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PHOTODYNAMIC THERAPY-FUTURITY IN DISINFECTING ROOT CANAL

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ABSTRACT

Photodynamic therapy in endodontic was proposed in attempt to reduce any residual bacteria on the root canal system to the lowest possible level. Photodynamic therapy in endodontic is used as an effective cleaning and disinfection of the root canal and even in post treatment endodontic disease which may occur due to persistent bacteria in the root canal system. Photodynamic therapy was effective in reducing the multispecies biofilm model of endodontic infection. It has been used to improve root canals disinfection without including bacterial resistance. Even drug resistant bacteria and viruses are also removed.

KEYWORDS: It has been used to improve root canals disinfection without including bacterial resistance.

INTRODUCTION

Root canal treatment is a logical action to reverse the existing infection, which requires removal of infected tissue and intervention of root canal to disinfect it by instrumentation, irrigation protocols, intracanal medicament and final sealing it with 3 dimentional obturation.[1]

Endodontic treatment can still fail even if all steps are accurately carried out. Endodontic failure can be attributed to a number of causes, including inadequate or overextended root canal fillings, complex tooth anatomy, an untreated canal, and a poor coronal seal. However, a significant factor in endodontic failure is the persistence of bacterial biofilm even after following standard disinfection protocol.[2]

Conventional endodontic irrigation solutions, such as sodium hypochlorite (NaOCl) and chlorhexidine and intracanal medicaments, such as calcium hydroxide alone may not exterminate the bacteria proficiently from root canal space and complex anatomic structures like isthmus, lateral canals, accessory canals, ramifications.[3]

Despite endodontic treatment, a few percent of putative pathogens can survive in the root canal system in a lack of nutrients. E faecalis a unique bacteria can survive even after disinfection. E faecalis can enter the dentinal tubules, endure conditions like low nutrients and pH, resist high salinity and temperatures, survive in the presence of irrigates and intercanal medicaments, develop antibiotic resistance, and build biofilms in root canals.[4] To increase the success rate and disinfection of root canal system scientists are constantly searching for additional disinfection approaches to improve root canal disinfection, such as Photodynamic therapy (PDT).

Photodynamic therapy is an treatment modality that has been investigated since 1960s, but it gained attention after late 1990s. It is an non- invasive treatment method, involving photosensitizer light of a specific wavelength and the generation of singlet oxygen and reactive oxygen species for inactivation of cells, microorganisms or molecules.[5]

The major photosensitizes used are phenothiazine salts, namely toluidine blue o and methylene blue with wavelength of absorption 600-660nm. Light sources used are LASER, light -emitting diodes and halogen lamps.

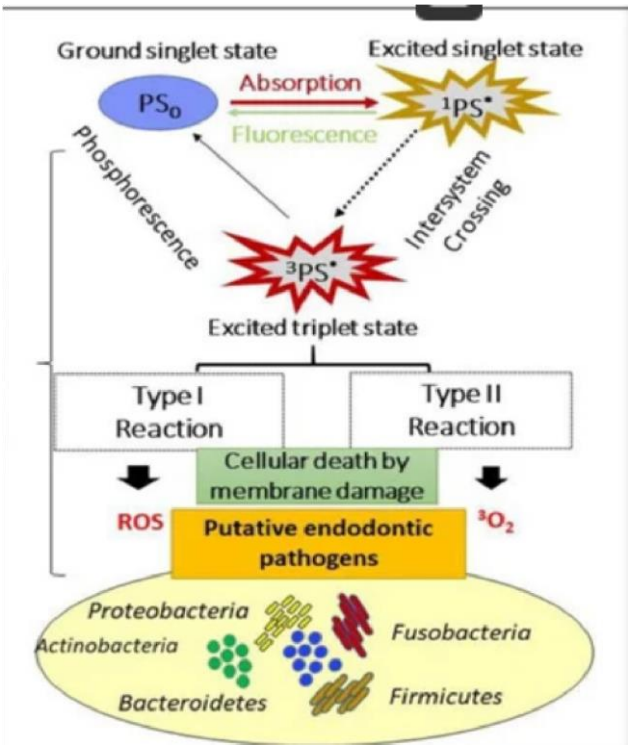
Photodynamic therapy is an adjunctive, conservative, non-selective bacterial kill approach. Photodynamic therapy is an adjuvant technique used to improve root canals disinfection without inducing bacterial resistance.

MECHANISM OF ACTON

Gram-positive bacteria are more easily inactivated by antimicrobial PDT using a variety of Photosensitizer compounds than Gram-negative bacteria. The two groups' differing cell wall architectures give birth to their different susceptibilities to PDT. A moderately porous layer of peptidoglycan and lipoteichoic acid surrounds the cytoplasmic membrane in Gramm positive bacteria, allowing the PS to pass through. Gram- negative bacteria

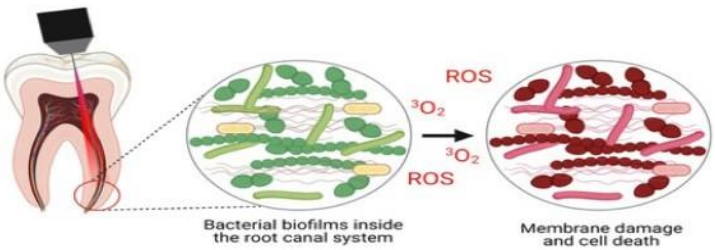
have an outer membrane and an inner cytoplasmic membrane that are separated by periplasm, which contains peptidoglycan. The outer membrane acts as a permeability barrier and prevents many PS from binding to and penetrating through it. Gram-negative bacteria were successfully treated with PDT when PS was used in conjunction with a permeabilizing agent such polymyxin nonapeptide or EDTA.[6]

In this technique, a light at a specific wavelength is used to activate PSs, followed by photochemical reactions of the excited PS with various cellular substrates and molecular oxygen, eventually leading to cell death. However, each component of PDT is non-toxic when used alone, but when the photosensitive material is exposed to light with a certain wavelength, a chemical reaction occurs that results in the formation of toxic species, which kills cells through a variety of molecular mechanisms.[5] The PDT mechanisms are mainly divided into Type I and Type II.



Type I: The light-excited PS engages in an electron or hydrogen atom exchange with the molecules around it. One of reactive oxygen species responsive forms, hydroxyl radicals, are produced because of this reaction. A cascade of released oxygen ions and free radicals damage the targeted cells when the PS is activated by light. Relying on the improved penetration and accessibility of the reactive oxygen species is one of the PDT's key advantages.[7]

Type II: In a manner like Type I, light activates the PS, which then combines with molecular oxygen in its ground state to produce excited singlet-state oxygen (O2) that specifically attacks diseases brought on by biofilms. Both kinds of responses might occur at once. The PS molecules and type employed determine the ratio between these processes.[7]



Photosensitizers

Photosensitizers are special chemical components that are light-sensitive and possess low toxicity in the absence of light. PSs are typically macrocyclic compounds with a heterocyclic ring structure that is similar to chlorophyll or heme.[8]

Characteristics of ideal photosensitizers

- Very high chemical purity.
- Constancy at ambient temperature.

- Only a particular wavelength has a photosensitive effect.
- High photochemical reactivity; maximum light absorption should occur between 600 and 800 nanometers in wavelength.
- Minimum absorption in the 400–600 nm range.
- Minimal cytotoxicity in the dark
- Ease of solubility in bodily tissues.[9]

PSs can be categorised according to their chemical structure, it is more typical to divide them into three large families based on their clinical traits.

1ST GENERATION

Photosensitizers were introduced to the treatment on a commercial scale for the first time in the 1970s and early 1980s. The limitations of first generation were low chemical purity or poor tissue penetration due to maximum absorption at a relatively short wavelength - 630 nm high aggregation tendency, lack of specificity, low solubility in physiological liquids and cutaneous phototoxicity.

2nd GENERATION

Second generation evolved in early 1980s, the group of the second generation photosensitizers includes hematoporphyrin derivatives and synthetic photosensitizers. Second-generation photosensitizers are distinguished by a higher chemical purity, a higher yield of singlet oxygen production, and improved penetration to deeply placed tissues than first generation. The second generation PS's main drawback is its weak water solubility.[8]

3rd GENERATION

Most recently developed compounds, these are second generation PS compounds that are conjugated with biological molecules. They have higher affinity to the target tissue, which reduces damage to surrounding, healthy tissues and increased bioavailability.[8]

Light sources

Although PDT light delivery provides great therapeutic benefits, each tissue type has unique treatment requirements (light dose, dose rates, and tissue destruction that follows) that must be taken into consideration prior to therapy. Light that easily penetrates tissues, such as red light in the visible spectrum, is best for use in PDT because the light wavelength closely correlates to the depth of tissue absorption. The wavelength range for PDT is between 600 and 900 nm.[10]

The literature describes three main classes of clinical PDT light sources

1. Broad spectrum lamps
2. Light emitting diode lamps
3. Lasers

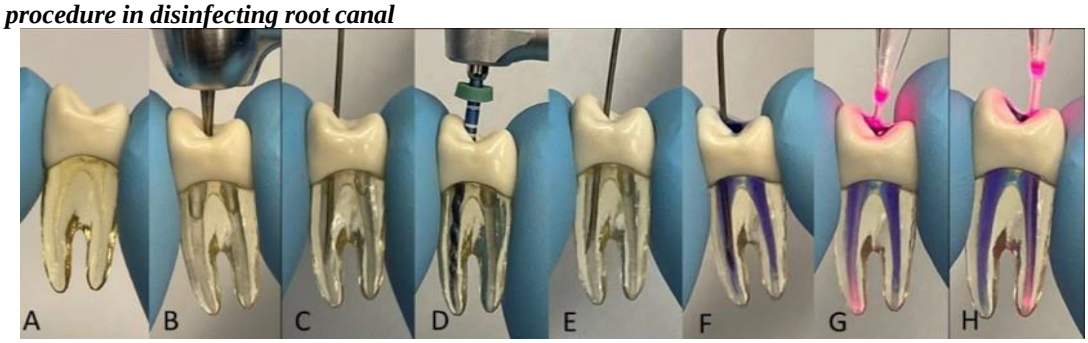
In Endodontics

PDT is used conjunction with conventional chemo-mechanical preparations. The most current data was presented by Okamoto et al., who used PDT with the photosensitizer methylene blue and a 660 nm laser light after performing conventional root canal therapy on five anterior and deciduous teeth. After that, a saline irrigation and sealant were applied to the root canal. The contaminated and cleaned root canal was sampled for microorganisms, and the bacterial colonies were studied under a microscope. The findings supported the claim that PDT can be used as an alternate approach to promote root canal disinfection by demonstrating a bacterial reduction from 37.6% to a staggering 100%. PDT has demonstrated very encouraging outcomes when compared to irrigation using the traditional sodium hypochlorite, which is regarded as the gold standard for irrigation of root canals.[11] PDT has demonstrated to be a highly effective antibacterial agent against both Gram-positive and Gram-negative endodontic bacteria especially Enterococcus faecalis, which exhibits high levels of resistance to conventional chemo-mechanical irrigation systems and is a very problematic species due to its mechanisms for developing antibiotic resistance.[12]

Pre-irradiation time and irradiation dose

'Pre-irradiation time' (Trindade et al. 2015) refers to the interval of time between the transport of the PS into the root canal system and the actual photo-activation. Pre-irradiation time is a crucial component of PDT because it enables PS to pass through dentine and exert its antibacterial effect. It also aids in maintaining PS inside the bacteria, increasing light absorption (Usacheva et al. 2001; Figueiredo et al. 2014). Pre-irradiation times range from 5 to 15 minutes, according to data that is currently accessible despite conflicting research about this topic.[5]

Clinical procedure in disinfecting root canal



A. Teeth in need of root canal therapy
B. Access cavity preparation
C. Locating the canals and working length determination
D. Biomechanical preparation
E. Irrigating the root canlals
F. After completion of canal preparation, the canal is inoculated with the PS solution
G. The PS solution is left in situ for a period of 60s to permit the solution to come in contact the bacteria and diffuse through any biofilm structure
H. The light emitter is then placed in root canal and irradiation carried out for 30s

EFFECT ON BOND STRENGTH

- AH Plus, Sealapex, and MTA Fillapex root canal sealers were tested utilising the push-out test method in an in vitro investigation to see how the PDT system affected
  the bond strength of the sealers. Findings showed that AH Plus and MTA Fillapex root canal sealers had stronger bonds than Sealapex sealers. It was also discovered that the MTA Fillapex root canal sealer's ability to adhere to dentin had been negatively impacted by the PDT system.[13]
- Combination of 2.25% NaOCl with PDT and 17% EDTA for canal disinfection with AH Plus sealer, calcium silicate sealer, and MTA-based bioceramic sealers have an unfavorable effect on the extrusion bond strenght of gutta-percha to the root canal wall.[14]

PHOTOACTIVATED DISINFECTION IN REGENERATIVE ENDODONTICS

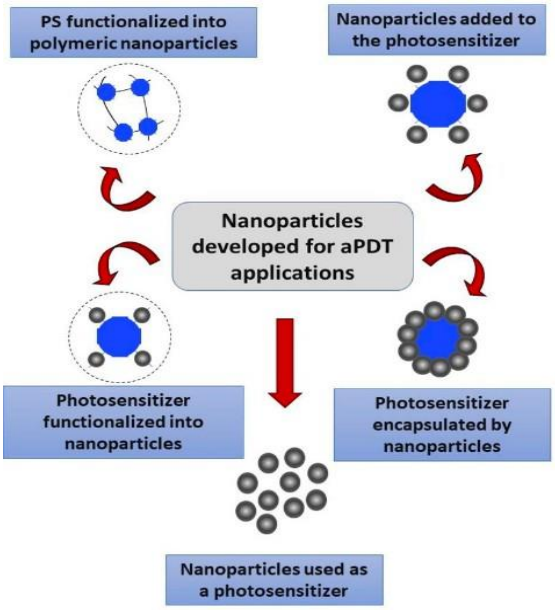
Pulp revascularization with canal disinfection employing a combination of a low-power laser light and PS solution. NaOCl was utilised to irrigate the infected root canal, and after it had been dried with paper points, PDT was used to disinfect the canal and platelet-rich fibrin to revive the pulp. Then, a permanent restoration was placed after the canal had been sealed with mineral trioxide aggregate. A subsequent radiograph revealed root lengthening, continuing wall thickening, and apical closure.[15]

ADVANCEMENT OF PHOTODYNAMIC THERAPY

The limited penetration of photosensitizer (PS) and light propagation into the dentinal tubules are two key drawbacks of existing phototherapeutic interventions for the disinfection of root canals. The effectiveness of bacterial disinfection has been considerably improved by nanoparticles used in PDT. Emergent PS carriers in the form of nanoparticles (1-100 nm in size) have considerable promise for PDT. They can be organic, inorganic, or a combination of the two and show the three dimensions in nanoscale.[7]

The benefits of nanoparticle-based photosensitizers.

- When PS are coupled with nanoparticles, a greater PS per mass content can be produced, which increases ROS generation.
- The target microorganism's capacity to pump molecules out of the cell is diminished, which results in decreased resistance to agents.
- Possibility of focusing on microorganisms due to the enhanced interaction between nanoparticles and bacteria as a result of the electric charge on the surfaces of nanoparticles.
- The PS is more stable when nanoparticles are added.
- Less physical quenching as a result of PS accumulation.
- The potential for regulated ROS release upon photoactivation.[7]



The following are the most notable methods for using nanotechnology in PS to improve PDT disinfection results

1. PS Loaded in Polymeric Nanoparticles
2. Nanoparticles as an Active PS
3. PS in Nano emulsions
4. Quantum Dots in Antimicrobial Photodynamic Therapy
5. The Conjugates of PS and Nanodiamonds
6. The Conjugates of PS and Magnetic Nanoparticles
7. The conjugates of PS and liposomes[7]

CONCLUSION

PDT is an effective strategy for preventing reinfection without causing bacterial resistance. The failure of PDT in endodontic disinfection, however, may be seriously hampered by the absence of defined procedures for its application. The use of photodynamic antimicrobial treatment is quite important, particularly at this time, when minimally invasive dentistry and prevention are the primary goals of dental medicine, photodynamic antimicrobial treatment is extremely important. Hence

PDT have been advocated to increase the disinfection level of the root canal system.

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