

Photodynamic Therapy in Endodontics: A Review

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Abstract

Irrigants that are frequently utilized do not usually completely eliminate the microbial flora in infected root canals. As a result, other more strategies have been developed, including photodynamic therapy (PDT). The primary reason of endodontic treatment failures is thought to be the persistence of pathogens in the mechanical chemical preparation. The most frequent bacteria identified in these situations is *Enterococcus faecalis*. To get rid of these persistent microbes, photodynamic therapy (PDT) appears to be a potential adjuvant therapy to traditional endodontic treatment. To produce harmful species for the bacteria, this therapy involves pairing a certain light source with a photosensitizer in the presence of oxygen. As a result, the current research intends to examine the literature on the use of photodynamic therapy in endodontics, a test that has been demonstrated to help with root canal preparation.

Keywords: *Enterococcus faecalis*, Laser, Photodynamic therapy.

INTRODUCTION

Numerous research on humans, as well as animals, have shown how important bacteria are in the development of pulpoperiapical lesions. Eliminating pathogens from diseased root canal systems are a challenging task due to the intricate anatomy of the root canal system.^[1] In endodontic treatment, chemical irrigation creates a suitable bactericidal effect;^[2] however, frequently used irrigation solutions, such as sodium hypochlorite (NaOCl) and chlorhexidine (CHX), and intracanal medications, such as calcium hydroxide (Ca(OH)₂), cannot completely eradicate all microorganisms in infected canals.^[3] Other methods, like photodynamic treatment (PDT), have been developed to boost the root canal system's level of disinfection.

OVERVIEW OF CURRENT MEDICATIONS

Chemomechanical techniques are used during endodontic therapy to remove diseased tissues and clean the root dentin.^[4] The contaminated tissues are removed during a single consultation for treatment employing rotary file systems referred to as "intracanal instrumentation." After instrumentation, about 35% of the intracanal walls may still be intact, which is reflected in the remaining diseased tissues.^[5] This scenario requires integrating mechanical instrumentation with sodium hypochlorite (NaOCl) solution irrigation of the canals.^[6] NaOCl irrigation is beneficial for both cleaning

the canals and getting rid of endotoxins that the alleged endodontic bacteria create.^[7] Although effective disinfection of the root canal system has not yet been achieved, robust bacterial reduction was achieved using instrumentation and irrigation.^[8]

The success of this chemomechanical method may be constrained, as previously indicated, by certain anatomic landmarks and the intricacy of the produced biofilms. *Enterococcus faecalis* is capable of deeply penetrating dentinal tubules, evading irrigation and instrumentation.^[9]

Ca(OH)₂ is the most commonly used intracanal medication in endodontic treatment. Ca(OH)₂ reduces the bacterial content through the cell layer's damage by direct contact and increasing the pH. Even though it has a wide range of antibacterial activity, Ca(OH)₂ is not effective against *E. faecalis*.^[10]

CHX at 2% was found more effective against *E. faecalis* than Ca(OH)₂. However, there is no further bacterial reduction when compared to chemomechanical instrumentation.^[11]

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MECHANISM OF ACTION OF PDT

The interaction of a photosensitive antibacterial agent and a light source is the basis of photoactivated disinfection (PAD). It makes use of a harmless dye (photosensitizer PS) and low-intensity visible light. In the presence of oxygen, they combine to form several cytotoxic species. PS molecules bind to bacterium membranes.^[12] Irradiation with a specific wavelength of light may result in the creation of singlet oxygen, which causes the microbial cell wall to rupture.^[13]

The most common PSs are phenothiazine, cyanine, phytotherapeutic agents, hematoporphyrin derivatives, and xanthene derivatives.^[14] Phenothiazine dyes have been claimed to have intense absorption in 620–660 nm wavelength and so be useful in PDT.^[15]

Toluidine blue O and methylene blue are the most frequently used PSs. Sarkar and Wilson^[16] demonstrated that toluidine blue O is effective against oral bacteria. Zeina *et al.* showed that when exposed to a wavelength of 630 nm, it has a maximum level of absorption and good photodynamic properties for destroying different microorganisms.^[17]

Fernandes *et al.* showed that toluidine blue O was preferred as a PS because it can easily pass through cell membrane.^[18] These suitable properties are shared by another dye, methylene blue;^[19] however, toluidine blue O can interact with LPS of Gram-negative bacteria better than methylene blue.^[20]

PRE IRRADIATION TIME AND RADIATION DOSES

The time elapsed between the delivery of the PS into the root canal system and the actual photoactivation is called “pre-irradiation time.”^[21]

The pre-irradiation time is a key factor in PDT, as it permits the PS to penetrate through the dentine and to exert its antibacterial effect and it helps to keep the PS inside the bacteria, allowing more light absorption. Research is controversial regarding the pre-irradiation time, and available data show pre-irradiation times ranging from 5 to 15 min.^[22,23]

According to Williams *et al.* (2003), the energy dose and irradiation time of light are the most important factors in killing the microorganisms using PDT.^[24]

Pourhajibagher and Bahador (2018b) used an output power of 220mW at 635 nm wavelength for 60 s.^[25]

CLINICAL PROCEDURE

The PDT principle is effective not just against bacteria, but also against other microbes such as viruses, fungi, and protozoa. Because the used PS has a far lower affinity for mammalian cells, toxicological testing has revealed no detrimental side effects in the treatment.

After the canal has been prepared, it is inoculated with the PS solution, which is left in place for a set amount of time (60 s) to allow the solution to come into contact with the bacteria and

diffuse through any biofilm structures. The emitter is then put in the root canal, and each channel is irradiated for 30 s. This has been shown in the lab to destroy high numbers of bacteria commonly seen in root canals.

Maximum wetness must be achieved since the solution must come into contact with the bacteria for the photosensitization process to take place. When the PS got to the bacteria, it has been claimed that the PDT procedure was successful in getting rid of all the cultivable germs. It also emphasized the need for caution when using the emitter to avoid getting it too tightly bent or stuck in the canal.^[26]

APPLICATIONS

PDT has various applications in dentistry. The removal of microorganisms from the diseased area is the foundation of a successful periodontal treatment. For this reason, phenothiazinium PSs have been found to be highly effective and safe. However, scaling and root planning should be done before the PDT. PS should be injected into the periodontal pocket and left to pigment for 120 s before executing the PDT. The specific fiber should then be introduced and lased 1 mm short of the pocket base.^[27]

Photodynamic treatment has also been used to disinfect caries dentin before restoration, to disinfect oral tissues before or during surgical procedures, to treat denture stomatitis, and to treat oral candidiasis in immunocompromised individuals.^[28]

According to Williams *et al.*,^[24] current clinical protocols for PAD treatment of carious dentin include the use of a 0.8 mm diameter spherical isotopic diffuser to give even irradiation of the cavity floor.

Ng *et al.* selected extracted teeth with pulp necrosis. The study was done comparing 6% of sodium hypochlorite and PDT usage. The concentration of methylene blue used was 50 µg/mL and diode LASER at a wavelength of 665 nm connected to an optical fiber. The result showed PDT was able to eliminate 86.5% of microorganisms in the canal and only 49% of microbial elimination when PDT was not used.^[29]

Photodynamic therapy can be used with mechanical instruments and chemical antibacterial agents like NaOCl and hydrogen peroxide. Endodontic therapy alone reduced germs by 90, while PDT alone reduced bacteria by 95%, according to Garcez *et al.*^[30] A study reported that 2.5% of sodium hypochlorite and PDT using 15 µg/mL Toluidine blue and diode LASER at a wavelength of 625 nm eliminate *E. faecalis* in single-rooted canals of freshly extracted teeth.^[31]

Meire *et al.* evaluated the antimicrobial efficiency of neodymium-doped yttrium aluminum garnet (YAG), erbium-doped YAG (Er: YAG), and two commercial antimicrobial PDT (aPDT) systems and found that NaOCl is the most effective, but Er: YAG laser also resulted in considerable bacterial reductions. Both aPDT devices produced just a little reduction in bacteria.^[32]

George and Kishen showed that PDT destroyed the integrity of cell wall, deoxyribonucleic acid, and membrane proteins of bacteria.^[33]

PULP REVASCULARIZATION

Johns *et al.* described a new technique for pulp revascularization with canal disinfection employing a low-power laser light and PS solution. PDT was used to disinfect the canal after irrigation with NaOCl and drying with paper points, and platelet-rich fibrin was administered to regenerate the pulp. The canal was then sealed with mineral trioxide aggregate before permanent rehabilitation was placed. A follow-up radiograph revealed root lengthening, persistent canal wall thickening, and apical closure.^[34]

LIMITATIONS

Even though the application of PDT has significant advantages, potential adverse events have been reported. The pre-irradiation time of 10 min promoted more severe discoloration of the tooth structure when compared with a pre-irradiation time of 5 min. Furthermore, dentine, dentine matrix, pulp tissue, bacterial lipopolysaccharides, and bovine serum albumin were found to significantly decrease PDT antimicrobial efficacy. A chemical smear layer may form, promoting the obliteration of dentinal tubules, which can lead to microleakage and a decrease in the bond strength of root-filling materials to dentine.^[27]

CONCLUSION

The effect of PDT on root canal system disinfection is extensively documented in the endodontic literature. PDT is a promising method for preventing bacterial resistance without causing resistance. The lack of specified guidelines for using PDT, on the other hand, is a significant hurdle that may compromise the efficacy of PDT in endodontic disinfection. Further research may produce a dependable and effective strategy capable of inducing clinical benefits in root canal system disinfection.

REFERENCES

- Möller AJ. Microbiological examination of root canals and periapical tissues of human teeth. Methodological studies. *Odontol Tidskr* 1966;74:1-380.
- Mohammadi Z, Abbott PV. On the local applications of antibiotics and antibiotic-based agents in endodontics and dental traumatology. *Int Endod J* 2009;42:555-67.
- Kishen A, Shrestha A. Photodynamic therapy for root canal disinfection. In: Bettina B, editor. *Endodontic irrigation: Chemical Disinfection of the Root Canal System*. Switzerland: Springer International Publishing; 2015. p. 237-51.
- Siqueira JF Jr., Guimarães-Pinto T, Rôças IN. Effects of chemomechanical preparation with 2.5% sodium hypochlorite and intracanal medication with calcium hydroxide on cultivable bacteria in infected root canals. *J Endod* 2007;33:800-5.
- Peters OA, Schönenberger K, Laib A. Effects of four Ni-Ti preparation techniques on root canal geometry assessed by micro computed tomography. *Int Endod J* 2001;34:221-30.
- Melo MA, Rolim JP, Passos VF, Lima RA, Zanin IC, Codes BM, *et al.* Photodynamic antimicrobial chemotherapy and ultraconservative caries removal linked for management of deep caries lesions. *Photodiagnosis Photodyn Ther* 2015;12:581-6.
- Martinho FC, Gomes BP. Quantification of endotoxins and cultivable bacteria in root canal infection before and after chemomechanical preparation with 2.5% sodium hypochlorite. *J Endod* 2008;34:268-72.
- Sjögren U, Figdor D, Persson S, Sundqvist G. Influence of infection at the time of root filling on the outcome of endodontic treatment of teeth with apical periodontitis. *Int Endod J* 1997;30:297-306.
- Vivacqua-Gomes N, Gurgel-Filho ED, Gomes BP, Ferraz CC, Zaia AA, Souza-Filho F. Recovery of *Enterococcus faecalis* after single- or multiple-visit root canal treatments carried out in infected teeth *ex vivo*. *Int Endod J* 2005;38:697-704.
- Distel JW, Hatton JF, Gillespie MJ. Biofilm formation in medicated root canals. *J Endod* 2002;28:689-93.
- Basrani B, Tjäderhane L, Santos JM, Pascon E, Grad H, Lawrence HP, *et al.* Efficacy of chlorhexidine- and calcium hydroxide-containing medicaments against *Enterococcus faecalis* *in vitro*. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2003;96:618-24.
- Dai T, Huang YY, Hamblin MR. Photodynamic therapy for localized infections-state of the art. *Photodiagnosis Photodyn Ther* 2009;6:170-88.
- Ochsner M. Photophysical and photobiological processes in the photodynamic therapy of tumours. *J Photochem Photobiol B* 1997;39:1-18.
- Meisel P, Kocher T. Photodynamic therapy for periodontal diseases: State of the art. *J Photochem Photobiol B* 2005;79:159-70.
- Wainwright M, Giddens RM. Phenothiazinium photosensitisers: Choice in synthesis and application. *Dyes Pigm* 2003;57:245-57.
- Sarkar S, Wilson M. Lethal photosensitization of bacteria in subgingival plaque from patients with chronic periodontitis. *J Periodontol Res* 1993;28:204-10.
- Zeina B, Greenman J, Purcell WM, Das B. Killing of cutaneous microbial species by photodynamic therapy. *Br J Dermatol* 2001;144:274-8.
- Fernandes LA, de Almeida JM, Theodoro LH, Bosco AF, Nagata MJ, Martins TM, *et al.* Treatment of experimental periodontal disease by photodynamic therapy in immunosuppressed rats. *J Clin Periodontol* 2009;36:219-28.
- Wainwright M, Phoenix DA, Gaskell M, Marshall B. Photobactericidal activity of methylene blue derivatives against vancomycin-resistant *Enterococcus* spp. *J Antimicrob Chemother* 1999;44:823-5.
- Usacheva MN, Teichert MC, Biel MA. Comparison of the methylene blue and toluidine blue photobactericidal efficacy against gram-positive and gram-negative microorganisms. *Lasers Surg Med* 2001;29:165-73.
- Trindade AC, De Figueiredo JA, Steier L, Weber JB. Photodynamic therapy in endodontics: A literature review. *Photomed Laser Surg* 2015;33:175-82.
- Fimpe JL, Fontana CR, Foschi F, Ruggiero K, Song X, Pagonis TC, *et al.* Photodynamic treatment of endodontic polymicrobial infection *in vitro*. *J Endod* 2008;34:728-34.
- Fumes AC, da Silva Telles PD, Corona SA, Borsatto MC. Effect of aPDT on *Streptococcus mutans* and *Candida albicans* present in the dental biofilm: Systematic review. *Photodiagnosis Photodyn Ther* 2018;21:363-6.
- Williams JA, Pearson GJ, Colles MJ, Wilson M. The effect of variable energy input from a novel light source on the photoactivated bactericidal action of toluidine blue O on *Streptococcus mutans*. *Caries Res* 2003;37:190-3.
- Pourhajibagher M, Bahador A. An *in vivo* evaluation of microbial diversity before and after the photo-activated disinfection in primary endodontic infections: Traditional phenotypic and molecular approaches. *Photodiagnosis Photodyn Ther* 2018;22:19-25.
- Plotino G, Grande NM, Mercade M. Photodynamic therapy in endodontics. *Int Endod J* 2019;52:760-74.
- Vohra F, Akram Z, Safii SH, Vaithilingam RD, Ghanem A, Sergis K, *et al.* Role of antimicrobial photodynamic therapy in the treatment of aggressive periodontitis: A systematic review. *Photodiagnosis Photodyn Ther* 2016;13:139-47.
- Nagata JY, Hioka N, Kimura E, Batistela VR, Terada RS, Graciano AX, *et al.* Antibacterial photodynamic therapy for dental caries: Evaluation

- of the photosensitizers used and light source properties. Photodiagnosis Photodyn Ther 2012;9:122-31.
29. Ng R, Singh F, Papamanou DA, Song X, Patel C, Holewa C, *et al.* Endodontic photodynamic therapy *ex vivo*. J Endod 2011;37:217-22.
 30. Garcez AS, Nuñez SC, Hamblin MR, Suzuki H, Ribeiro MS. Photodynamic therapy associated with conventional endodontic treatment in patients with antibiotic-resistant microflora: A preliminary report. J Endod 2010;36:1463-6.
 31. Vaziri S, Kangarlou A, Shahbazi R, Nazari Nasab A, Naseri M. Comparison of the bactericidal efficacy of photodynamic therapy, 2.5% sodium hypochlorite, and 2% chlorhexidine against *Enterococcus faecalis* in root canals; an *in vitro* study. Dent Res J (Isfahan) 2012;9:613-8.
 32. Meire MA, De Prieck K, Coenye T, Nelis HJ, De Moor RJ. Effectiveness of different laser systems to kill *Enterococcus faecalis* in aqueous suspension and in an infected tooth model. Int Endod J 2009;42:351-9.
 33. George S, Kishen A. Augmenting the antibiofilm efficacy of advanced noninvasive light activated disinfection with emulsified oxidizer and oxygen carrier. J Endod 2008;34:1119-23.
 34. Johns DA, Shivashankar VY, Krishnamma S, Johns M. Use of photoactivated disinfection and platelet-rich fibrin in regenerative endodontics. J Conserv Dent 2014;17:487-90.