Journal of
Lasers
in Medical Sciences

J Lasers Med Sci. 2025;16:e57

Original Article

http://journals.sbmu.ac.ir/jlms

doi 10.34172/jlms.2025.57

Effect of Low-Level Laser Therapy on Reversal of Soft Tissue Local Anesthesia in Children: A Randomized Clinical Trial

Alaa M. Eldehna[1*], Amira A Mohamed[2], Sherine Badawy[3], Mohammed H Mostafa[1]

[1]Department of Pedodontics and Oral Health, Faculty of Dental Medicine for Girls, Al-Azhar University, Cairo, Egypt
[2]Egyptian Ministry of Health, Cairo, Egypt
[3]Department of Pediatric Dentistry, Fujairah University, Fujairah, UAE

***Correspondence to**
Alaa M. Eldehna,
Email: alaaaldehna.26@azhar.edu.eg

Received: March 25, 2025
Accepted: September 6, 2025
ePublished: November 17, 2025

Abstract

Introduction: Prolonged numbness after local dental anesthesia in children can cause significant discomfort, patient anxiety, and risk of accidental lip or cheek injury, limiting normal eating and speaking. Current reversal approaches may require additional injections and risk side effects, underscoring the need for safer alternatives. Recent advances suggest photobiomodulation (PBM) by low-level laser therapy (LLLT) may accelerate recovery, but clinical data in pediatric dentistry remain limited.
Methods: In a randomized clinical trial, 20 children with 40 affected teeth were divided into two groups: Group I received anesthesia with 1:100,000 epinephrine, while Group II received 1:200,000 epinephrine. Using a deactivated laser, a split-mouth design was used to compare the laser-treated and control sides. Anesthesia withdrawal was evaluated at 15-minute intervals following patient-reported resolution of numbness. Data were analysed using a paired t-test.
Results: Group I showed statistically significant differences from the control in all parameters except chin and cheek numbness. Group II exhibited statistically significant differences in all parameters except chin and cheek numbness resolution and recovery of normal lip sensation.
Conclusion: LLLT at 650 nm accelerated anesthesia withdrawal compared to standard conditions, with enhanced effects observed at higher V.C. concentrations. LLLT effectively reduces anesthesia duration by inducing vasodilation and improving blood flow to the irradiated area.
Keywords: Photobiomodulation, Laser, Local anesthesia, Low-level laser therapy, Diode laser

Introduction

Adequate pain management is essential for efficient behavior management in children during dental procedures. Local anesthetics are a primary strategy for pain control, but they present challenges due to their prolonged effects. While most dental procedures take less than an hour, the numbing effect typically lasts 3 to 5 hours. This extended period of numbness can lead to complications, particularly in pediatric patients. In a study of 320 participants, 13% of all patients experienced postoperative soft tissue trauma like lip biting with a trauma frequency of 18% (<4 years of age), 16% (4–7 years of age), 13% (8–11 years of age), and 7% (>12 years of age).[1] Additionally, prolonged numbness can cause patient anxiety and difficulties in eating, speaking, and drinking.[2] Dental professionals must carefully balance effective pain management with these potential drawbacks, especially when treating children.

The long-acting action of dental anesthesia is due to the presence of vasoconstrictors, which improve the depth and duration of anesthesia. Without them, local anesthetics have a very short duration of action intraorally. The most common agent for this purpose is epinephrine, which is available in formulations of 1:50,000, 1:100,000, and 1:200,000. Vasoconstriction is due to epinephrine's stimulation of α1 receptors in mucous membranes. However, it also stimulates the ß1 receptor in the heart, increasing heart rate, contraction strength, and myocardial oxygen consumption, as well as the ß2 receptors.[3]

Several modalities have been introduced to counteract the effects of long-lasting anesthesia, including the use of vasoconstrictor-mediated antagonists. Phentolamine mesylate (PM) is one such medication used to increase blood flow in the injection area, helping to eliminate the anesthetic solution more quickly. Despite its potential benefits, the clinical use of PM has been the subject of debate due to concerns regarding possible side effects.[4] Also, Hydralazine hydrochloride (HCl) reduces the duration of local anesthesia through two primary mechanisms. Firstly, it functions as a vasodilator, similar to PM (Oraverse), thereby enhancing the systemic absorption of the anesthetic. Secondly, it lowers the pH at the injection site by increasing the hydrogen ion concentration, which shifts the anesthetic equilibrium

Please cite this article as follows: Eldehna AM, Mohamed AA, Badawy S, Mostafa MH. Effect of low-level laser therapy on reversal of soft tissue local anesthesia in children: a randomized clinical trial. *J Lasers Med Sci.* 2025;16:e57. doi:10.34172/jlms.2025.57.

toward its cationic form. This reduces the diffusion of the drug into nerve tissues, subsequently diminishing its anesthetic effect and promoting faster recovery. A notable limitation of HCl is the requirement for a second injection, which may affect its clinical practicality.[5]

Laser technology was originally developed for dental purposes, and it is now used in several oral applications. Lasers are generally classified into high-power and low-power types. High-power lasers are used for cutting, vaporization, and coagulation; for example, they are used for gingival removal to expose restoration areas, correction of abnormal frenal attachments, modification of gingival architecture, management of gingival hyperplasia caused by drugs, cosmetic gingival contouring, and treatment of aphthous ulcers and herpes labialis lesions. The low-level laser, which is of interest to us, is also known as photobiomodulation (PBM). It provides analgesic effects by promoting endorphin release, boosts the immune system by balancing cellular and humoral immunity, enhances antioxidant activity in the blood, stabilizes lipid peroxidation in cell membranes, stimulates erythropoiesis, promotes vasodilation, helps normalize the blood's acid-base balance, and exerts reflexogenic effects on the functional activity of various organs and systems. Since it is a non-invasive and safe treatment modality, many children may experience laser treatment on their first visit to the dentist; accordingly, there is a possibility that a new generation of patients will grow up with a different attitude towards dental care.[6]

Extensive research has examined the therapeutic effects of laser therapy on biological tissues through PBM. This non-invasive technique uses low-power light (5–500 mW) and produces non-thermal effects, which stimulate healing, reduce inflammation, and promote optimal cellular function. These biological effects occur due to near-infrared (NIR) light absorption by chromophores such as cytochrome c oxidase (CCO), the terminal enzyme in the mitochondrial electron transport chain. Increased oxygen consumption and photodissociation of nitric oxide are believed to enhance blood flow to the irradiated area, thereby improving tissue healing. PBM typically uses wavelengths ranging from 600 to 1100 nm. The effectiveness of this therapy depends on various factors, including the light source, wavelength, energy density, light pulse structure, and duration of laser application. Understanding and optimizing these parameters is crucial for maximizing the therapeutic benefits of PBM in various clinical applications[7].

The null hypothesis stated that PBM therapy would not affect the duration of soft tissue local anesthesia.

In this study, we aimed to evaluate the effectiveness of PBM therapy using a diode laser in enhancing microcirculation in the anesthetized region, potentially accelerating the elimination of the anesthetic drug and reducing prolonged numbness.

Materials and Methods

Ethical Aspects

The parents who agreed to participate with their children in this study were informed of its objectives and characteristics, and they signed an informed consent form. Twenty children aged 6 to 9 years were selected from patients attending the pediatric department's outpatient clinic.

Sample Size Calculation

The sample size was calculated based on a previous study,[8] as a reference. If the mean ± the standard deviation of the laser group was 145.15 ± 23.27 minutes, while the estimated mean difference with a control group was 16 minutes, the study needed 20 patients (split-mouth design, 40 in both groups), with a 0.68 effect size. When the power was set at 80%, the type 1 error probability (alpha) associated with this test was set at 0.05%. The sample size was determined using two dependent t-tests (matched pairs used in the split-mouth technique) using G*Power 3.1.9.7.

Study Design and Allocation of Participants

Twenty patients with 40 affected teeth were allocated into two groups (Figure 1). The split-mouth technique was implemented for each patient, with the 650 nm LLLT applied on one side and the sham laser (deactivated laser) on the contralateral side. For each patient, "side" referred to the right or left halves of the same dental arch, meaning that treatment was performed either on both upper teeth (right vs. left) or on both lower teeth (right vs. left), but not a combination of upper and lower teeth in the same patient. During separate visits, the order of interventions was randomized to minimize potential carryover effects.

- Group (I): 10 Patients were anesthetized with 4% articaine containing 1/100,000 epinephrine.
- Group (II): 10 Patients were anesthetized with 4% articaine containing 1/200,000 epinephrine.

Participants were randomly allocated to the intervention and control groups using a computer-generated random

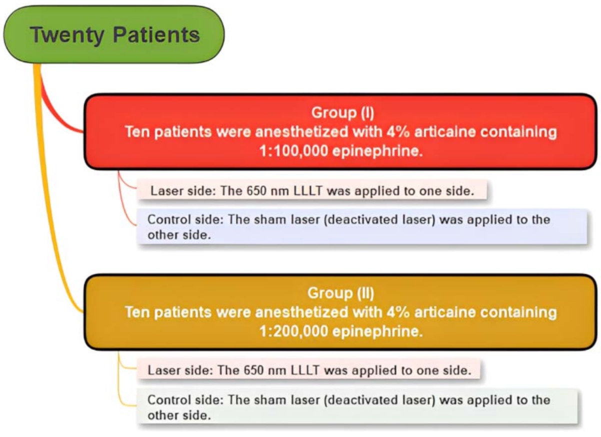

Figure 1. Sample Grouping

sequence. The allocation list was prepared in advance by an independent researcher using (random.org - Sequence Generator) with a 1:1 allocation ratio. Each assignment was placed in a sealed, opaque, sequentially numbered envelope to ensure allocation concealment until the moment of assignment.

Blinding

The operator performing the laser irradiation was aware of the allocation, as they were responsible for applying the active or deactivated laser to the designated side. However, participants, outcome assessors, and data analysts were blinded to the allocation. To maintain masking, the control side was treated with the deactivated laser for the same duration and with the same application technique as the active treatment side**.** Participant flow through the trial is presented in the CONSORT flow diagram (Figure 2).

Inclusion Specifications

The study included patients requiring bilateral lower or upper first primary molar treatment. The included patients must be cooperative and able to properly evaluate the soft tissue anesthesia. All patients were classified as ASA I, indicating they were healthy with no systemic diseases or medically compromising conditions.

Exclusion Specifications

The study excluded children who showed any signs of inflammation and those who were mentally disordered or handicapped. Moreover, patients with any systemic diseases and current or recent medication use that could interfere with laser therapy or anesthesia effects were excluded from the study.

Self-experimental Pilot Study

A pilot study was conducted on the researcher, who

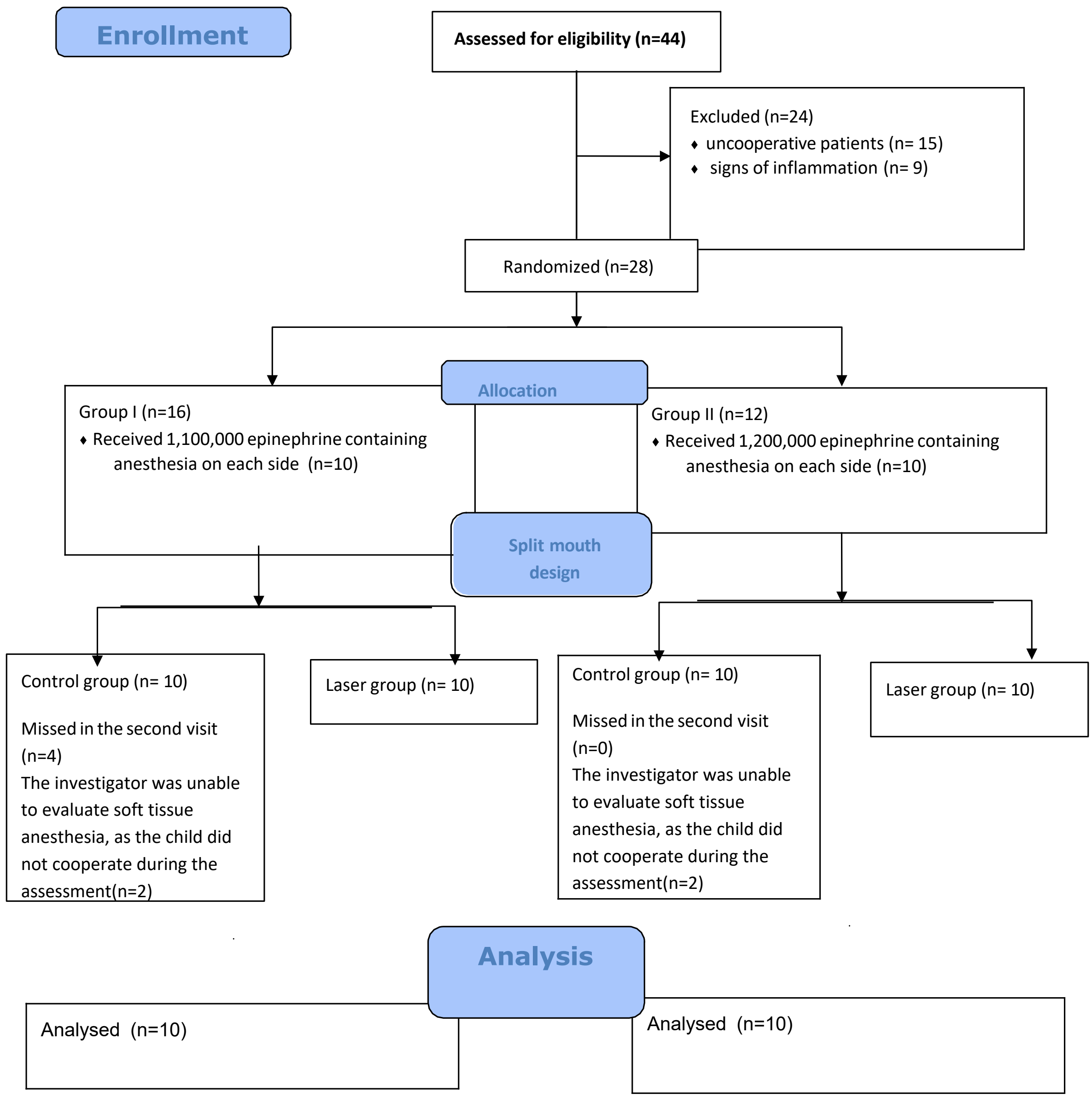

Figure 2. CONSORT Flow Diagram Illustrating the Enrolment, Allocation, Follow-up, and Analysis of Participants in the Study

received anesthesia after obtaining ethical committee approval. The aim was to determine the most effective laser wavelength for this trial. Two different laser wavelengths were utilized in the study: two diode lasers with wavelengths of 650 nm[9] and 980 nm,[10] each with two distinct sets of parameters.

For the 650 nm wavelength diode laser, the first set of parameters used 200 mW power intraorally and extraorally, and the time of application was 30 seconds per point. The second set of parameters used 50 mW power intraorally and 100 mW power extraorally, and the time of application was 20 seconds per point.

For the 980 nm wavelength diode laser, the first set of parameters was 200 mW power intraorally and 400 mW power extraorally, and the time of application was 20 seconds per point. The second set of parameters was 500 mW power intraorally and 1000 mW power extraorally, and the time of application was 30 seconds per point. The spot size used was 17 mm intraorally and 22 mm extraorally.

No changes were observed in the duration of anesthesia withdrawal for the 980-nm wavelength. The 65 nm wavelength demonstrated a notable difference. The researcher employed a 650-nm diode laser in this study, taking into account the findings from the pilot study.

Clinical Procedure

Initially, the patient was informed that the assessment of soft tissue anesthesia through palpation and evaluating the anesthesia at the injection site through probing would be performed before administering the first injection. Any child who was unable to express their emotions or demonstrate cooperation was excluded from the study.

Then, the patients were divided into two groups. Ten patients received 1.4 mL of 4% articaine cartridge containing 1:100,000 epinephrine, and the other 10 received 1.4 ml of 4% articaine cartridge containing 1:200,000 epinephrine. The same operator did dental injections for all patients.

Anesthesia Withdrawal by Photobiostimulation Mode of Diode Laser

After 20 minutes of injection corresponding to the approximate time of treatment, a 650-nm diode laser (LX16Plus, Woodpecker, China) with a flat-top profile (FT) handpiece of 17 mm external diameter was used intraorally, and 22 mm was used extraorally. The irradiation was done in continuous wave and contact mode with mild pressure. The laser beam covered a target-size area of 2.269 cm^2 intraorally and 3.8 cm^2 extraorally. The patient received irradiation of the laser at 7 points. The time of irradiation per point was 25 seconds. The irradiated points were as follows: 2 points at the injected site, 2 points on the lip, 1 point on the lip commissure, 1 point below the vermillion at the injection site, and the last point was on the chin or cheek, depending on whether the tooth was upper or lower (Figure 3). The power used was 50 mW intraorally and 100 mW extraorally, and the energy delivered to the tissues per point was 1.25 J intraorally and 2.5 J extraorally. The energy density per point was 0.5 J/cm^2 intraorally and 0.65 J/cm^2 extraorally. The total energy density was 4.25 J/cm^2 (Table 1). During irradiation, both the operator and patient wore safety goggles.

Clinical Assessment

Determining the anesthesia withdrawal was done by observing the return of the lip to normal appearance (after being tilted slightly during anesthesia) and also by asking the following questions:

1. Do you feel pain? (on probing at the injection site).
2. Do both sides of your lips feel the same? (on palpation of the anesthetized side compared to the other side)
3. Is the tingling sensation gone (numbness in the cheeks and chin)?

This assessment was conducted at 15-minute intervals and upon the patient's report of complete alleviation of numbness. Subsequently, the data were recorded.

Statistical Analysis

Statistical analysis was performed with SPSS 20®, GraphPad Prism®, and Microsoft Excel 2016. All data were presented as minimum, maximum, mean, and standard deviation values. A paired t-test was used to compare the duration of anesthesia.

Results

Group I

Table 2 and Figure 4 compare control and laser treatments for various oral health indicators in group I patients.

- Pain on probing: Laser treatment resulted in significantly less pain (114.17 ± 18.1) compared to control (145.00 ± 13.12), $P = 0.0001$, with a 30.83 ± 13.44 difference between them.
- Removal of numbness: No significant difference between laser (231.67 ± 34.72) and control (230.00 ± 78.68) groups as $P = 0.92$, with a 1.6 ± 53.06

Table 1. Irradiation Parameter

Parameter (unit)	Extraorally	Intraorally
External diameter of the flat top handpiece (mm)	22 mm	17 mm
Exposure duration (s)	25 per point	25 per point
Number of points irradiated	5	2
Application technique	Contact mode	Contact mode
Beam spot size at target (cm^2)	3.8 cm^2	2.269 cm^2
Power	100 mW	50 mW
Radiant energy per point (J)	2.5 J	1.25 J
Radiant exposure (J/cm^2)	0.65 J/cm^2	0.5 J/cm^2
The total energy density	4.25 J/cm^2	

Table 2. Descriptive Results of Pain on Probing, Removal of Numbness, Normal Sensation of Lip, Normal Appearance of the Lip, And Normal Smiling in Control and Laser Groups Regarding Group I, Comparison Between Control and Laser Using Paired T Test

Group I		Descriptive				Paired Differences					*P* Value
		Minimum	Maximum	Mean	Standard Deviation	Mean	Standard Deviation	Standard Error Mean	95% Confidence Interval of the Difference: Lower	95% Confidence Interval of the Difference: Upper	
Pain on probing	Control	120.00	165.00	145.00	13.12	30.83	13.44	4.25	-40.45	-21.22	0.0001*
	Laser	90.00	155.00	114.17	18.10						
Removal of numbness	Control	70.00	315.00	230.00	78.68	1.67	53.06	16.78	-36.29	39.62	0.92
	Laser	175.00	285.00	231.67	34.72						
Normal sensation of lip	Control	135.00	285.00	227.50	43.30	21.67	27.00	8.54	-40.98	-2.35	0.03*
	Laser	125.00	260.00	205.83	40.00						
Normal appearance of the lip	Control	135.00	320.00	243.33	58.87	20.83	5.27	1.67	-24.60	-17.06	0.0001*
	Laser	125.00	305.00	222.50	57.34						
Normal smiling	Control	135.00	320.00	247.50	51.37	19.17	24.89	7.87	-36.97	-1.36	0.04*
	Laser	125.00	305.00	228.33	56.06						

Figure 3. Seven Points of Application of the Laser. A: point on the labial side of the site of injection, B: point on the chin area, C: 2points on the lip, D:2 points on the site of injection intraorally, and E: point on the corner of the mouth

difference between them.

- Normal sensation of lip: Laser group (205.83 ± 40) achieved normal sensation significantly faster than control (227.50 ± 43.3), as $P = 0.03$ with a 21.67 ± 27 difference between them.
- Normal appearance of the lip: Laser treatment (222.50 ± 57.34) resulted in significantly faster return to normal appearance compared to control (243.33 ± 58.87), as $P = 0.0001$, with a 20.83 ± 5.27 difference between them.
- Normal smiling: Patients in the laser group (228.33 ± 56.06) regained normal smiling significantly quicker than control (247.50 ± 51.37), as $P = 0.04$, with a 19.17 ± 24.89 difference between them.

Group II

Table 3 and Figure 5 compare control and laser treatments for various oral health indicators in group II patients.

- Pain on probing: Laser treatment resulted in significantly less pain (49.17 ± 23.78) compared to control (75.83 ± 21.02), $P = 0.0001$, with a 26.67 ± 14.86 difference between them.

- Removal of numbness: No significant difference between laser (121.67 ± 56.36) and control (154.17 ± 55.11) groups, as $P = 0.06$, with a 32.50 ± 45.56 difference between them.
- Normal sensation of lip: No significant difference between the Laser group (108.33 ± 32.98), which achieved normal sensation faster than the control (118.33 ± 27.96), as $P = 0.22$ with a 10 ± 23.78

Table 3. Descriptive Results of Pain on Probing, Removal of Numbness, Normal Sensation of Lip, Normal Appearance of the Lip, and Normal Smiling in Control and Laser Groups Regarding Group II, Comparison Between Control and Laser Using Paired T Test

Group II		Descriptive				Paired Differences					*P* Value
		Minimum	Maximum	Mean	Standard Deviation	Mean	Standard Deviation	Standard Error Mean	95% Confidence Interval of the Difference		
									Lower	Upper	
Pain on probing	Control	50.00	100.00	75.83	21.02	-26.67	14.86	4.70	-37.30	-16.04	0.0001*
	Laser	10.00	95.00	49.17	23.78						
Removal of numbness	Control	70.00	235.00	154.17	55.11	-32.50	48.56	15.36	-67.24	2.24	0.06
	Laser	40.00	240.00	121.67	56.36						
Normal sensation of lip	Control	55.00	145.00	118.33	27.96	-10.00	23.78	7.52	-27.01	7.01	0.22
	Laser	65.00	165.00	108.33	32.98						
Normal appearance of the lip	Control	175.00	290.00	225.83	40.00	-71.67	61.29	19.38	-115.51	-27.82	0.0001*
	Laser	75.00	250.00	154.17	59.16						
Normal smiling	Control	155.00	290.00	210.83	40.94	-21.67	29.08	9.20	-42.47	-0.86	0.04
	Laser	125.00	250.00	189.17	35.47						

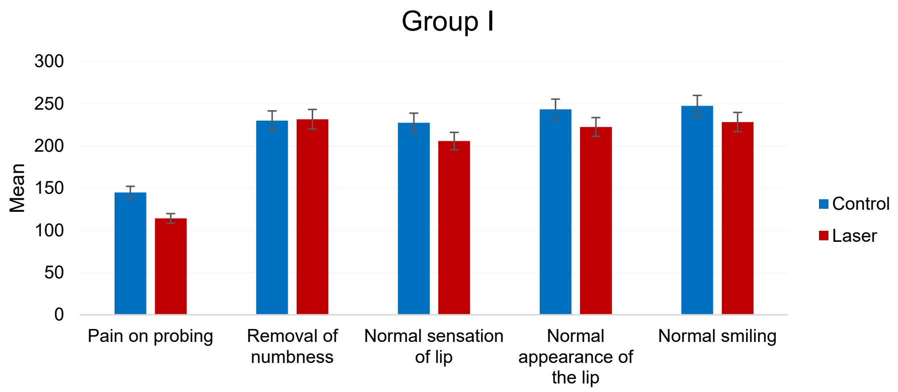

Figure 4. Bar Chart Showing Pain on Probing, Removal of Numbness, Normal Sensation of Lip, Normal Appearance of the Lip, and Normal Smiling in the Control and Laser Groups (With Low Concentration of Vasoconstrictor)

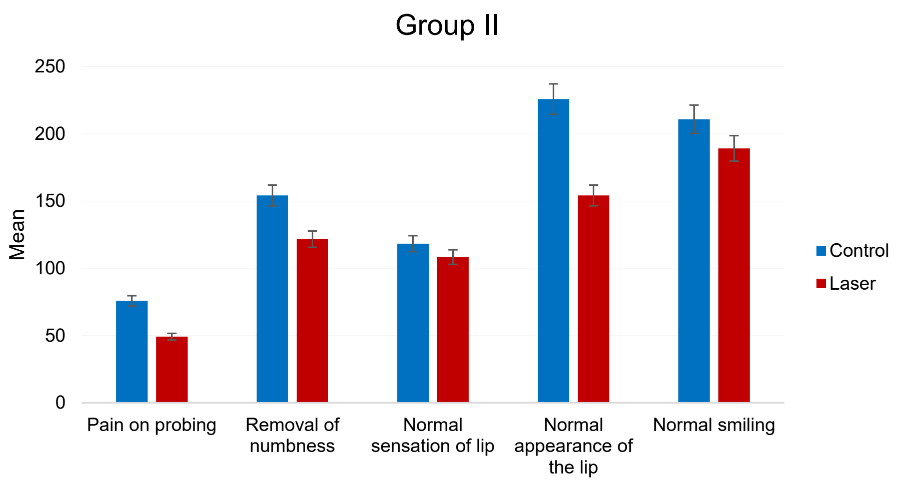

Figure 5. Bar Chart Showing Pain on Probing, Removal of Numbness, Normal Sensation of Lip, Normal Appearance of the Lip, and Normal Smiling in Control and Laser Regarding Group I I(With High Concentration of Vasoconstrictor)

difference between them.

- Normal appearance of the lip: Laser treatment (154.17 ± 59.16) resulted in significantly faster return to normal appearance compared to control (225.83 ± 40), as $P = 0.0001$ with a 71.67 ± 61.29 difference between them.
- Normal smiling: Patients in the laser group (189.17 ± 35.4) regained normal smiling significantly quicker than control (210.8 ± 40.9), as $P = 0.04$, with a 21.67 ± 29.08 difference between them.

Discussion

In pediatric dentistry, patients often express dissatisfaction with the prolonged anesthetic effects that persist after dental procedures. This extended numbness can cause discomfort and impair a child's ability to eat and drink normally, while also increasing the risk of accidental lip and cheek biting. The prolonged effect is largely due to the inclusion of vasoconstrictors in local anesthetic solutions. These sympathomimetic drugs act directly on adrenergic receptors and also stimulate epinephrine release from adrenergic nerve terminals. The activation of alpha receptors causes smooth muscle contraction in blood vessels, resulting in vasoconstriction, which prolongs the anesthetic effect but may also cause complications[11]. Understanding these mechanisms is crucial for developing strategies to balance effective pain management with patient comfort and safety in pediatric dental care. In this study, lip biting was observed in one patient in the control group.

To address concerns regarding prolonged anesthesia in pediatric dentistry, medications like PM (Oraverse) have been developed to reduce the duration of anesthesia withdrawal. While effective, this approach presents challenges, particularly for pediatric patients, as it requires a second injection. Moreover, it carries potential adverse cardiovascular effects, including arrhythmias, tachycardia, hypotension, and shock. Patients may also experience additional side effects such as headaches, sweating, nausea, diarrhoea, visual disturbances, miosis, and hypoglycemia. These limitations highlight the need for alternative methods to manage prolonged anesthesia effects in pediatric patients, balancing efficacy with safety and practicality.[12]

This study explores the potential of PBM therapy using laser technology as an alternative approach to managing prolonged anesthesia effects in pediatric dentistry. We focus on this method due to its minimally invasive nature and the minimal to negligible side effects it offers in counteracting the effects of vasoconstrictors. By investigating this innovative technique, we seek to provide a safer and more comfortable solution for pediatric patients, addressing the challenges associated with extended anesthesia duration while avoiding the drawbacks of pharmacological interventions.

Previous research has demonstrated that PBM using LLLT induces vasodilation and enhances blood flow to the irradiated area.[13-15] This effect is attributed to the observed arteriolar dilation, which appears to be associated with a decrease in calcium ion concentration ([Ca^{2+}]) in microvascular smooth muscle cells.[13] These findings suggest that PBM could potentially counteract the vasoconstriction caused by local anesthetics, offering a promising approach to managing prolonged anesthesia effects in dental procedures.

The pilot study aimed to identify the optimal wavelength and parameters for LLLT in anesthetic withdrawal. The primary researcher volunteered for the study, undergoing anesthesia and multiple LLLT sessions to determine the most effective parameters. The wavelength used was a 650-nm diode laser based on a pilot study and previous research that indicated better outcomes than the 980-nm wavelength. The efficacy of the 650-nm wavelength may be attributed to its optimal absorption by hemoglobin, which is prevalent in blood, as opposed to other types that exhibit diminished absorption. This absorption results in efficient heating and subsequent vasodilation, enhancing blood circulation in the targeted tissues.[16]

For intraoral application, the study employed a power of 50 mW for 25 seconds with a 17-mm spot size, delivering 1.25 J of energy per point. In contrast, for extraoral application, the parameters were adjusted to a power of 100 mW for the same duration but with a 22-mm spot size, yielding 2.5 J of energy per point (Figure 3). These carefully selected settings optimized the PBM effect while ensuring patient safety and comfort throughout the procedure (Table 1).

This study utilized a split-mouth design to enhance the precision and efficiency of evaluating the effectiveness of laser therapy. By comparing the laser-treated side to the control side within each patient, the research team established a standardized method for assessing the impact of the laser relative to the untreated area. The investigation focused on the effects of laser therapy across different vasoconstrictor (VC) concentrations, with group I receiving VC at 1:100,000 and group II at 1:200,000. This approach enabled the researchers to evaluate not only the efficacy of laser therapy in reducing anesthesia duration but also its interaction with varying VC concentrations. Consequently, the study provides valuable insights into the potential of the treatment across diverse clinical scenarios, contributing to a more comprehensive understanding of its applications and effectiveness.

The outcome of this study aligns with a prior investigation[8] that employed 810-nm diode laser irradiation to reverse the anesthesia of lidocaine 2% with 1:100,000 epinephrine, revealing a significant difference in the duration of anesthesia between the two groups ($P < 0.001$). In the current study, we test a new wavelength of LLLT, incorporate additional details into the withdrawal process, and examine multiple concentrations of VCs to update the data in this research area.

Group I, which received a higher VC concentration, demonstrated highly significant differences in anesthesia withdrawal compared to the control group. These differences were particularly notable in pain on probing, numbness removal, normal lip sensation recovery, and normal smiling. However, the resolution of numbness in the chin (lower arch) and cheek area (upper arch) did not show a significant improvement (Table 2 and Figure 4), possibly due to the extensive area involved, requiring additional laser application points. The study revealed that laser therapy had a more pronounced effect at higher VC concentrations, achieving significant results in the recovery of normal lip sensation. This finding is particularly important for preventing lip biting, a common concern among pediatric dental patients, thus enhancing both safety and comfort in clinical practice.

In group II, which received a lower vasoconstrictor concentration, significant differences were observed in pain on probing, removal of numbness, and normal smiling compared to the control side. However, the resolution of numbness in the chin and cheek areas, as well as the recovery of normal lip sensation, did not show a significant improvement (Table 3 and Figure 5). The limited effect of laser therapy in this group can be attributed to the reduced amount of vasoconstrictor used, which typically does not require an extended withdrawal period under normal circumstances. Notably, the non-significant result regarding lip sensation recovery is particularly crucial, as it provides an important contrast to the findings in group I and contributes valuable insights to the overall study outcomes.

The most significant observation across all measurements reported in the two groups is the intraoral pain on probing. This is only an objective result, as it provides accurate and precise data that reflects pain, in contrast to other subjective measurements that depend on average responses from different children. Another concern is that the laser may have a greater effect on the intraoral mucosa than on the extraoral skin. Consequently, the parameters in the extraoral approach may require modification in future studies.

The limitations of the study indicated that the efficacy of LLLT in reducing numbness in the chin and cheek regions was less significant. This signifies that additional research is required to improve treatment settings and application methodologies.

Conclusion

Within the limitations of the present clinical study, it has been clearly shown that photo-biomodulation via LLLT at 650 nm significantly affects the acceleration of anesthesia recovery, demonstrating a notable difference in the withdrawal of anesthesia between the irradiated and non-irradiated areas. The data indicate that the effectiveness of laser therapy in diminishing anesthesia duration is significantly enhanced when combined with elevated concentrations of vasoconstrictor, potentially providing a superior approach for addressing extended numbness in dental procedures.

While our sample size was based on prior power calculations and aligns with similar studies, its modest size, particularly for subjective endpoints, may have contributed to wide confidence intervals and non-significant findings in group II; future larger-scale studies with more objective measures are recommended. Recommendations involve investigating diverse laser parameters and additional application sites to enhance treatment protocols. Additionally, comparative studies with existing reversal agents such as PM are essential for establishing best practices in pediatric dental anesthesia management.

Authors' Contribution

Conceptualization: Alaa M. Eldehna, Mohammed H Mostafa, Sherine Badawy.
Data curation: Amira A Mohamed, Sherine Badawy.
Formal analysis: Mohammed H Mostafa.
Investigation: Alaa M. Eldehna, Mohammed H Mostafa, Amira A Mohamed.
Methodology: Alaa M. Eldehna, Amira A Mohamed.
Project administration: Amira A Mohamed, Sherine Badawy.
Resources: Mohammed H Mostafa, Sherine Badawy.
Software: Alaa M. Eldehna, Amira A Mohamed.
Supervision: Alaa M. Eldehna, Mohammed H Mostafa.
Validation: Mohammed H Mostafa, Amira A Mohamed.
Visualization: Alaa M. Eldehna, Amira A Mohamed, Sherine Badawy.
Writing–original draft: Alaa M. Eldehna, Amira A Mohamed.
Writing–review & editing: Alaa M. Eldehna, Amira A Mohamed.

Competing Interests

no financial and non-financial conflicts of interest.

Ethical Approval

The study was approved by the Research Ethics Committee (REC) of the Faculty of Dental Medicine for Girls, Al-Azhar University. with the primary Code (P-PE-23-06) and final Code (REC-PE-24-02). This research was also registered with Clinical Trials ID NCT06193460.

Funding

The authors declare that no funds, grants, or other support were received during the preparation of this manuscript.

Informed Consent

The parents who agreed to involve their children in this study were aware of the objectives and characteristics and signed an informed consent form.

References

1. Sardana D, Lee J, Yiu CK, Li KY. Effectiveness of phentolamine mesylate in reversal of local anesthesia: systematic review and meta-analysis. J Evid Based Dent Pract. 2023;23(3):101861. doi: 10.1016/j.jebdp.2023.101861.
2. Chi D, Kanellis M, Himadi E, Asselin ME. Lip biting in a pediatric dental patient after dental local anesthesia: a case report. J Pediatr Nurs. 2008;23(6):490-3. doi: 10.1016/j.pedn.2008.02.035.

3. Haas DA. An update on local anesthetics in dentistry. J Can Dent Assoc. 2002;68(9):546-51.
4. Prasanna JS. OraVerse: reverses numbness after dental procedures. J Maxillofac Oral Surg. 2012;11(2):212-9. doi: 10.1007/s12663-011-0318-6.
5. Martens LC. Laser physics and a review of laser applications in dentistry for children. Eur Arch Paediatr Dent. 2011;12(2):61-7. doi: 10.1007/bf03262781.
6. Fakheran Esfahani O, Pouraboutaleb MF, Khorami B. Effect of hydralazine on duration of soft tissue local anesthesia following dental treatment: a randomized clinical trial. Gen Dent. 2015;63(5):39-42.
7. Dompe C, Moncrieff L, Matys J, Grzech-Leśniak K, Kocherova I, Bryja A, et al. Photobiomodulation-underlying mechanism and clinical applications. J Clin Med. 2020;9(6):1724. doi: 10.3390/jcm9061724.
8. Seraj B, Ghadimi S, Hakimiha N, Kharazifard MJ, Hosseini Z. Assessment of photobiomodulation therapy by an 8l0-nm diode laser on the reversal of soft tissue local anesthesia in pediatric dentistry: a preliminary randomized clinical trial. Lasers Med Sci. 2020;35(2):465-71. doi: 10.1007/s10103-019-02850-0.
9. Fabre HS, Navarro RL, Oltramari-Navarro PV, Oliveira RF, Pires-Oliveira DA, Andraus RA, et al. Anti-inflammatory and analgesic effects of low-level laser therapy on the postoperative healing process. J Phys Ther Sci. 2015;27(6):1645-8. doi: 10.1589/jpts.27.1645.
10. Saydjari Y, Kuypers T, Gutknecht N. Laser application in dentistry: irradiation effects of Nd:YAG 1064 nm and diode 810 nm and 980 nm in infected root canals-a literature overview. Biomed Res Int. 2016;2016:8421656. doi: 10.1155/2016/8421656.
11. Malamed SF. Handbook of Local Anesthesia-E-Book. Elsevier Health Sciences; 2019.
12. Dodwad R, Raghu KN, Kaslekar M, Shetty V, Antony A, Salma U, et al. Local anesthesia reversal–a review. Int J Oral Health Dent. 2021;7(2):89-93. doi: 10.18231/j.ijohd.2021.020.
13. Maegawa Y, Itoh T, Hosokawa T, Yaegashi K, Nishi M. Effects of near-infrared low-level laser irradiation on microcirculation. Lasers Surg Med. 2000;27(5):427-37. doi: 10.1002/1096-9101(2000)27:5<427::Aid-lsm1004>3.0.Co;2-a.
14. Buzinari TC, de Moraes TF, Conceição-Filho JC, Cárnio EC, Almeida-Lopes L, Salgado HC, et al. Nitric oxide storage levels modulate vasodilation and the hypotensive effect induced by photobiomodulation using an aluminum gallium arsenide (AlGaAs) diode laser (660 nm). Lasers Med Sci. 2022;37(6):2753-62. doi: 10.1007/s10103-022-03551-x.
15. Keszler A, Lindemer B, Weihrauch D, Jones D, Hogg N, Lohr NL. Red/near infrared light stimulates release of an endothelium dependent vasodilator and rescues vascular dysfunction in a diabetes model. Free Radic Biol Med. 2017;113:157-64. doi: 10.1016/j.freeradbiomed.2017.09.012.
16. Jawad HJ, Sultan AF. Review recent developments in high-power diode lasers for biomedical applications. J Opt. 2025;54(3):763-8. doi: 10.1007/s12596-024-01778-1.