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Original Research

Er:YAG Laser Irradiation Induces Behavioral Changes in *V. harveyi*

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Abstract

Objectives: Laser technologies have many different applications in medical, agricultural, and industrial fields. Studies have shown several effects of laser energy on different bacterial species, in a wide variety of settings. Recent reports have found that one of the unique features of bacteria is their ability to communicate among themselves (quorum sensing). We sought to investigate whether low-energy laser irradiation affects bacterial behavior, which is regulated by quorum sensing. ***Methods:*** Laser irradiations were performed using Er:YAG laser (2940 nm wavelength) at output powers of 0.5, 1.5, 2.5, and 4 W on wild-type *Vibrio harveyi.* Bioluminescence, motility, and biofilm forming capability were assessed on the bacteria after irradiation. ***Results:*** After irradiation of bacteria, positive dose/output power dependencies were found in the bioluminescence omitted from tested experimental groups. Motility of colonies on semi-solid media was inhibited as irradiation output power was increased. However, after irradiation, biomass analysis of biofilm samples showed negligible differences between the irradiated samples and controls. ***Conclusions:*** Results indicate the impact of low-energy laser irradiation on bacterial behavior such as quorum sensing and motility, without affecting bacterial growth patterns.

Keywords: laser, biofilm, quorum sensing

Introduction

Secretion of small signal molecules (autoinducers [AIs]) by bacteria has been documented as means of cross-communication in different environments.[1] This cross-talk, termed ''quorum sensing,'' facilitates functional genetic adaptations of bacteria, including the formation of biofilms, resistance to antibiotics, acid production/tolerance, and other characteristics and virulence factors.[2,3] Although gram-positive bacteria such as Streptococci or Enterococci rely mostly on competence stimulating proteins as quorum-sensing signal molecules,[3] gram-negative bacteria such as Pseudomonas use homoserine lactones (HSLs) for signaling and cross-talk purposes.[4] The autoinducer-2 (AI-2) is referred to as a ''universal autoinducer'' as it is found in numerous gram-positive and gram-negative bacteria.[5]

The free-living bacterium *Vibrio harveyi* is widely used as a model for studying quorum sensing. These bacteria produce three types of AIs that regulate its bioluminescence: the species-specific HSL(AI-1),[6] the ''universal AI'' (AI-2),[7] and the *Vibrio cholerae* AI (CAI-1).[6,8,9] Quorum-sensing cascades regulate bacterial properties as bioluminescence,[6] motility in semi-solid medium,[10] and biofilm production.[10–17]

Lasers constitute an emerging treatment modality in medicine. Different lasers interact in a variety of ways with tissues and microorganisms. These interactions depend on different characteristics of the laser such as specific wavelengths, values of energy emitted, and exposure time. The Er:YAG laser contains a medium of Yttrium-Aluminum-Garnet crystal coded with Erbium. The wavelength of the Er:YAG laser is mid-infrared at 2.94 μm, a wavelength with a peak absorption in water molecules,[18] which are abundant in all living organisms.

Persistent bacterial infections and resistance to common antibiotic therapy have emerged as major challenges in the medical field, emphasizing the need to find new methods to address these issues. In the past decade, the introduction of different methods aimed at inhibiting bacterial cross-communication has been suggested as a feasible mean for the prevention and control of emerging bacterial infections.[19–20] Photon energy-mediated techniques may have a bacteriostatic and bactericidal effect on bacteria when coupled with a photosensitizer agent[21,22] or when applied directly to the desired target.[23–25] However, the effect of direct low-dose laser energy on bacterial quorum sensing is a new avenue of research. This study aims to address this issue.

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