

The Effect of Low-Level 980-810 nm Diode Laser on Postoperative Pain of Crown Lengthening Surgery

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ABSTRACT

Introduction: Low-level laser therapy is utilized to manage postoperative pain after periodontal surgery. This study investigated the impact of low-level diode lasers at 980 and 810 nm on postoperative pain following surgical crown lengthening procedures.

Method: This single-blind clinical trial and split-mouth study was conducted on 20 patients who needed bilateral crown lengthening in maxillary premolar teeth. Among samples, one side of the maxilla was randomly chosen for laser treatment and the other one for the control group. As soon as the operation was completed, the dual laser was simultaneously irradiated with 980 and 810 nm wavelengths in the test group's treatment area. Pain intensity was evaluated based on the number of analgesic capsules consumed by patients and through a visual analog scale. The data were analyzed using SPSS software version 26 through repeated measures ANOVA, paired t-test and Wilcoxon ($P < 0.05$).

Results: On days one ($p = 0.002$), two ($p = 0.003$) and four ($p = 0.033$), the mean pain intensity measured by VAS was significantly lower for patients following the crown lengthening surgery in the laser group compared to controls. The mean number of analgesics consumed by patients was significantly lower in the low-level laser group than the control group on days 1 ($p = 0.003$), 2 ($p = 0.042$) and 4 ($p = 0.033$). Finally, pain intensity and the number of analgesics consumed by patients significantly decreased in both the control and laser groups from day 1 to day 7 ($p < 0.001$).

Conclusion: Simultaneous irradiation of low-level diode 980 and 810 nm lasers led to a notable decrease in pain intensity and number of analgesics used after crown lengthening respective surgery.

Keywords: low-level laser therapy, crown lengthening surgery, pain.

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INTRODUCTION

Periodontal health is a prerequisite and indispensable component in successful dental treatment. The treatment of active periodontal infection should be prioritized before initiating restorative or aesthetic treatments to achieve long-term goals related to convenience, good performance, predictable treatment outcomes and treatment persistence, as well as convenience in restorative and maintenance care (1). Sometimes, patients cannot take the necessary measures before their treatment to ensure adequate clinical crowns and complete the restoration margins, which can lead to complications and failure. Crown lengthening surgery should be performed to prevent violation of the biological width. The biological width is relatively constant at about 2 mm. A minimum distance of three millimeters should be maintained between the gingival margin and the bone crest (2).

The application of crown lengthening surgeries is for correcting uneven smile lines, gummy smiles, dental fractures, caries and dental abrasion caused by parafunctional habits like bruxism. The common method of crown lengthening surgery includes surgical incision, bone remodeling and recontouring with or without gingivectomy (3). Surgery is associated with pain, discomfort, stress and, sometimes, prolonged wound healing (4).

Postoperative complications during the initial stage of recovery after periodontal surgery can undermine patient's confidence in treatment. Postoperative pain was associated with open flap debridement in 79% of patients, and 89% of subjects reported pain following periodontal surgery (5). A study conducted in 2019 evaluated the postoperative complications following periodontal surgery among 3900 patients. Postoperative complications were observed following the crown lengthening surgery in 16% of cases. The most common complications included dentin hypersensitivity, severe pain, postoperative bleeding, edema and delayed wound healing (6). Controlling postoperative pain is an essential component of periodontal treatment, which results from tissue trauma and the release of inflammatory mediators, peaking after the administration of local anesthesia (7, 8).

Low-level laser therapy has been proposed as a method to reduce postoperative pain. It has

more advantages over analgesics and non-steroidal anti-inflammatory drugs (NSAIDs) because the therapeutic protocol of the anti-inflammatory effect of this type of laser overlaps with its potential in wound healing progression. The analgesic mechanism of a low-level laser is still unclear. Numerous studies have mentioned physiological changes resulting from the interaction of light with various cells as the underlying cause. The mechanisms include the stability of the lipid bilayer membrane and its proteins, improving the recovery system and increasing ATP production (7, 8). This laser can reduce inflammation and matrix metalloproteinase-8 (MMP-8) levels to prevent the increased activity of plasminogen and prostaglandin synthesis. Studies have shown that low-level laser therapy may decrease interleukin-1 beta (IL-1 β) levels, with their extent depending on the duration of irradiation. Meanwhile, interferon gamma (IFN- γ) can also be reduced while exerting stimulatory effects on producing platelet-derived growth factor (PDGF) and transforming growth factor (TGF) (9).

The low-level laser can modify the inflammation process in a dose-dependent manner, thereby reducing inflammatory pain. In cases of acute pain, the best results are achieved when low-level laser therapy is administered within the first 72 hours after surgery (7, 8). Generally, the effects of low-level laser therapy are exerted through non-heating mechanisms, leading to the stimulation of fibroblast production (10). *In vitro* and *in vivo* experiments have shown that low-level lasers can accelerate healing (11, 12).

In some studies, the effect of low-level laser therapy has been shown to reduce pain following endodontic, periodontal and tooth extraction surgeries (13, 14). Nevertheless, very few studies have evaluated the effect of irradiation of low-level laser on the level of pain following crown lengthening surgery (4, 15). So far, no study has examined the impact of concurrent irradiation of two wavelengths of low-level diode laser 810-980 nm on the pain level following crown lengthening surgery. Thus, our study aimed to examine the effect of low-level laser 810-980 nm on the pain level after crown lengthening surgery. $\square$

METHOD

This single-blind split-mouth clinical trial study was conducted on 20 patients who needed

crown lengthening. It was carried out in 2020, in the Periodontics Department of the Faculty of Dentistry at Jundishapur University of Medical Sciences, Ahvaz, Iran (ethics code: IR.AJUMS.REC.1399.632, registration code on the clinical trial website: IRCT20201102049237N1). Sampling was initiated after presenting information about the research procedure and its objectives, and obtaining written informed consent from eligible patients and assuring them of the confidentiality of their information.

The primary sampling method was convenience, based on specific inclusion and exclusion criteria. The inclusion criteria were participants aged 18 years and older, individuals needing bilateral crown lengthening surgery for the maxillary premolar teeth, those with good systemic health and those with no history of surgical procedures. The exclusion criteria included patients with active periodontal problems, those older than 60 years, smokers, individuals with a history of prolonged antibiotic and corticosteroid use or medications that could impact healing, pregnant women and patients with systemic diseases.

Preparation before surgery

In the first session, patients' characteristics (age, gender) and their medical records were completed. Participants were educated about oral health instructions using a rubber cup polishing procedure and they were included in the study when they could control the plaques.

Method of blinding and random allocation concealment

In this study, the surgical process was conducted as a single-blind study. Patients were unaware of which quadrant of the jaws would receive low-level laser therapy, with only the laser operator being informed. Each individual's mouth sides were randomly chosen as intervention or control using the dice-throwing method, with one side being treated with low-level laser therapy and the other one as control.

Surgical procedure

Before the surgical procedure, the patients rinsed their mouths with 0.2% chlorhexidine gluconate for 30 seconds. After local anesthesia infiltration using 2% lidocaine hydrochloride (HCl) with 1/100,000 epinephrine, the periodontal pocket depth was measured using a periodontal probe

(Williams, Denapouya, Iran) and the bleeding points on the external surface of the gingiva were determined. A periosteal elevator set the flap aside and the interdental incision was made using an interdental knife (Orban #1 and #2, Denapouya, Iran). After removing the soft tissue using a periodontal curette (Gracey #5-6, Denapouya, Iran) and sickle scaler (Denapouya, Iran), the distance between the sound edge of the dental structure and the bone crest was assessed using a probe. In regions where the distance was less than 4 mm, bone resective surgery was performed using rotary tools or an interdental chisel (KIRKLAND PERIODONTAL CHISEL # 13K/TG, Hue-Friday, USA) along with a Sugarman Bone file (Hue-Friday, USA). After osteotomy, the flap was positioned and sutured using simple or sling sutures (silk, 0-4, Supa, Iran).

Low-level laser irradiation

Immediately after surgery, a dual laser with wavelengths of 980 and 810 nm (QuickLase, England) irradiated the treatment region in the low-level laser therapy group. The laser had a power of 0.5 W and was applied using a Laser Therapy Prism (surface area 2.25 cm²) in continuous mode for 100 seconds to both the buccal and palatal flaps from a distance of 3 mm. For safety, both the operator and patients wore protective goggles. In the control group, the laser was used in the off mode as part of the single-blind method and the surgical intervention was terminated using the previous method. All operations were performed by the same surgeon in both groups. In addition, to eliminate any systemic effects of the laser, the interval between all operations in the laser and control groups was one month.

After surgery, all patients were prescribed an analgesic (ibuprofen 400 mg) and they were instructed to use the medication when they experienced pain and according to the severity of pain. In addition, chlorhexidine 0.2% was prescribed twice daily for one week. Brushing and flossing were prohibited in the surgical area for one week.

The pain level was measured by two methods: the number of capsules consumed by the patient and the visual analog scale (VAS) (a 100 mm horizontal line, where the left side represents no pain and the right side indicates unbearable pain). A form was provided to all patients, who were asked to note the surgical region, record the severity of pain and document the number of analgesic cap-

sules taken from the day of surgery for seven days after surgery. This study recorded the site of the region with the most severe pain associated with surgery. The VAS is a standard instrument used to measure pain intensity. The reliability and validity of the pain measurement scale have been examined and confirmed in numerous studies (16-18).

The data were analyzed using SPSS 26 (SPSS Inc., Chicago, IL, USA). First, the normality of distributional variables was assessed using the Kolmogorov-Smirnov test. Next, the repeated measures ANOVA, paired t-tests and Wilcoxon tests were employed ($p < 0.05$). □

RESULTS

On days 1 ($p = 0.002$), 2 ($p = 0.003$) and 4 ($p = 0.033$), patients' mean pain level was significantly lower in the laser group compared to the control one, as measured by VAS following crown lengthening surgery. Based on repeated measures ANOVA, patients' mean pain measured by VAS decreased significantly in the control and laser groups from days 1 to 7 ($p < 0.001$) (Table 1).

The number of analgesics consumed by patients following crown lengthening surgery was significantly lower compared to controls on days 1 ($p = 0.003$), 2 ($p = 0.042$) and 4 ($p = 0.033$). According to repeated measures ANOVA, the number of analgesics used by patients significantly decreased in both the control and laser groups from days 1 to 7 ($p < 0.001$) (Table 2). □

DISCUSSION

Postoperative pain management is crucial for assessing the efficacy of surgical interventions (14) and is a significant aspect of periodontal treatment (7). This pain results from tissue damage and the release of inflammatory mediators (7). As an alternative to systemic antibiotics and NSAIDs, low-level laser has been proposed as a protocol for pain management (14). In this method, the anti-inflammatory effect of the laser is complemented by its ability to improve wound healing, making it more advantageous than analgesics and NSAIDs (7). Another advantage of a low-level laser is the lack of any reported side effects, which leads to the promotion of tissue repair (19). This study examined the impact of dual-diode low-level lasers at 980 and 810 nm

TABLE 1. The mean and standard deviation (SD) of postoperative pain, as measured by the visual analog scale (VAS), on days 1-7 following crown lengthening surgery across the groups

Time of VAS assessment	Laser (n=20)	Control (n=20)	P-value
	Mean±SD	Mean±SD	
Day 1	27.55±8.59	32.70±7.63	0.002*
Day 2	17.60±9.30	21.80±8.43	0.003*
Day 3	8.85±8.53	11.15±8.42	0.169*
Day 4	1.60±3.03	4±5.26	0.032**
Day 5	0.0±0.0	0.30±0.97	1.000**
Day 6	0.0±0.0	0.0±0.0	1.000**
Day 7	0.0±0.0	0.0±0.0	1.000**
P-value#			
P-value#			

*: paired t-test; **: Wilcoxon test; #: repeated measure ANOVA

TABLE 2. The mean and standard deviation (SD) of the number of analgesics consumed by patients on days 1-7 after crown lengthening surgery across the groups

Time of VAS assessment	Laser (n=20)	Control (n=20)	P-value*
	Mean±SD	Mean±SD	
Day 1	2.40±0.88	3.10±0.78	0.003
Day 2	1.60±0.99	2.35±1.08	0.042
Day 3	0.9±0.85	1.05±0.82	0.248
Day 4	0.15±0.36	0.55±0.86	0.033
Day 5	0.0±0.0	0.0±0.0	1.000
Day 6	0.0±0.0	0.0±0.0	1.000
Day 7	0.0±0.0	0.0±0.0	1.000
P-value**	p<0.001	p<0.001	

*: Wilcoxon test; **: repeated measure ANOVA

on postoperative pain following resective crown lengthening surgery.

Since the degree of inflammation or pain intensity can vary among patients (20), the present study was designed as a split-mouth design to prevent bias. Thus, every person was in control of themselves.

The results showed that the simultaneous use of low-level laser diodes at 980 and 810 nm significantly reduced pain levels on days 1, 2 and 4 after crown lengthening surgery. In addition, the number of analgesic drugs consumed on days 1, 2 and 4 after crown lengthening surgery was significantly lower in the low-level laser group compared to the control one. Note there was no consensus on the role of medications in masking the effect of photobiomodulation (PBM), thereby leading to negative outcomes (14).

The analytical mechanism in low-level laser therapy is still unclear. Nevertheless, studies have shown that physiological changes resulting from light interference with various cells can explain the cause. The mechanisms include lipid bilayer

membrane stability and proteins, an enhanced recovery system and increased ATP production. The low-level laser can alter the inflammation process through a dose-dependent mechanism, thereby reducing inflammatory pain (7). There is also evidence that treatment with low-level laser therapy has significant neuropharmacological effects on the synthesis, release and metabolism of neurotransmitters such as serotonin and acetylcholine at the central level and histamine and prostaglandin at the peripheral level. This analgesic effect can be explained by the synthesis of endorphins and reduced activity of C fibers or bradykinin (20).

After scaling, low-level laser can reduce inflammation, inhibit MMP-8 and prevent the higher activity of plasminogen and prostaglandin synthesis. Studies have indicated that low-level laser therapy can reduce IL-1 β levels, and this effect depends on the irradiation duration (21). The IFN- γ can also be decreased while stimulating the PDGF and TGF- β production. Thus, the anti-inflammatory effects of laser therapy do not originate from only one mechanism; instead, various mechanisms are involved in this process. Briefly, the low-level laser affects cyclooxygenase-2 (COX-2), IL-1 β , MMP-8, PDGF, TGF- β , basic fibroblast growth factor (bFGF) and the expression of plasminogen (7).

Shafigh *et al* (2019) investigated the impact of an 810 nm wavelength low-level laser on postoperative pain after crown lengthening surgery and found a significant decrease in pain levels on the first day after surgery, which was consistent with the findings of the current study (15). In Shafigh *et al*'s study, patients did not use analgesic drugs after surgery. In this regard, the systematic review carried out by Zhao *et al* (2021) (14) also reported that photobiomodulation (PBM) as a complementary method in periodontal surgery can reduce pain on day 3 and decrease the consumption of analgesics within the first week postoperatively. The free gingival graft (FGG) procedure may also speed up the process of re-epithelialization after surgery (14). Sanz-Moliner *et al* (2013) reported that the use of an 810 nm laser diode following modified Widman flap surgery resulted in reduced pain and decreased the use of analgesic drugs (22). Özberk *et al* (2018) utilized a 980 nm low-level laser diode in necrotizing ulcerative gingivitis (NUG) patients. They reported that the use of this laser decreased pain and increased recovery speed (23). Hamid (2017) used a low-level

laser 810 nm after the third mandibular molar extraction surgery and found a reduction in pain similar to the current study (24). Derikvand *et al* (2018) (4) evaluated the effect of a low-level laser with a 980 nm wavelength on postoperative pain following crown lengthening surgery and observed that this laser could improve wound healing. Heidari *et al* (2018) also reported a significant reduction in pain following the use of a 980 nm low-level laser diode after non-moving flap surgery (25).

Daily use of low-level laser therapy is recommended to achieve optimal results and effectiveness (10). Ultimately, the biological effects of low-level lasers can depend on many factors, including wavelength, irradiated dose and the mode of radiation (continuous or pulsating) (26, 27). Further, some variables, such as age and gender, can be confounding variables in treatment (26, 27). Meanwhile, the absence of a standard method for laser usage among studies based on sample selection, sample size, control, as well as parameters of the low-level laser can reduce the effectiveness of pain mitigation postoperatively (24). $\square$

CONCLUSION

Concurrent use of low-level laser diodes at 980 nm and 810 nm significantly reduced pain and the number of analgesics required after crown lengthening surgery.

Study limitation and suggestion:

One of the limitations of this study was the small number of patients who needed bilateral maxillary premolar crown lengthening surgery. Another limitation during the covid-19 pandemic was the inability to administer laser radiation over multiple sessions to patients.

Future studies should evaluate the effects of low-level laser therapy in multiple sessions on wound healing. $\square$

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