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Antimicrobial photodynamic therapy as an adjunctive therapy in dentistry

Shima Afrasiabi; Nasim Chiniforush*

Laser Research Center of Dentistry, Dentistry Research Institute, Tehran University of Medical Sciences, Tehran, Iran.

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***Corresponding Author:** Nasim Chiniforush, Laser Research Center of Dentistry, Dentistry Research Institute, Tehran University of Medical Sciences, Tehran, Iran. Tel/Fax: +98-2188384303.
Email : n-chiniforush@sina.tums.ac.ir.

Abstract

Oral health is an important factor in maintaining general well-being. Dental caries, endodontic, and periodontal diseases can affect oral soft and hard tissues in the oral cavity. Due to traditional chemo- mechanical method risks in dentistry, antimicrobial photodynamic therapy (aPDT) as an interesting therapeutic approach has been developed. This review focused on the role of aPDT as an adjunctive therapy in dentistry.

Keywords: Antimicrobial photodynamic therapy, dentistry, periodontal infection, endodontics dental caries.

Introduction

The long-term success rate of conventional treatment depends on several factors, such as the diverse and complex anatomy of the target sites, which do not allow direct access during the biomechanical preparation [1]. Therefore, complete removal of bacterial deposits in vivo is accomplished rather seldom, and bacterial reservoirs can survive in mechanically inaccessible areas. In order to maintain stable, long-term results after therapy, supportive therapy has to be performed in regular intervals [2].

Antimicrobial photodynamic therapy (aPDT) as a complementary therapy in dentistry seems to be a relatively new method towards traditional antimicrobial chemotherapy. aPDT uses non-toxic photosensitizer in combination with a harmless visible light source in the presence of oxygen [3]. Photosensitizer has an important role in the outcome of aPDT [4]. The numerous studies have shown that efficient bactericidal effect of aPDT [1,5,6]. This review will focus on the role of aPDT in dentistry.

History

The application of light as a potential therapeutic factor can be traced back thousands of years. The ancient Egyptians treated some skin diseases with herbs and sunlight. They used natural photosensitizers such as oralens photosensitizers to treat leprosy lesions. Oscar Raab, a medical student, found that dyes such as acridine combined with light could kill Paramecium species, and that acridine was not effected without light exposure. A few years later, Von Tappeiner finally coined the term “photodynamic phenomenon” [7].

Mechanism of action of aPDT

In the aPDT process, when the photosensitizer components are exposed to a certain wavelength of light, they obtain higher energy levels through the transfer of electrons. At this excited stage, the photosensitizer can react with oxygen to produce hydrogen peroxide (H_2O_2), superoxide anion radical (O_2), and hydroxyl radicals (•OH) [type 1] or react with molecular oxygen to form single ($^1O_2$) [type 2]. The generated ROS in these reactions can cause significant damage to microorganisms and irreversibly alter their metabolic activity, resulting in the death of the target cell [8].

Role of aPDT in periodontal infection

In periodontology, the application of aPDT could be useful, either for restricting antibiotic therapy or for improving treatment results [9]. Systemic use of antibiotics causes side effects including gastrointestinal intolerance and the development of bacterial resistance. Furthermore, it is also limited due to lack of access to periodontal pathogens in periodontal pockets [10,11]. Therefore, aPDT may be effective on the healing outcomes (reduction in bleeding on probing and reduction of probing pocket depths) as an adjunctive therapy to scaling and root planning (SRP) of advanced periodontitis and in sites with difficult access [12]. Several studies suggested that bacterial counts related to periodontitis reduced if SRP was potentiated with aPDT [13-15].

Role of aPDT in endodontics

In endodontics field, aPDT may be a valuable add-on for decontamination of highly infected root canals [16]. Several microorganisms are resistant and considered to be difficult to eliminate from infected root canals. Enterococci are most often involved in persistent infections with endodontic treatment failures [17]. Several studies demonstrated complete eradication of resistant bacterial strains from the root canals cannot be effectively achieved [17-19]. Yamamoto et al. reported that aPDT leads to a significant reduction of bacterial

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load in root canals infected with Enterococcus faecalis [17]. Likewise, Garcez et al. compared microbiological samples subsequent endodontic treatment before and after treatment with conventional surgery alone or in combination with aPDT. Following aPDT treatment, a 5-log reduction in bacterial counts was observed. They reported periapical healing of 78% during a 36-month follow-up [19].

Role of aPDT in dental caries

Pulp exposure after direct complete excavation could be expected [20]. As the contemporary manner, partial caries removal appears a promising minimally invasive policy for caries-affected dentin, in order to help maintain tooth structure and avoid the risk of pulp exposure or root canal treatment [4]. There is a growing demand for clear guidelines or methods that facilitate caries management with minimally invasive [21]. aPDT as a favored procedure has received attention due to reducing the bacterial load in cariogenic biofilms [22]. Furthermore, aPDT as a supplementary modality for partial removal of dental caries may give the pulp a chance to recover, thereby reducing the risk of pulp exposure [5].

Conclusion

Oral infection can deliver many challenges to clinicians. The adjunctive use of aPDT appears to provide better clinical outcomes in dentistry.

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