

Ozone Therapy – Ozone Applicability in Various Dental Specialties

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Abstract— Ozone (O₃) is an allotropic oxygen compound, found in abundance in the stratosphere and which, due to its antimicrobial, disinfectant and healing properties, provide therapeutic applications for more than 260 different pathologies. Ozone therapy is a technique that uses this gas, in its gaseous, aqueous and oily forms as a disinfection treatment option, being considered a safe, minimally invasive and conservative modality. This study aimed to review the literature on ozone therapy applied to dentistry, aiming to clarify its benefits and care during use as complementary therapy. For that, searches were carried out in databases addressing the theme proposed between 2007 and 2020, in three languages: Portuguese, English and Russian. It is concluded that Ozone therapy can be used safely and efficiently in dentistry as a complementary disinfection practice, without contraindications. Although laboratory studies have emerged as a promising potential for ozone in dentistry, more in-depth studies with standardized methodologies are needed to, in short, obtain more information about its applicability.

Keywords— Ozone therapy, Dentistry, Application.

I. INTRODUCTION

Ozone (O₃), an allotropic oxygen compound (O₂) also known as triple oxygen or oxygen, is formed in the atmosphere through photochemical analyzes, that is, after generating an electrical discharge in the oxygen molecule, the same breakdown releasing atoms and binding to another oxygen molecule, forming O₃. It contains a half-life of approximately 40 min at 20 °C (AZARPAZHOOH, LIMEBACK, 2008). It is a dynamically unstable and oxidizing structure, being easily created and destroyed in O₂ molecules (BOCCI, et al., 2011).

Found in the stratosphere at a concentration of 1 to 10 ppm, ozone is important due to its ability to filter out ultraviolet (UV) rays emitted by the sun. On the other hand, ozone in the atmosphere is considered toxic to the lung, since it is produced by chemicals that involve sunlight, car exhaust and oxygen, while the atmosphere can be caused by the action of ultraviolet rays or artificially with the aid of a generator (OLIVEIRA, MENDES, 2009).

It was discovered in 1785 by Martin Van Marum and substantiated in 1840 by the German researcher Christian Friedrich Schonbein, who already worked with water electrolysis when he included ozone in one of his experiments. According to or researcher, after performing an electric discharge in the water in a glass hood using oxygen, the use of gas that had a bluish color and a strong

odor, calls it "Ozon", which derives from the Greek oil and means "what it smells." He considers ozone to be a potent disinfectant (FERREIRA, 2011).

During the First World War, the use of ozone was reported for the first time in the German physician Albert Wolf, whose main objective was to treat post-traumatic ulcerations, infected wounds, burns and fistulas in German soldiers, obtaining satisfactory results that, soon after, created a technique for exporting blood directly to the gas mixture composed of oxygen-ozone (NOGALES, 2011).

In Dentistry, its first use was in the form of ozonized water by Dr. Edward A. Fisch (1899–1966) during a surgery on the German Dr. Erwin Payr (1871-1946), being the main objective in employment in the technical era for promote hemostasis, inhibiting the proliferation of bacteria and, thus, improving the local oxygen supply. Fisch was fascinated by the technique and went on to research deeply. In 1935, he published the work "On Ozone Treatment in Surgery" at the 59th Congress of the German Surgical Society in Berlin and then started Ozone therapy as it is known today. (FERREIRA, 2011).

Ozone therapy is a complementary technique that uses ozone (O₃), in its gaseous, aqueous and oily forms, as a therapeutic option in the treatment of various pathologies, due to its biocompatibility generated by its bacteriological and immunostimulating power. In Brazil, a practice that

started in 1975 and gained more followers in the 1980s, due to the interest of some universities. In March 2018, the Unified Health System (SUS) included the use of ten new complementary practices, one of which is ozone therapy (NESI, 2018).

Nesi (2018) relates that Ozone therapy can be performed in several dental practices, for example: Periodontics (prevention and treatment of infectious/inflammatory conditions); Surgery (assist in tissue repair); Temporomandibular joint pain and dysfunction (reduction of symptoms); Jaw necrosis (osteoradionecrosis, drug-induced necrosis and osteomyelitis); Stomatology (accelerated healing of ulcers, cold sores and other gum infections); Caries treatment; Endodontics (intensifying an antiseptic phase of the root canal system, acute and chronic infections); Biosafety (acting as a technique in the sterilization of dental materials).

Therefore, this objective work reviews the literature on the use of ozone in several dental specialties, helps to clarify its benefits and care when using complementary therapy.

II. MATERIALS AND METHODS

The type of study addressed was a literature review, whose bibliographic survey was guided by the question: Is there evidence of benefit from ozone therapy in dentistry? To ensure the relevance of the information contained in this work, searches were carried out on the PubMed electronic portals using the Health Sciences Descriptors (DeCS) "Ozone therapy" and "Dentistry" and "Application"; and Google Scholar searching for "Ozonioterapia na Odontologia". In the crossing of the adopted words, the expression of Boolean logic "AND" was used. As inclusion criteria, it was determined: articles available in the aforementioned databases that reported on the therapeutic use of ozone in dental specialties. All studies that did not address the proposed theme and also those that presented duality were excluded.

Initially, to check if there was a relationship with the theme of the present study, the articles were previously selected from reading the titles and abstracts. After a more in-depth analysis of the research content, publications that were in agreement with the guided question and with the pre-defined inclusion and exclusion criteria were inserted in this bibliographic review. Thus, a total of 30 articles were included in this literature review and presented in three languages: English (22), Portuguese (08) and Russian (01).

III. RESULTS AND DISCUSSION

Ozone therapy is proposed in dentistry due to its biocompatibility, curative properties, oxidizing, antimicrobial, fungicidal and bactericidal action (LONCAR, et al., 2009; OLIVEIRA, MENDES, 2009; LYNCH, 2009; SAINI, 2011; NOGALES, 2011; FERREIRA, et al., 2013). The gas has been applied to enhance the healing of epithelial wounds, such as ulcerations and herpetic lesions; promote remineralization; and sterilize cavities, root canals and periodontal pockets (AZARPAZHOOH, LIMEBACK, 2008). Thus, Loncar, et al., (2009) state that, despite being frequently used in other dental specialties and proving effective for them, ozone in gaseous form is more used in Dentistry and Endodontics.

Ozonized oil is the most stable form obtained which, in addition to stimulating enzyme systems of oxide reduction, also has excellent antimicrobial and antibacterial action (NESI, 2018; ANZOLIN, BERTOL, 2018). According to Oliveira, Mendes (2009) and Abreu, et al., (2015), topical applications of Oil ozonized have been frequent both in prosthetic stomatitis and alveolitis and, according to Ferreira (2011), in fistula.

If compared to oxygen, ozone is 10 times more soluble in water (LONCAR, 2009; OLIVEIRA, MENDES, 2009; SAINI, 2011; FERREIRA, 2011; NOGALES, 2011). In the study by Loncar, et al., (2009), ozonized water decontaminated the root surface of loose teeth without causing damage to periodontal cells and proved to be useful for endodontic treatment. Azarpazhoooh, Limeback (2008), Lynch (2009) and Nogales (2011) show that it is effective against oral microorganisms. Ferreira (2011) states that ozone in aqueous form did not show resistance to drugs, has low toxicity, is more biocompatible than other antimicrobials and is cheaper than other antiseptics. Ferreira, et al., (2013) add that the use of ozonized water as an antiseptic in oral surgeries improves tissue oxygenation, enhancing the repair process.

There is no agreement on the time of application and the ideal concentration of the therapeutic levels of ozone, as they vary according to each objective (OLIVEIRA, 2007). Loncar, et al., (2009) point out that the duration of the application varies from 10 to 80 seconds, however, according to Oliveira, Mendes (2009), it is 2 to 3 minutes. Makeeva, et al., (2017) observed that in less invasive procedures, such as in white spot lesions, for example, the gas mixture was used for 24 seconds under the element in question, while in EAR lesions, Al-Omiri, et al., (2016) claim that exposure to ozone gas lasted 60 seconds. Ferreira, et al. (2013) explain that, in the third molar ostectomy, ozonized water was administered as an

irrigating agent throughout the procedure and, Oliveira, et al., (2018) add that, in the context of GUN, the ozonized oil was applied without a specific time interval. Regarding the concentration, it is known that the maximum allowed for the clinical application of the ozone-oxygen gas mixture is 5% or 100 µg / ml of ozone, where 1 µg / ml means that it contains 0.05% O₃, and 100 µg / ml contains 5% (FERREIRA, 2011; NOGALES, 2011).

Nesi (2018) guarantees that Ozone therapy contributes to periodontics in both acute and chronic periodontal processes. Oil and ozonized water significantly reduced the bacterial count and the depth of the periodontal pockets (OLIVEIRA, 2018; OLIVEIRA, MENDES, 2009). Oliveira (2018) also states that, regardless of obtaining statistical improvements in periodontal parameters, ozonized water cannot replace RAR. Ozonized oil, while not the most widely used form, is an effective and safe therapeutic alternative for the treatment of necrotizing ulcerative gingivitis, promoting the reduction of inflammatory symptoms (URAZ, et al., 2019). The application of the gas was not associated with significant changes in periodontal recovery in cases of generalized chronic periodontitis and aggressive periodontitis (URAZ, et al., 2019; TASDEMIR, et al., 2019; DENGIZEK, et al., 2019).

Ozone acts fully in surgery and in infectious conditions, because, in addition to reducing painful symptoms, it can even induce a cure (OLIVEIRA, MENDES, 2009). Both gas, water and ozonized oil have shown promise in reducing complications and postoperative discomfort (AZARPAZHOOH, LIMEBACK, 2008; OLIVEIRA, MENDES, 2009; FERREIRA, et al., 2013; ABREU, et al., 2015; SIVALINGAM, et al., 2017). Additionally, Isler, et al., (2018) and Nesi (2018) report that, due to the scarcity of adverse effects, ozonized oil can serve as a substitute for systemic antibiotics.

After the application of the gas, lesions such as aphthous ulcerations, cold sores and oral candidiasis had their signs and symptoms ceased (AL-OMIRI, et al, 2016; AMIN, 2018; OLIVEIRA, et al., 2018). Amin (2018) states that this is due to the fact that ozone is an excellent fungicidal agent and serves as a warning to the immune system. Oliveira, Mendes (2009) explain that ozonized oil proved to be more effective than the antifungal Nystatin in the treatment of prosthetic stomatitis and, in cases of herpetic gingivostomatitis, it also contributed to the improvement of the infectious process.

Studies show that surgical procedures combined with ozone therapy are beneficial to patients who use

bisphosphonates (OLIVEIRA, MENDES, 2009). Anzolin, Bertol, (2018) claim that application of the gas under the wounds, in addition to enhancing healing and reducing genotoxic damage, in agreement with Nesi (2018), is also capable of stabilizing frames of osteonecrotic lesions induced by bisphosphonates and minimizing the painful symptoms in individuals with TMD. However, Celakil et al., (2019) claim that the occlusal plaque is the best therapeutic option to treat TMD. Anzolin, Bertol, (2018) state that ozonized water reduced the painful symptoms of osteoarthritis and, in accordance with Oliveira (2018), partially or totally improved TMD.

Loncar, et al., (2008) and Makeeva, et al., (2017) recognize that, in restorative dentistry, gas acts as a disinfectant, is an excellent therapeutic option for primary caries injuries and enhances remineralization. Kronic, et al., (2018) add that it is biocompatible, provides a good antimicrobial effect and can reduce children's anxiety in dental treatment. Ozonized water can have a lethal effect on *S. mutans* and *L. acidophilus*, proving its effectiveness in eliminating cariogenic microflora (AYKUT-YETKINER, et al., 2013). Within the dentinal tubules, it proves its high inhibitory power of biofilm accumulation and growth of gram-positive and gram-negative microorganisms (ALMAZ, SONMEZ, 2015). On the other hand, Durmus et al., (2019), emphasize that O₃ is not a disinfectant as effective as 2% chlorhexidine.

In endodontics, Oliveira, Mendes (2009) did not notice a significant difference in the antimicrobial effect of O₃ when compared to other chemical agents such as, for example, MTA and 3% NaOCl. For Loncar et al., (2009), Lynch (2009) and Nogales (2011), ozone (in gaseous and aqueous forms) does not eliminate microorganisms such as *E. faecalis* and *S. mutans*, and have antimicrobial activity similar to NaOCl 2.5% to 5% and CHX 2%. In contrast, for Noites, et al., (2014), the association of 2% chlorhexidine with ozone gas for 24 seconds, completely eliminates *Candida albicans* and *Enterococcus faecalis*. Ferreira (2011) believes that gas is more effective than ozonized water. Silva, et al., (2019) concluded that, for microbial reduction, ozonized water cannot replace or complement NaOCl, as it is less effective than conventional therapy. While Ferreira (2011) shows that patients who received ozonized oil as an intracanal medication had their recovery enhanced, Nogales (2011) states that there was no significant difference between him, calcium hydroxide associated with camphorated paramonochlorophenol and glycerin. The author adds that, in situations where NaOCl cannot be used in high concentrations, ozone in gaseous form can be an equivalent substitute.

Table.1: Summary of the main articles found

Dental Specialty	Author / Title / Year	Study Objectives	Research Method	Results and Conclusions
Periodontics	Oliveira, <i>et al.</i> Ozone therapy and Dentistry: new perspectives. 2018.	- Assess the permeability of oral microorganisms and dental plaques after using ozonized water as a subgingival irrigant;	Systematic review Data base: PubMed	- Efficacy proven in three studies;
	Dengizek, <i>et al.</i> Evaluating clinical and laboratory effects of ozone in non-surgical periodontal treatment: a randomized controlled trial. 2019.	- To evaluate the clinical, biochemical and microbiological efficacy of Ozone therapy associated with RAR in patients with generalized chronic periodontitis.	Randomized Controlled Study Data base: PubMed	- In three studies it did not generate an additional effect to the periodontal parameters.
Surgery	Oliveira, Mendes. Clinical applications of ozone in dentistry. 2009.	- Treatment of osteomyelitis and alveolitis;	Systematic review Data base:: Academic Google	-
	Sivalingam, <i>et al.</i> Does topical ozone therapy improve patient comfort after surgical removal of impacted mandibular third molar? A randomized controlled trial. 2017.	- Assess the influence of ozone therapy on patient comfort after extraction of the third molar.	Randomized Controlled Study Data base: PubMed	- In all studies, it accelerated healing and also reduced the amount of microorganisms, postoperative infectious complications, trismus, swelling and painful symptoms.
TMD and Jaw Necrosis	Anzolin, Bertol. Ozone therapy as an integrating therapeutic in osteoarthritis treatment: a systematic review. 2018;	- Evaluate the current evidence of Ozone therapy in the treatment of osteoarthritis;	Systematic review Data base: PubMed	- In four studies, there was total or partial cure of the cases and reduction of painful symptoms;
	Celakil, <i>et al.</i> Management of pain in TMD patients: Bio-oxidative ozone therapy versus occlusal splints. 2019	- To test the bio-oxidative effect of ozone in the treatment of symptomatic TMD compared to the treatment with occlusal plaque.	Randomized double-blind clinical study Data base: PubMed	- In one study it did not obtain significant results, concluding that the occlusal plaque is the best treatment option.
Stomatology	Al-Omiri, <i>et al.</i> Ozone treatment of recurrent aphthous stomatitis: a double blinded study. 2016;	- Treatment of recurrent aphthous stomatitis;	Double-blind study Data base: PubMed	-
	Amin. Biological assessment of ozone therapy on	- Check if oral candidiasis may be	Randomized	- Signs and symptoms ceased, improvement in healing and even healing.

	experimental oral candidiasis in immunosuppressed rats. 2018	associated with impaired defense mechanisms generated by immunosuppressive drugs.	Clinical Trial Data base: PubMed	
Dentistry	Krunic, <i>et al.</i> Clinical antibacterial effectiveness and biocompatibility of gaseous ozone after incomplete caries removal. 2018; Durmus, <i>et al.</i> Effectiveness of the ozone application in two-visit indirect pulp therapy of permanent molars with deep carious lesion: a randomized clinical trial. 2019.	- Analyze the antimicrobial effect and the biocompatibility of ozone after incomplete caries removal; - Evaluate and compare the clinical and microbiological aspects of ozone therapy with other cavity disinfectants in indirect pulp therapy.	Randomized Controlled Study Data base: PubMed Randomized Controlled Study Data base: PubMed	- Seven studies showed that there was remineralization, little caries progression and a decrease in cariogenic microorganisms; - A study stated that CHX is the best cavity disinfectant;
Endodontics	Loncar, <i>et al.</i> Ozone Application in Dentistry. 2009. Ferreira. Effect on ozone therapy periapical bone repair as an adjunct to endodontic treatment: a radiographic clinical study. 2011.	- Evaluate in vitro the effects of ozone therapy and other root canal disinfectants infected with <i>Enterococcus faecalis</i> . - Examine the effect of ozone as an intracanal medication.	Systematic review Data base: PubMed Clinical and radiographic study Data base:: Academic Google	- In the other studies, it did not show significant results; - In three studies, ozone combined with other media completely inhibited pathogens and enhanced recovery.

IV. CONCLUSION

Ozone therapy is consolidated as a promising, safe and low cost complementary treatment option, generating benefits, especially for low-income patients. It is a widely known and used therapeutic modality due to the large number of bacteria and infectious diseases being sensitive to ozone.

Although laboratory studies advocate that ozone therapy is biologically effective and atraumatic for dental practices, there is still a discrepancy in the concentrations of therapeutic ozone levels, requiring more randomized, double-blind clinical trials with well-designed sample sizes and that present standardized measurement and analysis methods, in order to clarify the ideal concentrations and periods of ozone administration.

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