

The Effects of Diode Laser (980 nm Wavelength) and Chlorhexidin Gel in the Treatment of Chronic Periodontitis

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Abstract:

Introduction: The aim of the present study was to investigate the effects of SRP assisted by the two clinical treatment methods of diode laser or Chlorhexidine Gel applications in comparison with SRP alone.

Methods: Eight patients with moderate to severe chronic periodontitis, each with at least three pockets 4–7 mm deep, were selected for this study. Over 66 pockets were selected and randomly treated by either scaling and root planning (SRP) alone, or by SRP + diode laser (1.5 W, 980 nm, 30sec, continuous wave) (laser group), or by SRP + chlorhexidine gel-xanthan based (gel group). The clinical indices (probing pocket depth [PPD], clinical attachment level [CAL], and papillary bleeding index [PBI] mean score) and microbiological index (total bacterial count [TBC]) before, 1 month and three months after treatment were measured and evaluated.

Results: The results showed that SRP assisted by chlorhexidine gel and diode laser therapies exhibits better results than SRP alone in reducing PPD, improving clinical CAL, and reducing PBI mean score and TBC ($p < 0.05$) both at one month and three months follow ups. Comparison of clinical indices between the laser group and the gel group showed no significant differences at neither of the follow up stages, but in 3 months follow up interval, the TBC reduction in the laser group was significantly more than the gel group ($P < 0.05$).

Conclusion: Treatment with diode laser or chlorhexidine gel as an adjunct to SRP may improve periodontal and microbiological indices compared to SRP alone. Diode laser showed better bactericidal effects in long term.

Keywords: diode laser; periodontal pocket; chronic periodontitides

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Introduction

Periodontal diseases are initiated by sub-gingival periodontal pathogenic bacteria in susceptible periodontal sites. Currently, mechanical

debridement of the microbial plaque is the most frequently used method of periodontal disease treatment. However, conventional periodontal treatments are not equally effective in removal of all type of periopathogens and their toxins from

periodontal pockets. Thus, numerous adjunctive therapeutic strategies have evolved to manage periodontal diseases (1).

Systemic and local anti-infective therapy can reduce the bacterial challenge to the periodontium (2). The local antimicrobial agents have wider applications, since they create higher concentrations of the effective agent within the pocket and compared to antibiotics, they cause fewer side effects. The difficulty of maintaining therapeutic concentrations of antimicrobials in the oral cavity and the disruption of the oral micro-flora are also problems associated with the use of these agents (3, 4). Today, chlorhexidine is the most common antiseptic agent used in dentistry and several studies have proved its effectiveness in reducing oral bacterial deposits (5-7). Recently, advances in delivery technology have resulted in the controlled release of drugs such as chlorhexidine chips which can sustain their localized concentration at effective levels for a sufficient time, while concurrently evoking minimal, or no side effects (8, 9). According to Vinholis et al. (9) Chlorhexidine gel 1% can be used as an effective adjunct both during treatment and maintenance phase of periodontal therapy. A recent study by Dinca et al. (10) demonstrated that a novel type of xanthan based chlorhexidine called Chlosite may be more effective than Plakout chlorhexidine, which lacks the xanthan base, in improving periodontal indices. In our previous study, efforts were made to compare the efficiency and effectiveness of two adjunctive methods including therapies using Nd:YAG laser (Neodymium-Doped Yttrium Aluminium Garnet) and chlorhexidine gel with a xanthan base (Chlosite) following a conventional SRP treatment. The results revealed that both methods had better therapeutic effects than the SRP alone, giving rise to higher PPD (Probing Pocket Depth) and BOP (Bleeding on Probing) reduction as well as enhanced CAL (Clinical Attachment Level) (11).

On the other hand, the use of laser in the field of periodontology has been of enormous scientific interest throughout the last decade and a variety of laser systems have been investigated in numerous studies (12-20). Er:YAG (Erbium Substituted: Yttrium Aluminium Garnet), Nd:YAG and CO₂ lasers have been used for calculus removal, bacterial reduction in periodontal pockets, soft-tissue management, gingival curettage, and melanin

pigmentation removal (21). The relatively new diode laser is portable, compact surgical unit with efficient and reliable benefits. Recently, the diode laser has been reported to have similar tissue effects as the Nd: YAG laser in comparable studies, with less thermal effects on the deeper tissues (22). Diode laser is mainly applied in periodontal pocket debridement and epithelial lining removal as well as granulomatous tissue in clinics (23-25). Moreover, it is an excellent hemostatic agent and can be used for cutting and coagulating gingiva and oral mucosa (23). They are also designed according to economic and ergonomic considerations and they have reduced costs in comparison to other modern hard laser equipments (26).

There are controversial results in the literature about the efficacy of diode laser treatment as an adjunctive therapy to nonsurgical periodontal treatment in adults with periodontal diseases. While Moritz et al. (24), and Angelov et al. (27) showed that diode laser therapy can significantly improve periodontal pocket healing and periodontal indices, other studies by Caruso et al. (28), and Borrajo et al. (29) reported moderate or no additional benefits for diode laser compared to conventional periodontal therapy.

This research was conducted to evaluate the effects of the two diode laser and chlorhexidine xanthan based gel on the bacterial reduction and clinical parameters of periodontal diseases compared to those of the SRP alone.

Methods

Patient Selection

Eight volunteered individuals (four female, and four male) with moderate to severe chronic periodontitis, each with at least three pockets 4–7mm deep were selected for this study. Over 66 pockets with untreated chronic periodontitis were selected and randomly treated by scaling and root planing (SRP) alone (control group) or by SRP + diode laser (laser group) or by SRP + chlorhexidine gel-xanthan based (gel group). The subjects were non-smokers and none of them had any known systemic disorder, or used prescribed antibiotics and/or anti-inflammatory medications in the last 3 months, and none of them had previously undergone

any treatment for their chronic periodontitis. All patients had appropriate cooperation.

Written informed consent was obtained from all patients, in line with the Helsinki declaration, before inclusion in this study. The protocol was reviewed and ethical approval was given by our institutional review board.

Clinical and Microbiologic Parameters

Clinical parameters including papillary bleeding index (PBI), probing pocket depth (PPD) and clinical attachment level (CAL) were measured at the selected sites at the baseline. All measurements were carried out by the same examiner which was blinded to the study.

Before the initiation of treatment one sample per site was obtained from the deepest part periodontal pocket for microbiologic evaluation. Sterile paper points (size 40) were used for this purpose. Paper points were introduced in periodontal pockets as far apically as possible and kept still for 15 seconds. After that, sub-gingival portion of each paper point was cut off and put into a jar containing transport material.

Treatment Procedure

At the first treatment session, all patients underwent careful SRP by ultrasonic dental unit (Mectron, Carasco, GE, Italy). All patients received special training on brushing their teeth twice daily using the modified Bass technique and flossing.

A week later, patients would be checked again for any remaining calculus to undergo another SRP session if necessary. In a following session a week later, the patients would then be subjected to diode laser therapy as well as chlorhexidine gel therapy. In this way, 22 pockets would be randomly selected for laser therapy and 22 pockets for gel therapy, while leaving the rest of the pockets without either of the adjunctive therapies to be used as control.

In the laser group, a 980 nm diode laser (A.R.C Laser, Nurnberg, Germany) operating at a power output of 1.5 W (1.5 W, 30sec, continuous wave) was used. Laser light was delivered by means of a 300 micron optical fiber. The fiber was used in light contact with a sweeping action that covers the entire epithelial lining, from the base of the

pocket upward.

In the gel group, chlorhexidine gel-xanthan based gel / Chlosite (GHIMAS, s.p.a Bologna, Italy) was used. The round, blunt tipped syringe containing the gel was placed into the pocket progressing into its depth so that the gel encompassed the overall pocket wall with its excess coming out of the pocket opening.

At the third appointment, one month after the first session, all patients underwent another evaluation of the periodontal indices (PBI, PPD and CAL), and microbiological samples were obtained from the same periodontal pockets as in the first examination. Then, the laser and the chlorhexidine gel therapies were repeated for each of the experimental groups according to their treatment plan.

At the last recall appointment after 3 months, microbiologic samples were again obtained from the same periodontal pockets as before, using the same procedure. Furthermore, measurement of periodontal indices (PBI, PPD and CAL) was obtained for all treated pockets by the same examiner.

Microbiologic Evaluation

The collected bacterial samples were divided according to the previously mentioned groups. Specimens were subjected to a culture in blood agar + simple gelose and MacConkey. Culture media included nutrient agar with the following for gram positives: Pepton; meat extracts 3.0, agar, agar 12.0, meat 5.0 (Merck, KGaA, Darmstadt, Germany). The culture media for gram negatives was the MacConkey with the following structures: Pepton from casein – peptone from meat – sodium chloride – lactose – bile salt mixture - neutral red – crystal violet and agar – agar (kGaA, MERCK, Germany). The plates were stored at 37°C for 48 hours, and after this period the total number of colony-forming units (CFU/mL), or total bacterial count (TBC) was counted in both the anaerobic and aerobic cultures.

Statistical Analysis

The SPSS 14.0 (SPSS Inc., Chicago, IL, USA) statistical package was used for all of the statistical calculations. The data were analyzed by paired T-test, one-way ANOVA, Tukey's HSD Test,

repeated measures ANOVA, Kruskal-Wallis test, Friedman test and Wilcoxon signed rank test. A significant difference was assumed when $P < 0.05$.

Results

Clinical Parameters

At baseline, comparable recordings were made. This could indicate that all changes at follow-up periods were directly related to the intervention performed later.

Tables 1 and 2 show the changes in PPD and CAL over time, and per treatment modality. Paired T-test revealed that treatment in all three groups significantly improved PPD ($P < 0.001$) and CAL ($P < 0.05$) compared to pretreatment conditions both at the 1 month and 3 months follow up stages. Also the One-way ANOVA showed that there were significant improvements in PPD and CAL in all three groups ($P < 0.001$). For both clinical parameters, the differences were more evident at

1 month follow up, while the reduction process slowed down through the 3 months recall. Only in the laser group a significant decrease in PPD was found between 1 vs. 3 months follow-up ($P = 0.033$).

Both at 1 month and 3 months follow up, Tukey's test showed that in the laser and gel groups, PPD reduction and enhanced CAL were significantly more than that in the control ($P < 0.05$), while the two experimental groups did not show significant differences in this respect.

The PBI mean score in each of the 3 groups were compared in baseline and the two follow-up stages using the Friedman and Wilcoxon signed rank tests. The test results demonstrated significant differences only between baselines vs. 1 month follow-up and, between baselines vs. 3 months follow-up in all three groups ($P < 0.001$) (Table 3).

Kruskal-Wallis test revealed that the PBI mean score in the two gel and laser therapy groups had no significant differences after treatment. However, these changes in the controls were significantly less

Table 1. Comparison of mean and standard deviation (SD) of PPD at different observation periods in different groups

Group	Observation Period	Mean \pm SD (in mm)	Comparison	Mean \pm SD	P-value
Laser + SRP	Baseline (BL)	5.44 \pm 1.16			
	1 month (1M)	3.43 \pm 1.19	BL vs 1M	1.98 \pm 0.41	> 0.001
	3 months (3M)	2.81 \pm 1.10	BL vs 3M	2.63 \pm 0.62	> 0.001
			1M vs 3M	0.62 \pm 0.11	0.033
Gel + SRP	Baseline (BL)	5.40 \pm 1.00			
	1 month (1M)	3.58 \pm 1.30	BL vs 1M	1.82 \pm 0.71	> 0.001
	3 months (3M)	3.04 \pm 1.48	BL vs 3M	2.35 \pm 0.50	> 0.001
			1M vs 3M	0.54 \pm 0.34	0.131
SRP alone	Baseline (BL)	5.08 \pm 1.21			
	1 month (1M)	4.25 \pm 1.96	BL vs 1M	0.83 \pm 0.43	> 0.001
	3 months (3M)	3.92 \pm 1.52	BL vs 3M	1.16 \pm 0.42	> 0.001
			1M vs 3M	0.33 \pm 0.19	0.345

Table 2. Comparison periods for mean and standard deviation (SD) of CAL at different observations and different groups.

Group	Observation Period	Mean \pm SD (in mm)	Comparison	Mean \pm SD	P-value
Laser + SRP	Baseline (BL)	5.35 \pm 1.23			
	1 month (1M)	3.64 \pm 2.13	BL vs 1M	1.75 \pm 0.54	> 0.001
	3 months (3M)	3.03 \pm 1.15	BL vs 3M	2.33 \pm 0.65	> 0.001
			1M vs 3M	0.64 \pm 0.34	0.054
Gel + SRP	Baseline (BL)	5.26 \pm 1.16			
	1 month (1M)	3.73 \pm 1.44	BL vs 1M	1.67 \pm 0.46	0.001
	3 months (3M)	3.20 \pm 1.53	BL vs 3M	2.16 \pm 0.56	> 0.001
			1M vs 3M	0.50 \pm 0.41	0.089
SRP alone	Baseline (BL)	4.77 \pm 1.56			
	1 month (1M)	3.93 \pm 2.17	BL vs 1M	0.86 \pm 0.52	0.011
	3 months (3M)	3.68 \pm 1.91	BL vs 3M	1.12 \pm 0.64	0.002
			1M vs 3M	0.26 \pm 0.13	0.105

than those in the experimental groups ($P < 0.001$).

Microbiologic Parameter

Table 4 shows the change in TBC over time and per treatment Modality. The One-way ANOVA revealed that treatment in all three groups significantly decreased TBC compared to pretreatment conditions both at the 1 month and 3 months follow ups ($P < 0.05$). The decrease in all groups seems to be more intensive in the 1 month follow up, while it is further adjusted at 3 months recall, while only in the laser group there was a significant decrease in TBC between 1 vs. 3 months follow-up ($P = 0.038$).

When colony counts were compared in 1 month follow-up, the One-way ANOVA showed no significant differences between two gel and laser group after treatment ($P = 0.064$). However, these changes in the control were significantly less than those in the experimental groups ($P < 0.001$). In 3

months follow up episode, TBC reduction in laser group was significantly more than other groups ($P < 0.05$), while a significant difference was also found in TBC between the gel group and control ($P < 0.05$).

Discussion

There has been an essential change in concepts of periodontal disease treatments over the past three decades. For instance, nowadays local delivery of antimicrobials, host modulators, and laser has many applications in periodontal therapy (6). However, no definitive answers can yet be given as to the efficiency and application method of each of these agents in treating periodontal diseases. Therefore, the aim of this study was to investigate the effectiveness of the two adjunctive methods including therapies using diode laser and chlorhexidine gel with a xathan base (Chlosite) following a conventional SRP treatment.

In the present study, we revealed that diode laser irradiation inside periodontal pockets with average depths of 4 to 7 mm following SRP can significantly reduce PPD and PBI mean score and improve CAL compared to the SRP alone. Similar findings were obtained by Moritz et al. (24), and Kamma et al. (30), despite slight differences in the application of diode laser and the parameters used in the present study and those cited. Moritz et al. (24) performed a long-term study (six months), in which the rate of bleeding after this period showed a 96.9% improvement in the group treated with the laser, compared with a 66.7% one in the control group. They also reported a significant decrease in the number of deep periodontal pockets and

Table 3. Comparison of PBI mean scores at different observation periods in different groups.

Group	Observation Period	Mean Score	Comparison	P-value
	Baseline (BL)	2.53		
Laser + SRP	1 month (1M)	1.53	BL vs 1M	> 0.001
	3 months (3M)	0.95	BL vs 3M	> 0.001
			1M vs 3M	0.089
	Baseline (BL)	2.55		
Gel + SRP	1 month (1M)	1.52	BL vs 1M	> 0.001
	3 months (3M)	1.15	BL vs 3M	> 0.001
			1M vs 3M	0.101
	Baseline (BL)	2.60		
SRP alone	1 month (1M)	1.86	BL vs 1M	> 0.001
	3 months (3M)	1.55	BL vs 3M	> 0.001
			1M vs 3M	0.655

Table 4. Comparison of mean and standard deviation (SD) of TBC at different observation periods in different groups.

Group	Observation Period	Mean ± SD	Comparison	Mean ± SD	P-value
	Baseline (BL)	2505.11 ± 981.11			
Laser + SRP	1 month (1M)	1153.44 ± 231.13	BL vs 1M	1351.47 ± 131.34	> 0.001
	3 months (3M)	202.29 ± 661.35	BL vs 3M	2303.32 ± 110.46	> 0.001
			1M vs 3M	951.25 ± 111.45	0.038
	Baseline (BL)	2318.41 ± 1210.55			
Gel + SRP	1 month (1M)	1136.13 ± 1383.33	BL vs 1M	1181.50 ± 110.57	> 0.001
	3 months (3M)	701.50 ± 711.34	BL vs 3M	1608.11 ± 120.14	> 0.001
			1M vs 3M	434.51 ± 101.20	0.135
	Baseline (BL)	2495.22 ± 1191.52			
SRP alone	1 month (1M)	1644.01 ± 1311.59	BL vs 1M	700.04 ± 142.35	0.015
	3 months (3M)	1413.83 ± 711.35	BL vs 3M	851.30 ± 1170.44	0.001
			1M vs 3M	230.42 ± 170.58	0.263

also the PPD values after diode laser application. Bearing this in mind, Romanos et al. (25) showed that the 980-nm laser to be superior to SRP in removing thin pocket epithelium, and this may be one mechanism that improves periodontal parameters.

In contrast to our results, some other studies reported no clinical parameter improvements for diode laser application in the treatment of periodontal diseases. Yilmaz et al. (31) used a GaAlAs laser in a randomized controlled trial and found no beneficial effect over SRP alone. Kreisler et al. (23) studied the clinical efficacy of semiconductor laser application as an adjunct to conventional SRP and reported a significant reduction in tooth mobility, and PPD, while they found no significant group differences for the plaque index, gingival index, bleeding on probing, and the sulcus fluid flow rate. They used low level diode laser with different irradiation parameters (an 809 nm GaAlAs semiconductor laser operating at a power output of 1.0 W) compared to our study. It has been reported that an in vitro significant bacterial reduction cannot be achieved at these irradiation parameters (26). Moreover, the results of their study were obtained from a population with a rather mild form of periodontitis as shown by the distribution of periodontal pocket depths at baseline. In contrast, our study was conducted in patients with more severe form of periodontal disease.

In agreement with previous reports (24-25), the result of our study revealed that in both follow-up stages diode laser therapy led to significant improvement in clinical parameter compared to the controls, and there was also a significant difference for all these indices between baselines vs. the 1 month follow-up and also, between baselines vs. the 3 months follow-up, and for BPI mean score between 1 vs. 3 months. Thus, it seems that these improvements in gingival health remain more stable than with conventional SRP treatment alone and tend to last longer.

The present study also showed an improvement in microbiological parameter (TBC) after treatment in all the three groups. At both follow up stages, TBC reduction in the laser group was significantly more than the controls ($P < 0.001$). There is very compelling evidence in the dental literature that the addition of diode laser treatment to SRP has

a significant bactericidal and detoxifying effect in periodontal therapy (26). In agreement with our study, Moritz et al. (24) reported significant bacterial reduction with long term high power diode laser therapy compared to SRP alone. Several other studies (32-34) have revealed that diode laser may significantly suppress microorganisms related to periodontal diseases, such as *Porphyromonas gingivalis*, *Aggregatibacter actinomycetem comitans* (previously *Actinobacillus actinomycetem comitans*), *Fusobacterium nucleatum*, *Prevotella intermedia*, and *Streptococcus sanguis* under different environmental conditions (pure cultures, pure or multispecies biofilms). Moreover, it has been shown that laser therapy can reduce key virulence factors (lipopolysaccharide and proteases) present after the destruction of bacteria (35). In contrast, Ryden et al. (36) reported that the use of low level diode laser had no significant additional effects on microbiological parameters. The bactericidal effect of diode laser depends on species of bacterium, wavelength and dose. It was reported that different from high-power lasers; low power lasers do not increase tissue temperature (26). Therefore, when used alone, the same antimicrobial effect as that of high-power lasers in periodontitis active sites cannot be expected, and this may account for the discrepancy between the results.

In our study, diode laser was used as an adjunctive treatment to conventional mechanical treatment methods (SRP), but not as a primary treatment of periodontal pockets for calculus removal or pocket curettage. One should keep in mind that it is only reasonable to perform diode laser therapy in a decontaminated and calculus-free periodontal pocket and conventional periodontal treatment should not be discarded. Observations at 7 days after laser therapy with no SRP revealed early re-colonization of periodontal pocket by a verity of periopathogens (37).

According to previous reports, another advantage of diode laser therapy may be its positive effects on wound healing. A study by Safavi et al. (38) demonstrated that laser therapy may inhibit the production of interleukin 1β (IL- 1β), and interferon γ (IFN- γ), while it may have stimulatory effect on platelet derived growth factor (PDGF) and transforming growth factor β (TGF- β). Moreover, diode laser therapy may significantly enhance patient comfort during the post-operative healing

phase because it involves minimal pain (39).

The findings from present study also indicate that application of Chlorhexidine gel with a xathan base to periodontal pockets leads to significantly improved clinical parameters such as PBI, PPD, and CAL ($P < 0.001$), and microbiologic parameter (TBC) ($P < 0.05$) compared to the controls at the two follow-up stages. These findings match those of Cheng et al. (40), Vinholis et al. (9), and Perinetti et al. (41), and our previous study (11). Due to its mucoadhesive property and long retention time within the pocket, Chlosite gel preserves its effective concentration within the periodontal pocket for over two weeks, and results in significant decrease in bacterial re-colonization (41).

Comparison of the effects of diode laser and chlorhexidine gel therapies on clinical indices in our study revealed that the values of PPD reduction, CAL enhancement and PBI mean score reduction after treatment in the two experimental groups exhibit no significant differences in TBC reduction between the two gel and laser groups at 1 month (0.064); interestingly, in the 3 months follow up episode, the TBC reduction in the laser group was significantly more than that of the gel group ($P < 0.05$). Therefore, it seems that diode laser therapy has better bactericidal effects, even compared to chlorhexidine gel therapy in the long term.

Histological studies on the side effects of diode laser have demonstrated no detectable surface alteration to root or cementum (42-43). Additionally, no signs of thermal side effects in any of the teeth treated were reported (43). According to diode laser very effective bactericidal action on periodontal pathogens, it can be considered a safe co-adjutant in nonsurgical treatment of chronic periodontitis. This also eliminates the problem of bacterial resistance and systemic side effects associated with antibiotic use.

Conclusion

Based on the findings of the present study, treatment with diode laser or chlorhexidine gel as an adjunct to SRP may improve periodontal (PPD, CAL, and PBI) and microbiological (TBC) indices, compared to SRP alone. Diode laser showed better bactericidal effects in the long term.

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