ORIGINAL RESEARCH

Effectiveness of Photobiomodulation with and without Hyaluronic Acid Gel on Gingival Depigmentation: A Randomized Control Clinical Trial

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Abstract

Aim: To evaluate the efficacy of low-level laser therapy and hyaluronic gel in the management of gingival hyperpigmentation.

Materials and methods: Sixty patients willing to receive treatment for gingival depigmentation were grouped into the following three groups: group I – laser-assisted gingival depigmentation ($n = 20$); group II – low-level laser-assisted gingival depigmentation ($n = 20$); and group III – low level laser-assisted gingival depigmentation with hyaluronic acid ($n = 20$). The clinical effectiveness of the depigmentation procedure as per patient's opinion of mean smile perception changes was assessed using a visual analog scale (VAS) scoring line (0–10 cm) at preoperative (T0), on 7th day (T1) and 21st day (T2) with the question "How do you classify your smile?" with a rating from 0 – not attractive to 10 – completely attractive. Data were compiled in a Microsoft Office Excel worksheet and subjected to statistical analysis. The Mann–Whitney *U* test and Friedman test was done for inter- and intragroup comparison, respectively. Statistical significance was set at p-value < 0.05.

Results: In group I, the VAS scores at baseline (T0), T1, and T2 were 7.60, 5.00, and 3.4, respectively, while in group II, the VAS scores at T0, T1, and T2 were 8.80, 4.40, and 3.5, respectively. The VAS scores in group III were 7.90, 1.0, and 0.4 at T0, T1, and T2, respectively. The smile perception changes (VAS scores) were lesser in group III, followed by group II and group I at T0, T1, and T2 intervals. The differences were statistically significant.

Conclusion: Photobiomodulation combined with hyaluronic gel topical application can produce superior results with very minimal recurrence. This noninvasive modality can be an effective alternative to invasive surgical depigmentation procedures.

Clinical significance: Gingival depigmentation is a common esthetic procedure. Laser-assisted depigmentation with hyaluronic acid can overcome the tissue necrosis caused by heat produced by laser and hastens healing. Photobiomodulation with hyaluronic acid can be a better alternative to invasive surgical depigmentation procedures.

Keywords: Gingival depigmentation, Gingival pigmentation, Hyaluronic acid, Low-level laser therapy, Photodynamic therapy.

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Introduction

A smile is the best ornament of the face. The harmony of a smile relies on the shape, position, and color of the teeth. In addition to these factors, the color and position of the gingival tissues also contribute to overall harmony.[1] The shading of the gingiva differs from person to person and is thought to be correlated with cutaneous pigmentation. In the clinical scenarios, the patient often complains about the "dark-colored gums" and considers them unesthetic.[2]

Gingival hyperpigmentation is multifactorial; however, it is primarily due to the physiological deposition of melanin pigmentation produced by melanoblasts.[3] Melanin is a natural brown pigment that is a nonhemoglobin-derived pigment.[4,5] Though these are normal physiological pigmentation, it is often considered unesthetic. In the last decade, cosmetic dentistry has evolved meticulously with the requirement of understanding the values, choice, and the demands of each individual.

Gingival depigmentation is a periodontal plastic surgical procedure through which the gingival hyperpigmentation is removed or reduced by various techniques. Various techniques have been practiced in gingival depigmentation, i.e., procedure to remove the gingival pigmentation.[6] These procedures are often invasive and range from simple scalpel method, chemical peeling, gingivectomy, grafting, cryosurgery, and laser-assisted depigmentation.[3,7] The invasive techniques of gingival depigmentation are often associated with postoperative discomfort, risk of complications, and the potential for gingival recession.[8]

In recent years, lasers have been utilized in almost all fields of dentistry. This has led to the shift of our interest towards low-level laser (LLL) in the gingival depigmentation procedure. Literature reveals that LLL or photobiomodulation (PBM) enhances tissue healing and regeneration. Carbon dioxide (CO_2, 10,600 nm),

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neodymium: yttrium-aluminum-garnet (Nd: YAG), and diode (980 nm) lasers are the most often utilized lasers for gingival depigmentation.[9]

Lasers have a high affinity to penetrate into epithelial cells, hemoglobin pigment, and melanin pigments, thereby removing pigmentation.[10] However, the heat produced necrotize tissues and disrupt healing.[9] Hyaluronic gel (HA), known for its biocompatibility and tissue-regenerating properties, has also shown potential to reduce pigmentation and enhance tissue healing.[11]

Despite the growing interest in these noninvasive treatments, scientific evidence supporting their efficacy in gingival depigmentation remains limited, particularly within the framework of randomized controlled trials. Therefore, this study aims to evaluate the efficacy of PBM and hyaluronic gel in the management of gingival hyperpigmentation.

Materials and Methods

Study Design, Setting, and Duration

The present randomized controlled study was conducted on patients who visited the Department of Periodontology and Implantology, Shree Balaji Dental College and Hospital, Chennai, India during March 2023 to April 2024. Consecutive participants were allocated into three groups randomly. Institutional Ethics Committee approval was obtained before the study commenced (ethical committee number).

Sample Size Calculation

The sample size was calculated using G*power analysis software. The mean and standard deviation (SD) from Yakout et al.[11–14] were utilized. For a 95% confidence level, the minimum sample size was calculated to be 17 per group, which was increased to 20 to make up for cases lost to follow-up. The total sample size required = number of groups × number per group = 3 × 20 = 60.

Selection Criteria

Inclusion criteria were: age 20–50 years, general health, patients with hyperpigmentation grades II and III as per Hedin's classification, and those providing consent by signing an informed consent form.

Pregnant and lactating women, patients with a history of systemic disease, hypersensitivity to PBM or hyaluronic gel were excluded from this study. Use of medications influencing pigmentation or wound healing and active periodontal disease or untreated oral infections were excluded from this study.

Study Population

A total of 60 consecutive patients who were willing to receive treatment for gingival hyperpigmentation were recruited. Participants were randomly allocated into three groups: group I – laser-assisted gingival depigmentation (n = 20); group II – LLL-assisted gingival depigmentation (n = 20); and group III – LLL-assisted gingival depigmentation with hyaluronic acid (HA) (n = 20). The sealed opaque envelopes with numbers 1, 2 or 3 were given to the participants and were segregated into three groups based on the number (Fig. 1).

Study Procedure

The entire study was performed by a single operating clinician. In all the patients, in phase one therapy, scaling was done and the patient was recalled after 7 days. Before applying the laser, both the operating staff and patients wore special laser-protective eyeglasses corresponding to the laser wavelength. Highly reflective instruments or those with mirrored surfaces were avoided.

- Group I – In group I patients, on the 7th day, the procedure was explained. Local infiltration was administered. A stent was made and a laser diode (BIOLASE, 910 nm, power – 2 W, energy – 200 J, time – 60 s, continuous mode, noninitiated tip) was used for depigmentation, extending from the right canine to the left

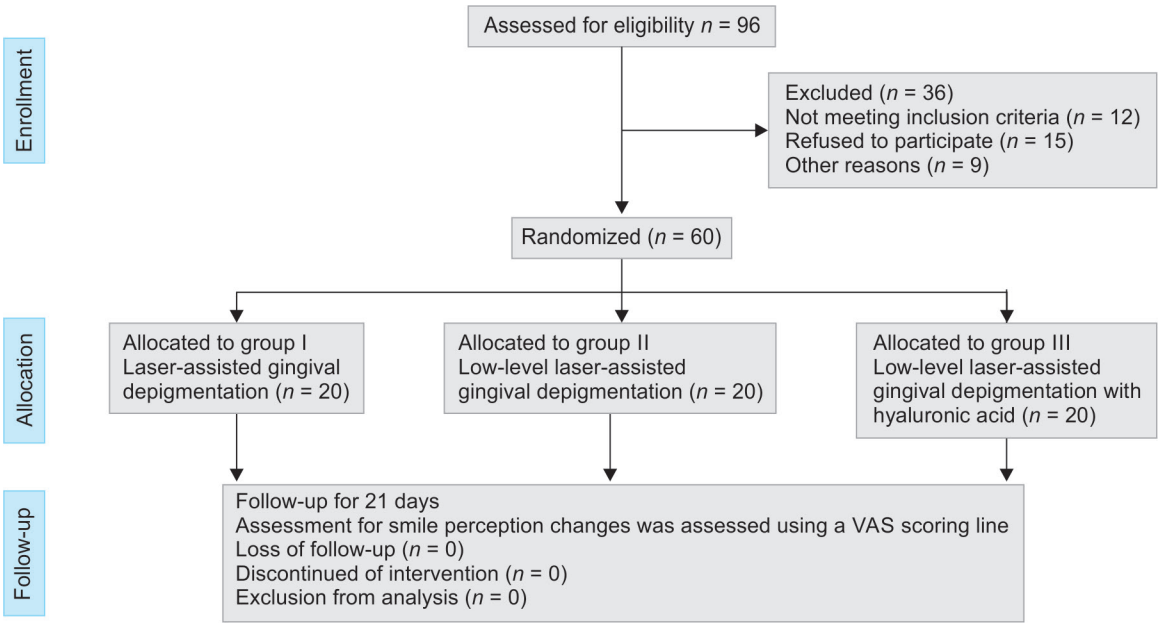

Fig. 1: CONSORT flowchart of the study

canine in both the maxillary and mandibular arches. In order to avoid overheating, depigmentation was carried out horizontally, with the laser tip in contact mode on the pigmented gingiva and parallel to the root surfaces. The depigmented area was then washed with gauze soaked in saline to remove epithelial remnant and to confirm no pigmented areas were left out.

- Group II – In group II patients, on the 7th day, the procedure was explained. The same procedure as in group I was performed using a diode laser (BIOLASE, 910 nm, power – 2 W, energy – 200 J, time – 60 s, continuous mode, noninitiated tip). Following this, LLL therapy (LLLT) (BIOLASE 910 nm, power – 0.8 W, energy – 120 J, time – 60 s, noninitiated tip) was done. The depigmented area was then washed with gauze soaked in saline to remove epithelial remnants and confirm that no pigmented areas were left.
- Group III – In group III patients, the same procedure as in group II was done, following which 0.8% HA gel was applied on the laser area with an applicator stick. After 5–7 minutes, the HA gel is wiped out with a gauze.

No periodontal pack was placed, and no antibiotics were prescribed. Postoperative instructions, such as avoiding smoking and eating hot and spicy food for the first 24 hours, were given to all patients. The patients were recalled after the 7th and 21st post-treatment days for re-evaluation.

Outcome Assessment

Clinical effectiveness of the depigmentation procedure as per patient's opinion of mean smile perception changes was assessed using a visual analog scale (VAS) scoring line (0–10 cm) at pre-op (T0), on 7th day (T1) and 21st day (T2) with the question "How do you classify your smile?", with a rating from 0 – not attractive to 10 – completely attractive.

Statistical Analysis

The collected data were compiled into a Microsoft Office Excel worksheet and then subjected to statistical analysis using IBM SPSS for Windows (Version 26.0). Descriptive statistics were calculated as means, SD, medians, interquartile range, frequencies, and percentages. Comparisons between the three study groups were performed using the Mann–Whitney *U* test, while comparisons between different time points within each group were performed using the Friedman test. Statistical significance was set at *p*-value < 0.05.

Results

Out of the total 60 patients, 65% ($n = 39$) were female, and 35% ($n = 21$) were male, with a mean age of 31.25 years (Table 1).

In group I, the VAS scores at baseline, T1, and T2 were 7.60, 5.00, and 3.4, respectively, while in group II, the VAS scores at baseline, T1, and T2 were 8.80, 4.40, and 3.5, respectively. The VAS scores in group III were 7.90, 1.0, and 0.4 at baseline, T1, and T2, respectively. Intragroup comparisons were performed using the Friedman test. In all groups, the scores were highest in the preoperative period (T0) and gradually decreased on the 7th day and 21st days. The results were statistically significant ($p < 0.05$) (Table 2).

Intergroup comparisons were performed using the Mann–Whitney *U* test. The VAS scores were lesser in group III, followed by group II, with the highest noted in group I with respect to all the three different time periods; T0, T1, and T2 intervals. The differences were statistically significant ($p < 0.05$) (Table 3).

Table 1: Demographic characteristics of the study subjects

Gender	Males	35% ($n = 21$)
	Females	65% ($n = 39$)
Mean age	31.25 years	

Table 2: Intergroup comparison of smile perception changes (VAS – 0–10 cm) in three groups at different time intervals

Groups	*Time interval*	*Mean*	*SD*	*p*
Group I	Baseline (T0)	7.60	0.58	0.05*
	7 days (T1)	5.00	0.71	
	21 days (T2)	3.4	0.55	
Group II	Baseline (T0)	8.80	0.84	0.04*
	7 days (T1)	4.40	0.55	
	21 days (T2)	3.5	0.00	
Group III	Baseline (T0)	7.90	0.99	0.02*
	7 days (T1)	1.0	0.21	
	21 days (T2)	0.4	0.68	

*A *p*-value < 0.05 suggests that the differences observed at baseline (T0) are statistically significant. This means that the initial smile perception scores varied significantly among the groups

Table 3: Intragroup comparison of smile perception changes (VAS – 0 to 10 cm) in three groups at different time intervals

Groups	*Time interval*	*Mean*	*SD*	*p*
Baseline (T0)	Group I	7.60	0.58	0.05*
	Group II	8.80	0.84	
	Group III	7.90	0.99	
7 days (T1)	Group I	5.00	0.71	0.03*
	Group II	4.40	0.55	
	Group III	1.0	0.21	
21 days (T2)	Group I	3.4	0.55	0.056*
	Group II	3.5	0.00	
	Group III	0.4	0.68	

*A *p*-value < 0.05 suggests that the differences observed at baseline (T0) are statistically significant. This means that the initial smile perception scores varied significantly among the groups

Discussion

Pigmented gingival tissue many times forces the patient to seek cosmetic treatments. Although over time, various techniques for gingival depigmentation have evolved, the choice of the appropriate technique for this treatment is challenging for clinicians. Lasers have a significant impact on dentistry, and its application has been used in gingival depigmentation also.

Various lasers have been investigated for their effectiveness in gingival depigmentation procedure, as it is an effective and relatively safer treatment modality with low rate of recurrence.[15] Frequently used lasers for gingival depigmentation include carbon dioxide (CO_2, 10,600 nm) lasers, neodymium: Yttrium, aluminum, and garnet (Nd: YAG, 1,064 nm) lasers, and diode (980 nm) lasers.[14]

Following laser irradiation, cellular rupture and vaporization occur across all layers of epithelial cells, including those at the basal layer, thereby reducing repigmentation.[12] Alongside, melanin and hemoglobin absorb most of the 980 nm diode laser and are destroyed. However, there is significant collateral thermal damage

because of the high energy density level utilized. In this study, we compared laser, LLLT and LLLT + HA in the gingival depigmentation procedure. Raaman et al.[16] Hedge et al.[17] and Kishore et al.[18] noted that lesser pain was seen in laser-assisted depigmentation.

Raaman et al.[16] studied postoperative pain on 1st, 4th, and 7th days as evinced by the VAS and compared repigmentation rates on the 30th and 90th days in 25 patients each treated with scalpel and the 980 nm diode laser. They found that all patients reported a painless experience with the lasers, while repigmentation rates were similar between both groups of patients treated by both modalities.

Kishore et al.[18] in their randomized split-mouth study, investigated Er:YAG and CO_2 laser depigmentation in 21 young patients. The authors observed that both laser modalities were highly effective for depigmentation, yielding excellent esthetics results. However, when considering pain and wound healing, Er:YAG was better than CO_2 laser.

Thangavelu et al. reported that repigmentation occurred less while using laser and cautery compared to the scalpel.[2,12] Additionally, laser is advantageous as it is easy to handle, shortened chair time, hemostasis, decontamination, and sterilization effects.[13] Thereby, patient compliance was comparatively better with lasers than with other techniques.[2]

In this study, better results were obtained in the LLLT with the HA group than in the other groups. Hyaluronic acid, also known as hyaluran, is considered to improve healing of surgical wounds and was used in this study to limit the inflammation caused by the heat produced by irradiation. Hyaluronic acid has an anti-edematous effect. Also, HA has an anti-inflammatory effect as it scavenges and drains the components that increase inflammatory activities.[19] The effects of HA in wound healing can be categorized into three phases. Firstly, in the inflammatory phase, where HA allows inflammatory cell migration. Secondly, in the proliferative phase, where HA draws fibroblasts to the wound site, it promotes keratinocyte migration and proliferation. Thirdly, in the remodeling phase, HA contributes to promote normal healing and to increase wound strength progressively.[11]

Several studies have shown that HA has superior effects in wound healing.[11,20] In laser-induced wounds, HA can hasten the wound healing process, especially through secondary intention.[21–23]

In terms of safety, laser-assisted depigmentation procedures were safe, with hemostasis and hastened wound healing. However, as a precautionary measure, before applying the laser, both the operating staff and the patients wore special laser-protective eye glasses corresponding to the laser wavelength. Highly reflective instruments or those with mirrored surfaces were avoided.

Based on a review of the literature, no similar studies have been performed evaluating the clinical effectiveness of LASER, LLLT, and LLLT + HA on gingival depigmentation. An important finding of this study is that PBM combined with HA gel topical application can produce superior results with very minimal recurrence. This noninvasive modality can be an effective alternative to invasive surgical depigmentation procedures.

Limitations and Strength

The present study has a few limitations. Firstly, the sample size was very small. Secondly, we evaluated only smile perception changes using VAS scoring. Other operator outcomes, such as Dummett oral pigmentation index, Hedin index, or patient-related outcomes, such as pain scores, are necessary to obtain more conclusive results. Moreover, the study has been followed up only for 3 weeks. A longer follow-up of at least for 6 months is necessary for assessing the recurrence of pigmentation.

Despite these limitations, our study is the first published trial to evaluate and compare laser-assisted depigmentation, LLL-assisted depigmentation and LLL-assisted depigmentation with HA gel.

Conclusion

In conclusion, we suggest that PBM combined with HA gel topical application can produce superior results with very minimal recurrence. Also, LLLs alone have also shown better results. This noninvasive modality can be an effective alternative to invasive surgical depigmentation procedures. For better reliable results, studies must be performed in future with larger included samples, and a follow-up period that is longer than the present study should be considered.

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