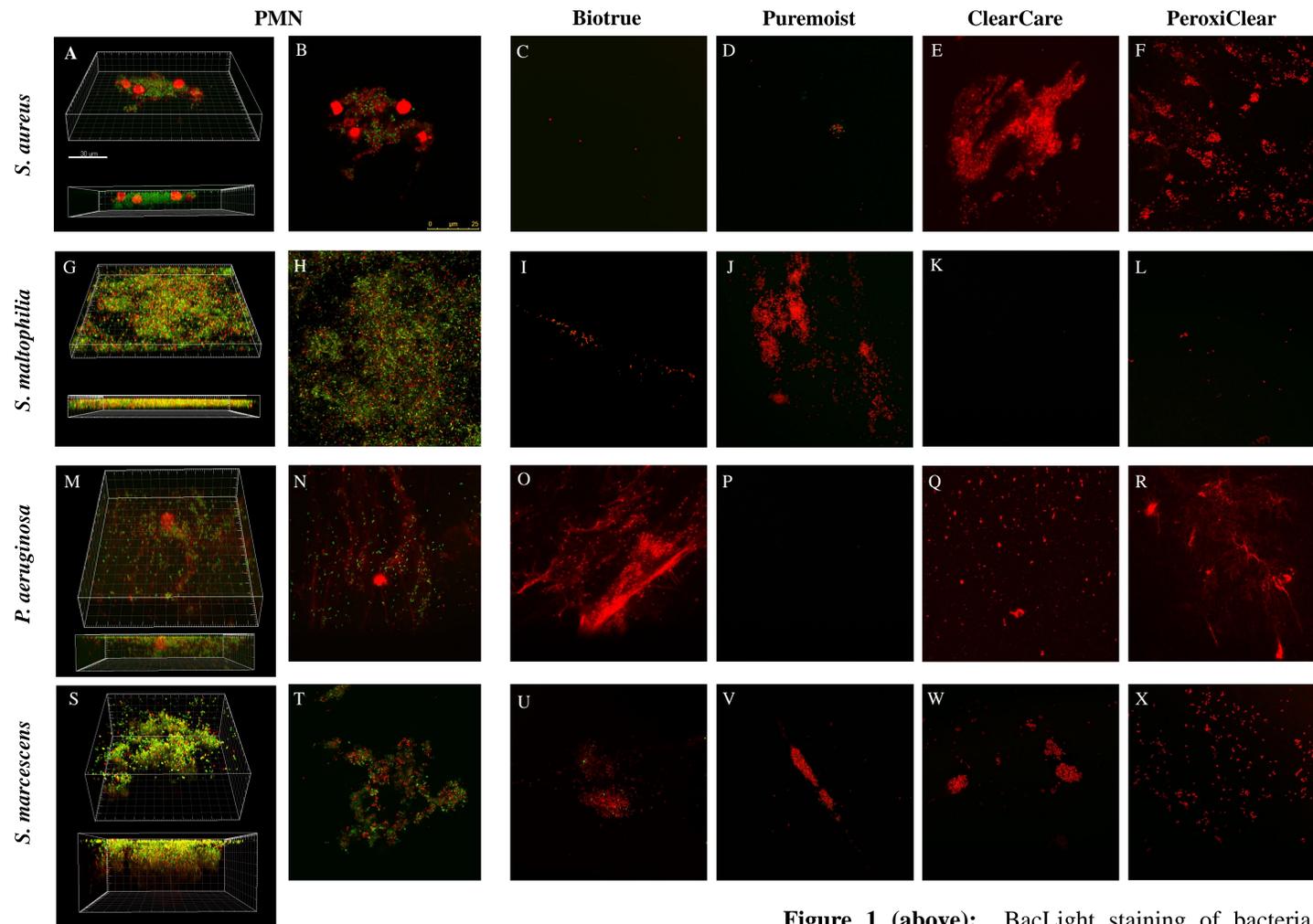


Figure 1 (above): BacLight staining of bacteria adherent to CTL surfaces. CTLs inoculated with 5×10^7 CFU/mL. Green: viable bacteria, red: non-viable. Panels A,G,M,S: Representative images of PMN enhanced bacterial biofilms formed on CTL surfaces for each of the four test strains after 24 hours. Panels C-F: Representative images of residual debris on CTLs incubated in SA after cleaning by respective LCPs (specified at top of column). Panels I-L: CTLs incubated in ST. Panels O-R: CTLs incubated in PA. Panels U-X: CTLs incubated in SM. Scale bar: 25 μ m.

Figure 2 (left): Bactericidal activity of LCPs against *S. aureus*, *S. maltophilia*, *S. marcescens*, and *P. aeruginosa*. SA exhibited a 7-log reduction with all LCPs; ST exhibited a 9-log to 10-log reduction for all LCPs $\diamond P \leq 0.040$; PA showed a 9-log reduction for all LCPs except BT, which showed a 7-log reduction $** P \leq 0.001$.

Table 1. Lens Care Products

LCP	Biocide
BioTrue (Bausch & Lomb)	polyaminopropyl biguanide 0.00013% and polyquaternium 0.0001%
PureMoist (Alcon Laboratories)	polyquaternium-1 0.001% and myristamidopropyl dimethylamine 0.0006%
ClearCare (Alcon Laboratories)	Hydrogen peroxide 3%
PeroxiClear (Bausch & Lomb)	Hydrogen peroxide 3%

- All four test strains showed increased colonization of contact lens surfaces when incubated in the presence of dying neutrophils (Fig. 1).
- All four LCPs tested had a 7-10 log reduction in disinfection efficacy (Fig. 2)
- Residual cellular debris was evident on contact lens surfaces for the majority of LCPs tested (Fig. 1).

DISCUSSION

This is the first study to evaluate disinfection efficacy of current LCPs against neutrophil-derived cellular debris enhanced biofilms. Although all LCPs met the long-standing FDA criterion of a 3-log reduction minimum, substantial cellular debris remained on the CTL surface. The presence of extracellular DNA is a contributor to biofilm formation and may enhance bacterial colonization of the CTL surface when stored overnight in contaminated CTL storage cases.

REFERENCES

1. Poggio et al. *N Eng J Med* 1989.
2. Schein et al. *N Eng J Med* 1989.
3. Robertson et al. *Invest Ophthalmol Vis Sci* 2011.
4. Walker et al. *Infect Immun* 2005.
5. Szczotka-Flynn et al. *Cornea* 2009.
6. Retuerto et al. *Opt Vis Sci* 2012.
7. Hampton D. *Eye Contact Lens* 2015.