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Case Report

Application of Ozone and Photobiomodulation in the Treatment of Surgical Complications: A Case Report

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Abstract: The wound healing processes involve a complete healing of soft and hard tissues, the absence of abnormal clinical symptoms, and postoperative complications. When a wound present with impaired healing, a thorough examination is recommended to rule out or correct underlying local or systemic factors. The use of low-level laser therapy (LLLT) and Ozone applications have been proposed as an adjuvant therapy, in the treatment of wounds and postoperative complications such as alveolar osteitis, relieving painful symptoms and shortening healing times with positive results. This study shows a clinical case where both therapies were applied in a patient with soft tissue necrosis after an implant placement, with a bone grafting, and connective tissue grafting in the area of the mandibular left second premolar. A two-phase treatment consisting of three sessions of photobiomodulation and three sessions of ozone therapy was applied obtaining positive results with a complete wound closure, maturation and formation of keratinized tissue and the patient reported no discomfort during the therapy and was pleased with the treatment. In conclusion, current evidence suggests that both LLLT and ozone represent promising therapeutic modalities for aiding to improve the wound healing and preventing or treating surgical complications in the oral cavity.

Keywords: Ozone Therapy; Low-Level Laser Therapy; Wound Healing; Oral Surgery.

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1. Introduction

Surgical healing is a complex process of repair or regeneration of the treated tissue that occurs in four main phases: hemostasis, inflammation, proliferation and remodeling [1-5]. The ultimate goal of the wound healing process is complete healing of soft and hard tissues, the absence of abnormal clinical symptoms, and postoperative complications. When a wound present with impaired healing, a thorough examination is recommended to rule out or correct underlying local or systemic factors.

A postoperative complication is considered to exist when any situation occurs that deviates from normal recovery during the period following surgery and requires some type of intervention to resolve. During the early stages of healing, the main complications may include the opening of sutures, bleeding, infection, inflammation, tissue death (necrosis), blood accumulation (hematoma), swelling or inflammation and pain. These can occur after surgeries such as the placement of implants, bone grafts, or soft tissue grafts [3,5].

The use of lasers for photobiomodulation (PBM) treatment, also known as low-level laser therapy (LLLT), has recently been proposed as an adjuvant therapy, even for non-surgical periodontal treatment. The benefits of PBM on periodontal tissues have been evaluated both in vitro and in vivo; in particular, PBM administration has a positive effect on cell proliferation of gingival fibroblasts and produces an increase in the expression of FGF-β and collagen type 1, increases and accelerates the healing

process in damaged tissue, normalizes blood vessel permeability, and improves microcirculation by causing vasodilation. Therapeutic doses generally used range from 1 to 500 mW, with wavelengths from 600 to 1000 nm [6,7].

Ozone (O_3) is a triatomic molecule composed of three oxygen atoms. Although it is usually present as a gas, it has been used in both gaseous and aqueous forms and can be dissolved in water or oil [8]. The use of ozone for medical purposes is due to its antimicrobial, disinfectant, and wound-healing properties. Ozone is commonly used in restorative dentistry, endodontic procedures, oral surgery, and periodontology [9]. It can also be used during various clinical procedures, such as the treatment of early carious lesions, ulcerations, and herpetic lesions of the oral mucosa; the sterilization of cavities, root canals, periodontal pockets, and the cleaning of dentures [9,10].

At low concentrations, ozone acts as a potent oxidant with broad-spectrum antimicrobial activity and the ability to promote healing processes and reduce inflammation through protective antioxidant pathways, providing therapeutic benefits in the treatment of various diseases [11]. The antimicrobial action is due to ozone-induced oxidation, which causes direct and indirect damage to cellular structures and microbial metabolism. Ozone also participates in pharmacological immunomodulation, as it induces mild oxidative stress, which triggers antioxidant responses by activating specific molecular pathways and triggering anti-inflammatory mechanisms. Furthermore, topical ozone application has been reported to improve the rheological properties of blood by inducing functional and structural changes at the erythrocyte level, thereby improving peripheral oxygen perfusion and overall metabolism [11-14].

The recommended concentration for a mixture of oxygen and ozone for medical use is between 5 and 50 μg of ozone/1 ml of oxygen, according to the guidelines and recommendations of good clinical practice in oxygen therapy, published in the Madrid Declaration on Ozone Therapy ISCO3 (2020) [11,15]. The concentrations in ozonized water and the volumes used also vary depending on the clinical case. The concentration of ozonized water that can be used safely and without showing negative effects varies between 4 μg/mL to 20 μg/mL [15]. However, there have been no reports of adverse effects due to ozone applications in the ranges and durations commonly used in dentistry. Ozone applications have yielded positive results in the treatment of wounds and postoperative complications such as alveolar osteitis, relieving painful symptoms and shortening healing times without potential side effects associated with traditional treatments for these oral ulcerative conditions, as well as for wounds and surgical complications [16,17].

In the literature review conducted, no other case reports were found related to the combined application of photobiomodulation and ozone for the treatment of tissue necrosis following the placement of implants, grafts, and membranes for guided tissue regeneration. However, several systematic reviews were found analyzing the effects of ozone therapy on the healing of periodontal and peri-implant wounds [18], on traumatic and autoimmune ulcers [19,20] or non-pharmacologic treatment options for ulcerative oral lesions [21]. All conclude that while the reported results are positive and can be applied as treatment options, further studies are still needed.

This article discusses the use of ozone therapy and low-level laser therapy (LLLT) as alternative treatments for improving wound healing, especially in postoperative complications of dental procedures. A clinical case is described where both therapies were applied, with positive results in the recovery of a patient with soft tissue necrosis following implant surgery.

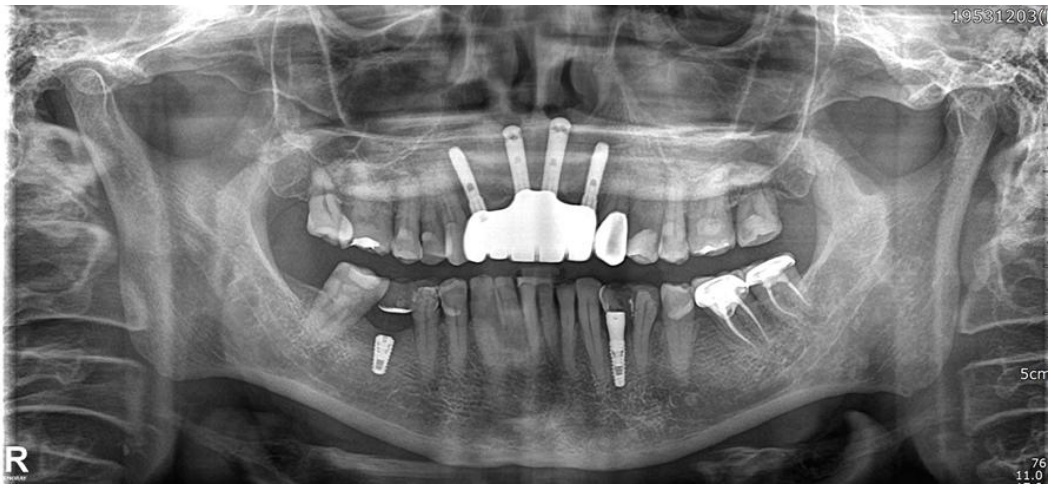
2. Case Report

A 71-year-old male patient was referred to the Department of Periodontology at the Almón-Brito IPD Institute (Caracas, Venezuela) due to postoperative complications one week after implant placement, bone grafting, and connective tissue grafting in the area of the mandibular left second premolar. Clinical examination revealed

inflammation, granulation tissue, and soft tissue necrosis in the flap area, clinical manifestations indicating impaired wound healing. A diagnosis of flap necrosis was made. When asked about his systemic history, the patient did not report any comorbidities that could interfere with treatment.

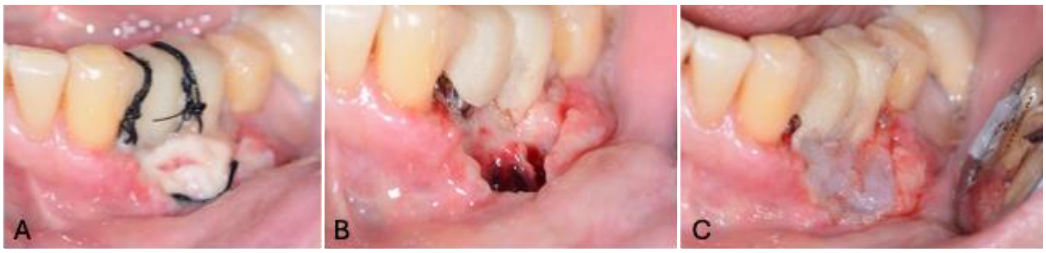
The panoramic radiograph did not show any radiolucent or radiopaque images compatible with alterations around the implant in the lower left quadrant (Figure 1).

Figure 1: Panoramic radiograph.



At that first appointment, after the clinical and radiographic evaluation, the necrotic tissue and sutures were removed, the patient was rinsed with saline solution, and blue®m oral gel was applied (Figures 2A, 2B, 2C).

Figure 2: A. Initial image 7 days after implant placement surgery. B. Image of the wound after removal of sutures and necrotic tissue. C. Image of the wound covered with blue® oral gel.



At the second appointment, three (3) days after the removal of necrotic tissue, an improvement in wound healing was observed, expressed by the presence of vascularized tissue at the base of the lesion. It was decided to implement a two-phase treatment consisting of three sessions of photobiomodulation and three sessions of ozone therapy (Figure 3A) (Table 1). For LLLT application, the Gemini EVO™ diode laser (Ultradent Products, Inc., South Jordan, Utah) was used with dual wavelengths of 810/980 nm, a super pulsed beam, a power of 0.3 W with a 7 mm tip, a duration of 22 seconds, and a fluence of 17.36 J/cm^2, performing an intraoral sweeping motion. Two more sessions were applied every other day using the same doses. After these sessions, the clinical evaluation of the area showed greater connective tissue formation, epithelialization of the area, and a decrease in wound size (Figure 3B). The patient's mouth was subsequently scanned, and a custom splint was made for ozone gas placement (Table 2 and Table 3).

Figure 3: A. Image of the wound three days after removal of necrotic tissue. B. Image of the area after three sessions of LLLT, showing formation of connective tissue, epithelialization of the area and reduction in wound size.

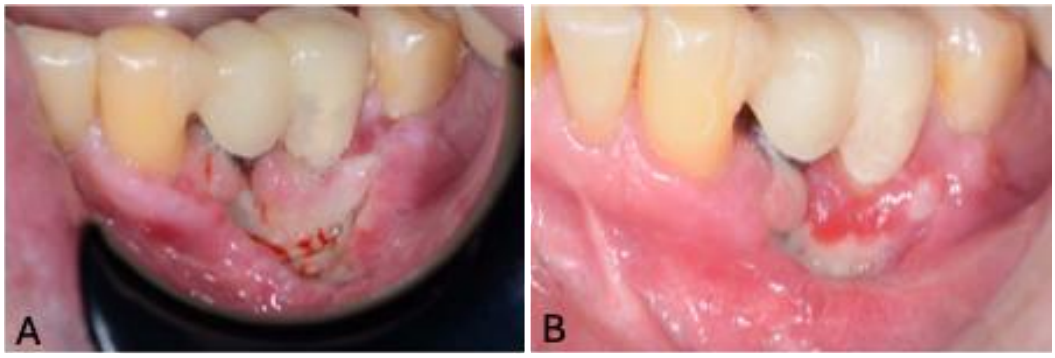


Table 1: Ozone application parameters.

Ozone application	Concentration (μg/ml)	Dose
Ozonized water	55 μg/mL	250 mL
Ozone gas with a splint	20 μg/mL	10 minutes
Ozone gas infiltration	4 μg/mL	3 points, 1 cc per point
Sessions number		3

Table 2: Laser specifications, dosimetry.

Wavelengths	nm	810/910
Dose	J/cm²	17.36
Power	W	0.3
Area	cm²	0,38
Applied energy	J	6.6
Distance	cm	1
Time	sec	22
Sessions	Number	3

Table 3: Steps for making a custom splint for ozone placement.

Step	Procedure Description
Step 1	The patient's mouth was scanned, and a 3D printed model of the patient's mouth was obtained. The extent to which the splint will be enlarged was delineated on the model.
Step 2	Heavy impression material was placed over the entire area of the model, approximately 5 mm thick, without covering the marked area. This step creates a space for ozone circulation.
Step 3	The model was taken to the thermoforming machine. The thermoplastic sheet was heated to the desired tempera-

	ture, and pressure or vacuum was applied to create a replica of the model. Once cooled, it was trimmed with a scalpel at a 45° angle.
Step 4	The test splint was fitted in the patient's mouth to ensure a precise and comfortable fit with a deep vacuum seal. The locations for the ozone hoses were defined: 4 holes on the buccal surface (ozone access) and 2 on the incisal edge (ozone exit).
Step 5	Holes were made using a burr, and the hoses were inserted. The edges of the splint were then finished and polished for patient comfort.

Two weeks after the laser therapy was completed, ozone application was started using an ozone generating unit (Ozone & Life) with the following protocol: irrigation with 250 mL ozonized water at a concentration of 55 µg/mL, 20 µg/mL of ozone gas with a splint for 10 minutes, taking all necessary safety precautions during intraoral ozone applications to avoid accidental inhalation, and infiltration of 4 µg/mL of gas at three points, 1 cc per point. This procedure was repeated two more times, one session per week (Figures 4A, 4B, and 4C). By the third session, complete wound closure is clinically evident, and after 45 days, maturation and formation of keratinized tissue are observed (Figures 5A and 5B). The patient reported no discomfort during the therapy and was pleased with the treatment.

Figure 4: A. Ozone gas application with a custom splint. B. Gas infiltration. C. Ozonized water irrigation.

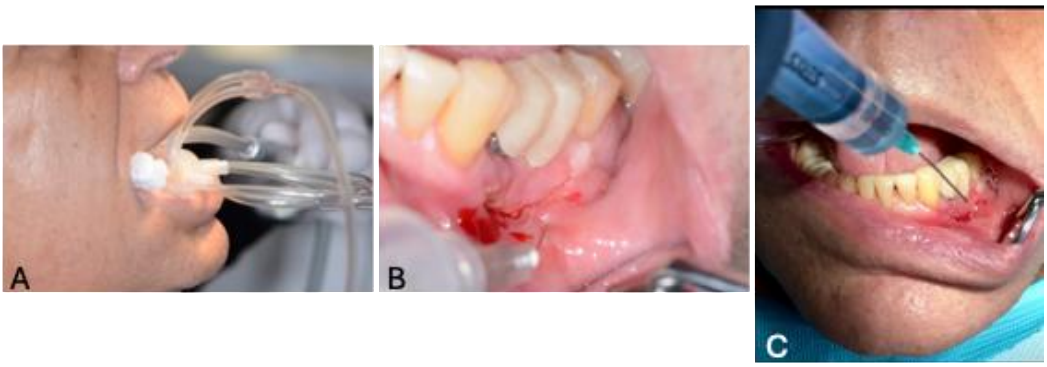
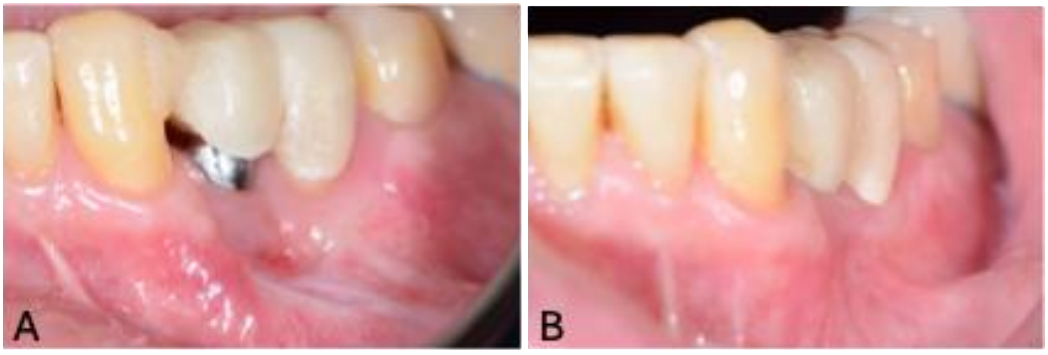


Figure 5: A. Image of the area one week after ozone therapy. B. Image of the area 45 days after ozone therapy was performed.



3. Discussion

Photobiomodulation (LLLT) and ozone are increasingly being used in dentistry to complement treatments in diverse areas such as periodontics, endodontics, and surgery, where they offer new avenues to improve outcomes and patient well-being in complex dental procedures [9]. Wound healing in the oral cavity represents a biological process influenced by a unique environment [1]. Postoperative complications, defined as deviations from the normal course that require intervention, can arise following surgical procedures such as implant or graft placement [3]. Recent research has explored the potential of adjuvant therapies such as photobiomodulation (PBM) with low-level laser light (LLLT) and ozone therapy to optimize healing and attenuate these complications [6-11]. The evidence presented suggests that both LLLT and ozone possess mechanisms of action that could be beneficial in the context of oral surgical wound healing.

This article reports a clinical case treated with the combined application of LLLT and ozone for a surgical complication following implant placement, bone and soft tissue grafts. In the first phase of the treatment, three LLLT sessions were administered every other day. Subsequent clinical evaluation of the area showed increased connective tissue formation, epithelialization of the area, and a decrease in lesion size. These findings are consistent with the notion that LLLT may positively influence the proliferative and remodeling phases of wound healing through mitochondrial stimulation and increased oxygen availability, promoting cell proliferation and bone consolidation, as observed in animal models of experimentally induced periodontitis [22,26].

In the second phase of the treatment, three ozone sessions were administered in the form of gas infiltration and irrigation with ozonized water. In this case, doses of 20 μg/mL of ozone gas were applied with a customized splint, 55 μg/mL for irrigation with ozonized water, and 4 μg of gas for infiltrations. This procedure was repeated two more times, one session per week. Clinical examination after the third session revealed complete wound closure, with maturation and formation of keratinized tissue.

Ozone therapy has demonstrated promising effects in encouraging healing through various mechanisms, including the activation of growth factors, antimicrobial properties, increased tissue oxygenation, stimulation of collagen production, and reduction of inflammation [15]. Animal studies have indicated improved angiogenesis and fibroblast counts in the oral mucosa following ozone application, suggesting an accelerating effect in the initial stages of wound healing and bone formation [23,24,25,26]. Several meta-analyses also support the use of ozone in the treatment of chronic wounds, although its superiority over standard treatments requires further investigation [15,21,29].

There is a discrepancy between the ozone concentration parameters used by laboratory researchers and those used by clinicians. This makes it difficult to make recommendations on the optimal therapeutic ranges of ozone for use in dentistry. Concentrations between 10 μg/mL or 50 μg/mL, and even lower, have been shown to have therapeutic effects with a wide safety margin. However, some published studies using high ozone concentrations in the range of 10 to 60 μg/mL demonstrated significant positive results [14,15]. These results suggest that the concentration, contact time, and flow or volume of ozone are all related and should be adapted to the clinical case and the type of ozone-generating unit.

It is important to highlight that, although in vitro evidence and some preliminary clinical studies are encouraging, the application of LLLT and ozone in the management of oral surgical complications requires further evaluation in the clinical setting. The study by Cetiner et al., [30] evaluating the short-term efficacy of antimicrobial photodynamic therapy (aPDT), FBM with LED and topical ozone therapy after periodontal regenerative treatments found no significant differences in clinical parameters, except for the decrease in gingival recession which was slightly better with FBM. These results suggest that the benefits of these adjuvant therapies could be

more pronounced in specific clinical situations or in patients with particular characteristics [30,31].

The disparity between laboratory results and clinical applications could be attributed to several factors. Animal models, although useful for elucidating biological mechanisms, do not always replicate the complexity of the human clinical setting, where multiple variables such as the patient's systemic health, oral hygiene, and the specific nature of the surgical complication can influence the healing process. Furthermore, the heterogeneity in LLLT (wavelength, dose, application time) and ozone (concentration, exposure time, application method) application protocols across studies makes difficult to compare directly the results obtained and the formulation of definitive clinical recommendations.

Other factors to be considered include the type and location of the lesion, whether hard or soft tissue, as the nature and severity of the pathology will dictate the necessary parameters to be used. The treatment objective is another important variable; each objective may require adjustments in dose, wavelength for LLLT, as well as concentration, and application time for ozone therapy. The density, vascularity, and composition of each tissue influence light penetration and interaction with ozone. There are also differences in the equipment used. Low-power lasers vary in wavelength, power, emission mode (continuous or pulsed), and beam size. Ozone generators vary in concentration and application mode (gas, ozonized water, ozonized oil). These technical differences directly impact clinical outcomes.

Like other medical approaches that use potent drugs, ozone therapy can present risks, which can be avoided if the ozone therapist is well-trained, both theoretically and practically. In addition to the predominantly beneficial properties, the occurrence of some possible adverse effects, mainly related to inhalation toxicity, should be considered. Furthermore, certain forms of ozone therapy, particularly those that induce systemic effects, are contraindicated in cases of myocardial infarction, hyperthyroidism, acute alcohol intoxication, severe anemia, severe glucose-6 deficiency phosphate dehydrogenase, thrombocytopenia, active hemorrhage, and pregnancy [27].

In this case report, the combined application of LLLT and ozone yielded satisfactory clinical results. The implant remained in place, and the patient reported no discomfort during the therapy and was pleased with the treatment. These results, related to the relief of painful symptoms and the reduction of healing times, are important for patient well-being and are attributed to the analgesic and anti-inflammatory effects of these auxiliary therapies [16,17]. Despite the positive results seen in this case, controlled clinical studies are still needed to confirm the efficacy of these therapies and to standardize treatment protocols.

4. Conclusion

In conclusion, current evidence suggests that both LLLT and ozone represent a complementary approach to pharmacological treatment to help improve wound healing and prevent or treat surgical complications in the oral cavity. However, additional research, including well-designed controlled clinical trials with standardized protocols, is required to confirm their clinical efficacy, identify optimal application protocols, and define specific indications for their use in dental practice. Well-documented clinical case reports can significantly contribute to understanding the potential of these therapies in specific clinical situations.

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Conflicts of Interest: None.

Supplementary Materials: None.

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