Photo-activated Disinfection In Endodontics

Abstract Development of resistance against antibiotics and side effects of the drugs has urged to search for alternatives; to eliminate the micro-organisms from the root canal system. Failure in root canal therapy has been accounted for insufficient removal of the micro-organisms, which has been attributed to the intricate nature of dental anatomy, which in turn strongly limits the effect of mechanical debridement. Moreover, the lateral canals and apical ramifications are inaccessible to root canal instrumentation. Methods of root canal disinfection that supports the chemo-mechanical debridement have a strong bactericidal effect, but the commonly used irrigants, such as sodium hypochlorite or chlorhexidine digluconate do not always eradicate the entire microbial flora. Currently, Photoactivated disinfection (PAD) has been proposed as an alternate adjunct to conventionalendodontic disinfection.

Key words Photodynamic, Disinfection, Photosensitizer

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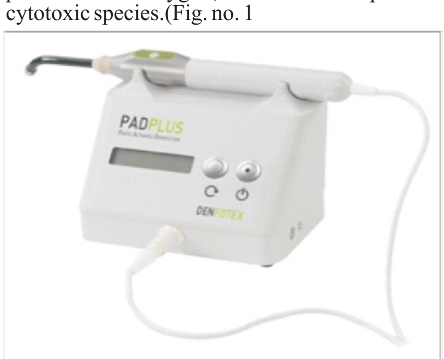
Introduction

The main goal of endodontic therapy is to eliminate the bacterial infection from the root canal space and allow healing of the periapical infection. Elimination of micro-organism from the infected root canal system is a complex task.

Although the bulk of infective micro-organisms are removed through chemo-mechanical debridement procedure, residual bacteria are still readily detectable in approximately one-third of the teeth at the time of obturation [1]. This has been attributed to the complexity of the root canal system that make complete debridement of the bacteria almost impossible even when conventional automated methods of endodontic instrumen-tation and irrigation are performed. Thus debridement of the root canal space is critical and the need for better root canal disinfection is clear and compelling. Currently, the use of photodynamic therapy (PDT) has become an alternate method for root canal disinfection.

The word photodynamic means the applications of dynamics of photons of light on the biological molecules. German physician Friedreich Mayer performed the first study, which was first called as photo-radiation therapy with porphyrins (1913) in humans. It is also known as photo-radiation or phototherapy which involves the use of a photoactive dye that is activated by exposing it to a specific light source in the presence of oxygen. It is an emerging. treatment modality that became popular after the invention of laser,which allowed the production of monochromatic light that could be easily coupled into optical fibres. This optical fibre enable the light can to be directed easily to the desired region. The use of photodynamic therapy (PDT) for the inactivation of microorganisms was first shown by Oscar Raab who reported the lethal effect of acridine hydrochloride on Paramecia caudatum[2].

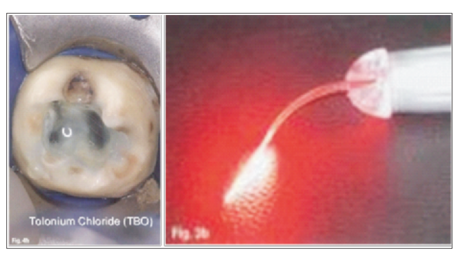
Photo-activated disinfection (PAD) employs a non-toxic dye, termed a photosen-sitizer (PS), and low intensity visible light which, in the presence of oxygen, combine to produce cytotoxic species.(Fig. no. 1

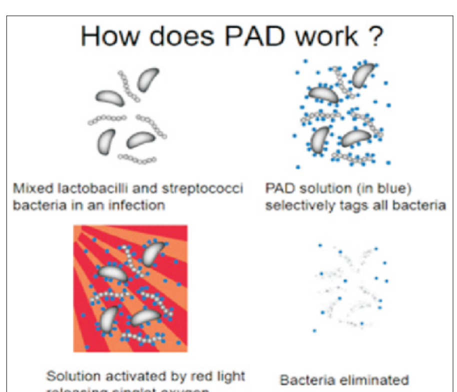


Principle: It is based on the principle that when the PS is excited by light source of suitable wavelength, it is activated from the ground level to the triplet state and produce free radicals, which have a site-specific toxic effect to the cells. Longer the life time of the triplet state, enables the excited PS to interact more with the surrounding molecules which leads to the formation of cytotoxic products. These products usually cannot migrate more than > 0.02 mm after its formation and thus it is ideal for local application, since and hence it avoids damage to the distant molecules, cells and organelles [3]

Extensive laboratory studies have shown an important aspect of this system: PS and light source when used independently produce no effect on bacteria or on normal tissue; their combination alone has an effect on the pathogens [4-6]. Using the principles described above, a system has been developed for endodontic use consisting of a lamp (FotoSan; CMS Dental, Copenhagen, Denmark): this is a treatment based on the combination of a PS and a powerful red light.

The PS is a watery solution of toluidine blue O (TBO) that attaches to the membranes of microorganisms and binds itself to their surface, absorbs energy from the light and then releases this energy to oxygen (O2), which is transformed into highly reactive oxygen species (ROS), such as oxygen ions and radicals. The ROS reacts strongly and destroys the microorganisms instantly and effectively. (Fig. no.2,3)





TBO is available in low, medium and high viscosities. All solutions have the same concentration of active ingredients.

The PAD principle is not only effective against bacteria, but also against other micro-organisms including viruses, fungi and protozoa[7,8].

Reaction

There are two types of reaction by which the triplet state PS can react with the biomolecules

Type I Pathway It involves electron transfer reaction directly from the PS producing ions or electrons/hydrogenremoval with the partici-pation of a substrate molecule to produce free radical ions that rapidly react with oxygen to produce highly reactive oxygen species such as superoxide, hydrogen peroxide, hydroxyl radicals and lipid derived radicals.

Type II Pathway It produces electronically excited and highly reactive state of oxygen known as singlet oxygen, which can oxidize many biological molecules such as proteins, nucleic acids and lipids and lead to cytotoxicity. The mechanism of damage is by contribution of both the reactions which in turn depends on oxygen tension and photo-sensitizer.

Application

Clinically, after canal preparation, the canal is inoculated with the PS solution, which is left in situ for a fixed period of time (60 seconds) to permit the solution to come into contact with the root canal and irradiation carried out for 30 seconds in each canal. This has been demonstrated in the laboratory to kill high concentrations of bacteria generally found in root canals [9,10]

Several factors affect the results created using PAD. These include the type of dye used, the dye concentration, the dose of radiation applied

Dyes

Over 400 different photoactive dyes are known. Some of them are already used in dentistry:

Toloniurn chloride (Toluidine Blue 0 or TBO)

- Aqueous solution
- Sodium phosphate buffer
- Peak absorption 633 nm
- Dye concentration 12-100 mg/ml. These areempirically derived values, but further research is needed for an optimalization of theconcept
- Radiation dose of typically 40 J/cm2
- Temperature of the dye is also an unknown factor and deserves further research
- Long-term safety proven (oral carcinoma staining protocols with much higher doses,eg,Orascreen)
- Experience in dentistry: evidence based

Methylene Blue Peak absorption 670 nm

Rose Bengal Peak absorption 550 nm

Aluminum disulphonated phthalocyanine Peak absorption 675 nm

Parphyrin conjugates Different peak

absorptions

Polylysine conjugates Different peak absorptions

Chlorine conjugated dyes Different peak absorptions

PAD can be obtained with more than 400photoactive substances, combined with different laser devices. Ten kinds of blue, purple and green dyes are the most effective and popular, mainly of the phenylmethane family. Blue seems to work the best and is best documented

Radiation dose

Several visible red semiconductor diode lasers are available.

SaveDent diode laser (Denfotex Light Systems Ltd., Scotland), now commercially available as Aseptim™ PAD (SciCan, Germany): 635 nm, 50-100 mW with TBO + customized emitters.

Ceralase PDT diode laser (CeramOptic, Germany): 662 nm, 0.5 W with chlorine dyes.

Biolitec diode laser (Biolitec AG, Germany): 665 nm with chlorine dyes.

Radiation doses are typically related to time, power, and energy density:

40 J/cm2

Power 100 mW

Time 120-150 sec.

PAD safety:

PAD using TBO sensitizer and low-power diode laser light has proven to be a safe combination. Several safety issues have been examined:

-PAD does not give rise to deleterious thermal effects for adjacent tissues.

-PAD treatment does not cause sensitization and killing of adjacent human cells such as fibroblasts and keratinocytes.

-Neither the dye nor the reactive oxygen species produced from it are toxic to the patient.

Until today, bacteria are not able to produce resistant strains to the photoactive agent

II.discussion

Methylene blue (MB) is a well-established photosensitizer that has been used in PDT for targeting various gram-positive and gram-negative oral bacteria and was previously used to study the effect of PDT on endodontic disinfection [11-18]. Several studies have shown incomplete destruction of oral biofilms using MB-mediated PDT due to reduced penetration of the photosensitizer [19-22].

Soukos et al. used the combined effect of MB and red light (665 nm) exhibited up to 97% reduction of bacterial viability [12]. The results suggested the potential of PDT to be used as an adjunctive antimicrobial procedure after standard endodontic chemo-mechanical debridement, but they also demonstrated the importance of further optimization of light dosimetry for bacterial photodestruction in root canals. Along with methylene blue, tolonium chloride has been also used as a photosensitizing agent. It is applied to the infected area and left in situ for a short period. The agent binds to the cellular membrane of bacteria, which will then rupture when activated by a laser source emitting radiation at an appropriate wavelength (e.g., 635 nm radiation emitted by SaveDent; Denfotex Light Systems Ltd., Inverkeithing, United Kingdom). The light is transmitted into the root canals at the tip of a small flexible optical fiber that is attached to a disposable handpiece.(Fig. no. 4).

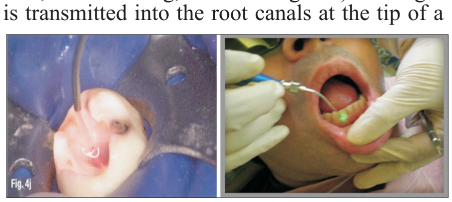


Fig. 4

The laser emits a maximum of only 100 mW and does not generate sufficient heat to harm adjacent tissues. Furthermore, tolonium chloride dye is biocompatible and does not stain dental tissue. The data quoted by the manufacturer suggest that this PAD system has antimicrobial efficacy [23]. Lethal photosensi-tization of Streptococcus inter-medius biofilms in root canals is unable to achieve a total kill rate when a combination of a helium-neon laser and tolonium chloride is used [24].

Leticia et al. investigated the antibacterial effects of photodynamic therapy (PDT) with methylene blue (MB) or toluidine blue (TB) (both at 15 mg/mL) as a supplement to instrumentation/irrigation of root canals experimentally contaminated with Enterococcus faecalis [25]. The study revealed that PDT with either MB or TB may not exert a significant supplemental effect to instrumen-tation/irrigation procedures with regard to intracanal disinfection, until further adjustments in the PDT protocol are modified before clinical use is recommended.

In contrast, irrigation with sodium hypochlorite (3%) eliminated the entire bacterial population. The difference could be because the optical fiber was not properly introduced into the root canals, and so the light could not transmit through the tooth structure. Thus, PAD might not be able to achieve a 100% kill rate in infected root canals that have complex anatomic features and colonized by polymicrobial biofilms of varying properties.

Pagonis et al. studied the in vitro effects of poly (lacticco- glycolic acid) (PLGA) nanoparticles loaded with the photosensitizer methylene blue (MB) and light against Enterococcus faecalis [26]. The study showed that utilization of PLGA nanoparticles encapsulated with photoactive drugs may be a promising adjunct in antimicrobial endodontic treatment.

III.conclusion

Photodynamic therapy represent a novel approach in the management of various oro-dental infective conditions. It includes preservation of functionality, good patient acceptance, good cosmetic result, willingness by the patient to repeat the treatment and low invasiveness. It is unlikely for the bacteria to develop resistance to the photodynamic action as has been reported by the conventional antimicrobial treatment .Thus Photo-activated disinfection is considered to be an useful adjunct and rapidly emerging alternative to current antimicrobial regimen.

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