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Photo activated disinfection in Restorative Dentistry: A technical review

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Abstract:
The purpose of this review is to summarize the recent developments regarding photodynamic therapy (PDT) in the field of restorative dentistry. A search of pertinent literature was carried out in PubMed to determine the current applications of photo activated disinfection (PAD) in dentistry. This overview will provide the practitioners, the current status and use of PAD. Within the limitations of the present review, it can be concluded that although PAD cannot replace antimicrobial therapy at its current stage, it may be used as an adjunctive tool in restorative dentistry. Further long-term clinical studies are necessary in establishing a more specific place of the technique in the field of dentistry.

Keywords:
Photodynamic therapy, photosensitizing agent, photo activated disinfection, lactobacilli, streptococcus mutans.

Introduction:
In recent years, the emergence of antibiotic resistant strains, such as methicillin resistant Staphylococcus aureus and vancomycin-resistant Enterococcus faecalis, stimulated a search for alternative treatments. Photodynamic therapy (PDT) has the potential to be such an alternative, especially for the treatment of localized infections of the skin and the oral cavity. Microorganisms that are killed by photo activated disinfection (PAD) include bacteria, fungi, viruses, and protozoa.[1]

Photo dynamic therapy (PDT) involves the use of low power lasers with appropriate wave length to kill microorganisms treated with a photo sensitizer drug.

Photodynamic antimicrobial chemotherapy (PACT) uses a visible light source with photo sensitizer (Fig 1).[2]

The development of resistance to PACT appears to be unlikely, since, in microbial cells singlet oxygen and free radicals interact with several cell structures and different metabolic pathways. PACT is equally effective against antibiotic-resistant and antibiotic- susceptible bacteria.

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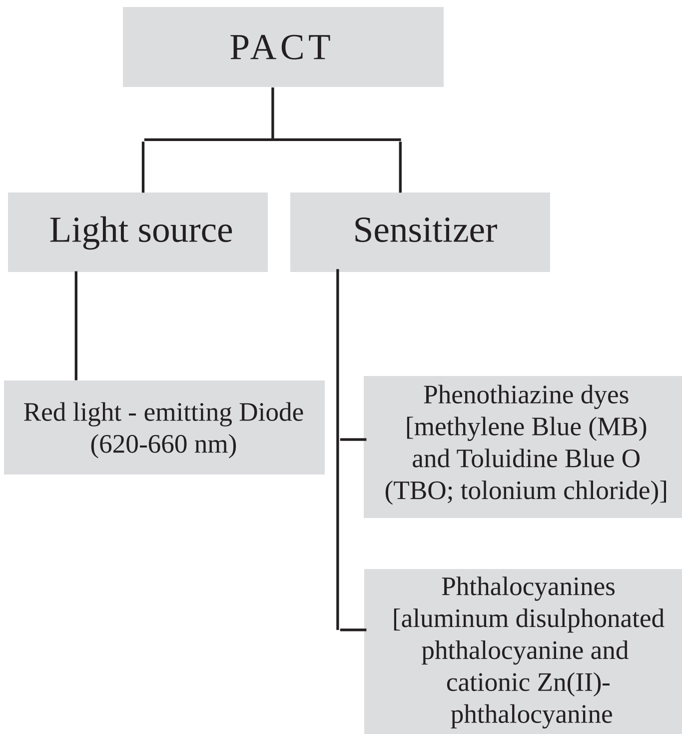
PACT is a process in which microorganisms are treated with a photosensitizing drug and then irradiated with low-intensity visible light of the appropriate wavelength.[3, 4]

Fig 1: PACT



The photosensitizer can be delivered to infected areas by topical application, instillation, interstitial injection, or aerosol delivery. The bacterias that can be destroyed include total Streptococci, Actinomyces, Lactobacillus, Prevotella intermedia, Peptostreptococcus micros, Fusobacterium nucleatum and Enterococcus faecalis.[5] Photosensitizer compound in its ground state is activated by light and transformed into a high energized triplet state.

Two mechanisms of action explain the effectiveness of PACT:

The triplet compound interacts with the cell's organic substrate molecule, producing free radicals and radical ions. These in turn react with endogenous oxygen and reactive oxygen species (ROS) such as hydrogen peroxide and hydroxyl radicals which irreversibly damage the cell membrane. ROS compounds can also damage subcellular organelles and enzymes as well as DNA.

The triplet compound interacts directly with the molecular oxygen to produce singlet oxygen, which is highly reactive. It also causes irreparable cellular damage including the cell wall. Although both mechanisms exist in relation to each other, singlet oxygen generally produces the lethal bacterial effects of PACT. The interaction is extremely rapid, since the radius of action of singlet oxygen is estimated to be on the order of 0.01 to 0.02 µm, corresponding to a lifetime of 0.01 to 0.04 µm in cells.[6]

Photodynamic antimicrobial chemotherapy in a suitably administered photosensitizer may be seen to have the following advantages over "conventional" laser use:

- Nonsurgical (sub ablative) photonic energy values employed
- Primary (indirect) interaction through chemical mediator (photosensitizer)
- Little risk of collateral damage within confined target sites.
- The use of non-collimated light through a diffuser tip can overcome limited access and be further compensated by scatter through the body of the liquid sensitizer. There is limited migration of the molecule from its formative site, thus its effect is much localized.

The advantage is that surrounding structures can be preserved; however, the placement of the photosensitizer should be as close to the infection as possible.[7]

Other applications of PACT:

- Tooth surface disinfection prior to dental treatment.
- Disinfection of infected root canals in endodontics
- Periodontology
- Gingivitis and pericoronitis
- Peri-implantitis[8]
- Treatment of candidiasis
- Treatment of superficial precancers and cancers

Table 1: Various studies done by authors using PACT

Author	Study conclusion
Giusti et al[5]	Use of light emitting diode (LED) energy in association with Photogem or TBO was effective for bacterial reduction in carious dentin, and that the greatest effect on S. mutans and L. acidophilus was obtained with TBO.
Zanin et al[7]	Biofilm model was shown to be suitable for studying changes in bacterial numbers and enamel mineralization and for demonstrating the potential value of photosensitization in the control of in vitro biofilms.
Guqliemi et al[8]	PACT led to statistically significant reductions in mutans streptococci, Lactobacillus species and total viable bacteria. This therapy may be an appropriate approach for the treatment of deep carious lesions using minimally invasive procedures.
Teixeira et al[2]	The same dose of PACT was effective in killing oral microorganisms present in S. mutans biofilms grown in vitro and not effective in killing oral streptococci present in multispecies biofilms grown in situ.
Lima et al[9]	PACT was effective in killing oral microorganisms present in dentine caries produced in situ and may be a useful technique for eliminating bacteria from dentine carious lesions before restoration.
Ribeiro et al[10]	Association of Photogem® and red LED caused severe toxic effects on normal cell cultures, characterized by the reduction of mitochondrial activity and morphological alterations, but did not cause damage to the rat palatal mucosa in vivo.
Silva et al[11]	The high-throughput active attachment biofilm model is applicable for evaluating novel caries-preventive agents on both biofilm and demineralization inhibition. PACT had a killing effect on 24 h. S. mutans biofilms and could inhibit the demineralization process
Ribeiro et al[12]	Authors concluded that significant decrease of mitochondrial activity (90% to 97%) for all Photogem® concentrations associated to blue LED, regardless of irradiation time. It was also demonstrated that the mitochondrial activity was not recovered after 12 or 24 hrs, characterizing irreversible cell damage. PDT-treated cells presented an altered morphology with ill-defined limits.

Conclusion:

In vitro studies and experimental models have shown PACT to be effective on S. mutans and lactobacilli, most commonly isolated microorganisms in carious dentin. Further in vivo studies and human trails, has to be done before this therapy can be used for the management of deep carious lesions with minimally invasive procedures.

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