
**Photo-activated disinfection of the root canal: a new role for lasers in endodontics.**

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Because micro-organisms play a crucial role in the development of pulpal and periapical disease, the prognosis of endodontic therapy is intimately related to the presence of bacteria within the root canal system. Micro-organisms may persist in the apical region of the root canal system despite chemomechanical preparation. The usefulness of Class IV lasers (such as Nd:YAG, diode, KTP and Er:YAG) for photo-thermal disinfection of the root canal has been demonstrated in numerous studies. An alternative approach to microbial killing in the root canal system by laser light involves the use of low-power lasers to drive a photochemical reaction that produces reactive oxygen species, a technique termed photo-activated disinfection (PAD). By using exogenous photosensitisers such as tolonium chloride, killing of all types of bacteria can be achieved. In vitro studies of PAD have demonstrated its ability to kill photosensitised oral bacteria (such as E. faecalis), and more recently microbial killing in vivo in the root canal system has been demonstrated. While PAD can be undertaken as part of the routine disinfection of the root canal system, it also has potential use for eradicating persistent endodontic infections for which conventional methods have been unsuccessful.

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BACKGROUND AND OBJECTIVES: The sanitation of the root canal system and the adjacent dentin has always been a key requirement for successful endodontics. In recent years, various laser systems have provided a major contribution to this aim, namely the Nd:YAG-, the 810 nm Diode-, the Er:YAG-, and the Er,Cr:YSGG laser. Numerous studies could prove their efficiency within the endodontic procedure. Recently, two new wavelengths have been introduced to the field of oral laser applications: The KTP laser emitting at 532 nm and the 980 nm diode laser. The present in vitro investigation was performed to evaluate the effects of these laser systems focusing on their antibacterial effect in deep layers of dentin and their impact on the root canal dentin. STUDY DESIGN/MATERIALS AND METHODS: Two-hundred slices of root dentin with a thickness of 1 mm were obtained by longitudinal cuts of freshly extracted human premolars. The samples were steam sterilized and subsequently inoculated with a suspension of either Escherichia coli or Enterococcus faecalis. After the incubation, the samples were randomly assigned to the two different laser systems tested. Each laser group consisted of two different operational settings and a control. The dentinal samples underwent "indirect" laser irradiation through the dentin from the bacteria-free side and were then subjected to a classical quantitative microbiologic evaluation. To assess the temperature increase during the irradiation procedure, additional measurements were carried out using a thermocouple. To assess the impacts on the root canal walls, 20 additional samples underwent laser irradiation at two different settings and were subjected to scanning electron microscopy. RESULTS: Microbiology indicated that both laser systems were capable of significant reductions in both test strains. At an effective output power of 1 W, E. coli was reduced by at least 3 log steps in most of the samples by the tested wavelengths, with the best results for the KTP laser showing complete eradication of E. coli in 75% of the samples. E. faecalis, a stubborn invader of the root canal, showed minor changes in bacterial count at 1 W. Using the higher setting of 1.5 W, significant reductions of E. coli were again observed with both laser systems, where the lasers were capable of complete eradication of E. faecalis to a significant extent. There was no significant relation between the temperature increase and the bactericidal effect. CONCLUSIONS: The present study demonstrates that both wavelengths investigated could be suitable for the disinfection of even the deeper layers of
Diode laser radiation and its bactericidal effect in root canal wall dentin.

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OBJECTIVES: The aim of this study was to investigate the antibacterial effect of a diode laser in deep root canal dentin. BACKGROUND DATA: The microbial colonization of root canal dentin can lead to failures in conventional endodontic treatment if an inadequate bacterial reduction only is achieved through canal treatment and chemical disinfection. METHODS: 100 microm, 300 microm and 500 microm bovine dentin slices obtained by longitudinal sections were sterilized and inoculated on one side with an Enterococcus faecalis suspension. Laser radiation was performed on the opposite side with the diode laser (810 nm) at a setting of 3 W in continuous mode (CW). Radiation was performed using a 400-microm tapered fiber tip at an angle of approximately 5 degrees to the surface over a period of 30 seconds. The output power at the distal end of the tip was 0.6 W. The bacteria were then eluted through vibration and cultured on blood agar plates. The colony count reflected the antibacterial effect of laser radiation as a function of the layer thickness. RESULTS: A mean bacterial reduction of 74% was achieved even with a 500-microm thick slice. CONCLUSION: This investigation indicates that the diode laser radiation reduces the number of bacteria in deep layers of infected root canal wall dentin.

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Antimicrobial photodynamic therapy combined with conventional endodontic treatment to eliminate root canal biofilm infection.

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BACKGROUND AND OBJECTIVE: To compare the effectiveness of antimicrobial photodynamic therapy (PDT), standard endodontic treatment and the combined treatment to eliminate bacterial biofilms present in infected root canals. STUDY DESIGN/MATERIALS AND METHODS: Ten single-rooted freshly extracted human teeth were inoculated with stable bioluminescent Gram-negative bacteria, Proteus mirabilis and Pseudomonas aeruginosa to form 3-day biofilms in prepared root canals. Bioluminescence imaging was used to serially quantify bacterial burdens. PDT employed a conjugate between polyethylenimine and chlorin(e6) as the photosensitizer (PS) and 660-nm diode laser light delivered into the root canal via a 200-micro fiber, and this was compared and combined with standard endodontic treatment using mechanical debridement and antiseptic irrigation. RESULTS: Endodontic therapy alone reduced bacterial bioluminescence by 90% while PDT alone reduced bioluminescence by 95%. The combination reduced bioluminescence by >98%, and importantly the bacterial regrowth observed 24 hours after treatment was much less for the combination (P<0.0005) than for either single treatment. CONCLUSIONS: Bioluminescence imaging is an efficient way to monitor endodontic therapy. Antimicrobial PDT may have a role to play in optimized endodontic therapy. (c) 2006 Wiley-Liss, Inc.

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Photodynamic therapy for root canals infected with Enterococcus faecalis.

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OBJECTIVE: The aim of this study was to investigate the effects of photodynamic therapy (PDT) on endodontic pathogens by evaluating the decrease in numbers of Enterococcus faecalis colonies in the canals of extracted human teeth. BACKGROUND DATA: Failure in endodontics is usually related to inadequate cleaning and disinfection of the root canal system. This is due to the establishment of microorganisms in areas where the instruments and chemical agents used during root canal preparation cannot eliminate them. PDT is a complementary therapeutic method that could be used to eliminate these remaining bacteria. PDT is a process in which radiation acts on a dye that is applied to the target organism, resulting in bacterial death.

MATERIALS AND METHODS: Forty-six uniradicular teeth had their canals contaminated with bacteria and were incubated for 48 h at 35 degrees C. After that, the teeth were divided into a control group (CG) and a test group (TG). The 23 CG teeth did not undergo any intervention, whereas in the TG the teeth received a solution of 0.0125% toluidine blue for 5 min followed by irradiation using a 50-mW diode laser (Ga-Al-As) at a wavelength of 660 nm. Bacterial samples were taken before and after irradiation. In each of the samples, the number of colony-forming units (CFU) was counted. RESULTS: The mean decrease in CFU was 99.9% in the TG, whereas in the CG an increase of 2.6% was observed. CONCLUSION: PDT was effective as a bactericidal agent in Enterococcus faecalis-contaminated root canals.

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