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Effect of Various Laser Systems in Smokers and Non-smokers with Peri-implantitis: A Randomized, Prospective, Single-blind Clinical Trial

Sigara İçen ve İçmeyen Peri-implantitisli Hastalarda Çeşitli Lazer Sistemlerinin Etkisi: Randomize, Prospektif, Tek Kör Klinik Çalışma

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Abstract

Objective: The aim of this study was to evaluate the effects of different laser systems in smokers and nonsmokers with peri-implantitis.

Materials and Methods: Subjects were divided into six groups according to the study protocol: Group 1: Smokers who underwent diode laser application; group 2: Erbium, chromium: Yttrium, scandium, gallium, garnet (Er, Cr: YSGG) laser application. Group 3: smokers undergoing Erbium: Yttrium-aluminum-garnet (Er: YAG) laser application; group 4: non-smokers undergoing diode laser application; group 5: non-smokers undergoing Er,Cr: YSGG laser application; and group 6: non-smokers undergoing Er: YAG laser application. Peri-implant sulcus depth (SD), clinical attachment level (CAL), suppuration, modified plaque index (mPI), gingival index (GI), and modified sulcus bleeding index (mSBI) were recorded, and peri-implant sulcus fluid (PISF) was collected to evaluate osteocalcin.

Results: There were statistically significant differences in the baseline and six-month SD, CAL, mPI, GI, mSBI measurements, and osteocalcin values in all groups ($p<0.05$).

Conclusion: Laser applications for treating peri-implantitis have significantly improved clinical parameters and PISF osteocalcin levels.

Keywords: Bone, dental implants, lasers, osteocalcin, peri-implantitis, risk factors

Öz

Amaç: Bu çalışmanın amacı, peri-implantitis olan sigara içen ve içmeyen hastalarda çeşitli lazer sistemlerinin etkisini değerlendirmektir.

Gereç ve Yöntemler: Çalışma protokolüne göre hastalar altı gruba ayrılmıştır: Grup 1: Sigara içen diyot lazer uygulanan grup; grup 2: sigara içen Erbiyum, kromiyum: yitriyum, skandiyum, galliyum, garnet (Er,Cr: YSGG) lazer uygulanan grup; Grup 3: Sigara içen Erbium: yitriyum-alüminyum-garnet (Er: YAG) lazer uygulanan grup; grup 4: Sigara içmeyen diyot lazer uygulanan grup; grup 5: Sigara içmeyen Er,Cr: YSGG lazer uygulanan grup ve grup 6: sigara içmeyen Er: YAG lazer uygulanan grup. Peri-implant sulkus derinliği (SD), klinik ataşman seviyesi (KAS), süpürasyon, modifiye plak indeksi (mPI), gingival indeks (GI) ve modifiye sulkus kanama indeksi (mSKI) kaydedilmiştir ve peri-implant sulkuler sıvısı osteokalsin seviyesini değerlendirmek için toplanmıştır.

Bulgular: Tüm gruplarda başlangıç ve altı aylık değerlendirmede SD, KAS, mPI, GI, mSKI ölçümleri ve osteokalsin seviyelerinde istatistiksel olarak anlamlı farklılıklar bulunmuştur ($p<0,05$).

Sonuç: Peri-implantitis tedavisinde lazer uygulamaları, klinik parametrelerde ve peri-implant sulkuler sıvı osteokalsin seviyelerinde önemli iyileşmeler sağlamıştır.

Anahtar Kelimeler: Kemik, dental implant, lazerler, osteokalsin, peri-implantitis, risk faktörleri

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Introduction

Today, satisfying results are obtained in an aesthetic and functional sense with dental implant-supported prosthetic approaches (1). However, it is possible to encounter biological complications affecting the tissues around dental implants even in cases of successful osseointegration.

Serum osteocalcin has been shown to be a bone turn-over marker and a clinical diagnostic marker of metabolic bone diseases (2). Kunimatsu et al. (3) showed that no significant amount of osteocalcin was detected in gingivitis whereas osteocalcin levels increased in periodontitis.

Lasers can provide positive outcomes in the treatment of peri-implantitis, since it effectively reaches implant surfaces that cannot be accessed by using mechanical methods and removes the tartar and has bactericidal effects (4). Laser therapy can further contribute to the decontamination of peri-implant tissues, the development of regeneration and healing (5).

In light of all this information, the hypothesis of our study was laser monotherapy provides less improvement in clinical parameters in smokers with peri-implantitis compared to non-smokers with peri-implantitis. This study aimed to evaluate the effect of various laser systems on clinical parameters and peri-implant osteocalcin levels in smokers and non-smokers with peri-implantitis.

Materials and Methods

This study was prepared in accordance with Consort 2010 guidelines (Figure 1). This study was designed as a randomized, prospective, and single-blind clinical trial. Individuals who applied to Kırıkkale University Faculty of Dentistry Department of Periodontology were included in the study. The study was performed in accordance with the principles of the Declaration of Helsinki and was approved by Kırıkkale University Clinical Research Ethics Committee (09/02) and the Turkish Medicines and Medical Devices Agency (2019/060). Prior to the study, all individuals to be

Section/Topic	Item No	Checklist item	Reported on page No
Title and abstract			
	1a	Identification as a randomised trial in the title	1
	1b	Structured summary of trial design, methods, results, and conclusions (for specific guidance see CONSORT for abstracts)	1
Introduction			
Background and objectives	2a	Scientific background and explanation of rationale	1
	2b	Specific objectives or hypotheses	1
Methods			
Trial design	3a	Description of trial design (such as parallel, factorial) including allocation ratio	2
	3b	Important changes to methods after trial commencement (such as eligibility criteria), with reasons	-
Participants	4a	Eligibility criteria for participants	2
	4b	Settings and locations where the data were collected	2
Interventions	5	The interventions for each group with sufficient details to allow replication, including how and when they were actually administered	2
Outcomes	6a	Completely defined pre-specified primary and secondary outcome measures, including how and when they were assessed	2
	6b	Any changes to trial outcomes after the trial commenced, with reasons	-
Sample size	7a	How sample size was determined	2
	7b	When applicable, explanation of any interim analyses and stopping guidelines	-
Randomisation:			
Sequence generation	8a	Method used to generate the random allocation sequence	2
	8b	Type of randomisation; details of any restriction (such as blocking and block size)	2
Allocation concealment mechanism	9	Mechanism used to implement the random allocation sequence (such as sequentially numbered containers), describing any steps taken to conceal the sequence until interventions were assigned	2
Implementation	10	Who generated the random allocation sequence, who enrolled participants, and who assigned participants to interventions	2
Blinding	11a	If done, who was blinded after assignment to interventions (for example, participants, care providers, those assessing outcomes) and how	2
	11b	If relevant, description of the similarity of interventions	-
Statistical methods	12a	Statistical methods used to compare groups for primary and secondary outcomes	2
Results			
Participant flow (a diagram is strongly recommended)	13a	For each group, the numbers of participants who were randomly assigned, received intended treatment, and were analysed for the primary outcome	3
	13b	For each group, losses and exclusions after randomisation, together with reasons	
Recruitment	14a	Dates defining the periods of recruitment and follow-up	3
	14b	Why the trial ended or was stopped	3
Baseline data	15	A table showing baseline demographic and clinical characteristics for each group	3
Numbers analysed	16	For each group, number of participants (denominator) included in each analysis and whether the analysis was by original assigned groups	3
Outcomes and estimation	17a	For each primary and secondary outcome, results for each group, and the estimated effect size and its precision (such as 95% confidence interval)	3
	17b	For binary outcomes, presentation of both absolute and relative effect sizes is recommended	3
Ancillary analyses	18	Results of any other analyses performed, including subgroup analyses and adjusted analyses, distinguishing pre-specified from exploratory	-
Harms	19	All important harms or unintended effects in each group (for specific guidance see CONSORT for harms)	-
Discussion			
Limitations	20	Trial limitations, addressing sources of potential bias, imprecision, and, if relevant, multiplicity of analyses	3
Generalisability	21	Generalisability (external validity, applicability) of the trial findings	3
Interpretation	22	Interpretation consistent with results, balancing benefits and harms, and considering other relevant evidence	3
Other information			
Registration	23	Registration number and name of trial registry	-
Protocol	24	Where the full trial protocol can be accessed, if available	2
Funding	25	Sources of funding and other support (such as supply of drugs), role of funders	

*We strongly recommend reading this statement in conjunction with the CONSORT 2010 Explanation and Elaboration for important clarifications on all the items. If relevant, we also recommend reading CONSORT extensions for cluster randomised trials, non-inferiority and equivalence trials, non-pharmacological treatments, herbal interventions, and pragmatic trials. Additional extensions are forthcoming: for those and for up to date references relevant to this checklist, see www.consort-statement.org.

Figure 1. 2010 checklist of information to include when reporting a randomised trial

included in the study were given detailed information about the purpose and the method of the research and informed consent forms were obtained.

Study Groups

A total of 103 implants with peri-implantitis in 42 participants were included in the study: 20 implants of smoking patients undergoing Er:YAG, 15 implants of non-smoking patients undergoing Er:YAG, 19 implants of smoking patients Er,Cr:YSGG laser application, 15 implants of non-smoking patients undergoing Er,Cr:YSGG, 18 implants of smoking patients undergoing diode laser application, and 16 implants of non-smoking patients undergoing diode laser application. Twenty eight participants who did not meet the inclusion criteria were excluded from the study. Simple randomization method was used in the study. Randomization was provided by draw up.

The inclusion criteria were as follows:

1. Presence of a pocket at probing depth of ≥4 mm in at least one implant

2. No mobility of the implant

3. No systemic disease that could affect the outcome of treatment

4. No systemic use of antibiotics in the last six months

5. No peri-implantitis treatment in the last three months

6. Individuals between the ages of 30-60 years.

The exclusion criteria were as follows:

1. Individuals who did not consent to participate in the study

2. Subjects receiving radiotherapy

3. Persons consuming alcohol

4. Presence of pregnancy and lactation

5. Individuals with parafunctional habits such as teeth grinding or bruxism.

Peri-implantitis was diagnosed with the presence of pocket in probing depth of ≥4 mm, radiographic bone loss of >2 mm, bleeding on probing (BoP), and suppuration (present or not) (6). Individuals who smoke at least 10 cigarettes daily for at least 5 years and more are considered to be smokers (7). Groups were created as follows:

Group 1: Smokers treated with a diode laser; **Group 2:** Smokers treated with an Er,Cr:YSGG laser; **Group 3:** Smokers treated with an Er:YAG laser; **Group 4**: Non-smokers treated with a diode laser; **Group 5:** Non-smokers treated with an Er,Cr:YSGG laser; **Group 6:** Non-smokers treated with an Er:YAG laser.

Clinical Measurements

Before the laser applications, clinical periodontal parameters including sulcus depth (SD), clinical attachment level (CAL), suppuration, modified plaque index (mPI), gingival index (GI), mSBI and keratinized mucosa measurements were obtained from all implants and implant sulcus fluid (PISF) was collected. Re-evaluation was performed at the 6th month. The changes in SD and CAL were the primary outcome of this randomized trial and as well as the secondary variables GI, mPI and modified sulcus bleeding index (mSBI). Pressure was applied to the mucosa to determine whether there was an inflammatory flow. It was evaluated dichotomously. All clinical measurements were recorded with a standard, color-coded, discontinuous, pressure calibrated plastic periodontal probe (Click-Probe Blue, Kerr GmbH, Biberach, Germany). All measurements were done by the same examiner (K.B.).

$$\text{Concentration (ng/mL)} = \text{Osteocalcin value} \times \frac{\text{Amount of Dilution (0.2 mL)}}{\text{PISF volume}}$$

$$\text{Total amount (ng/site)} = \text{Osteocalcin concentration} \times \frac{\text{PISF volume (mL)}}{\text{site (2)}}$$

Peri-implantitis Treatment Procedure

After the baseline measurements, patients received treatments (K.B.), the diode laser (Epic10, Settings: 940±10 nm, 2.5W, CP2 mod) was applied for 30 seconds using a 400-µm-thick fiber tip (E4 7 & 9 mm). The laser tip was applied as vertical and horizontal scan along the subgingival implant (8). The procedure was carried out on day 0, 7 and 14.

Pockets were treated using an Er,Cr:YSGG laser (Waterlase, Settings: 1.5 W power, 30 Hz, Water 50%, Air 40%, 50 mJ/pulse, 140 µs pulse duration) by inserting a 14-mm long, 500 µm diameter radial firing tip (RFPT5) into the pocket. The tip was placed at the bottom of the pocket and kept at an angle parallel to the long axis of the implant and epithelial tissue as much as possible. After contact with bone, the tip was slightly retracted and moved up and down in the pocket in the apical-coronal direction with a slow sweeping motion and the buccolingual or mesiodistal direction, depending on the location of the pocket (9).

Er:YAG laser [Fotona, Settings: 100 mJ/pulse (12. 7 J/cm^2), 10 pps, pulse energy of the tip was about 85 mJ/pulse] was applied to the implant surfaces under irrigation using a conical glass fiber tip (R14 CD FIBER TYPE, TAPER 12/0.6). The fiber tip was applied parallel to the implant surface in contact mode or a circular motion from the coronal to the apical direction for 60 seconds with an opening of 10-15 degrees (6).

Statistical Analysis

Power analysis calculations displayed a minimum requirement of 66 samples per group in order to compare data at α=0.05 with a power value of 95%. The statistical significance level in the study was determined as $p<0.05$. Statistical analyses were performed by using IBM SPSS Statistics 22.0 and MS-Excel 2016.

Results

Age and gender distribution of the participants are shown in Table 1. When the sixth-month measurement results were evaluated, it was determined that there was a significant difference among the groups in terms of SD, CAL, mPI, GI and total amount results. Post-hoc test showed that the GI value of patients in the Er,Cr:YSGG laser group was significantly higher than the other groups (Chart 1).

The initial values of the diode laser group revealed that the amount of mPI, concentration and total amount were significantly different in the smoker and non-smoker groups. It was determined that these measurements were higher in the non-smoker group and lower in the smoker group. As a result of the six-month evaluation, the concentration of osteocalcin was found to be seven times higher in the smoker group than the non-smoker group and the difference was also significant in the total amount results (Table 2).

There was a significant difference between the Er,Cr:YSGG laser group and other groups in terms of GI values. The difference in GI was found to be caused by the smoker group which had higher median value. In other clinical measurements, the results in the groups were similar. There was a significant difference between the groups in terms of the six-month total amount. When the clinical evaluation results were examined, there was a significant decrease in sixth-month measurements in all evaluation results (Table 3).

Table 1. Demographic variables

	n (%)		n (%)
Gender		**Smokers**	
Female	54 (52.4)	S+	57 (55.3)
Male	49 (47.6)	S-	46 (44.7)
Laser group		**Age**	
Diode laser	34 (33.0)	Min; max	44; 59
Er,Cr:YSGG laser	34 (33.0)	Mean	54.7
Er:YAG laser	35 (34.0)		

S+: Smoker, S-: Non-smoker, Min: minimum, Max: Maximum

Discussion

It is a very important fact that peri-implant diseases are increasing as implant applications increase. In our study, Er:YAG, Er,Cr:YSGG, diode laser were applied as monotherapy in the treatment of peri-implantitis and clinical measurements such as mPI, GI, SD, CAL, mSBI were observed to decrease significantly. Biochemically, a significant decrease in concentration and the total amount of osteocalcin were observed. The decrease in the total amount was higher in diode laser group than in the other groups.

A meta-analysis examining the relationship between smoking and peri-implantitis shows that smoking can change treatment outcomes in peri-implant diseases (10). In our study, when the smokers and non-smokers in diode laser group were compared according to the initial and six-month results, CAL was found to be significantly higher in the S- group than in the S+ group. The concentration and the total amount of osteocalcin decreased nearly 6 times in the non-smoker group.

Decontamination in peri-implant disease includes mechanical debridement, chemical debridement, laser, antimicrobial photodynamic therapy issues (11). In a study that the efficacy of diode laser as a supportive option to the conventional non-surgical treatment of peri-implant mucositis and initial peri-implantitis are analyzed, twenty-three patients were evaluated and pointed out that diode laser could be used as an adjunct to the conventional non-surgical treatment of peri-implant mucositis and peri-implantitis (12). Mettraux et al. (8) used diode laser in addition to mechanical debridement in their study. In the 2-year follow-up, a significant decrease was observed in SD, BoP, and radiographic bone filling was observed. Al-Falaki et al. (13) evaluated the treatment outcome at 2 and 6 months following the use of Er,Cr:YSGG laser in the non-surgical treatment of peri-implantitis. A significant decrease in BoP was observed in the depth of the sulcus

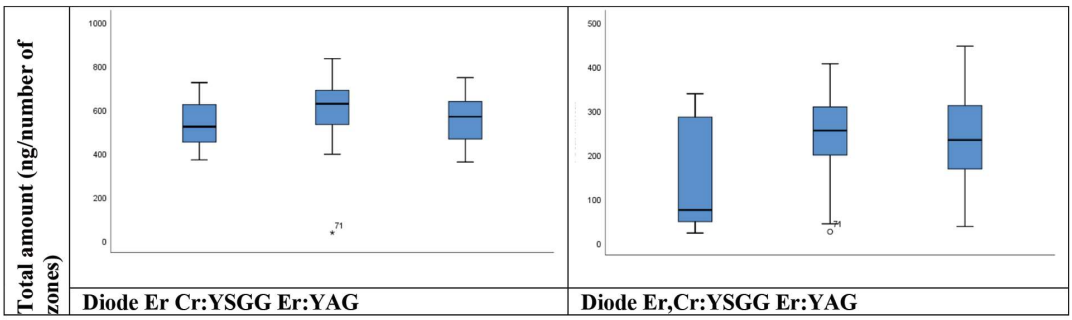

Chart 1. Examination of lasers baseline (T-1) and six-month (T-2) of total amount

T-1: Baseline, T-2: Six-month

Table 2. Examination of lasers baseline (T-1) and six-month (T-2) measurements by smoking status

Variables	Diode laser				Er,Cr:YSGG laser				Er:YAG laser			
	S+† groups (n=18)	S-‡ groups (n=16)	Test	Statistics	S+ groups (n=18)	S- groups (n=16)	Test	Statistics	S+ groups (n=20)	S-groups (n=15)	Test	Statistics
	Median (min; max)	Median (min; max)	Z	p	Median (min; max)	Median (min; max)	Z	p	Median (min; max)	Median (min; max)	Z	p
T-1												
SD	5.0 (4.5; 5.0)	5.0 (5.0; 7.0)	1.944	0.281	5.0 (4.0; 9.0)	5.0 (4.8; 6.0)	1.338	0.202	5.0 (5.0; 6.0)	5.0 (4.5; 6.0)	1.263	0.314
CAL	4.0 (3.5; 4.0)	4.0 (3.5; 6.0)	0.703	0.646	4.0 (2.5; 7.5)	4.0 (3.0; 5.0)	0.232	0.837	4.0 (3.5; 5.0)	4.0 (3.5; 5.0)	0.655	0.542
mPI	3.0 (3.0; 3.0)	2.5 (2.0; 3.0)	4.137	<0.001*	2.0 (2.0; 3.0)	3.0 (2.0; 3.0)	0.533	0.656	2.0 (2.0; 3.0)	3.0 (2.0; 3.0)	1.195	0.283
GI	3.0 (2.0; 3.0)	2.8 (1.5; 3.0)	1.278	0.281	3.0 (2.0; 3.0)	2.0 (2.0; 3.0)	3.351	0.004**	2.0 (2.0; 3.0)	2.0 (2.0; 3.0)	2.421	0.069
mSBI	2.0 (2.0; 2.0)	2.0 (2.0; 2.0)	0.000	1.000	2.0 (2.0; 2.0)	2.0 (1.0; 2.0)	1.616	0.515	2.0 (1.0; 3.0)	2.0 (1.0; 2.0)	1.147	0.542
Concentration	11.2 (6.9; 19.9)	6.3 (5.6; 8.6)	4.623	<0.001*	9.8 (0.5; 18.7)	9.7 (7.2; 15.5)	0.676	0.515	9.6 (4.7; 19.2)	9.1 (6.0; 17.7)	0.633	0.542
Total amount	609.5 (416.0; 723.0)	464.5 (369.0; 567.0)	3.968	<0.001*	622.0 (35.0; 746.0)	683.0 (498.0; 833.0)	1.839	0.066	567.5 (359.0; 746.0)	534.0 (366.0; 722.0)	0.367	0.730
T-2												
SD	3.0 (3.0; 3.0)	3.0 (2.8; 4.3)	0.836	0.551	3.8 (2.3; 6.3)	4.0 (3.0; 4.0)	0.386	0.732	4.0 (3.0; 5.5)	4.0 (3.0; 5.0)	1.068	0.400
CAL	2.0 (2.0; 3.0)	3.0 (2.0; 3.5)	2.912	0.009****	3.0 (2.0; 5.3)	3.0 (2.0; 3.3)	1.737	0.147	3.0 (3.0; 4.5)	3.0 (2.0; 4.0)	0.761	0.564
mPI	1.0 (1.0; 1.0)	1.0 (1.0; 2.0)	2.521	0.126	2.0 (1.0; 2.0)	1.0 (1.0; 2.0)	2.022	0.066	1.0 (1.0; 2.0)	1.0 (1.0; 2.0)	0.302	0.882
GI	1.0 (1.0; 1.0)	1.0 (1.0; 1.0)	0.000	1.000	2.0 (1.0; 2.0)	1.5 (1; 2.5)	0.908	0.410	1.0 (1.0; 1.0)	1.0 (1.0; 1.0)	0.000	1.000
mSBI	1.0 (1.0; 1.0)	1.0 (1.0; 1.0)	0.000	1.000	1.0 (1.0; 1.0)	1.0 (1.0; 2.0)	1.125	0.758	1.0 (1.0; 1.0)	1.0 (1.0; 1.0)	0.000	1.000
Concentration	7.7 (1.8; 16.3)	1.4 (0.6; 3.7)	4.313	<0.001*	6.7 (0.9; 14.9)	5.5 (0.9; 11.9)	0.989	0.336	7.1 (1.5; 10.3)	5.5 (0.9; 10.7)	1.533	0.131
Total amount	271.0 (40; 338)	50.5 (22; 126.0)	3.779	<0.001*	300.0 (25.0; 406.0)	209.0 (43.0; 308.0)	2.637	0.007***	236.0 (75.0; 446.0)	229.0 (37.0; 373.0)	0.833	0.419

†S+: Smoker, ‡S-: Non-smoker

*p<0.001, **p<0.004, ***p<0.007, ****p<0.009. SD: Sulcus depth, CAL: Clinical attachment level, mPI: Modified plaque index, GI: Gingival index, mSBI: Modified sulcus bleeding index

Table 3. Examination of Diode laser, Er,Cr:YSGG laser, Er:YAG laser baseline (T-1) and six-month (T-2) measurements

Variables	Diode laser		Test	Statistics	Er,Cr:YSGG laser		Test	Statistics	Er:YAG laser		Test	Statistics
	T-1 Median (min; max)†	T-2 Median (min; max)‡	Z	p	T-1 Median (min; max)	T-2 Median (min; max)	Z	p	T-1 Median (min; max)	T-2 Median (min; max)	Z	p
SD	5.0 (4.5; 7.0)	3.0 (2.8; 4.3)	5.287	<0.001*	5.0 (4.0; 9.0)	4.0 (2.3; 6.3)	5.119	<0.001*	5.0 (4.5; 6.0)	4.0 (3.0; 5.5)	5.316	<0.001*
CAL	4.0 (3.5; 6.0)	3.0 (2.0; 3.5)	5.164	<0.001*	4.0 (2.5; 7.5)	3.0 (2.0; 5.3)	4.948	<0.001*	4.0 (3.5; 5.0)	3.0 (2.0; 4.5)	5.093	<0.001*
mPI	3.0 (2.0; 3.0)	1.0 (1.0; 2.0)	5.205	<0.001*	2.9 (2.0; 3.0)	1.5 (1.0; 2.0)	4.735	<0.001*	2.5 (2.0; 3.0)	1.0 (1.0; 2.0)	5.273	<0.001*
GI	3.0 (1.5; 3.0)	1.0 (1.0; 1.0)	5.248	<0.001*	3.0 (2.0; 3.0)	1.8 (1.0; 2.5)	5.002	<0.001*	2.0 (2.0; 3.0)	1.0 (1.0; 1.0)	5.445	<0.001*
mSBI	2.0 (2.0; 2.0)	1.0 (1.0; 1.0)	5.831	<0.001*	2.0 (1.0; 2.0)	1.0 (1.0; 2.0)	5.568	<0.001*	2.0 (1.0; 3.0)	1.0 (1.0; 1.0)	5.578	<0.001*
Concentration	8.0 (5.6; 19.9)	2.4 (0.6; 16.3)	4.419	<0.001*	9.8 (0.5; 18.7)	6.0 (0.9; 14.9)	5.001	<0.001*	9.4 (4.7; 19.2)	6.5 (0.9; 10.7)	4.553	<0.001*
Total amount	521.0 (369.0; 723.0)	74.5 (22.0; 338.0)	5.086	<0.001*	626.0 (35.0; 833.0)	254.5 (25.0; 406.0)	5.087	<0.001*	567.0 (359.0; 746.0)	233.0 (37.0; 446.0)	5.078	<0.001*

†max: Maximum; ‡min: Minimum
*p<0.001. SD: Sulcus depth, CAL: Clinical attachment level, mPI: Modified plaque index, GI: Gingival index, mSBI: Modified sulcus bleeding index

and in almost all areas of application. The surface of the implants removed due to peri-implantitis was examined by electronic and microscopic methods. It was observed that almost all of the surfaces of the implants treated with the Er,Cr:YSGG laser are decontaminated (14). Schwarz et al. (15) compared the Er:YAG laser application with mechanical debridement using a plastic curette. The decrease in SD revealed a statistically significant difference in both groups at 12 months. Only BoP values decreased statistically at 24 months, while CAL and BoP decreased significantly at 12 months in both groups. When we evaluate according to clinical parameters in our study, it is seen that three lasers are successful. However, when looking at the change in the total amount, it was observed that there was a 6.99-fold decrease in the diode laser group, 2.45-fold decrease in the Er,Cr:YSGG laser group, and 2.43-fold decrease in the Er:YAG laser group between the initial and the 6th month samples. The limitations of our study are the evaluation of smoking according to the information given by the patient and the lack of serum osteocalcin levels.

Conclusion

This study is a unique clinical study in its field in terms of applying three doses of lasers and comparing various laser wavelengths in the same study, which evaluates the effects of smoking on laser therapy and finds lasers effective in the treatment of peri-implantitis.

Ethics

Ethics Committee Approval: The study was performed in accordance with the principles of the Declaration of Helsinki and was approved by Kırıkkale University Clinical Research Ethics Committee (decision no: 09/02, date: 14.05.2019) and the Turkish Medicines and Medical Devices Agency (2019/060).

Informed Consent: Prior to the study, all individuals to be included in the study were given detailed information about the purpose and the method of the research and informed consent forms were obtained.

Peer-review: Externally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: K.B., Concept: K.B., E.O., Design: K.B., E.O., N.D.B., Data Collection or Processing: K.B., E.O., N.D.B., Analysis or Interpretation: K.B., E.O., N.D.B., Literature Search: K.B., E.O., Writing: K.B., E.O., N.D.B.

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