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Comparative Evaluation of Clinical Outcome to Gingival Depigmentation Using Diode Laser Ablation and Vitamin C Mesotherapy

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Abstract

Background: Gingival hyperpigmentation is a common aesthetic concern. Although diode laser and injectable vitamin C are used for depigmentation, comparative clinical evidence is limited. **Objective:** This present study was aimed at a comparative evaluation of the clinical outcome of gingival depigmentation using diode laser and Vitamin C mesotherapy. **Materials and Methods:** Twenty-six systemically healthy participants with gingival hyperpigmentation were randomly assigned to a diode laser group (n = 13) or a vitamin C group (n = 13). Clinical outcomes were assessed using the Dummett–Oral Pigmentation Index (DOPI) and Gingival Pigmentation Index (GPI) at baseline, 1, 2, and 3 months. Pigmented area reduction was measured using ImageJ software at baseline and 3 months. Postoperative pain (VAS), color improvement, and patient satisfaction were also evaluated. **Results:** Both groups showed significant reductions in DOPI and GPI scores from baseline to 3 months ($p < 0.01$). The laser group demonstrated significantly greater improvement at 1 month ($p < 0.01$), with no significant intergroup differences at 2 or 3 months. Pigmented area was significantly reduced in both groups, with greater reduction in the vitamin C group ($p < 0.01$). The laser group reported higher immediate postoperative pain ($p < 0.01$), whereas patient satisfaction was significantly greater with vitamin C therapy ($p < 0.01$). Color improvement was comparable between groups. **Conclusion:** Both diode laser and injectable vitamin C are effective for gingival depigmentation. Laser therapy provides faster initial clinical improvement, whereas injectable vitamin C offers superior patient comfort and satisfaction, making it a promising minimally invasive alternative.

Keywords: Gingival Hyperpigmentation, Gingival Depigmentation, Diode Laser, Vitamin C Mesotherapy, Gingival Pigmentation Index, Patient Satisfaction.

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INTRODUCTION

In today's world with the current trends focusing on facial aesthetics and smile design, patients' aesthetic demands and expectations have also risen. The harmony of smile is attributable to the shape, colour, and position of the teeth in conjunction with the gingival tissue [1]. The gingival tissue along with the face, lips, and teeth is a significant element in dentofacial aesthetics. In contemporary dentistry, achieving a harmonious dental appearance encompassing both teeth and gingiva is crucial for smile aesthetics.

The colour of the gingiva is usually coral pink but varies among individuals and is often associated with cutaneous pigmentation [2]. It also depends on the number and size of the vasculature, the thickness of keratinised epithelium, and pigments within the gingival epithelium [3]. The colour of the gingiva significantly influences overall aesthetics. Visible gingival pigmentation (GP) during speech and smiling can cause embarrassment. Beyond addressing biological and functional concerns, periodontists are also responsible for achieving optimal gingival aesthetics.

Gingival hyperpigmentation is characterised by an increased intensity of gingival colour due to excessive melanin deposition. Excessive melanin deposition in the basal and supra-basal cell layers of the epithelium leads to gingival hyperpigmentation (Dummett, 1963) [4]. Perioaesthetics deals with overall biological and functional harmony between teeth and gingiva [5]. Gingival depigmentation is not a functional indication but a treatment of choice where there is demand for cosmetic therapy and is desired by the patients [6]. The dentist's clinical expertise and individual patient preferences play a primary role in choice of surgical or non-surgical technique used.

Laser therapy is an effective treatment for gingival hyperpigmentation that works by removing areas of hyperpigmentation via tissue ablation. The most commonly used lasers for this treatment are CO_2, Nd:YAG,

and diode lasers. Diode lasers are highly absorbed by soft tissue, making them particularly effective in dentistry. They offer several advantages, including efficient coagulation, short treatment time, accelerated healing, and excellent aesthetic outcomes [6].

To mitigate the risk of post-operative complications, it is essential to proactively take measures that support safe and minimally invasive procedures such as vitamin C treatment, instead of traditional surgical procedures. Vitamin C has been introduced as a promising therapeutic agent for reducing melanin hyperpigmentation due to its ability to suppress the activity of tyrosinase, the rate-limiting enzyme in melanin biosynthesis. Moreover, vitamin C offers additional advantages including antioxidative properties, promotion of collagen synthesis, and immune system support. This present study was aimed at a comparative evaluation of the clinical outcome of gingival depigmentation using diode laser and Vitamin C mesotherapy.

MATERIALS AND METHODS

Study Design and Participants

This randomized controlled clinical trial was conducted in the Department of Periodontics, A.J. Institute of Dental Sciences, Mangalore, India. Twenty-six systemically healthy patients (18–45 years) presenting with physiologic gingival melanin hyperpigmentation in the anterior maxillary and mandibular regions and seeking esthetic treatment were enrolled after obtaining written informed consent. Ethical approval was obtained from the Institutional Ethics Committee (Reference number: IEC/PERIO 24/238/V2).

Patients with a Dummett Oral Pigmentation Index (DOPI) score >1, high or very high smile line, healthy periodontium, and willingness to comply with follow-up visits were included. Patients with systemic diseases associated with pigmentation, pregnancy or lactation, smoking or tobacco habits, medications affecting pigmentation, metallic restorations or orthodontic appliances, occlusal discrepancies, missing anterior teeth, occupational pigmentation, or hypersensitivity to ascorbic acid were excluded.

The study included 26 systemically healthy participants aged 18–45 years with physiologic gingival melanin hyperpigmentation involving the anterior maxillary and mandibular regions. All participants sought aesthetic treatment and fulfilled the predefined inclusion criteria. Following randomization, participants were equally allocated into two groups, with 13 participants in the diode laser group and 13 in the Vitamin C mesotherapy group. The baseline demographic and clinical characteristics were comparable between the two groups.

Randomization and Intervention

Following Phase I periodontal therapy (oral prophylaxis and oral hygiene instructions), eligible participants were randomly allocated using a computer-generated randomization sequence into two equal groups (n = 13 each):

- Group I: Diode laser depigmentation
- Group II: Vitamin C mesotherapy

Baseline clinical and photographic assessments were performed before treatment.

Clinical Procedures

Group I (Diode Laser):

Depigmentation was performed using a 980-nm diode laser (NovoLase Tri-Blu, continuous contact mode) (Figure 1) at a power output of 1.5–2.0 W with a 200–300 µm fiber-optic tip. After local infiltration anesthesia (2% lignocaine with adrenaline), laser ablation was carried out from the mucogingival junction toward the free gingival margin using the brush technique until a uniform pink appearance was achieved. Residual tissue debris was removed with sterile saline-soaked gauze (Figure 2).

Group II (Vitamin C Mesotherapy):

Topical anesthesia (10% lidocaine spray) was applied before administration of L-ascorbic acid (500 mg/2 mL). The Vitamin C preparation used was VC Injection (2 mL ampoule containing 500 mg of ascorbic acid; Vesco Pharmaceuticals) (Figure 1). Using a 30-gauge insulin syringe, 0.1 mL of solution was injected at 2–3 mm intervals into the superficial gingival connective tissue (depth: 0.5–2.0 mm) until blanching was observed. The procedure was repeated once weekly for four consecutive weeks (Figure 3).

Postoperative instructions were standardized for both groups and included dietary precautions, use of an ultrasoft toothbrush, and 0.2% chlorhexidine mouthwash twice daily for two weeks. Ibuprofen (200 mg) was prescribed only when required for pain management.

Outcome Assessment

Clinical evaluations were performed at baseline and at 1, 2, and 3 months postoperatively by a calibrated examiner.

The primary outcome measures included:

- Dummett Oral Pigmentation Index (DOPI) for assessment of pigmentation intensity [7].
- Gingival Pigmentation Index (GPI) for evaluation of pigmentation distribution [8].
- Photographic analysis using standardized digital photographs analyzed with ImageJ software (Version 1.43, National Institutes of Health, USA) to quantify the pigmented surface area [9] (Figure 4).

Secondary outcomes included patient-reported pain using a 10-point Visual Analog Scale (VAS) recorded on the day of treatment, perceived color improvement using a 5-point improvement scale, and overall patient satisfaction using a 5-point Likert scale at the 3-month follow-up [10].

Statistical Analysis

Data were analyzed using appropriate statistical software. Continuous variables were expressed as mean ± standard deviation. Intragroup comparisons were performed using the paired t-test, whereas intergroup comparisons were analyzed using the independent Student's t-test or the corresponding non-parametric test when data did not satisfy normality assumptions. A P value <0.05 was considered statistically significant.

RESULTS

Twenty-six participants completed the study, with 13 patients allocated to each treatment group. Baseline demographic and clinical characteristics were comparable between the groups.

Clinical Pigmentation Indices

Baseline DOPI and GPI scores were similar in both groups (mean DOPI = 2.69; mean GPI = 2.69; P = 1.00). At 1 month, the diode laser group demonstrated significantly greater reductions in both DOPI (P = 0.006) and GPI (P < 0.001) compared with the Vitamin C mesotherapy group. However, no statistically significant intergroup differences were observed at 2 or 3 months (P > 0.05), indicating comparable long-term clinical outcomes (Table 1 & 2).

Pigmented Area Assessment

The mean pigmented area was comparable between the groups at baseline (P= 0.58). At the 3-month follow-up, the Vitamin C mesotherapy group showed a significantly greater reduction in pigmented area than the diode laser group (54.84 ± 3.48 vs. 73.61 ± 2.75; P < 0.001) (Table 3).

Patient-Reported Outcomes

Immediate postoperative pain was significantly higher in the diode laser group than in the Vitamin C group (3.92 ± 0.75 vs. 1.38 ± 0.50; P < 0.001). At 3 months, patient-perceived color improvement did not differ significantly between the groups (P= 0.19). However, overall patient satisfaction was significantly greater in the Vitamin C group (3.76 ± 0.43) than in the diode laser group (3.07 ± 0.49; P = 0.002).

Intragroup Analysis

Both treatment modalities demonstrated significant improvements in DOPI and GPI scores from baseline to 3 months (P< 0.001). Significant reductions in the pigmented area were also observed in both groups, although the reduction was greater following Vitamin C mesotherapy. Overall, both interventions were effective in reducing gingival pigmentation, with diode laser providing faster early depigmentation, whereas Vitamin C mesotherapy produced superior reduction in pigmented area, lower postoperative pain, and higher patient satisfaction (Figure 5).

Table 1: DOPI comparison between Group 1 and Group 2 at baseline, 1 month, 2 months and 3 months

	Group	N	Mean	Std. Deviation	Median	Z value	P value
DOPI_BASELINE	Group 1 - Laser	13	2.69	0.48	3	0	1.00
	Group 2 - Vitamin C	13	2.69	0.48	3		
DOPI_1M	Group 1 - Laser	13	1.69	0.48	2	-2.77	0.006 HS
	Group 2 - Vitamin C	13	2.30	0.48	2		
DOPI_2M	Group 1 - Laser	13	1.53	0.51	2	-0.38	0.69
	Group 2 - Vitamin C	13	1.61	0.50	2		
DOPI_3M	Group 1 - Laser	13	0.69	0.48	1	-0.43	0.66
	Group 2 - Vitamin C	13	0.76	0.43	1		

Statistical test applied: Mann Whitney U test; HS – Highly significant at p<0.01

Table 2: GPI comparison between Group 1 and Group 2 at baseline, 1 month, 2 months and 3 months

	Group	N	Mean	Std. Deviation	Median	Z value	P value
GPI_BASELINE	Group 1 - Laser	13	2.69	0.48	3	0	1.00
	Group 2 - Vitamin C	13	2.69	0.48	3		
GPI_1M	Group 1 - Laser	13	1.69	0.48	2	-3.52	0
	Group 2 - Vitamin C	13	2.61	0.50	3		
GPI_2M	Group 1 - Laser	13	1.53	0.66	2	-0.92	0.35
	Group 2 - Vitamin C	13	1.76	0.43	2		
GPI_3M	Group 1 - Laser	13	0.76	0.43	1	-0.48	0.62
	Group 2 - Vitamin C	13	0.84	0.37	1		

Statistical test applied: Mann Whitney U test; HS – Highly significant at p<0.01

Table 3: Area comparison between Group 1 and Group 2 at baseline and 3 months

	Group	N	Mean	Std. Deviation	Median	T value	P value
AREA_BASELINE	Group 1 - Laser	13	122.76	3.49	123	-0.54	0.58
	Group 2 - Vitamin C	13	123.61	4.33	124		
AREA_3M	Group 1 - Laser	13	73.61	2.75	74	15.23	0.000 HS
	Group 2 - Vitamin C	13	54.84	3.48	55		

Statistical test applied: Independent t test; HS – Highly significant at p<0.01

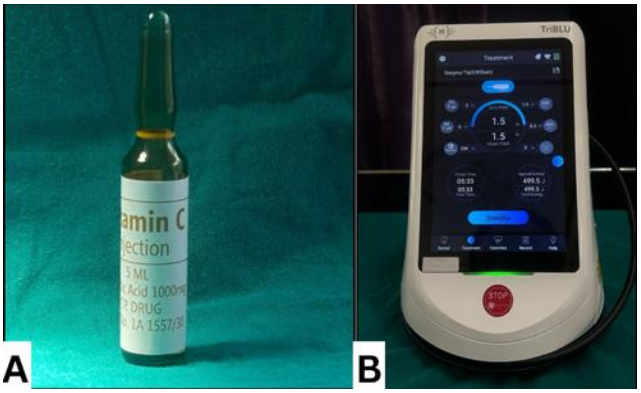

Figure 1: Armamentarium (A- Vitamin C; B-Diode Laser Unit)

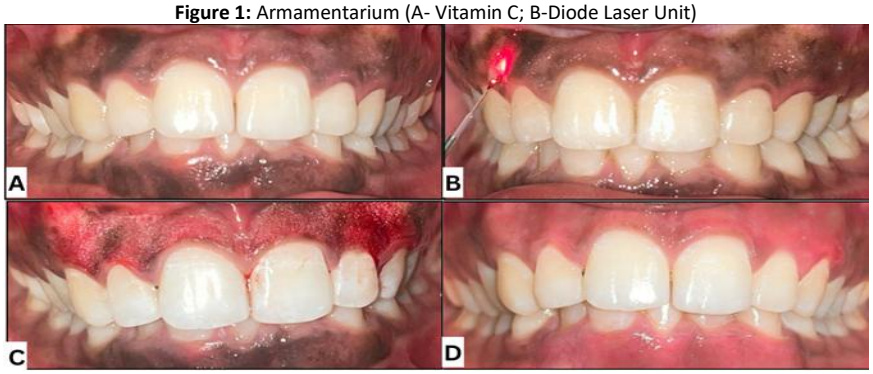

Figure 2: Diode Laser - Group 1(A- Baseline; B- Intraoperative; C- Immidiete Post-Operative; D- 3 Month Re-Evaluation)

Figure 3: Vitamin C Mesotherapy – Group 2 (A- Baseline; B- Intraoperative; C- 1 Month Re-Evaluation ; D- 3 Month Re-Evaluation)

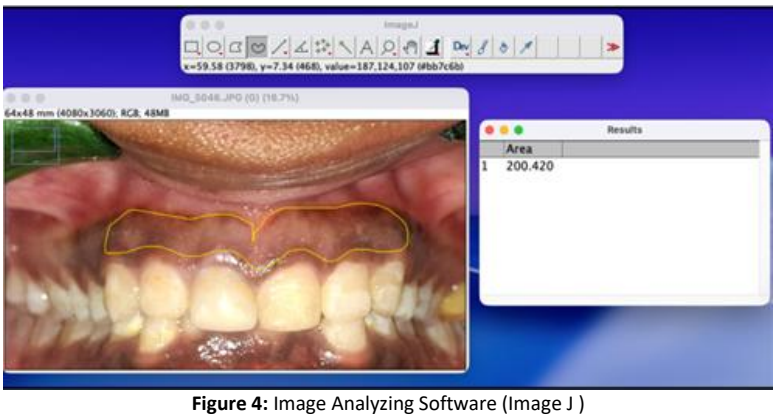

Figure 4: Image Analyzing Software (Image J)

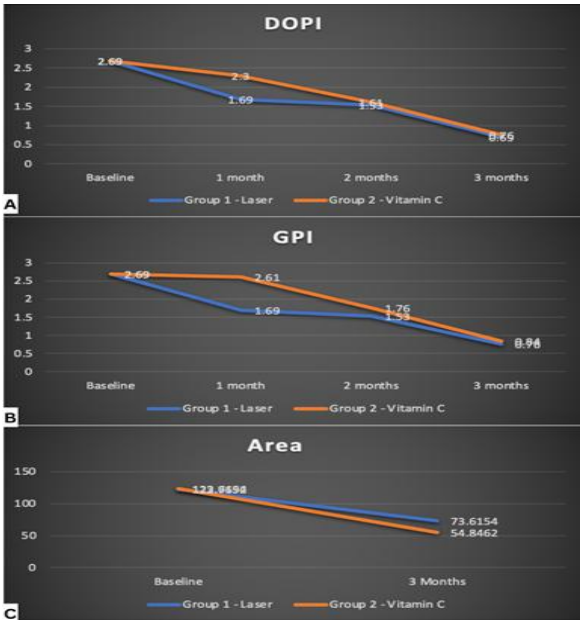

Figure 5: Intragroup Analysis (A- DOPI score changes from baseline to 3 months in Group 1 and Group 2; B- GPI score changes from baseline to 3 months in Group 1 and Group 2; C-Area score changes from baseline to 3 months)

DISCUSSION

In the current study, we compared two clinically relevant approaches for gingival depigmentation, local Vitamin C mesotherapy and ablation by Diode laser in patients with physiologic gingival hyperpigmentation. Both modalities resulted in substantial reductions in gingival pigmentation from baseline, demonstrating patient satisfaction and establishing them as viable options for aesthetic gingival depigmentation.

Aesthetics is a crucial part of modern dental care, contributing to a pleasant smile and increased confidence. In modern dentistry the ultimate goal is to attain "white and pink esthetics" [11]. Gingival tissue makes up a large percentage of dentofacial esthetics along with face, lip, and teeth [12]. Gingival pigmentation plays a crucial role in smile harmony [6]. Garber and Salama emphasised that the harmony between dentofacial structures and gingiva is fundamental to dental aesthetics in achieving a perfect smile [13].

Gingival hyperpigmentation is characterised by an increased intensity of gingival colour due to excessive melanin deposition. Patients find gingival hyperpigmentation unattractive and it can have a psychological impact. The pink aesthetics is the cornerstone in smile design. Gingival depigmentation is a periodontal plastic surgery treatment that uses a range of both surgical and non-surgical techniques to eliminate or minimize gingival hyperpigmentation. Gingival pigmentation can be effectively treated by various surgical procedures using both invasive and non-invasive methods.

The differential effects of the two approaches stated in the present study likely stem from fundamentally different mechanisms. Diode lasers achieve depigmentation through selective photothermal ablation of melanin-containing epithelial tissues and simultaneous coagulation of small blood vessels, resulting in effective pigment removal with excellent hemostasis. In contrast, Vitamin C acts by inhibiting tyrosinase activity, the rate-limiting enzyme in melanin synthesis, while its antioxidant properties promote collagen synthesis and tissue healing. Consequently, laser therapy physically removes existing pigmentation, whereas Vitamin C suppresses melanogenesis and gradually reduces pigmentation.

The present findings are consistent with previous studies comparing these modalities. Esmat *et al* [14] reported significant improvements in DOPI and GPI scores with both diode laser and Vitamin C mesotherapy, although laser produced more rapid clinical depigmentation. Similarly, studies by Arif *et al* [15] and Harb *et al* [16] demonstrated the effectiveness of diode lasers in gingival depigmentation with favorable bleeding control and predictable clinical outcomes. Our findings agree with these reports, showing superior early clinical improvement with diode laser, while both treatments achieved comparable pigmentation scores after three months.

Patient-reported outcomes provide additional clinical relevance. Although color improvement was comparable between the groups at 3 months, Vitamin C mesotherapy resulted in significantly lower immediate postoperative pain and higher overall patient satisfaction. Reduced postoperative discomfort may improve patient acceptance and compliance, particularly among individuals seeking minimally invasive treatment. Similar observations have been reported by Yussif *et al* [17], who demonstrated lower postoperative pain following Vitamin C therapy compared with conventional depigmentation techniques. Furthermore, recent systematic reviews suggest that although diode lasers produce more rapid and consistent depigmentation, Vitamin C remains an effective, economical, and biologically safe alternative, particularly in resource-limited settings.

From a clinical perspective, both treatment modalities have distinct advantages. Diode laser offers rapid pigment removal, excellent hemostasis, and often requires only a single treatment session, making it suitable for patients seeking immediate aesthetic improvement. Conversely, Vitamin C mesotherapy is inexpensive, minimally invasive, does not require specialized equipment, and provides superior patient comfort, making it an attractive alternative where access to laser therapy is limited. However, the gradual response and requirement for multiple treatment sessions should be considered during treatment planning.

The present study has several limitations. The relatively small sample size, single-center design, and short follow-up period limit the generalizability of the findings and preclude assessment of long-term repigmentation. In addition, histological evaluation of melanocyte activity was not performed, and subjective assessment of pigmentation and patient satisfaction may have introduced observer bias. Future multicenter randomized controlled trials with larger sample sizes, standardized treatment protocols, longer follow-up (12–24 months), objective colorimetric evaluation, and histological assessment are required to establish long-term efficacy and recurrence rates. Investigation of combination therapies involving diode laser and

adjunctive Vitamin C may also provide valuable insights into improving treatment outcomes and minimizing repigmentation.

CONCLUSION

Within the limitations of this study, both diode laser and injectable vitamin C were effective in reducing gingival hyperpigmentation, demonstrating significant improvements in DOPI, GPI, and pigmented area over 3 months. Injectable vitamin C was associated with lower post-operative pain and higher patient satisfaction, whereas diode laser provided faster depigmentation in a single clinical visit despite greater early discomfort. Injectable vitamin C may be considered a minimally invasive and cost-effective alternative to laser therapy. Further long-term studies with larger sample sizes are required to evaluate treatment stability and recurrence, and treatment selection should be individualized based on patient preference, clinical requirements, and resource availability.

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Authors Contributions

MHP, NDV conceptualized and designed the study, conducted data collection and analysis, and drafted the manuscript. MHP, RSD supervised the study, critically reviewed the analysis, and revised the manuscript. MHP, RSD provided overall supervision, developed the methodology, edited the manuscript, and managed journal correspondence as the corresponding author. NDV, SJ co-supervised data collection and reviewed the manuscript. RSD, SJ assisted with data collection and reviewed the manuscript. All authors reviewed and approved the final version of the manuscript.

Data Availability Statement

The data that support the findings of this study are available and will be made available upon request.

Use of AI in Drafting of Manuscript

The authors declare that they have not used any generative AI/AI-assisted technologies in the writing of this manuscript.

Conflicts of Interest

The authors declared no conflict of interest.

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