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Antimicrobial properties of laser treatment in periodontal therapy

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Abstract. Periodontitis is a multifactorial disease with complex inflammatory responses caused by the disruption of normal homeostatic processes by oral bacteria in the periodontal tissue. In periodontal therapy, the clinical-microbiological properties of the laser therapy may positively affect wound healing. This study involves extensive literature review to examine the antimicrobial impact of laser therapy on the progression of post-treatment periodontal tissue responses. The literature we reviewed was searched and compiled from Pub Med using the following terms: antimicrobial properties, laser technology, periodontal therapy, periodontitis, laser therapy, and periodontal wound healing. As per the literature review, the laser treatment exhibits antimicrobial activity, indicated by the decrease in biofilm formation and enhanced wound healing of the periodontal tissue. Laser technology is a recent approach employed for the management of periodontal disease. Various wavelengths are effective and have antibacterial effect. The comparison of different lasers and their effects on the periodontal tissue is difficult because of the availability of a wide range of treatment protocols for using laser.

1. Introduction

Periodontitis is a multifactorial disease characterised by complex inflammation and disruption of normal homeostatic processes by bacterial species found in subgingival plaque [1]. Severe damage caused by periodontal disease can cause pain, reduced effectiveness of mastication and loss of teeth [2]. Pathogens in the oral microbiota that colonise the teeth surfaces enter the periodontal tissues and form subgingival plaque biofilms. In general, the pathogenesis of periodontitis is a complex interaction between microbes, host tissues and individual immune responses [3], which are then modified by various factors, including environment, age and habits, such as smoking [4]. Indeed, periodontitis occurs when a species of pathogenic bacteria begins to dominate and defeats the host defence system, triggering dysregulation of the immune response, thereby causing chronic inflammation.

Periodontitis is categorised as a recurrent disease, particularly if the treatment is less effective. Generally, periodontitis treatment procedures involve scaling and root planning, application of local



antiseptic, administration of systemic antibiotics, periodontal surgery and in the worst cases, tooth extraction [5, 6].

The effectiveness of treatments of periodontal disease can be maximised by increasing decontamination in periodontal tissue, particularly in the periodontal pocket, as well as ensuring radiologically monitorable bone mineralisation and regeneration. Literature review shows that the use of lasers can enable long-lasting decontamination against invasion of pathogenic bacteria in the periodontal tissues [7].

Over the past decades, increasing use of lasers in dentistry has resulted in remarkable technological inventions for use in dental care. In the treatment of periodontal disease, the most commonly used lasers include CO₂, Neodymium: yttrium-aluminum-garnet (Nd:YAG), and Erbium:yttrium-aluminum-garnet (Er:YAG). These are generally used to remove calculus, facilitate osseous surgery and reduce soft tissue impairments, such as gingivectomy, curettage and melanin pigmentation removal [8].

The use of lasers in periodontal treatment is believed to maximise decontamination during treatment, provide antiseptic action on nonvascularised tissues (such as bone and dentine) and overcome subgingival biofilm resistance to antibiotics [9].

In addition, several studies [10, 11] have shown that laser irradiation can induce the activity of fibroblasts and osteoblasts, for example, the activation of pathways associated with BMP-2 signalling increases the production of collagen during the periodontal healing phase. However, these results have been reported in a limited number of cases; thus, our systematic review was undertaken to broadly explore the use of periodontal lasers against microbial activity to aid periodontal healing.

2. Methods

Numerous research papers were compiled from *Pub Med* using the following terms: antimicrobial properties, laser technology, periodontal therapy, periodontitis, laser therapy, periodontal wound healing.

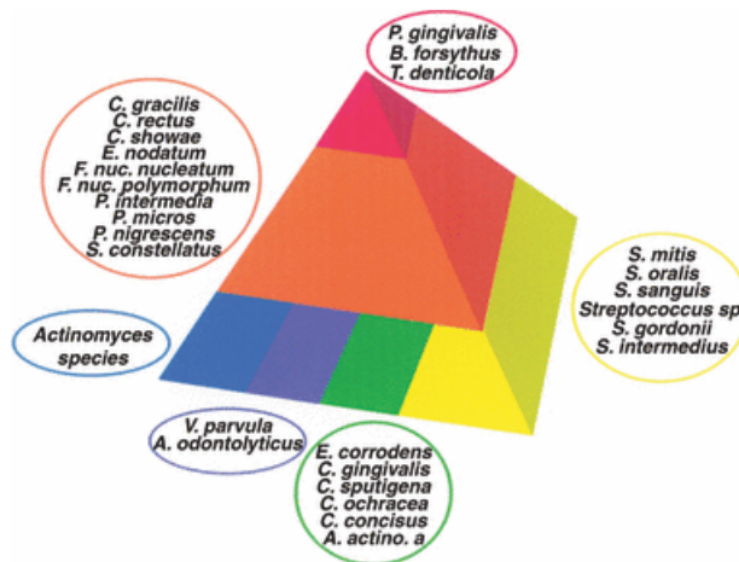


Figure 1. Periodontal pathogens.

3. Results and Discussion

3.1 Periodontal pathogens

Socransky et al. [12] proposed that microflora in plaque is a successive series of colonisations by periophorogenic bacteria, culminating in a triumvirate of *Porphyromonas gingivalis*, *Treponema denticola* and *Bacteriodes forsythus*. They referred to this as 'red group'. Each group of organism determines the location or builds a base for colonisation at the next level and this process is represented as a pyramid in Figure 1. Non-surgical therapy aims to destroy as many of these pyramids as possible to prevent the formation of climactic populations sufficient to cause disease progression [13].

3.2 Laser in periodontal treatment

Lasers have been used in periodontal treatment since the mid-1980s. Light Amplification of Stimulated Emission by Radiation (Laser) creates a collimated beam, with a single wavelength and colour. Photon rays that reach biological tissues can be reflected, dispersed, absorbed or transmitted to surrounding tissues. Lasers can cause excellent tissue ablation, bactericidal and detoxifying properties that leave little or no smear layer so that can stimulate surrounding cells to improve healing [13].

Dental lasers are classified into several categories based on wavelength, with most used for dental applications being in the range 500–10,000 nm. Several media exist to generate this energy, ranging from semiconductors to crystals, and each creates a particular wavelength with a unique affinity for a respective target (chromophore) based on absorption coefficients and depth of penetration (Figure 2) [14].

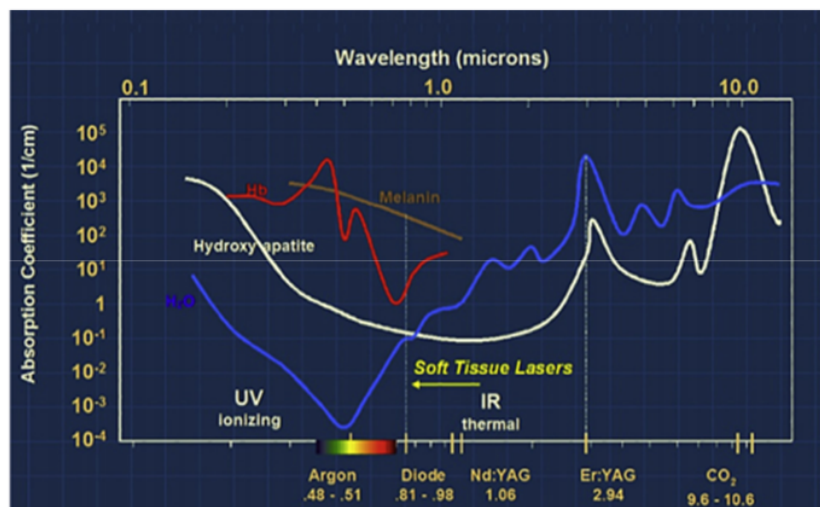


Figure 2. Approximate net absorption curves of various tissue components.

The most widely used lasers in dentistry are carbon dioxide, Neodymium: yttrium-aluminum-garnet (Nd: YAG), Erbium: yttrium-aluminum-garnet (Er: YAG) and diode laser. Initially, these tools were only employed in hard tissue procedures, such as caries removal and cavity preparation. Lasers in periodontology were originally used to remove calculus; however, it caused thermal damage to the underlying tooth structure, which included carbonisation, microcracking, melting and resolidification on dentin and root surfaces [13].

In recent years, lasers have been developed so as to cause no thermal damage to the pulp and tooth structure during treatment. The most commonly used laser images in current periodontal treatment are summarised in Table 1.

Table 1. Periodontal laser.

Laser	Wavelength (nm)	Chromophore	Reference
Carbon dioxide	9.3–10.5	Hydroxyapatite, water	Aoki A, <i>et al.</i> [15]
Nd:YAG	1064	Melanin, water, dentin	Cobb CM [16]
Er:YAG	2780–2940	Water, hydroxyapatite	Aoki A, <i>et al.</i> [17]
Diode	812–980	Melanin, water	Darby I [13]; Low SB and Mott [14]

3.3 Antimicrobial activity of laser therapy

The presence of bacteria in the gingival sulcus and periodontal connective tissues is a determining factor in the development of periodontitis [18]. In areas of difficult access in the mouth, such as furcations, invaginations and concavities, the use of manual curettes or ultrasound is not sufficient to ensure the eradication of periodontal pathogenic bacteria. Based on these facts, alternative methods are being studied for formulating more efficient therapies, such as antimicrobial phytochemicals and light-activated killing agents [19].

The development of laser technologies and the discovery of their significant antimicrobial effects has resulted in the introduction of these treatment modalities as possible coadjuvants in the treatment of periodontitis. Different from high-power lasers, the low-power variations do not increase tissue temperature [20], and therefore when used alone, the same antimicrobial effect as that of high-power lasers cannot be expected [21]. Instead, the antimicrobial effect of low-power lasers is achieved in association with extrinsic photosensitisers, which results in the production of highly reactive oxygen species [22] that cause damage to membranes, mitochondria and DNA, resulting in the death of the microorganisms [23–25].

For effective treatment of bacterial infectious diseases, it is essential to have an adequate light source and a photosensitiser that is capable of binding to the targeted pathogen, so that photosensitisation may occur in either subgingival or superficial oral tissues. Different light sources have been studied, such as light emitting diodes [26, 27], conventional light [28, 29] and low-power lasers [30]. The interaction between the photosensitiser and microorganisms occurs within a few minutes, and this incubation or preirradiation time must be considered before laser irradiation [31,32].

Several *in vitro* studies have demonstrated that some microorganisms related to periodontal disease are significantly suppressed by antimicrobial photodynamic therapy under different environmental conditions (pure cultures, pure or multispecies biofilms). The list of such microorganisms presently includes *Porphyromonas gingivalis*, *Aggregatibacter actinomycetemcomitans* (previously *Actinobacillus actinomycetemcomitans*), *Fusobacterium nucleatum*, *Prevotella intermedia* and *Streptococcus sanguis* [30,33–36].

Literature review shows that laser treatment has antimicrobial effects, which is indicated by the decrease in biofilm formation and enhanced wound healing of periodontal tissue (Table 2).

Table 2. Antimicrobial activities of periodontal laser.

Reference	Result
Qin YL, <i>et al.</i> [36] Komerik N, <i>et al.</i> [37] de Almeida JM, <i>et al.</i> [38]	a decrease in bone loss and reduction of periodontal signs of redness and bleeding on probing after periodontal treatment
Yilmaz S., <i>et al.</i> [39] de Oliveira RR., <i>et al.</i> [40] Dortbudak O., <i>et al.</i> [41] Chondorus P., <i>et al.</i> [42]	effective in the treatment of chronic and aggressive periodontitis and peri-implantitis, and even in treatment maintenance at follow-up session

Table 2. *Continue*

Reference	Result
Qin YL, <i>et al.</i> [36]	reduces the signs of inflammation and microbial infection without any harmful effects on adjacent periodontal tissues
Luan XL., <i>et al.</i> [43]	potential effect in improving wound healing
Jori G, <i>et al.</i> [31]	reduced probability of side effects associated with the systemic administration of antimicrobial agents
Chan Y. and Lai CH.[32]	suppresses microorganisms in a short time by producing reactive oxygen species that interact with various cell structures and targets.
Bhatti M., <i>et al.</i> [23]	
Bhatti M., <i>et al.</i> [24]	

Although more controlled clinical studies are still required to better understand the effectiveness of lasers in treating periodontal diseases, the *in vitro* and *in vivo* studies presented in the current literature review indicate that periodontal lasers may become a successful modality in the management of periodontal disease.

4. Conclusion

Laser technology is a relatively new approach being utilised in the management of periodontal disease. Various wavelengths employed in laser treatment have been shown to have significant antibacterial effects. The comparison of different lasers and their effects on the periodontal tissue is difficult because of the availability of wide range of protocols for using laser.

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