THE ROLE OF LASER IN TREATING GINGIVAL PIGMENTATION AMONG SMOKING PATIENTS

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ABSTRACT

Background: Gingival pigmentation results from excessive melanin deposition in the basal layer of the epithelium. It is regarded as a major aesthetic concern that can affect a patient's self-confidence, particularly in individuals with a gummy smile. The present study aimed to compare the clinical efficacy and patient comfort of three depigmentation techniques: surgical scraping using a diamond bur, diode laser, and a combination of bur abrasion followed by low-level laser therapy.

Materials and methods: 60 patients aged 18-45 years who had chief complaints of pigmented or dark gingiva were selected and randomly placed into three groups, Group A (n=20) treated with diode laser 810nm wavelength in continuous contact-mode, Group B (n=20) treated by bur abrasion, Group C (n=20) treated by a combination of bur abrasion followed by diode laser 635nm wavelength in continuous non-contact mode.

Results: Significant differences were observed among groups. The diode laser showed minimal bleeding, with a mean score of 1.10 (0.31) ($p < 0.0001$), and the shortest procedure time with a mean score of 16.1 ($p < 0.0001$). On the first postoperative day, pain scores were significantly lower in the diode laser group, with a mean of 0.80 (0.95), compared to the bur abrasion group, with a mean of 1.90 (0.79) ($p = 0.0004$), and the combination group, with a mean of 1.45 (0.83), By day 3, pain levels had reduced in all groups with no significant difference ($p = 0.1510$). No significant differences were found in gingival depigmentation ($p = 0.3547$), healing index ($p = 0.8844$), or re-pigmentation after three months ($p = 0.7603$) among groups.

Conclusion: The Diode laser resulted in the shortest procedure time, better hemostasis, and patient comfort compared to other techniques.

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A harmonious smile is considered a fundamental aspect of modern dental aesthetics, where the appearance of both teeth and the gingiva plays a crucial role[1]. A common aesthetic concern is gingival melanin pigmentation, which may become noticeable during speech or smiling and can negatively affect patient confidence[2]. Normally, the gingiva appears pale pink; however, in some individuals, melanin deposition by melanocytes primarily located in the basal and suprabasal epithelial layers results in gingival pigmentation[3].

Oral pigmentation can result from a variety of factors, including genetic predisposition, certain medications, exposure to heavy metals, endocrine disorders, and habits such as tobacco use[4]. Notably, smokers' melanosis is linked to both the duration and intensity of smoking[5]. Substances like nicotine and benzopyrenes stimulate melanocytes, increasing melanin

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production and resulting in diffuse, patchy pigmentation[6].

Gingival depigmentation can be achieved through many different types of surgical techniques, each with varying degrees of effectiveness, including Electro-surgery, Surgical scraping, bur abrasion, cryosurgery, and lasers[7].

The term LASER is an abbreviation for "Light Amplification by Stimulated Emission of Radiation". Maiman introduced it to dentistry in the 1960s. Numerous applications in both soft and hard tissues have been the focus of continual studies, and it is used in a wide range of medical and cosmetic procedures[8].

The diode lasers are semiconductor devices that use solid-state elements to convert electrical energy into light energy. The light energy from the diode laser is mainly absorbed by soft tissue (like gingiva, skin, blood) and poorly absorbed by bones and teeth. Water and other chromophores, including melanin and especially oxyhemoglobin, absorb this particular wavelength, making it useful for oral soft tissue surgical procedures[9].

Therefore, this study aimed to compare the clinical effectiveness and patient comfort of three depigmentation techniques: surgical scraping with a diamond bur, diode laser, and a combination of bur abrasion followed by low-level laser therapy. This comparison seeks to determine which method offers the optimal balance of therapeutic outcomes and patient satisfaction.

MATERIALS AND METHODS

Setting and Time of the Study

This study was carried out at the Department of Periodontics, College of Dentistry, in Duhok city. The research involved patients who attended the Periodontics Department during the study period, which extended from November 2024 to March 2025.

Study population and design

The study design was a randomized clinical trial designed to evaluate the clinical effectiveness and patient comfort of gingival depigmentation using three techniques: surgical scraping with a diamond bur, the diode laser technique in continuous contact mode, and a combination of diamond bur followed by a diode laser in continuous non-contact mode. 60 patients between the ages of 18 and 45 participated in the current study who met the following Inclusion criteria: healthy patients with the chief complaint of hyperpigmented gingiva on the facial aspect and a desire for aesthetic improvement with pathological hyperpigmentation due to smoking. On the other hand, the Exclusion criteria included patients with a history of drug-related hyperpigmentation, patients with diseases compromising healing (uncontrolled diabetes, autoimmune diseases), patients with acute gingival/periodontal diseases, and Pregnant or lactating women.

Patients were classified randomly into the following three groups: Group A, gingival depigmentation by diode laser (810 nm) alone in continuous contact mode. Group B, gingival abrasion by diamond Bur alone. Group C, a combination of diamond bur followed by a diode laser (635 nm) in continuous non-contact mode.

Ethical Approval

The current study was approved by the research team ethics committee of Duhok Directorate of Health and the College of Dentistry, University of Duhok (Reference number: 30102024-9-3). All participants received detailed information about the nature of the study, study purposes, possible side effects, and required follow-up appointments. Then, each participant in the study signed an informed written consent form. The participants could leave the study at any time.

Clinical Assessment

The following parameters were evaluated at baseline: Gingival Pigmentation Index

(GPI)[10], Bleeding index[3], and Duration of the Operation.

The following parameters were evaluated at the follow-up evaluation: Healing index of Landry, Turnbull, and Howley[11], and the verbal rating scale was used to record pain (VRS)[12].

Surgical procedures

All procedures were initiated under local anesthesia using 2% lidocaine hydrochloride with 1:80,000 epinephrine administered at the surgical site. A cheek retractor was employed to optimize access and visibility of the surgical field. Protective eyewear was provided to the patient, operator, and assistant in procedures involving laser application to ensure ocular safety throughout the procedure. A saliva ejector was used as needed for the evacuation of water and fluids. After each surgical procedure, the site was left exposed without the application of any periodontal dressing.

Group A: diode laser (wavelength: 810 nm; QuickLase, UK) was employed with a power output of 1 W in continuous wave (CW) mode, delivered through a fiber-optic tip with a diameter of 200–400 µm. The laser tip was placed in direct contact with the gingival surface and was maintained parallel to the root surfaces to minimize collateral thermal damage. Laser ablation was performed using a sweeping or "brushing" motion, starting at the mucogingival junction and progressing coronally toward the free gingival margin. The ablated area was gently cleansed with sterile saline to remove residual tissue debris and ensure a clean surgical field.

Group B: A fissure diamond bur with medium grit (ECO-Germany) was used in a high-speed rotary instrument with water coolant to remove the pigmented gingiva. The bur was moved in a controlled and uniform manner to abrade the entire pigmented epithelial layer while avoiding excessive trauma. Continuous motion was maintained to prevent deep penetration. Saline-soaked gauze with gentle pressure was used to control any minor bleeding.

Group C: This group underwent a combined technique involving mechanical abrasion followed by adjunctive laser irradiation. Initially, pigmented gingival epithelium was removed using a medium-grit fissure diamond bur (ECO-Germany) in a high-speed handpiece with water coolant, following the same protocol as in Group B. After mechanical de-epithelialization, the treated surface was irradiated with a diode laser (wavelength: 635 nm; WISER 3) in continuous non-contact mode, positioned 1–2 mm from the surface for 4 seconds per area. The laser tip was held perpendicular to the gingival surface at a safe distance to avoid contact with blood or fluids.

Post-Surgical Care

All patients were instructed to resume their routine daily activities following the surgical procedure. They were advised to avoid spicy and acidic foods for the first three days to support optimal healing. Gentle tooth brushing was recommended to maintain oral hygiene while minimizing trauma to the surgical site. A 0.12% chlorhexidine mouthwash was prescribed for use twice daily for one week. Paracetamol 500 mg was recommended as needed for pain management. Follow-up visits were scheduled for one week and three months postoperatively to assess healing and monitor the overall recovery process.

Statistical analysis

The homogeneity of the diode laser, bur abrasion, and bur abrasion followed by laser groups was examined in ANOVA one-way and Chi-squared test, respectively. The comparisons of Gingival Pigmentation Index, Bleeding Index, Healing index, and pain among study groups at baseline, and other follow-up times were examined in a Chi-squared test or ANOVA one-way as appropriate. The pair-wise comparisons were examined in a Tukey test. The comparisons of the outcomes between different times were examined in a

Bonferroni correction test. The significant level of difference was identified as $p<0.05$. The statistical calculations were performed using JMP®, Version 18.0. SAS Institute Inc., Cary, NC, 1989–2023.

RESULTS

Comparisons of Gingival Pigmentation Index (GPI) among the study groups at baseline and follow-up times

At baseline, all three groups exhibited a similar distribution of pigmentation grades (Table 1). One week after treatment, there was a substantial reduction in pigmentation across all groups. However, the differences among the groups were not statistically significant ($p = 0.3547$). At the three-month follow-up, mild re-pigmentation was observed in all groups, while no statistically significant differences were detected ($p = 0.7603$), indicating comparable clinical outcomes across the three treatment modalities.

Table 1: Comparisons of Gingival Pigmentation Index (GPI) among study groups at baseline and follow-up times

	Study groups no (%)			
GPI grades	**diode laser**	**bur abrasion**	**bur abrasion & laser**	**P (pair-wise comparisons)**
Baseline				
1	2 (10.0)	2 (10.0)	3 (15.0)	0.9790
2	11 (55.0)	10 (50.0)	10 (50.0)	
3	7 (35.0)	8 (40.0)	7 (35.0)	
Score mean (SD)	2.25 (0.64)	2.30 (0.66)	2.20 (0.70)	0.8931
One week				
0	18 (90.0)	18 (90.0)	20 (100)	0.3425
1	2 (10.0)	2 (10.0)	0 (0.0)	
Score mean (SD)	0.10 (0.31)	0.10 (0.31)	0.00 (0.00)	0.3547
Three months				
0	14 (70.0)	12 (60.0)	12 (60.0)	0.7505
1	6 (30.0)	8 (40.0)	8 (40.0)	
Score mean (SD)	0.30 (0.47)	0.40 (0.50)	0.40 (0.50)	0.7603

ANOVA one-way and Pearson Chi-squared test were performed for statistical analyses. GPI: gingival pigmentation index. No: number of participants.

Comparisons of Bleeding Index among study groups intra-operatively

The intraoperative bleeding index showed significant differences among the three study groups ($P <0.0001$). Pair-wise comparisons revealed that the bur abrasion group had significantly higher bleeding than the diode laser group ($P < 0.0001$), and the combination technique also resulted in significantly more bleeding than the diode laser group ($P < 0.0001$), as shown in Table 2.

Table 2: Comparisons of Bleeding Index among study groups intra-operatively

	Study groups no (%)			
bleeding index	**Diode laser**	**Bur abrasion**	**Bur abrasion & laser**	**P (pair-wise comparisons)**
Intraoperatively bleeding				
1	18 (90.0)	0 (0.0)	0 (0.0)	<0.0001 Bur abrasion >diode laser(P<0.0001) Bur abrasion &laser>diode laser(P<0.0001)
2	2 (10.0)	0 (0.0)	1 (5.0)	
3	0 (0.0)	10 (50.0)	13 (65.0)	
4	0 (0.0)	10 (50.0)	6 (30.0)	
Score mean (SD)	1.10 (0.31)	3.50 (0.51)	3.25 (0.55)	

ANOVA one-way and Pearson Chi-squared test were performed for statistical analyses. The pairwise comparisons were performed using the Tukey test.

Comparisons of Healing Index (HI) among study groups at baseline and follow-up times

The healing response after one week was comparable among the study groups, and the differences were not statistically significant (P = 0.8844). in pair-wise comparisons, indicating that all three modalities resulted in similar short-term healing effectiveness, as shown in Table 3.

Table 3: Comparisons of Healing Index (HI) among study groups at baseline and follow-up times

	Study groups no (%)			
Healing index	**diode laser**	**bur abrasion**	**bur abrasion & laser**	**P (pair-wise comparisons)**
One-week				0.6138
2	1 (5.0)	0 (0.0)	0 (0.0)	
3	1 (5.0)	1 (5.0)	1 (5.0)	
4	9 (45.0)	14 (70.0)	13 (65.0)	
5	9 (45.0)	5 (25.0)	6 (30.0)	
Score mean (SD)	4.30 (0.80)	4.20 (0.52)	4.25 (0.55)	0.8844
Three months 5 excellent Score mean (SD)	20 (100) 5.00 (0.0)	20 (100) 5.00 (0.0	20 (100) 5.00 (0.0)	Not applicable

ANOVA one-way and Pearson Chi-squared test were performed for statistical analyses. The pairwise comparisons were performed using the Tukey test.

Comparisons of pain among study groups at baseline and follow-up times, and duration of procedure among study groups

Pain was assessed postoperatively using a verbal rating scale on the first and third days following surgery. No pain was reported intraoperatively in any group due to the administration of local anesthesia. On the first postoperative day, statistically significant differences in pain levels were observed among the groups (P = 0.0007). Pairwise comparisons indicated that the bur abrasion group experienced significantly higher pain levels compared to the diode laser group (P = 0.0004). By the third day, pain had markedly decreased in all groups, and no statistically significant differences were found (P = 0.1510) as illustrated in Table 4.

In addition to higher pain scores, Table 4 shows that the bur abrasion group and the combination group also demonstrated significantly longer procedure durations compared to the diode laser group. These differences in operative time further highlight the clinical advantages of the diode laser in terms of patient comfort and procedural efficiency

Table 4: Comparisons of pain among study groups at baseline and follow-up times, and duration of procedure among study groups

	Study groups no (%)			
pain grade	**diode laser**	**bur abrasion**	**abrasion & laser**	**P (pair-wise comparisons)**
1st day				0.0003
0	9 (45.0)	2 (10.0)	2 (10.0)	
1	8 (40.0)	1 (5.0)	9 (45.0)	
2	1 (5.0)	14 (70.0)	7 (35.0)	0.0007
3	2 (10.0)	3 (15.0)	2 (10.0)	Bur abrasion > diode laser (p=0.0004)
Score mean (SD)	0.80 (0.95)	1.90 (0.79)	1.45 (0.83)	
3rd day				0.3264
0	18 (90.0)	15 (75.0)	18 (90.0)	
1	2 (10.0)	3 (15.0)	2 (10.0)	
2	0 (0.0)	2 (10.0)	0 (0.0)	
Score mean (SD)	0.10 (0.31)	0.35 (0.67)	0.10 (0.31)	0.1510
Procedure duration mean (SD)	16.1 (4.04)	23.1 (6.15)	22.7 (4.09)	<0.0001 bur abrasion >diode laser bur abrasion & laser>diode

ANOVA one-way and Pearson Chi-squared test were performed for statistical analyses. The pairwise comparisons were performed using the Tukey test.

Comparisons of the gingival pigmentation index in bur abrasion, diode laser, and bur abrasion & laser study groups over time

All groups showed a significant reduction in the gingival pigmentation index (GPI) after one week and maintained improvement at three months compared to baseline ($P < 0.0001$), indicating effective treatment. However, from one week to three months, there was some gingival re-pigmentation over time (lowest in the diode laser). The mean scores for the three study groups are shown in Table 5.

Table 5: Comparisons of the Gingival pigmentation index in bur abrasion, diode laser, and bur abrasion & laser study groups over time

Outcomes	Time periods (mean)					
GPI	One-week vs. baseline	p	three-month vs. baseline	p	Three months vs. one week	p
diode laser	0.1 vs. 2.25	<0.0001	0.3 vs. 2.25	<0.0001	0.3 vs. 0.1	0.0421
bur abrasion	0.1 Vs. 2.30	<0.0001	0.4 vs. 2.30	<0.0001	0. 4 vs. 0.1	0.0102
bur abrasion & laser	0.0 vs. 2.20	<0.0001	0.4 vs. 2.20	<0.0001	0.4 vs. 0.0	0.0021

Bonferroni correction test and paired-t-test were performed for statistical analyses.

DISCUSSION

The current study aimed to assess the effectiveness of three gingival depigmentation techniques: diamond bur abrasion, diode laser (810 nm), and a combination of bur abrasion with low-level laser therapy (LLLT) using a 635 nm diode laser. The evaluation was based on multiple clinical parameters, including the gingival pigmentation index, intraoperative bleeding index, healing index, postoperative pain levels, and total procedure duration.

According to the GPI, which measures the gingival pigmentation, all the study groups were successful in removing the pigmentation. These results are consistent with those of Negati et al. (2019), who reported similar results using laser and soft tissue trimmer methods[13]. The cosmetic result of Bur abrasion is the same as that of laser therapy since it mechanically removes the pigmentation.

The current study shows that the diode laser had the best hemostatic effect during the surgery. which is in line with a study conducted by Desale et al. (2023), who found that the diode laser considerably reduced intraoperative bleeding in comparison to traditional techniques[14]. This is mainly because the diode laser offers precise cutting with simultaneous coagulation, which successfully seals blood vessels during surgery[15]. Compared to conventional surgical techniques, this hemostatic effect highlights the clinical significance of the diode laser.

The present study assessed healing outcomes among the treatment groups and found no statistically significant differences ($P = 0.8844$). These findings are consistent with those reported by Fouda et al. (2024), who found similar healing in areas treated with bur and laser techniques[16]. Similarly, Mikhail et al. (2023) reported no significant differences in healing among groups treated with scalpel, bur, and laser techniques[17]. In contrast, Koca-Unsal et al. (2021) noted that while the diode laser and scalpel methods achieved satisfactory clinical results, the scalpel group exhibited complete epithelialization by the seventh day postoperatively. In comparison, laser-treated sites demonstrated delayed epithelialization, due to thermal effects associated with diode laser use[18]. In addition, laser parameters also have an effect on the clinical outcomes.

In the present study, postoperative pain levels varied across the study groups, with the diode laser group reporting the least discomfort. These findings align with those of Chandna and Kedige (2015), who reported reduced discomfort in patients

treated with laser compared to electrosurgical methods following gingival depigmentation[19]. Similarly, Mahayni et al. (2023) observed greater postoperative discomfort in sites treated with a ceramic bur compared to those treated with laser[6]. The reduced pain associated with diode laser application can be attributed to its inherent analgesic effects. These effects are believed to result from the disruption of the sodium-potassium pump in neuronal cell membranes, leading to a temporary loss of nerve impulse conduction. Additionally, the formation of a protein coagulum during laser ablation may contribute to the sealing of nerve endings, further minimizing nociceptive signaling. Collectively, these mechanisms support the use of diode lasers not only for effective depigmentation but also for enhancing patient comfort during the postoperative period

The shorter procedure time observed in the diode laser group is consistent with previous research. Jagannathan et al. (2020) demonstrated that diode lasers significantly reduced operative time compared to the traditional technique[20]. Similarly, Moeintaghavi et al. (2022) reported that diode lasers required less operative time than CO_2 lasers in comparable soft tissue procedures[21] Together, these studies support the present findings and reinforce the efficiency of diode lasers across different clinical contexts. The consistent reduction in operative time may be attributed to the diode laser's precision, effective coagulation, and short chairside procedure, making it a time-efficient modality for soft tissue management.

Limitations of the study

One limitation of this study was the small sample size, which may affect the generalizability of the findings. In addition, the three-month follow-up period might not have been enough to assess the results of long-term re-pigmentation. Furthermore, subjective patient reporting was used to determine clinical outcomes like pain, which could induce response bias.

Conclusion

This clinical study found that all three techniques were effective for gingival depigmentation. However, the diode laser showed favorable outcomes in terms of reduced pain, patient comfort, and shorter treatment time.

Recommendations

Larger sample sizes and longer follow-up times are recommended for future research to better understand the long-term outcomes, potential for gingival re-pigmentation. It is also recommended that objective clinical indices be used to standardize pain. Further studies comparing different laser wavelengths and power settings could also help in improving treatment protocols for gingival depigmentation.

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پوختە

رۆلێ لیزەری د چارەسەرکرنا رەنگبوونا پدیێ لنك نەخۆشێن جگارەکێش

پێشەکی و ئارمانج: زێدەهی د رەنگبوونا پدیێ ژ ئەگەرێ گیرهەگرتنەکا زێدەیە یا میلانینی ل سەر چینا تفتی ژ رویکرنێ، و ئێکە ژ مەزنترین ئاریشێن جوانیێ کو چێدبیت کارتێکرنێ لسەر باوەری ب خوبوونا نەخۆشی بکەت، ب تایبەت دگەل گرنژینا ب پدیێ. گەلەك رێکێن راکرنا رەنگبوونا هاتنە پێشنیارکرن دگەلدا نشتەر و نشتەرگەریا کارەبێ، و لیزەر، و رەنینا پدیێ. ئارمانجا ڤەکولینێ ئەوە کو کاریگەریا تەختەبەندی و خۆشیا نەخۆشی بو سێ تەکنیکاران بهەلسەنگینیت، ئەوژی ئەڤانە: رێکارێن نشتەرگەریێ بکارئینانا کونکەرێ ماس و لیزەرێ دەڤۆکێ دووانی، و تێکەلێ رەنینا پدیێ، لدویفدا چارەسەرکرن ب لیزەرێ کێم ئاست ئەوێ دهێتە بکارئینان بو راکرنا رەنگبوونا پدیێ.

رێکێن ڤەکولینێ: نێزیکی (60) نەخۆش هاتنە هەلبژارتن کو تەمەنێ وان دناڤبەرا (18 و 45) سالاندایە، ژ ئەوێن تووشی رەنگبوونا پدیێ بووین یان رەنگێ وێ بێ تاری، و ب شێوەکێ بەرەڵا بو سێ کۆمەلان هاتنە دابەشکرن: کۆمەڵا أ (ژمارە = 20) ب لێزەرێ دەڤۆکیێ دووانی هاتنە چارەسەرکرن ب درێژیا پێلا (810 نانومەتر) د رەوشەکا ڤێکەفتنەکا بەردەوام، و کۆمەڵا ب (ژمارە = 20) ب رەنینا پدیێ هاتنە چارەسەرکرن، و کۆمەڵا ج (ژمارە = 20) ب تێکەلێ رەنینا پدیێ هاتنە چارەسەرکرن، لدویفدا لێزەرێ دەڤۆکێ دووانی ب درێژیا پێلا (625 نانومەتر) د رەوشا ڤێکنەکەفتنا بەردەوام.

ئەنجام: جیاوازیەکا هێما ئاماری د خوینبەربوون و ئێشانێ و ماوێ نشتەرگەریێ هاتە دیتن. لێ چ جیاوازێن هێما ئاماری د نیشاندەرێ رەنگبوونا پدیێ و ساخبوونێ و ڤەگەراندنا رەنگبوونێ دناڤبەرا کۆمەڵاندا نەهاتە دیتن.

دەرئەنجام: لێزەرێ دەڤۆکێ دووانی بو ئەگەرێ کێمبوونا دەمێ رێکارێ، و راگرتنا خوینبەربوونا باشتر و خوشیەکا باشتر بو نەخۆشی ب بەراوردکرن ب تەکنیکارێن دی.

الخلاصة

دور الليزر في علاج تصبغ اللثة لدى المرضى المدخنين

الخلفية والأهداف: ينتج فرط تصبغ اللثة عن ترسب مفرط للميلانين في الطبقة القاعدية من الظهارة، ويعتبر من أكثر المشاكل الجمالية التي قد تؤثر على ثقة المريض بنفسه، خاصة مع الابتسامة اللثوية. وقد طورت العديد من طرق إزالة التصبغ، بما في ذلك المشرط، والجراحة الكهربائية، والليزر، وكشط اللثة. هدفت الدراسة الى تقييم الفعالية السريرية وراحة المريض لثلاث تقنيات، وهي: الكشط الجراحي باستخدام مثقب الماس، وليزر الصمام الثنائي، ومزيج من كشط اللثة، يليه العلاج بالليزر منخفض المستوى المستخدم لإزالة تصبغ اللثة.

المواد والطرق: تم اختيار (60) مريضا تتراوح أعمارهم بين (18 و45) عاما، ممن يعانون من تصبغ اللثة أو لونها الداكن، وقسموا عشوائيا الى ثلاث مجموعات: المجموعة أ (العدد = 20) عولجت بليزر الصمام الثنائي بطول موجة (810 نانومتر) في وضع التلامس المستمر، والمجموعة ب (العدد = 20) عولجت بمبرد السن، والمجموعة ج (العدد =20) عولجت بمزيج من بمبرد السن، يليه ليزر الصمام الثنائي بطول موجة (635 نانومتر) في وضع عدم التلامس المستمر.

النتائج: لوحظت فروق ذات دلالة إحصائية في النزيف والألم ومدة العملية، بينما لم تلاحظ أي فروق ذات دلالة إحصائية في مؤشر تصبغ اللثة والشفاء وإعادة التصبغ بين المجموعات.

الاستنتاجات: أدى ليزر الصمام الثنائي الى أقصر وقت للإجراء، ووقف نزيف أفضل، وراحة أفضل للمريض مقارنة بالتقنيات الأخرى.