Photodynamic therapy in periodontal therapy: Microbiological observations from a private practice

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In recent years, the combination of laser light and photosensitizer known as *photodynamic therapy* (PDT) has been used in periodontal therapy. However, there are not enough clinical studies to fully evaluate the effects of PDT on the periodontal tissues. This microbiological study examined the effects of PDT on the periodontal bacteria in combination with scaling and root planing (SRP) in the same group of patients by randomly selecting PDT or SRP for use in different quadrants of the mouth.

For the present study, PDT was compared with a diode laser (980 nm) and an Nd:YAG laser (1,064 nm). Microbiological samples were examined and evaluated over a period of three months. Significant bacterial reduction has been observed in all cases. The diode laser with SRP presented long-term positive results, while PDT showed a significant bacteria reduction during the entire observation period.

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Various clinical guidelines for the treatment of periodontitis have been used successfully in daily practice, and the different methods of therapy and the various recall intervals are well-documented in the literature.[1,2] However, antibiotic therapy is also necessary for subjects who are refractory for treatment or have an aggressive type of periodontitis. Concerns about resistance to and the side effects from antibiotic therapy indicate the need for alternative methods of treatment.

Recent years have seen an increased focus on using laser systems as an adjunct in periodontal therapy.[3-5] Clinicians and researchers have different opinions regarding the results of laser-tissue interactions and the laser wavelengths that are used. Photodynamic therapy (PDT) uses a laser in combination with a dye, thus utilizing the power of light and its resulting antibacterial properties.[6-8] PDT is used primarily as an alternative to chemotherapy or radiotherapy for the treatment of cancer on a routine basis; in addition, PDT has been used effectively to reduce bacteria or viruses in the fields of dermatology, cardiology, ophthalmology, and gastroenterology.[9]

In periodontal disease, the inflamed junctional epithelium at the bottom of the sulcus migrates apically, thus establishing the environment of the periodontal pocket. This migration is caused directly by microorganisms and indirectly by the potentially harmful side effects of the inflammatory response to the accumulation of plaque.[10,11] The inflammatory response to plaque is a fundamental defense mechanism of the organism against microbial infections.[12] However, this defense reaction simultaneously leads to tissue destruction, and the cytokines and prostaglandins can stimulate bone resorption. It appears that changes in the microflora can be very different from person to person as well as from site to site in the same person. In pocket formation, there are periods of disease activity followed by clinical findings, such as bleeding and suppuration.[11] A disease can be prevented not only by a specific kind of treatment against periodontopathogenic microorganisms, but also by influencing the environmental factors that promote changes to equilibrium in the microflora.[12]

One must understand the mechanisms of inflammation and the therapeutic options for controlling the growth of the anaerobic microorganisms. Etiological cofactors like stress, occlusal trauma, and smoking can have a negative effect on tissue response. Changes in the immune system that result from systemic factors (that is, diabetes mellitus and thromboembolic, cardiovascular, and allergic and rheumatic diseases) have been shown to affect the periodontal tissues.[13]

Typical periodontal treatment begins with professional prophylaxis, followed by a manual or mechanical debridement of the diseased root surfaces. In certain situations, surgery may be necessary to access the root surface and thus reduce bacteria and establish periodontal health. Bacteria or their

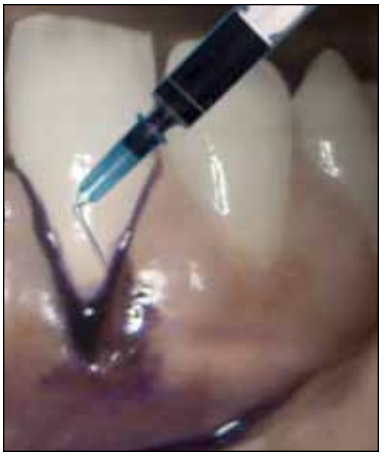


Fig. 1. A photosensitizer is applied to a sample receiving PDT.

Fig. 2. The pocket is irradiated for a second time using PDT.

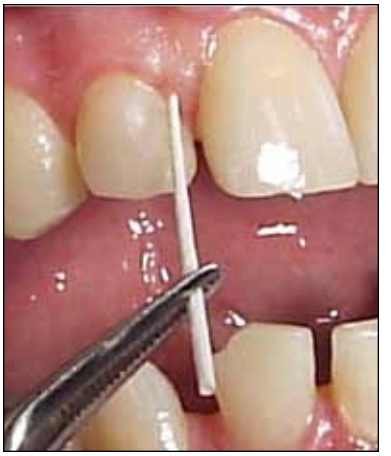


Fig. 3. A sample taken six weeks after the start of therapy.

endotoxins may remain even after complete treatment, and recolonization may lead to further loss of attachment.[14]

Laser-assisted therapy, which should lead to a greater reduction in bacteria, is a controversial subject.[3,15,16] The literature has discussed the risk of thermal damage to the surrounding tissues and tooth structures.[17,18] Antimicrobial agents (such as chlorhexidine) or local and systematic antibiotic administration (tetracycline, amoxicillin, or metronidazole) generally are recommended for periodontal therapy.[19] However, the current increase in resistance to antibiotics must be considered and antibiotic therapy should follow bacterial analysis.[13] Possible allergic reactions to mouthrinses must be considered as well.[20]

PDT might also be used to control specific pathogenic microorganisms. According to the literature, periodontopathogenic germs (particularly *Prevotolla intermedia, Porphyromonas gingivalis, Fusobacterium nucleatum*, and *Actinobacillus actinomycetemcomitans*) can be significantly reduced by low-energy laser light if the cells are marked beforehand with photosensitive dyes.[21-26] This study sought to compare the antimicrobial effects of PDT with those of other laser wavelengths during periodontal therapy in a group of patients with periodontitis.

Materials and methods

Ten patients (between 40 and 50 years of age) with active periodontal sites (in a total of 253 teeth) were treated with scaling and root planing (SRP). None of the patients were smokers, had implants, had any significant findings in their medical history, or had received antibiotic therapy within the last six months prior to the start of treatment. At a re-evaluation six weeks after SRP, different laser systems were assigned randomly to the four tooth quadrants.

For Group 1, 62 sites received SRP and irradiation from an Nd:YAG laser (with a wavelength of 1,064 nm). For Group 2, 63 sites received SRP and irradiation from a diode laser (with a wavelength of 980 nm). For Group 3, 63 sites received SRP and PDT using a wavelength of 670 nm. The last quadrant (Group 4; 64 sites) received only SRP and served as the control group.

For Groups 1 and 2, the sulcus was first widened with the laser (using a 400 µm fiber), then scaled and irradiated (at a laser setting of 2 W) for 20 seconds in the periodontal pocket. The sites in Group 3 assigned to receive PDT were scaled before the application of a photosensitizer (Helbo Blue, HELBO Photodynamic Systems) (Fig. 1). At that point, the pocket was irradiated with a low-intensity laser (Minilaser 2075 dent, HELBO Photodynamic Systems) for 20 seconds. The photosensitizer was left in the sulcus for 60 seconds before the residual dye was washed out using saline solution; at that point, the pocket was irradiated again for 20 seconds (Fig. 2). In total, 325 microbiological samples were taken from sites (one or two sites per quadrant), all of which had a pocket depth of more than 5 mm (Fig. 3) six weeks after initial treatment (baseline); samples were collected at three days, seven

Table. Percentage of examined sites that demonstrated complete reduction of bacteria (in %) at examined sites.

	Groups			
	1	2	3	4
A. actinomycetemcomitans	Reduction not complete	Reduction not complete	Reduction not complete	Reduction not complete
Porphyromonas gingivalis	22.22	10.00	27.27	16.67
Prevotolla intermedia	22.22	11.11	25.00	25.00
T. forsythensis	9.09	13.33	14.29	18.75
Peptostroptococeus micros	7.14	11.11	33.33	18.75
F. nucleatum	Reduction not complete	5.56	Reduction not complete	5.88
T. denticola	Reduction not complete	11.76	40.99	16.67

days, one month, and three months after the initial therapy.

The microbiological sample analysis was performed to evaluate the presence of the seven marker germs: *A. actinomycetemcomitans, Porphyromonas gingivalis, Prevotolla intermedia, Treponema forsythensis, Peptostreptococcus micros, F. nucleatum,* and *T. denticola.*

Results

The table indicates the percentage of sites in each quadrant that eliminated bacteria as a result of treatment. Charts 1–4 indicate the bacterial reduction of the individual marker germs at the various sampling times.

Based on the results of the present study, Group 3 achieved the greatest bacterial reduction among all examined individual germs. Three days after treatment, Group 2 showed a 67.72% reduction compared to baseline ($p < 0.05$), Group 4 showed a 64.11% reduction ($p = 0.05$), and Group 3 reported a reduction of 87.57% ($p < 0.05$). Group 1 achieved less reduction compared to baseline (55.31%; $p < 0.05$). The total overall results for all groups improved at seven days.

After one month of treatment, Group 2 reported a 62.20% reduction in bacteria ($p < 0.05$) compared to baseline, compared to 42.7% for Group 1 ($p < 0.05$) and 54.43% for Group 4 ($p < 0.05$). Group 3 produced the greatest reduction in bacteria ($p > 0.05$) after one month (80.11%) and after three months (91.37%). Three months after the start of therapy, Group 1 reported a 48.14% reduction in bacteria ($p < 0.05$), while Group 2 reported a 71.65% reduction and Group 4 reported a 54.22% reduction ($p < 0.05$).

Discussion

The present study showed that PDT was particularly efficient at reducing pocket bacteria compared with the other laser-assisted treatment groups.[23,26] However, the literature indicated that PDT led to a greater reduction of *F. nucleatum* than could be confirmed in the present study.[23,25] In the present study, different therapies each resulted in significant reductions of bacteria.

It is possible that the so-called *biostimulation* using a low-intensity laser will become more popular than the traditional method of treatment.[27,28] The long-term success observed in the present study suggests not only that the mechanism of cell destruction has clinical significance, but also that stimulation of wound-healing mechanisms and alterations in the intra- and extracellular cell areas may play a significant role in healing. Further multicenter and controlled studies (using longer periods of observation) are necessary to uncover the mechanisms of the cellular biological processes after laser irradiation.

Complete elimination of the examined bacteria was not observed in all cases. It should be considered that, in general, antibiotic therapy is not always clinically effective when the pathogenic germs (*A. actinomycetemcomitans, Porphyromonas gingivalis,* and *Prevotolla intermedia*) are present, particularly in cases of aggressive forms of periodontitis. To reduce the risk of resistance, a microbiological sampling should be conducted to determine which germs are present and thus select the correct antibiotic therapy.

Porphyromonas gingivalis is not found in the normal flora of periodontally healthy individuals.[4] *Porphyromonas gingivalis* has a high pathogenic potential.[19] Although *Porphyromonas gingivalis* is an anaerobic germ, most patients can eliminate it from the oral cavity through normal periodontal therapeutic methods. *A. actinomycetemcomitans* is a key germ found in aggressive forms of periodontitis that appears only occasionally in healthy individuals; it is considered responsible for many cases of advanced attachment loss in adults, even among those who have received generalized mechanical debridement.[5] Clinical

Chart 1. Reduction of each type of germ (%) three days after the start of testing.

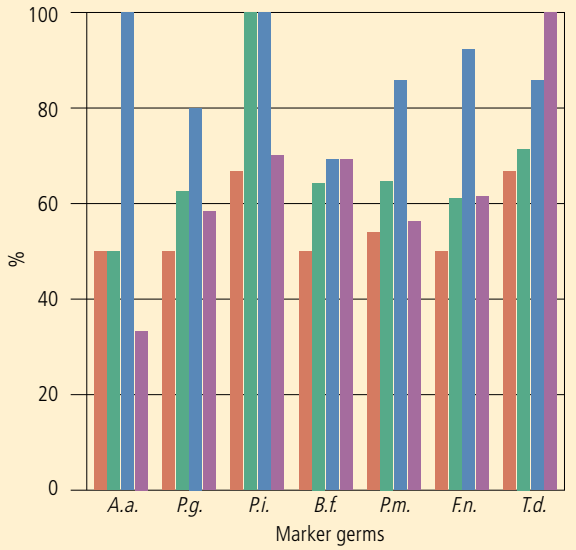


Chart 2. Reduction of each type of germ (%) seven days after the start of testing.

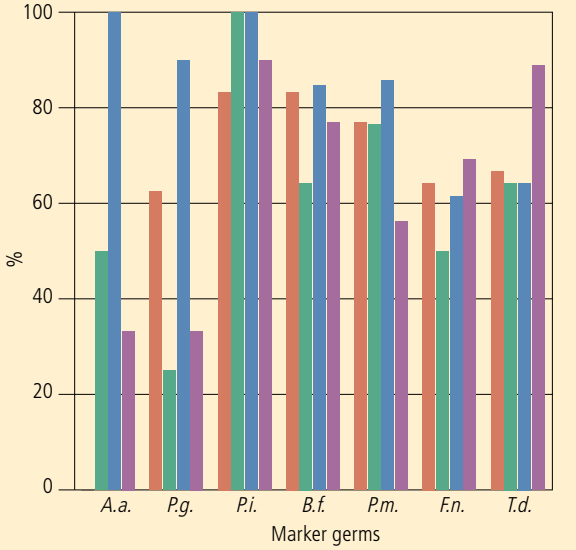


Chart 3. Reduction of each type of germ (%) one month after the start of testing.

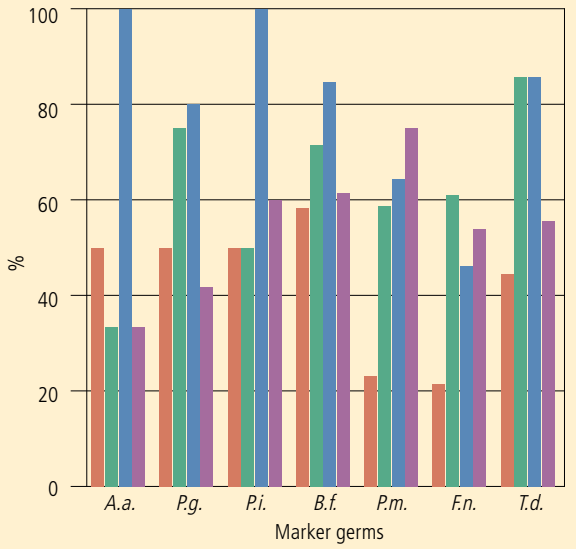
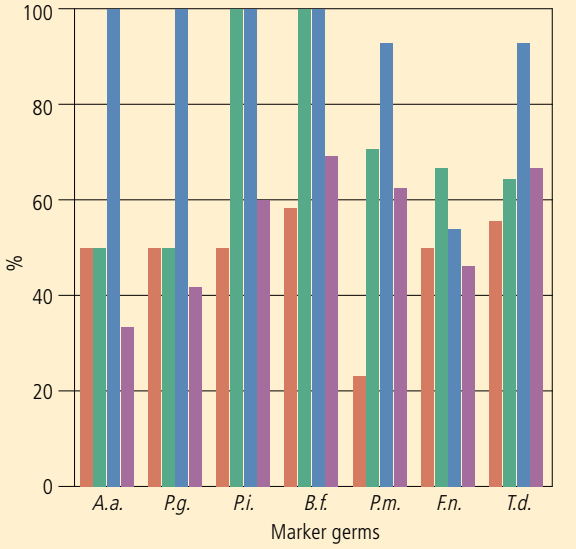
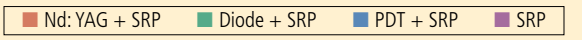


Chart 4. Reduction of each type of germ (%) three months after the start of testing.





studies have shown a direct association between the complete elimination of *A. actinomycetemcomitans* and the success of therapy in susceptible individuals.[11] *Prevotolla intermedia* is a typical opportunistic inhabitant in the oral cavity; it appears commonly in the general population (even occurring in periodontally healthy individuals) and especially among periodontitis patients.[11] Due to its widespread distribution, it is unrealistic to consider eliminating *Prevotolla intermedia* completely; rather, the goal of treatment should be to reduce this species of bacteria to an acceptable level in the periodontal tissues. Because

these pathogenic species have an additional systemic effect (due to their transmission and ability to penetrate into the bloodstream and the gastrointestinal tract), PDT could be utilized to significantly reduce bacteria and thus improve the clinical outcome.

Unlike other laser wavelengths, PDT does not require dentists to use local anaesthesia; as a result, PDT can be applied during the initial phase of periodontal treatment (as an adjunct to SRP).

PDT may be especially relevant for pregnant women because a high prevalence of *Prevotolla intermedia* is associated within the second trimester, in pregnancy-associated periodontitis, or in patients with a compromised medical history. Based on the authors' experience, antibiotic administration appears to be unnecessary when PDT is used. PDT's bactericidal effects on periodontopathogenic bacteria mean that it also can be used as an adjunct treatment to SRP. A 2007 study by Andersen *et al* 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.[29]

In general, the photosensitizer dye absorbs photon energy and forms singlet oxygen (O_2), which is capable of reacting with biological systems and destroying them.[9] Specifically, O_2 exerts strong cytotoxic effects, destroying cellular constituents and microorganisms, such as viruses, bacteria, protozoa, and fungi. A higher level of energy may result in the formation of hydroxyl radicals reacting with organic molecules in redox reactions; oxidative destructions of the membrane lipids and enzymes may cause cell destruction. This biochemical effect occurs frequently in the unsaturated fatty acids of the bacterial membranes and infrequently in the membranes of healthy cells, which have a defense mechanism against radicals.[6,30]

Even though PDT has no routine use in daily practice, there are potential benefits for this therapy beyond mechanical debridement. The amount of cementum that must be removed is reduced significantly, which allows for better tissue regeneration without an increased risk of hypersensitivity. Furthermore, PDT's antibacterial effects are advantageous for patients with systemic diseases (such as cardiovascular diseases, diabetes, and immunosuppresion) and for those who display high resistance to antibiotic therapy.[31]

PDT cannot perform the various applications of other lasers during the surgical stage of periodontal therapy (that is, incision, excision, or carbonization), but it may improve both the wound healing mechanisms and the regenerative potential of cells. Additional research is necessary to examine these possibilities.

Conclusion

This study compared PDT's ability to reduce bacteria with that of diode and Nd:YAG lasers. During an observation period of three months, the examined periodontal sites showed significant bacterial reduction when PDT was used as an adjunctive therapy to SRP.

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