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Comparison of the Effectiveness of CO2 and Diode Lasers for Gingival Melanin Depigmentation: A Randomized Clinical Trial

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Abstract

Introduction: Gingival hyperpigmentation is an esthetic concern for some individuals. This study compared the effectiveness of CO_2 and diode lasers for gingival depigmentation.

Methods: This randomized, split-mouth, clinical trial consisted of 12 patients with the chief complaint of hyperpigmented gingival areas. The upper right and left anterior segments and the mandibular anterior segment were randomly allocated to one of the treatment groups. The segments in group 1 underwent gingival depigmentation with a diode laser (810 nm) at 6 W and pulsed mode, whereas group 2 was ablated with a diode laser at 3 W and continuous mode. The removal of gingival pigments in group 3 was contemplated with a CO_2 laser (10600 nm, 3 W, continuous mode). The operation chair time, bleeding during the procedure and post-operative pain were recorded. The gingival color and esthetic appearance were measured before the operation and at 1 week and 6 months later.

Results: There was no significant difference in the bleeding scores, pain level, and color alteration values between the groups ($P>0.05$). The operation chair time was significantly shorter when the diode laser was applied at pulsed mode ($P<0.05$). The segments treated with the diode laser (pulsed or continuous mode) showed a higher esthetic appearance at the 6-month follow-up compared to those ablated with the CO_2 laser ($P<0.05$).

Conclusions: Higher esthetic appearance is expected when using the diode laser for gingival depigmentation compared to the CO2 laser. The application of the diode laser at pulsed mode could be recommended for gingival depigmentation, as it produced pleasing esthetic outcomes at reduced chair time.

Keywords: Gingiva; Pigmentation; Melanin; Laser; Diode; CO_2

Introduction

Gingival color is an important component of facial and smile esthetics. It is determined by several factors such as the vascular supply, the thickness of the epithelium, the quantity of keratinization, and the amount of pigments including melanin, melanoid, oxyhemoglobin, carotene, and iron within the tissue.[1,2] Gingival hyperpigmentation occurs due to physiological or pathological conditions. The most common type of hyperpigmentation is the physiologic pigmentation resulting from the excessive deposition of melanin within melanocytes that are located in the basal layer of the gingival epithelium. Although physiologic hyperpigmentation is a completely benign condition, it creates esthetic problems in some persons with the chief complaint of black-colored gums.[3] These persons frequently make a request for removing gingival color to enhance oral esthetics while smiling or speaking.

There are different therapeutic approaches for gingival depigmentation. These include scalpel technique, electrosurgery, cryosurgery, concealing the pigmented gingiva with normal gingival areas (free gingival autograft or acellular dermal matrix allograft), abrasion with a large round diamond bur, and different types of lasers.[1-7] The most conventional modality for the removal of undesirable pigmentation is the use of the scalpel technique. In this procedure, the gingival epithelium and a layer of the connective tissue are eliminated, and after that, the denuded connective tissue heals by secondary intention.[2] A common event associated with scalpel surgery is the experience of moderate pain and discomfort during gingival depigmentation and after the operation. Other technical problems associated with the scalpel technique include the occurrence of unpleasant bleeding during and after the procedure, increased chair time, leaving a delicate scar, and the necessity to protect the exposed lamina propria with a periodontal pack for 7 to 10 days.[3,5] Therefore, modern devices and techniques have been proposed as alternatives to the conventional procedure

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for removing or alleviating gingival hyperpigmentation.

Since the introduction of the ruby laser in 1960, lasers have been used for various applications in medicine and dentistry.[8-11] The use of lasers for soft tissue surgery is associated with several advantages for both the operator and the patient, including less pain and discomfort, relatively bloodless surgical field, reduced operative trauma, and minimal swelling and scarring after the surgical procedure.[12] Different lasers such as semiconductor diode (800-980 nm), carbon dioxide (CO_2), neodymium-doped: yttrium aluminum garnet (Nd:YAG), and erbium-doped: yttrium aluminum garnet (Er:YAG) lasers have been used for surgical therapy of oral lesions. The family of diode lasers exhibit a high affinity for hemoglobin and melanin. Therefore, the use of the diode laser for gingival depigmentation can not only control hemorrhage by hemostasis of blood vessels but also cause effective ablation of pigment-containing cells due to the high absorption of the laser beam in melanin. Diode laser radiation can be emitted in continuous or pulsed mode. In the continuous mode, the beam is delivered continuously and without interruption, whereas in the pulsed mode, the beam is interrupted by a gate with a defined interval between pulses. The use of pulsed mode can minimize the thermal damage by allowing the surrounding tissues to cool between pulses.

The CO_2 laser is another widely used laser for soft tissue surgery and removing oral lesions. The main soft tissue chromophore for the absorption of the CO_2 laser wavelength is water, not melanin. Following the absorption of the CO_2 laser beam into intracellular water, the water temperature gets to the boiling point, leading to the evaporation of soft tissues layer by layer. Although depigmentation by the CO_2 laser is not selective, this laser is effective for gingival depigmentation because of the high water content of soft tissues.[13]

There are some studies that have compared different modalities to treat gingival hyperpigmentation. Most of these studies are uncontrolled studies or case reports and case series with small sample sizes.[14-17] There is little information concerning the performance of pulsed versus continuous modes of diode laser and CO_2 laser for gingival depigmentation. Therefore, the present randomized controlled clinical trial was conducted to compare the effectiveness, postoperative morbidity, operation chair time, bleeding during the operation, and aesthetic outcomes following gingival depigmentation by diode (pulsed and continuous modes) and CO_2 lasers.

Methods and Materials

Study Design and Participants

This study was designed as a prospective, randomized, double-blind clinical trial with a split-mouth design. The patients were selected from those attending the Laser Department, School of Dentistry, Mashhad University of Medical Sciences, Mashhad, Iran, with the chief complaint of unsightly hyperpigmented gingival areas. The selected patients were over 18 years old and showed bilateral physiologic gingival pigmentation (score 2 of the melanin pigmentation index according to Takashi et al[1]) in the anterior parts of upper and lower jaws. The exclusion criteria involved patients who showed hyperpigmentation due to systemic or genetic disorders or consuming drugs. Furthermore, patients who were smokers, pregnant or breast-feeding and those having periodontal diseases were excluded from the sample.

Treatment Protocol

Three treatment areas were defined in the participants: 1. the distal point of the upper right canine to the midpoint between upper central incisors (Figure 1a), 2. the distal point of the upper left canine to the midpoint between upper central incisors (Figure 1b), 3. the distal point of the lower right lateral incisor to the distal point of the lower left lateral incisor (Figure 1c).

Before the operation, anesthesia was achieved with the infiltration of lidocaine 2% with epinephrine 1:100 000 in the maxillary and mandibular anterior vestibular regions. The patient and staff wore spectacles according to the wavelength of the operating laser. The treatment areas were then randomly assigned to one of the following procedures for gingival depigmentation. The randomization was accomplished using a computer-generated table.

Group 1 (Diode laser/pulsed mode): The segments in this group underwent depigmentation with a semiconductor diode laser unit (ARC Laser GmbH, Nürnberg, Germany). The laser emitted a wavelength of 810 nm and was set at 6 W and pulsed mode with a pulse length of 50 ms and a duty cycle of 50%. The beam was delivered by a 300 µm-diameter fiber tip in contact mode (initiated tip). The tip was moved in the cervico-apical direction using small brush strokes back and forth to prevent heating the tissue. The fiber tip was frequently cleaned during the procedure.

Group 2 (Diode laser / continuous mode): The gingival depigmentation in this group was carried out with the diode laser similar to that described in group 1, but the laser was set at 3 W and continuous-wave mode.

Group 3 (CO2 laser): A CO2 laser (Daeshin Enterprise Corp, Guro-gu, Seoul, Korea) was used in group 3 to ablate the pigmented anterior gingiva. The apparatus emitted a wavelength of 10 600 nm and operated at

Figure 1. Pre-operative View Showing Gingival Melanin Hyperpigmentation in the Maxillary Right (a) and Left (b) Anterior Segments, and Mandibular Anterior Segment (c).

continuous-wave mode and at output power of 3 W. The laser was held manually and perpendicular to the target area, and the light was delivered in non-contact and focused mode with the spot diameter of approximately 1 mm. The pigmented areas were eliminated with cervico-apical scanning movements.

Laser ablation was performed by one experienced operator in all groups. Each treatment segment was lased at one session with the interval of at least one week between the operations. During ablation, the tissue remnants were removed with sterile gauze soaked in normal saline solution to enhance visualization, and care was taken to prevent damaging tooth surfaces. The tissue removal was performed within the thickness of keratinized attached gingiva while maintaining the distance of 1 mm from the gingival margin to minimize the risk of gingival recession. The laser operation was continued until no pigmentation was detected through inspection. No periodontal pack was applied. The patients were advised to avoid eating spicy and hot food for the first 24 h following the procedure and take gelofen 200 mg if they perceived pain.

Post-operative Assessments

The following criteria were measured during and after the laser operation in the study groups:

1- *Operation chair time:* The chair time for each laser procedure was recorded in seconds, beginning immediately after the start of laser ablation and ending at the complete depigmentation of the treatment segment.

2- *Bleeding:* The degree of bleeding during the laser procedure was assessed using the following criteria: A. none, B. slight, C. moderate, D. Severe.[1]

3- *Pain assessment:* A visual analogue scale (VAS) was used for evaluating the subjective pain level. The patient was requested to mark the degree of pain perceived on a 10-cm horizontal line, with the left side displaying no pain and the right side displaying "unbearable" pain. The pain level was assessed at 6 and 12 hours after the operation and at bedtime on days 1, 3, 5 and 7 after the procedure.

4- *Colorimetry measurements:* The Easyshade spectrophotometer (Vita Zahnfabrik, Bad Säckingen, Germany) was used for gingival color assessment according to the CIELAB (Commission Internationale de l'Eclairage L*a* and b*) color space system. In this system, the L coordinate corresponds to the degree of lightness, whereas the a and b values exhibit positions on red/green (+a = red, -a = green) and yellow/blue (+b = yellow, -b = blue) axes respectively. The color of the gingiva was measured at keratinized attached gingiva between the lateral incisor and canine teeth at both sides of the upper jaw and between the central and lateral incisors in the right side of the lower jaw. The color assessment was performed before the treatment and after 7 days and 6 months of the surgical procedure under similar lighting conditions. The color change (ΔE) between the different treatment stages was measured using the following formula: $\Delta E = [(\Delta a)2 + (\Delta b)2 + (\Delta L)2]0.5.18$

5- Est*hetic evaluation:* Before the treatment, the intraoral photographs were taken from the right and left sides of the upper jaw and from the frontal view in the lower jaw. For taking right and left images, the center of the image was set perpendicular to the upper lateral incisors. The patients were recalled at 1 week and 6 months post-operatively, and the photographs were taken again. The images were printed in high-quality papers of the same size and were evaluated by two professionals (one periodontist and one dentist), who had high clinical experience and were blinded to the therapies. The esthetic level of each image was determined with respect to the gingival color by a 10-cm line (VAS), showing the least amount of esthetics on the left side (0) and the highest degree of esthetics on the right side (10). There was no time limit during the rating process. The mean of the scores given by two raters per image was considered in the statistical analysis.

Statistical Analysis

The Friedman test was run to determine any significant differences in chair time, VAS scores, color change measurements, and esthetic ratings between the study groups. Pairwise comparisons were made with the Wilcoxon test. The between-group difference in the severity of bleeding was assessed by the Fisher exact test. The data were analyzed by SPSS software (version 16.0, SPSS Inc, Chicago, Il, USA) and the statistical significance was set at $P < 0.05$.

Results

The study consisted of 12 patients (3 males, 9 females) with an age range of 18 to 39 years (a mean age of 30 years). No participant was lost over the 6-month follow-up, and all of the patients contributed to the statistical analysis. The representative images of one patient treated with three treatment modalities immediately after the operation and one week later are illustrated in Figures 2 (a-c) and 3 (a-c).

The mean and standard deviation of operation chair time

Figure 2. Clinical Images Taken Immediately After Gingival Depigmentation by the Diode Laser at Pulsed Mode (a), the Diode Laser at Continuous Mode (b), and the CO_2 Laser (c).

in the study groups are presented in Table 1. A statistically significant difference in chair time was observed between the three laser groups ($P=0.007$). Pairwise comparisons revealed that the operation chair time was significantly shorter in the segments treated by the pulsed diode laser than those treated by the continuous mode of the diode laser and CO_2 laser ($P<0.05$), which showed no significant difference to each other ($P>0.05$; Table 1).

The severity of bleeding during the laser procedure is presented in Table 2. During operation, 11 patients (91.7%) in both diode laser groups had no bleeding and 1 showed slight bleeding, whereas in the CO_2 laser group, 10 patients (83.4%) had no bleeding and others showed slight bleeding. The Fisher exact test revealed no significant difference in the distribution of bleeding scores between the three groups ($P=1.00$, Table 2).

Figure 3. Clinical Images Taken 1 Week Following Gingival Depigmentation by the Diode Laser at Pulsed Mode (a), the Diode Laser at Continuous Mode (b), and the CO_2 Laser (c).

Table 3 presents the pain level of the participants in the study groups. VAS scores increased after the treatment and got the highest value at 6 hours after the operation and then decreased continuously. The patients in the diode laser groups experienced a bit higher extent of discomfort than those in the CO2 laser group. The Friedman test revealed no significant difference in pain perception between the groups at any of the assessment intervals ($P>0.05$; Table 3).

Table 4 demonstrates the descriptive statistics and the results of statistical analysis for comparison of color change (ΔE) values between different treatment stages among the study groups. The statistical analysis revealed no significant difference in the color change between T1 (pretreatment) and T2 (1 week after operation), T1 and T3 (6 months after operation), and T2 and T3 intervals, among the study groups ($P>0.05$; Table 4).

Table 5 presents the mean and standard deviation of esthetic ratings of gingiva in the treatment groups at three assessment intervals. A considerable improvement in esthetic appearance was detected in all groups after

Table 1. The Mean and Standard Deviation (SD) of Operation Chair Time (Second) in the Study Groups

	Diode Laser (Pulsed) Mean ± SD	Diode Laser (Continuous) Mean ± SD	CO_2 Laser Mean ± SD	*P* Value
Chair time	7204 ± 2762	19357 ± 40021	11479 ± 4371	0.007*

*$P<0.05$ indicates a statistically significant difference between groups.

Table 2. The Number and Percent of Patients Showing Bleeding During the Procedure in the Study Groups

	Diode Laser (Pulsed) No. (%)	Diode Laser (Continuous) No. (%)	CO_2 Laser No. (%)	*P* Value
Without bleeding	11 (91.7)	11 (91.7)	10 (83.4)	>0.99
Low bleeding	1 (8.3)	1 (8.3)	2 (16.6)	

Table 3. The Mean and Standard Deviation (SD) of Pain Degree (cm) in the Study Groups Before and up to 7 Days After the Operation

	Diode Laser (Pulsed)	Diode Laser (Continuous)	CO_2 Laser	*P* Value
Before treatment	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	---
6 hours	2.89 ± 2.40	3.18 ± 2.68	2.35 ± 2.85	0.202
12 hours	2.71 ± 2.28	2.79 ± 2.48	2.30 ± 3.09	0.417
Day 1	2.67 ± 2.72	2.67 ± 2.54	2.00 ± 3.02	0.674
Day 2	1.71 ± 2.26	1.54 ± 1.88	1.10 ± 2.13	0.223
Day 3	1.42 ± 2.39	1.83 ± 3.10	1.00 ± 2.16	0.411
Day 5	0.75 ± 2.01	0.58 ± 1.44	0.6 ± 1.35	0.670
Day 7	0.58 ± 2.02	0.42 ± 1.44	0.40 ± 1.26	0.368

Table 4. The Mean and Standard Deviation (SD) of Color Differences (ΔE) Between Different Treatment Stages Among the Study Groups[a]

	Diode Laser (Pulsed)	Diode Laser (Continuous)	CO_2 Laser	*P* Value
	Mean ± SD	Mean ± SD	Mean ± SD	
ΔE T1-T2	21.08 ± 9.30	22.27 ± 7.22	19.90 ± 9.61	0.407
ΔE T1-T3	19.54 ± 5.91	19.69 ± 7.68	19.05 ± 7.07	0.741
ΔE T2-T3	10.61 ± 4.26	10.58 ± 5.58	15.95 ± 13.00	0.497

[a] T1: pretreatment, T2: 1 week after operation, T3: 6 months after operation.

Table 5. The Mean and Standard Deviation (SD) of Esthetic Scores (cm) for Gingival Color in the Study Groups Over the Experiment

	Diode Laser (Pulsed)	Diode Laser (Continuous)	CO_2 Laser	*P* Value
	Mean ± SD	Mean ± SD	Mean ± SD	
Before treatment	2.79 ± 0.51	2.79 ± 0.51	2.79 ± 0.51	--
1 week after operation	7.96 ± 1.72	7.92 ± 1.73	7.10 ± 1.31	0.247
6 months after operation	8.64 ± 1.71	8.55 ± 1.76	7.65 ± 2.45	0.032*

*$P < 0.05$ indicates a statistically significant difference between groups

therapies. There was no significant difference in esthetic scores between the groups either at pretreatment interval or at 1 week post-operatively ($P > 0.05$; Table 5). At 6 months after therapy, however, a significant difference in esthetic appearance was found between the groups ($P = 0.032$; Table 5). The pairwise comparison demonstrated that the degree of esthetics was significantly greater in both diode laser groups than the CO_2 laser group ($P < 0.05$), but no significant difference was found in cosmetic outcomes after therapy with pulsed versus continuous modes of diode laser ($P > 0.05$).

Discussion

The current trial compared the performance of pulsed and continuous modes of diode laser and CO_2 laser with respect to the morbidity and cosmetic outcomes after eliminating pigmented gingival tissues. The elimination of gingival hyperpigmentation was contemplated at the distance of 1 mm from the free gingiva in order to reduce the chance of injuring the delicate gingival margin and interdental papilla, which can lead to gingival recession and unfavorable tooth lengthening. The outcomes of this study demonstrated that the three laser techniques can be successfully applied for the treatment of gingival hyperpigmentation, as the degree of postoperative discomfort/pain, the amount of bleeding during the procedure, and the color alteration values were comparable among the groups. However, the application of the diode laser at pulsed mode for gingival depigmentation was associated with less treatment chair time compared to the other laser groups. Furthermore, the esthetic outcome was significantly better at the 6-month follow-up when using either pulsed or continuous modes of diode laser as compared to the CO_2 laser.

The mechanism of gingival depigmentation by diode and CO_2 lasers is different. The absorption of the laser beam in tissues is achieved by tissue elements called chromophores. The main chromophores in oral tissues are melanin, hemoglobin, hydroxyapatite, and water.[19] Each of these chromophores has a greater tendency to absorb a specific wavelength of light. The diode laser beam is well absorbed by pigmented elements such as melanin that is present within the active melanocytes. The light energy is then converted to heat and destroys the cells, leading to the ablation of pigmented tissues during the process of selective photothermolysis. The CO_2 laser beam, in contrast, targets the water in the soft tissue and boils it, then vaporizes the tissue layer by layer and cell by cell to reach the pigmented area.[13]

In the current study, the operative chair time was significantly shorter when using the diode laser at pulsed mode compared to the continuous mode of diode laser and CO_2 laser. Several reasons may be responsible for this finding. During the procedure, carbonization occurs as a result of laser interaction with the gingival tissue. The carbonized tissue should be removed frequently to increase treatment efficacy. It is possible that employing the continuous mode of diode and CO_2 lasers produces greater carbonization than that of the pulsed diode laser. When using the diode laser at pulsed mode, the tissue has a chance to cool down between pulses and thus carbonization reduces and the working speed increases. Another factor that could increase the working time with the CO_2 laser is the non-contact mode of operation and the presence of a heavy articulated arm. In contrast, the light handpiece of the diode laser comes in contact with the soft tissue during ablation, which makes the operation more comfortable.

There are few studies regarding the comparison of operation chair time when using different techniques for gingival depigmentation. Ribeiro et al.[2] concluded that both the Nd:YAG laser and the scalpel technique produced similar esthetic outcomes for the treatment of melanin gingival hyperpigmentation, but Nd:YAG laser therapy showed extra advantages in terms of reducing chair time and creating minor degree of pain/discomfort over the post-operative period.

The difference in the frequency of bleeding scores among the three laser groups was not significant in the present study. In the diode laser groups, 91.7% of the patients showed no bleeding, whereas in the CO_2 laser group, 81.8% of the subjects had no bleeding during gingival depigmentation. The lack of bleeding in surgical laser interventions can be attributed to the thermal effects of lasers, leading to coagulation and closure of blood vessels and thus providing a better trans-operative visualization.[20] As both diode and CO_2 lasers rely on thermal interaction with soft tissue, there was no significant difference in bleeding scores between the three groups.

In the present study, the patients revealed a comparable extent of pain/discomfort in the areas treated by three laser groups during the post-therapy period. Although VAS scores were slightly higher on the segments treated by the diode laser (both pulsed and continuous modes)

compared to that of the CO_2 laser, the difference between groups was small and not significant. Pain intensity exhibited the highest value at 6 hours after the operation, then decreased and reached a negligible value after a few days. The perception of minimal pain after laser ablation of pigmented gingiva could be attributed to the occurrence of negligible trauma during this therapeutic approach and to the formation of a biologic dressing on the wound surface, which provides a faster postoperative repair.[2] Several studies reported that laser elimination of gingival hyperpigmentation was associated with a less degree of post-operative pain and morbidity, which was significantly lower than electrosurgery[4] or scalpel treatment.[2,21-23] In contrast, Grover et al[24] reported that both the laser and the scalpel were efficient for gingival depigmentation with no statistical difference in pain scores and repigmentation scores at various time intervals.

In the current study, the gingival color was recorded with a spectrophotometer before the treatment and 7 days and 6 months later. All three groups showed comparable color alteration between the treatment stages. Therefore, both continuous and pulsed modes of the diode laser and the CO_2 laser have similar effectiveness in the management of melanin pigmented gingiva. The efficacy and superiority of laser ablation in the elimination of pigmented gingiva have been demonstrated in several studies.[7,24-32] However, Hedge et al[33] implied that surgical stripping still remains the gold standard for gingival depigmentation, although Er:YAG and CO_2 lasers can also be effectively used for this application. Alhabashneh et al[34] displayed similar outcomes for the Er:YAG laser and the scalpel technique with respect to the efficacy of depigmentation, pain perception during the procedure, and time required for the treatment. They believed that the scalpel technique is the gold standard for gingival depigmentation because of the higher financial costs of laser therapy.[34]

In this study, the professional opinion regarding gingival esthetics was obtained before the treatment and 7 days and 6 months after the removal of pigments. The esthetic rating was performed according to the gingival color. All three groups showed a great improvement in esthetic scores following gingival depigmentation. On day 7, the difference in esthetic appearance was not significant among the three laser groups. At the 6-month follow-up, the professional evaluation of esthetic appearance demonstrated that the pulsed and continuous modes of diode laser achieved comparable ratings, which were significantly higher than that of the CO_2 laser. The lower esthetic appearance after depigmentation with the CO_2 laser can be attributed to the occurrence of repigmentation at some gingival areas. It is possible that the application of the diode laser provides a lower degree of relapse than the CO_2 laser due to its selective absorption in melanin pigments. Altayeb et al[35] also reported that both diode and Er,Cr:YSGG lasers efficiently eliminated gingival pigments, but the long-term stability of gingival color was better with the diode laser. Recently, Nammour et al[36] compared the durability of esthetic results after gingival depigmentation by diode, CO2 and Er:YAG lasers. They exhibited that the diode laser produced the longest-term stability after treatment, whereas the Er:YAG laser provided the shortest time before the recurrence of gingival pigments.[36]

Overall, the outcomes of this study indicate that both diode and CO_2 lasers can be employed successfully for gingival depigmentation in patients with dark gums. However, gingival depigmentation by the diode laser provides greater esthetic outcomes compared to the CO_2 laser, possibly due to the lower rate of recurrence. The application of the diode laser at pulsed mode also provides faster ablation, while giving the chance of tissue cooling between pulses. Therefore, the diode laser at pulsed mode could be considered as the best option for gingival depigmentation at the clinical situation. Other advantages of the diode laser are the small size and the light weight of the apparatus, the presence of delicate fiber optic cables, and the relatively low cost compared to other high-power lasers. Furthermore, the diode laser can be applied safely in close proximity to dental structures, as it does not create any deleterious effect on the tooth surface.

The limitation of this study was the low sample size and the short follow-up period. The melanin pigmentation index used in this study did not assess the severity of pigmentation and was based on just the extension of the pigmented area. However, the split-mouth design of the study allowed the clinician to measure the variables in different segments of the same patient, thus minimizing the effect of interindividual variations on the outcomes of the study.[37] All operations were performed by one experienced laser therapist to avoid different surgical skills that can affect the treatment results. Further clinical trials are suggested using a larger sample size to compare long-term cosmetic outcomes and the recurrence rate following different methods of removing gingival melanin hyperpigmentation.

Conclusion

Under the conditions used in this study:

1. Both diode and CO2 lasers proved to be effective in the management of melanin gingival hyperpigmentation in patients with dark gums and produced negligible intensity of pain/discomfort during the first week post-operatively.
2. At the 6-month follow-up, the application of the diode laser (3 W/continuous-wave mode or 6 W/pulsed mode) produced greater cosmetic outcomes with respect to the gingival color than that of the CO_2 laser.
3. The operative chair time was significantly shorter when using the diode laser at pulsed mode compared

to the CO_2 laser and continuous mode of the diode laser.

4. The diode laser at pulsed mod could be recommended as the most preferred technique for removing gingival melanin pigmentation, as it presented advantages in terms of operative chair time and cosmetic outcomes compared to other modalities.

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Conflict of Interests

The authors declare that they have no conflict of interest.

Ethical Considerations

The study protocol was reviewed and approved by the Ethics Committee of Mashhad University of Medical Sciences (IR.mums.sd.REC.1395.124) and was recorded in the Iranian Registry of Clinical Trials with IRCT identifier IRCT20091118002736N4. An informed consent document was taken from each patient after the complete verbal description of the treatment process. The study was conducted between November 2019 and March 2020, and the procedures were performed in accordance with the World Declaration Statement of Helsinki.

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