The Effect of 808-nm GaAlAs Diode Laser Treatment on Periodontal Pockets and Gingival Health During Routine Prophylaxis: A Randomized Clinical Trial

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ABSTRACT

Objective: The aim of this study was to examine the effect of the 808 ± 5 nm diode laser during routine periodontal maintenance prophylaxis on gingival health and on periodontal pocket depth.

Materials and Methods: Seventy-seven subjects were randomly assigned in two groups. All subjects had periodontal pockets depths measured and the Gingival Index (GI) taken. Each group received a prophylaxis and oral hygiene instruction, but only the Laser group was treated with the laser. Three months later, the subjects returned and the measures were recorded.

Results: The mean for the entire mouth pocket depths was significantly reduced by the laser treatment (P value < 0.05) compared to the Control group. Under Löe's Gingival Index criteria, the GI significantly improved in the Laser group as compared to the GI of the Control group (P value < 0.01).

Conclusion: Laser treatment during routine periodontal maintenance and prophylaxis significantly reduces the depth of the periodontal pockets; thus, the laser is useful in improving gingival health in patients undergoing periodontal maintenance in a 3-month interval. Its use should be considered by all dental professionals during periodontal maintenance in treating patients who exhibit periodontal pocketing, particularly in conjunction with dental prophylaxis.

INTRODUCTION

Nearly half of adults over 30 years old in the United States suffer from some form of periodontal disease.[1] Eighty-six percent of adults have multiple sites with 3 mm or greater attachment loss, and should undergo periodontal therapy.[1] In periodontal therapy, dental practitioners aim to reduce pocket depths to minimize periodontal attachment loss and alleviate gingival bleeding. After initiating periodontal treatment, most general dentists and periodontists recommend that these patients continue routine prophylaxis every 3 months for maintenance.[2] Many studies have demonstrated that improved oral hygiene and regular professional dental prophylaxis can prevent recurrence of disease.[3-4] Axelsson *et al.* followed adult subjects for a 15-year longitudinal study.[5] They found that plaque control measures, topical fluoride, and repeated regular professional teeth cleaning reduces the occurrence of caries and periodontal disease. However, they also report this regimen was ineffective for a small number of subjects. Use of the diode laser may be useful for cases in which standard periodontal maintenance alone is inadequate.

In the past decade, laser use has increased in the medical and dental fields. A number of lasers are utilized in dentistry with various wavelengths and power settings.[6-7] Several factors play a role in achieving different functions: photostimulation, photoablation, and bacterial reduction.[8-10] For example, when employing a laser at a photostimulation setting, such as an 808-nm laser with a power setting of 10 milliwatts (0.01 Watt) in continuous mode, the clinician can promote healing and avoid ablation or cutting. When the target tissue containing water is raised to 100°C vaporization occurs and the tissue is ablated. At an ablative power level setting, such as an 808-nm laser at a power setting of 1.5 Watts using an initiated tip in continuous mode, the clinician can achieve photoablation to cut or remove tissue, such as in a gingivectomy or excision of a lesion. At a bacterial reduction setting, such as an 808-nm laser at a power setting of 1.5 Watts using a noninitiated tip with a pulse duration of 10 Hz, 0.05 seconds, the clinician can achieve bacterial reduction. Further, one can use an initiated laser tip, which focuses the laser energy to the tip where the dark pigment is located and activates the cutting ability. A noninitiated laser tip can become initiated by operating the laser tip against a pigment, such as blue articulating paper. A noninitiated tip does not focus the laser energy to the tip only so little to no "cutting" occurs. The laser will also generate greater heat when lasing a continuous beam than when it is set to pulse (in pulse mode). A pulsed laser will allow cooling of the tissue between cycles of the emission of laser energy.

Lasers offer benefits to periodontal therapy including hemostasis,[6] minimizing pain,[11] and bacterial reduction.[12] Previous studies have demonstrated that the diode laser is useful as an adjunct in periodontal therapy. For example, researchers have reported possible beneficial effects of laser therapy, including *in vitro* stimulation of fibroblasts[13] and a decrease in inflammatory mediators.[14] One study found that over a 2-year period, the laser-treated group maintained clinical attachment levels significantly better in comparison to the group with scaling and root planing alone.[15] However, some researchers have indicated that the laser did not offer any additional benefits.[16-18] Schwarz *et al.* noted that when researchers employed the diode laser in conjunction with nonsurgical procedures, periodontal scaling and root planing, they yielded mixed results.[19] Several authors have also indicated that more studies need to be performed to determine the effectiveness of the diode laser.[19-20]

Previous studies have focused on laser use in nonsurgical periodontal therapy, often for patients with severe periodontitis; however, the use of the diode laser in routine prophylaxis visits, as part of periodontal maintenance, has not been adequately investigated. The aim of this study was to examine the effect of the diode laser (808 nm ± 5 nm) during routine periodontal maintenance prophylaxis on periodontal pocket depth and on gingival health in patients with marginal-to-moderate periodontitis.

MATERIALS AND METHODS

Seventy-seven adult subjects with marginal or moderate periodontitis were randomly assigned to 2 parallel groups: the experimental Laser group or the Control group. To be included in the study, subjects had to be at least 30 years old and the initial mean pocket measurements in each subject's mouth greater than 3.0 mm. Subjects were required to have at least 17 teeth and have at least six 4-mm pockets or greater in their mouth. Subjects with medical pathology or other underlying medical conditions which may have affected the periodontium (such as smoking, uncontrolled diabetes, osteoporosis, cancer, anticoagulant medications, pregnancy) were excluded from the study. All subjects gave informed consent prior to participating in the study. Ten subjects did not return within the time frame of the study and all of their data were excluded.

The Laser-treated group consisted of 45 subjects and the Control group consisted of 22 subjects. There were 17 male and 28 female subjects in the laser group, mean age of 64.5 years, and 7 male and 15 female subjects in the Control group, mean age 67.2 years. The age range for the laser group was 34-91 years; the age range for the Control group was 34-89 years. Table 1 displays the demographic characteristics (age and gender) for all patients.

Table 1: Pretreatment Demographic Characteristics for All Subjects: Age and Gender

Factor	Laser Group (n = 45)		Control Group (n = 22)	
	n	(%)	n	(%)
Gender				
Female	28	(62)	15	(68)
Male	17	(38)	7	(32)
Age				
60 and under	14	(31)	5	(23)
61 to 69	17	(38)	9	(41)
Over 70	14	(31)	8	(36)
Mean	64.5		67.2	
SD	10.7		13.9	

All subjects had a dental prophylaxis 3 to 6 months prior to inclusion into the study. Periodontal pockets were measured in 6 sites around each tooth in the entire mouth (mesiobuccal, direct-buccal, distobuccal, mesiolingual, direct-lingual, and distolingual). Neither the care providers nor the examiner who made the recordings knew the group to which the subject was assigned. Each subject then received a prophylaxis, including ultrasonic scaling, hand scaling, and polishing.

All subjects were given proper oral hygiene instruction, a soft toothbrush, toothpaste, and floss, and instructed to brush twice per day and floss once per day.

The study utilized a gallium aluminum arsenide (GaAlAs) diode laser, which generated a wavelength of 808 nm ± 5 nm delivered by a 400-µm fiber-optic tip (Sapphire Dental Laser, DenMat Corp., Santa Maria, Calif., USA). For the laser-treated group, the laser was set at a power setting of 1.5 Watts with a pulse duration of 10 Hz, 0.05 seconds (10 pulses per second with a duty cycle of 50%). This setting achieves bacterial reduction with minimal ablation. The noninitiated fiber tip was inserted parallel to the long axis of the tooth into the sulcus of each tooth and circumferentially lased for 10 seconds total per tooth (Figure 1). The Control group had only a plastic periodontal probe placed in the sulcus of each tooth for 10 seconds and did not receive the laser treatment.

Figure 1: *Laser technique for bacterial reduction. The noninitiated laser tip is inserted parallel to the long axis of the tooth into the sulcus of each tooth and circumferentially lased for 10 seconds.*

The periodontal pocket measurements were analyzed using an analysis of variance (ANOVA) model with factors for treatment, gender, and age. The age factor was categorized in 3 groups: ≤ 60 years, between 60 and 70 years, and ≥ 70 years. An exploratory data analysis was performed for each variable, and the distributions were plotted, checking for model assumptions of normality. The ANOVA model was run with main effects and with each factor by treatment interaction. If no interactions were found to be significant, the final results were reported based on the main effects model.

Löe's Gingival Index (GI) was used to classify the health of the patient's gingiva.[21] For further analysis, GI values were arranged in the following categories to gauge deviation from baseline:

Improved (I) if the changes were positive, specifically a value of 2 changed to 0, 2 changed to 1, and 1 changed to 0;

Unchanged (U) if there was no change;

Deteriorated (D) if the change was negative, specifically 1 changed to 2, 0 changed to 1, 0 changed to 2.

The two treatment groups were compared, categorized as described above, using Pearson's chi-square test.

The analysis described above accounts for the individual changes in each tooth as a result of the treatment applied, ignoring the correlation that exists between the teeth of the same patient. In order to account for and compare the overall change in each patient, the following measures were defined: a patient has at least 1 improvement (one tooth decrease in the GI) if $I > 0$; otherwise $I = 0$. The two treatment groups were compared using Pearson's chi-square test. All P values reported in this study are nominal.

The data for the Gingival Index was recorded for 6 teeth from each patient for the initial baseline (visit 1) and post-treatment (visit 2) for both groups. The subject's 4 first molars and the maxillary and mandibular right central incisors were measured. After 3 months the subjects returned, and the Gingival Index and periodontal pocket measurements were recorded.

RESULTS

At baseline (visit 1), the mean pocket depth for the entire mouth was 3.23 mm in the Laser group and 3.17 mm in the Control group.

Figures 2a and 2b depict the individual means for each patient for the entire mouth. The baseline (visit 1) and post-treatment (visit 2) are displayed for the Laser group and Control group. Table 2 depicts the ANOVA for the pocket data.

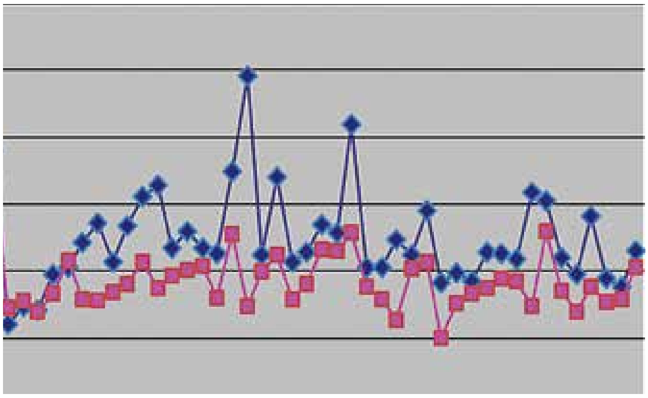

Figure 2a: *Mean of pocket depths for all teeth per subject. Laser Group (n = 45)*

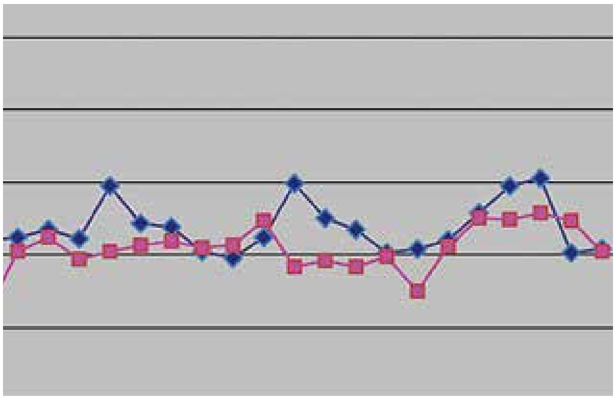

Figure 2b: *Mean of pocket depths for all teeth per subject. Control Group (n = 22)*

Table 2: ANOVA for Pocket Depth Data (in mm)

Treatment	Visit 1 Mean (V1)	Visit 2 Mean (V2)	Mean Difference (V2-V1)	P value*
Laser	3.24	2.93	-0.31	0.01531
Control	3.17	3.04	-0.13	

*Based on the ANOVA model with factors for age and gender

The mean for the pocket depths were significantly reduced by the laser treatment (*P* value < 0.05) compared to the Control group.

The gender and age were not significant, indicating that these factors do not influence the outcome of the analysis. Results of this analysis are displayed in Table 1.

The anterior and posterior teeth were analyzed separately to determine whether anterior or posterior teeth responded differently to the treatment. All tooth numbers reported are in the universal 1-32 numbering system. The baseline mean pocket depth for the posterior teeth (teeth #1-5, 12-21, and 28-32) was 3.58 mm in the Laser group, and 3.53 mm in the Control group. The baseline mean pocket depth for the anterior teeth (teeth #6-11 and 22-27) was 2.80 mm in the Laser group, and 2.72 mm in the Control group. The laser did not significantly affect the normal pocket depths of the anterior teeth, although the mean pocket depth decreased slightly. The mean for the posterior pocket depths was reduced with even greater significance by the laser treatment compared to the Control group (*P* value < 0.01). The gender and age factors were not significant, indicating that these factors do not influence the outcome of the analysis.

Figures 3a and 3b depict the individual means for each patient for the posterior teeth. The baseline (visit 1) and post-treatment (visit 2) are displayed for the Laser group and Control group. Table 3 depicts the ANOVA for posterior pocket data.

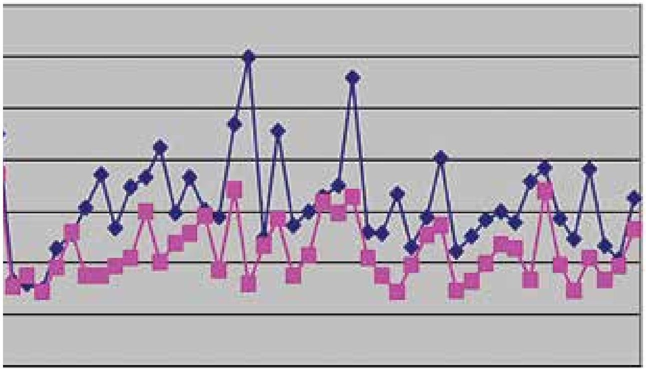

Figure 3a: *Mean of posterior pocket depth per subject. Laser Group (n = 45)*

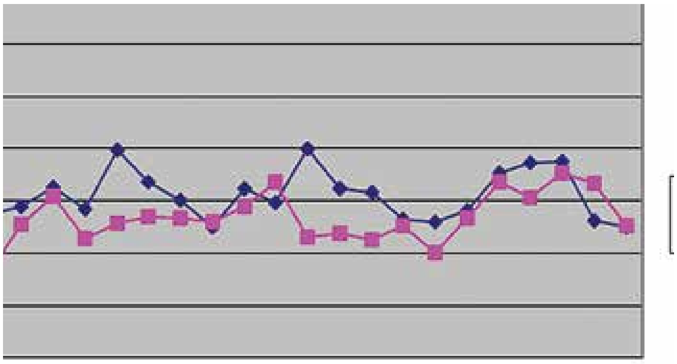

Figure 3b: *Mean of posterior pocket depth per subject. Control Group (n = 22)*

Table 3: ANOVA for Posterior Pocket Depth Data (in mm)

Treatment	Visit 1 Mean (V1)	Visit 2 Mean (V2)	Mean Difference (V2-V1)	P value*
Laser	3.58	3.12	-0.46	0.00809
Control	3.53	3.34	-0.19	

*Based on the ANOVA model with factors for age and gender

There were 2 outliers in the posterior teeth data for the Laser Group. These two subjects showed extremely significant improvement. To investigate whether these subjects would skew the results, an analysis excluding these values was performed and the overall trend was not influenced.

The results were analyzed using Löe's Gingival Index and showed that the GI mean was significantly improved from 1.2 at baseline to 0.78 at visit 2 in the Laser group, while in the Control group the mean GI was measured 1.1 at baseline and 1.14 at visit 2 ($P < 0.01$).

Table 4 displays the categories of changes for each of the 6 teeth measured, between baseline and post-treatment measures by group. These results confirm that the laser significantly reduces the GI in the subjects. This Gingival Index analysis by categories was strongly associated with the application of the laser treatment as shown by the P value < 0.01 (i.e., the laser treatment results in a more favorable result than the control, with more positive changes (I) recorded in the Laser group).

Table 4: Categories of Changes (I, U, D) Between the Pre and Post-Treatment Gingival Index Measures, by Group

Tooth Number	Laser Group			Control Group		
	Improved (I)	Unchanged (U)	Deteriorated (D)	Improved (I)	Unchanged (U)	Deteriorated (D)
#3	15	30	2	3	17	2
#8	23	21	3	5	15	2
#14	15	32	0	3	17	2
#19	19	27	1	3	14	5
#25	24	22	1	2	15	5
#30	17	28	2	4	14	4
Total Counts	113	160	9	20	92	20

Table 5 depicts the counts of improved changes in each group. The odds of having at least one tooth improved are about 9 times greater for the Laser group than the Control group (Pearson's chi-square test $P < 0.001$). This analysis also indicates that the laser significantly reduces the GI in the subjects.

Table 5: Number of Subjects with at least 1 Tooth's Gingival Index Designated as Improved (I), by Treatment Group

	Laser	Control
At least 1 ($I \neq 0$)	43	12
No Improved teeth ($I = 0$)	2	10
There were no adverse reactions reported postoperatively from any group.		

DISCUSSION

Many patients with a history of periodontal therapy or periodontal surgery exhibit pocket measurements greater than 3 mm, often for years, which are not reduced by regular periodontal maintenance prophylaxis visits alone. Many treatments employed by practitioners to reduce pocketing achieve limited success; such measures include the use of oral rinses, medications, or oral hygiene aids, which are very dependent on patient compliance. Patient compliance has been shown to be a significant factor in periodontal maintenance.[22] However, laser use during periodontal maintenance only requires that the patient performs standard oral hygiene (brushing and flossing) between periodontal maintenance visits. This study analyzed the diode laser's clinical effect on the periodontium and gingiva as an adjunct to periodontal maintenance. The statistically significant improvement observed in this study demonstrated the value of laser treatment for patients on periodontal maintenance for a 3-month interval.

An important goal for a dentist is to utilize a safe, painless, and minimally invasive treatment to reduce periodontal pocketing to ultimately improve gingival and periodontal health. This investigation confirmed that a pulsed diode laser output power of 1.4-2.5 Watts does not cause damage to the periodontium or harm the pulpal tissue.[8, 23-24] Lin *et al.* indicated that in their study, the test (810-nm diode laser) group, "the patients perceived less treatment discomfort during treatment."[25] Other studies reported that subjects treated with a laser reported less treatment discomfort and had a decrease in sensitivity.[11, 26] A pulsed laser with noninitiated fiber tip has a minimal cutting and heat effect on the periodontium and tooth structure. For this study, a noninitiated tip was used with a power setting of 1.5 Watts and a pulse duration of 10 Hz, 0.05 seconds (10 pulses per second with a duty cycle of 50%), which was consistent with these findings for a safe and clinically effective design. No subjects in this study reported pain during treatment.

Every effort was made to ensure that laser application was the only influencing factor in the experiment. The use of 0.12% chlorhexidine mouthrinse, which could reduce clinical differences between experimental groups, was not allowed. Additionally, the subjects received a prophylaxis 3-6 months prior to participation in the study. If the subject did not receive a prophylaxis for years, it is possible that any improvement could have been a result of the first prophylaxis in the study. All subjects received identical home care oral hygiene instruction, toothpaste and floss, but were not supervised daily. Individual compliance could be a factor in both groups, but did not statistically influence the result of the groups.

Previous studies utilizing the laser in nonsurgical periodontal therapy with pockets greater than 5 mm have shown mixed and conflicting results.[20, 27] These conflicting results may stem in part from the fact that these studies used lasers with different wavelengths, power settings, and duration of laser exposure. Studies by Dukic *et al.*[28] and Kamma *et al.*[29] implemented a 980-nm laser. Kusek *et al.*[9] used a 940-nm diode laser. Studies by Qadri *et al.,*[30] Giannelli *et al.,*[10] and Angelov *et al.*[31] used a 630-670-nm laser. Other studies by Pirnat,[6] Moritz *et al.,*[8] de Micheli *et al.,*[27] Kusek *et al.,*[9] Qadri *et al.,*[30] Giannelli *et al.,*[10] Aykol *et al.,*[18] Kreisler *et al.,*[13, 32] and Euzebio Alves *et al.*[33] utilized an 800-830-nm wavelength laser.

Bacterial reduction and immunologic effects of the laser must be considered since these factors are critical in periodontal disease. Many studies have demonstrated that the diode laser reduced bacteria and inactivated bacterial toxins.[8, 10, 29] These benefits translate into the reduction in pocketing and improved gingival health, which were clinically supported with this study and others.[10, 29, 30, 34] Previous studies have demonstrated why the laser could be effective on the cellular level. Sakarai *et al.* reported benefits of laser therapy in decreasing inflammatory mediators.[14] Kreisler *et al.* reported that using a 809-nm GaAlAs laser at low power (10 mW) in continuous mode promotes proliferation of periodontal ligament fibroblasts.[13] Stimulating fibroblast activity would support wound healing, while decreasing inflammatory mediators would slow bone resorption and tissue degradation. In another study, Kreisler *et al.* used an 809-nm GaAlAs laser at 1 Watt and saw significant reduction in tooth mobility, pocket depth, and clinical attachment loss. They speculated that the 809-nm laser causes de-epithelization of periodontal pockets, leading to enhanced connective tissue attachment.[32] These studies demonstrate that the 809-nm laser may have more benefits than bacterial reduction, depending on the setting and mode utilized. These findings are compelling, as scaling and root planing alone does not have such effects directly on the periodontium. Further research into the various laser settings in the treatment of periodontitis is recommended.

Kusek *et al.* used both 810-nm and 940-nm lasers in laser-assisted periodontal therapy. They studied patients with moderate periodontal disease and found it to be a useful adjunct to root planing and scaling.[9] The laser was used in the initial therapy and on recall visits over the course of the 5-year retrospective study. On recall visits, the pockets greater than a healthy 3 mm were retreated with scaling and laser. They reported that 80% of the pockets treated with the diode laser were restored to a healthy pocket depth of 3 mm after 5 years of treatment. The present experiment had similarities to Kusek's, but used a different design, which included a control group and provided additional statistical analysis to support the findings. The analysis proved the results to be statistically significant.

Numerous studies investigated the use of the laser in conjunction with scaling and root planing. Euzebio Alves *et al.* used an 808 ± 5 nm diode laser set at 1.5 W in continuous mode to treat very deep pockets (baseline mean 6.91 ± 1.94 mm) non-urgically.[33] They found no significant difference 6 months after treatment when compared to standard scaling and root planing. This may be attributed to the fact that they restricted their study to deep periodontal pockets. Giannelli *et al.* treated periodontal pockets with scaling and root planing after laser pocket de-epithelization.[10] The Giannelli group used a combination of a photoablative 810-nm diode laser and a photodynamic 635-nm diode laser. They then utilized multiple laser photodynamic treatments using 0.3% methylene blue as a photosensitizer and found a significant reduction in probing depth. Several studies found the laser used in conjunction with scaling and root planing showed significant improvements, but only in moderate periodontal pockets (4-6 mm).[28, 32] These findings suggest that laser use is more effective as an adjunct in moderate periodontal pockets. In addition, studies which did not find significant differences over scaling and root planing alone might be due in part that the laser has limited value if it is not used in conjunction with regular periodontal maintenance treatments. These parameters should be investigated further.

This investigation may lead to several useful future studies. One limitation of this study was that patients were evaluated only for a 3-month period. Laser treatment could be examined over the course of a number of years to determine whether pocket reduction would continue. Another limitation is that the bacteria affected were not studied. It would be interesting to sample the patients' bacterial flora during each periodontal maintenance visit to see what bacteria species are reduced. Perhaps each bacterial species responds to the laser in a different way. The laser may selectively kill bacteria containing certain pigments. Photodynamic antimicrobial chemotherapy may also kill certain bacteria species more effectively. Also, the way the flora repopulates the subgingival environment may differ post-laser treatment versus other modalities of treatment. This would help provide a better understanding of the bacterial processes involved. Further research should also investigate how to increase the effectiveness of laser bacterial reduction in severe periodontal pockets. Patients with severe periodontitis may greatly benefit from incorporation of the diode laser's use if the most effective laser settings and techniques can be determined.

CONCLUSION

Laser treatment during routine periodontal maintenance significantly reduces the depth of the periodontal pockets and significantly improves the Gingival Index with the use of laser treatment. The use of the diode laser in routine prophylaxis and periodontal maintenance is an important adjunct in reducing pockets and improving gingival health. Its use should be considered by all dental professionals in treating patients who exhibit periodontal pocketing.

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REFERENCES

1. Eke PI, Dye BA, Wei L, Thornton-Evans GO, Genco RJ. Prevalence of periodontitis in adults in the United States: 2009 and 2010. *J Dent Res* 2012;91(10):914-920.
2. Renvert S, Persson GR. Supportive periodontal therapy. *Periodontol 2000* 2004;36(1):179-195.
3. Lindhe J, Nyman S. Long-term maintenance of patients treated for advanced periodontal disease. *J Clin Periodontol* 1984;11(8):504-514.
4. Suomi JD, Greene JC, Vermillion JR, Doyle J, Chang JJ, Leatherwood EC. The effect of controlled oral hygiene procedures on the progression of periodontal disease in adults: Results after third and final year. *J Periodontol* 1971;42(3):152-160.
5. Axelsson P, Lindhe J, Nyström B. On the prevention of caries and periodontal disease. Results of a 15-year longitudinal study in adults. *J Clin Periodontol* 1991;18(3):182-189.
6. Pirnat S. Versatility of an 810 nm diode laser in dentistry: An overview. *J Laser Health Acad* 2007;4(2):1-9.
7. Bains VK, Gupta S, Bains R. Lasers in periodontics: An overview. *J Oral Health Community Dent* 2010;4(Suppl):29-34.
8. Moritz A, Schoop U, Goharkhay K, Schauer P, Doertbudak O, Wernisch J, Sperr W. Treatment of periodontal pockets with a diode laser. *Lasers Surg Med* 1998;22(5):302-311.
9. Kusek ER, Kusek AJ, Kusek EA. Five-year retrospective study of laser-assisted periodontal therapy. *Gen Dent* 2012;60(6):540-543.
10. Giannelli M, Formigli L, Lorenzini L, Bani D. Combined photoablative and photodynamic diode laser therapy as an adjunct to non-surgical periodontal treatment. A randomized split-mouth clinical trial. *J Clin Periodontol* 2012;39(10):962-970.
11. Tomasi C, Schander K, Dahlén G, Wennström JL. Short-term clinical and microbiologic effects of pocket debridement with an Er:YAG laser during periodontal maintenance. *J Periodontol* 2006;77(1):111-118.
12. Moritz A, Gutknecht N, Doertbudak O, Goharkhay K, Schoop U, Schauer P, Sperr W. Bacterial reduction in periodontal pockets through irradiation with a diode laser: A pilot study. *J Clin Laser Med Surg* 1997;15(1):33-37.
13. Kreisler M, Christoffers AB, Willerstausen B, d'Hoedt B. Effect of low-level GaAlAs laser irradiation on the proliferation rate of human periodontal ligament fibroblasts: An *in vitro* study. *J Clin Periodontol* 2003;30(4):353-358.
14. Sakurai Y, Yamaguchi M, Abiko Y. Inhibitory effect of low-level laser irradiation on LPS-stimulated prostaglandin E_2 production and cyclooxygenase-2 in human gingival fibroblasts. *Eur J Oral Sci* 2000;108(1):29-34.
15. Schwarz F, Sculean A, Berakdar M, Georg T, Reich E, Becker J. Periodontal treatment with an Er:YAG laser or scaling and root planing. A 2-year follow-up split-mouth study. *J Periodontol* 2003;74(5):590-596.
16. Yilmaz S, Kuru B, Kuru L, Noyan Ü, Argun D, Kadir T. Effect of gallium arsenide diode laser on human periodontal disease: A microbiological and clinical study. *Lasers Surg Med* 2002;30(1): 60-66.
17. Karlsson MR, Diogo Löfgren CI, Jansson HM. The effect of laser therapy as an adjunct to non-surgical periodontal treatment in subjects with chronic periodontitis: A systematic review. *J Periodontol* 2008;79(11):2021-2028.
18. Aykol G, Baser U, Maden I, Kazak Z, Onan U, Tanrikulu-Kucuk S, Ademoglu E, Issever H, Yalcin F. The effect of low-level laser therapy as an adjunct to non-surgical periodontal treatment. *J Periodontol* 2011;82(3):481-488.
19. Schwarz F, Aoki A, Becker J, Sculean A. Laser application in non-surgical periodontal therapy: A systematic review. *J Clin Periodontol* 2008;35(Suppl 8):29-44.
20. Cobb CM. Lasers in periodontics: A review of the literature. *J Periodontol* 2006;77(4):545-564.
21. Löe H, Silness, J. Periodontal disease in pregnancy. I. Prevalence and severity. *Acta Odontol Scand* 1963;21(6):533-551.
22. Mendoza AR, Newcomb GM, Nixon KC. Compliance with supportive periodontal therapy. *J Periodontol* 1991;62(12):731-736.
23. Theodoro LH, Haypek P, Bachmann L, Garcia VG, Sampaio JEC, Zezell DM, Eduardo Cde P. Effect of Er:YAG and diode laser irradiation on the root surface: Morphological and thermal analysis. *J Periodontol* 2003;74(6):838-843.
24. Haypek P, Zezell DM, Bachmann L, Marques MM. Interaction between high-power diode laser and dental root surface. Thermal, morphological and biocompatibility analysis. *J Oral Laser Appl* 2006;6(2):101-109.
25. Lin J, Bi L, Wang L, Song Y, Ma W, Jensen S, Cao D. Gingival curettage study comparing a laser treatment to hand instruments. *Lasers Med Sci* 2011;26(1):7-11.

26. Borrajo JLL, Varela LG, Castro GL, Rodríguez-Nuñez I, Torreira MG. Diode laser (980 nm) as adjunct to scaling and root planning. *Photomed Laser Surg* 2004;22(6):509-512.

27. de Micheli G, de Andrade AKP, Alves VTE, Seto M, Pannuti CM, Cai S. Efficacy of high intensity diode laser as an adjunct to non-surgical periodontal treatment: A randomized controlled trial. *Lasers Med Sci* 2011;26(1):43-48.

28. Dukić W, Bago I, Aurer A, Roguljić M. Clinical effectiveness of diode laser therapy as an adjunct to non-surgical periodontal treatment: A randomized clinical study. *J Periodontol* 2013;84(8):1111-1117.

29. Kamma JJ, Vasdekis VGS, Romanos GE. The effect of diode laser (980 nm) treatment on aggressive periodontitis: Evaluation of microbial and clinical parameters. *Photomed Laser Surg* 2009;27(1):11-19.

30. Qadri T, Miranda L, Tunér J, Gustafsson A. The short -term effects of low-level lasers as adjunct therapy in the treatment of periodontal inflammation. *J Clin Periodontol* 2005;32(7):714-719.

31. Angelov N, Pesevska S, Nakova M, Gjorgoski I, Ivanovski K, Angelova D, Hoffmann O, Andreana S. Periodontal treatment with a low-level diode laser: Clinical findings. *Gen Dent* 2009;57(5):510-513.

32. Kreisler M, Al Haj H, d'Hoedt B. Clinical efficacy of semiconductor laser application as an adjunct to conventional scaling and root planing. *Lasers Surg Med* 2005;37(5):350-355.

33. Euzebio Alves VT, de Andrade AKP, Toaliar JM, Conde MC, Zezell DM, Cai S, Pannuti CM, De Micheli G. Clinical and microbiological evaluation of high intensity diode laser adjutant to non-surgical periodontal treatment: A 6-month clinical trial. *Clin Oral Investig* 2013;17(1): 87-95.

34. Parker S. Lasers and soft tissue: Periodontal therapy. *Br Dent J* 2007;202(6):309-315. .