Research Article

BIOMEDICAL Journal of Scientific & Technical Research

ISSN: 2574 -1241

DOI: 10.26717/BJSTR.2024.57.008990

# Photodynamic Therapy in Periodontal and Peri-Implant Diseases - A New Insight

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**ARTICLE INFO**

**Received:** June 24, 2024

**Published:** July 03, 2024

**Citation:** G Kamala, R Divya Lakshmi, K B Roshni and Neetha J Shetty. Photodynamic Therapy in Periodontal and Peri-Implant Diseases - A New Insight. Biomed J Sci & Tech Res 57(2)-2024. BJSTR. MS.ID.008990.

**ABSTRACT**

Periimplantitis is a biofilm-mediated disease, hence an antimicrobial approach is essential to prevent its further progress. The microbial colony that causes peri implantitis is highly diverse, it is crucial to eliminate the biofilm surrounding the implant during the treatment. Various non-surgical and surgical methods, which include flap debridement, laser decontamination, regenerative methods, and many others, are available to treat periimplantitis. Additionally, in the past, local and systemic chemical antimicrobial agents were utilised to improve mechanical therapy approaches, which has its drawbacks. So, Nonsurgical modalities were looked into the depth for its management. This review article aims to evaluate the effects of photodynamic therapy and thiocyanate as a photosensitizing dye used to treat periimplantitis. Antimicrobial photodynamic therapy is used for the eradication of pathogenic microbial cells and involves the light excitation of dyes in the presence of oxygen, yielding reactive oxygen species including the hydroxyl radical and singlet oxygen. To chemically enhance Photodynamic therapy (PDT) by the formation of longer-lived radical species, thiocyanate was used to enhance the light mediated killing of gram positive and gram-negative organisms. Thiocyanate enhances PDT killing in a concentration dependent manner of Streptococcus aureus and Escherichia coli. This review highlights photodynamic therapy features and its photosensitizing enhancing strategies which yield in antimicrobial outcomes.

**Keywords:** Thiocyanate; Low Level Energy Laser; Photosensitizers; Photodynamic Therapy; Periimplantitis

## Introduction

Peri-implant infections are of two types, Peri-implantitis and Peri-implant mucositis. The bacteria that cause these infections are present in the oral biofilm [1]. Peri implant mucositis is defined as “an inflammatory process around a dental implant without loss of supporting bone beyond biological bone remodelling” [2]. Periimplantitis is defined as “the inflammation of supporting tissues of dental implants in association with bone loss, which will result in the progressive destruction of bone around the implant, if left untreated” [3]. Generally, peri-implant mucositis is defined by the following symptoms and signs: irritation of the mucosa without loss of alveolar bone, whereas peri-implantitis is defined by the loss of supporting bone along with mucosal inflammation [4]. It is noticeable under the microscope that peri implantitis is characterized by an increase in inflammatory cells infiltrating around implants, which can be seen apical to the pocket epithelium the microbial colony that causes peri implantitis is quite complex and heterogenous [4].

Microorganisms responsible for periimplantitis include anaerobic gram negative, fusiform pathogens and aerobic gram-positive pathogens. Hence, the removal of biofilm from the surface of implant as well as the immediate surrounding area is of utmost importance in the case of periimplantitis [5]. There are various approaches to treating periimplantitis, including both non-surgical and surgical, including flap debridement, laser decontamination, regenerative approach, and many more [2], in the past, systemic and local chemical antimicrobial agents were employed to treat periimplantitis, to decrease the load of periodontal pathogens in comparison to mechanical techniques. Additionally, these treatments were designed to enhance the efficacy of mechanical therapeutic techniques. The use of antimicrobial agents, however has its disadvantages. This includes an increase in the number of resistant microorganisms, use of different antibiotics that are specific to each microbe, a decrease in therapeutic effects in immunosuppressed patients and an increased occurrence of unfavourable reactions.

Consequently, alternative techniques for treating periimplantitis have been recommended as a more suitable solution [3]. Lasers can be used to disinfect implant surfaces and help treat the inflammatory process surrounding the implant in the presence of photosensitizers. This is known as photodynamic therapy. Lasers used in dentistry includes different types of wavelengths that are delivered in continuous, pulsed or continuous wavelengths. The table attached below gives a brief description about various lasers used in dentistry (Table 1) [6].

**Table 1:** Lasers of different wavelength used in clinical dentistry.

| | Common Abbreviation | Wavelength | Waveform | Delivery Tip | Reported Periodontal Applications |
|---|---|---|---|---|---|
| Carbondioxide | $CO_2$ | 10.6 um | Gated/ continuous | Hollow waveguide; beam is focused when it is 1 to 2 mm from target surface | Soft tissue incision and ablation; subgingival curettage |
| Neodymium ttrium-aluminum- garnet | Nd: YAG | 1.064 um | Pulsed | Flexible fiber optic system of different diameters contact with surface is needed for most of the procedures | Soft tissue incision and ablation; subgingival curettage and bacterial elimination |
| Holmium yttrium aluminum- garnet | Ho: YAG | 2.1 um | Pulsed | Flexible fiber optic system; contact with surface is needed for most of the procedures | Soft tissue incision and ablation subgingival curettage and bacterial elimination |
| Erbium yytrium aluminum- garnet | Er: YAG | 2,94 um | Free-running pulsed | Flexible fiber optic system or hollow waveguide contact with surface Is needed for most of the procedures | Soft tissue incision and ablation subgingival curettage; scaling of root surfaces; osteoplasty and ostectomy |
| Erbium chromium yttrium- selenium-gallium- garnet | Er, Cr: YSGG | 2.78 um | Free-running pulsed | Sapphire crystal inserts of varying diameters Contact with surface is needed for most of the procedures | Soft tissue incision and ablation subgingival curettage; osteoplasty and ostectomy |
| Neodymium ttrnum aluminum berovskite | Nd: YAP | 1,340 nm | Pulsed | Flexible fiber optic system; contact with surface is needed for most of the procedures | Soft tissue incision and ablation subgingival curettage and bacterial elimination |
| Indium-gallium arsenide- phosphide; gallium aluminum arsenide; gallium- arsenide | InGaAsP (diode) GaAIAs (diode) GaAs (diode) | Diodes can range from 635 to 950 nm | Gated/ continuous | Flexible fiber optic system; Contact with surface is needed for most of the procedures | Soft tissue incision and ablation; subgingival curettage and bacterial elimination |
| Argon | Ar | 488 to 514 am | Gated/ continuous | Flexible fiber optic system | Soft tissue incision and ablation |

## Photodynamic Therapy

The most commonly used lasers are diode, erbium lasers, $CO_2$ lasers because of their haemostatic properties, bactericidal effects and selective calculus ablation [7]. In today's rapidly growing technological world, the application of photodynamic therapy (PDT) as a means of antimicrobial treatment has become increasingly important. The increase in PDT as an alternative approach to treating a variety of periodontal infections is due to the sudden increase in the number of antibiotic-resistant microorganisms. These organisms living in biofilms are up to 1,000 times more resistant to antimicrobials [8]. Photodynamic therapy is a non-invasive therapeutic treatment used to treat a variety of infections caused by bacteria, fungi and viruses. PDT has been defined as "an oxygen dependent reaction that occurs by action of low energy single frequency light and activation of photoactive materials/photosensitizers" [9]. Photodynamic therapy involves the use of a low-power diode laser in conjunction with photosensitization compounds (Figure 1) [7,10].

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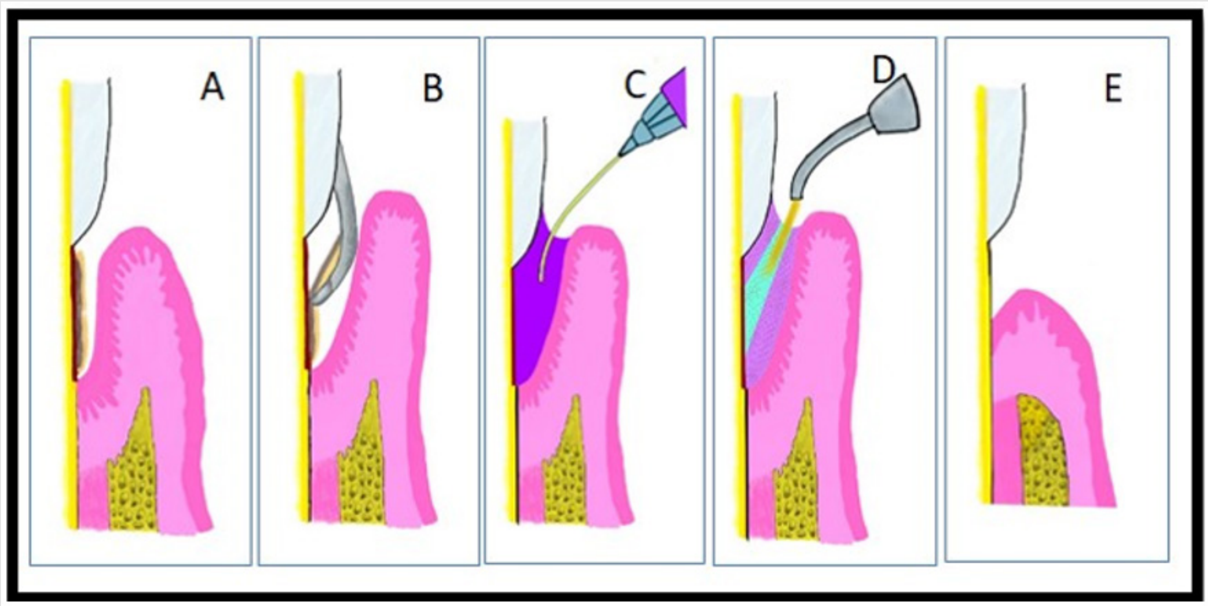


**Figure 1:**

A. Periodontal diseases prior to treatment,
B. Debridement using curette,
C. Photosensitizer application using syringe at the target site,
D. Photosensitization done using intensive light,
E. Wound healing achieved [10].

## Photosensitizers

A sensitizing dye is used to kill the microorganism under the action of visible light. Many dyes used for PDT have inherent antibacterial effects, but the photodynamic bactericide effect is only produced during irradiation. The subgingival and supragingival plaque biofilm on the surface of the tooth are easily accessible to rinse with the dye and activate them by light [11]. In recent decades, low-intensity lasers with photosensitizers have been increased to reduce or eliminate bacteria, also known as aPDT (antimicrobial photodynamic therapy) [5]. Specific photosensitizers used in aPDT are methylene blue (MB), toluidine blue, erythrosine, and hematoporphyrin, and are safe to use. When combined with light, methylene blue is shown to be effective in killing C. albicans, Helicobacter pylori, and influenza viruses. Methylene blue and toluidine blue are known to be highly effective photosensitizers for inactivating periodontal pathogens present in biofilms. Two types of lasers exist in the dental field: high and low power laser irradiation. High-power laser irradiation does not activate the photoactive dyes, as even relatively weak irradiation has a high bactericidal effect. Thus, the light sources used in photodynamic therapy are - argon lasers (488-514nm), gallium-aluminium-arsenide diode lasers (630-690nm) and helium-neon lasers (633nm) [10]. In 2013, Methylene blue (MB) (10 μM) was supplemented with a thiocyanate (SCN-) salt to test whether it improved responses against Staphylococcus aureus and Escherichia coli. Within the solution, MB-SCN produced cyanide ions and sulphite equally.

Each salt when individually added enhanced the aPDT process. The final results showed that thiocyanate enhanced aPDT killing of both bacterial strains in a light dependent and concentration gradient manner [12]. A study conducted to evaluate the efficacy of thiocyanates as photosensitizers to treat peri-implantitis found that thiocyanates can increase photodynamic inactivation of S. aureus in a concentration-dependent manner. was observed. It has also been suggested that thiocyanate can achieve PDT enhancement compared to azide [13]. The use of low-power lasers has been stated to have added beneficial consequences on surrounding cells and tissues, in addition favouring periodontal healing due to potential bioregulatory consequences inclusive of cell proliferation and stimulation [10].

## Mode of Action

Photosensitizing and light individually cannot cause an effective cytotoxic effect on cells. Photosensitizing dyes are usually applied to the affected area through interstitial injection, aerosol delivery or topical application. The photosensitizer is activated by the light that has specific wavelength. This therapy turned out to be a major evolutionary as it was possible to use uniform intensive light with the right low energy to trigger a photodynamic response [10]. The photosensitizing molecules binds to the appropriate cells and when light with specific wavelength is used along with oxygen, it undergoes a transition from basal state of low energy to excited state (Figure 2) [7,12].

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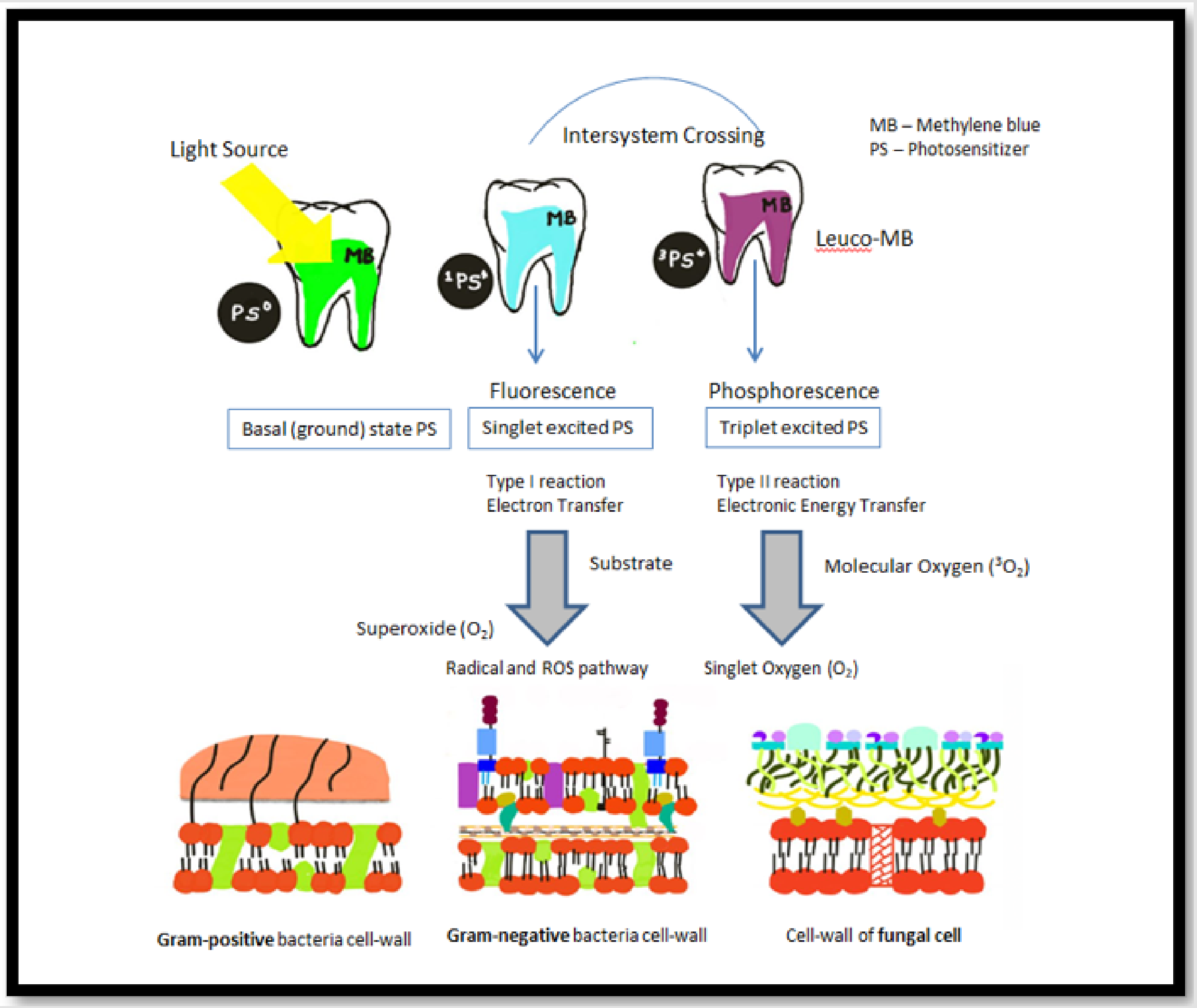


**Figure 2:** Working mechanism of photodynamic therapy [12].

## Conclusion

Periodontal and peri-implant diseases are orchestrated by bacterial challenge and a compromised host response. The treatment of such conditions should thus involve mechanical debridement combined with adjunctive therapies which are capable of minimising the bacterial load and also modulating the local host response. A constant demand for non-invasive yet effective clinical procedures have thus led to the advent and application of Photodynamic Therapy in the field of dentistry. Among the various other agents recently investigated, thiocyanate, a nontoxic inorganic salt, has been shown to potentiate the mechanism of PDT mediated by Methylene blue by imparting antimicrobial properties. Not only that, it has also shown to enhance wound healing of tissues. However, further in-depth clinical studies are necessary to support this review of literature and more Randomised controlled trials should be done to compare the use of thiocyanate and other salts which could enhance the functioning of the photosensitizer used in photodynamic therapy. Nevertheless, LASERs are here to stay and this therapy offers a promising approach which can substitute for chemotherapy in the treatment of periodontal and peri implant diseases.

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**ISSN: 2574-1241**

DOI: 10.26717/BJSTR.2024.57.008990

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