

Efficacy of low-level laser therapy in the management of pain, facial swelling, and postoperative trismus after a lower third molar extraction. A preliminary study

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Abstract Pain, swelling, and trismus are the most common complications after surgical removal of impacted lower third molars. The aim of this study was to evaluate the analgesic and anti-inflammatory effects of a low-level laser therapy (Laser Smile™, Biolase®, San Clemente, USA) applied to the wound appeared after the surgical removal of impacted lower third molars. A prospective, randomized, and double-blind study was undertaken in 20 healthy patients with two symmetrically impacted lower third molars. The application of a low-level laser was made randomly on one of the two sides after surgery. The experimental side received 5 J/cm² of energy density, a wavelength of 810 nm, and an output power of 0.5 W. On the control side, a handpiece was applied intraorally, but the laser was not activated. Evaluations of postoperative pain, trismus, and swelling were made. The sample consisted of 11 women and nine men, and mean age was 23.35 years (18–37). The pain level in the first hours after surgery was lower in the experimental side than in the placebo side,

although without statistically significant differences ($p=0.258$). Swelling and trismus at the 2nd and 7th postoperative days were slightly higher in the control side, although not statistically significant differences were detected ($p>0.05$). The application of a low-level laser with the parameters used in this study did not show beneficial effects in reducing pain, swelling, and trismus after removal of impacted lower third molars.

Keywords Soft laser · Low-power laser · Low-level laser therapy · Third molar extraction · Trismus · Pain · Swelling

Introduction

The third molar extraction is one of the most common surgical procedures in oral surgery [1]. After a surgical trauma, an inflammatory process usually appears accompanied with pain, trismus, and facial edema. These symptoms can affect quality of life of the patients during the first days of the postoperative process [2].

We dispense of a wide variety of analgesics, non-steroidal anti-inflammatory drugs (NSAIDs), local or systemic corticosteroids, long-term anesthetics, etc., designed to control these complications [3–9]. However, these drugs are unsafe and can sometimes induce side-effects. Hence, there is a growing interest in developing alternative or complementary methods free of adverse effects [5].

The most severe pain usually occurs during the first 3–5 h after the disappearance of the effect of the local anesthesia [10]. Swelling, in contrast, usually reaches its peak between the first 24–48 h and gradually decreases in

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the following days to completely disappear between 5 and 7 days later [11, 12]. As the pain and swelling subside, trismus decreases [13].

The application of physical methods such as a low-power laser or low-level laser therapy (LLLT) seems to offer many benefits in controlling the inflammatory process by reducing swelling, pain and by promoting the healing of the tissues, without having adverse effects in patients [14–17].

The exact biological mechanism of the analgesic effect produced by the LLLT still remains unclear. There is evidence to suggest that the LLLT may have significant neuropharmacological effects in the synthesis, release, and metabolism of a series of biochemical substances, such as the increase in serotonin and acetylcholine production at a central level, and by modulating key mediators of inflammation at a peripheral level, such as histamine and prostaglandins. It has also been demonstrated that the LLLT induces analgesia by stimulating the synthesis of endogenous endorphins (β -endorphin), decreasing the activity of C-fibers and bradykinin, and altering the pain threshold [15, 18]. Recently, it has been shown that LLLT induce morphological neurons changes, reduce the mitochondrial membrane potential, and block the fast axonal flow, leading to neural conduction blockage [19].

The anti-inflammatory effect of the LLLT could be due to an increase of the phagocytic activity, the number and diameter of lymphatic vessels, a decrease in the permeability of blood vessels and a restoration of microcapillary circulation, normalizing the permeability of the vascular wall, and decreasing the edema [20–23]. Boschi et al. [24] demonstrated that LLLT induced an anti-inflammatory effect by inhibition of IL-6, MCP-1, IL-10, and TNF- α in a dose-dependent manner.

LLLT was first used in the field of dentistry and oral surgery in the early 1970s [25]. Its use spread in the prevention of inflammation and pain after the extraction of third molars [4, 21, 26–32] after periodontal surgery procedures [33] to reduce pain after orthodontic treatment settings [34] as well as for the treatment of chronic facial pain [35], craniomandibular disorders [36], sinusitis, gingivitis [14], cold sores [37], sensory disturbances of the inferior alveolar nerve [38], dentin hypersensitivity [39], and mucositis from chemotherapy or radiation therapy, among others [40]. While their applications are numerous, their efficacy for the prevention of pain, postoperative swelling, and trismus after the surgical extraction of third molars, is still controversial. This may be due to methodological differences used in the various studies, depending on the type of laser and the laser application parameters [41].

The main purpose of this study was to evaluate the analgesic effect of the diode laser 810 nm AsGaAl (Laser

Smile™, Biolase®, San Clemente, CA, USA) applied intraorally after the surgical removal of impacted lower third molars. Secondly, another purpose was to evaluate the effects on postoperative facial swelling and trismus.

Patients and methods

This preliminary study is a prospective, randomized, and double-blind clinical trial conducted in 20 patients attending the Oral Surgery Dental Clinic Department of the University of Barcelona between January 2009 and March 2010 for the surgical removal of impacted third molars. A split-mouth study was conducted, the patients being their own controls.

The inclusion criteria were patients of ASA I, aged 18 years, who required the removal of two impacted lower third molars in the same position as the classifications of Pell & Gregory and Winter. It did not included patients with acute pericoronitis, severe periodontal disease, associated pathology in the adjacent teeth, and allergy to local anesthetics or to the medication prescribed in the study, as well as pregnant or nursing women, or patients being treated with analgesics and/or anti-inflammatory drugs.

The study was approved by the Research Ethics Committee of the Dental Clinic of the University of Barcelona, and all patients signed an informed consent to undergo a surgical treatment, so as to take part in the study.

All operations were performed by the same surgeon, in two sessions separated by at least a month. Surgery was performed under local anesthesia, with a maximum of three cartridges of 1.8 ml of 4% articaine with epinephrine 1:100000 (Artinibsa®, Inibsa, Barcelona, Spain), using a technique similar to the one described by Figueiredo et al. [42] and Leonard [43] in previous studies. All patients required the same surgical procedure on both occasions, since the two third molars were symmetric and with a similar degree of difficulty, each patient was his own control.

The medication prescribed after surgery was: 750 mg of Amoxicillin (Clamoxyl®, GlaxoSmithKline, Madrid, Spain), applied orally every 8 h for 7 days, Ibuprofen 600 mg (Kern Pharma® SL, Terrassa, Spain), applied orally every 8 h for 2 days, rinsing twice a day for 15 days with Chlorhexidine 0.12% (Lacer®, Cerdanyola del Vallés, Spain) and Metamizol 575 mg (Normon® SA, Madrid, Spain) as rescue medication. All patients were told not to apply ice during the postoperative period, in order to determine the effect of the laser on facial swelling.

The application of laser in the right or left side was chosen randomly, according to a sheet of randomization. Upon completion of the suture in the experimental side was applied laser AsGaAl with a wavelength of 810 nm

(LaserSmile®, Biolase Technology, Inc., Irvine, USA). The laser was placed intraorally, at a distance of 1 cm in the theoretical position of the location of the spine of Spix, with the spot of 0.7 cm, moving in a circle to irradiate an area of 2 cm in diameter. The power applied was 0.5 W on the display (loss of 20%), as the real power was 0.4 W in continuous mode for 32 s. The total real energy released was 12.8 J and the real energy density applied was 4 J/cm². On the control side, the same handpiece was applied intraorally, but it was not connected to the laser. Thus, to activate the laser, patients listened to its sound, but they did not know the type of treatment received.

The variables studied were age, gender, smoking status, as well as variables related to the third molar characteristics, duration of surgery, degree of mouth opening, facial swelling, and level of pain. The duration of the surgery was determined from the moment of the incision to the placement of the last suture.

The pain level was evaluated using a visual analogue scale (VAS) of 100 mm, whose extreme scores were from 0 (no pain) to 100 (the worst pain imaginable). The pain was recorded every 2 h during the first 6 h after the completion of the surgery, and for the next 3 days, once in the morning and once before going to bed, always at the same time. In case of requiring rescue medication, patients had to record the time of intake. Facial swelling and mouth opening were recorded on three occasions, before surgery, after 48 h, and after 7 days. The mouth opening was determined by measuring the interincisal distance with a caliper and taking into account the overbite. Facial swelling was assessed by using a modification of the method described by Schultze-Mosgau et al. [44]. Two measurements were made between four benchmarks: tragus-lip commissure and gonion-external canthus of the eye.

All measurements were made by an independent examiner, previously calibrated and unaware of the type of treatment received.

A descriptive analysis was conducted for demographic variables. Pain, trismus, and facial edema were analyzed by ANOVA for a repeated-measures test. Rescue medication was assessed by Student's *t* test for paired samples. The significance level was set at $p < 0.05$ with a confidence interval of 95%. All data were analyzed using the Statistical Package for the Social Sciences for Windows v14.0 (SPSS, SPSS Inc., Chicago, IL, USA), licensed from the University of Barcelona.

Results

Initially, a total of 25 patients were enrolled in the study, of which, after applying the inclusion and exclusion criteria, we obtained a final sample consisting of 11 women (55%) and nine men (45%), with a mean age of 23.35 (18–37). The

duration of surgery was similar in both groups, without statistically significant differences ($p > 0.05$) (Table 1, Fig. 1).

The most common position and inclination were, respectively, the IIB (85%) and mesioangular (45%) according to the classification of Pell & Gregory and Winter. All interventions required of osteotomy and tooth sectioning, only crown (70%) or crown and roots (30%).

There was a slight decrease in pain intensity in the experimental side for the first 72 h after surgery, although differences were not statistically significant ($p = 0.258$) (Fig. 2). In addition, the LLLT-treated side required a lower consumption of rescue analgesics (0.75 tablets), compared with the control side (1.40 tablets).

In relation to facial swelling, none of the evaluated distances (tragus-lip commissure and gonion-external canthus of the eye) showed significant differences between the two groups after 2 or 7 days ($p = 0.218$ and $p = 0.09$, respectively) (Table 2).

The experimental group showed a greater degree of mouth opening than the control group 48 h after surgery, however, no statistically significant differences were observed ($p > 0.05$) (Table 2).

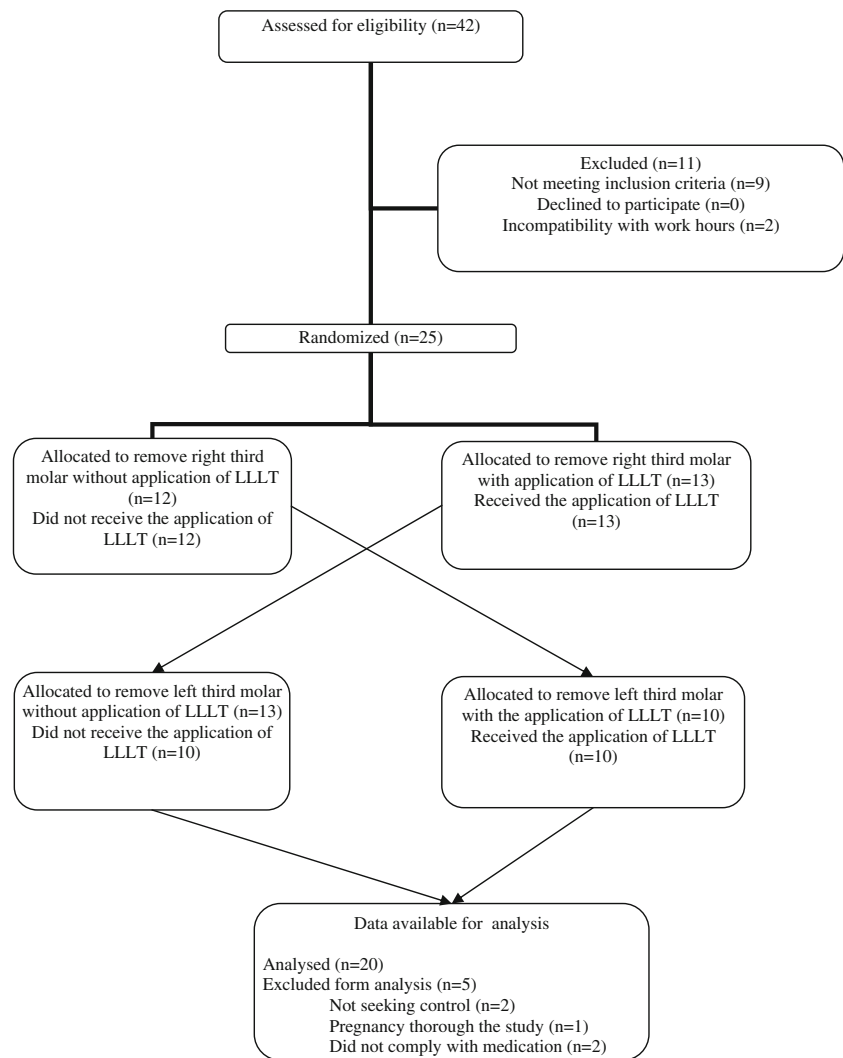
There were no infectious complications or adverse effects attributable to the application of the laser.

Discussion

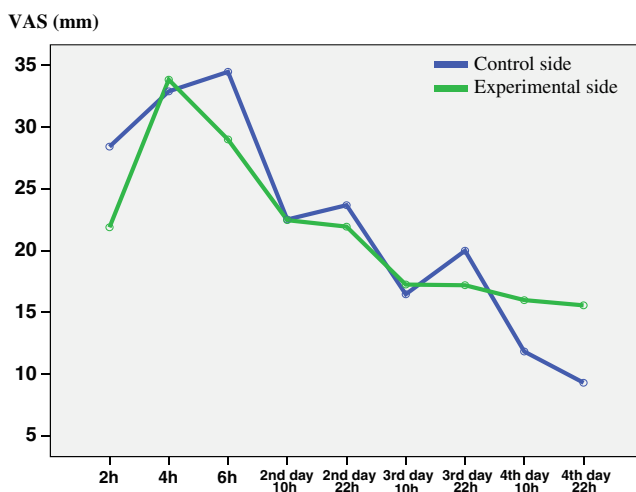
In the last 30 years, there has been a growing interest in investigating the physiological effects of LLLT and its various clinical applications in different medical specialties,

Table 1 Demographic and preoperative data of the 20 patients

		Experimental side (n=20)	Control side (n=20)
Gender	Male	9 (45%)	
	Female	11 (55%)	
Average age		23.35 years (18–37)	
Smoking habit (cigarettes/day)	Smoker	8 (40%)	
	Non-smoker	12 (60%)	
Pell & Gregory classification	I	0 (0%)	
	II	20 (100%)	
	III	0 (0%)	
	A	1 (5%)	
	B	18 (85%)	
	C	2 (10%)	
Winter classification	Mesioangular	9 (45%)	
	Horizontal	7 (35%)	
	Vertical	2 (10%)	
	Distoangular	2 (10%)	
Duration of surgery		25.25 min	23.75 min

Fig. 1 Flowchart of the study

either as a single therapy or a complementary therapy [15]. However, the lack of quality publications on the analgesic and anti-inflammatory effects of LLLT after the surgical

**Fig. 2** Evolution of the postoperative pain

removal of third molars, together with the obtained controversial results, calls into question its efficacy. So far, the parameters of ideal radiation for this purpose have not been determined due to the great diversity of variables (for example, type of laser wavelength, power, pulse rate, time, and mode of application, etc.).

The He-Ne laser was first used to investigate the effects of the LLLT in reducing pain, postoperative swelling, and trismus after a third molar extraction. In the first report written by Carrillo et al. [26] in 1990, there were no significant differences in the levels of pain and swelling between the laser group and the control group (placebo). However, this laser allowed a significant reduction of trismus after 7 days in both groups.

Later, in the early 1990s, the diode laser began to gain popularity. Among all the types of soft lasers present on the market, such as helium-neon (HeNe), gallium arsenide (GaAs), aluminium-gallium-indium phosphide (InGaAlP) and AsGaAl, the last one has been the most widely used in published studies [4, 15, 21, 29–32] (Table 3).

Table 2 Relevant data concerning oral aperture and facial swelling

		Experimental side (mm)	Control side (mm)
Preoperative	Oral aperture	50.45±8.61	52.45±7.05
	Tragus-commissure	103.40±5.06	102.95±6.03
	Gonion-External cantus	106.75±5.80	106.80±6.29
Postoperative 48 h	Oral aperture	33.35±8.79	30.75±8.99
	Tragus-commissure	109.65±4.97	111.85±5.47
	Gonion-External cantus	111.55±8.73	114±7.84
Postoperative 7 days	Oral aperture	38.40±7.24	38.65±9.64
	Tragus-commissure	105.65±5.72	106.00±5.35
	Gonion-External cantus	108.70±6.94	107.10±6.49

According to the results of our study, no statistically significant differences were observed in the levels of pain, swelling, or trismus between both groups. However, Marković and Todorović [4] obtained a reduction of postoperative pain by applying the laser AsGaAl after the surgical removal of third molars. This study included 90 patients divided into three groups of 30. The parameters used were: wavelength (λ) of 637 nm, energy density of 4 J/cm², and a power of 50 mW. The laser was applied for 10 min, 1 cm away from the surgical wound. Group 1 received the laser only, group 2 was given one tablet of 100 mg of diclofenac before the surgery, and group 3 was designated as the control. Statistical analysis indicated a significant reduction ($p < 0.05$) in pain levels of patients treated only with laser (group 1), compared to those premedicated with diclofenac (group 2) and those of the control group. However, in this work we could find some limitations, such as no indication of the exact time of pain assessment and the variability inherent to the study design when comparing results from different individuals. As in our study, the laser was used intraorally, keeping a distance of 1 cm with the application area, thus obtaining a larger area of irradiation. Instead, we used a higher wavelength and a higher power, and we decreased the time of application of the laser in order to approach an energy density of 4 J/cm², the recommended dosage to achieve an analgesic and anti-inflammatory effect [4]. However, other authors have obtained these therapeutic effects despite applying this same amount of energy [26, 28].

With reference to the effect of the LLLT on postoperative inflammation, Marković and Todorović [21] wanted to compare the effect of the LLLT used alone or in combination with topical and systemic corticosteroids, after the extraction of third molars. The authors designed four study groups: group 1 received the postoperative LLLT, with the same irradiation parameters that the previous study [4]; group 2, apart from receiving the LLLT, was injected with 4 mg of dexamethasone in the internal pterygoid; group 3 received the same dose of LLLT supplemented with intramuscular 4 mg of dexamethasone in the deltoid region,

followed by 4 mg of dexamethasone, applied orally, 6 h after the extraction; and group 4 was the control. According to the results of this study, the best anti-inflammatory effect was obtained with the combination of the LLLT and the local intramuscular (medial pterygoid) dexamethasone (group 2), and the authors suggested that this effect was obtained through a summation effect of both procedures. However, with the use of the LLLT and the systemic administration of dexamethasone (group 3), there was a higher anti-edematous effect than with the implementation of the LLLT alone (group 1), although without statistically significant differences between both groups. For this reason, the authors did not justify the use of corticosteroids in case of having irradiated with LLLT. In contrast, this study showed no significant differences in regards to facial swelling between both groups. An interesting highlight of this study [21] is that the degree of inflammation was determined immediately after the surgery. A local inflammation of a surgical wound is not a phenomenon that takes place immediately after surgery, but that appears gradually and reaches its peak between 24 and 48 h after the surgery [11, 12]. Besides, the authors took a reference distance to determine the facial edema (from the tip of the chin to the bottom of the earlobe), unlike our study, where we evaluated two facial distances, at two different times, 48 h and 7 days after [3, 44].

Pain intensity and degree of inflammation or trismus can vary between patients. For this reason, the split-mouth design of our study is able to avoid bias in the information collection [45], unlike when cases and controls are different individuals [4, 21, 29–32]. Our study was conducted with third molars in symmetrical positions with a similar degree of difficulty, so that each patient was his own control. Furthermore, a single surgeon performed all surgical procedures in order to avoid differences among different surgeon's skills, which might have influenced the results.

The main purpose of the recently published studies [31, 32] has been to evaluate the effect of the LLLT in the

Table 3 Review of methods and parameters used in LLLTs after removal of impacted third molars in previous studies

Author (year)	Laser (λ)	Laser output power	Laser dose energy (J/cm^2)	Application	Application place	Application reason	Effectiveness
Carrillo et al. (1990) [26]	He-Ne (632,8 nm)	300 mW	10 J/cm^2	Time not reported, postoperative (six points of different application)	Intraoral	Pain, swelling, trismus	Only in trismus
Fernando et al. (1993) [27]	AsGaAl (830 nm)	30 mW	4 J/cm^2	132 s, intraoperative	Intraoral	Pain, swelling	No
Roynesdal et al. (1993) [28]	AsGaAl (830 nm)	40 mW	6 J/cm^2	Time not reported, pre- and postoperative	Intraoral	Pain, swelling, trismus	No
Freitas et al. (2001) [29]	AsGaAl (830 nm)	40 mW	4,8 J/cm^2	Time not reported, postoperative	Intraoral	Swelling (C-reactive protein levels measured)	No
Marcović & Todorović (2006) [4]	AsGaAl (637 nm)	50 mW	4 J/cm^2	10 min, postoperative	Intraoral	Pain	Yeas
Marcović & Todorović (2007) [21]	AsGaAl (637 nm)	50 mW	4 J/cm^2	A few minutes, postoperative	Intraoral	Swelling	Yeas
Aras & Güngörmüş (2009) [31]	AsGaAl (808 nm)	100 mW	4 J/cm^2	120 s, postoperative	Intraoral group, extraoral group	Swelling, trismus	Extraoral application more effective than intraoral
Aras & Güngörmüş (2009) [30]	AsGaAl (808 nm)	100 mW	4 J/cm^2	120 s, postoperative	Intra- and extraoral	Swelling, trismus	Yeas
Amarillas-Escobar et al. (2010) [32]	AsGaAl (810 nm)	100 mW	4 J/cm^2	Time not reported, postoperative	Intraoral (one application) and extraoral (24, 48, 72 h) in six irradiating points	Pain, swelling, trismus	No
Present study	AsGaAl (810 nm)	400 mW	5 J/cm^2	32 s, postoperative	Intraoral	Pain, swelling, trismus	No

control of pain, swelling, and trismus after the removal of impacted lower third molars, depending on whether the application is done intraorally or extraorally. Aras and Güngörmüş [31] found that the diode laser offers better results in reducing swelling and trismus when the laser is applied extraorally near the insertion of the masseter muscle than when it is used in intraoral application. According to these authors, surgical procedures may cause the spasm of certain muscles, especially the masseter, so intraoral laser therapy would not act directly to this muscle. This could be one of the reasons why in our study we obtained favorable results in the reduction of trismus, although perhaps the intraoral application could enhance the relaxation of other muscles of mastication, such as the medial pterygoid.

In the same way, the effects of LLLT when it is applied intraorally and extraorally on the same patient [30, 32] has also been studied. Aras and Güngörmüş [30] observed that irradiation with a diode laser at 808 nm and 100 mW, for 120 s, 1 cm away from the surgical wound, and for another 120 s placed in contact with the insertion of the masseter and immediately after surgery, significantly decreased trismus and swelling 7 days after the surgery.

Yellow-Escobar et al. [32] made a similar study, but in order to assess the accumulative effect of the therapeutic laser, they applied multiple daily doses to the patients. In this case, patients received intraoral application immediately after surgery, and three sessions postoperatively (24, 48, and 72 h) were irradiated by six points distributed on the facial area of the affected side. The study results showed no significant differences in reducing pain, swelling, or trismus between the laser and the control group.

Conclusions

The results of this preliminary study show that the intraoral application of a 810-nm diode laser with the parameters used did not significantly reduce pain, postoperative swelling, and trismus after a surgical removal of impacted lower third molars. It is necessary to increase the sample size and to consider new studies to evaluate the analgesic and anti-inflammatory efficacy of this simple and non-invasive method for the patient in order to find adequate irradiation parameters and the ideal anatomical area to apply the laser.

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