ANTIMICROBIAL PHOTOTHERAPY USING BLUE LASER LIGHT: A PROMISING STRATEGY TO TREAT WOUND INFECTIONS

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Abstract

Background and Objectives: The development of novel antimicrobial strategies has returned of crucial importance due to increasing resistance towards conventional antibiotics. The aim of the present study was to evaluate the antimicrobial effect of blue laser light on Pseudomonas aeruginosa (PAO) in vitro and in vivo.

Materials and Methods: A multiple wavelength diode laser device was employed. To evaluate the antimicrobial efficacy of blue laser (445nm) and select the most effective protocols, multiple screening sessions have been performed employing several irradiation protocols in terms of power density and fluence on PAO grown in planktonic state and on agar plates. The protocols showing the best antimicrobial activities have been then applied on eukaryotic cell lines (human keratinocytes and fibroblasts) to evaluate possible toxicity. All the experiments have been conducted testing also a red (660nm) and infrared (970nm) laser wavelength. The effect of laser irradiation has been evaluated also on mature PAO biofilms grown in flow cells visualized in 3-dimensional reconstructions using laser scanning confocal microscopy. The best protocol in terms of antimicrobial efficacy and low toxicity was then employed in vivo on a mouse model of skin wound infection. The possible involvement of oxidative stress in the mechanism of action has also been investigated. Furthermore, a blue LED light source was tested for possible differences.

Results: Among the different laser wavelengths tested with multiple protocols, only the blue ones showed a significant antimicrobial effect ($p<0,0001$). The irradiation protocol with power density 0,3W/cm2 and fluence 60J/cm2 was selected, confirming its efficacy and low toxicity in vivo ($p<0,01$). Oxidative stress seems to be involved in the blue light-mediated antimicrobial mechanism. Blue LED light showed a similar but slightly lower antimicrobial effect.

Conclusions: The use of antimicrobial phototherapy employing blue laser light has the potential to become a concrete treatment option for superinfected wounds.

Image

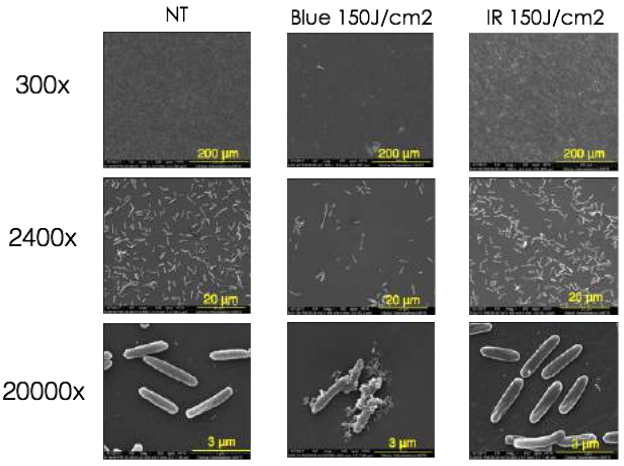


Figure. Scanning Electron Microscopy imaging at different magnifications of PAO treated with blue and infrared laser (IR) with the same parameters. Only Blue laser was able to exert antimicrobial effects.

Recent Publications (minimum 5)

1. Rupel K et al. A systematic review of therapeutical approaches in bisphosphonates-related osteonecrosis of the jaw (BRONJ). Oral Oncol. 2014 Nov;50(11):1049-57. Review.
2. Gobbo M, Bussani R, Perinetti G, Rupel K, Bevilaqua L, Ottaviani G, Biasotto M. Blue diode laser versus traditional infrared diode laser and quantic molecular resonance scalpel: clinical and histological findings after excisional biopsy of benign oral lesions. J Biomed Opt. 2017 Dec 1;22(12):121602.
3. Laser Therapy Inhibits Tumor Growth in Mice by Promoting Immune Surveillance and Vessel Normalization. Ottaviani G, Martinelli V, Rupel K, Caronni N, Naseem A, Zandonà L, Perinetti G, Gobbo M, Di Lenarda R, Bussani R, Benvenuti F, Giacca M, Biasotto M, Zacchigna S. EBioMedicine. 2016 Sep;11:165-172.
4. Evaluation of nutritional status in head and neck radio-treated patients affected by oral mucositis: efficacy of class IV laser therapy. Gobbo M, Ottaviani G, Perinetti G, Ciriello F, Beorchia A, Giacca M, Di Lenarda R, Rupel K, Tirelli G, Zacchigna S, Biasotto M. Support Care Cancer. 2014 Jul;22(7):1851-6.
5. Rupel K et al .Laser surgical treatment of chronic graft-versus-host disease (cGvHD)- induced buccal mucosal sclerosis". Photonics and lasers in medicine 01/2015.



Biography (150 word limit)

After completing an undergraduate degree with merit in Molecular Biology, collaborating with a research project regarding the use of phage display technique for the identification of new epitopes in multiple sclerosis patients, Katia moved into a more clinical field and obtained a degree in Dentistry. She is currently a candidate at the PhD programme in Nanotechnologies at the Trieste University still working as a hospital dentist at the Dental Clinic in Trieste (Italy). The multidisciplinary topic of her PhD project (Exploring of the antimicrobial properties of blue laser light) allows her to collaborate with important institutions such as the International Centre for Genetic Engeneering and Biotechnology (Trieste, Italy) and the Department of Microbiology of the University of Washington, Seattle, USA.

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Notes/Comments: