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EVALUATION OF THE USE OF PHOTODYNAMIC THERAPY IN ENDODONTICS, LITERATURE REVIEW

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ABSTRACT

Photodynamic therapy treatment (PDT) was introduced in 1900. Uses for it in dentistry have been considered in order to decrease the infection level of the root canal system. This therapy regained popularity in the last decade due to its effectiveness in treating endodontic microbial infections, particularly because the most commonly used chemical irrigations such as chlorhexidine and sodium hypochlorite are not always 100% successful in eradicating the microbial flora in the infected root canal. Understanding of the mechanism of microbes and a total microorganism eradication from the system of the root canal. The Pubmed, Embase, NCBI, and Cochrane databases were searched for studies of photodynamic therapy and its effects in endodontic treatments. Both clinical and laboratory studies as well as *in vitro* and *in vivo* studies were analyzed. In recent years, studies that were done showed PDTs' antibacterial potential, however, most of them were unable to adequately confirm better disinfection when contrasted with regular chemomechanical formulation with NaOCl.

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Introduction

'The light-induced inactivation of cells, microorganisms, or molecules' [1] has been used as a definition of Photodynamic therapy (PDT) [1]. PDT has been called several different names, including photodynamic antimicrobial chemotherapy (PACT), photodynamic disinfection (PD), and antimicrobial photodynamic therapy (APD) [2-4]. Multiple studies have demonstrated positive results in treating infection of the root canal. Indeed, photodynamic therapy in the treatment of microorganisms has proven to be quite useful in the treatment of periapical and pulpal infections. The quantifier of the successfulness of endodontic treatment is the relative eradication of root canal microbes [5]. However, it is an unfeasible task to perform the total eradication of microorganisms from the root canal system [6, 7].

Generally, gram-positive (G +) bacteria are the main composition of endodontic failure infections (secondary infections) that are caused by one or multiple species of bacteria. This being said, an apparent predominance of anaerobes or facultatives cannot be declared in them [8]. The microflora associated with the infected root canal is typically a mix of species with a predominance of gram-negative (G -) anaerobic rods.

This review aims to discuss Photodynamic therapy in endodontics management and how it helps in the dental industry.

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Materials and Methods

The indicated keys were put to work in the mesh of the PubMed database for the choosing of articles ((“Photodynamic therapy "[Mesh]) AND (“in endodontic management” [Mesh]) OR (Photodynamic therapy in endodontics management) Mesh])).

Article selection was based on the inclusion of certain topics that lined up with the objective as the ones that did not have the indicated key topics as their chief directive were not considered. The topics were: Photodynamic therapy in endodontics management.

Around 90 publications were chosen as the most clinically relevant out of 1,202 articles indexed in the previous two decades, and their full texts were evaluated. A total of 31 of the 90 were included after a thorough examination. Additional research and publications were found using reference lists from the recognized and linked studies. Expert consensus recommendations and commentary were added where relevant to help practicing physicians assess cirrhosis most simply and practically possible.

Results and Discussion

The consequences of microorganisms entering the root canal can range from reversible pulpitis to necrosis of the pulp, which leads to a periapical lesion [9]. Additionally, pulpal necrosis without the involvement of microorganisms does not always lead to periapical lesions [10]. When mechanical or thermal trauma occurs to the pulp, the lack of blood circulation and defense mechanisms create a welcoming environment for intruding microorganisms and the pulp doesn’t stand much chance of remaining sterile for long.

A dye that has the ability to light source energy absorption and transference of this energy to another molecule is considered a photosensitizer (PS) [11]. Said photosensitizers are involved in photodynamic therapy. The most common are phenothiazine salts, used in clinical trials.

Photodynamic therapy is a two-stage treatment: the first stage involves the application of an applied PS compound to targeted tissues [12], which compound is then activated with exposure to light whose wavelengths are controlled to excite the compound. In the second step, light is emitted by a device used directly on the targeted tissue or directed to inner sites.

Photoactivated disinfection (PAD) is a therapy that consists of the contact between a light source and a photosensitive antibacterial agent. The photosensitizer generally used is a harmless dye combined with low-intensity visible light, which molecules attach to the bacteria membrane [13, 14]. In the presence of oxygen, it results in the production of certain cytotoxic species. Rupture of the microbial cell wall occurs when irradiation with a specific wavelength of light produces singlet oxygen [15, 16].

Treatment

In Oral Surgery and Periodontics, antimicrobial PDT represents a theoretical treatment alternative for peri-implantitis, post-extraction pain, alveolar osteitis [17], and localized microbial periodontal infections [18-26]. It requires the use of a photosensitizer along with low-concentration laser light, together with fostering the destruction of harmful microorganisms by singlet oxygen molecules. Despite the fact that it was unsuccessful in eliminating bacteria, PDT nonetheless resulted in a significant bacterial reduction [27, 28].

Recently, PDT treatments with photosensitizing dyes combined with the usage of lasers or LEDs of different wavelengths have been explored as dental plaque removal treatments [28, 29] and to minimize dental caries that are conductive to aetiological factors [30].

The effectivity of this photodynamic approach has been seen in ridding the root canals of microorganisms both *in vitro* and *in vivo* [31]. The potential of PDT has been demonstrated by these studies alongside standard endodontic antimicrobial treatment.

A wide range of irrigating and disinfecting solutions are used to help in debridement and scrubbing of the canal [32]. Indeed, complete cleaning of the root canal system cannot be achieved by mechanical instrumentation alone [33]; debridement of the endodontic space and poor disinfection, limited filling, untreated canals, and leaking of the coronal are all likely cases of post-treatment endodontic disease or failures that may cause bacteria to persist within the root canal system [34].

New methods and substances have recently been suggested to improve disinfection of the root canal, in replacement of conventional chemo-mechanical procedures or in addition to these procedures [35]. PDT was suggested as a promising addition to the clinical treatment of periapical lesions, alongside standard antimicrobial intracanal cleaning and shaping [36, 37], especially for teeth going through endodontic retreatment or treatment [35], Asnaashari *et al*. [38], Pourhajibagher *et al*. [39], Rabello *et al*. [40]. Indeed, when PDT parameters were optimized for the best photodynamic effect, colony-forming unit counts decreased by 99% in experimentally infected root canals of extracted teeth [31, 41].

Recently, positive results have been indicated in the use of PDT in root canal treatment when looked at in terms of the reduction of the bacterial load *in vivo* [40, 42-44], also *in vitro* [31, 45-47] and *ex vivo* [48].

Clinical Procedure

A non-intrusive method of treatment that involves photosensitizers, a specific wavelength of light, and the generation of reactive oxygen species (ROS) and singlet oxygen to eradicate unwanted pathogenic microorganisms is Photodynamic therapy (PDT). The highly reactive oxygen species (ROS) destroys the microorganisms.

Viruses, fungi, and protozoa are among other microorganisms that are greatly reduced by PDT [48-50]. Additionally, toxicological tests have reported no negative side effects in the treatment with the applied photosensitizer [51].
Clinically, a PS solution flush that is done post canal preparation, is allowed to sit for approximately 60 seconds, in order for the solution to interact with the bacteria. Radiation is performed for 30 seconds on each canal, by the emitter which is placed in the root canal. This method has been clinically proven capable of killing high concentrations of the bacteria found in root canals [52]. However, it is crucial to ensure that the preparation completely floods the area; indeed, the solution must come into contact with all bacteria or the photosensitization will not be effective [53].
However, it has been mentioned by Kosarieh *et al*. [54] that irrigation lasting 2 minutes along with 17% EDTA improves photosensitizer penetration inside the dentinal tubules, possibly ensuring that the bacteria in deeper areas of the wall of the root canal are got to by the photosensitizer.
PDT is also an effective reducer of biofilm [55]. Indeed, advanced noninvasive PDT with an oxidizer/oxygen-based photosensitizer formulation disrupts the biofilm matrix and has been proven to allow the comprehensive disinfection and inactivation of endodontic biofilm that is matured [56].
According to laboratory studies performed by Nunes *et al*. [57], there is doubt concerning the necessity of light delivery as it does not drastically affect the antimicrobial action of PDT. It should therefore be effective with or without an intracanal fiber. Additionally, according to Pinheiro *et al*. [58], it appears there is also doubt concerning penetration depth of the fiber; indeed, PDT was administered before and after instrumentation and similar values were reported. This study also reports that when the canal's complete length is not penetrated by the probe, it prevents the removal of apical microbial pathogens. Lastly, Firmino *et al*. [59] noted accelerated healing of a periapical lesion, which is probably due to the fact that bone repair in permanent teeth with the periapical disease is heightened with the red spectrum's laser light [60].
The application of PDT has many advantages but also reports potential adverse effects. Indeed, there is no evidence of the bacteria developing resistance after PDT [61], even after multiple applications [50, 62, 63]. PDT is also effective against antibiotic-sensitive and antibiotic-resistant microorganisms.
However, the methylene blue photosensitizer causes tooth staining and discoloration [64, 65], and chemical smear layer is also formed while obliterating the dentinal tubules has led to microleakage root filling materials having a lesser bond strength to the dentine [66]. The potential cytotoxicity of PDT is also a cause for concern. *In ex vivo and vitro* studies are being done to look into the safety of PDT for future aspirations *in vivo* applications [67, 68].

Conclusion

PDT has several applications in dentistry because the basis of successful periodontal treatment is the removal of bacteria from the infected area. Phenothiazinium PSs are effective and safe for this purpose [69]. However, it is worth mentioning that to administer PDT, scaling and root planing should be performed beforehand.
PDT has significant antibacterial potential as highlighted by recent studies. However, most of these studies do not show significant improvement of disinfection as compared with conventional chemomechanical preparation with NaOCl. PDT is one among many strategies (using intracanal medicaments, e.g., calcium hydroxide, irrigation solutions, e.g., NaOCl and chlorhexidine) advocated as useful in increasing the level of disinfection of the root canal system [70, 71].

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