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# Laser As An Antimicrobial Photodynamic Therapy In Endodontics - Literature Review

Review Article

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## Abstract

**Introduction:** LASER ( Light Amplification by Stimulated Emission of Radiation) is an important evolving tool in dentistry which has its implication mainly in contamination control, caries removal, tissue removal, tissue decontamination, melanin depigmentation, teeth brightening, haemostasis and coagulation. In endodontics LASERS are mainly used to disinfect the root canals ,as the success of root canal treatment depends on the complete elimination of the endodontic microorganisms which is achieved by the physical methods to agitate the irrigation fluids to improve their penetration in areas which are not reached by the endodontic instruments.Antimicrobial photodynamic therapy is based on use of a chemical photosensitive dye,visible light and reactive oxygen.
**Aim:** The aim of this review is to evaluate the available literature both in invivo and invitro for effectiveness of Antimicrobial photodynamic therapy in endodontics.
**Materials And Methods:** Literature search was conducted using databases including PubMed, Scopus, and Google Scholar with the keywords “photodynamic therapy,” “antimicrobial photodynamic therapy,” or “photoactivated disinfection” and “endodontic,” “Enterococcus faecalis,” or “root canal treatment.
**Results:** According to literatures, aPDT can be used as an adjuvant with conventional chemomechanical preparation in endodontics for canal disinfection.However the success of this aPDT also depends on the type of photosensitizer, output power of the laser used, irradiation time, pre-irradiation time, and type of tips used.

Keywords: LASER; Antimicrobial Photodynamic Therapy; Disinfection; Enterococcus Faecalis; Photo sensitiser; Root Canal.

## Introduction

The success of endodontic treatment depends on the thorough cleaning and shaping of root canal system followed by microbial free tight filling.Complete elimination of micro organism from the infected root canal system is very difficult because of the deep penetration of the bacteria and its products into the anatomical structures such as accessory canals, isthmus, and dentinal tubules. [1] The most common and basic method of chemomechanical debridement of the root canal system fails to completely remove the bacteria and their products.In Order to achieve complete disinfection high power lasers were used which eliminates bacteria by temperature rising and protein denaturation. [2]. Inorder to increase the effect of disinfection and to overcome the side effects of conventional irrigants, laser assisted endodontic disinfection is employed [3].

The word LASER is an acronym for Light Amplification by Stimulated Emission of Radiation. Lasers in endodontics are mainly used to increase success rate of pulp capping or apical surgery procedures and to directly irradiate the dentin walls [4] or to activate the photo active substances or irrigants indirectly, thus enhancing the effect of disinfection [5].

Photo activated disinfection (PAD) also called as antibacterial photodynamic therapy (aPDT) has been defined as the light induced inactivation of cells, microorganism, or molecules.[6-8]

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PAD involves the application of three principle elements namely

• A photosensitizer (PS)
• A light source
• Tissue oxygen.

Previously our team has a rich experience in working on various research projects across multiple disciplines [9-23] now the growing trend in this area motivated us to pursue this project.

## Principle

PAD is based on the principle that when the photosensitizer is excited by a light source of suitable wavelength,it gets activated from the ground state to triplet state where the free radicals are produced which causes site specific toxic effects on the cells .As the lifetime of triplet state is longer ,it interacts more with the surrounding molecules leading to the formation of cytotoxic products .but these products could not travel more than 0.02mm which contributes to its localised action preventing damage to the distant cells [24, 25].

There are two types of reaction photosensitizer in triplet state interacts with the biomolecules.

Type I Pathway: It involves the transfer of electrons directly from the PS producing ions or electrons/hydrogen removal with the participation of a substrate molecule to produce free radical ions that rapidly react with oxygen to produce highly reactive oxygen species (ROS)such as superoxide, hydrogen peroxide, hydroxyl radicals and lipid derived radicals.

Type II Pathway: It produces singlet oxygen, an electronically excited and highly reactive state of oxygen that oxidizes many biological molecules such as proteins, nucleic acids and lipids and lead to cytotoxicity. In PDT, it is difficult to exactly delineate between the two reactions mechanisms. The mechanism of damage depends on oxygen tension and photosensitizer concentration.

## Procedure

The PS agent is administered into the tissue which is activated by light of a specific wavelength. The wavelength of light ranges between 600- 800nm which is called a 'therapeutic window'. This range of energy of each photon is high enough to excite the photosensitizer and yet it is low enough so that the light has sufficient penetration into the tissue. It consists of two stages; first the PS I gets accumulated in the target tissue then in the second stage, the PS is exposed to light at the absorption spectrum of the PS agent. This activated agent transfers energy to the molecular oxygen generating reactive oxygen species (ROS) .These ROS cause subsequent oxidation of lipids, amino acids and proteins which in turn induces necrosis and apoptosis of the cells. ROS indirectly stimulates the transcription and release of inflammatory mediators. ROS damages the plasma membrane by oxidation of the cell constituents and the cell organelles altering the permeability and transport functions between the intra and extra-cellular media. [26]

The two basic mechanisms that cause lethal damages are:

• DNA damage.
• Damage to the cytoplasmic membrane which causes leakage of cellular contents or inactivation of membrane transport system and enzymes [27].

## Photosensitizer

The most commonly used photosensitizers in dentistry are Toluidine blue O,Methylene blue, Rose Bengal,Chlorine,Curcum in,Indocyanine green and Riboflavin.Among these toluidine blue,methylene blue, chlorine conjugates can be excited by the light sources in the red visible spectrum (635 to 675 nm) while indocyanine green can be excited by near infrared spectrum (800 nm) and riboflavin can be activated by visible blue light (380-500nm) [25, 27].

The Ideal Characteristics of a PS Include:

• Low cytotoxicity
• Non-toxic.
• High stability and high affinity
• Selectivity (penetration into bacterial cells rather than healthy tissues)
• Short half life.
• Rapid elimination from normal tissue.
• Activation at wavelength at which penetration into the target tissue is very good.
• Ability to produce a large amount of cytotoxic products.

## Light

PDT require light source to activate the PS agent at a specific wavelength and the light source available for PDT belongs to three major groups.

• Broad spectrum lamps
• Light emitting diode lamps
• Lasers.

Lasers include argon lasers, Nd:Yag, gold, or copper vapor lasers. Diode lasers are now used most because of their low cost and portability.LED or the conventional halogen light are also used frequently.PS are mostly activated by red light ranging between 630 - 700 nm [2].

PDT decreases the bacterial load and is an appropriate treatment of oral infection. Antimicrobial PDT is an efficient nontoxic means to destroy micro-organisms which is left inside the root canal system even after conventional endodontic therapy. Thus PDT can be used as an adjuvant to conventional endodontic treatment. PDT increases the patient's comfort and decrease treatment time [7].

## Pre-Irradiation Time (PIT) And Irradiation Dose

PIT is the time elapsed between the PS application and its activation by light. It is necessary to allow PS to be taken by the target before irradiation, and it is expected to bind or even translocate into the cell membrane.[7]

## Safety

• Should not cause any deleterious thermal effects to adjacent tissues.
• Neither the dye nor the reactive oxygen produced are toxic to the patient.
• Adjacent human cells are not affected are not affected during the treatment procedure.
• Until today, no resistant bacterial strains were developed to photoactive agent.
• No mutagenic or genotoxic effects.
• Increased healing process

## Limitations

The therapy sometimes develops burning, tingling or prickling pain restricted to the site of illumination. It can lead to hyper or hypo-pigmentation occasionally. [28, 29] Thus PDT represents 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. PDT approaches to kill bacteria is clearly a rapidly emerging alternative to current antimicrobial regimen.[28]

Our institution is passionate about high quality evidence based research and has excelled in various fields [13][30-39].

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