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Case Report

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Combination of Different Laser Wavelengths as a Treatment Strategy for Maxillary Osteonecrosis: A Case Report

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Abstract

Introduction: Osteonecrosis causes the death of bone tissue due to insufficient blood flow, which disrupts the supply of oxygen and nutrients, compromising the structural integrity of the bone. The jaws are particularly vulnerable due to their high bone turnover and vascularization. This study aimed to present the complex case of a patient diagnosed with maxillary osteonecrosis associated with osteomyelitis, treated exclusively with laser therapy.

Case Report: We present the case of a 62-year-old male patient with maxillary osteonecrosis associated with osteomyelitis, manifested by an oroantral fistula located in the upper jaw. The treatment consisted of various laser therapy modalities, starting with the surgical phase on hard tissue for the excision of the necrotic bone (Er,Cr:YSGG 2780 nm laser), followed by photodynamic therapy (650 nm diode laser) for wound disinfection and intravascular laser irradiation of blood (ILIB) therapy (880 nm diode laser) in each session.

Conclusion: The combination of different laser wavelengths was effective for the treatment of osteonecrosis.

Keywords: Osteonecrosis; Osteomyelitis; Laser therapy; Photochemotherapy; Diode laser.

Introduction

Osteonecrosis is a condition characterized by the death of bone tissue due to insufficient blood flow, leading to a total or partial interruption of the supply of oxygen and nutrients to the bone. This results in the death of bone cells and the collapse of tissue. The pathophysiology also involves alterations in bone remodeling; an imbalance in the processes of resorption and bone formation compromises the structural integrity and vasculature of newly formed bone, increasing the risk of bone necrosis. This is the case for osteonecroses associated with medication use, such as anti-resorptive drugs.[1]

Due to the high rate of bone turnover in the maxillae, caused by the constant functional loads of chewing and their high vascularization, these areas are very susceptible to the development of osteonecrosis.[2] The first case, associated with the use of intravenous bisphosphonates, was published in 2003.[3] Currently, maxillary osteonecrosis is recognized as progressive bone destruction in the maxillofacial region, which can have various causes. Reported cases include medication-induced osteonecrosis, osteoradionecrosis, traumatic osteonecrosis, non-traumatic osteonecrosis (associated with metabolic diseases, hematological conditions, infections, oncological disorders), and idiopathic osteonecrosis.[4,5]

The clinical presentation of maxillary osteonecrosis can vary depending on the origin and severity of the disease. Generally, it manifests as one or more necrotic bone lesions, either exposed or not, in the oral cavity, persisting for at least 8 weeks without resolution. Patients may experience pain, and symptoms such as inflammation, mobility or loss of teeth, intraoral or extraoral fistulas, erythema, and suppuration may also occur.[6,7]

The treatment for osteonecrosis has two approaches. Depending on the stage of the disease, either conservative or surgical treatment is chosen. Conservative treatment focuses on reducing symptoms and involves educating the patient to adopt optimal oral hygiene habits, regular dental check-ups, systemic antimicrobial therapy, and local therapy using chlorhexidine-based antimicrobial mouth rinses. If the patient does not respond to conservative therapy, surgical debridement is indicated to remove necrotic bone, promote bone and mucosal repair, and prevent microorganism colonization.[2,8]

Currently, laser therapy emerges as a treatment modality increasingly implemented for the management of osteonecrosis of the jaw, generally combined with other treatment approaches such as platelet-rich plasma and systemic antibiotic therapy, among others. Its primary application is based on photobiomodulation therapy

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and photodynamic therapy, whose main effects include symptom reduction, stimulation of wound healing, and increased new bone formation.[9]

The objective of this article is to present the complex case of a patient diagnosed with osteonecrosis of the jaw associated with osteomyelitis, treated exclusively with laser therapy.

Case Report

A 62-year-old male patient was referred from maxillofacial surgery service with a diagnosis of craniofacial osteomyelitis complicated by an infectious process and a frontal brain abscess, with a history of a 25-day hospitalization. During the hospitalization, necrotic lesion debridement, frontal bone tissue scraping, daily wound care, systemic antibiotic therapy, and hyperbaric therapy were performed. Despite medical treatment, the patient experienced a recurrence and an increase in purulent and foul-smelling discharge through fistulas at the level of the upper jaw, leading to the referral.

In the medical history, the patient reported having type 2 diabetes mellitus, chronic arterial hypertension, and acute chronic sinusitis. The patient also mentioned having received two doses of intravenous tocilizumab (IV) due to severe pneumonia caused by COVID-19. The patient denies having undergone treatment with antiresorptive drugs, antiangiogenic agents, or monoclonal antibodies.

On physical examination, the following were observed: blood pressure of 130/80 mm Hg, glucose level of 157 mg/dL, glycosylated hemoglobin at 6.8%, pulse rate of 65 beats per minute, temperature of 36.7 ºC, and oxygen saturation of 99%. The intraoral clinical examination revealed erythema and edema in the anterior region of the maxilla, accompanied by total edentulism of the upper jaw and extensive necrotic bone exposure involving the anterior maxillary region, associated with dehiscence in the vestibular alveolar mucosa and an oro-sinusal fistula (Figure 1A). The patient reported pain, halitosis, and altered taste sensitivity. The axial computed tomography scan revealed resorption of the maxillary palatine bone and changes in the trabeculation of the cranial bone (Figure 1B).

Analysis of the clinical findings, along with the maxillary computed tomography, led to the diagnosis of maxillary osteonecrosis associated with craniofacial osteomyelitis. As a treatment plan, laser therapy was proposed to the patient, which included a surgical phase, photodynamic therapy, and intravascular laser irradiation of blood (ILIB) therapy.

Before the treatment, the objective and the steps of the intervention to be performed were explained to the patient, who voluntarily agreed to receive the treatment by signing an informed consent form.

Surgical Phase

This involved necrotic bone ablation using an Er,Cr: 2780 nm laser with a hard tissue protocol (pulsed mode; output power: 5 W; frequency: 30 Hz; air: 70%; water: 90%; mode: H; non-contact; tip: MZ6 - 8:6 mm x 800 microns). On soft tissue, a superficial epithelial peeling was performed around the fistula to create a bleeding edge to promote healing by secondary intention. The procedure was carried out using an Er,Cr: 2780 nm laser with a soft tissue protocol (Pulsed mode; output power: 2.5 W; frequency: 50 Hz; air: 40%; water: 50%; mode: S; contact; tip: MC3 - 6 mm)[10] (Figure 2).

Photodynamic Therapy

The main objective was wound disinfection. The therapy was performed using a 650 nm diode laser, with a 1 cm² handpiece, continuous mode, an output power of 200 mW, and a power density of 8 J/cm². The treated area was divided into 1 cm² sections. The procedure began by applying 0,01% methylene blue to the area to be treated (Figure 3A), waiting for 4 minutes, and then irradiating with the laser for 40 seconds, with the tip positioned very

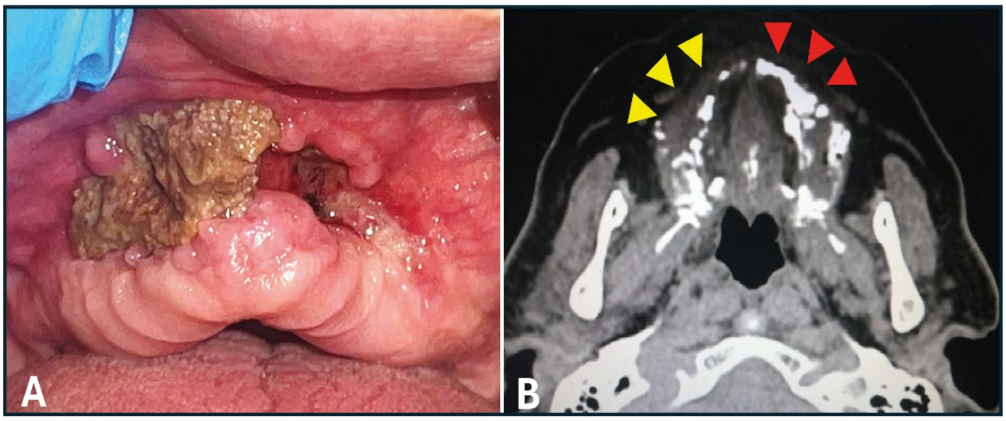

Figure 1. (A) Initial photo: An area of exposed necrotic bone is observed in the maxilla, characterized by an irregular surface and intraoral fistula. **(B)** Axial computed tomography: A marked necrotic bone widening and numerous bone sequestrums are observed, encompassing almost the entire maxillary arch. In addition, extensive osteolytic lesions with bone destruction of the vestibular cortex on the right side are visible (yellow arrows). Sclerotic changes in the left alveolar region are also appreciated (red arrows)

close to the tissue without making contact (Figure 3B). This process was repeated for each section until the entire area was treated.[11,12]

Lymphatic Drainage

This was performed using a 650 nm diode laser, with an output power of 200 mW in continuous mode. A conical photobiomodulation tip was used to irradiate the entire extraoral area of the anterior section of the maxilla, applying a slow dragging motion, ultimately draining into the submental, submaxillary, and deep cervical lymph nodes (Figure 3C).[13]

ILIB Therapy

This was performed simultaneously with the previously mentioned photodynamic therapy. An 880 nm diode laser in continuous mode was used, with an output power of 100 mW and an area of 0.2 cm². The device was attached to the ILIB bracelet placed over the radial artery on the patient's right wrist, with the therapy lasting 1 hour in continuous contact (Figure 3D).[14]

Photodynamic therapy and ILIB therapy were carried out continuously for 20 days. The fistula was not sutured during any of the treatment sessions or after the treatment. Weekly clinical evaluations were conducted (Figure 4), through which it was possible to observe the closure of the fistula, absence of secretions and foul odor. The patient reported no pain, and vital signs were within normal parameters.Follow-up was performed at 10 months, and the report of the findings of the tomography of the upper jaw indicated "loss of continuity of the cortical continuity of the anterior wall and floor without apparent perforation of Schneider's membrane, presence of hypodense area in the process of scarring, in the anterior area of the upper jaw, anterior nasal spine, heterogeneous trabeculation, lax spongy, partially continuous cortices".

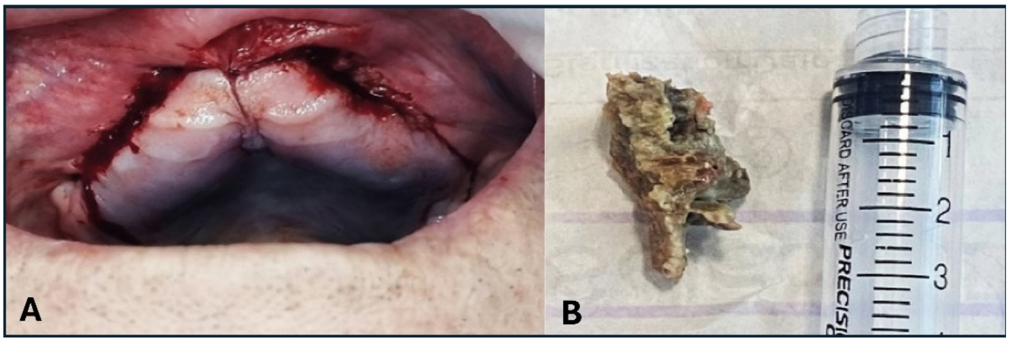

Figure 2. (A) Photo of the immediate post-surgical period, showing the raw edge of the fistula induced by laser. **(B)** Removed bone sequestrum

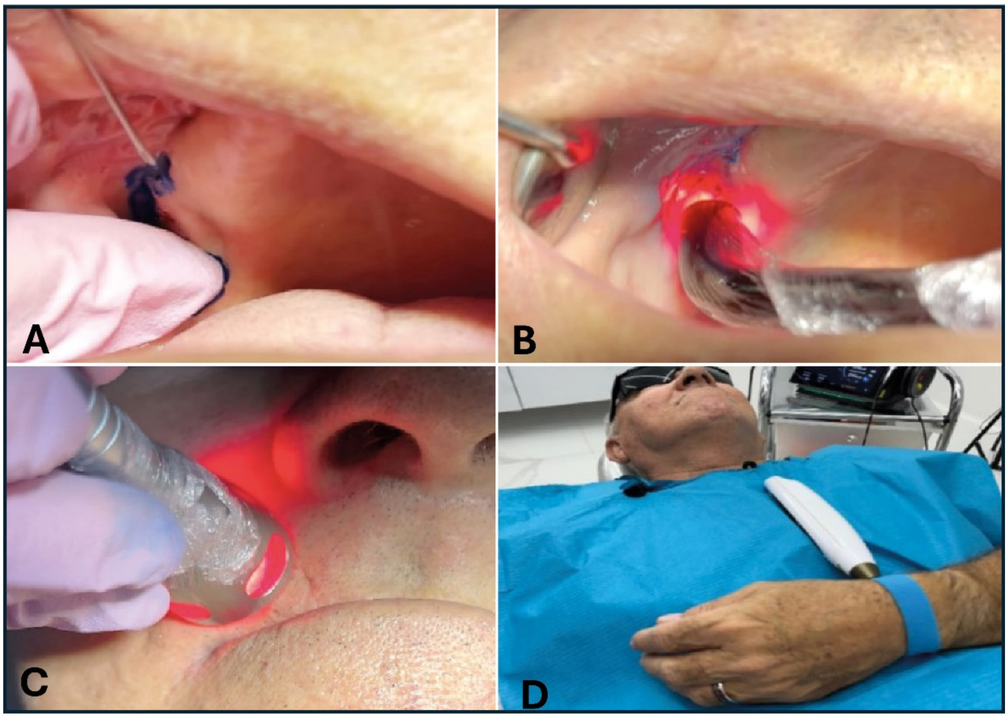

Figure 3. Photodynamic Therapy and Photobiomodulation. **(A)** Application of methylene blue, **(B)** laser irradiation for 40 seconds (without tissue contact), **(C)** lymphatic drainage, **(D)** ILIB therapy on the radial artery

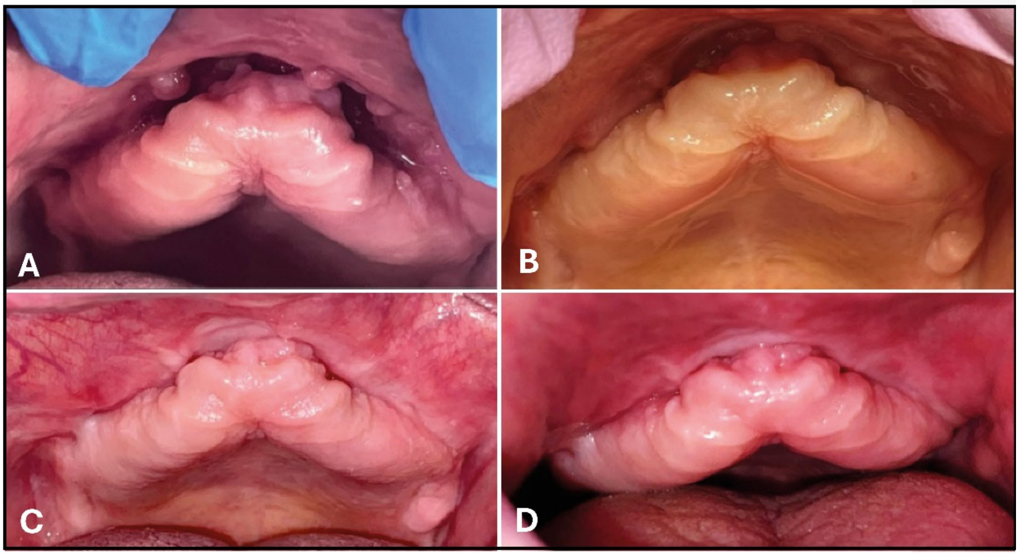

Figure 4. **Postoperative Evolution.** **(A)** Week 1, **(B)** Week 2, **(C)** Week 4, **(D)** 1 year after treatment

One year after treatment, complete closure of the fistula was observed, with no recurrence, and the oral tissues remained intact and healthy (Figure 4D).

Discussion

Osteonecrosis of the jaw associated with osteomyelitis is a complex condition that significantly affects the patient's quality of life. The case described in this article is particularly challenging due to the presence of local and systemic risk factors that influenced the progression of osteonecrosis. The main local factor is the presence of osteomyelitis, a condition that can lead to jaw osteonecrosis by disrupting proper blood supply due to the accumulation of pus and pressure within the bone caused by infection and inflammation. From this perspective, it is understood that the underlying local infection plays a key role in the pathogenesis of osteonecrosis.[15]

Regarding systemic factors, the patient's underlying chronic systemic diseases, especially diabetes mellitus, constitute a risk factor for the development of infectious complications and compromise the patient's ability to heal.[16] Another important antecedent is severe COVID-19 pneumonia, which involves treatment with Intravenous tocilizumab (IV). This treatment plays an important role as a systemic risk factor by influencing bone metabolism[17] since it is a drug consisting of a monoclonal antibody used in the treatment of various chronic inflammatory diseases, and it exerts inhibitory activity on interleukin-6 (IL-6), a proinflammatory cytokine that promotes the differentiation and activation of osteoclasts. By inhibiting IL-6, it reduces bone resorption levels; therefore, prolonged use can have an adverse effect similar to antiresorptive drugs by preventing the proper renewal of jawbone tissue, making it more susceptible to necrosis. In this case, the use of intravenous tocilizumab (IV) was not associated as a direct causative agent of osteonecrosis, as the patient received only two doses, but it clearly represents a risk factor.

The patient was referred by the maxillofacial surgery department due to a history of treatments that failed to resolve the fistula and osteonecrosis. Given the need for surgical intervention, bone regeneration to facilitate wound healing, and pain management, laser therapy was indicated as part of the treatment plan, supported by clinical evidence demonstrating its efficacy. Laser therapy was proposed to stimulate the formation of new bone and promote soft tissue healing. For this purpose, necrotic bone tissue was removed using Er,Cr:YSGG laser ablation at 2780 nm. The main advantages of this type of laser include the controlled removal of necrotic bone while minimizing damage to the surrounding healthy tissue. It features a hydrokinetic system based on the release of photons in a mist of air and water that ultimately impacts the tissue; this mechanism significantly reduces the thermal effect on the tissue. Like other types of lasers, the Er,Cr:YSGG laser at 2780 nm possesses antibacterial properties, thereby decreasing the risk of postoperative infections.[18]

The molecular mechanisms involved in the repair of damaged bone tissue after laser intervention are complex and continue to be studied. The effects that have been described at the tissue level include the expansion of the organic bone matrix and an increase in the mitotic index of osteoblasts, meaning that their proliferation and activity increase.[19] Furthermore, the synthesis of type I collagen has been observed during healing; this type of collagen is the main protein of the bone matrix, and therefore, its synthesis contributes to the generation of new bone tissue.[20]

The second phase of treatment was focused on promoting healing and fistula closure, and to achieve this, photobiomodulation therapy and photodynamic therapy were applied. Photodynamic therapy is a technique that combines the action of light with photosensitive compounds (methylene blue) directed at chromophores to destroy microorganisms and applied for decontamination and photobiostimulation purposes using a 650 nm diode laser.

Photobiomodulation is directly related to the properties of light. When the affected area is irradiated, light energy is converted into chemical energy that is useful for the cell. Light has the ability to be absorbed by chromophores present in cells (Cytochrome C oxidase from the electron transport chain). This interaction generates biochemical effects that stimulate cellular metabolism and enhance the tissue's reparative capacity by restoring the electron transport chain, increasing ATP production, modulating calcium levels, and activating transcription and growth factors. This signaling cascade ultimately promotes cell proliferation and migration, the synthesis of new proteins, and angiogenesis.[21]

In complement to the surgical treatment and photodynamic therapy, ILIB therapy was administered to promote systemic improvement in blood oxygenation, pain and inflammation management, and the regulation of various physiological functions of the body, as the patient had systemic complications.[14]

ILIB is a non-invasive technique developed in 1970 and performed with a low-power laser, and it involves the irradiation of blood through an optical fiber positioned over the radial artery. It is a vascular photobiomodulation technique which can modulate redox signaling in mitochondria through the stimulation of respiratory chain components, increasing ATP synthesis. This signaling cascade triggers beneficial effects on blood immunoglobulins, interferons, and interleukins, leading to analgesic, antispasmodic, and sedative effects. In addition, it has been linked to an increase in arteriovenous oxygen capable of counteracting tissue hypoxia and promoting oxygen enrichment, which is a sign of normalization of tissue metabolism.[14,22]

It is observed that other authors[23,24] administer pharmacological therapy and use laser therapy as a complementary treatment, whereas the case described here was managed solely with laser therapy, employing different techniques and wavelengths. The outcome was successful; suppuration was halted, and the intraoral fistula closed 15 days after the treatment. In line with this result, the experimental study by Cubas-Mogollón et al[25] reported partial bone repair in rats after 15 days of treatment with the application of 1 J of energy using an 808 nm gallium-aluminum-arsenide (GaAlAs) laser. In our case, a power density of 8 J/cm² was applied with a 650 nm diode laser, obtaining results similar to those of Cubas-Mogollón et al, suggesting that, after 15 days, some significant new bone tissue synthesis was achieved, leading to fistula closure.

When comparing laser therapy with conventional therapy for the treatment of maxillary osteonecrosis, clinical evidence highlights the advantages of laser treatment in terms of tissue regeneration and improved patient quality of life. Due to its photobiomodulatory effect, laser therapy promotes wound healing, enhances microcirculation in the affected area, and reduces both inflammation and pain, while also significantly decreasing the risk of infections.

In contrast, conventional therapy, according to Atalay et al,[26] relies on local and systemic medical treatments such as the combination of antibiotics, chlorhexidine mouth rinses, and anti-inflammatory drugs. While these approaches provide temporary relief, they do not ensure sustained improvement in pain or infection-related symptoms over the long term.

To address this limitation, Weber et al,[27] propose an integrative approach, emphasizing that the combination of antibiotics, minimally invasive surgery (including laser surgery), and low-level laser therapy in the early stages of the disease should be considered the gold standard for managing osteonecrosis. This treatment model not only provides a more comprehensive disease management strategy but also optimizes clinical outcomes with a lower impact on the patient.

In this case, the treatment was carried out without limitations. The procedures were minimally invasive and allowed direct access to the lesion site. Throughout the sessions, a progressive improvement in signs and symptoms was observed until complete closure of the fistula was achieved. No modifications to the protocols or the treatment plan were necessary, as the initially proposed approach proved to be successful.

Conclusion

In conclusion, before establishing the treatment plan, it is important to identify all possible factors involved in the development of the pathology in order to provide the patient with the most complete treatment. In this case, the combination of different laser therapy modalities and wavelengths was decisive for the patient's recovery, effectively controlled infection, inflammation, and pain, and promoted healing.

Authors' Contribution

Conceptualization: Pilar Blanco Flores, Jennifer Orozco Páez.
Funding acquisition: Pilar Blanco Flores.
Investigation: Pilar Blanco Flores, Jennifer Orozco Páez.
Methodology: Pilar Blanco Flores, Jennifer Orozco Páez.
Project administration: Jennifer Orozco Páez.
Resources: Pilar Blanco Flores.
Supervision: Pilar Blanco Flores, Jennifer Orozco Páez.
Visualization: Jennifer Orozco Páez.
Writing–original draft: Pilar Blanco Flores, Jennifer Orozco Páez.
Writing–review & editing: Pilar Blanco Flores, Jennifer Orozco Páez.

Competing Interests
None declared.

Ethical Approval
In the present clinical case, where laser therapy with different wavelengths was applied for the treatment of a patient with maxillary osteonecrosis, the highest ethical standards in medical care were ensured. Informed consent was obtained clearly and voluntarily, ensuring that the patient understood the objectives, benefits, risks, and alternatives of the proposed treatment. The principles of autonomy, beneficence, non-maleficence, and justice were respected, safeguarding the privacy and confidentiality of clinical information.

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