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Laser Assisted Photodynamic therapy for periodontal diseases: A strategic review

Medical Science

KEYWORDS :

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ABSTRACT

The primary etiological factor in any form of the gingival or periodontal disease is microbial dental plaque, but there is a dynamic interaction between the microbial challenge and host response. The oral cavity is the major reservoir of a variety of pathogens including bacteria, fungi and viruses. Most of the dental pathogenic microorganisms are highly resistant to the known and newly developed antibiotics and appear responsible to the expansion of dental complications. Photodynamic killing of periodontopathogenic bacteria may be an alternative to the systemic application of antibacterial drugs used in the treatment of periodontal diseases. Even though the method is still in the experimental stage, increasing bacterial resistance problems may promote the introduction of photodynamic therapy (PDT) into periodontal practice. PDT also represents a novel therapeutic approach in the management of oral biofilms. Studies are now leading toward selective photosensitizers, since killing the entire flora leaves patients open to opportunistic infections. Keeping this in consideration this review mainly focuses on the application of photodynamic technology as antimicrobial agent in adjunct to the routine oral prophylaxis around the natural dentition as well as implant prosthesis.

INTRODUCTION:

Current dental practice has been emphasizing more on early diagnosis and prevention of common oral diseases and to conserve tooth structure as much as possible during restorative procedures. Thus atraumatic and non invasive treatment modalities have been the key thrust in dentistry today. Periodontal diseases are bacterial infections that affect the supporting structures of the teeth (gingiva, cementum, periodontal membrane and alveolar bone). The most common form, gingivitis, is an inflammatory condition of the gums. It is associated with accumulations of bacterial plaque in the area. Diseases that are confined to the gum usually do not lead to loss of teeth, but there are other more serious forms of periodontal disease that affect periodontal membrane and alveolar bone resulting in tooth loss.[1] Periodontitis is conventionally treated with mechanical debridement procedures and adjunctive antimicrobial therapy.

Photodynamic therapy is a novel non invasive therapeutic approach with increased site specificity and pathogen specificity. Microorganisms in gelatinous matrix are less accessible to antibiotics. Using antimicrobial agents to treat periodontitis without disruption of biofilm ultimately results in treatment failures. It is difficult to maintain therapeutic concentrations at the target site and target organisms can develop resistance to drugs.[2] Antimicrobial photodynamic therapy (aPDT) has emerged in the clinical field as a potential alternative to antibiotics to treat microbial infections.[3] This review is aimed to discuss the role of PDT in periodontal therapy.

MECHANISM OF ACTION OF PDT

Photodynamic therapy (PDT) is the light-induced nonthermal inactivation of cells, microorganisms, or molecules. This utilizes light to activate a photosensitizing agent in the presence of oxygen. The exposure of the photosensitizer to light results in the formation of toxic oxygen species, causing localized photodamage and cell death. Clinically, this reaction is cytotoxic and vasculotoxic. Depending on the type of agent, photosensitizers may be injected intravenously, ingested orally, or applied topically.[4] It also minimizes the occurrence of bacterial resistance.

The photodynamic process can be described as a combined action of three components such as a photoactive compound (photosensitizer), the proper light from the visible and near infra-red spectra, and the presence of molecular oxygen atmosphere.[5] Photo sensitizers are activated by red light between 630 and 700 nm corresponding to a light penetration depth from 0.5 cm (at 630 nm) to 1.5 cm at (700 nm) which is sufficient for periodontal treatment.[6] Sources of this light include a range of lasers, and at present, diode lasers are used predominantly. Non-laser light sources like light emitting diode (LED) and light cure units have been tried. An ideal photosensitizer should be non-toxic, should display local toxicity only after activation by illumination. Most commonly used photosensitizers include phenothiazine dyes, methylene blue, and toluidine blue.[7]

Clinical PDT is continuing to grow because of the relatively recent availability of portable and dependable light sources. The concept of photodynamic laser therapy itself is very attractive because it selects the target tissue by "marking" it with the photosensitizer, and the therapy (laser energy) is active (focused) only on "marked" cells or tissues.

Advantages of Photodynamic Therapy [8-10]

1. Simple method
2. Time required is less
3. Post-treatment infection risk is reduced
4. Local anesthesia may be avoided
5. No damage to the adjacent host tissues
6. No bacterial resistance
7. Inactivation of endotoxins
8. Kill bacteria in complex biofilms
9. Effective: kills > 99.9% microorganisms
10. Advantageous in children and dental surgery phobic patients.

Indications for the use of Photodisinfection.

- With debridement for aggressive cases (instead of antibiotics)
- With debridement (when purulence and generalized bleeding on probing are present)

- Refractory and recurrent cases of periodontitis
- Maintenance of difficult cases
- Disinfection of roots and furcation areas during regenerative surgery
- Disinfection of class II and III furcation involvement and deep vertical defects
- Peri-implantitis treatment

EFFECT OF PDT ON BIOFILM

The microbiota of periodontal disease is predominantly anaerobic from the three groups of microorganism's species. Bacteria in these lesions are very complex populations consisting of the Gram-positive organisms (including *Actinomyces*) and the Gram-negative organisms (primarily *Porphyromonas gingivalis*, *Aggregatibacter actinomycetemcomitans*, *Bacteroides forsythus*, *Prevotella intermedia*, *Fusobacterium nucleatum* and spirochaetes).[11]

Apical periodontitis is a sequel to endodontic infection and manifests itself as the host defence response to microbial challenge emanating from the root canal system. *Enterococcus faecalis* (Gram-positive, facultatively anaerobic cocci, which occurs singly, in pairs or short chains) is resistant to most of the intracanal medicaments probably due to its ability to regulate internal pH with an efficient proton pump.[12] *Candida albicans* (diploid fungus/a form of yeast) is the most frequently isolated fungus from root-filled teeth with apical periodontitis.[13]

The penetration of the photosensitizer into the biofilms during different stages of biofilm growth is also very important part for the success of the treatment procedure. Recently, the combination of PDT and hydrogen peroxide was reported as a solution to the penetration problem with limited transfer of drugs throughout the biofilm channels.[14]

PDT may be important in dealing with aggressive periodontitis because the photosensitizer is capable of penetrating through the epithelium and connective tissue, as are the periodontopathogens, especially Aggregatibacter actinomycetemcomitans, which can infiltrate through the epithelial barrier into the periodontal tissues.

Antimicrobial PDT not only kills the bacteria, but may also lead to the detoxification of endotoxins such as lipopolysaccharide. It has been demonstrated that bacteria associated with periodontal disease can be killed through photosensitization with Toluidine blue O by irradiating with helium - neon soft laser.[15]

Applications of Photodynamic therapy in periodontics

PDT can be considered as an adjunctive to conventional mechanical therapy. The technical simplicity and effective bacterial eradication are the two reasons why photodynamic therapy is extensively studied in periodontics. patients with chronic periodontitis, aggressive periodontitis and peri-implantitis, the adjunctive use of PDT to scaling and root planning may result in greater clinical attachment level gains, reduction in bleeding on probing and probing pocket depths. The use of PDT in furcation involvement shows some advantages over use of conventional antimicrobials, reduced need for flap procedures and shorter treatment time with lack of microflora disturbance in other sites of oral cavity. Thus PDT may be an effective alternative for control of bone loss.[7]

In vivo studies have also proved that PDT may be an effective alternative for control of bone loss in furcation areas in periodontitis.[16] In a study that included 30 patients, comparison was made based on the clinical parameter bleeding on probing (BOP) between sites that underwent scaling and root planning (SRP) alone and sites that were treated with adjuvant PDT. Significant diminishing of BOP was noted after photodynamic laser therapy, compared with SRP alone.[17] Another study included 20 patients with untreated chronic periodontitis. Their results showed baseline median values for probing depth (PD), gingival recession (GR), and relative attachment level (RAL) which were not different in the test group and control group. Values for RAL, PD, sulcus fluid flow rate (SFFR), and BOP decreased significantly 3 months after treatment in the control group with a higher impact on the sites treated with adjunctive PDT, and the authors summarized that in patients with chronic periodontitis, clinical outcomes of conventional subgingival debridement can be improved by adjunctive PDT.[18]

A study by Andersen et al 2007, used PDT in combination with conventional SRP and reported a significant reduction of pocket depth after 6–12 weeks, which increased the effectiveness of PDT in the treatment of chronic periodontitis.[19]

Laboratory studies have shown that the system is effective against the pathogens which cause periodontal disease.[10] If this technique can be extrapolated to the clinical situation and PDT can be used in periodontal pockets then disinfection of the pathogenic bacteria may lead to a cessation of attachment loss and create an environment conducive to healing. Unlike root canal, periodontal pocket is harder to render bacteria free and harder to maintain it due to its anatomy. Several mechanisms are proposed to explain the decrease in pain after LPT in Dentinal Hypersensitivity (DH). The positive effects are mainly attributed to the formation of tertiary dentin and the reduction in sensory nerve activity.[20]

Peri-implantitis seems to occur in 5-10% of all implant cases. There is considerable debate, however, about whether bacterial contamination, occlusal overload, or some combination of the two is the primary factor responsible for inducing peri-implantitis. "Whatever its genesis," it was found that poor oral hygiene accelerates the process. Laser treatment is best combined with surgical opening of the implant site for cleaning and disinfecting the local defect. In this way, photodynamic therapy can be used successfully to decontaminate the implant surface.[21] Intraoperatively used PDT or peri-implant care of ailing implants with the CO2 laser seems to be more of value than the Conventional methods. Data suggest that lethal photosensitization may have potential in the treatment of peri-implantitis.

LIMITATIONS OF PDT.

There are a few limitations such as fluid in the pocket (eg. Blood, gingival crevicular fluid and pus), which could dilute the photosensitiser potentially affecting its action. It may also be difficult access all of the pocket with light. More clinical research is required to overcome these potential a clinical protocol applicable to periodontal use.

CONCLUSION:

Its nonsurgical profile improves the comfort of treatment and thus makes the process more attractive to patients. Its ease of use makes it suitable for both dentists and auxiliaries (when permitted). The role of photodisinfection in dental treatment is beginning to expand and should provide exciting new opportunities in oral healthcare.

There is a great need to develop an evidence based approach to the use of PDT for the treatment of periodontitis, peri-implantitis, and endodontic therapy. It would be prudent to say that there is an insufficient evidence to suggest that PDT is superior to the traditional modalities of periodontal therapy. Antimicrobial photodynamic therapy may hold promise as a substitute for currently available chemotherapy in the treatment of periodontal disease.

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