



Retrospective Comparison of Clinical Outcomes between Surgical Scalpel and Diode Laser Techniques for Gingival Depigmentation: A Five-Year Study

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ABSTRACT:

Background: Gingival melanin pigmentation, while physiological, often presents as an aesthetic concern for patients with high smile lines. Various depigmentation methods exist, with the surgical scalpel being a conventional approach. Diode lasers, particularly at 940 nm, have emerged as a minimally invasive, efficient, and patient-friendly alternative.

Aim: To compare the clinical outcomes of gingival depigmentation using surgical scalpel versus diode laser (Biolase Epic X – 940 nm) techniques, focusing on healing time, post-operative discomfort, recurrence, and patient satisfaction.

Materials and Methods: This retrospective study included 60 patients, divided equally into scalpel (n=30) and diode laser (n=30) groups. Clinical parameters recorded included the Dummett Oral Pigmentation Index (DOPI), healing time, post-operative pain using the Visual Analog Scale (VAS), bleeding, need for sutures, recurrence of pigmentation, and overall patient satisfaction. The diode laser group was treated using Biolase Epic X at 940 nm, 1.2 W, continuous wave, in contact mode. Statistical analysis was performed using independent t-tests and Chi-square tests ($p < 0.05$).

Results: The diode laser group showed significantly faster healing (6.2 ± 1.4 days vs. 10.3 ± 2.1 days), lower VAS pain scores (2.1 ± 0.9 vs. 5.0 ± 1.1), and minimal bleeding. Recurrence was lower in the laser group (3.3%) compared to the scalpel group (13.3%). Patient satisfaction was also significantly higher in the diode laser group.

Conclusion: Diode laser depigmentation using Biolase Epic X (940 nm) demonstrated superior clinical outcomes over the scalpel technique. It is associated with faster healing, reduced discomfort, lower recurrence, and improved patient satisfaction, making it the preferred method for aesthetic gingival depigmentation.

1. Introduction

The perception of facial aesthetics plays a significant role in social interactions and self-confidence. Within the scope of facial beauty, the smile is a central component, and the appearance of the gingiva contributes significantly to smile harmony. While the color of healthy gingiva is typically coral pink, some individuals present with brown or black pigmentation due to excessive melanin deposition. This condition, though physiological and benign, often raises aesthetic concerns,

especially among patients with a high smile line or a heightened sense of cosmetic self-awareness [1,2].

Gingival pigmentation can result from several causes, including physiological racial pigmentation, systemic conditions (e.g., Addison's disease), medications, smoking, amalgam tattoos, and other exogenous factors [3]. However, in most cases, the pigmentation is melanin-related and confined to the epithelium of the attached and marginal gingiva. The responsible cells, melanocytes, are dendritic cells located in the basal and



suprabasal layers of the epithelium, which synthesize melanin and transfer it to neighboring keratinocytes. While the melanocyte count is relatively consistent across races, the activity level differs, explaining the variation in visible pigmentation [4].

The need for depigmentation procedures arises not from pathology but from the patient's subjective dissatisfaction with gingival aesthetics. As the demand for cosmetic dental procedures grows, especially among younger patients and those in professions with high aesthetic awareness, clinicians are increasingly required to provide options for gingival depigmentation.

1.1. Conventional Techniques for Gingival Depigmentation

Historically, various methods have been used to manage gingival hyperpigmentation. The scalpel technique is one of the oldest and most widely practiced methods. It involves surgically scraping off the pigmented gingival epithelium using a blade, such as a #15 scalpel. This procedure exposes the underlying connective tissue, which eventually heals through secondary intention, allowing the overlying new epithelium to regenerate without pigmentation. While effective in removing surface pigment, this approach is associated with significant drawbacks: intraoperative bleeding, post-operative pain, delayed healing, and patient discomfort [5].

Other methods explored in literature include cryosurgery, electrosurgery, chemical cauterization, and abrasion. Each of these has its limitations. Cryosurgery requires specialized equipment and precision to avoid over-freezing; electrosurgery can cause unwanted thermal damage and patient discomfort; chemical agents (like phenol or alcohol) have a high risk of tissue toxicity; and abrasion is technique-sensitive and inconsistent in results [6].

Given these limitations, the emergence of laser-assisted depigmentation has offered clinicians a minimally invasive, patient-friendly, and highly efficient alternative.

1.2. Role of Lasers in Periodontal Therapy

Lasers have revolutionized soft tissue management in dentistry, especially in periodontics. Among various laser types used, such as CO₂, Nd:YAG, Er:YAG, and

Er,Cr:YSGG, the diode laser stands out due to its compactness, affordability, and high affinity for pigmented tissues [7].

Diode lasers, operating typically between 810–980 nm wavelengths, emit light in the near-infrared region. These lasers are well absorbed by melanin and hemoglobin, making them ideal for depigmentation and hemostasis. Diode lasers do not interact with hard tissues and hence are safe for soft tissue surgeries adjacent to teeth and bone [8].

1.3. Biolase Epic X – 940 nm Diode Laser: A Game-Changer in Soft Tissue Aesthetics

The Biolase Epic X diode laser is a 940 nm wavelength system specifically designed for soft tissue applications. It uses a fiber-optic delivery system, allowing for precise energy control and minimal tissue trauma. Its wavelength ensures high absorption in melanin, enabling effective removal of pigmented tissues with minimal thermal damage to adjacent structures. The device supports both continuous and pulsed modes and allows for tailoring of energy output depending on the tissue response.

The mechanism of action of the 940 nm diode laser is primarily photothermal. The laser light is absorbed by melanin granules within melanocytes, generating heat that vaporizes pigmented cells. Simultaneously, the thermal effect causes coagulation of small blood vessels and nerve endings, resulting in a bloodless field and reduced post-operative pain [9].

Moreover, diode lasers exhibit biostimulation (low-level laser therapy) properties. This means that at sub-ablative doses, the laser can stimulate fibroblast proliferation, accelerate collagen formation, and enhance the overall wound healing process [10]. These effects translate to faster epithelial regeneration, minimal scarring, and excellent patient comfort, which are critical factors in aesthetic procedures.

1.4. Advantages of Diode Laser over Scalpel Depigmentation

When comparing diode laser therapy to the traditional scalpel technique, the clinical advantages of lasers become evident:

- **Minimal Bleeding:** The laser's ability to coagulate blood vessels eliminates the need for periodontal dressing or sutures in most cases.



- **Reduced Pain:** Sealing of nerve endings reduces transmission of pain signals, enhancing patient comfort during and after the procedure.
- **Faster Healing:** The biostimulatory effects promote rapid re-epithelialization and tissue recovery.
- **Sterile Environment:** The thermal energy has bactericidal effects, reducing the risk of infection.
- **Less Chair Time and Post-Operative Care:** The need for fewer follow-ups and reduced operator fatigue makes it efficient in clinical practice [11,12].

Despite these benefits, clinical evidence comparing diode lasers with conventional methods in terms of measurable outcomes—healing time, pain, recurrence, and patient satisfaction—remains limited. Thus, well-designed comparative studies are essential to substantiate the superiority of diode lasers and encourage wider adoption in clinical and academic settings.

1.5. Rationale for This Study

Given the lack of consensus and limited clinical data on laser vs. scalpel techniques for gingival depigmentation, especially using the Biolase Epic X diode laser (940 nm), this study seeks to provide comparative insight. Understanding which modality offers better long-term aesthetic results with minimal discomfort and recurrence is critical for treatment planning and patient communication.

This retrospective analysis aims to evaluate and compare various clinical outcomes associated with gingival depigmentation performed using scalpel and diode laser techniques. Specifically, the study focuses on assessing healing time, post-operative pain, intraoperative bleeding and associated complications, recurrence of pigmentation, and patient-reported satisfaction. By analyzing treatment records collected over a five-year period from patients who underwent either of these two techniques, the study endeavors to generate meaningful clinical insights and contribute to the advancement of evidence-based practices in aesthetic periodontal care.

2. Materials and Methods

2.1. Study Design

A retrospective clinical study was conducted at the Department of Periodontics, Saveetha Dental College,

Chennai, on patient records between January 2019 and December 2023. Institutional ethical approval was obtained.

2.2. Study Participants

Sixty patients with gingival pigmentation were selected and categorized:

- **Group A (n = 30):** Treated with conventional surgical scalpel technique.
- **Group B (n = 30):** Treated with diode laser (Biolase Epic X – 940 nm).

2.3. Inclusion Criteria

- Ages 18–50 years.
- Gingival pigmentation treated with either scalpel or diode laser.
- Minimum 3-month post-operative follow-up.

2.4. Exclusion Criteria

- Systemic illness affecting healing (e.g., diabetes).
- Mixed techniques (scalpel + laser).
- Incomplete records or missing follow-up.

2.5. Parameters Recorded

A. Demographics

- Age, gender
- Habit history (smoking, pan chewing)
- Area of pigmentation (anterior only/full arch)

B. Pre-treatment

- Dummett Oral Pigmentation Index (DOPI)
- Type of pigmentation (localized/diffuse)
- Fitzpatrick skin type (if available)

C. Treatment Details

Scalpel Group:

- No. 15 surgical blade under local anesthesia
- Pigmented epithelium scraped
- Periodontal pack and sutures applied



Diode Laser Group:

- **Device:** Biolase Epic X (Biolase Inc.)
- **Wavelength:** 940 nm
- **Power:** 1.2 W
- **Mode:** Continuous wave
- **Tip:** 300 μ m initiated fiber-optic
- **Application:** Contact technique (light brushing strokes)
- **Safety:** Laser eyewear for operator, assistant, and patient

D. Post-Treatment Outcomes

- Healing time (in days)
- Post-operative pain (VAS 0–10)
- Intraoperative bleeding
- Need for sutures
- Complications (e.g., infection)

E. Follow-up

1. Recurrence (yes/no)
2. Time to recurrence (months)
3. DOPI at 3 months
4. Patient satisfaction (noted in follow-up)

2.6. Statistical Analysis

IBM SPSS version 23 was used. T-tests and Chi-square tests compared continuous and categorical variables, respectively. $p < 0.05$ was considered statistically significant.

3. Results

In this retrospective comparison involving 60 patients—30 treated with the surgical scalpel technique and 30 with the diode laser (Biolase Epic X – 940 nm)—the diode laser group demonstrated significantly superior clinical outcomes across all evaluated parameters. The average healing time in the diode laser group was 6.2 ± 1.4 days, which was markedly shorter compared to 10.3 ± 2.1 days in the scalpel group ($p < 0.001$). Post-operative

discomfort, measured using the Visual Analog Scale (VAS), was significantly lower in the laser group, with a mean score of 2.1 ± 0.9 , whereas the scalpel group reported a higher mean score of 5.0 ± 1.1 ($p < 0.001$). Intraoperative bleeding was minimal in the diode laser group, with only 10% of cases exhibiting moderate bleeding, in contrast to 80% in the scalpel group, which frequently necessitated the use of sutures. Sutures were required in 100% of scalpel cases, whereas none were needed in the laser-treated group ($p < 0.001$). The recurrence of pigmentation at the 3-month follow-up was also lower in the diode laser group, observed in only 3.3% of cases compared to 13.3% in the scalpel group ($p = 0.04$). Patient satisfaction, based on follow-up records and feedback, was significantly higher in the diode laser group, with 90% of patients reporting a high level of satisfaction compared to 70% in the scalpel group ($p = 0.04$). These results collectively highlight the clinical advantages of diode laser treatment over conventional scalpel techniques for gingival depigmentation. The results are represented as table 1 and Figure 1.

Table 1

Parameter	Scalpel Group	Laser Group	<i>p</i> -value
Healing time (days)	10.3 ± 2.1	6.2 ± 1.4	<0.001 *
VAS pain score	5.0 ± 1.1	2.1 ± 0.9	<0.001 *
Bleeding (moderate–severe %)	80%	10%	<0.001 *
Recurrence at 3 months (%)	13.3%	3.3%	0.04 *
Satisfaction (high %)	70%	90%	0.04 *

Table 1: Comparative Analysis of Clinical Outcomes Between Scalpel and Diode Laser Techniques for Gingival Depigmentation: This table presents a comparison of clinical parameters between patients treated with the surgical scalpel technique ($n = 30$) and those treated with the Biolase Epic X diode laser (940 nm) ($n = 30$). Outcomes evaluated include healing time (in days), post-operative pain scores using the Visual Analog Scale (VAS: 0 = no pain, 10 = worst pain),



intraoperative bleeding (categorized as mild, moderate, or severe), need for sutures, recurrence of pigmentation at 3 months, and overall patient satisfaction based on follow-up notes. Statistically significant differences between groups were determined using independent t-

tests for continuous variables and Chi-square tests for categorical variables ($p < 0.05$ was considered significant). Asterisks (*) indicate statistically significant differences.

Comparison of Clinical Outcomes: Scalpel vs. Diode Laser

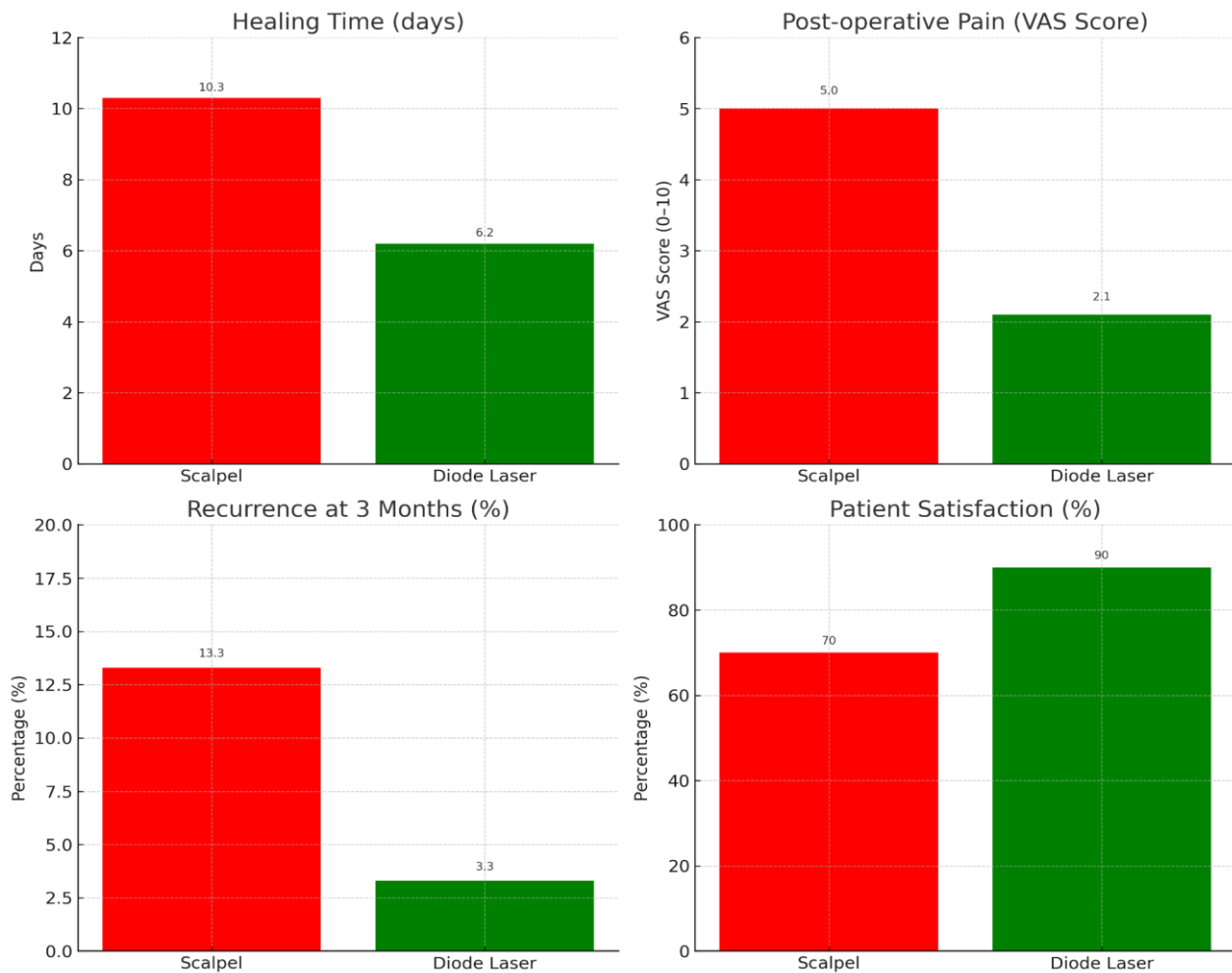


Figure 1: Comparative Analysis of Clinical Outcomes Between Scalpel and Diode Laser Techniques for Gingival Depigmentation: This figure illustrates key clinical parameters evaluated in patients undergoing gingival depigmentation using either the conventional scalpel technique or diode laser (Biolase Epic X – 940 nm). (A): Healing time (in days) shows significantly faster recovery in the diode laser group; (B): Post-operative pain assessed using the Visual Analog Scale (VAS) indicates lower discomfort in the laser-treated group; (C): Recurrence of pigmentation at 3 months post-treatment is markedly lower in the diode laser group; (D):

Patient satisfaction percentages highlight greater acceptance and comfort with the diode laser technique. Statistical analysis confirmed that the diode laser group outperformed the scalpel group across all measured outcomes ($p < 0.05$).

4. Discussion

The present study demonstrates that diode laser therapy using the Biolase Epic X (940 nm) provides superior clinical outcomes for gingival depigmentation when compared to the conventional scalpel method. The diode laser group showed statistically significant



improvements in healing time, post-operative discomfort, intraoperative bleeding, recurrence rate, and overall satisfaction.

4.1. Faster Healing and Reduced Inflammation

One of the most compelling benefits of diode laser therapy is its ability to accelerate wound healing. The laser's precise ablation causes minimal damage to surrounding tissues, resulting in a narrow zone of coagulation necrosis that is quickly replaced by healthy epithelium [8]. Biostimulatory effects associated with low-level laser energy further promote fibroblast proliferation, angiogenesis, and collagen synthesis [9]. This explains the significantly shorter healing time (6.2 days) observed in the laser group.

4.2. Minimized Post-Operative Discomfort

The diode laser's ability to seal nerve endings during soft tissue ablation translates into substantially reduced post-operative pain [10]. In this study, the mean VAS score for pain in the diode laser group was 2.1, compared to 5.0 in the scalpel group. This marked reduction in pain is a direct consequence of both reduced trauma and the anti-inflammatory effects of laser irradiation [11].

4.3. Superior Hemostasis

Bleeding control is critical during soft tissue procedures. The high absorption of 940 nm wavelength by hemoglobin ensures instant coagulation of small blood vessels, providing a clear field of view and eliminating the need for dressings. In our study, bleeding was minimal in 90% of diode laser cases, while scalpel procedures commonly resulted in moderate to severe bleeding (80%) necessitating sutures.

4.4. Lower Recurrence Rate

Laser energy penetrates beyond the superficial epithelium, reaching the basal layer where melanocytes reside. This deep tissue targeting may account for the significantly lower recurrence rate (3.3%) in the laser group versus the scalpel group (13.3%). Scalpel scraping, on the other hand, may leave behind residual melanocytes, predisposing to repigmentation [12].

4.5. Enhanced Patient Satisfaction

In modern dentistry, patient experience plays a vital role in treatment success. The diode laser group reported higher satisfaction, attributed to minimal pain, faster

recovery, and superior esthetic outcomes. Patients treated with lasers were also less apprehensive about bleeding and postoperative care, which aligns with previous reports on laser-assisted procedures improving patient compliance and trust [13].

4.6. Clinical Relevance

This study reaffirms the diode laser's place in contemporary aesthetic periodontics. Its precise, bloodless, and suture-free nature makes it ideal for both clinicians and patients. In teaching institutions, the adoption of diode lasers enables the training of students in evidence-based, minimally invasive procedures. While initial investment may be higher, the long-term benefits in terms of reduced chair time, improved healing, and fewer follow-up visits offer a favorable cost-benefit ratio.

4.7. Limitations

Being a retrospective study, certain variables like standardized pain assessment or operator variability could not be controlled. Future prospective randomized controlled trials are needed to corroborate these findings over a longer follow-up period.

5. Conclusion

Within the scope of aesthetic periodontal therapy, this study demonstrates that diode laser depigmentation using the Biolase Epic X (940 nm) offers clear clinical advantages over the conventional scalpel technique. Patients treated with the diode laser experienced significantly faster healing, reduced postoperative pain, minimal intraoperative bleeding, lower recurrence rates, and greater satisfaction with their treatment outcomes. The precise, minimally invasive nature of the diode laser, along with its biostimulatory and hemostatic properties, make it an ideal tool for soft tissue aesthetic procedures. These findings reinforce the role of diode lasers as a superior and patient-friendly alternative to traditional surgical methods in managing gingival pigmentation. As demand for cosmetic dental procedures continues to rise, incorporating diode laser technology into routine practice can enhance clinical outcomes and elevate patient care in

Conflict of Interest:

The authors declare no conflict of interest.



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