The comparison of postoperative wound healing following different gingivectomy techniques: A randomized prospective clinical trial

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Abstract

Aim: The aims of this study were to examine the degree of clinical discomfort condition experienced by patients and to improve wound healing by dental researcher throughout two weeks after gingivectomy treatment.

Material and Methods: Forty-one patients suffering from gingival overgrowth were included in this study. Patients were divided into three groups for gingivectomy technique defined as; scalpel group (SG), ceramic rotary bur group (CG) and diode laser group (LG). The postoperative evaluating parameters as pain, burning, bleeding, epithelization, carbonization is recorded and standardized photographs were taken at 1st, 3rd, 5th, 7th, and 14th days postoperatively. All photographs were examined by the image analyzing software program.

Results: The percentage of epithelization in the CG group is higher than the SG and LG group, but this value is not statistically significant on postoperative day 3. The LG group showed statistically significantly lower epithelization value on postoperative day 5. On postoperative day 1, VAS pain scores were significantly higher in the SG than in the LG; however, there were no statistically significant differences between the SG and CG. On postoperative day 3 and day 5, the SG pain scores were significantly higher than those from the CG; however, there were no statistically significant differences between the LG and CG.

Conclusion: Aspect to controlled gingival tissue removing than diode laser and postoperative inflammation and wound healing values were observed almost equal with diode laser value; so ceramic gingiva burs may be an alternative treatment that is comparatively easier to implement and provide faster gingival recovery.

Keywords: Laser; Gingivectomy; Surgery; Postoperative Complications; Wound Healing.

INTRODUCTION

An increase in the size of the gingiva is defined as gingival enlargement, or gingival overgrowth. Numerous surgical techniques such as the use of a scalpel, electrosurgery, cryosurgery and laser surgery are implemented in gingivectomy and gingivoplasty procedures. The scalpel has been commonly used in gingival surgery for many years because of its ease in operating with minimal damage to periodontal tissue (1).

Lasers are used in periodontology for oral soft- and hard-tissue surgical procedures in order to provide light tissue ablation, a bactericidal effect, less intraoperative bleeding and a shorter operating time (2).The most common lasers for soft-tissue surgery are neodymium-dopedyttrium aluminum garnet (Nd:YAG), carbon dioxide (CO2), and diode lasers (3). Through the use of diode lasers, surgeons have achieved effective results in periodontal surgical procedures such as excessive gingival tissue removal (4), pocket epithelium elimination (5), and detoxification of root surface (6), as well asassistance with homeostasis (7), orthodontic treatment-related tissue changes and oral ulcerative lesions (8). The essential principle of laser treatment is the biomodulation of cells. A light beam at a specific wavelength is able to modify the cellular condition by acting on the mitochondrial cytochrome-C oxidase in the electron chain or on porphyrins on the membrane calcium channels, which modulates the levels of reactive oxygen and decreases inflammation, thereby promoting wound healing and coagulation (9,10).

A ceramic-oxide gingival trimmer bur, used with rotary systems are known to provide a precise and reliable

dilatation in the gingiva. Surgical procedures with a gingival trimmer are performed with mild heat, without external cooling, at 300 rpm–500 rpm (11).

Recent studies have indicated that treatment using scalpel surgery was found to be more painful but resulted in faster wound healing, however have shown that laser application provided less discomfort and delays in wound healing (12-14). A clinical study found that patients had less swelling, bleeding, pain, and scar-tissue formation after the application of a diode laser (9). However, in a comparison study of two different techniques (i.e., theuse of a rotary carbide bur and an Er:YAG laser) used in gingival depigmentation, there were no significant differences between the groups in terms of pain, as measured via the visual analog scale (VAS); clinically, however, one case report indicated that the Er:YAG laser group experienced more pain and more persistent wound healing (11). In the literature regarding this topic, there is no general consensus as to which technique is superior.

The aim of this study was to evaluate the degree of clinical discomfort and the issues experienced by patients and to use a software image program to compare wound healing during the 2-week period following gingivectomy performed with different techniques.

MATERIAL and METHODS

Forty-one patients aged from 18 to 61 years and suffering from gingival overgrowth were included in this randomized, prospective clinical study. Participants were selected from individuals who were referred to the Department of Periodontology, Faculty of Dentistry, Gazi University and Dumlupınar University between October 2015 and April 2017.

The study was conducted in agreement with the Helsinki Declaration of 2008 and Ethical approval was obtained from the Institutional Review Board of Dumlupınar University (2015-KAEK-86/06-57), and written informed consent was obtained from all of the patients.The trial is registered at ClinicalTrials.gov, number NCT03435068.

Study Design
This study was a randomized, controlled clinical trial comparing different gingivectomy surgery techniques. The patients were divided into three groups:the scalpel group (SG; n=14), the ceramic rotary bur group (CG; n=15), and the diode laser group (LG; n=12). Follow-up sessions were controlled on postoperative days 1, 3, 5, 7 and 14.

Study Population
The criteria for inclusion in the study were as follows: 1) at anterior region, a minimum of four teeth at each surgical site 2) plaque-induced inflammatory gingival enlargement due to prosthetic or orthodontic reasons 3) horizontal and vertical gingival enlargement index with a "score 1" or "score 2", 4) good oral hygiene, 5) no clinical attachment loss and 6) systemically healthy individuals 7) nonsmokers. The exclusion criteria were as follows: 1) hereditary gingival fibromatosis, drug-induced

gingival enlargement 2) pregnancy and/or lactation, 3) allergy, 4) conditions requiring antibiotic prophylaxis and anti-inflammatory medications, 5) acute or untreated periodontitis 6) systemic disease that could influence the outcome of the treatment.

Randomization
Subjects were assigned to one of the three groups using a computer-generated randomization scheme. Allocation concealment was obtained using number-labeled opaque envelopes.

Clinical Measurements
All patients received phase I periodontal treatment that included oral hygiene instruction and mechanical debridement using hand instruments. After 4 weeks, the clinical status of each patient was re-evaluated. All patients had mean full mouth plaque scores (15)<10% and bleeding-on-probing scores < 20% before surgical treatment.

All clinical measurements were recorded for four sites (i.e., mesiobuccal, distobuccal, mid-buccal, and palatal/lingual) per teeth, and after phase I therapy using Williams-type periodontal probes (Nordent Manufacturing Inc., Elk Grove Village, Illinois, USA) to calibrate full mouth scores in 1-mm increments. These clinical measurements were described as follows: 1-plaque index (PI) (16), 2-gingival index (GI) (17), 3-probing depth (PD), and 4-bleeding on probing (BOP).

Horizontal and vertical gingival overgrowth indexes were evaluated before surgery to assess the inclusion criteria for the study. The vertical distance of gingival tissue was measured from the gingival margin to the cement-enamel junction (gingival overgrowth [GO] index) (18). Horizontal gingival values were also recorded between the tooth surfaces and the papillary tissue surface at the interdental contact point as buccolingual aspect (mesiobuccal [MB] index) (19).

Postoperative Evaluations
The postoperative parameters, including pain, burning, epithelization, bleeding and carbonization, were recorded at 1, 3, 5, 7, and 14 days postoperatively. Postoperative pain and burning were assessed via the visual analogue scale (VAS) (20). The VAS is a 100-mm horizontal-line scale that is used to quantify subjective symptoms such as pain, burning. In the present study, researchers used a standard VAS on which patients drew a vertical sign along a 10-cm scale from 0 (no pain) to 10 (highest degree of pain). Bleeding and carbonization during the postoperative period were assessed as either present or absent. Patients evaluated their postoperative pain, burning, and bleeding values. The same researchers evaluated epithelization and carbonization values in two centers. Patients were asked to report the number of systemic analgesic tablets they had taken during the first week after the surgery.

Space, Surgical Techniques

Space all surgical procedures were performed after administering local anesthesia to the patients. All surgical techniques were as follows: (1) topical anesthesia (20% benzocaine), (2) local anesthesia using the bilateral vestibular infiltration technique, with 0.6 ml (1/3 of the carpule contents) of 4% articaine and 1:200.000 epinephrines (Maxicaine, Vem Ilaç Ltd. Şti, Tekirdağ, Turkey). In the scalpel group (SG) following the local anesthetic administration, the gingivectomy was performed with a #15 scalpel. Subsequent to the operation, the borderline of gingiva was determined via the use of a pointer dental tweezers, and excessive gingival tissue was then removed with Gracey curettes (Figure 1).

Figure 1. Postoperative healing of scalpel group A) preoperative view B) postoperative day 1 C) postoperative day 3 D) postoperative day 5 E) postoperative day 7 F) postoperative day 14

For the ceramic bur group (CG) gingivectomies, ceramic rotary burs (Meisinger Gingiva Trimmer GT135 FG 016 L 8.0, Neuss, Germany) were used with 400-rpm rotary systems and with no serum irrigation, per the manufacturer's recommendation. Gingivoplasties were performed with the same ceramic burs to easily provide a knife-edge appearance (Figure 2).

Figure 2. Postoperative healing of ceramic rotary bur group A) preoperative view B) postoperative day 1 C) postoperative day 3 D) postoperative day 5 E) postoperative day 7 F) postoperative day 14

In the laser group (LG), a diode laser (SIROLaser Advance, Sirona, Bensheim, Germany) was applied to the operation sites in accordance with the manufacturer's guidelines (2.8 W continuous wave mode, wavelength 980 nm). The fiberoptic laser tip had a 320-µm diameter with a 2.8 W output power. The laser never made contact with the gingival tissue. The practice distance did not affect the laser spot size, which was 0.5 cm–1 cm. Smoke associated with the laser application was aspirated from the surgical site (Figure 3).


Figure 3. Postoperative healing of diode laser group A) preoperative view B) postoperative day 1 C) postoperative day 3 D) postoperative day 5 E) postoperative day 7 F) postoperative day 14

Postsurgical Care

To ensure accurate evaluations of follow-up wound healing, no periodontal packs were applied following the procedures. During the postsurgical period, all the patients practiced special oral hygiene care and avoided hot, hard, and/or acidic, spicy foods. Patients were instructed not to receive any form of analgesic medication space, having a flurbiprofen (Majezik, Sanovel, Istanbul, Turkey)active substance during the postsurgical period except in the case of unbearable pain. During the 7 days following surgery, all the patients used a 0.12% chlorhexidine digluconate solution twice a day (Kloroben, Drogsan, Ankara, Turkey).

Evaluation of Surgical Wound Area

After gingivectomy operation, the surgical site was evaluated with hydrogen peroxide to detect the presence of epithelization. Hydrogen peroxide has been applied to all groups. The researchers who used a standard digital camera (Canon Powershot G16, U.S.A. Inc.) to take standard magnification (x10) photographs assessed the operation area, consisting of the epithelium. The lens was placed perpendicular to the center point of the wound area in the axis of the tooth. The mesio-distal width of the maxillary right central tooth was recorded for each patient, and photographs were calibrated via the reference values (21). The researcher examined all photographs with the assistance of an image-analyzing software program (Image processing and analysis in Java, Image J software). In the areas subjected to hydrogen peroxide application and experiencing tissue reaction, there was a lack of an epithelial layer in the wound area. The wound surface areas of foamy fields on the all of the groups' photographs were recorded on days 1, 3, 5, 7, and 14 following the gingivectomies (Figure 4).
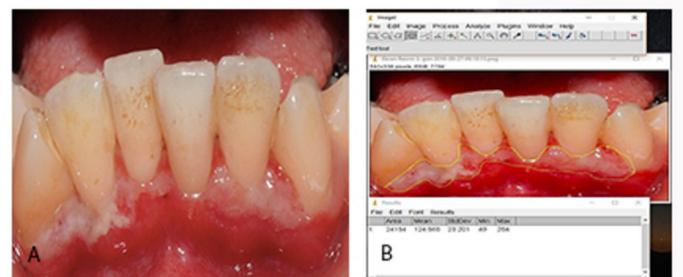
Figure 4. A) Application of hydrogen peroxide B) Surgical wound area measurement with Image J software program

Statistical Analyses

Normality was checked via the Shapiro–Wilk test of continuous variables. Nonparametric tests were chosen because the data were not distributed normally. The analysis of variance (ANOVA) test was used to analyze the vertical and horizontal gingival overgrowth, burning, values, and the Kruskal-Wallis test was used to analyze the epithelization values; due to non-parametric variables, bleeding and carbonization values were analyzed with Fisher's exact test. The data were expressed as median (minimum–maximum); p < 0.05 was accepted as the rejection of the null hypothesis (H0). The statistical analysis was performed using a statistical package software program (SPSS v. 20.0; SPSS Inc., Chicago, USA). To achieve a power of 80%, the minimum required sample size was determined to be 12 in the paired study groups. The Kruskal-Wallis test was applied in comparisons of the groups.

RESULTS

Demographic Data

Forty-five patients were included in this study, but four patients were excluded from the study because they did not continue their follow-up sessions. Postoperative wound healing was uneventful in all patients and no complications (e.g., ulcers, persistent bleeding, or infections) were observed. Demographic values were shown in Table 1.

Table 1. Demographic Data

	CG	LG	SG	P values
Age	19.06+10.08	24.33+19.54	21.92+8.16	0.198
Female/Male ratio	5/10	5/7	2/12	-
Total (n)	15	12	14	-
MB index	0.85+0.5	1.19+0.69	1,23+0.31	0.104
GO index	1.46+0.37	1.61+0.46	1.44+0.39	0.646

Comparison between groups; SG: Scalpel group; CG: Ceramic bur group; LG: Diode laser group ,

Intragroup Comparisons

On an intragroup basis, statistically significant differences were found between all the parameters in all the groups (p<0.05). The intragroup evaluations revealed increases

in epithelization; and decreases in pain, burning, bleeding and carbonization scores.

Initially, the values of MB and GO are similar and there were no statistically significant differences between the vertical and horizontal gingival overgrowth measurements between the groups.

Intergroup Comparisons

PI, GI, and PD were similar for all groups and the difference was not statistically significant at baseline. On postoperative day 1, the VAS pain scores were significantly higher in the SG than in the LG; however, there were no statistically significant differences between the SG and CG. On postoperative day 3 and day 5, the SG pain scores were significantly higher than those from the CG; however, there were no statistically significant differences between the LG and CG. No statistically significant differences were found between the groups' VAS pain scores on postoperative days 7 and 14 (Table 2). The amount of systemic analgesic consumption within the first postoperative week did not vary significantly between the groups (p=0.167).

The mean VAS burning scores were significantly higher in SG than the LG on postoperative day 1. No statistically significant differences were found between the CG and the SG (p>0,05). While burning scores were significantly lower in the LG than in the other groups on postoperative day 3 (p=0,039), no statistically significant differences were found between the burning scores of the SG and the CG.The mean VAS burning scores were significantly higher in SG than the LG and CG on postoperative day 5 and day 7 (Table 3).

The percentage of epithelization in the CG group is higher than the SG and LG group, but this value is not statistically significant on postoperative day 3. While the CG and SG groups showed statistically similar values. The LG group showed statistically significantly lower epithelization value on postoperative day 5. On the postoperative day 7, SG showed statistically significantly better epithelization compared to other groups. Also, CG showed a statistically significantly higher degree of epithelization compared to the LG group. Epithelization was almost completely ensured on postoperative day 14 (Table 4).

Table 2. Intergroup comparison of VAS scores of Pain

Pain	1st day		3rd day		5th day		7th day		14th day	
	Median (Min-Max)	p	Median (Min-Max)	P	Median (Min-Max)	P	Median (Min-Max)	P	Median (Min-Max)	P
SG	1 (0-4)	0.014*	0.5 (0-3)	0.287	0 (0-1)	0.129	0 (0-0)	1	0 (0-0)	1
CG	1 (0-4)	0.061	1(0-6)	0.541	0 (0-3)	0.129	0 (0-0)	1	0 (0-0)	1
LG	0 (0-3)	1	0 (0-1)	0.009	0 (0-0)	0.129	0 (0-0)	1	0 (0-0)	1

Comparison between groups (Kruskal-Wallis test); SG: Scalpel group; CG: Ceramic bur group; LG: Diode laser group; *statistically difference between SG and LG; ¥ statistically difference between SG and CG; ¶ statistically difference between LG and CG

Table 3. Intergroup comparison of VAS scores of Burning										
Burnin	**1st day**		**3rd day**		**5th day**		**7th day**		**14th day**	
	Median (Min-Max)	**p**	**Median (Min-Max)**	**P**	**Median (Min-Max)**	**P**	**Median (Min-Max)**	**P**	**Median (Min-Max)**	**P**
SG	3(0-5)	0.000*	3 (0-5)	0.000*	2.5 (0-5)	0.001*	0 (0-2)	0.047*	0 (0-0)	1
CG	2(0-6)	0.067	1 (0-4)	0.039¶	0 (0-4)	0.049¥	0 (0-0)	0.031¥	0 (0-0)	1
LG	0(0-1)	0.109	0 (0-0)	0.127	0 (0-0)	0.592	0 (0-0)	1	0 (0-0)	1
Comparison between groups (Kruskal-Wallis test); SG: Scalpel group; CG: Ceramic bur group; LG: Diode laser group;*statistical difference between SG and LG; ¥ statistical difference between SG and CG; ¶ statistical difference between LG and CG										

Table 4. Comparison of epithelization(%) rates between the groups										
Epithelization (%)	**1st day**		**3rd day**		**5th day**		**7th day**		**14th day**	
	Median (Min-Max)	**p**	**Median (Min-Max)**	**P**	**Median (Min-Max)**	**P**	**Median (Min-Max)**	**P**	**Median (Min-Max)**	**P**
SG	0 (0-0)	1	25 (12.5-50)	0.112	78.25 (62.75-9375)	0.001*	95.37 (68.75-100)	0.001*	100 (100-100)	0.78
CG	0 (0-0)	1	35.62 (25-50)	0.112	80 (62.5-100)	1	90 (62.5-100)	0.000¥	100 (87.5-100)	0.78
LG	0 (0-0)	1	25 (12.5-50)	0.112	50 (18.75-62.5)	0.000¶	62.5 (18.75-87.5)	1	100 (50-100)	0.78
Comparison between groups (Kruskal-Wallis test); SG: Scalpel group; CG: Ceramic bur group; LG: Diode laser group; *statistically difference between SG and LG; ¥ statistically difference between SG and CG; ¶ statistically difference between LG and CG										

No postoperative bleeding was observed in the SG, while it was observed in the CG and LG on postoperative day 1 (p=0.008). The degree of postoperative bleeding was statistically significantly higher in the LG than in the SG and CG on postoperative day 3. (p=0.018). No bleeding was observed on postoperative days 5, 7, or 14 in any ofthe groups.

The levels of carbonization were determined solely in the LG on postoperative follow-up and there was a statistically significantly difference between the postoperative day 1 and day 3 (p=0,002). There was no statistically significantly difference between the day 3 and day 5 (p=0,149). Carbonization has not been monitored in postoperative 7th and 14th days.

DISCUSSION

The present study aimed to compare the efficacy of mechanical surgical treatment with ceramic bur and diode laser surgery with the conventional scalpel technique in the performance of gingivectomy. Previous studies have examined gingivectomy procedures using a steel bur; however, there has been no clinical comparative study to date on ceramic bur and laser application in gingivectomy. The present clinical study wasthe first to compare the use of ceramic bur, diode laser, and conventional techniques in gingivectomy procedures.

The present study was reported that the use of laser treatment resulted in less intra- and postoperative pain and wound healing without complications (22). The

other study was conducted that free gingival grafts at the application site have not been as successful as the use of low-level laser in achieving a significant analgesic effect (23). Sanz-Moliner et. al. revealed that, when used during periodontal maintenance, an 810-nm diode laser contributed to wound healing andto less edema and postoperative pain (24). The diode laser used in our study achieved successful results in terms of wound healing. The report related to clinical observations after the application of a diode laser showed that patients had less swelling, bleeding, pain, and scar-tissue formation (8).

Many techniques using various lasers have recently been introduced, and a number of studies have reported the use of the laser in gingivectomy procedures. Clinical trials have revealed that diode-laser application eliminates the use of surgical sutures, a finding that indicates that laser surgery reduces the surgical period, is associated with minimal bleeding, and decreases the need for analgesic drugs. Pick and Colvard recommended laser gingivectomy due to minimal post-operative discomfort (25). In the case series were presented that using two different surgical techniques (e.g., an Er:YAG laser combined with a rotary carbide round bur) for melanin depigmentation and this study found that patients in a carbide bur group experienced higher postoperative pain values than those in an Er: YAG laser group, while mechanical depigmentation areas in the rotary carbide bur group recovered more quickly than those in the laser groups (26). In our study, there were no statistically significant differences in wound

healing among the SG, the CG, and the LG on postoperative 1 and 3 days. Some studies have shown that wound healing after diode laser treatment is delayed than in gingivectomy using conventional technique (14,27). Romanoset. al. reported that laser treatment constitutes a minimally invasive approach and that it initiates gingival and oral tissue regeneration, thereby promoting better periodontal and peri-implant wound healing (27). In this study, the SG's epithelization values were statistically lower than those of the CG and the LG, while there were no significant differences between the LG and the CG on postoperative days 5 and 7. Although higher pain values were recorded in theLG, the use of a ceramic rotary bur can be considered a cost-effective alternative treatment to diode laser application.

In two other studies comparing the application of the diode laser and conventional techniques in surgical procedures performed on oral tissues, pain values were evaluated on postoperative days 1 and 7, but no statistically significant differences between the groups were found. However, in both of these studies, the use of analgesic drugs in the conventional group was much greater than that in the laser groups (28). The studies also found that photoablation increased lymphatic flow and reduced stress on tissues treated with a diode laser and resulted in lower pain values; moreover, connective tissue capillary vasoconstraction was inhibited, thereby releasing local inflammatory mediators after the diode laser treatment (29,30). The studies therefore concluded that less pain occurs in diode laser treatment compared to other methods (8,11). In contrast, Mavrogiannis et. al. compared the scalpel and diode laser (810 nm) techniques used in gingivectomy and reported that after the procedure, laser surgery patients experienced slightly more pain than those treated with scalpel gingivectomy, as reflected by their need for postoperative analgesia (30). Patients who received painkillers were excluded in our study, because the use of painkillers can affect the VAS values. In the present study, on postoperative day 1, the VAS pain scores were significantly higher in theSG than in the LG, and on postoperative day 3, these scores were significantly higher in the CG; however, no statistically significant differences were observed between the SG and the CG. The pain values of the SG and the CG, which were similar, were higher than those of the LG, possibly due to mechanical trauma.

Laser applications on gingival and mucosal tissues result in carbonized tissue; this carbonized layer protects the underlying connective tissues (8). The study was reported that lower pain values may be attributable to a protein coagulum formed on the wound surface after gingivoplasty and the ends of sensory nerves may seal due to protein coagulum (31). In this study, the burning scores were significantly lower in the LG than in the other groups on postoperative days 1 and 3. Based on this finding, it may be concluded that the lower burning levels after diode laser application were due to the protein formation that results from the carbonized layer.

CONCLUSION

An experimental study that compared scalpel, diode laser, and Er:YAG laser applications found that a diode laser provides good bleeding control; however, more tissue damage and late wound healing occurred in the diode laser group (32). In our study, bleeding scores in the LG were lower than those in the SG. The diode laser demonstrates good coagulation ability with soft tissues, and its clinical application is considered to be beneficial for daily practice in oral soft-tissue surgery. On the other hand, a histological clinical study by Giannelli et. al.found that the diode laser provided homogeneous tissue removal of the epithelium layer and did not damage the connective layer and capillary vessels under the epithelium layer (33).There was no study on the use of a gingival trimmer has been published in the literature. Therefore, it is clear that there is a need for more experimental and clinical studies on the ceramic bur in the context of its use in the treatment of gingival tissues.

The limitation of this study was planned to evaluate short-term gingival wound healing. However, it may be possible to examine the gingival enlargement and recurrence values retrospectively in the 6-month and 1-year periods. The patients included in the study were selected from patients with gingival growth due to inflammation. However, in the larger group of patients, the use of ceramic rotary bur should be searched in the drug-induced gingival enlargements.

The use of the ceramic rotary bur may therefore be an alternative treatment to diode laser surgery in gingivectomy or gingivoplasty, compared to scalpel gingivectomy surgery, additionally diode laser advantages or disadvantages, such as the high cost and difficulties in handling; aspect to controlled gingival tissue removing than diode laser and postoperative inflammation and wound healing values were observed to be almost equal with diode laser values. As there were limitations in this study, there is a need for prospective, long-term studies related to recurrence after gingivectomy surgery. There is therefore a need comparative experimental and clinical studies on ceramic rotary bur gingivectomy are also indicated.

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REFERENCES

1. Ryu SW, Lee SH, Yoon HJ. A comparative histological and immunohistochemical study of wound healing following incision

with a scalpel, CO2 laser or Er,Cr:YSGG laser in the guinea pig oral mucosa. Acta Odontol Scand 2012;70:448-54.

2. Aykol G, Baser U, Maden I, et al. The effect of low-level laser therapy as an adjunct to non-surgical periodontal treatment. J Periodontol 2011;82:481-8.

3. Esposito M, Maghaireh H, Grusovin MG, et al. Soft tissue management for dental implants: what are the most effective techniques? A Cochrane systematic review. Eur J Oral Implantol 2012;5:221-38.

4. Ribeiro FV, Hirata DY, Reis AF, et al.Open-flap versus flapless esthetic crown lengthening: 12-month clinical outcomes of a randomized controlled clinical trial. J Periodontol 2014;85:536-44.

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

6. Lopes BM, Theodoro LH, Melo RF, et al. Clinical and microbiologic follow-up evaluations after non-surgical periodontal treatment with erbium:YAG laser and scaling and root planing. J Periodontol 2010;81:682-91.

7. Favia G, Tempesta A, Limongelli L, et al. Diode laser treatment and clinical management of multiple oral lesions in patients with hereditary haemorrhagic telangiectasia. Br J Oral Maxillofac Surg 2016;54:379-83.

8. Romanos G, Nentwig GH. Diode laser (980 nm) in oral and maxillofacial surgical procedures: clinical observations based on clinical applications. J Clin Laser Med Surg 1999;17:193-7.

9. Smith KC. Ignorance of photobiology: a major pitfall in using lasers in medicine. Pain 1991;47:243-5.

10. Harris DM. Editorial comment biomolecular mechanisms of laser biostimulation.J Clin Laser Med Surg 1991;9:277-80.

11. Tomasi C, Schander K, Dahlén G, et al. Short-term clinical and microbiologic effects of pocket debridement with an Er:YAG laser during periodontal maintenance. J Periodontol 2006;77:111-8.

12. Gupta G, Kumar A, Khatri M, et al. Comparison of two different depigmentation techniques for treatment of hyperpigmented gingiva. J Indian Soc Periodontol 2014;18:705-9.

13. Amaral MB, de Ávila JM, Abreu MH, et al. Diode laser surgery versus scalpel surgery in the treatment of fibrous hyperplasia: a randomized clinical trial. Int J Oral Maxillofac Surg 2015;44:1383-9.

14. Haytac MC, Ozcelik O. Evaluation of patient perceptions after frenectomy operations: a comparison of carbon dioxide laser and scalpel techniques. J Periodontol 2006;77:1815-9.

15. O'Leary TJ, Drake RB, Naylor JE. The plaque control record. J Periodontol 1972;43:38-8.

16. Loe H, Silness J. Periodontal disease in pregnancy. i. prevalence and severity. Acta Odontol Scand 1963;21:533-51.

17. Silness J, Loe H. Periodontal disease in pregnancy. ii. correlation between oral hygiene and periodontal condtion. Acta Odontol Scand 1964;22:121-35.

18. Miller CS, Damm DD, Incidence of verapamil-induced gingival

19. hyperplasia in a dental population. J Periodontol 1992;63:453-6.

19. Miranda J, Brunet L, Roset P, et al. Prevalence and risk of gingival enlargement in patients treated with nifedipine. J Periodontol 2001;72:605-11.

20. Ozturan S, Ay E, Sagir S. Case series of laser-assisted treatment of excessive gingival display: an alternative treatment. Photomed Laser Surg 2014;32:517-23.

21. Isler SC, Uraz A, Guler B, et al. Effects of Laser photobiomodulation and ozone therapy on palatal epithelial wound healing and patient morbidity. Photomed Laser Surg 2018;36-571-80:

22. Stubinger S, Saldamli B, Jürgens P, et al. Soft tissue surgery with the diode laser--theoretical and clinical aspects. Schweiz Monatsschr Zahnmed 2006;116:812-20.

23. Masse JF, Landry RG, Rochette Cet al. Effectiveness of soft laser treatment in periodontal surgery. Int Dent J 1993;43:121-7.

24. Sanz-Moliner JD, Nart J, Cohen RE, et al. The effect of an 810-nm diode laser on postoperative pain and tissue response after modified Widman flap surgery: a pilot study in humans. J Periodontol 2013;84:152-8.

25. Pick RM, Colvard MD. Current status of lasers in soft tissue dental surgery. J Periodontol 1993;64:589-602.

26. Lee EA. Aesthetic crown lengthening: classification, biologic rationale, and treatment planning considerations. Pract Proced Aesthet Dent 2004;16:769-78.

27. Romanos GE, Gladkova ND, Feldchtein FI, et al. Oral mucosa response to laser patterned microcoagulation (LPM) treatment. An animal study. Lasers Med Sci 2013;28:25-31.

28. Bornstein E. Near-infrared dental diode lasers. Scientific and photobiologic principles and applications. Dent Today 2004;23:102-8.

29. Dominguez A, Gómez C, García-Kass AI, et al. IL-1beta, TNF-alpha, total antioxidative status and microbiological findings in chronic periodontitis treated with fluorescence-controlled Er:YAG laser radiation. Lasers Surg Med 2010;42:24-31.

30. Mavrogiannis M, Ellis JS, Seymour RA, et al. The efficacy of three different surgical techniques in the management of drug-induced gingival overgrowth. J Clin Periodontol 2006;33:677-82.

31. Hegde R, Padhye A, Sumanth S, et al. Comparison of surgical stripping; erbium-doped:yttrium, aluminum, and garnet laser; and carbon dioxide laser techniques for gingival depigmentation: a clinical and histologic study. J Periodontol 2013;84:738-48.

32. Jin JY, Lee SH, Yoon HJ. A comparative study of wound healing following incision with a scalpel, diode laser or Er,Cr:YSGG laser in guinea pig oral mucosa: A histological and immunohistochemical analysis. Acta Odontol Scand 2010;68:232-8.

33. Giannelli M, Formigli L, Bani D. Comparative evaluation of photoablative efficacy of erbium: yttrium-aluminium-garnet and diode laser for the treatment of gingival hyperpigmentation. A randomized split-mouth clinical trial. J Periodontol 2014;85:554-61.