

Clinical comparison of the use of Er,Cr:YSGG and diode lasers in second stage implant surgery

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ABSTRACT

الأهداف: في هذه الدراسة نهدف إلى مقارنة تأثيرات ال (diode laser) و (Er,Cr: YSGG) على المرحلة الثانية من عملية الزراعة.

الطريقة: تم تنفيذ هذا العمل على المرضى الذين تلقوا علاج لزراعة الأسنان في جامعة Van Yuzuncu Yil، كلية طب الأسنان، في كل من أقسام: قسم جراحة الفم والوجه والفكين وقسم اللثة. تم تعريض زرعات المرضى في المجموعة الأولى (n=20) بـ 940 نانومتر من (Ga-Al-As diode laser)، في حين تم تعريض زرعات المجموعة الثانية (n=20) بـ 2780 نانومتر من (Er,Cr: YSGG laser)، في المرحلة الثانية من عملية الزراعة. تم تسجيل قيم (VAS) لدرجة النزيف أثناء العملية، وعدد المسكنات المستخدمة في الفترة ما بعد العملية، ووقت العملية لكل زرعه، والمضاعفات لما بعد الجراحة خلال (يوم 0) وبعد العملية بـ (يوم 1، 2، 3).

النتائج: عندما تم تحليل نوع الجنس، التدخين، وجود أمراض جهازية، عدد مرات تنظيف الأسنان بالفرشاة، استخدام المسكنات، النزيف والمضاعفات في جلسة المراقبة ما بعد العملية، لم يتم العثور على علاقة ذات دلالة إحصائية بين المجموعتين. إحصائياً لوحظ أن الذكور لديهم قيم VAS أعلى من الإناث ($p < 0.05$).

الخاتمة: نظراً لأن (diode laser) أكثر اقتصاداً، أصغر حجماً، ويمكن أن يلبي الاحتياجات السريرية للأطباء، فمن المحتمل أن هذه الليزر قد يكون الخيار المفضل للأطباء في العمليات الجراحية.

Objectives: To compare the effects of diode and erbium, chromium: yttrium-scandium-gallium-garnet (Er,Cr:YSGG) lasers in second-stage implant surgery applications.

Methods: This is a cross-sectional study that was carried out on patients who received implant treatment at the Departments of Oral and Maxillofacial Surgery and Periodontology, Van Yuzuncu Yil University, Van, Turkey between January 2017 and January 2018. Implants of the patients in the first group (n=20) were exposed with 940 nm Ga-Al-As diode laser while the implants of the second group (n=20) were uncovered with 2780 nm Er,Cr:YSGG laser in the second-stage surgery. Visual

analogue scale (VAS) values during day 0 and following the operation on days 1, 2, 3 intraoperative bleeding grades, number of analgesics used in the postoperative period, operation time per implant, and postoperative complications were recorded.

Results: When gender, smoking, the presence of systemic disease, toothbrushing frequency, analgesic use, bleeding and complications observed at the control session were analyzed, no statistically significant relationship was found between the 2 groups. It was observed that males had statistically significant higher VAS values than females ($p < 0.05$).

Conclusion: Since diode lasers are more economical, smaller, and can meet the clinical needs of clinicians, it is likely that these lasers may be the preferred choice of the clinicians in surgical procedures.

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Dental implants are routinely used in the rehabilitation of tooth loss. Dental implants are often described as a root form that is made of titanium and placed in the position of the natural tooth.¹ A number of surgical procedures are performed to insert the dental implants into the bone and to uncover them after completing the osseointegration. While implant surgery can be performed by conventional methods, the dental lasers are also utilized in some stages increasingly more often.² In all areas of dentistry, there is widespread use of dental lasers. Dentists prefer dental lasers because

of their ability to ablate the tissue, their hemostatic properties, biostimulatory effects, decontamination and antibacterial properties, and their use without the need for local anesthesia.² In the implant therapy, dental lasers are used in soft tissue flap surgery, uncovering of the osseointegrated implants in second stage surgery, in the consolidation of the gingiva, and in periimplantitis treatment.³⁻⁵ Implant surgery is usually performed in 2 stages. The first stage is the placement of the implant into the bone and the completion of the osseointegration. The second stage is the uncovering of the implants that have completed their osseointegration to take impressions for prosthetic restoration and put the healing cap. Lasers at various wavelengths can be used to uncover the embedded implants at the second-stage surgery.⁶ Diode lasers are small, portable and economical surgical units that can be used for a multitude of operations on soft tissues (incision, excision, disinfection) and hard tissues (disinfection). These lasers have a broad wavelength range with good absorption in soft-tissue chromophores such as melanin and hemoglobin, provide excellent soft tissue incisions, coagulation, thermal ablation and with antimicrobial activity (95-98% reduction of pathogenic bacteria).² Several researchers have also reported the use of diode lasers in second-stage surgery.^{2,3,7-9} Erbium, chromium: yttrium-scandium-gallium-garnet (Er,Cr:YSGG) lasers have many different applications in dentistry. This versatility enables the treatment of both hard (enamel, dentin, bone) and soft tissues. Erbium, chromium: yttrium-scandium-gallium-garnet laser provides gentle, smooth and clear ablation with the use of water on the surface of the tissues. The use of Er,Cr:YSGG lasers have been reported to result in minimal damage to the tissues and thus induce faster healing of the wounds. Moreover, with these lasers, the bone-growth over the closure screw of especially the subcrestal implants can be eliminated quickly and reliably, without causing any complications during the second-stage surgery.^{5,10-13} In this study, we aimed to compare the clinical effects of diode laser (940 nm) and Er,Cr:YSGG laser (2780 nm) in second-stage implant surgery applications.

Methods. The study protocol was approved by the Clinical Investigations Ethics Committee, Van Yuzuncu Yil University Medical Faculty (YYU-01-24112017).

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This cross-sectional study was carried out on patients who received implant treatment at the Departments of Oral and Maxillofacial Surgery and Periodontology, Van Yuzuncu Yil University, Van, Turkey, between January 2017 and January 2018. All surgical procedures were carried out in accordance with the Helsinki Declaration. Before the operation, all patients were informed about the method by which the implants would be exposed and written informed consent was obtained from all participants. All the implants were the same brand (IMPLANT Direct, CA, USA). A total of 265 osseointegrated implants in 75 patients were evaluated in detail for the application of second-stage surgical procedures. Conventional methods were preferred for the second-stage implant surgeries of 164 osseointegrated implants in 35 patients and they were excluded from the study due to the lack of adequate keratinized gingiva in the implant site or the fact that localization of the implant is not known due to the thickness of the gingiva. Patients who needed tissue transposition techniques (Roll flap, Palacci technique, and so forth) were also not included in the study. Periapical radiographs of the implants were obtained for all patients. Implants which showed signs of probable bone growth on the closure screw were not included in the study for standardization between groups.

Forty patients were found to be eligible for the second-stage surgical operation with dental lasers. The study group consisted of healthy individuals aged between 18-60 years. These patients had no risk for second-stage surgery. The patients were randomly divided into 2 groups. The systemic disease, smoking status and toothbrushing habits of the patients were also recorded.

The second-stage implant surgeries of the patients in the first group (n=20) were performed with 940 nm Ga-Al-As diode laser (Ezlase™, BIOLASE Technology Inc, USA) and the surgeries of the second group (n=20) were performed with 2780 nm Er,Cr:YSGG laser (Waterlase iPlus®, BIOLASE Technology, Inc, USA).

The second-stage implant surgery of both groups began in the absence of local anesthesia (LA). Patients were informed that they will be treated with topical LA (Vemcaine Pump Spray 10% 50 ml; Vem, Ankara, Turkey) if they had any pain during treatment.

In the first group, the procedures were performed with a 940 nm wavelength diode laser (Ezlase 940; Biolase Technology, Inc., Irvine, CA) according to the guidelines recommended by the manufacturer (surgical E4 400 µm tip, 2.5 W power, average power: 1.25 W, pulse length CP2: 1.00 ms, pulse interval: 1.00 ms, duty cycle 50½, pulsative mode).

In the second group, the procedure was performed in line with the recommended “implant recovery” setting of the Er,Cr:YSGG laser with a wavelength of 2780 nm (MZ5-6mm tip, 2.00 W power, 100 Hz, H mode, 10% water and 10% air). The patients were instructed to use a mouthwash containing 0.2% chlorhexidine gluconate (Klorhex Gargara, 200 mL; Drogsan Ilaç, Ankara, Turkey) 3 times a day.

To uncover the implant, laser-assisted incisions were expanded in a circular fashion, starting from the most likely position of the implant’s closure screw in both groups. Patients were recommended to use paracetamol (Parol 500 mg tablets, Atabay Ilac San, Istanbul) as a pain reliever in the postoperative period, only when needed. Visual analogue scale (VAS) values (0-10), intraoperative bleeding grades (intraoperative bleeding: 1=minimal, 2=normal, 3=excessive hemorrhage), the number of analgesics used in the postoperative period and the duration of operation (min) were recorded. The total operation time was divided by the number of implants, and the mean operation time per implant was determined and recorded. Complications observed in the wound area during the control visits were scored and noted (soft tissue inflammation=1, edema=2, gingival bleeding=3).

Statistical methods. The Student’s 2 independents sample t-test was used to analyze the individual characteristics of the patients for continuous variables after Shapiro Wilk normality test for comparisons between the diode and Er,Cr:YSGG laser groups. The categorical variables were analyzed by Pearson Chi squared test and likelihood ratio Chi-squared test, as appropriate, to compare the diode and Er,Cr:YSGG laser groups.

Generalized linear mixed model (GLMM) was used for analysis of VAS outcomes. Fixed effects factors in GLMM were used laser groups, time (days), gender, and brush and as covariates operation durations and age. The results of GLMM were obtained according to residual subject specific pseudo likelihood method with first-order autoregressive covariance structure and negative binomial distribution. Holm-Tukey multiple comparison adjustment were used for the p -values and obtained confidence limits for the differences of LS-means (least square means). For all tests, $p < 0.05$ were considered as statistically significant. However, the raw p -values were expressed in the tables. The statistical analyses were executed with Statistical Analysis System V9.4 software (SAS Institute Inc, Cary, North Carolina, USA).

Results. The mean age of the patients was 40.87 ± 12.58 years (range between 20-66 years). Descriptive statistics of demographic and clinical characteristics of study participants and statistical comparisons in terms of laser groups are given in Table 1. A total of 50 second-stage implant surgeries were performed in the diode laser group on 20 patients, while 51 surgeries were performed in the Er,Cr:YSGG laser group in the second group of patients with 20 patients. The mean operation time per implant was 16.70 ± 6.49 min in the first group and 16.65 ± 6.37 min in the second group. Diode and Er,Cr:YSGG laser groups were compared in terms of mean age and operation time per implant, and no statistically significant correlation was found between the 2 variables ($p > 0.05$).

Overall, 21 participants were male and 19 were female. There was no statistically significant difference in the distribution of gender between the laser groups. When the analgesic consumption of the patients in postoperative period was analyzed, 14 (35%) reported that they did not need to take any pain medication after the procedure, and 8 (15%) of them required a total of 4 pain relievers. While no excessive bleeding was observed in any of the patients during the procedure, a minimal bleeding score was observed in 29 patients, and a normal bleeding score was observed in the remaining 11 patients. Among the complications seen in the postoperative period, the most common complaint was soft tissue inflammation which was reported by 38 patients, followed by edema in 2 patients. In the present study, 6 of the patients had a systemic disease ($n=3$: under-control diabetes, $n=1$: hypertension, $n=2$: hyperthyroidism), while 34 patients had no systemic disease. Six patients were smokers and 34 of them were non-smokers. The patients reported to brush their teeth once ($n=15$, 37.5%) or twice ($n=18$, 45%) a day.

No statistically significant correlation was found when gender, smoking, systemic disease, toothbrushing, analgesic use, bleeding, and complications observed were compared between the 2 groups ($p > 0.05$). This result showed that the treatment groups were homogeneous in terms of above-mentioned characteristics.

Table 2 shows the maximum likelihood estimates obtained for the regression coefficients of the model generated as constant effects in the GLMM for the VAS dependent variant. For each independent argument in the model, the last categories are considered as the reference category. Diode laser application decreased the VAS value but this decrease was not statistically significant ($p > 0.05$) (Table 2). When the VAS values were compared in terms of time, it was found that the highest VAS value was observed on the first day and the

Table 1 - Descriptive statistics and comparison groups.

Variables	Diode laser (n=20)	Er,Cr:YSGG laser (n=20)	T-value (Chi-square)	P-value
Age	40.75 ± 10.36	41.00 ± 14.75	-0.06	0.9505
Operation duration per implant	16.70 ± 6.49	16.65 ± 6.37	0.03	0.9791
Gender				
Male (1)	12 (60)	9 (45)	0.9023	0.3422 [†]
Female (2)	8 (40)	11 (55)		
Smoke				
Smoking	2 (10)	4 (20)	0.7843	0.3758 [*]
Non-smoking	18 (90)	16 (80)		
Systemic disease				
0	17 (85)	17 (85)	0	1.0000 [*]
1	3 (15)	3 (15)		
Daily tooth brushing frequency				
0	3 (15)	2 (10)	4.4744	0.3456 [†]
1	9 (45)	6 (30)		
2	7 (35)	11 (55)		
3	1 (5)	0		
4	0	1 (5)		
Number of postoperative analgesic use				
0	6 (30)	8 (40)	3.4040	0.4926 [†]
1	2 (10)	3 (15)		
2	4 (20)	3 (15)		
3	2 (10)	0		
4	6 (30)	2 (30)		
Intraoperative bleeding				
1 minimal	15 (75)	14 (70)	0.1254	0.7233 [*]
2 normal	5 (25)	6 (30)		
3 excess	0	0		
Complications seen in controls				
1 soft tissue inflammation	19 (95)	19 (95)	0	1.000
2 edema	1 (5)	1 (5)		
3 gingival bleeding	0	0		

Er,Cr:YSGG - Erbium, chromium: yttrium-scandium-gallium-garnet, **p*-value for Pearson Chi-square, †*p*-value for likelihood ratio chi square *p*<0.05, Values are presented as number and percentage (%).

difference was statistically significant when day 3 was considered as the reference point (*p*<0.05). Although day 0 (baseline) and day 2 had higher VAS values than day 3, the differences were not statistically significant (*p*>0.05). The interaction between laser groups and time was also not statistically significant. In other words, it was observed that VAS variations of both laser groups at all time points showed a parallel change.

In terms of gender, the difference between the VAS scores of males and females was statistically significant (*p*<0.05). Although the effect of brushing was not statistically significant, an increase in daily tooth brushing showed positive effects on the VAS values. Operation duration increased the VAS values and was a statistically significant variable (*p*<0.05). Age did not have a statistically significant effect on VAS scores. In

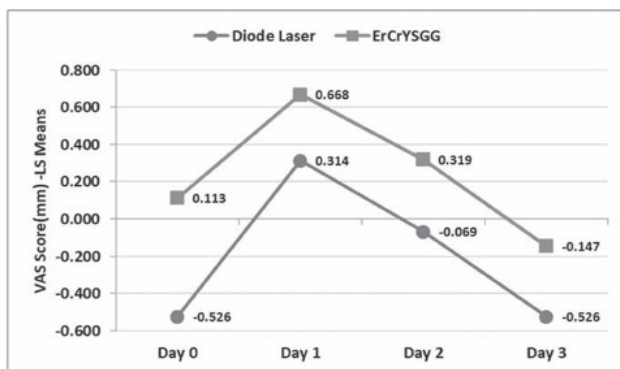
Table 3, Type III F statistics and statistical power values are shown for all variables that have an effect on VAS scores.

Table 4 displays the estimates of the least squares (LS means) and raw mean values of VAS scores of each laser group and different days in the laser groups. Least square means values were considered as the mean VAS score since the averages of the smallest squares are the averages corrected to the model independent variables. There was no statistically significant difference between the 2 laser groups, although the VAS value was found to be much lower in the diode laser group than in the Er,Cr:YSGG laser group. The highest VAS value was on the first day in both laser applications; however, diode laser group showed lower VAS values on all the following days. Interaction charts between laser groups

Table 2 - The results of maximum likelihood estimates for fixed effects.

Effect	Groups	Time	Gender	Brush	Estimate	Standard error	DF	T-value	Pr > |t|
Intercept					-3.4925	1.2961	31	-2.69	0.0113
Groups	Diyot laser				-0.3792	0.3851	114	-0.98	0.3268
Groups (Ref.)	Er,Cr:YSGG				0	.	.	.	.
Time		Day 0			0.2595	0.2561	114	1.01	0.3131
Time		Day 1			0.815	0.2312	114	3.53	0.0006
Time		Day 2			0.4654	0.2455	114	1.9	0.0606
Time (Ref.)		Day 3			0	.	.	.	.
Groups*Time	Diyot laser	Day 0			-0.2595	0.4134	114	-0.63	0.5314
Groups*Time		Day 1			0.02471	0.3589	114	0.07	0.9452
Groups*Time		Day 2			-0.0086	0.3824	114	-0.02	0.9821
Groups*Time (Ref.)		Day 3			0	.	.	.	.
Groups*Time (Ref.)	Er,Cr:YSGG	Day 0			0	.	.	.	.
Groups*Time (Ref.)		Day 1			0	.	.	.	.
Groups*Time (Ref.)		Day 2			0	.	.	.	.
Groups*Time (Ref.)		Day 3			0	.	.	.	.
Gender			Male		0.6397	0.3079	114	2.08	0.04
Gender (Ref.)			Female		0	.	.	.	.
daily tooth brushes				0	1.4292	1.2695	114	1.13	0.2626
daily tooth brushes				1	1.678	1.2323	114	1.36	0.176
daily tooth brushes				2	1.6057	1.2164	114	1.32	0.1895
daily tooth brushes				3	2.6449	1.3926	114	1.9	0.0601
daily tooth brushes (Ref.)				4	0	.	.	.	.
Operation duration					0.02485	0.006103	114	4.07	<0.0001
Age					0.01386	0.01216	114	1.14	0.2568

Er,Cr:YSGG - erbium, chromium: yttrium-scandium-gallium-garnet, Ref - reference category, DF - degree of freedom

**Figure 1** - Least square-means plot of visual analogue scale score for laser groups and days interaction effect.

and days are given in **Figure 1**. Visual analogue scale values were the same on day 0 and day 3 in the diode laser group, and in the Er,Cr:YSGG group it decreased below the day 0 value (**Table 4**, **Figure 1**).

In **Table 5**, LS means differences of VAS variations for different days in both of the laser groups and Holm-Tukey corrected p -values of these differences are shown. Differences between day 0 and day 1, and day 1 and day 3 were statistically significant ($p < 0.05$) according to corrected p -values in both groups.

Visual analogue scale LS means values and standard errors for genders were 0.3382 ± 0.3082 for men and -0.3015 ± 0.3586 for women. Mean VAS values of men was one-fold higher than for women. The inter-gender VAS LS means difference was 0.6397, which was equal to the predicted regression parameter, and was statistically significant ($p < 0.05$).

Discussion. Second-stage surgery of embedded implants requires the use of scalpels, electrosurgery or dental lasers.¹⁴ Laser-assisted second-stage implant surgery is less aggressive than the traditional method of scalpel surgery. It is also known to have positive effects on postoperative pain and swelling.¹⁵ It has been argued that second-stage implant surgeries which utilize diode laser or other lasers are reliable and effective treatment methods that achieve similar results.^{3,5,15} In this study, we aimed to compare the clinical efficacy of the 2 different lasers at 2 different wavelengths, which have different working principles and are considered to be more advantageous compared to the scalpels. The second stage implant surgery is not advised to be performed with dental lasers in situations with inadequate keratinized gingiva and increased gingival thickness.¹⁶ The effects of keratinized gingiva on the soundness of the peri-implant tissues have long been

Table 3 - Overall F test statistic results for fixed effects and statistical power.

Effect	Numerator d.f.	Denomintor d.f.	F-value	Pr>F	Power
Groups	1	114	2.57	0.1116	0.35595
Time	3	114	9.54	<0.0001	0.99675
Groups*time	3	114	0.25	0.8646	0.09533
Gender	1	114	4.32	0.04	0.53978
Toothbrush	4	114	1.12	0.3515	0.34237
Operation duration	1	114	16.58	<0.0001	0.98113
Age	1	114	1.3	0.2568	0.20429

DF - degree of freedom

Table 4 - Estimates of least square and raw means for groups and group*time.

Groups	Time	Least squares means estimates							Raw means	
		Means	S.E.	DF	T value	Pr > |t|	95% Lower	95% Upper	Mean	S.E.
Diyode laser		-0.202	0.331	114	-0.61	0.544	-0.858	0.454	0.817	0.271
Er,Cr:YSGG		0.238	0.323	114	0.74	0.462	-0.401	0.878	1.269	0.410
Diyode laser	Day 0	-0.526	0.390	114	-1.35	0.180	-1.299	0.247	0.591	0.231
	Day 1	0.314	0.350	114	0.90	0.371	-0.379	1.007	1.369	0.479
	Day 2	-0.069	0.365	114	-0.19	0.850	-0.791	0.653	0.933	0.340
	Day 3	-0.526	0.390	114	-1.35	0.180	-1.299	0.247	0.591	0.231
Er,Cr:YSGG	Day 0	0.113	0.355	114	0.32	0.751	-0.591	0.817	1.120	0.398
	Day 1	0.668	0.338	114	1.98	0.050	0.000	1.337	1.951	0.659
	Day 2	0.319	0.348	114	0.92	0.361	-0.370	1.007	1.375	0.478
	Day 3	-0.147	0.367	114	-0.40	0.690	-0.873	0.580	0.864	0.317

Er,Cr:YSGG - erbium, chromium: yttrium-scandium-gallium-garnet, DF - degree of freedom, SE - standard error

Table 5 - Comparing days is means within groups with adjusted *p*-values according to Holm-Tukey.

Groups	Diffience	Estimate difference	Standard error	T-value	Pr > |t|	Adj. p
Diode laser	Day 0-Day 1	-0.8398	0.2745	-3.06	0.0028	0.0145
	Day 0-Day 2	-0.4568	0.2932	-1.56	0.1220	0.4068
	Day 0-Day 3	0.0000	0.3244	0.00	1.0000	1.0000
	Day 1-Day 2	0.3830	0.2368	1.62	0.1085	0.3729
	Day 1-Day 3	0.8398	0.2745	3.06	0.0028	0.0145
	Day 2-Day 3	0.4568	0.2932	1.56	0.1220	0.4068
Er,Cr:YSGG	Day 0-Day 1	-0.5555	0.212	-2.62	0.010	0.0484
	Day 0-Day 2	-0.2059	0.2277	-0.90	0.3678	0.8026
	Day 0-Day 3	0.2595	0.2561	1.01	0.3131	0.7421
	Day 1-Day 2	0.3497	0.1991	1.76	0.0818	0.3000
	Day 1-Day 3	0.8150	0.2312	3.53	0.0006	0.0034
	Day 2-Day 3	0.4654	0.2455	1.90	0.0606	0.2359

a subject of research. Some researchers argue that the existence of a keratinized gingiva is not very effective in long-term follow-ups and that a good oral hygiene is sufficient to achieve good results.^{17,18} However, previous studies reported that the existence of a keratinized gingiva reduces the periimplantitis risk.^{3,11,16,19} Based on this information, we did not include the cases where there was an inadequate keratinized gingiva, aesthetic necessity, and difficulty in determining the location of the implant due to gingival thickness, in order not to further reduce the keratinized gingiva. Some

researchers^{5,11,21,22} worked on understanding the effects of lasers with various wavelengths on surface alteration and temperature increase of implant microstructure. In several studies, it was reported that the diode lasers do not impair the implant surface and does not cause an increase in temperature at a level that would damage the implant.^{11,20-22} On the other hand, more frequent rest periods are recommended during the use of some diode lasers in the contact mode, since the resting periods enable lowering the temperature of the implant whose temperature should not rise more than 10°C

in order to prevent negative changes in the clinical parameters.²³ The cooling requirement during laser use might suggest that Er,Cr:YSGG laser, which operates with water cooling, could have more positive effects on the soft tissue in terms of postoperative complications with respect to the diode laser, which does not operate with water cooling. However, in our study, there was no statistically significant difference in the rates of postoperative complications (swelling, pain, soft tissue inflammation, and hemorrhage) between the laser groups at both wavelengths.

All of the patients who applied to our clinic for implant surgery were operated only after they accepted to cooperate on the study's oral hygiene and smoking terms. We can, therefore, suggest that patients' smoking and tooth brushing rates did not lead to a clinically negative postoperative effect after second-stage implant surgery.

Visual analogue scale scores after oral surgery were evaluated in terms of age, gender, and duration of surgery.²⁴⁻²⁶ In studies conducted on patients undergoing oral surgery, VAS values of women were higher than those of men. The reason for this was proposed to be that women can express their pain and worries more easily than men.^{24,25,27} Unlike the previous results in the literature, we observed that the VAS scores of male subjects were statistically significantly higher than that of the female subjects ($p < 0.05$) (Table 2). The reason for this may also be the fact that the women in this demographic group were hesitant than men when expressing their pain and worries.

It has been reported that the pain after previous oral surgery is lower in younger patients compared to older patients since young people are systemically healthier and their bone structures are more flexible.^{24,27} Since the patients in both groups included in this study consisted of young patients, it is safe to say that postoperative VAS values were not too high.

Prolonged operation times were reported to result in an increase in postoperative VAS.²⁴ Our results suggest that the VAS values for both groups increased in the postoperative period when the operation time was longer (Table 2). However, there was no statistically significant difference between the 2 groups in terms of operation time per implant and postoperative VAS values.

In several studies, the use of dental lasers was shown to reduce the need for anesthesia, decrease postoperative pain and accelerate wound healing in second stage implant surgeries.^{10,28,29} Eroglu et al indicated that there was no statistically significant difference in terms of postoperative analgesic consumption between scalpel

and Er,Cr:YSGG laser for surgery.¹⁰ In the present study, analgesic requirement did not show a statistically significant difference for both laser groups in the postoperative period, where 30% of the patients in the diode laser group and 40% of the patients in the Er,Cr:YSGG laser group did not need any pain relievers.

In studies comparing laser and scalpel use, it was observed that the laser use statistically significantly reduces postoperative pain levels.^{6,23,30} However, there are also reports that there is no significant difference in terms of pain.^{10,29} In the present study, lower postoperative pain levels were observed in the diode laser group compared to the Er,Cr:YSGG laser group, but no statistically significant difference was found between the groups.

In second-stage implant surgery with dental lasers, lasers provide hemostasis, exhibit antibacterial activity, and reduce postoperative pain and swelling. Thus, the operation is more comfortable for both the physician and the patient and also with respect to the postoperative complications.^{10,28,29} One of the reasons for preferring dental lasers in second-stage implant surgery is the unnecessary for suturing.^{29,31}

Diode lasers ablate the soft tissue layers without damaging the underlying bone while uncovering the implants.^{23,29} Because of low shrinkage and enhanced wound healing, prosthetic impression can be taken during the same procedure. Minimizing hemorrhage enables faster treatment in clinical applications.^{3,29,32} The Er,Cr:YSGG laser uses cooling with water and known to be less effective on preventing bleeding thus it is expected that Er,Cr:YSGG laser will be less effective than diode laser, which is known to be more effective on intraoperative and postoperative bleeding by using thermal ablation and coagulation. However, similar results were observed in intraoperative and postoperative bleeding in both groups, where the minimal bleeding score was found to be high in both groups and no excessive bleeding score was observed in any patient. These results suggest that the Er,Cr:YSGG laser does not present a high risk of bleeding complications in soft tissue surgery.

In soft tissue surgeries, diode lasers are generally used more frequently.^{23,29,32} However, some researchers have suggested that Er,Cr:YSGG lasers are more feasible because surgical procedures can be performed faster with them than with diode lasers.^{15,23,33}

Considering the positive effects of faster surgical procedures on both the patient and physician comfort, it is expected that the choice between laser types might be confusing. In this study, 2 dental lasers with different wavelengths and different working principles were used

but no statistically significant difference was observed in terms of mean operation time per implant.

One of the limitations of our study was that the sample size was low and the other was that the conventional method (scalpel-assisted second stage implant surgery) was not evaluated as a control group. The reason for not placing the scalpel use as a control group in this study was that the laser groups and scalpel use were previously compared in several studies.^{3,11,15,29,31} These studies have also reported that dental lasers have clinical advantages with respect to the conventional method. Nevertheless, more studies should be carried out on increased number of cases involving more extensive soft tissue treatments, which are applied with lasers of different wavelengths to have a better understanding of this study area.

In conclusion, considering the advantages of both diode and Er,Cr:YSGG lasers, such as less anesthesia requirement, less surgical trauma, better visualization due to minimal hemorrhage, and postoperative patient comfort, these lasers can be considered as safe and effective methods in second-stage implant surgery. Nevertheless, diode lasers may be more feasible for clinicians because they are smaller, more economical, and could meet the clinical needs of the clinicians.

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References

- Byakodi S, Kumar S, Reddy RK, Kumar V, Sepolia S, Gupta S, et al. Systemic assessment of patients undergoing dental implant surgeries: a trans- and post-operative analysis. *Niger J Surg* 2017; 23: 58-62.
- Deppe H, Horch HH. Laser applications in oral surgery and implant dentistry. *Lasers Med Sci* 2007; 22: 217-221.
- Yeh S, Jain K, Andreana S. Using a diode laser to uncover dental implants in second-stage surgery. *Gen Dent* 2005; 53: 414-417.
- Parker S. Surgical laser use in implantology and endodontics. *Br Dent J* 2007; 202: 377-386.
- Miller RJ. Treatment of the contaminated implant surface using the Er,Cr:YSGG laser. *Implant dentistry* 2004; 13: 165-170.
- Romanos GE, Gutknecht N, Dieter S, Schwarz F, Crespi R, Sculean A. Laser wavelengths and oral implantology. *Lasers Med Sci* 2009; 24: 961-970.
- Coleton S. The use of lasers in periodontal therapy. *Gen Dent* 2008; 56: 612-616.
- Andreana S. The use of diode lasers in periodontal therapy: literature review and suggested technique. *Dent Today* 2005; 24: 130, 132-135.
- Lomke MA. Clinical applications of dental lasers. *Gen Dent* 2009; 57: 47-59.
- Eroglu CN, Tunc SK, Elasan S. Removal of epulis fissuratum by Er,Cr:YSGG laser in comparison with the conventional method. *Photomed Laser Surg* 2015; 33: 533-539.
- Arnabat-Dominguez J, Espana-Tost AJ, Berini-Ayres L, Gay-Escoda C. Erbium:YAG laser application in the second phase of implant surgery: a pilot study in 20 patients. *Int J Oral Maxillofac Implants* 2003; 18: 104-112.
- Gouw-Soares S, Stabholz A, Lage-Marques JL, Zezell DM, Groth EB, Eduardo CP. Comparative study of dentine permeability after apicectomy and surface treatment with 9.6 microm TEA CO2 and Er:YAG laser irradiation. *J Clin Laser Med Surg* 2004; 22: 129-139.
- Wang X, Ishizaki NT, Suzuki N, Kimura Y, Matsumoto K. Morphological changes of bovine mandibular bone irradiated by Er,Cr:YSGG laser: an in vitro study. *J Clin Laser Med Surg* 2002; 20: 245-250.
- GE R. Treatment of periimplant lesions using different laser system. *J Oral Laser Appl* 2002; 2: 75-81.
- Arnabat-Dominguez J, Bragado-Novel M, Espana-Tost AJ, Berini-Ayres L, Gay-Escoda C. Advantages and esthetic results of erbium, chromium:yttrium-scandium-gallium-garnet laser application in second-stage implant surgery in patients with insufficient gingival attachment: a report of three cases. *Lasers Med Sci* 2010; 25: 459-464.
- Marquez IC. The role of keratinized tissue and attached gingiva in maintaining periodontal/peri-implant health. *Gen Dent* 2004; 52: 74-78; quiz 9.
- Artzi Z, Tal H, Moses O, Kozlovsky A. Mucosal considerations for osseointegrated implants. *J Prosthet Dent* 1993; 70: 427-432.
- Alpert A. A rationale for attached gingiva at the soft-tissue/implant interface: esthetic and functional dictates. *Compendium* 1994; 15: 356, 358, 360-362 passim; quiz 68.
- Maksoud MA. Manipulation of the peri-implant tissue for better maintenance: a periodontal perspective. *J Oral Implantol* 2003; 29: 120-123.
- Quirynen M, Vogels R, Peeters W, van Steenberghe D, Naert I, Haffajee A. Dynamics of initial subgingival colonization of 'pristine' peri-implant pockets. *Clin Oral Implants Res* 2006; 17: 25-37.
- Romanos GE, Everts H, Nentwig GH. Effects of diode and Nd:YAG laser irradiation on titanium discs: a scanning electron microscope examination. *J Periodontol* 2000; 71: 810-815.
- Kato T, Kusakari H, Hoshino E. Bactericidal efficacy of carbon dioxide laser against bacteria-contaminated titanium implant and subsequent cellular adhesion to irradiated area. *Lasers Surg Med* 1998; 23: 299-309.
- Matys J, Fliieger R, Dominiak M. Effect of diode lasers with wavelength of 445 and 980 nm on a temperature rise when uncovering implants for second stage surgery: An ex-vivo study in pigs. *Adv Clin Exp Med* 2017; 26: 687-693.
- de Santana-Santos T, de Souza-Santos A, Martins-Filho PR, da Silva LC, de Oliveira ESED, Gomes AC. Prediction of postoperative facial swelling, pain and trismus following third molar surgery based on preoperative variables. *Med Oral Patol Oral Cir Bucal* 2013; 18: e65-e70.
- Akpinar A, Toker H, Lektetur Alban A, Calisir M. Postoperative discomfort after Nd:YAG laser and conventional frenectomy: comparison of both genders. *Aust Dent J* 2016; 61: 71-75.
- Calisir M, Ege B. Evaluation of patient perceptions after frenectomy operations: A comparison of neodymium-doped yttrium aluminum garnet laser and conventional techniques in the same patients. *Niger J Clin Pract* 2018; 21: 1059-1064.

27. Eli I, Schwartz-Arad D, Baht R, Ben-Tuvim H. Effect of anxiety on the experience of pain in implant insertion. *Clin Oral Implants Res* 2003; 14: 115-118.
28. Christensen GJ. Soft-tissue cutting with laser versus electrosurgery. *J Am Dent Assoc* 2008; 139: 981-984.
29. El-Kholey KE. Efficacy and safety of a diode laser in second-stage implant surgery: a comparative study. *Int J Oral Maxillofac Surg* 2014; 43: 633-638.
30. Garg AK. Lasers in dental implantology: innovation improves patient care. *Dent Implantol Update* 2007; 18: 57-61.
31. van As G. Uncovering the tooth: the diode laser to uncover teeth, brackets and implants. *Dent Today* 2012; 31: 168.
32. Sotoode SM, Azimi S, Taheri SA, Asnaashari M, Khalighi H, Rahmani S, et al. Diode laser in minor oral surgery: a case series of laser removal of different benign exophytic lesions. *J Lasers Med Sci* 2015; 6: 133-138.
33. Gianfranco FS, Paul RJ. Erbium and diode lasers for operculisation in the second phase of implant surgery: a case series. *Timisoara Med J* 2010; 60: 117-123.