Journal of Lasers in Medical Sciences

J Lasers Med Sci. 2025;16:e70

Original Article

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

doi 10.34172/jlms.2025.70

Evaluation of the Effect of Light Emitting Diodes Therapy (LEDT) to Reduce the Recovery Period of Rhinoplasty

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Received: July 16, 2025
Accepted: November 3, 2025
ePublished: December 27, 2025

Abstract

Introduction: Rhinoplasty, as one of the most common cosmetic surgeries, can cause several postoperative complications. Management of the early complications, such as edema and ecchymosis, can reduce patients' concerns and shorten the recovery period. Several methods have been applied to reduce these complications. Recently, light-emitting diode therapy, which operates on the principles of photobiomodulation, has gained some attention in managing these complications. Its ability to enhance tissue healing and shorten the recovery period can play a role in improving postoperative outcomes. This study evaluates the effects of light-emitting diode therapy on ecchymosis, edema, and wound healing after rhinoplasty.

Methods: A randomized controlled clinical study was conducted. Sixty patients who underwent rhinoplasty were included. Patients were randomly assigned to either the control or intervention group. The intervention group received light-emitting diode therapy using red light (660nm) three times a day for 10 minutes at each session, over 14 days. The effects of light-emitting diode therapy on early postoperative complications, such as ecchymosis, edema, and the wound healing process, were evaluated. The outcomes were compared between the two groups.

Results: In the intervention group, patients had a significant reduction in ecchymosis and edema at one and two weeks after the surgery compared to the control group. Pairwise comparison in the intervention group revealed that ecchymosis reduced significantly during first and second weeks ($P<0.001$ and $P=0.03$, respectively). However, edema showed significant improvement primarily during the second week ($P<0.001$). This suggests a slower resolution rate for edema. Additionally, the rate of wound healing was significant in the intervention group at two weeks post-surgery ($P=0.037$), with further notable improvement observed at one month ($P<0.001$). No adverse effects were reported.

Conclusion: Light-emitting diode therapy can reduce early postoperative complications, such as ecchymosis and edema, and accelerate wound healing during the first two weeks after rhinoplasty.

Keywords: Rhinoplasty; Low level laser therapy; Edema; Ecchymosis; Wound healing.

Introduction

Rhinoplasty is one of the most common performed surgical procedures globally, aimed at modifying the structure and function of the nose.[1] Open and closed approaches are two common techniques for nasal modification. Regardless of the chosen approach, several complications may occur, including discomfort, edema, periorbital hematoma, and ecchymosis.[2] Furthermore, due to the vital role of the nose in respiration, immune defense, and olfaction, as well as facial aesthetics, special attention is required to shorten the recovery period following rhinoplasty. Therefore, the management of postoperative complications has significant importance during the recovery period.

Many studies have been done to improve cosmetic outcomes and reduce the complications following rhinoplasty, including tissue inflammation, edema, ecchymosis, and pain.[3-5] These findings indicate that corticosteroid administration and the application of certain surgical methods, such as osteotomies and dissection planes, may be beneficial in reducing inflammation and ecchymosis.[6-9] Nonetheless, conventional management strategies, such as cryotherapy and corticosteroid

Please cite this article as follows: Hoseini A, Barikbin B, Razzaghi Z, Rahnamay Farnood P, Ajam S. Evaluation of the effect of light emitting diodes therapy (LEDT) to reduce the recovery period of rhinoplasty. *J Lasers Med Sci.* 2025;16:e70. doi:10.34172/jlms.2025.70.

administration, may not sufficiently mitigate these issues.[10, 11]

Photobiomodulation therapy (PBMT), commonly known as low-level laser therapy (LLLT), has shown a promising effect in wound healing through accelerating tissue repair.[12] In recent years, light-emitting diode therapy (LEDT) has emerged as a promising non-invasive adjunct for enhancing postoperative recovery. This therapy operates on the principles of PBM, where specific wavelengths of light (600-1000 nm) stimulate cellular activity, thereby enhancing tissue repair and mitigating inflammation.[13] Evidence suggests that LED therapy can accelerate wound healing through mechanisms such as increased collagen synthesis, enhanced microcirculation, and reduced oxidative stress.[14] Li et al [15] suggested that 630-nm LED can mediate NF-κB signaling pathways and therefore exert an anti-inflammatory effect. In fact, LLLT photons are absorbed by mitochondrial chromophores, leading to the photodissociation of nitric oxide (NO), increased production of reactive oxygen species (ROS), and thereby stimulating stem cell activation.[16]

Preliminary investigations into the application of LEDT in clinical settings have indicated potential therapeutic effects, such as shortened recovery period, reduced bruising and erythema, and improved appearance of scars.[17, 18] A study by Karimi and colleagues suggested that applying photobiomodulation on the first postoperative day after rhinoplasty can effectively reduce ecchymosis.[4] The favorable safety profile and ease of application further support the integration of LEDT into postoperative care protocols.

Nonetheless, only a limited number of studies have examined the effect of PBMT in rhinoplasty patients, particularly regarding ecchymosis. Furthermore, to date, no studies have evaluated the efficacy of LEDT in concurrently addressing ecchymosis, edema, and the wound healing process after rhinoplasty.

Hence, this study tries to rigorously evaluate the efficacy of LEDT in reducing the recovery period following rhinoplasty by analyzing clinical outcomes such as edema, ecchymosis, and the wound healing rate at the incision site. Through this study, we will seek to provide some empirical evidence that may inform better practices in postoperative care for rhinoplasty patients.

Methods

Study design

A randomized, blinded, controlled clinical trial with a parallel-group design and a 1:1 allocation ratio was conducted to evaluate the efficacy of LEDT in improving postoperative complications and shortening the recovery period after rhinoplasty. Sixty patients aged 18-70 years of both sexes who underwent rhinoplasty for aesthetic or functional purposes were enrolled. Also, revision rhinoplasty cases were not included. Patients were selected from Central City Clinic, a private clinic in Tehran, between November 2022 and November 2024. This trial was conducted following the Declaration of Helsinki and reported in accordance with the CONSORT 2010 guideline.

Patient selection

The inclusion criteria were defined as the following: Participants aged 18-70 years, who had undergone rhinoplasty, and were willing to participate in the study and complete the treatment and follow-ups. Patients were informed about the procedures during the study, and after obtaining written consents, they were enrolled. All data and identities of patients were kept confidential.

Participants with a history of diabetes, secondary hypertension (hypertension in the presence of an identifiable disease), LEDT contraindications, photosensitivity, seizure, and congenital malformation were excluded from this study. Also, pregnant and breastfeeding women were not included. Patients with seasonal or persistent allergic rhinitis were also excluded from the study. Furthermore, all patients underwent a preoperative CT scan, and any detected sinus or mucosal disease was treated before surgery.

Intervention Protocol

All patients in the study underwent septorhinoplasty, which was performed by one of the authors (AH) using an external incision approach. In this approach, internal lateral and medial osteotomies were carried out under general anesthesia. For reshaping and repositioning the nasal cartilages and bones, an internal splint was placed following the surgery and then removed after 7 days. Patients received routine postoperative orders (IV fluids, cefazolin, and acetaminophen IV), and the only prescribed analgesic at discharge was oral acetaminophen. Following removal of the splint, patients were instructed to apply nasal taping for 2 months to support nasal shaping and reduce unintended edema.

To mitigate postoperative complications, photobiomodulation therapy was performed in the intervention group. In this group, patients were instructed to use the LED device three times a day for 10 minutes each session, over 14 days at home. The device was handed to the patients, and all necessary instructions were provided as follows. Patients were advised to continue nasal taping as usual and to apply the LED treatment each night after removing the tape. No skin preparation, such as gel or cream, was required before LED exposure. In addition, patients were carefully trained on how to turn on and hold the device at a distance of 5-10 cm from the nasal bridge and periorbital region without direct contact. Also, they were asked to cover their eyes with protective goggles and to avoid using the device over any open or infected wounds.

The portable MedoMars LED device (Tehran, Iran) was used in this study (Figure 1). The treatment protocol was irradiation of red light with a wavelength of 660 nm, at dose of 10 J/cm^2, in continuous mode, and power of 500mW. The protocol used was based on the manufacturer's instructions, which were aligned with the treatment protocol of the World Association of Laser Therapy (WALT) guidelines.

Finally, patients were assessed for ecchymosis, edema, and incision site characteristics before and after LEDT. These assessments were conducted by two expert dermatologists who were independent of the study and blinded to the group assignment at the following intervals: 24 hours, one week, two weeks, and one month after the surgery.

Randomization and Allocation

In this randomized controlled trial, patients were allocated to the intervention and control groups in a 1:1 ratio. A computer-generated random sequence was created using Excel software. Group assignment was concealed by allocating patients with odds numbers to one group and those with even numbers to the other. Enrollment continued sequentially until the predetermined sample size was reached. The evaluators who rated outcomes of both groups were blinded to group assignment. In the intervention group, patients received LEDT, while in the control group, only routine postoperative care was given.

Sample size

The sample size was calculated based on the effect size reported in the randomized controlled trial by Taş et al,[8] considering the study power of 90% and significance level of 5% and 10% miss to follow-up. The sample size for each group was calculated as 30 patients based on the following formula.

$$n = \frac{1}{1-f}\frac{(z_{1-\frac{\alpha}{2}} + z_{1-\beta})^2(s_1^2 + s_2^2)}{(\bar{X}_1 - \bar{X}_2)^2}$$

Outcome Measures

In this trial, demographic characteristics, as well as postoperative data, including ecchymosis, edema, and the rate of wound healing, were collected. Digital photographs were taken before the rhinoplasty, after 24 hours, one week, two weeks, and one month postoperatively using a Canon EOS 6D camera. Photos were taken in a standardized manner, with the camera positioned 1m from the patients at the same distance each time. Based on the collected photos, two independent dermatologists who were blind to the group assignment assessed and rated the patients' complications, including the severity of edema, extension of ecchymosis, and the rate of wound healing progress. The assessors rated each complication during the aforementioned period using a 1 to 4 scale as shown in Table 1. Subsequently, the scores for each patient were collected and used for statistical analysis.

Statistical analysis

Data were analyzed with SPSS for windows 26.0 (IBM Corp Released 2016, NY, USA). Comparison within and between groups was performed by Mann-Whitney U and Wilcoxon ranked tests. Within-group comparison was done with the Friedman test. The level of significance for all statistical tests was set at $P < 0.05$.

Results

During the study period, a total of 74 patients were screened, and 60 of them met the inclusion criteria for recruitment. Patients were allocated equally to the intervention and control groups, as shown in Figure 2. In this study, 60 patients, of whom 54 (90%) were female, were evaluated. The mean age of patients was 29.05±9.72 (Rang: 18-51) years. In each group, 30(50%) patients were enrolled. Twenty-nine (96.7%) patients in the intervention group and 25 (83.3%) patients in the control group were female (P value = 0.195). The mean age was 28.47±9.09 and 29.63±10.43 years in the intervention and control

Figure1. Portable MedoMars LED device. Protective goggles were worn prior to use

Table 1. Scoring system for ecchymosis, edema, and the rate of wound healing

Rating	Ecchymosis	Edema	Wound healing
1	No ecchymosis	No edema	Localized erythema around the wound with a clean, well-approximated suture line and no unusual inflammation
2	Mild: Localized to the nasal area	Mild: Presence of edema with visible nasal band marks	Erythema and inflammation extending beyond the wound margin with clean, well-approximated suture line
3	Moderate: Extending to the nasal and buccal areas	Moderate: Localized to the nasal region with obscured nasal band marks	Severe inflammation with wound separation and poorly-approximated suture line
4	Severe: Extending beyond the buccal area	Severe: Extending beyond the nasal region, involving the buccal and periorbital areas	Presence of infection or granulation tissue and dehiscence of the suture line

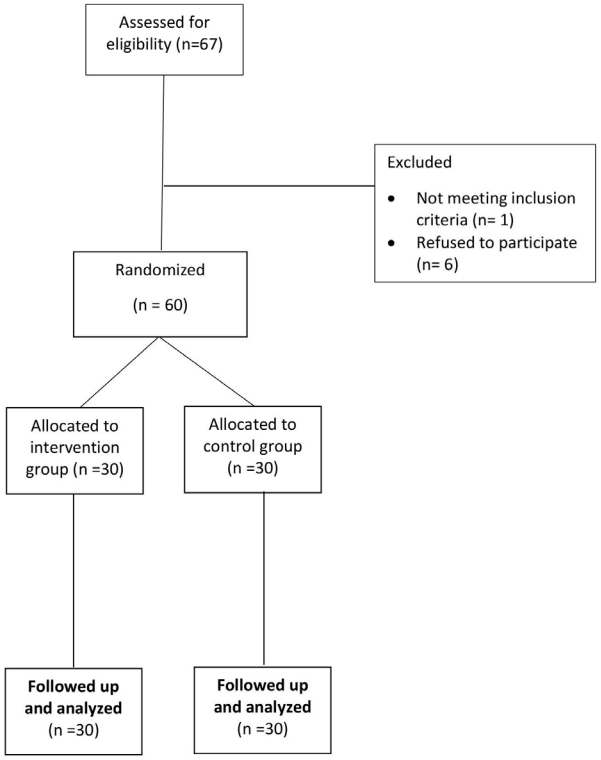

Figure 2. Consort flow chart

groups, respectively (*P* value = 0.888). All participants completed the study, and no dropouts occurred during the follow-up period.

Two evaluators showed concordance, with Cronbach's alpha values of 0.96, 0.77, and 0.85 for each item. The comparison of the median rank for each item within and between groups is shown in Table 2.

Both intervention and control groups had significant improvement in all three times after 1 month.

Within-group pairwise comparisons showed that the control group did not have a significant reduction in Ecchymosis from Day 1 to Week 1 and from Week 1 to Week 2. In contrast, these comparisons were significant in the intervention group.

Moreover, the intervention group demonstrated significantly lower median scores for ecchymosis and edema at 1week and 2 weeks following the surgery (*P* value at one week: 0.001 and 0.0001; at two weeks: 0.032 and 0.0001, respectively).

Moreover, during the follow-ups, ecchymosis did not recur in any of the patients. None of the participants experienced any adverse effects during the study period while using the LED device.

Table 2. Comparison of median of rank for each item within and between groups

	Time	Intervention group	Control group	*P*-value
Ecchymosis	1 day	3.5(1-4)	3.25(2-4)	0.883
	1 weeks	2.5(1-4)	3(1-4)	0.001
	2 weeks	1(1-2.5)	2(1-3)	0.032
	1 month	1(1-1)	1(1-2)	0.308
P value		<0.001	<0.001	
Edema	1 day	4(3-4)	4(3-4)	0.116
	1 weeks	2(1.5-3.5)	3(2-4)	0.0001
	2 weeks	1.5(1-2)	2(1-3)	0.0001
	1 month	1(1-1)	1(1-2)	0.381
P value		<0.001	<0.001	
Wound healing	1 day	3(2-4)	3(2-4)	0.819
	1 weeks	2(1-3)	2(1-3)	0.003
	2 weeks	1(1-2)	1(1-2)	0.636
	1 month	1(1-1)	1(1-1)	-
P value		<0.001	<0.001	

Discussion

As one of the most common plastic surgeries, rhinoplasty can cause different postoperative complications. Patients are usually concerned about the early complications after rhinoplasty, especially ecchymosis, edema, and the wound healing process. To reduce the ecchymosis, which occurs as a result of subcutaneous bleeding, the submembranous dissection and drainage of the bleeding during the surgery have been performed. Moreover, the inflammatory response of the soft tissue to trauma forms swelling and edema, which can affect the final result of the surgery. Furthermore, the wound healing process and formation of scar tissue are other concerns of patients seeking rhinoplasty. Several approaches have been employed to mitigate these complications, including surgical technique modifications, corticosteroid administration, herbal supplements, and the use of various taping, casting, and massage methods. It is worth mentioning that proper postoperative care is a key factor in achieving the best final results.

The biological effects of LLLT, such as reducing inflammation, pain, and edema, as well as accelerating tissue regeneration, have received attention for their clinical applications. LLLT is emerging as a non-invasive, safe modality for managing postoperative complications. LEDT devices have been developed to enhance cellular function and accelerate the wound healing process. Therefore, to reduce the aforementioned complications and achieve the best possible results, this study aimed to examine the efficacy of LEDT on rhinoplasty outcomes.

The current study results showed that both intervention and control groups experienced significant improvement in all three outcomes within the first month postoperatively, which can be attributed to the natural healing process.

Importantly, we observed that ecchymosis and edema were reduced significantly in the intervention group compared to the control group at one and two weeks following the surgery (Figure 3). Pairwise comparisons within the intervention group revealed that ecchymosis subsided significantly during both the first and second weeks after the surgery. However, a significant improvement in edema was observed only during the second week. This indicates that although LLLT can subside the ecchymosis and edema effectively during the early postoperative period, the rate of edema resolution is slightly slower compared to ecchymosis. Nonetheless, edema can still be reduced significantly with laser therapy over time.

Regarding the wound healing process, the median rank of wound healing was significantly lower in the intervention group compared to the control group at one week post-surgery. This suggests a more favorable outcome with laser therapy after one week. Pairwise comparison showed that the incision site had improved considerably during the second week post-surgery compared to the first week. In other words, LLLT can accelerate wound healing during the initial postoperative period, which is known as the early phases of tissue repair.

Studies have investigated the effect of pulsed-dye laser (PDL) treatment on ecchymosis of different causes, including after facial cosmetic procedures.[19,20] A rapid resolution of ecchymosis following PDL was observed in these studies. Furthermore, it has been reported that LEDT, using an 830nm wavelength, can accelerate the resolution of sequelae following aesthetic procedures, such as hematoma, edema, and erythema.[21] In a clinical trial, Karimi et al [4] examined the efficacy of PBM on periorbital ecchymosis following rhinoplasty. A three-step treatment regimen, using red light (660nm), infrared light (840nm), and infrared laser was applied on the first day post-surgery. Their results demonstrated a significant and rapid reduction of ecchymosis at one week after surgery, with a less pronounced effect observed at one month. This is in concordance with our findings, in which we observed a lower median rank in the intervention group compared to the control group at one week and two weeks, suggesting a more effective reduction at these points. However, in our study, the patients' follow-up at one month did not reveal any significant difference between the ranks of these groups. The observed discrepancies at one month could be related to differences in patient characteristics, assessment methods, and variation in LLLT protocols across studies.

Experimental studies have shown that LEDT can reduce edema formation by decreasing pro-inflammatory cytokines, such as IL-1β, IL-6, and TNF-α.[22] Moreover, clinical studies have reported that postoperative edema can be reduced effectively using LEDT in dental surgery and facial trauma, as it enhances lymphatic drainage and promotes the reduction of inflammation.[23] This reduction was significant within 24 hours and throughout the first postoperative week.[24] Similarly, Baek and colleagues demonstrated that treatment with LEDT (590/830 nm wavelengths) from day 1 to day 5 following traumatic facial bone fracture can significantly resolve edema compared to the sham treatment.[23] These studies were consistent with our findings that LEDT can decrease

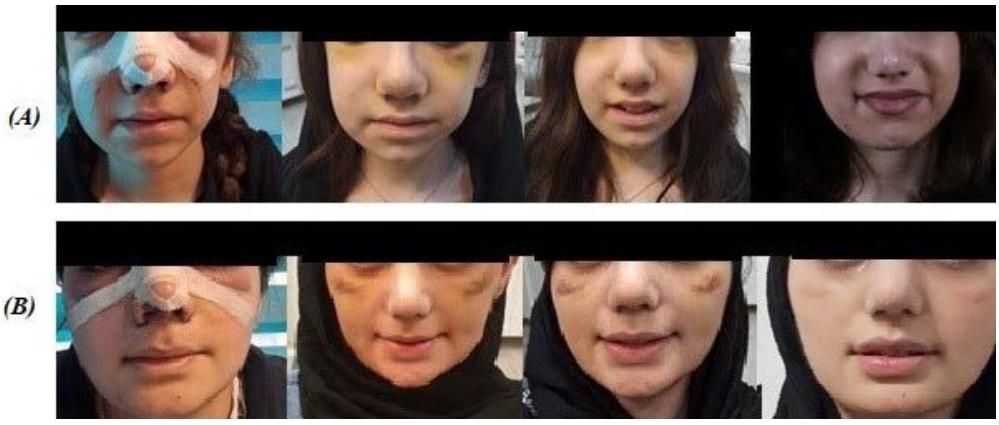

Figure 3. Post-operative recovery of edema and ecchymosis after rhinoplasty. Clinical photographs were taken at 1 day, 1 week, 2 weeks, and 1 month post-operation. (A) The intervention group received LLLT for 14 days post-surgery. (B) The control group received routine postoperative care only

edema during the first postoperative weeks.

Moreover, LEDT can promote wound healing by increasing ATP synthesis, which is involved in the stimulation of fibroblast proliferation, collagen synthesis, and granulation tissue formation. Studies have shown that both red (633nm) and near-infrared (830 nm) wavelengths can lead to neovascularization and increase the blood flow.[25] Besides, various cytokines and macromolecules- such as FGF, VEGF, BDNF, IL-1α, IL-2, and IL-4 - are activated by LLLT, thereby enhancing the wound healing process. In addition, studies have indicated that LLLT can accelerate tissue repair and improve scar quality in surgical wounds.[26] These findings support our results showing enhanced wound healing during the first postoperative weeks, which is considered the early phase of tissue repair.

One limitation of our study is that subjective variables, such as the Visual Analogue Scale (VAS), were not included. This was due to the inability to blind patients to the intervention, which may affect their postoperative satisfaction and cause bias in self-reported outcomes. Future studies with different treatment protocols, including subjective variables, and enrolling larger, multicenter patient populations can provide better insight into the efficacy of this modality. In addition, laser therapy was free of charge in this study. However, the cost of the devices and treatment sessions may cause some challenges to the widespread application of this modality. Therefore, the cost-effectiveness of this treatment should be evaluated.

Conclusion

This study demonstrated that LEDT can reduce the early complications after rhinoplasty. Edema and ecchymosis were significantly alleviated during the first two weeks post-surgery. In addition, the wound healing process was accelerated during this period. These findings suggest that applying this non-invasive modality may be beneficial in the postoperative care of aesthetic surgery. While these results are promising, further studies are required to evaluate the long-term effects and to optimize treatment protocols.

Acknowledgements

We sincerely thank all the patients who participated in our research. We also express our gratitude to Dr. Anoosh Shafiee and Dr. Somayeh Hejazi, dermatologists, for their valuable guidance and collaborative support in data collection.

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Competing Interests

The authors declare that they have no competing interests.

Ethical Approval

The study protocol was registered with the Iranian Registry of Clinical Trial (ID: IRCT20111121008146N36) and approved by Shahid Beheshti Medical Science University Authority Research Ethics Board (IR.SBMU.RETECH.REC.1400.355).

Funding

None.

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