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ORIGINAL ARTICLE

# Comparison of the influence of ozone and laser therapies on pain, swelling, and trismus following impacted third-molar surgery

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**Abstract** This study aims to evaluate the efficacy of the ozone and laser application in the management of pain, swelling, and trismus after third-molar surgery. Sixty consecutive patients with asymptomatic impacted mandibular third molars were recruited into the study. Patients were randomized into three treatment groups of 20 patients each: two study groups (group 1=low-level laser therapy (LLLT), group 2=ozone therapy) and a control group (no-LLLT or ozone therapy). Twenty teeth extractions were performed in each group. Evaluations of postoperative pain, the number of analgesics tablets taken, trismus, swelling, and quality of life (Oral Health Impact Profile-14 questionnaire) were made. The sample consisted of 28 female and 32 male patients, whose total mean age was 23.5±3.4 (range, 18–25)years. The pain level and the number of analgesics tablets taken were lower in the ozonated and LLLT applied groups than in the control group. This study showed that ozone and low power laser therapies had a positive effect on the patients' quality of life. Trismus in the LLLT group was significantly less than in the ozonated and control groups ($p$=0.033). Ozone application showed no superiority in regards of postoperative swelling; however, LLLT group had significantly lower postoperative swelling. This study demonstrates that ozone and laser therapies are useful for the reduction of postoperative pain and they increase quality of life after third-molar surgery. Although the ozone therapy had no effect on postoperative swelling and trismus after surgical removal of impacted lower third molars, LLLT had a positive effect.

**Keywords** Ozone · Laser · Dentistry · Wisdom teeth · Pain · Trismus · Swelling

## Introduction

Wisdom teeth extraction is one of the most common surgical procedures in oral surgery [1]. Pain, swelling, and restricted mouth opening due to muscle spasm are the most common complications after the surgical removal of impacted lower third molars [2]. Pain reaches maximum intensity 3–5 h after local anesthesia has worn off, continues for 2–3 days, and gradually diminishes until the seventh day [3, 4]. Swelling reaches peak intensity in 12–48 h, resolving between the fifth and seventh day [5, 6]. As the pain and swelling subside, trismus decreases [7].

The quality of life experienced by patients following third-molar surgery is increasingly becoming a health concern. Third-molar surgeries are associated with an unpleasant experience by patients, referred to as postoperative morbidity. They can be divided into immediate postoperative tissue reactions and complications [8]; therefore, many clinicians have emphasized the necessity for better control of pain, swelling, and trismus in patients who undergo third-molar surgery [9, 10].

The use of local or systemic corticosteroids and nonsteroidal anti-inflammatory drugs are often recommended, but the majority of them may manifest side effects such as a tendency to systemic bleeding, gastrointestinal irritation, and allergic reactions [1, 5, 6]. These observations

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justify efforts to find a new method of postoperative pain control that does not induce side effects.

Nonmedication methods used to minimize tissue injury after third-molar extraction include compression, cryotherapy, and laser application [6, 9]. 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 [7]. The exact biological mechanism of the analgesic effect produced by the LLLT still remains unclear [6], but evidence suggests that the LLLT may have significant neuropharmacological effects in the synthesis, release, and metabolism of a series of biochemical substances, such as increasing serotonin and acetylcholine production at a central level, and at a peripheral level by modulating key mediators of inflammation, like histamine and prostaglandins. It has also been demonstrated that the LLLT induces analgesia by stimulating the synthesis of endogenous endorphins ($\beta$-endorphin), decreasing the activity of C-fibers and bradykinin, and altering the pain threshold [11].

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 vascular walls, and decreasing edema [12, 13].

Another nonmedication method used in dentistry is ozone therapy. Ozone is a naturally occurring compound consisting of three oxygen atoms. It is the form of a gas in the stratosphere layer of the earth in a concentration of 1–10 ppm, continually created from and degraded to molecular $O_2$ [10].

Ozone has for many years been used in medicine for treatment of ocular diseases, acute and chronic bacterial, viral, and fungal infections, ischemic diseases, age-related macular degeneration, orthopedic diseases, and dermatological, pulmonary, renal, hematological, and neurodegenerative diseases [14]. Previous studies used ozone in dentistry in the areas of pedodontics, endodontics, periodontology, and restorative dentistry.

Ozone can react with blood components (erythrocytes, leukocytes, platelets, endothelial cells, and the vascular system) and positively affect oxygen metabolism, cell energy, the immunomodular property, antioxidant defense system, and microcirculation in tissues [15]. Such effects resemble the biostimulatory property of LLLT that have been widely studied [6, 7].

In dental surgery, ozone may be useful to promote hemostasis, enhance local oxygen supply, and inhibit bacterial growth [16]. The aims of this study were, first, to compare the influence of ozone and laser therapy on pain, swelling, and trismus after impacted third-molar surgery, and, second, to measure patients' perceptions of changes in their life quality for 7 days in the immediate postoperative period.

## Materials and methods

Sixty consecutive patients with asymptomatic impacted mandibular third molar were recruited into the study. The inclusion criteria were:

1. Age >18
2. To have no systemic disease
3. To have impacted III B surgical difficulty grade (scales of Pell–Gregory and Winter) mandibular third molars

Exclusion criteria included contraindications to ozone or laser therapy, systemic disease, local infection, tobacco use, oral contraceptives use, pregnancy, and lactation. All patients were informed about the potential complications of oral surgery and ozone or laser treatments and gave written consent on an institutionally approved form. This study followed the Declaration of Helsinki's medical protocol and ethics. Ethical approval was obtained from the Bezmialem Vakif University Ethical Committee (no=27/16).

All patients were subjected to a standardized surgical protocol by the same surgeon (HOK). Another surgeon (SE) performed the ozone therapy. A third another operator (ND) carried out the measurements and was blind as to which patient was in which group control or study.

Patients were randomized into three treatment groups, each with 20 patients [two study groups (group 1=LLLT, group 2=ozone therapy) and a control group (no LLLT or ozone therapy)] and were told to avoid any analgesics 12 h before the procedure. Twenty teeth extractions were performed in each group.

Postoperatively, the patients were prescribed 1,000 mg amoxicillin and 550 mg naproxen sodium orally as necessary and an aqueous 0.2 % chlorhexidine mouth rinse (1 min, three times daily) for 1 week per day. Immediately after surgery, each patient received an icepack to apply to the surgical area for at least 30 min.

### Operative procedure

Third-molar extractions were carried out under local anesthesia via the buccal guttering technique after adequate elevation and reflection of the buccal mucoperiosteal flap. Articaine HCL 2.5 % plus 1:100,000 epinephrine (Ultracaine D-S forte Ampul, Aventis, Istanbul, Turkey) was used for inferior alveolar and buccal nerve blocks. Tooth delivery was followed by meticulous irrigation of the surgical site with physiologic saline (0.9 %). The three-sided mucoperiosteal flap was repositioned and sutured. The time necessary for the tooth

extraction (starting from the first incision to the last suture) as well as the number of complications (e.g., alveolar osteitis, paraesthesia, bleeding) was registered.

### Laser therapy

Laser treatment was performed extra-orally using a gallium–aluminum–arsenide (GaAlAs) diode laser (Fotona XD-2, Fotona, Ljubljana, Slovenia) with a continuous wavelength of 808 nm. The laser therapy was applied by using a hand piece at 100 mW (0.1 W) for a total of 120 s (0.1 W×120 s=12 J). Patients received 12 J (4 J/cm$^2$) low-level laser irradiation at the insertion point of the masseter muscle immediately after the operation, and at postoperative first, third, and seventh days.

### Ozone therapy

Ozone therapy was performed using an ozone generator (Biozonix GMbH, Germany) with a high frequency 7.5 cm deep tissue probe (Omega probe). The ozone generator was applied extraorally at the insertion point of the masseter muscle immediately after surgery and at postoperative first, third, and seventh days with an intensity of 80 % for 10 s.

### Evaluation

Pain was assessed at postoperative first, third, and seventh days with a visual analog scale (VAS) of 10 units in combination with a graphic rating scale [17]. On the VAS, the leftmost end represented absence of pain (score of 0) and the rightmost end indicated the most severe pain (score of 10).

Pre- and postoperative mouth openings were evaluated by the measurement of the maximal distance between the cutting edge of the right maxillary and right mandibular central incisors. Measurements were made with calipers [5].

The degree of postoperative swelling was measured (in centimeter) from the tragus to the corner of the mouth using a tape measure [18, 19]. The pre-operative measurement was considered as the baseline value and the size of the swelling was determined at postoperative first, third, and seventh days. The difference between each postoperative evaluation and baseline value indicated the cheek swelling for that day. Apart from the relevant objective assessments, each patient was asked to complete an Oral Health Impact Profile (OHIP)-14 questionnaire at postoperative one, third, and seventh days. The OHIP is based on a conceptual model of oral health outlined by Locker [20] that uses the World Health Organization International Classification of Impairments, Disabilities and Handicaps framework [20–22]. The original OHIP consists of 49 questions whereas OHIP-14 which is the shorter and patient-friendly version consists of 14 questions. The Turkish versions of OHIP-14 that were previously determined to be valid and reliable were used in this study [21]. The OHIP questionnaire encompasses seven conceptual domains of impact: functional limitation (e.g., difficulty chewing foods), physical pain (e.g., toothache), psychologic discomfort (e.g., self-consciousness), physical disability (e.g., avoiding foods); psychologic disability (e.g., embarrassment), social disability (e.g., difficulty doing jobs), and handicap (e.g., total inability to function) [22]. For OHIP-14, each item was scored "never" (score 0), "hardly ever" (score 1), "occasionally" (score 2), "fairly often" (score 3), "very often" (score 4), 0–4, respectively. Possible OHIP-14 scores range from 0 to 56. With higher OHIP score representing poor quality of life.

The mean values and SDs were determined for each parameter in the study and control groups. The data were analyzed by one-way analysis of variance. Variations in OHIP-14 scores between preoperative and postoperatively states were assessed employing paired sample $t$ tests. Significant differences among the groups were analyzed by the use of Duncan's multiple range tests.

## Results

The study consisted of 60 patients with asymptomatic impacted mandibular third molars. Of these, 32 were males and 28 were females with a mean age of 22.6±2.3 years (range, 18–25 years).

Sixty tooth extractions were performed without complication. The mean operation time (starting from the first incision to the last suture) was 25±11 min for the control group, 22±9 min for the ozonated group, and 23±08 min for the LLLT group ($p>0.05$).

Patients were recalled and evaluated for trismus, pain, and swelling. Table 1 shows that on the postoperative day 1, the average interincisal opening was 22.1±4.6 mm in the control group, 31.5±7.6 mm in the LLLT group, and 25.1±4.2 mm in the ozonated group. On postoperative day 7, the average interincisal opening was 38.3±5.2 mm in the placebo group, 42.6±8.0 mm in the LLLT group, and 40.6±7.2 mm in the ozonated group. At the first ($p=0.025$) and third ($p=0.033$) postoperative days, trismus in the LLLT group was significantly less than in the ozonated and control groups; however, on day 7, the values were similar in the three groups ($p>0.05$). Patients in the ozonated and LLLT groups experienced a significantly lower degree of pain than the control group in all evaluations (Table 2). The number of analgesics tablets taken was recorded, and it shows that the ozonated and LLLT groups took significantly fewer analgesics compared with the control group ($p<0.05$; Table 3). Postoperative swelling occurred for each group. Ozone application showed no superiority in regards to postoperative swelling; however, the LLLT group had significantly lower postoperative swelling (Table 4). Alveolar osteitis, paraesthesia,

**Table 1** Mean±SD mouth opening (in millimeter)

| | *n* | Preoperative | 1 Day | 3 Days | 7 Days |
|---|---|---|---|---|---|
| Control group | 20 | 41.1±2.2 | 22.1±4.6 | 27.4±7.3 | 37.3±5.2 |
| LLLT group | 20 | 43.1±2.6 | 31.5±7.6 | 35.5±3.3 | 39.6±8.0 |
| Ozonated group | 20 | 41.3±3.2 | 25.1±4.2 | 29.3±3.5 | 38.6±7.2 |
| *p* value | | >0.05 | 0.025 | 0.033 | >0.05 |

bleeding, or altered nerve sensation was not observed in any patient postoperatively.

This study showed that ozone therapy and LLLT positively affected OHIP-14 questionnaire results (Table 5), with large changes in OHIP-14 scores during the postoperative period compared with preoperative status. An increase in the mean OHIP-14 score of the subjects on postoperative first and third days. On the postoperative seventh day, mean OHIP-14 scores approximated preoperative values ($p>0.05$). No significant differences in changes in mean OHIP-14 scores occurred between the ozonated and LLLT groups ($p>0.05$). Major changes in oral health impact were observed. Also were apparent immense increases in functional limitation (>75 %), physical pain, psychological discomfort, physical disability, psychological disability, social disability, and handicap of the group.

## Discussion

Severity of pain, amount of swelling, and degree of trismus are the primary indicators of patients' discomfort following surgical extraction of an impacted third-molar tooth [8]. According to Oikarinen [23], the duration of operation correlates significantly with trismus, pain, and total intake of analgesics. In our study, we found no difference between control and study sides in terms of operation time ($p>0.05$).

Usage of local or systemic corticosteroids and nonsteroidal anti-inflammatory drugs may manifest several side effects. Because of this, a new nonmedication and comfortable treatment model is necessary.

The use of ozone has been proposed in dentistry because of its antimicrobial, disinfectant, and healing properties. The majority of the previous studies [14, 16] have reported that ozone can reduce the bacterial count in active carious lesions and, therefore, may temporarily arrest the progression of caries, resulting either in prevention or in delaying the need for tooth restorations [14].

Oral surgery might cause the spasm of some muscles, especially the masseter. Although LLLT has been reported to prevent swelling and trismus following the removal of impacted third molars, some of these studies reported a positive laser effect while others did not. Roynesdal et al. [24] investigated the effect of soft-laser application on postoperative swelling and trismus, while Taube et al. [25] and Clokie et al. [26] investigated the effect of soft-laser application only on postoperative swelling. All of these authors reported that soft-laser treatment had no beneficial effect on swelling and trismus after third-molar surgery. In all of these studies, the authors used different lasers at different powers and doses. In our study, we found that LLLT was effective in reducing trismus and swelling at the first and third postoperative days. No significant differences were found for swelling and trismus between the ozonated and the control groups. Our results were similar with both the Markovic and Todorovic [13] study, which reported that LLLT significantly reduced postoperative swelling, and with the Carillo et al. [27] findings that the percentage of trismus in the laser group was significantly less than in the placebo group.

The main purpose of the recently published studies [28, 29] has been to evaluate the effect of LLLT in the 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 Güngörmüs [28] 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 at the same location. According to these authors, surgical procedures may cause the spasm of certain muscles, especially the masseter; therefore, intraoral laser therapy would not act directly on this muscle. This

**Table 2** Mean±SD pain scores on VAS

| | *n* | 1 Day | 3 Days | 7 Days |
|---|---|---|---|---|
| Control group | 20 | 8.42±1.40 | 5.81±1.32 | 2.33±1.26 |
| LLLT group | 20 | 3.41±4.87 | 2.46±1.22 | 0.75±0.22 |
| Ozonated group | 20 | 4.62±3.12 | 2.49±1.15 | 0.81±0.32 |
| *p* value | | 0.012 | 0.035 | 0.044 |

**Table 3** Total numbers of analgesic doses in days

| | *n* | Mean | SD |
|---|---|---|---|
| Control group | 20 | 8.4 | 1.6 |
| LLLT group | 20 | 4.1 | 1.1 |
| Ozonated group | 20 | 4.6 | 2.1 |
| *p* value | | 0.002 | |

**Table 4** Mean±SD swelling (in centimeter) measured from the tragus to the corner of the mouth and tragus to the pogonion ($n$=20)

| | | Preoperative | 1 Day | 3 Days | 7 Days |
|---|---|---|---|---|---|
| Control group | T-C | 12.22±0.21 | 14.11±0.25 | 13.01±0.42 | 12.44±0.32 |
| | T-P | 16.33±0.31 | 18.22±0.35 | 17.01±0.80 | 16.41±0.35 |
| LLLT group | T-C | 11.34±0.34 | 12.11±0.23 | 12.01±0.65 | 11.44±0.87 |
| | T-P | 15.23±0.29 | 16.02±0.84 | 16.01±0.82 | 15.32±0.20 |
| Ozonated group | T-C | 11.35±0.41 | 14.41±0.11 | 14.76±0.14 | 12.81±0.67 |
| | T-P | 15.24±0.10 | 18.33±0.34 | 18.21±0.50 | 15.35±0.34 |
| $p$ value | | >0.05 | 0.039 | 0.041 | >0.05 |

*T-C* Tragus-Corner of the mouth, *T-P* Tragus-Pogonion

could be one of the reasons why in our study we obtained favorable results in the reduction of trismus, although perhaps intraoral application could enhance the relaxation of other muscles of mastication, such as the medial pterygoid. The same authors [30] reported that irradiation with a diode laser at 808 nm and 100 mW, for a period of 120 s, at a distance of 1 cm from the surgical wound, and for another 120 s placed in contact with the insertion of the masseter immediately after surgery, significantly decreased trismus and swelling 7 days after the surgery.

Preventive strategies for management of pain include the use of local or systemic corticosteroids and nonsteroidal anti-inflammatory drugs, and nonmedication methods such as compression, cryotherapy, and soft laser application [1, 6, 31]. Neckel and Kukizl [32] recorded lower pain values in the LLLT group compared with the control group after impacted lower molar surgery. In the present study, we evaluated the effect of ozone and low-power laser therapies on postoperative pain following surgical extraction of impacted mandibular third molars and found that VAS for pain and the number of analgesics taken were significantly higher in the control group than in the ozonated and LLLT groups at all the assessment sessions at the postoperative first, third, and seventh days.

Assessment of the physical, social, and psychological consequences of health states has in medicine been carried out for several decades, but only recently has it been employed in the dental arena [33]. Numerous oral health specific quality of life measures (questionnaires) have been developed and their psychometric properties evaluated. Their value and use in an oral and maxillofacial surgery setting are potentially manifold. Not only do they provide information about the importance of oral health status and how treatments may affect life quality; but they may in addition also emerge as important tools to measure quality, effectiveness, and efficiency of treatment approaches [34].

Delayed clinical healing after third-molar surgery significantly increased the prevalence of delayed recovery in terms of quality of life and oral function. The odds of a delay in health-related quality of life outcomes as reported by Ruvo et al. [35] were double if clinical healing was prolonged. The pre- and intraoperative risk factors for severe morbidity after removal of a third molar were compared in a prospective study by Grossi et al. [18] with patients' perceptions of changes in their quality of life.

In this study, at the end of the postoperative day 7, many patients were still experiencing a reduction in their oral health-related quality of life compared with preoperative status. At the end of the study period, the experience of trismus, limitation of mouth opening less than 40 mm, and clinical evidence of swelling was associated with reduced quality of life. Similarly, swelling is likely to influence comfort, function, and esthetics. Identifying factors and best treatment approaches to limit or avoid trismus and swelling would improve patients' recovery and reduce the burden that third-molar surgery places on life quality in the immediate postoperative period. Although, quality of life scores decrease after third-molar surgery, this study showed that ozone and LLLT therapies have a positive effect on quality of life.

## Conclusion

This study has demonstrated that both ozone and LLLT therapies are useful for the reduction of postoperative pain

**Table 5** Mean±SD values of OHIP-14 questionnaire ($n$=20)

| | $n$ | Preoperative | 1 Day | 3 Days | 7 Days |
|---|---|---|---|---|---|
| Control group | 20 | 11.12±2.35 | 33.22±5.22 | 30.15±4.40 | 20.01±3.34 |
| LLLT group | 20 | 12.24±1.31 | 22.13±4.98 | 17.45±0.53 | 14.43±1.32 |
| Ozonated group | 20 | 12.30±1.20 | 21.24±3.25 | 18.24±0.53 | 13.72±1.29 |
| $p$ value | | >0.05 | 0.002 | 0.014 | >0.05 |

and increase quality of life after third-molar surgery. The results of this preliminary study show that while, ozone therapy has no effect on postoperative swelling and trismus after a surgical removal of impacted lower third molars, extraoral application of an 808-nm diode laser has a positive effect. It is necessary to increase the sample size and to consider new studies to evaluate the analgesic and antiinflammatory efficacy of these simple and noninvasive methods for the patient in order to find adequate parameters and the ideal anatomical area to apply the laser.

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