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Original Article

Effects of 810-Nanometer Diode Laser as an Adjunct to Mechanical Periodontal Treatment on Clinical Periodontal Parameters and Gingival Crevicular Fluid Volume of Residual Periodontal Pockets

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Abstract

Background: Aim of this randomized controlled parallel-designed study was to evaluate the effects of diode laser as an adjunct to mechanical periodontal treatment on clinical parameters and gingival crevicular fluid (GCF) volume of the residual pockets diagnosed following initial periodontal treatment in chronic periodontitis (CP) patients. **Materials and Methods:** A total of 84 residual pockets on single-rooted teeth in 11 CP patients were included and randomly assigned into three groups. Residual pockets were treated either only by mechanical treatment (Group M) (n = 28) or only by diode laser disinfection (Group L) (n = 28) or by a combination of these techniques (Group M + L) (n = 28). Plaque index, gingival index (GI), bleeding on probing (BoP), probing depth (PD), clinical attachment level and gingival recession were assessed at baseline and 8 weeks after treatment of residual pockets. GCF samples were collected at baseline, 1 and 8 weeks after treatment. **Results:** All treatment modalities resulted in significant reductions in PD and attachment gain. GI and BoP showed a greater reduction in both Group M and Group M + L than Group L ($P < 0.001$), but there was no difference between the Groups M and M + L ($P > 0.05$). No difference was also found among groups for other clinical parameters. GCF volume decreased significantly in the Groups M and M + L ($P < 0.05$) but there was no difference among the groups ($P > 0.05$). **Conclusion:** Results demonstrated clinical improvements on residual pockets in CP patients treated with all three modalities. Moreover, our findings suggest that application of diode laser as an adjunct to mechanical periodontal treatment doesn't demonstrate any additional clinical effect on the residual pockets.

Keywords: *Chronic periodontitis, dental scaling, gingival crevicular fluid, lasers, periodontal pocket, root planing*

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Introduction

Chronic periodontitis (CP) is a periodontal disease seen in the early adulthood and characterized with spontaneous or provoked gingival bleeding, migration, and mobility of teeth, attachment and alveolar bone loss.[1] Initial periodontal treatment (IPT) consists of oral hygiene instructions, scaling and root planing and is the first step for the treatment of all kinds of periodontal diseases. Mild forms of periodontal diseases can be taken under control with IPT. However, in advanced cases, the efficacy of IPT is restricted due to deep periodontal pockets, incomplete elimination of colonized periodontal pathogens from deep periodontal pockets and invasion of these microorganisms into gingival connective tissue.[2,3]

Periodontal pockets with probing depth (PD) ≥5 mm and bleeding on probing (BoP) (+) after active periodontal therapy are defined as residual periodontal pockets.[4-7] Residual periodontal pockets carry the risk of recurrence of periodontal disease since they act-like a harbor for periodontal pathogens incompatible with periodontal health.[8] Thus, the elimination of residual pockets is crucial for the treatment of periodontal diseases and maintenance of periodontal health.

Residual pockets can be eliminated with mechanical treatment approaches associated with adjunctive use

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of local/systemic antimicrobials,[4,9] photodynamic therapy,[5,6,10] and pocket disinfection with lasers.[5,6] Elimination of residual pockets with adjunctive treatment approaches such as laser disinfection is a novel option, due to lack of relevant studies in the literature.

Laser therapy has been recommended as a novel approach for the treatment of periodontal diseases.[11,12] A wide spectrum of lasers from CO_2 lasers to neodymium-doped:yttrium aluminum garnet (YAG), erbium-doped: YAG, erbium, chromium:yttrium-scandium-gallium-garnet, and diode lasers have been used in dentistry.[11] Lasers demonstrate antibacterial effect due to direct ablation and thermomechanic disruption of bacterial cells.[11]

The diode laser with wavelength between 800 and 980 nm is highly absorbed in hemoglobin and other pigments and has minimal thermal side effects on dental hard tissues.[11] It can be used for the incision and coagulation of oral mucosa and gingiva, pocket disinfection for bacterial elimination, and sulcular curettage.[11] Üstün *et al*.[13] showed that pocket disinfection with a 810 nm diode laser as an adjunct to scaling and root planing reduced gingival index (GI) better than scaling and root planing alone. Moreover, gingival crevicular fluid (GCF) volumes and interleukin-1β levels in GCF demonstrated higher reductions after combined therapy.[13] Systematic reviews evaluating the potential benefit of laser application over mechanical debridement in nonsurgical periodontal therapy by meta-analysis failed to reach a conclusion due to the lack of comparable data.[14,15] Hence, the evidence to support the clinical applications of adjunctive diode laser use with mechanical debridement is still inconclusive.

GCF is a blood-originated fluid playing an important determinant role in the ecology of the gingival sulcus and periodontal pocket.[16] While GCF acts as a transudate in healthy periodontium, it becomes an exudate in periodontal inflammation.[17] The increased permeability of blood vessels underlying sulcular and junctional epithelium causes an upsurge in GCF volume.[17,18]

The purpose of this study was to evaluate the effects of 810 nm diode laser as an adjunct to mechanical periodontal treatment on the clinical periodontal parameters and GCF volume of the residual periodontal pockets diagnosed following IPT in CP patients, and additionally compared this combined treatment approach with mechanical debridement and diode laser individually. The null hypothesis states that there is no difference in the existing outcome variables of residual pockets treated with either combined approach consisting of mechanical periodontal treatment and diode laser or single approach.

Materials and Methods

This prospective study was planned as a single-centered randomized three-arm parallel-designed clinical trial. The duration of the study was 19 weeks. The Clinical Research Ethical Committee of Yeditepe University approved the protocol on November 13, 2012, with the reference number 255. The research was conducted according to the principles outlined in the Declaration of Helsinki on experimentation involving human subjects. This randomized clinical trial was approved by the ClinicalTrials.gov with the registration number NCT02531555.

Subjects

Eleven CP patients, recruited consecutively from the Clinics of Periodontology Department, Faculty of Dentistry, Marmara University, were invited to participate in this study. To be eligible for the study, the volunteer had to present the following inclusion criteria: Systemically healthy, nonsmoker, CP diagnosed according to Armitage,[1] aged between 35 and 65, not received any periodontal treatment within the last 3 months have horizontal bone loss radiographically, presence at least 20 natural teeth except third molars and consent to participate in the study. The exclusion criteria were as follows: Any systemic disease that might interfere with the prognosis of periodontal disease (i.e., diabetes mellitus, HIV infection), smoking, antibiotics, anti-inflammatory drugs or any other medication taken within the last 6 months that might affect the outcome of the study, any physical limitations or restrictions that might preclude normal oral hygiene procedures. Written informed consent was obtained from all participants.

IPT that includes oral hygiene instructions, scaling and root planing was applied to all subjects with ultrasonic (Cavitron® BOBCAT® Pro, Dentsply International, USA) and hand instruments (Gracey, SG 5/6, 7/8, 11/12, 13/14, Hu-Friedy Ins. Co., USA) in two sessions with a 1-week interval. Eight weeks after IPT, residual periodontal pockets demonstrating PD ≥5 mm and BoP (+) on single-rooted teeth were selected for this study.

The sample size was chosen based on clinical considerations.[19] Assuming that the common standard deviation for PD is 1 mm, a sample of 28 residual pockets per group would provide 80% power to detect a true difference of 0.75 mm among groups.

Study groups and randomization

Selected residual periodontal pockets were randomly assigned by a computer-generated table to receive one of the following three treatment modalities. Residual pockets present in the same patient were appointed into

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randomization table on clockwise direction starting from the pocket, which was located the most distal position of the maxillary right quadrant. Moreover, special attention was paid that each residual pocket was separated from another with at least one interdental papilla site.

The treatment groups in this study are as follows:

Mechanical periodontal treatment (Group M): Scaling and root planing were performed with ultrasonic and hands instruments until the operator feels that root surface is clean, hard and smooth

Pocket disinfection with a diode laser (Group L): Subgingival irradiation with a GaAlAs diode laser (CHEESE®, Gigaa Laser, China) was applied to residual pockets each for 20 s in continuous mode. The diode laser had a wavelength of 810 nm and power output of 1 W for subgingival irradiation (maximum output power of device was 7 W). Diode laser application was performed parallel to root surface by a 200 μm fiber tip inserted at the bottom of periodontal pocket and slowly moved from apical to coronal direction in a sweeping motion without local anesthesia

Combined treatment (Group M + L): Following mechanical periodontal treatment, pocket irradiation with diode laser was performed as mentioned above.

Clinical protocol

In the first session, all subjects went through detailed systemic and dental anamneses and received radiographical and periodontal examination. After 1-week, all subjects received IPT consisting oral hygiene instructions and supra/subgingival scaling and root planing applied with ultrasonic and hand instruments in two sessions with a 1-week interval. Eight weeks following the completion of IPT, periodontal pockets demonstrating PD ≥5 mm and BoP (+) on single-rooted teeth were selected as residual periodontal pockets, which were randomly assigned to three treatment groups.

The first session of treatment for residual pockets was accepted as a baseline of this study [Figure 1]. In this session, GCF samples were collected from the residual pockets, clinical periodontal parameters were recorded, and treatment protocols were applied. After 1-week, GCF samples were collected from the same sites, and after 8 weeks, GCF samples were collected, and clinical periodontal parameters were recorded again for the residual pockets.

Periodontal examination

Clinical periodontal parameters were evaluated at baseline and, 8 weeks after treatment of residual pockets. The measured parameters were plaque index (PI),[20] GI,[21] BoP, PD and clinical attachment level (CAL). PD was defined as the distance from the free gingival margin to the bottom of the periodontal pocket. CAL was defined as the distance from the cementoenamel junction to the bottom of the periodontal pocket. PD and BoP were the primary outcomes of this study.

All clinical examinations were carried out by a single examiner (standard error of mean). To achieve the intra-examiner calibration, five nonstudy subjects were selected, and full mouth PD scores were measured twice within 3 days. The intra-examiner correlation was calculated as 94.8% reproducibility.

Gingival crevicular fluid collection and volume calculation

GCF samples were collected from the residual pockets at baseline, 1 and 8 weeks after treatment. To prevent plaque and saliva contamination, supragingival plaque was gently removed and cotton rolls were placed in the vestibular and lingual sites of selected pockets.[17] Moreover, all saliva was aspirated from the mouth and sampling site. A prefabricated paper strip (Periopaper, Oraflow Inc., Smithtown, NY, USA) was gently inserted just at the entrance of pocket[22] and then left there for 30 s. Strips visibly contaminated with blood, saliva or microbial dental plaque were discarded. The GCF volume was measured with a calibrated Periotron 8000 (OraFlow, Inc., Smithtown, NY, USA) and then numerical readings were converted into actual volume (μl) with the reference to formulation obtained from the standard curve.

Statistical analyses

The statistical analysis was performed using SPSS 20 (SPSS Corporation, Chicago, IL, USA) with a significance level of 5%.

The Kolmogorov–Smirnov test was used to check the distribution for normality. Repeated measurements of clinical parameters and qualitative variables were analyzed with Wilcoxon signed rank test. Repeated measurements of GCF volumes were analyzed with Friedman test.

The Kruskal–Wallis analyses, the Mann–Whitney U-test, and Chi-square and Fisher's exact test were used to determine differences among the groups.

Results

The study population consisted of 11 CP patients with the mean age of 44.09 ± 4.48 years (range 37–51). A total of 84 residual periodontal pockets on single-rooted teeth in these patients were included in each group having 28 residual pockets. Distributions of these residual pockets on the patients are shown in Table 1.

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Table 2 displays the clinical periodontal findings of residual pockets at baseline and 8 weeks after treatment.

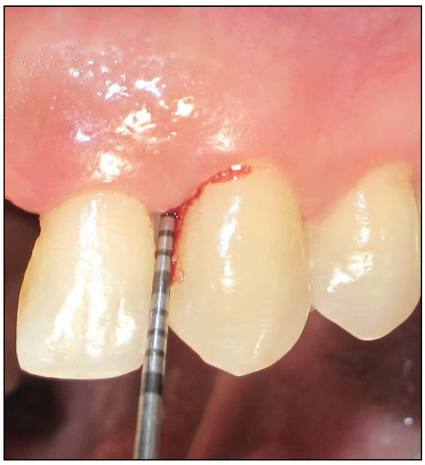

Figure 1: A residual pocket after initial periodontal treatment

Table 1: Distrubution of residual pockets in 11 patients

Patient code	Residual pockets (*n*)
I	12
II	16
III	11
IV	7
V	8
VI	5
VII	4
VIII	3
IX	5
X	7
XI	6
Total	84

At baseline, there was no difference among the groups regarding clinical parameters, as expected. All clinical parameters, except PI, showed significant improvements after treatment in the Group M and the Group M + L ($P < 0.001$), but in the Group L only PD ($P < 0.001$) and CAL ($P < 0.03$) showed significant improvements. GI and BoP of the Group M and the Group M + L demonstrated greater reduction than those of the Group L ($P < 0.001$), however, there was no difference between the Groups M and M + L ($P > 0.05$). No difference was found among the groups for the other clinical parameters after treatment. Before treatment, all experimental sites demonstrated PD equal or deeper than 5 mm and presented BoP. Approximately, 14% of the sites in the Group M, 50% of the sites in the Group L and 11% of the sites in the Group M + L still had PD ≥5 mm and BoP (+), which means they remained residual [Table 3]. The number of residual pockets in the Group L was significantly higher than those of the other two groups after treatment ($P < 0.001$) [Table 3]. At the end of the study period, a quarter of all sites were still residual independent from the treatment modality. The risk of a site to remain residual was approximately 5 times higher after treatment with diode laser alone compared with the other treatment approaches [Table 3].

GCF volume decreased statistically significantly after treatment in the Groups M and M + L ($P < 0.05$) but showed no difference among the groups at all time points ($P > 0.05$) [Table 4]. When the changes in GCF volume between different sample collection times of the groups were compared, the differences were also insignificant, as shown in Table 5 ($P > 0.05$).

Table 2: Intragroup and intergroup analyses of clinical findings at baseline and after 8 weeks

	Baseline				Week 8			
	Group M	Group L	Group M + L	*P**	Group M	Group L	Group M + L	*P**
PI[a]	0.43±0.57	0.71±0.71	0.71±0.66	0.18	0.36±0.49	0.50±0.64	0.64±0.68	0.19
GI[a]	2.00±0.00	2.00±0.00	2.00±0.00	-	1.25±0.65[λ]	1.93±0.47	1.29±0.79[λ]	<0.001
BoP (%)[a]	100.00±0.00	100.00±0.00	100.00±0.00	-	35.71±4.88[λ]	89.29±3.14	35.71±4.88[λ]	<0.001
PD (mm)[a]	6.32±0.90	6.16±0.74	6.29±0.79	0.27	5.04±1.10[λ]	5.37±0.82[λ]	4.97±1.15[λ]	0.17
CAL (mm)[a]	8.21±1.38	8.15±1.08	8.23±1.43	0.16	7.32±1.11[λ]	7.75±1.17[ψ]	7.27±1.25[λ]	0.52

[a]Mean±SD, PI=Plaque index; GI=Gingival index; BoP=Bleeding on probing; PD=Probing depth; CAL=Clinical attachment level; ANOVA=Analysis of variance; SD=Standard deviation. *Difference among groups, Kruskal–Wallis one-way ANOVA test, $P<0.05$; [λ]Different from baseline, Wilcoxon signed rank test, $P<0.001$; [ψ]Different from baseline, Wilcoxon signed rank test, $P<0.03$

Table 3: Number and percentage of residual pockets in each treatment group at baseline and after 8 weeks

	Baseline				Week 8			
	Group M	Group L	Group M + L	*P**	Group M	Group L	Group M + L	*P**
Residual pockets (*n*)	28	28	28	-	4	14	3	<0.001
Residual pockets (%)	100	100	100	-	14.28	50	10.71	<0.001

*Difference among groups after treatment, Chi-square test, $P<0.001$

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Table 4: Gingival crevicular fluid volume

	GCF Volume (µl)			
	Mean±SD			P^{λ}
	Group M (*n*=28)	Group L (*n*=28)	Group M + L (*n*=28)	
Baseline	0.45±0.32	0.38±0.27	0.45±0.38	0.39
First week	0.28±0.21	0.36±0.35	0.34±0.26	0.78
Eighth week	0.38±0.32	0.34±0.25	0.36±0.27	0.31
*P**	0.03	0.19	0.04	

*Friedman test, $P<0.05$; $^{\lambda}$Kruskal–Wallis one-way ANOVA test, $P<0.05$. GCF=Gingival crevicular fluid; µl=Microliter; SD=Standard deviation; ANOVA=Analysis of variance

Table 5: Changes in gingival crevicular fluid volume between different collection time points

	Changes in GCF volume (µl) Mean±SD			P^{λ}
	Group M (*n*=28)	Group L (*n*=28)	Group M + L (*n*=28)	
First week-baseline	−0.22±0.26	−0.09±0.39	−0.12±0.35	0.69
Eighth week-First week	0.12±0.31	−0.01±0.41	0.04±0.25	0.98
Eighth week-baseline	−0.07±0.32	−0.03±0.34	−0.07±0.31	0.37

$^{\lambda}$Kruskal–Wallis one-way ANOVA test, $P<0.05$. ANOVA=Analysis of variance; GCF=Gingival crevicular fluid; µl=Microliter; SD=Standard deviation

Discussion

Residual pockets represent a risk factor as they harbor periodontal pathogens that may cause initiation and progression of periodontitis which may result in tooth loss,[7] Therefore, it is necessary to take the residual pockets under control for the maintenance of periodontal health status. Residual pockets are the sites requiring additional therapeutic approaches.[10] To our knowledge, this is the first study evaluating clinical effects of 810 nm diode laser as an adjunct to mechanical periodontal treatment of residual pockets diagnosed after IPT.

The findings of presented study showed significant improvements in GI and BoP parameters achieved with both mechanical treatment alone and mechanical treatment combined with adjunctive use of diode laser, without any difference between these two approaches. Similarly, the percentages of the remaining residual pockets were significantly lower in the Group M and Group M + L 8 weeks after treatment, without any significant difference between them. Significant reduction in PD and attachment gain were obtained in all three-treatment approaches, without any differences among groups.

A positively directed association between GCF volume and gingival inflammation has been declared previously.[16,18] In this study, GCF volume decreased parallel to the declines in GI and BoP in the Group M and M + L.

Similar to our study, Üstün *et al*.[13] used 810 nm wavelength diode laser as an adjunct to mechanical treatment for 20 s/site. Adversely to ours, results of this study had better clinical outcomes with combined approach on GI, PD and CAL and GCF volume than mechanical treatment alone. Nevertheless, diode laser was used as adjunct to nonsurgical treatment on untreated sites of CP patient in that study.[13] It must be noticed that clinical improvement of residual pockets is limited and more difficult than the untreated periodontal sites.

So far, only two clinical trials have been published on the treatment of residual pockets in periodontology literature with similar study groups and designs.[5,6] In contrast with our study, both studies showed that pocket irradiation with diode laser and mechanical treatment alone had similar effects on the reductions of GI and BoP. However, residual pockets detected during maintenance phase 3–24 months after completion of comprehensive periodontal treatment were included in these abovementioned studies.[5,6] Therefore, included residual pockets, to these two studies may contain more pathogenic microorganisms that resulted in higher gingival inflammation to give a better response to pocket irradiation with a diode laser. Giannopoulou *et al*.[5] investigated levels of several cytokines and acute-phase proteins in GCF after treatment of residual pockets with diode laser pocket irradiation. Although, GCF volumes were not presented, levels of cytokines, and acute-phase proteins decreased significantly after treatment with diode laser application.

Selection of laser parameters correctly is significant to avoid thermal side effects. To be effective, each laser system has its own application parameters in different treatment modalities. In this study, 810 nm wavelength diode laser (1.0 W, 20 s/pocket) was applied to residual pocket parallel to the root surface in a sweeping motion like a scanning without local anesthesia. There were no feedbacks from patients about side effects related to laser application, such as burning sensation and pain with these laser settings and application technique. There were some clinical trials assessing adjunctive effect of laser irradiation to IPT that applied in longer than 20 s/pocket,[23,24] repeatedly applied in one session[24] or applied more than one session.[25] Consequently, longer application times or repeated applications of diode laser pocket irradiation for treatment of residual pockets can be evaluated in further studies.

Within the limitations of this study, the results of this clinical trial demonstrated that the 810 nm wavelength

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diode laser as an adjunct to mechanical treatment on residual pockets of CP patients is not superior to mechanical treatment alone. In addition, diode laser application alone has limited effects on clinical periodontal parameters of residual pockets. Since only a few clinical trials exist about the treatment of residual pockets, additional longitudinal, randomized, and controlled clinical trials are necessary to test the potential benefits of adjunctive of a diode laser to mechanical treatment of residual pockets. Future clinical trials supported with microbiological and biochemical variables to correlate with the clinical outcomes should be designed using 810 nm wavelength diode laser testing different application times and/or repeated, multiple applications.

Conclusion

Our research demonstrates that diode laser application as an adjunct to mechanical treatment of residual pockets appears to have no additional effect on clinical parameters and GCF volume.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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