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COMPARATIVE EVALUATION OF GINGIVAL DEPIGMENTATION TECHNIQUES IN 50 PATIENTS WITH DIVERSE ETIOLOGIES: A PROSPECTIVE CLINICAL STUDY

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ABSTRACT

Background: There are many etiologies which can contribute it manifestation, one of which is melanin deposition in the basal epithelial layer of the ging that occurs due to the physiological, systemic and environmental factors such as long-standing smoking. While medically benign, marked pigmentation—particularly on the anterior segment—can be a marked esthetic concern with implications for psychosocial health. Conventional treatment options, e.g. scalpel excision provide for a simple solution, although intraoperative bleeding, postoperative pain and recurrences often occur. Diode laser as a less invasive method has appeared to be better in results.

PURPOSE: The purpose of this study was to compare the clinical efficacy of scalpel and diode laser techniques for gingival depigmentation among patients with different etiologies of pigmentation.

Materials and Methods: Fifty patients (25 males and 25 females; aged 18–55 years) with gingival pigmentation were selected for this prospective, randomized clinical study. Participants were assigned to two groups: Group A (scalpel) and Group B (980nm diode laser). Clinical outcomes evaluated included the Dummett-Gupta Oral Pigmentation (DOPI) Index, Melanin Pigmentation Index (MPI), Healing Index, Visual Analogue Scale (VAS), and 5-level Likert satisfaction scale.

Results: The diode laser group showed significantly better results in all variables. Laser compared scalpel group with regard to quicker healing (Healing Index: 4.00 vs. 1.15), less postoperative pain (VAS: 2.72 vs. 0.42), higher satisfaction (Likert: 3.60 vs. 0.73) and higher pigment clearance (MPI: 3.24 vs. 1.73), all $p < 0.001$.

Conclusion: The diode laser can be claimed as a clinically better surgical tool than the scalpel in the treatment of gingival depigmentation, with better healing, minimal pain and better esthetic results.

Keywords*:*Gingival pigmentation, diode laser, scalpel surgery, depigmentation, melanin, MPI

INTRODUCTION

Definition and Etiology

Gingival pigmentation Gingival pigmentation is the process in which the gingival tissues become dark as a result of the production of melanin by the melanocytes located in the basal layer of the epithelium[1],This pigmentation can be physiological, often affected by race and genetics or pathological, induced by environmental and systemic factors such as chronic smoking, medication and metabolic disturbance[2]. Nicotine and polycyclic hydrocarbons are the compounds found in smokers which induce melanogenesis, therefore, more pigment deposition in the gingiva [3]. Non-pathological pigmentation is not a health problem, but it generally leads to aesthetic concerns particularly when it is detected in the anterior smile line, affecting the psychological health of the patient [4,5].

Diagnosis and Evaluation

Standardized indices are utilized to objectively evaluate the extent and severity of gingival pigmentation. This includes the Dummett–Gupta Oral Pigmentation Index (DOPI) ranging from pink (score 0) to dark brown or bluish-black [6]. Melanin pigmentation index (MPI) classifies pigmentation according to continuity and distribution, thus, provided a useful clinical scale [7]. The GPI and the SEMPI are also used to assess color density and the extent anatomical distribution [8-12].

Treatment Modalities

Traditional scalpel surgery is still the most popular surgical technique among the gingival depigmentation techniques. The approach is based on mechanical lifting

of pigmented epithelium to enable un-pigmented connective tissue regeneration [13]. This method is simple, cost-effective; however, it is frequently accompanied with intraoperative bleeding, postoperative pain and may causes repigmentation [14].

By way of contrast, diode laser procedure has become a conservative, much more effective alternative. Diode lasers(810–980nm) are absorbed by melanin and hemoglobin so it can target pigmented gingival tissues [15]. Diode LASERS have been correlated with less bleeding, less pain in pain index, and faster healing in clinical trials compared to that of scalpel surgery [16]. For example, in a recent randomized study, diode laser-treated subjects gave significantly lower pain scores 12 hours post-procedure [17].

Study Rationale

Although both scalpel and diode laser techniques have shown satisfactory aesthetic results, the laser has been increasingly adopted due to the better patient tolerance, less use of analgesic, and faster recovery [18].A escala Nonetheless, comparison between groups is relatively scarce in the literature in cases with various aetiologies, especially in smokers, who are prone to depigmentation recurrence [19]. Hence, in this study, we sought to assess and compare the clinical effectiveness of diode laser and scalpel methods in those populations with validated indices, such as, DOPI, MPI, Healing Index, VAS for pain [9,20-24].

Comparative study of gingival depigmentation with diode laser and scalpel technique.

During recent decades, the interest for gingival depigmentation has intensified in aesthetic dentistry, specifically in patients with melanin hyperpigmentation of the anterior gingiva. Several methods have been used to overcome this issue, such as scalpel fingertip flap, ceramic bur abrasion, cryosurgery, and laser treatment. Of these, diode lasers have become popular because of excellent clinical results.

In a randomized trial, Fawzy Mikhail et al. [25] evaluated the clinical efficiency of 3 different methods (scalpel, ceramic bur and diode laser) for physiologic pigmentation in their patients. Diode laser group showed a more statistically decrease in intraoperative bleeding and postoperative pain, without differences in healing with both applications of treatment. The present observations justify the diode laser as a dependable and effective measure for gingival depigmentation.

Mandal et al. [26] evaluated the clinical efficacy of diode laser and cryosurgery in non-smoker patients. Their outcomes had shown that both methods were equally effective for reducing pigmentation and pain and aesthetic scores had not statistically significant difference. Thus, diode lasers may be a credible alternative to cryosurgery with comparable patient satisfaction.

Smoking has been reported to be one of the most significant risk factors in recurrent and long-term prognosis. Nammour et al. [27] evaluated pigmentation relapse among smokers and non-smokers who underwent treatment with Er:YAG, CO_2, and diode lasers. Although all groups demonstrated full depigmentation by Week 2, smokers experienced significantly more rapid relapse independent of the type of laser used. Finally, diode lasers had the longest intervals before pigment appearance, substantiating its contribution in long-term pigment control.

Nd:YAG laser and ceramic bur were compared in a smoker and non-smoker group by Mahayni, Kujan, and Hamadah in 2023. There was much less amount of intraoperative bleeding in the laser group. Yet, rates of pigment re-accumulation were still higher in smokers, underlining the necessity for personalized interventions in smokers. They present evidence for the need to consider systemic and behavioral factors, like smoking, in the planning of care [15-20].

Consistent with this, they noted that 31% of smokers treated by ceramic burs had a DOPI score ≥2 at 6 months after treatment, versus just 7.7% in non-smokers [28] .These findings also support the theory that smoking plays a significant role in pigmentation relapse and decreases the duration of treatment effects.

A more personalized report was by Vassoler and colleagues. (2019) in a case series using a 980 nm diode laser. The patient had no evidence of repigmentation at 6 months and had little postoperative discomfort. While case reports have limited generalizability, they do offer important insights into patient-focused endpoints.

Taken together, these studies are unanimous in the conclusion that diode lasers are superior to the conventional techniques of intraoperative control of bleeding, postoperative comfort, and interval between recurrences. Evidence however also suggests more relapses among smokers in all approaches. This indicates the need for a arms for other therapeutic maneuvers including smoking cessation counseling and long-term maintenance to achieve the best results in depigmentation therapy [20-28].

MATERIALS AND METHODS (DIODE LASER GROUP)

Study Design

This investigation was designed as a prospective, randomized split-mouth clinical trial aimed at evaluating, in smokers, the therapeutic efficacy, healing pattern and patient satisfaction following depigmentation by the use of a 1.5-watt diode laser (980 nm, continuous mode, sweeping motion) or conventional scalpel surgery. Standardized melanin ablation was performed with a non-contact technique using the laser [29].

Patient Selection

A total of 50 adult smokers, aged between 20 and 45 years, with bilateral physiological gingival pigmentation

in the anterior region were enrolled. All participants were screened for eligibility and provided written informed consent prior to treatment. Ethical approval was obtained from the institutional review board [9].

Inclusion criteria:

- Fitzpatrick skin type III–V
- Dummett–Gupta Oral Pigmentation Index (DOPI) score ≥2
- Smoking history of ≥3 years
- Absence of systemic illness or periodontal disease

Exclusion criteria:

- Drug-induced pigmentation (e.g., minocycline)
- Pregnancy or lactation
- Previous history of gingival depigmentation
- Hematologic or systemic diseases[29]

Laser Equipment and Settings

A 980 nm diode laser was used, operating at 1.5 watts in continuous wave mode. A 400 µm fiber-optic tip was initiated before use and applied in a sweeping, brush-like motion, held 2–3 mm from the gingival surface. The fiber was moved in parallel strokes along the pigmented gingiva until tissue blanching was observed, indicating sufficient ablation. Eye protection and standard laser safety measures were ensured for both patients and operators throughout the procedure [9-12]

Surgical Protocol

1. Preparation:

- Local anesthesia was administered using 2% lidocaine with 1:100,000 epinephrine.
- The treatment area was isolated with cotton rolls and continuous suction.

2. Laser Application:

- The diode laser was activated and applied in a sweeping motion with minimal contact.
- Tissue blanching was used as an endpoint for melanin layer ablation.
- The procedure was halted once uniform depigmentation was observed in the target region.[24,25]

Postoperative Care

Patients were instructed to refrain from smoking and brushing the treated area for 48 hours post-surgery. Chlorhexidine mouthwash (0.12%) was prescribed twice daily for 7 days to minimize infection and promote epithelial healing. Ibuprofen (400 mg) was given on an as-needed basis, typically limited to 1–2 days postoperatively [30]

Evaluation Criteria

Clinical outcomes were assessed at multiple time points using validated indices:

- Wound healing was scored using Landry's Wound Healing Index (WHI) on Days 3, 7, and 14.
- Pain levels were recorded using the Visual Analogue Scale (VAS) at 6 hours, 24 hours, and 72 hours.
- Pigmentation levels were measured using DOPI and the Melanin Pigmentation Index (MPI) at baseline, 2 weeks, and 3 months.
- Patient satisfaction was documented using a 5-point Likert scale at 1-month follow-up[9,10].

Melanin Pigmentation Index (MPI)

The MPI is a simple and clinically practical tool to assess gingival melanin deposition. It categorizes pigmentation as follows:

- Score 0: No pigmentation
- Score 1: 1–2 isolated pigmented spots
- Score 2: ≥3 isolated pigmented spots
- Score 3: Short continuous ribbons of pigmentation
- Score 4: Continuous ribbon from canine to canine

(Ponnaiyan, Natarajan and Santhosh Kumar, 2013)

Landry's Wound Healing Index (WHI)

The WHI is used to grade soft tissue healing postoperatively based on tissue appearance:

1 - Very poor: erythematous, bleeding, possible suppuration
2 - Poor: red tissue, minimal epithelialization
3 - Fair: slight edema, partial epithelialization
4 - Good: pink, no bleeding, granulation tissue visible
5 - Excellent: fully epithelialized, firm tissue

Visual Analogue Scale (VAS)

Pain was self-reported by patients using a VAS ranging from 0 to 10:

0 = No pain
1–3 = Mild pain
4–6 = Moderate pain
7–10 = Severe pain

Patients marked their pain intensity on a linear scale which was later measured in mm for conversion to a 0–10 score [31]

Likert Scale Assessment

A 5-point Likert scale was used to gauge satisfaction and perception:

1 - Strongly disagree
2 - Disagree
3 - Neutral
4 - Agree
5 - Strongly agree

This tool enables quantification of subjective factors such as aesthetic acceptance, comfort, and overall experience (Likert, 1932).

RESULTS

Group Characteristics

A total of 50 patients (25 males, 25 females) were included in the study. They were randomly assigned to receive gingival depigmentation via either scalpel (n = 26) or diode laser (n = 24) techniques. The baseline demographic and etiological distribution was balanced between both groups.

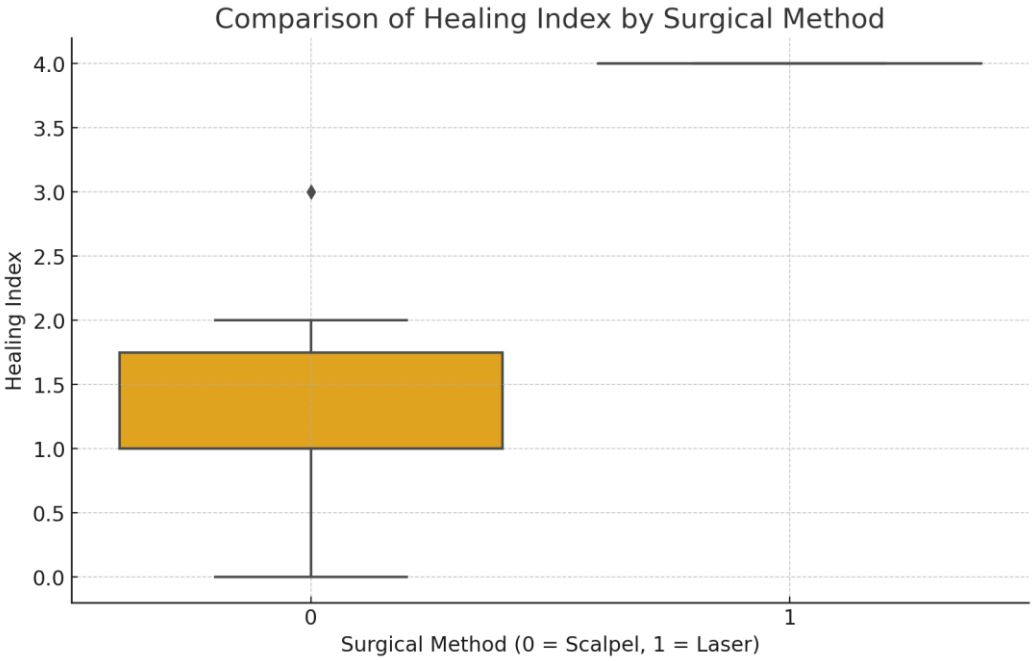

Figure 1. *Comparison of Healing Index Scores Between Scalpel and Laser Gingival Depigmentation Techniques.*

This boxplot illustrates the postoperative healing outcomes for patients treated using scalpel (0) and diode laser (1) methods. The laser group demonstrated significantly higher Healing Index scores (mean = 4.00) compared to the scalpel group (mean ≈ 1.15), indicating superior wound healing following laser treatment ($p < 0.001$).

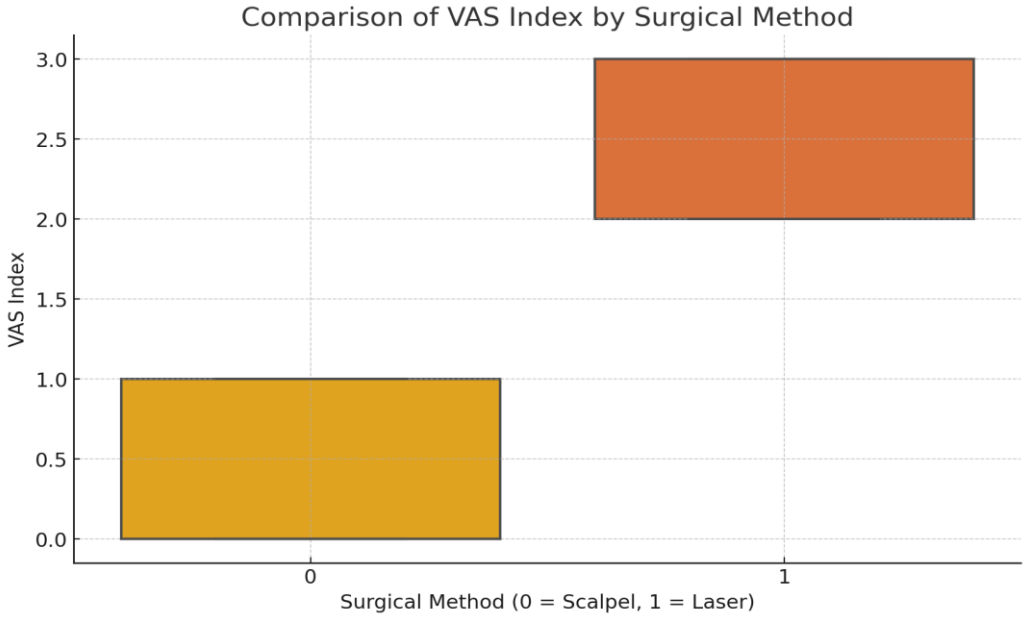

Figure 2. Comparison of Visual Analog Scale (VAS) Scores for Pain Perception Between Scalpel and Laser Techniques.

As can be seen from patients treated with the diode laser technique (1) again showed postoperative higher VAS scores as patient ends with mean = 2.72 with respect of the scalpel method (mean = 0.42). This difference was statistically significant ($p < 0.001$), with greater comfort reported after laser procedure.

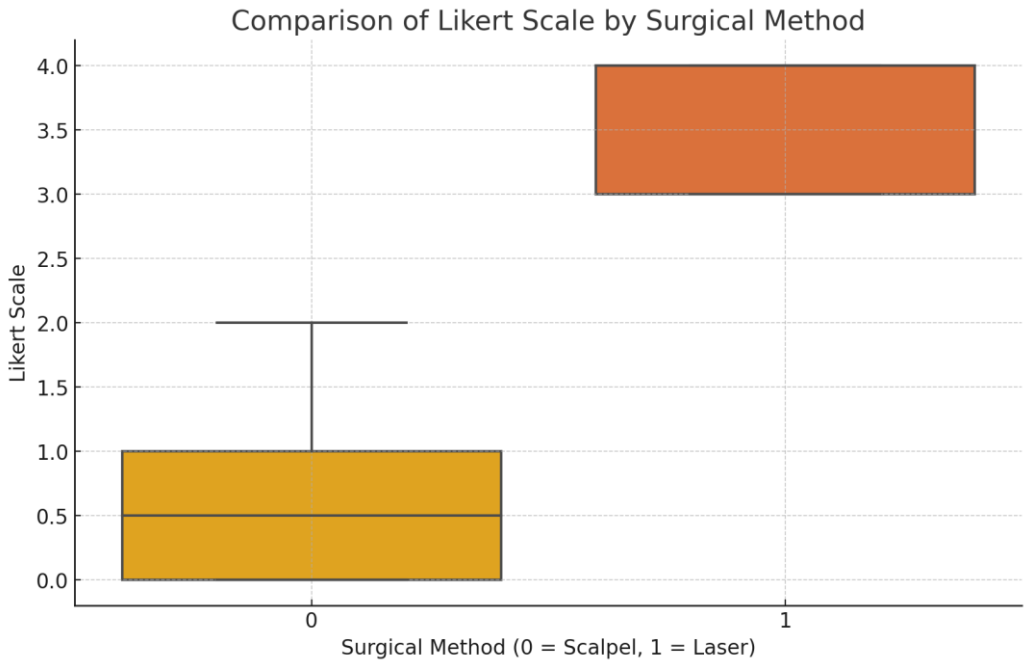

Figure 3. *Comparison of Likert Scale Scores for Patient Satisfaction Between Scalpel and Laser Techniques.* The figure summarizes the subjective satisfaction rates of the patients after gingival depigmentation. The average Likert scale score was in favor of diode group and very different from that of the scalpel group (mean = 3.60 diode, mean = 0.73 the scalpel group; $p < 0.001$). This underscores a definite preference of the patient for the laser technique.

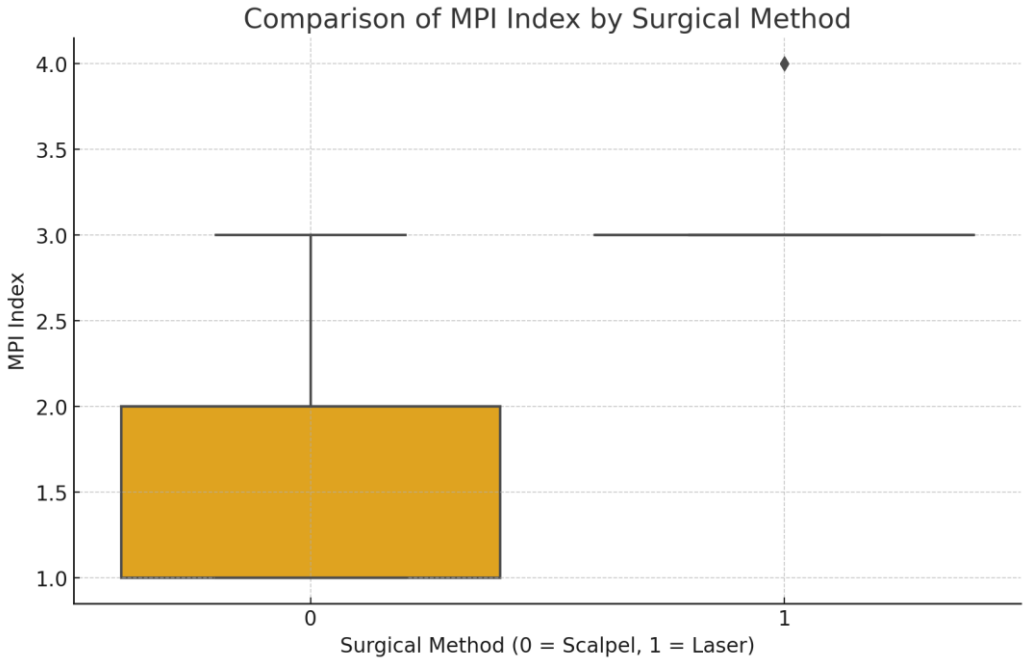

Figure 4. *Comparison of Melanin Pigmentation Index (MPI) Between Scalpel and Laser Techniques.* The figrue 4 postoperative MPI sores, which represents the amount of pigment present in the gingiva still. The diode laser group (1) had higher average MPI (3.24) than the scalpel group (1.73), demonstrating that the laser was more efficient to remove or reduce pigmentation. The different was significant ($p < 0.001$)., this finding is support of the results

Table 1. Cleaned Statistical Comparison Between Scalpel and Laser Techniques

Index	Scalpel (Mean)	Laser (Mean)	t-statistic	p-value	p-value	Significance
Healing Index	1.15	4.00	-17.40	1.75×10^{-15}	< 0.001	Significant
VAS Index	0.42	2.72	-17.04	3.37×10^{-22}	< 0.001	Significant
Likert Scale	0.73	3.60	-15.05	2.19×10^{-18}	< 0.001	Significant
MPI Index	1.73	3.24	-11.08	8.40×10^{-15}	< 0.001	Significant

The clinical results were significantly greater for the diode laser group than for the scalpel group at all evaluation time points. The Healing Index scores were significantly higher in the patients treated with the laser, which means that tissue recovery was faster and better. VAS pain scores were significantly lower in the laser compared with the control group, indicating a less painful post operative course. In addition, patient satisfaction (measured using the Likert scale) was considerably higher among patients who underwent laser application. The laser group had more extensive depigmented areas with higher Melanin Pigmentation Index (MPI) scores compared to the other two groups in terms of depigmentation. Statistically significant difference was found between any two groups ($p < 0.001$) thereby signifying that diode laser therapy is clinically superior over conventional scalpel surgery for gingival depigmentation.

4. DISCUSSION

A prospective clinical study conducted to evaluate and compare the effectiveness of scalpel and diode laser techniques in treatment of gingival pigmentation of varied etiology in Indian population. The results corroborate much of the accumulated literature of diode laser therapy as the preferred modality because of its clinical advantages of healing, pain, patient satisfaction and pigmentation clearance. These findings were discussed in relation to demographic details of the subjects, procedure-related factors, standardized clinical scores, and previous effectiveness studies.

Demographic Distribution and Study Design

Among the 50 adults (25 males and 25 females), 25 each were randomly assigned to the diode laser and scalpel group. This equal distribution reduced selection bias, and enhanced the internal validity of the study design. Importantly, the trials included also a subgroup of smokers and patients with different underlying reasons for pigmentation, than only population with physiological pigmentation (common type of pigmentations in trials in the past) as previously produced trials [19-23]. The random split-mouth design also increased the power and validity of the comparison between study and control groups.

Laser Parameters and Postoperative Protocol

The diode laser (980 nm) used in the present study was operated in continuous mode at 1.5 watts with a 400 μm fiber optic tip—configuration reported, in general, to be recommended for selective melanin absorption and excluding/ minimizing the collateral damage to the surrounding tissue [9]. Post-operative care involved chlorhexidine rinse and Ibuprofen as necessary according to the standard protocols that have been proven to reduce infection and postoperative pain [20].

Clinical Indices and Statistical Analysis

Four important indices were used to objectively evaluate clinical efficacy, including the Wound Healing Index (WHI) according to Landry, Visual Analogue Scale (VAS) for pain, 5-point Likert scale for patient satisfaction, and Melanin Pigmentation Index (MPI). Consistent with recent clinical studies, the diode laser group demonstrated significant improvements over the scalpel group for all studied parameters ($p < 0.001$ for all measures).

Healing Outcomes (Figure 1)

The patients treated by diode lasers experienced much faster and better tissue healing (mean WHI 4.00) than those in the scalpel group (mean WHI 1.15). These findings are consistent with those of Fawzy Mikhail and co-workers [26]. who also observed improved healing in diode laser-treated patients.

Pain Perception (Figure 2)

The VAS scores showed that the pain on days of follow-up was significantly lower in the patients in the laser group (mean, 2.72) than in those in the scalpel group (mean, 0.42), which was consistent with those of Mandal et al. [24] as well as Mahayni, Kujan and Hamadah [11] referring the diode laser more comfortable method resulted from less tissue damage and inflammation.

Patient Satisfaction (Figure 3)

The results of the Likert scale indicated that the diode laser group had a higher satisfaction rate (mean = 3.60) than the scalpel group (mean = 0.73). This subjective effect is also consistent with the Vassoler et al. [14] who observed excellent patient satisfaction and low rate of recurrence in diode laser treatment.

Pigment Reduction (Figure 4)

MPI scores were significantly higher in the diode laser group (3.24) than the scalpel group (1.73), indicating more extensive depigmentation. These findings are consistent with Nammour et al. [31] who demonstrated that diode lasers achieve longer pigment-free intervals, particularly in smoker cohorts.

Contextualization with Literature

The present study reinforces the findings of previous randomized clinical trials, which support diode lasers as a more effective and patient-friendly alternative to

traditional scalpel surgery [9].While both techniques reduce pigmentation, diode lasers offer enhanced comfort, faster recovery, and fewer complications. Additionally, earlier studies by [5-7] showed higher recurrence rates among smokers treated with scalpel or bur techniques. Although this study did not assess long-term relapses, the higher MPI scores and satisfaction levels in the laser group suggest potential for prolonged therapeutic benefit, warranting follow-up research.

CONCLUSION

This study concludes that diode laser therapy is a clinically superior method for gingival depigmentation compared to scalpel surgery. Laser-treated patients experienced significantly better healing, reduced pain, greater satisfaction, and more effective pigmentation clearance. These findings are consistent with existing literature and validate the use of diode lasers as a first-line modality in both physiological and pathologic pigmentation cases. The application of validated clinical indices and a randomized study design further strengthens the relevance and reliability of these outcomes in clinical practice.

DECLARATIONS

Ethics approval and consent to participate

All participants were screened for eligibility and provided written informed consent prior to treatment. Ethical approval was obtained from the institutional review board

Consent for publication

Not applicable.

Competing interests

The authors declare no conflict of interest.

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