

Anti-inflammatory and analgesic effects of low-level laser therapy on the postoperative healing process

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Abstract [Purpose] This study aimed to evaluate the anti-inflammatory and analgesic effects of intraoral application of low-level laser therapy (660 nm) to control pain, swelling and interincisal opening following the extraction of mandibular third molars. [Subjects and Methods] Ten patients underwent removal of lower third molars using the same surgical protocol and pharmacological approach. In the postoperative period, all patients received four consecutive daily sessions of low-level laser therapy, beginning 24 hours after the surgery. Intraoral applications using the diode laser with 660 nm wavelength in the continuous scan mode were performed covering the entire surgical area, which was divided into four quadrants, each of 1 cm² area at a distance of 1 cm. The energy applied at each point was 5 J/cm² during 8 seconds. [Results] The swelling and interincisal opening returned to normal 24 hours after the first low-level laser therapy application (Friedman test). Moreover, the pain intensity was reduced on the third postoperative day, according to the Friedman test. [Conclusion] Low-level laser therapy (660 nm), at the dosimetry used in this study, was effective in reducing postoperative pain and swelling following oral surgery.

Key words: Low-level laser therapy, Rehabilitation, Inflammation

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INTRODUCTION

Removal of third molars is a common procedure in oral surgery and it is associated with postoperative complications such as pain, swelling and trismus. Therefore, several medications such as corticosteroids and non-steroidal anti-inflammatory drugs are often recommended despite their common side effects such as bleeding, gastrointestinal irritation and allergic reactions, which can evoke discomfort and health risks in patients¹⁾.

In terms of strategies used to minimize tissue damage in oral surgeries, the low-level laser therapy (LLLT) seems to offer many benefits in the stimulation of the healing process and control of the inflammatory process by reducing the swelling and pain, with no reports of adverse effects²⁾.

According to Medeiros et al.³⁾, the effects of LLLT are

more evident in the early stages of wound healing. The use of polarized light helps in resolution of inflammation and in increasing the collagen deposition as well as the number of myofibroblasts. Moreover, it also fastens re-epithelialization during the experimental period. However, previous studies have reported that in teenagers, LLLT reduces pain intensity without modifying the healing process⁴⁾. On the other hand, LLLT showed better results in controlling swelling and trismus when compared to ozone therapy⁵⁾. However, Lopez-Ramirez et al.²⁾ found that LLLT showed no positive effects in reducing pain, swelling and trismus after the removal of third molars.

These differences in the effects of LLLT may be explained by the variability in the protocols and surgical procedures performed^{1, 2, 6)}.

The LLLT protocol should be determined considering the type of light used as well as the tissue layers that need to be irradiated. In this context, the red spectra in the visible to near-infrared spectra (620–830 nm) have the potential to stimulate photoreceptors in the plasma membranes of cells. The lower wavelengths are mainly absorbed by superficial tissues with red pigmentation. The higher wavelengths are absorbed by the deeper tissues and are less active in the surface tissues⁷⁾. Therefore, this study aimed to evaluate

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the efficacy of intraoral application of LLLT (660 nm) in controlling pain intensity, swelling and interincisal opening in oral surgery.

SUBJECTS AND METHODS

This study included 10 patients (7 women, 3 men, mean age 23 ± 6 years) and it was initiated after obtaining the approval of the Ethics in Research Committee (Protocol number: 512.476). All patients have signed a written informed consent prior to any procedure. The exclusion criteria were as follows: presence of local infections, various systemic diseases, smoking habit, use of oral contraceptives, pregnancy and lactation.

All patients underwent the same surgical protocol standardized by the same surgeon (R.L.N.). The same operator applied LLLT in all patients (H.S.C.F.). However, the values recorded for pain, swelling and trismus were assessed by a different surgeon in order to conduct a blind experiment. Before the laser application, the mean power of the equipment was measured and calibrated using the laser check power meter instrument.

Intraoral LLLT was applied using continuous scan mode at four different points, covering the entire suppurative surgical area, which was divided into four quadrants, each of 1 cm^2 area at a distance of 1 cm.

Preoperatively, all patients used a mouthwash with chlorhexidine (0.12%) and received a topical application of povidone-iodine (1%). Postoperatively, all patients received amoxicillin 500 mg, every 8 hours, for 7 days, ibuprofen 600 mg, every 8 hours, for 3 days, and paracetamol 500 mg, every 6 hours as rescue medication for pain during the first 72 hours. In cases with penicillin allergy, clindamycin was selected as the antibiotic at a dose of 300 mg, every 8 hours, for 7 days.

In this study, the laser model Endophoton LLT 0107 (KLD Biosystems Electronic Equipment Ltd., Amparo, SP, Brazil) with a pen station beam area of 0.035 cm^2 , AlGaInP visible diode with continuous wave (35 mW and wavelength of 660 nm) was used. The energy applied at each point was equal to $5 \text{ J/cm}^2/\text{dose}$, continuous rate for 8 seconds, as specified by the manufacturer.

The formula below was used to calculate the energy density (D), where the area (A: cm^2) corresponds to the broadcast area of the pen tip, power (P: W) corresponds to the maximum and constant power (20 mW or W 0.020) and the time (T) is measured in seconds.

$$D(J/cm^2) = \frac{P(W) \times T(s)}{A(\text{cm}^2)}$$

$$D(J/cm^2) = \frac{0.020(W) \times 8(s)}{0.035\text{cm}^2} = 4.57 J/cm^2$$

After applying the values supplied by the manufacturer in the formula, the energy density applied at each point was calculated to be 4.57 J/cm^2 multiplied by 4 quadrants of 1 cm^2 , resulting in a total of 18.28 J/cm^2 in each session. Considering previous reports of several authors, a dose of 3 J/cm^2 up to 6 J/cm^2 ,^{8,9)} has a regenerative action.

Four consecutive daily sessions, with the first session oc-

curing 24 hours after surgery, were applied. This protocol was chosen based on the fact that the process of wound repair is composed of 3 phases: inflammatory, proliferative, and remodeling phases involving the formation of collagen¹⁰⁾, and LLLT is more evident in the initial stages of healing²⁾. However, in this protocol, the acute phase of inflammatory process is avoided.

The outcome variables assessed were pain, interincisal opening, facial swelling, and presence of late infection. The experimental times considered in this protocol were as follows: t_0 (initial time), t_1 (24 h), t_2 (48 h), t_3 (72 h), t_4 (96 h), t_5 (120 h), t_6 (144 h), and t_7 (7 days after the surgery).

The interincisal opening was assessed by measuring with a caliper of maximum opening between the right upper and lower central incisors before surgery and in all subsequent sessions¹¹⁾.

To evaluate swelling, a measurement from one tragus to the opposite one was performed, according to method described by Schultz-Mosgauet et al¹²⁾.

All patients were instructed to register the daily intensity of pain, beginning 24 hours after surgery, for seven postoperative days, using a visual analogue scale (VAS) of 100 mm, in which the score for lack of pain was 0 (zero), and 100 (one hundred) was the score used for the worst imaginary pain.

All data were analyzed using GraphPad 5.0 (GraphPad Software, La Jolla, California, USA). The level of significance was set at $p < 0.05$ with a confidence interval of 95%.

RESULTS

This study included 10 patients (mean age: 23 ± 6.03 years) with asymptomatic third molars (no pain observed on the day prior to the surgery, as assessed by VAS). The average operative time was 29.45 ± 12.67 minutes. All data on the interincisal opening, swelling and pain intensity are shown in Table 1.

With regard to the interincisal opening, a statistical decrease was observed 24 hours after the surgery (Friedman test, $p = 0.0001$). Similarly, an increase in swelling was observed when comparing the initial condition and the first postoperative day (Friedman test, $p = 0.01$). Therefore, it may be noted that both the swelling and interincisal opening returned to normal condition 24 hours after the first LLLT application.

Concerning the pain intensity (assessed by VAS), no differences were observed between the first and second postoperative days (median: 49 *versus* median: 40). However, a reduction in pain intensity was observed immediately after the third postoperative day, reinforcing the possible effect of LLLT on pain (Friedman test, $p = 0.001$). Additionally, on the seventh day, the patients were asymptomatic. Even though the patients with a greater surgical duration had a slight increase in pain intensity on the first day, it was not statistically significant (Spearman's correlation, $p > 0.05$). Additionally, none of the analyzed cases had any late complications.

DISCUSSION

In this case series, we have focused on the local postop-

Table 1. All data on the interincisal opening, swelling, and pain intensity

Post-operative evaluation		T0	T1*	T2	T3	T4	T5
Interincisal opening (mm)	25th. quartile	45.0	32.2	36.7	33.5	38.0	43.5
	Median	47.5	37.0	43.5	43.0	44.0	48.0
	75th. Quartile	50.0	45.2	46.5	48.0	48.2	51.2
		T0	T1**	T2	T3	T4	T5
Swelling assessment (mm)	25th. quartile	271.5	271.5	273.3	273.0	271.0	273.5
	Median	280.0	283.5	283.5	280.5	279.5	283.5
	75th. Quartile	289.0	296.3	289.8	288.3	289.8	290.0
		T0	T1	T2	T3***	T4***	T5***
Pain intensity (100 mm)	25th. quartile		24.5	25.2	23.0	13.7	6.0
	Median		49.0	40.0	28.5	23.0	16.5
	75th. Quartile		70.2	54.0	45.0	29.7	25.2

* Statistically different from T0, Friedman Test, $p < 0.05$.

** Statistically different from T0, Friedman Test, $p < 0.05$.

*** Statistically different from T0, Friedman Test, $p < 0.05$.

erative clinical factors after removal of third molars, such as pain, swelling and trismus. Despite the proven efficacy of LLLT in the prevention of these factors, its mechanism of action is not yet fully known. Thus, studies with positive as well as negative results have been reported, due mainly to a poorly calculated dosimetry and lack of uniformity in laser application^{1, 2, 6}.

Sezer et al.¹³ found that only the diode laser with 808 nm wavelength were effective in reduction of trismus, whereas applying a laser diode with 660 nm wavelength was ineffective. Carrillo et al.¹⁴ showed that the incidence of trismus in the laser group (Helio neon, 633 nm with energy density of 10 J/cm²) was significantly lower than that in the placebo group seven days after extraction of third molars. Aras and Güngörmüş^{15, 16} found that irradiation with diode laser with wavelength of 808 nm and 4 J/cm² significantly decreases trismus.

Moreover, Lopez-Ramirez et al.² reported that LLLT (GaAlAs, 810 nm, energy density of 5 J/cm²) demonstrated no benefits in reducing pain and trismus after removal of impacted third molars. Similar results were described by Roynsdal and colleagues¹⁷ when applying LLLT with 830 nm 40 mW laser at 6 J.

According to Güngörmüş and Aras^{15, 16}, extraction of teeth can cause spasms of certain muscles, especially the masseter; therefore, applying an intraoral laser on a small area would not affect this muscle directly.

However, in this study, favorable results were verified, as the reduction in trismus was probably related to the relaxation effect of LLLT on other masticatory muscles such as masseter as well as the medial pterygoid.

López-Ramirez and colleagues² reported that LLLT was not statistically effective in the reduction of trismus. Amarillas-Escobar et al.¹⁸ conducted a similar study, but in order to assess the cumulative effect of the therapeutic laser, they applied multiple daily intraoral doses to the patients, immediately after surgery, and three sessions post-operatively (24, 48, and 72 h), using LLLT (660 nm). The results of this study showed no significant differences in reducing pain, swelling, or trismus between the laser and the control group, although

better conditions were noted in the laser group 24 hours after the application.

However, Sezer and colleagues¹³ found that only the diode laser (808 nm) was effective in biostimulation, whereas the diode laser (660 nm) was ineffective. However, the positive result observed at this study is probably due to the onset of laser application.

Although LLLT is considered to have analgesic effects, especially in neuralgic and muscular pain, its effects on pain related to inflammation are controversial^{2, 15-17, 19}.

There is evidence suggesting that LLLT can have significant pharmacological effects on the synthesis, release and metabolism of a series of biochemical mediators²⁰, such as increase in the production of serotonin and acetylcholine in the central nervous system as well as histamine and prostaglandins peripherally^{21, 22}.

It has also been shown that LLLT induces analgesia by stimulating the synthesis of endogenous endorphins (β -endorphin), decreasing the activity of bradykinin and C fibers and changing the pain threshold^{21, 22}. LLLT induces morphological changes of neurons, reduces the power of the mitochondrial membrane and blocks nerve conduction^{23, 24}.

A steady decrease in pain was observed during the application days in this study, which is in agreement with the results of a previous study by Marković and Todorović²⁵, who reported pain reduction by application of a GaAlAs laser after surgical removal of third molars, suggesting a dose-dependent effect. However, further investigation may be required to confirm this hypothesis. Moreover, it is important to state that there is a lack of knowledge concerning the use of this wavelength in oral surgery. A recently published meta-analysis and systematic review of the literature concluded that previous studies have important methodological differences that prevent establishment of the exact dose and ideal parameters for LLLT^{26, 27}, considering that there is a lack of standardization in the parameters as well as assessment tools employed²⁷.

In conclusion, considering the limitations of this case series, these data suggest that oral application of LLLT has anti-inflammatory and analgesic effects, which consequently

reduces postoperative complications of oral surgeries. Further studies are needed, especially randomized controlled clinical trials, to help elucidate the impact of laser therapy after third molar extraction and establish the ideal parameters for LLLT as an assessment tool in this promising therapy field.

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