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Antimicrobial Blue Light Inactivation of Microbial Isolates in Biofilms

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Background and Objectives: Biofilms cause more than 80% of infections in humans, including more than 90% of all chronic wound infections and are extremely resistant to antimicrobials and the immune system. The situation is exacerbated by the fast spreading of antimicrobial resistance, which has become one of the biggest threats to current public health. There is consequently a critical need for the development of alternative therapeutics. Antimicrobial blue light (aBL) is a light-based approach that exhibits intrinsic antimicrobial effect without the involvement of exogenous photosensitizers. In this study, we investigated the antimicrobial effect of this non-antibiotic approach against biofilms formed by microbial isolates of multidrug-resistant bacteria.

Study Design/Materials and Methods: Microbial isolates of *Acinetobacter baumannii*, *Candida albicans*, *Escherichia coli*, *Enterococcus faecalis*, MRSA, *Neisseria gonorrhoeae*, *Pseudomonas aeruginosa*, and *Proteus mirabilis* were studied. Biofilms were grown in microtiter plates for 24 or 48 hours or in the CDC biofilm reactor for 48 hours and exposed to aBL at 405 nm (60 mW/cm^2, 60 or 30 minutes). The anti-biofilm activity of aBL was measured by viable counts.

Results: The biofilms of *A. baumannii*, *N. gonorrhoeae*, and *P. aeruginosa* were the most susceptible to aBL with between 4 and 8 $\log_{10}$ inactivation after 108 J/cm^2 (60 mW/cm^2, 30 minutes) or 216 J/cm^2 (60 mW/cm^2, 60 minutes) aBL were delivered in the microplates. On the contrary, the biofilms of *C. albicans*, *E. coli*, *E. faecalis*, and *P. mirabilis* were the least susceptible to aBL inactivation (−0.30, −0.24, −0.84, and −0.68 $\log_{10}$ inactivation, respectively). The same aBL treatment in biofilms developed in the CDC biofilm reactor, caused −1.68 $\log_{10}$ inactivation in *A. baumannii* and −1.74 and −1.65 $\log_{10}$ inactivation in two different strains of *P. aeruginosa*.

Conclusions: aBL exhibits potential against pathogenic microorganisms and could help with the significant need for new antimicrobials in clinical practice to manage multidrug-resistant infections. Lasers Surg. Med. © 2019 Wiley Periodicals, Inc.

Key words: *Acinetobacter baumannii*; *Candida albicans*; *Escherichia coli*; *Enterococcus faecalis*; *Staphylococcus aureus*; *Neisseria gonorrhoeae*; *Pseudomonas aeruginosa*; *Proteus mirabilis*; biofilm; antimicrobial blue light

INTRODUCTION

Biofilms are associated with more than 80% of infections in humans, including more than 90% of all chronic wound infections [1]. They are surface-associated microbial communities enclosed in a self-produced extracellular polymeric substance (EPS) that protects them from environmental threats such as the immune response and antibiotics [2]. Biofilms display tolerance toward antimicrobials. This tolerance is due to two reasons, on one hand, biofilms have a subpopulation of slow-growing or growth-arrested bacteria known as persisters that account for 1% of the biofilm [3], on the other, EPS components of the matrix can substantially quench the activity of antimicrobial substances that diffuse through the biofilm in a form of inhibition known as diffusion–reaction inhibition, which can involve chelation by complex formation, enzymatic degradation of antimicrobials or even sacrificial reaction of EPS [4]. The first clinical biofilm-related infection was reported by Costerton et al. [5] who, years later linked their presence to chronic infections [6,7]. Biofilms attach to biotic and abiotic surfaces where they produce notoriously recalcitrant infections that often lead to prolonged treatment regimens or extreme measures, such as the removal and replacement of infected devices or debridement of infected wounds.

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