

## Antimicrobial Effects

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### **Antiinfectives and low-level light: a new chapter in photomedicine.**

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**OBJECTIVE:** The purpose of this study was to identify synergistic effects in the interaction of light with biosystems in the presence of chemical agents. Their systematic analysis promises therapeutic strategies. **BACKGROUND DATA:** Light intensities around 1000 Wm(2) potentially induce density variations in nanoscopic water layers adhering to surfaces in air or subaquatically. In permeable nanoscopic compartments in the interior of biosystems, this could result in powerful flow processes and bidirectional flows for repetitive applications of light. Consequently, external stimulation with light will force microorganisms and cells to incorporate a suitable antiinfective. Nanoscale biosystems, which respond to both light stimulation and antibiotics, are nanobacteria. Responses include growth, inhibition, and slime secretion. Slime secretion was provoked in vitro by gentamycin, an agent proposed for in vivo eradication, and blocked by light. Depending on the field of action, co-operative effects between light and an antiinfective can be exploited by considering two properties of the drug: transmission of light and resorption by the tissue. Antiinfectives can be administered in an active form or via drug delivery systems. In the latter case, a double action of the light could be exploited: stimulated release from the carrier and subsequent uptake by the targeted biosystem. **METHODS:** The attenuation of laser light (670 nm) by antiinfectives was measured in films of different thickness of a vaginal suppository. The effect of 670-nm laser light - not absorbed by water - on nanoscopic water layers was examined by comparing the evaporation time of irradiated drops of water-based nanosuspensions with non-irradiated controls. **RESULTS:** The 6-microm-thick suppository films were virtually transparent to the laser light, and the 1-mm-thick films totally attenuated it. Nanosuspension drops irradiated with 670-nm light needed more time to evaporate than controls. **CONCLUSION:** Low-level light (LLL) therapy is compatible with antiinfectives, and even capable of boosting effects of superficially applied and/or absorbed antiinfectives. Temporal coordination between light treatment and drug administration maximizes drug effects and minimizes possible adverse effects. Irradiation should start when the drug concentration has reached its maximum in the desired field of action. Light-induced flow in nanoscale cavities could represent one mechanism of LLL therapy.

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**Effects of low-level laser therapy (LLLT) of 810 nm upon in vitro growth of bacteria: relevance of irradiance and radiant exposure.**

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**OBJECTIVE:** The aim of this study was to investigate the irradiance-dependency of low-level laser therapy (LLLT) effects on bacterial growth. **BACKGROUND:** LLLT is applied to open wounds to improve healing; however, its effect on wound bacteria is not well understood. **MATERIALS AND METHODS:** Escherichia coli, Pseudomonas aeruginosa, and Staphylococcus aureus were irradiated using a wavelength of 810 nm at irradiances of 0.015 W/cm<sup>2</sup> (0-50 J/cm<sup>2</sup>) and 0.03 W/cm<sup>2</sup> (0-80 J/cm<sup>2</sup>). Bacteria were counted after 20 h of incubation. **RESULTS:** LLLT effects varied significantly with species. P.aeruginosa growth decreased overall dependent on an interaction of irradiance and radiant exposure; greatest inhibition was produced using high irradiance delivering radiant exposures in the range of 1-20 J/cm<sup>2</sup> (p = 0.001-0.04). In contrast, E. coli growth increased overall (p = 0.01), regardless of irradiance; greatest effects were produced using low radiant exposures (1-20 J/cm<sup>2</sup>). There was a main effect for irradiance (p = 0.03) on S. aureus growth; however, growth was not different compared with controls. Additional analysis showed that there were differences in growth of P.aeruginosa when comparing samples that were matched by exposure times (66, 329, 658, 1316, 1974, and 2632 sec) rather than radiant exposure; this suggests that irradiance rather than exposure time was the significant factor in P. aeruginosa inhibition. **CONCLUSION:** These findings have immediate relevancy in the use of LLLT for infected wounds. Exposure to 810-nm irradiation (0.03 W/cm<sup>2</sup>) could potentially benefit wounds infected with P. aeruginosa. However, increased E. coli growth could further delay recovery.

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**Effects of 630-, 660-, 810-, and 905-nm laser irradiation delivering radiant exposure of 1-50 J/cm<sup>2</sup> on three species of bacteria in vitro.**

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**OBJECTIVE:** To examine the effects of low-intensity laser therapy (LILT) on bacterial growth in vitro. **BACKGROUND DATA:** LILT is undergoing investigation as a treatment for accelerating healing of open wounds. The potential of coincident effects on wound bacteria has received little attention. Increased bacterial proliferation could further

delay recovery; conversely inhibition could be beneficial. **MATERIALS AND METHODS:** *Pseudomonas aeruginosa*, *Escherichia coli*, and *Staphylococcus aureus* were plated on agar and then irradiated with wavelengths of 630, 660, 810, and 905 nm (0.015 W/cm<sup>2</sup>) and radiant exposures of 1-50 J/cm<sup>2</sup>. In addition, *E. coli* was irradiated with 810 nm at an irradiance of 0.03 W/cm<sup>2</sup> (1-50 J/cm<sup>2</sup>). Cells were counted after 20 h of incubation post LILT. Repeated measures ANOVA and Tukey adjusted post hoc tests were used for analysis. **RESULTS:** There were interactions between wavelength and species ( $p = 0.0001$ ) and between wavelength and radiant exposure ( $p = 0.007$ ) in the overall effects on bacterial growth; therefore, individual wavelengths were analyzed. Over all types of bacteria, there were overall growth effects using 810- and 630-nm lasers, with species differences at 630 nm. Effects occurred at low radiant exposures (1-20 J/cm<sup>2</sup>). Overall effects were marginal using 660 nm and negative at 905 nm. Inhibition of *P. aeruginosa* followed irradiation using 810 nm at 5 J/cm<sup>2</sup> (-23%;  $p = 0.02$ ). Irradiation using 630 nm at 1 J/cm<sup>2</sup> inhibited *P. aeruginosa* and *E. coli* (-27%). Irradiation using 810 nm (0.015 W/cm<sup>2</sup>) increased *E. coli* growth, but with increased irradiance (0.03 W/cm<sup>2</sup>) the growth was significant ( $p = 0.04$ ), reaching 30% at 20 J/cm<sup>2</sup> ( $p = 0.01$ ). *S. aureus* growth increased 27% following 905-nm irradiation at 50 J/cm<sup>2</sup>. **CONCLUSION:** LILT applied to wounds, delivering commonly used wavelengths and radiant exposures in the range of 1-20 J/cm<sup>2</sup>, could produce changes in bacterial growth of considerable importance for wound healing. A wavelength of 630 nm appeared to be most commonly associated with bacterial inhibition. The findings of this study might be useful as a basis for selecting LILT for infected wounds.

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### **The effect of He-Ne laser (632.8 nm) and Solcoseryl in vitro.** **al-Watban FA, Andres BL.**

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He-Ne laser (632.8 nm) and Solcoseryl (SS), a non-protein calf haemodialysate, were used in the enhancement of wound healing. Nonetheless, a study on the use of He-Ne laser with SS has not been done. The purpose of this study is to determine the effect of He-Ne laser biostimulation in combination with SS on Chinese hamster ovary (CHO) and human skin fibroblast (HSF). A dose response for the cloning efficiency (CE) of CHO and HSF cells in 5% fetal bovine serum in minimum essential medium (FBS-MEM) with 6-125 micrograms/ml SS and He-Ne laser using an optimum power density of 1.25 mW/cm<sup>2</sup> and cumulative doses (CD) of 60-600 mJ/cm<sup>2</sup> given for three consecutive days, were done. The combined effects of He-Ne laser 180 mJ/cm<sup>2</sup> with 6 and 12 micrograms/ml SS were determined. Quadruplicate cultures were done. Student t-test was used to determine differences of treatment groups from controls. CHO and HSF CE were increased using 180 mJ/cm<sup>2</sup> laser by 13.1% +/- 4.5% ( $p < 0.0025$ ) and 39.1% +/- 7.9% ( $p < 0.0005$ ); SS 6 micrograms/ml by 14.4% +/- 8.7% ( $p = 0.01$ ) and 20.7% +/- 10.9% ( $p = 0.01$ ); SS 12 micrograms/ml by 17.7% +/- 6.3% ( $p = 0.001$ ) and 23.9% +/- 5.6% ( $p <$

0.0025); laser + SS 6 micrograms/ml by 15.1% +/- 8.8% ( $p < 0.01$ ) and 60.9% +/- 9.4% ( $p < 0.0001$ ); laser + SS 12 micrograms/ml by 23.0% +/- 1.5% ( $p < 0.0001$ ) and 70.7% +/- 11.4% ( $p < 0.0001$ ), respectively. Additional significant increases in CE were observed on CHO using laser + SS 12 micrograms/ml by 8.6% +/- 1.3% ( $p < 0.025$ ) and on HSF using laser + SS 6 micrograms/ml and laser + SS 12 micrograms/ml by 15.6% +/- 6.8% ( $p < 0.025$ ) and 22.7% +/- 10.6% ( $p = 0.01$ ), respectively, when compared to the effect of 180 mJ/cm<sup>2</sup> laser. Results suggest that further stimulation can be achieved by using He-Ne laser with SS. This could be exploited as a new treatment modality.

### **Low-intensity laser coupled with photosensitizer to reduce bacteria in root canals compared to chemical control. 2002. 91f.**

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The photodynamic therapy is a process in which a dye is associated with an appropriate wavelength of light and this dye goes to an excited state. The excited photosensitizer reacts with oxygen to form the highly reactive compound singlet oxygen, and this compound can kill bacteria and tumor cells. The purpose of this study was to evaluate the bacterial reduction in root canal contaminated with *Enterococcus Faecalis*. Thirty teeth with their root canals prepared were contaminated with *E. faecalis*. Ten teeth have received the chemical substance sodium hypochlorite for 30 minutes; ten teeth have received the azulene dye paste for 5 minutes and have been irradiated with a diode laser, output power 10mW and  $\lambda = 685\text{nm}$  for 3 minutes. Ten teeth have not received treatment (control group). The bacterial reduction was significantly higher for laser group when compared to chemical and control groups. These results indicate that photodynamic therapy was an effective method to kill bacteria.