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Research Article

Contributions of Low-Level Laser Therapy in the Postoperative Period of Impacted Third Molar Extractions: Integrative Literature Review

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Abstract

The use of low-power laser in oral and maxillofacial surgery has several applications in order to reduce consequences after the extraction of impacted molars, such as trismus, pain and facial edema. The objective of this integrative review was to demonstrate the effectiveness with the use of Low Power Lasers in the postoperative period of patients who underwent extraction of impacted third molars. After applying eligibility criteria for articles available in national and international databases, 15 articles were selected for qualitative analysis. The effectiveness of the laser has been demonstrated isolated to control edema, pain and post-operative trismus, although an enhancement of the repair effect has been obtained with the use of anti-inflammatory and antibiotic adjuvants. The clinical application protocol is not unanimous, considering the wide range of equipment and possibilities available in the use of the laser. Further studies are needed to elucidate convergent clinical protocols, as well as for better comparisons between the results of the researched works.

Keywords: Low-Level Light Therapy; Impacted Third Molars; Postoperative Period

Introduction

With the advancement of medicine and its new technologies, dentistry has been reinventing itself and innovating their protocols for care, among these innovations an application that has been widely used in this century are the lasers. Low power lasers have been a widely used and studied innovation, being used as a therapeutic adjuvant with several applications in medical areas, especially in dentistry due to its high efficacy, simple methodology, good cost-effectiveness, and because it is not invasive [1]. Its use has great relevance, since currently the dental surgeons are looking for methods that can transform the painful and traumatic dental practice into something more comfortable and effective; specifically in the area of surgery, lasers are used to minimize the complications associated with conventional techniques, providing a more peaceful postoperative period with satisfactory results.

The word LASER is an acronym from the English language: "Light Amplification by Stimulated Emission of Radiation", which in free translation means "Light Amplification by Stimulated Emission of Radiation", and its use actually becamea reality in the year 1960 when Theodore Maiman created a laser emitter that was excited through ruby and made of aluminum oxide [2]. Unlike conventional light, laser light is an electromagnetic radiation that has only a single wavelength that will propagate in a directed and collimated manner with high concentrations of energy [3].

In oral surgeries, one of the most common procedures in the clinic is the removal of impacted third molars. Although it is a routine surgery, it usually causes discomfort to the patient during the postoperative period because it involves the manipulation of hard and soft tissues, causing pain, edema, inflammation, and limitation in the mouth opening.

Objective of the Study

The objective of this study was to verify the efficacy and advantages of the use of photobiomodulation as a strategy to minimize

the impacts of surgery in the postoperative period of patients submitted to the extraction of impacted third molars.

Methodology

This is an integrative review study, in which articles were selected using the PRISMA strategy and the following databases: PubMed/MEDLINE, LILACS/BIREME/BVS and Scielo, using the descriptors "Exodontics" AND "third molars" AND "laser" and "third molars" AND "laser". Articles published between the years 2015 to 2020 were considered.

The guiding question that supported the present study was designed using the PICO strategy, in which P: (Exodontia of impacted unerupted third molars), I. (Low- intensity laser therapy), C: (Surgical treatments performed without laser therapy), O: (Mucosa repair): (Low intensity laser therapy), C: (Surgical treatments performed without laser therapy) O: (Mucosa repair). It is structured as follows: Does low intensitylaser therapy contribute to the repair of postoperative effects arising from impacted/included third molar exodontias?

The inclusion criteria considered articles published in English and Portuguese available online in national and international journals and that addressed the researched theme:the contributions of the Low Power Laser in the postoperative period after the exodontiaof impacted third molars. The articles that refer to High Power Lasers, Low Power Lasers acting in other dentistry areas, *in vitro* and animal studies, incomplete texts and the duplicated articles were counted only once were excluded.

With the methodology used it was possible to evaluate the speed of mucosal repair, reduction of pain, edema and trismus using the low intensity laser, and the need for other associated therapeutic methods when using the laser.

Results

The search for productions in the databases initially obtained the following numbers: 39 articles/scientific productions in PubMed, 13 in Scielo, and 16 in Lilacs/ Bireme/ Bvs, totaling 68 articles. After applying the inclusion and exclusion criteria, a total of 15 articles were selected for qualitative analysis.

The flowchart of article eligibility using the PRISMA strategy for systematic reviews is shown in figure 1. The selection was made by targeting the study question and also the endpoints established during the application of the PICO strategy.

By applying the eligibility criteria, seven double-blind randomized studies, two cohort studies, three case-control studies, one narrative review, and two systematic reviews were selected, total-

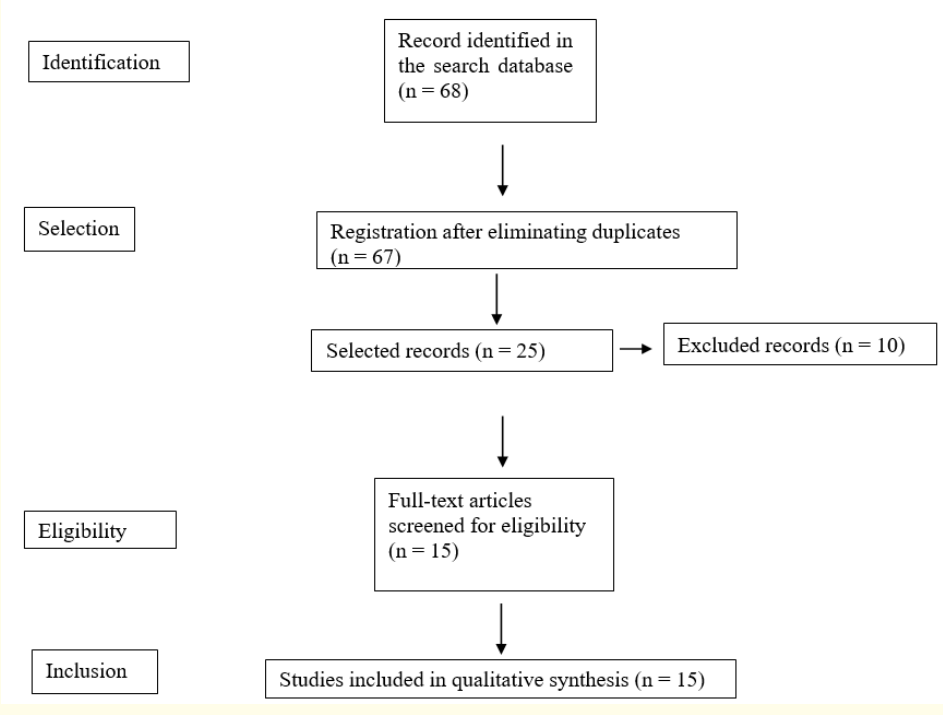

Figure 1: Flowchart of the selection of articles in this research.

	Title	Authors	Methodology	Magazine	Publication Year	Goal	Main Results	Level of Evidence
Article 1	Low-intensity laser efficacy in postoperative extraction of third molars	Mileto Tiago Nasciment o and Azambuja Fabiano Goulart	Narrative review	RGO	Jan/ Mar 2017	To analyze, from systematic reviews and randomized clinical trials, the use of low- intensity laser therapy to influence the clinical picture after third molar surgery (pain, swelling and trismus, and discomfort in the recovery phase)	The studies evaluated cited the efficacy of laser therapy as tissue repair, anti- inflammatory, and analgesic. However, the variety of analysis models and diversity of dosimetry leaves a gap in its true efficacy.	3B
Article 2	Photobiomodulat ion Alleviates Postoperative Discomfort After Mandibular Third Molar Surgery	Singh., *et al.*	Randomized, double-blinded	American Association of Oral and Maxillofacial Surgeons	2019	Reduction of pain, trismus and facial edema after mandibular third molar surgery	They suggest that photobiomodulation is effective in reducing pain and edema.	1B
Article 3	Photobiomodulat ion Enhances the Healing of Postextraction Alveolar Sockets: A Randomized Clinical Trial With Histomorphomet ric Analysis and Immunohistoche mistry	Scarano., *et al.*	Randomized Clinical Trial	American Association of Oral and Maxillofacial Surgeons J Oral Maxillofac Surg	2020	To histologically evaluate the impact of photobiomodulation on the healing processes of the mucosa that covers the alveolus after extraction and related complications	PBMT accelerates the healing process of the alveolus after third molar extraction.	1B
Article 4	Photobiomodulat ion in Oral Surgery: The Review	Hosseinpour., *et al.*	Systematic Review	Photobiomodulation, photomedicine, and laser surgery	2019	Review of current data on the applications of photobiomodulation in Brazil in the field of oral and maxillofacial surgery (pain, edema, trismus)	Suggests that PBM seems to be effective in reducing pain, swelling and trismus after third molar extraction	1A
Article 5	Assessment of Low-Level Laser Therapy Effects After Extraction of Impacted Lower Third Molar Surgery	Raiesian., et al.	Prospective, double-blind, randomized split-mouth study	Journal of Lasers in Medical Sciences	2017	To evaluate the effect of low power laser therapy (LLLT) on pain, swelling and maximum mouth opening	LLLT was helpful in reducing pain and may slightly reduce swelling compared to drug therapy	1B
Article 6	Effect of pre- operatory low- level laser therapy on pain, swelling, and trismus associated with third-molar surgery	Petrini., *et al.*	Cohort study	Oral Medicine Oral Pathology Oral Surgery	2017	If preoperative LLLT associated with impacted molar exodontia postoperative benefits	Both laser- treated groups were characterized by lower post- surgical complication events of pain, edema and trismus. Pre- surgical LLLT treatment seems to increase the analgesic effect of LLLT	2B
Article 7	Effects of low- level laser therapy following surgical extraction of the lower third molar with objective measurement of swelling using a	Koparal., *et al.*	Cohort study	Experimental and Therapeutic medicine	2017	Compare the effects of single and double dose low intensity laser (two different protocols) on postoperative swelling, trismus and pain	Intergroup analysis revealed no significant differences between the groups with regard to swelling and trismus at postoperative 2	2B
Article 8	Low-intensity laser efficacy in postoperative extraction of third molars	Mileto Tiago Nascimento and Azambuja Fabiano Goulart	Narrative review	RGO	Jan/ mar 2017	To analyze, based on systematic reviews and randomized clinical studies, the use of low-intensity use of low-intensity laser therapy to influence the clinical condition after third molar surgery (pain, swelling and trismus, and discomfort in the recovery phase)	The studies evaluated cited the efficacy of laser therapy as tissue repair, anti-inflammatory, and analgesic. However, the variety of analysis models and diversity of dosimetry leaves a gap in its true efficacy.	3B

Article 9	Effectiveness of Single Session of Low-Level Laser Therapy with a 940 nm Wavelength Diode Laser on Pain, Swelling, and Trismus After Impacted Third Molar Surgery	Eroglu Cennet Neslihan and Keskin Tunc Serap	Control case	Photomedicine and Laser Surgery	2016	To investigate the effects of LLLT with a 940 nm diode laser, which was performed extraorally on all primary and secondary affected areas immediately after surgery in a single session	There was no significant difference in pain, swelling, or trismus between the sides. However, according to the clinical results, the swelling and trismus were less noticeable on the laser-treated side than on the placebo side. Diode laser immediately after extraction of the impacted tooth may help patients to be less affected postoperatively.	3B
Article 10	Efficacy of a single dose of low level laser therapy in reducing pain, swelling, and trismus following third molar extraction surgery	Landucci., *et al*.	Control case	International Association of Oral and Maxillofacial Surgeons	2015	The clinical effectiveness of low-level laser therapy (LLLT) for reducing pain, swelling, and trismus	In conclusion, a single dose of LLLT was effective in reducing postoperative discomforts (pain, swelling, and trismus) associated with third molar exodontia.	3B
Article 11	Efficacy of Anti-Inflammatory and Analgesic of Superpulsed Low Level Laser Therapy After Impacted Mandibular Third Molars Extractions	Pol., *et al*.	Control case	J Craniofac Surg	2016	Evaluate anti-inflammatory and analgesic efficacy of superpulsed low-level laser therapy (SLLLT) after bilateral impacted mandibular extraction	The effectiveness of laser therapy is in the first 5 days after surgery, showing a significant reduction.	3B
Article 12	Is Low-Level Laser Therapy Effective for Pain Control After the Surgical Removal of Unerupted Third Molars? A Randomized Trial	Santos., *et al*.	Randomized, double-blind	J Oral Maxillofac Surg	2019	To evaluate the efficacy of LLLT for pain control after extraction of mandibular third molars	LLLT was effective in reducing pain after surgical removal of unerupted third molars.	1B
Article 13	Choosing Between Intraoral or Extraoral, Red or Infrared Laser Irradiation After Impacted Third Molar Extraction	Sierra., *et al*.	Randomized, double-blind clinical trial	Lasers in Surgery and Medicine	2016	Compare the effects of photobiomodulation therapy at two different wavelengths applied intra- orally and extra-orally to facial swelling and trismus	In addition to energy parameters, the combination of irradiation site and wavelength drives the results of laser therapy after removal of impacted teeth	1B
Article 14	The Use of Laser Therapy to Reduce Postoperative Morbidity After Third Molar Surgery: A Systematic Q2 Review and Meta- Analysis	Domah., *et al*.	Systematic review and meta-analysis	J Oral Maxillofac Surg	2020	To investigate the benefits of LLLT on postoperative healing after exodontic surgery. Specific aims: To systematically review the evidence on whether LLLT was effective in reducing postoperative pain, swelling and trismus.	It significantly reduces swelling after lower third molar extraction compared to the placebo group. LLLT was not shown to reduce postoperative pain and trismus	1A
Article 15	Does the Low- Intensity Laser Protocol Affect Tissue Healing After Third Molar Removal?	De Moraes., *et al*.	Prospective, double-blind, randomized study	Oral Maxillofac Surg	2020	Measure and compare periodontal tissue healing using 2 different laser protocols at red wavelength.	It was most effective in the group subjected to the 10-J/cm^2 laser protocol to improve periodontal tissue healing and in both laser therapy groups to reduce facial edema.	1B

Table 1: Study characterization, according to main author, year of publication, journal, objectives, methodology, main results and level ofevidence. Prepared by the authors themselves.

ing 15 studies for qualitative analysis and discussion. Information about the selected studies for qualitative analysis is available in table 1.

Discussion

In the literature consulted on low power laser therapy, it is clear that this method has been widely used for treatment in several therapeutic areas of medicine, especiallyin dentistry and its specialties, presenting a vast functionality. It has been observed that the extraction of impacted third molars is a procedure that is widely used in dental offices all over the world, and it presents a considerable degree of complexity; after the surgery most patients present some alteration such as pain, edema and trismus.

After the end of the effect of the local anesthesia the threshold of pain reaches the treated patients in its maximum intensity after 3 to 5 hours after the procedure, persisting for up to 3 days and decreasing significantly only on the seventh day, whereasthe edema reaches its maximum degree in 12 to 48 hours, ceasing only on the seventh day, with the end of the pain and edema the issue of trismus is also resolved. The big problem is that this causes inconvenience to patients, interfering with their quality oflife and social life, besides which a spontaneous healing of the surgical wound may be slower and expose the patient to risks such as infections, need for higher doses of medication and necrosis [5].

The medications used to treat these transient complications post-surgery are usually local or systemic glucocorticoids or non-steroidal anti-inflammatory drugs (NSAIDs) and antibiotics, although the literature shows that low-intensity laser therapy (LLLT) can be used as an alternative or complement to medication, without adverse effects.

Although the good results obtained are favorable to the use of lasers, the different study designs, associated with the wide range of different equipment, can make it complex to compare the results, which may vary depending on the study method, the types of lasers used, the irradiation parameters (dosimetry and wavelength), whether single or repetitive sessions are performed, the irradiated area (irradiationpoints), and the irradiation time [7,8], these variations make it difficult to compare the results.

Regarding postoperative pain, it can be seen from the research that the way the laser produces its effects is through biomodulation at the molecular level, to be effective it is necessary that the target tissue absorbs this light through the chromophores that will generate an increase in adenosine triphosphate (ATP) altering cellular metabolism and causing a series of secondary effects that will result in the clinical effects of the low power laser, as a consequence of this cascade of cellular events it will generate the analgesic effect, will modulate inflammation and tissue repair. Moreover, it modifies the central nervous system, releasing serotonin and acetylcholine, it also stimulates the production of endorphins and inhibits bradykinin and C fibers, altering the perception of pain [9].

In a literature review, authors [10] showed that low-power laser therapy was effective in reducing pain, although for each individual treatment a different type of laser and wavelength will be required. Nevertheless, the literature shows the efficacy of infrared wavelength (above 700 nm) for analgesia, such as gallium arsenide and aluminum diode laser (GaAlAs, λ = 790 to 830 nm), it was also suggested that when used at an energy dose of less than 4 J/cm^2 it would not influence postoperative analgesia [10].

Studies also suggest that for a better postoperative period, diode lasers with a wavelength of 810 nm (λ), 100 mW constant power and 4 J/cm^2 of energy should be used intra-oral and extra-oral, at least three times during surgery: after suturing, at 48 hours and at 72 hours.10 Another systematic review [11] shows that 18 of 30 articles showed satisfactory results in pain control with the use of laser mainly in the first days, taking into account parameters such as wavelength (650 - 980 nm), power (4 - 300 mW) and energy density (3 - 85.7 J/cm^2). However, the great heterogeneity of the designs and parameters makes it difficult to establish a consensus about these studies [10,11].

Randomized double blind studies [5,12-14] performed laser irradiation at intraoral and extraoral infrared wavelengths respectively: diode laser (830 nm), diode (980 nm) and gallium aluminum arsenide (830 nm) and diode (780 nm), postoperative pain was measured using the visual analog scale (VAS), in all studies postoperative medications were used (antibiotics, The analgesic effect of the low power laser was proven in all experiments, but there is a great variability in each one due to different protocols (type of laser, irradiated points, location, dosimetry).

In one study [5] there were significant differences on the 2nd, 4th and 7th postoperative days, with the pain index being significantly lower in the group that was performed photobiomodulation than in the placebo group with a reduction in the amount of analgesics used. The study by Kahraman., *et al*. (2019) [13] showed better results at 48 and 72 hours after the procedure; it is suggested that the selection of the treatment protocol is a decisive factor in effectiveness.

One hypothesis to explain the analgesic action of laser is the

ability to modulate several signaling pathways and physiological mechanisms, such as increased levels of β-endorphin (β-ep) and the action modules of pain-related biochemicals, includingsubstance P (SP), tumor necrosis factor-α (TNF-α) and cyclooxygenase-2 (COX-2) [15], COX-2 is also important for osteoblast maturation and modulation of gene differentiation, and may be beneficial for bone healing [11].

Petrini., *et al*. (2017) [15] reported that LLLT (diode 980 nm, 300 mW) applied intraorally for 60s on the lingual side of the alveolus, and for 60s on the buccal sideand extraorally at 1cm from the skin under the masseter muscle before surgery and immediately after was effective in reducing the pain perceived by patients in the first 24 hours postoperatively, they then suggested that a double dose of LLLT seems to increase the analgesic effect and requiring fewer NSAIDs in the first 24h. Koparal., *et al*. (2017) [6] using a gallium-aluminum arsenide diode laser (0.3 W, 40 sec, 4 J/ cm^2) suggested a significant pain reduction on day 7 with single dose.

The low intensity laser will also act in the tissue repair, this effect is only generated if the target tissue effectively absorbs the light and through this light the cellular processes of absorption by the endogenous chromophores are activated, which will act in the postoperative period that is divided into phases by the consulted literature. In the 1st phase called inflammatory, where the migration of cells to the lesion occurs, lasting about 3 days. In the 2nd phase or proliferative phase, where fibroblasts, macrophages and other endothelial cells will be recruited to repair the lesion, starting on the 3rd day and ending approximately on the 14th day and finally in the 3rd phase or remodeling phase, where an attempt is made to recover the tissue structure, with changes occurring in the extracellular matrix and the deposition of collagen, lasting until the 6th month [16].

Scarano., *et al*. (2020) [16] histologically evaluated the alveolar repair processes after 22 days of third molar extraction, which received photobiomodulation therapy performed intraorally with a neodymium YAG laser (Nd: YAG), 1064 nm, power 1W, frequency 10 Hz with sessions performed 48 and 92 hours after surgery and more twice a week for 2 weeks, through a bone biopsy and it was found that there was an increase in proliferation and organization of fibroblasts in the early stages of healing accelerating the healing of the mucosa covering the alveoli.

Another study [17] compared two different laser protocols acting on tissue healing using different energies 10 J/cm^2 and 30 J/cm^2 respectively for group 1 and 2, both using a diode laser intraorally (660 nm, 30 mW power in the immediate postoperative period, on the 3rd and 7th day) at four points on the mucosa: center of the alveolus, center of the cervical third of the lingual face, lingual face and apical third of the lingualface, it was observed that there was an improvement in probing depth mainly in clinical insertion in the group that received intensity of 10 J/cm^2 after 6 months; it is suggested that further studies with other protocols are needed for comparison, since only two protocols were used and the number of protocols available in the literature is diverse.

Trismus can be caused by inflammation after a surgical procedure or by constant mouth opening for a long time, affecting the jaw elevator muscles and the temporomandibular joint, and there are indications that photobiomodulation therapy with low power laser induces muscle relaxation [15]. A systematic literature review of 46 articles [11] showed that the laser parameters that were most effective in reducing trismus were wavelength of 660 - 910 nm, with 4 - 500 mW power and with energy of 4 - 106 J/cm^2 and the therapy seemed to improve mouth opening by 4 - 5 mm in 7 days after surgery.

Two case-control studies evaluated a single session with a low-power laser. The first [7] using a diode laser (with a continuous wavelength of 940 nm and power of 0.5 watt/cm^2 and 2.75 watts) irradiating from the tragus to the labial commissure and at the insertion of the masseter muscle showed a 20% decrease in postoperative trismus compared to the placebo group. The second study [8] used the laser (wavelength 780 nm, 10 mW and 7.5 J/cm^2) at four intraoral points (vestibular, distal, lingual and middle of the bone cavity) and six extraoral points (two at the origin of the masseter muscle, two at the insertion of the muscle and two at the center of the masseter), the reduction of trismus was demonstrated between 48 hours and 7 days postoperatively, suggesting that the laser when used at infrared length is effective; The authors put as an advantage the fact that the session is unique, optimizing the time of the patient and of the professional.

A randomized, controlled, double-blind study [18] compared applications done intraorally or extraorally using two different wavelengths (660 nm and 808 nm, respectively), and the interaction between wavelength and site was significant only 2 days after surgery; trismus was lower when the red laser was used intraorally and was even lower used extraorally with the infrared laser. When irradiated extraorally the red photons have a superficial action, being absorbed only by the tissue closest to the cheek,and the infrared photons reach deeper structures and stimulate the facial muscles and thethird molar region, if applied intraorally these

photons would travel through the affectedtissue and not stimulate the muscles.

Regarding postoperative edema of impacted third molars, the literature shows that most patients are dissatisfied with the facial deformity caused by postoperative edema after extractions, and even if it is temporary, it affects their quality of life. Therapy with low power laser, besides regulating a cascade of events associated with cellular, molecular, and enzymatic signals such as prostaglandins, interleukins, COX-2, and tumor necrosis factor, acts by decreasing the size of the vessel and its permeability, causing the influx of pro-inflammatory cytokines and regulating the inflammatory phase [19].

A major challenge in research is the measurement of edema, because it presentsitself in different planes in the tissues and can be diffuse or localized, and there is no standardization to assess its extent [9]. A careful systematic review showed that the laser therapy shows significant results in the reduction of the edema, where seven studies out of eleven selected showed effectiveness when the following low power lasers were considered: diode, infrared, helium-neon and gallium-aluminum-arsenic lasers; the energy generated with magnitude between 500 mW and 3 to 12 J/cm^2, with continuous or intermittent wave emission. However, according to the author, no study has evaluated the cost benefit of the laser in relation to the pharmaceutical industry, since it is a new therapy that requires investment in equipment and training, therefore it is not possible toconclude whether the possibility of making this therapy a standard in oral surgery practice [9].

In a randomized study it was evidenced that the edema did not differ between the two investigated groups in the interval from 24 hours to 1 week after exodontia. The groups were irradiated with diode laser (980 nm, 18J, 300 mW for 60 s at each site) at intraoral points (2 points - buccal and lingual, 1 cm from the surgeon) and extraorally at the insertion of the masseter muscle immediately after the end of surgery.537 mW/cm^2, 106 J/cm^2, 30 seconds, 3J at four points) with the 808 nm infrared laser (100 mW/cm^2, 12 J/cm^2, 30s at four points) was significant on day 2 after surgery, and was less irradiated intraorally with the use of the red laser, but there were no significant differences between extraoral and intraoral application [18].

The diode laser is more effective in reducing edema and trismus when irradiated extraorally, because muscle spasms can occur due to surgery, and intraorally it would not act directly on these muscles, which was proven in a randomized study [5], several applications were used extraorally (4 points) and intraorally, and the swelling was greater on the second day, probably due to the accumulation of interstitial fluid and after the procedure.

The difference between the two groups was statistically significant at all timeintervals, except in the immediate postoperative period. Eroglu and Tunc (2016) [7] reported the edema rate to be 32% lower in patients treated postoperatively with extraorally applied photobiomodulation (940 nm diode, continuous wavelength, 0.5 watt/cm^2). A case control study [8] showed significant reductions in edema at 48 hours and seven days postoperatively, being performed in a single dose (aluminum gallium arsenide - Ga-Al-As, 780 nm, 7.5 J/cm^2 and 10 mW), with the laser tip coated with a layer of polyvinyl chloride film to prevent light refraction, while another case-control study showed that the efficacy of low-power laser therapy is greater in the first five daysafter surgery, this being performed with a dual-source diode laser with two wavelengths simultaneously, wavelength between 904 and 910 nm, 0.5 mW in the main source (infrared) and in the secondary source (red) with wavelength 635 nm, continuous mode and 0.07 W [19].

Conclusion

The qualitative analysis of the selected studies showed that low-intensity laser therapy is effective in controlling the three main postoperative complications of complicated third molar exodontia: pain, edema and trismus. Despite this positive response to laser therapy alone, the association with anti-inflammatory and antimicrobial drugs can potentiate the action of photobiomodulation on tissue repair.

Given the variability of laser application protocols, comparisons between studiesare challenging and it should be emphasized that in designing clinical protocols, the individuality of each case, the available scientific evidence, and the experience of the professional should be taken into account, basing decisions on evidence-based practice. Nevertheless, further studies are needed to establish standardized clinical protocols, as well as to enable comparison

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