

Clinical utility of ozone therapy in dental and oral medicine

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Abstract

Ozone is a highly reactive compound composed of three oxygen atoms that acts as an oxidant and oxidizer. It exists at the ground level as an air pollutant and a constituent of urban smog, as well as in the Earth's upper atmosphere as a protective layer from ultraviolet rays. Healthy cells contain antioxidants such as vitamins C and E to protect against ozone oxidation. However, pathogens such as bacteria contain very trace amounts of antioxidants in their membranes, which make them susceptible to ozone and destroy the cell membrane. This review explores the history, composition, and use of ozone worldwide in dentistry. Ozone therapy has thus far been utilized with wound healing, dental caries, oral lichen planus, gingivitis and periodontitis, halitosis, osteonecrosis of the jaw, post-surgical pain, plaque and biofilms, root canals, dentin hypersensitivity, temporomandibular joint disorders, and teeth whitening. The utility of ozone will undoubtedly grow if studies continue to show positive outcomes in an increasing number of dental conditions.

Key words: ozone therapy; dentistry; gingivitis; halitosis; periodontitis; dental caries; osteonecrosis of the jaw; root canal; dentin hypersensitivity; dental plaque

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INTRODUCTION

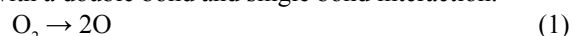
Ozone was first identified by Christian Friedrich Schönbein in 1840. In history, Native Americans noticed that there was a relationship between the strong odor generated by lightning strikes and successful fishing days. The successful fishing trips could be now explained as being caused by an increase in oxygen in the upper layer of the water. Since then, ozone has been experimented for various aspects of dentistry for over 100 years, the first use to disinfect operating rooms in 1856.¹ In 1870, ozone was used to purify blood. In the 1930s, dentist Edward Fisch used ozone therapy to disinfect and heal wounds for his dental surgeries with great success.² Today, ozone therapy has shown success with managing wound healing, dental caries, oral lichen planus, gingivitis and periodontitis, halitosis, osteonecrosis of the jaw, post-surgical pain, plaque and biofilms, root canals, dentin hypersensitivity, temporomandibular joint disorders, and teeth whitening. Herein we review the chemistry of ozone, forms of application, and uses in dentistry.

LITERATURE RETRIEVAL

A comprehensive MEDLINE® search of the literature ranging from 1968 to present, with an emphasis on the past 10 years, was conducted combining the search term “ozone therapy” with the following search criteria: “dentistry,” “dental medicine,” “gums,” “jaw,” and “teeth.” No specific exclusion criteria were set. Publication quality was assessed using the relative citation ratio derived from iCite bibliometrics.

FORMATION AND DECOMPOSITION OF OZONE

Molecular O₂ is photodissociated into individual oxygen atoms that are highly reactive and react with an O₂ to form O₃, which is ozone (Equations 1 and 2). The O₃ exists in an intermediate with a double bond and single bond interaction.



Ozone can radicalize into O₃·. In an aqueous solution, O₃· is protonated into HO₃· which then decomposes into OH· and O₂.

Ozone for medical purposes is produced using a generator by passing pure oxygen through a high voltage gradient of 5 to 13 mV. The final product is a gas mixture that contains 95% oxygen and 5% ozone. If there is any air within the mixture, toxic nitrogen dioxide can be created. As ozone is a very unstable gas with a half-life of 40 minutes at 20°C, it cannot be stored and must be immediately used. The generator must have an accurate photometer and calculate precise ozone concentrations in the mixture. Ozone, if not used correctly or in increased amounts, can be toxic and pulmonary complications. Oxidation of proteins, thiols, and amines during the process of peroxidation of polyunsaturated fatty acids can cause serious damage within the body.³

FORMS OF APPLICATION

Ozone can be administered *via* several mediums such as gas, water, and oil. An intravenous injection should not be used to administer ozone, as an air embolism may form.



Gaseous ozone

There are machines that can generate ozone gas *via* an open system or a sealed suction system. There are adverse effects (**Table 1**) that may arise in an open system upon inhalation, so the sealed suction system is usually used.

Ozonated water

Ozonated water is used as a mouthwash or drinking to kill off bacteria, viruses, and fungi for various issues such as halitosis or gum disease. It is a safer alternative to gaseous ozone.

Ozonated oil

Ozonated oil can be convenient and provide greater permeation.

USES IN DENTISTRY

Ozone therapy has been met with several applications in dentistry (**Table 2**), although there are contraindications (**Table 3**) to general ozone use to be mindful of.

Acceleration of healing

Planimetric, immunohistochemical, and micromorphological examinations of the wounds of the oral mucosa were conducted in an experiment at the University of Basel, Switzerland. The patients who applied ozonized water on their wounds showed an acceleration of wound healing and earlier wound closing than patients who applied regular water and did not receive treatment.⁵ This may be due to the fact that transforming growth factor beta 1 is produced in greater amounts when ozone is present.⁴

Dental caries management

Dental caries is a major oral health issue that affects many school children as well as a majority of adults. *Streptococcus mutans* and *Streptococcus sobrinus* are human odontopathogens that are causes of dental caries. Colonization by *Streptococcus mutans* can cause inevitable decay if they grow within deep fissures of the tooth, while *Streptococcus sobrinus* play a primary role in smooth-surface decay.⁶ However, when these bacteria were subject to ozone from an ozone-generating device, there was a significant reduction in ozone-treated samples.⁷ Dental caries must be controlled by various methods including preventing the attachment of cariogenic bacteria, changing cell signaling mechanisms, enhancing host defenses, or more. One way to control dental caries is by use of ozone. Ozone can be used in a preventative care routine for root caries. Trials have shown that non-cavitory root caries can be reversed and arrested of progression which eliminates the need for removal. The routine includes application of ozone for 40 seconds, following with the use of remineralizing products.⁸ Cavitated lesions are less likely to be successful with ozone application.⁹ As caries pyruvate contributes to the progression of tooth demineralization, ozone application can manage further tooth demineralization.¹¹

Anxiety can cause several limitations in the treatment of carious lesions in children as well as adults. In a study conducted by Dahnhardt et al.,¹² 93% of children lost their dental anxiety after being treated with ozone. This proves to be a valuable method of treatment in these cases.

Table 1: Side effects of ozone therapy

Side effects
Epiphora
Rhinitis
Cough
Headache
Nausea and vomiting

Table 2: Uses of ozone in dentistry

Applications in dentistry	References
Acceleration of healing	Bocci et al., ⁴ Filippi ⁵
Dental caries management	Loesche, ⁶ Baysan et al., ⁷ Holmes, ⁸ Baysan and Lynch, ⁹ Rickard et al., ¹⁰ Smith et al., ¹¹ Dahnhardt et al. ¹²
Oral lichen planus	Kazancioglu and Erisen ¹³
Gingivitis and periodontitis	Srikanth et al. ²
Halitosis	Shakunthala et al. ¹⁴
Osteonecrosis of the jaw	Ripamonti et al., ¹⁵ Petrucci et al., ^{16,17} Agrillo et al. ¹⁸
Pain management	Kazancioglu et al., ¹⁹ Taşdemir et al. ²⁰
Plaque and biofilm elimination	Baysan et al., ⁷ Nagayoshi et al. ²¹
Root canal therapy	Halbauer et al., ²² Subiksha, ²³ Lynch and Schemmer, ²⁴ Case et al. ²⁵
Sensitivity	Azarparzhoo et al., ²⁶ Dahnhardt et al. ²⁷
Temporomandibular disease	Daif, ²⁸ Doğan et al., ²⁹ Hammuda et al. ³⁰
Teeth whitening	Tessier et al., ³¹ Al-Omiri et al. ³²

Table 3: Contraindications for ozone use

Contraindications	References
Alcohol intoxication	Nogales et al. ³³
Anemia	Nogales et al. ³³
Autoimmune disorders	Nogales et al. ³³
Hemorrhage	Nogales et al. ³³
Hyperthyroidism	Nogales et al. ³³
Myasthenia	Nogales et al. ³³
Myocardial infarction	Nogales et al. ³³
Ozone allergy	Nogales et al. ³³
Pregnancy	Nogales et al. ³³

Oral lichen planus

Lichen planus is an inflammatory condition that affects the mucous membranes in the mouth. It can cause white, lacy patches or red swollen lesions and open sores in the gum. Application of gaseous ozone has been proven to be effective in increasing wound healing after a high-dose radiotherapy. Results have shown success in the resolution of symptoms at the end of the treatment, strengthening its potential to replace steroid treatment.¹³

Gingivitis and periodontitis

Gingivitis and periodontitis are common inflammatory diseases of the gums. They are a major source of teeth loss due



to infection. It can cause swelling or tenderness, loose teeth, bleeding, pus, sensitivity, and malocclusion. During the surgery to remove loose or infected teeth, ozonated water can be used as an irrigant. A thin layer of ozonated oil can be applied to the sutures three to four times a day to decrease chances of infection. If the patient has peri-implantitis, gaseous or aqueous ozone can be administered as an irrigant during debridement and curettage.² For deepithelialized gingival grafts, ozone-treated groups had higher quality of life due to decrease in postoperative pain.²⁰

Halitosis

Halitosis is chronic bad breath that may be caused due to several issues. Bacteria that forms volatile sulfur compounds such as hydrogen sulfide and methylmercaptan are the main causes of the oral malodor.³⁴ Some of these contributions to these bacteria may be cavities or gum disease. Deep pockets exist that can entrap bacteria even after a brush or dental cleaning. Infections of the mouth, nose, or throat that leads to postnasal drip can also cause bad breath. The mucus is a source of nourishment for the bacteria to grow. Smoking and tobacco can worsen the bad odors, as well as increase the likelihood of developing gum disease. It can dry out your mouth, which means there is no saliva to remove leftover food or substances from the mouth or fight cavities and infections. There is a correlational relationship between the amount of *Porphyromonas gingivalis* in saliva and halitosis.³⁵ Halitosis may also be linked to gastric reflux, diabetes, and kidney or liver disease. Ozone can kill the bacteria, fungi, and viruses within the mouth and diminish halitosis.¹⁴

Osteonecrosis of the jaw

Osteonecrosis of the jaw is a side effect that is experienced by patients who are undergoing cancer treatment, bisphosphonates, and denosumab, as well as after a trauma such as a tooth extraction or dental surgery. It is characterized by a loss of blood supply to the bone, causing the bone to break down and may cause exposed alveolar bone. Patients that have bisphosphonate-associated osteonecrosis of the jaw do not have a positive reaction to surgery.¹⁶ After surgery, there are mixed results of the effectiveness of mouthwashes and antibiotics. Ozone administration was proved to be an effective method to treat osteonecrosis of the jaw post-surgery, especially for patients who had a lesion greater than 2.5 cm.¹⁵

Post-surgical pain management

When ozone therapy and laser application therapy were paired, a study showed that there were significant lower pain levels following an oral surgery.¹⁹ Pain management is an important aspect of dental surgery, as it can negatively impact the quality of life for the patient for an extended period of time.

Plaque and biofilm elimination

A biofilm is a complex aggregation of microorganisms on a solid surface such as a tooth. Bacteria that grow in biofilm multiply and embed into a polymeric matrix in channels that have nutrients and water. Biofilms can grow on the tooth surfaces, cracks, epithelial cells lining the gingival sulcus,

and more. There are also over 700 bacterial species that can cause periodontal disease.⁷ Dental plaque is such an example of organized biofilm. In a study conducted in 2004, dental plaque was exposed to ozonated water. After, results showed that the number of viable *Streptococcus mutans* decreased, and the ozone inhibited the accumulation of dental plaque. The results suggests that ozonated water could be helpful in reducing infections caused by the oral microorganisms that exist in dental plaque.²¹

Root canal therapy

Ozone is being used to disinfect roots after removing the nerves and blood vessels. However, just emptying out the root canal is not the most effective method to prevent bacterial growth, as bacteria can flourish in harsh conditions. The bacteria can grow back, and cause increasing problems. Studies have shown that ozone can disinfect the canals and leave them clean for a year. A study conducted by the University of Zagreb showed that there is a significant decrease of *Streptococcus mitis* and *Propionibacterium acnes* after ozone treatment.²² This therapy works best when there is the least amount of organic debris that remains, and ozonized water or ozone gas may be utilized. This method is effective because oxygen has a toxic effect on the microaerophilic and anaerobic bacteria.²³

Dentin hypersensitivity

Dentin hypersensitivity is usually in association with chronic pupal problems. It causes sharp, short pains that are caused by exposed dentin when it is in contact with thermal, tactile, evaporative, chemical, or osmotic stimuli. There may be a lingering aching discomfort after the stimuli is removed. The amount of pain that is experienced varies in each individual, and can be affected by varying pain tolerance levels, emotional and mental states, previous experience in pain, and environmental factors. The hydrodynamic theory states that dentin is permeable throughout the tubules and when the dentinal fluid movement or permeability increases, sensitivity follows. A supporting study proved that there was an average of 55% decrease of pain level after ozone treatment.²⁶

Temporomandibular joint disorders

The temporomandibular joint is a hinge that connects your jaw to the temporal bone on your skull. In certain cases, patients have temporomandibular joint dysfunction, where there may be pain or dysfunction of the mastication muscles and the joints. Studies showed that intra-articular ozone gas injection can treat internal derangement of the temporomandibular joint. The ozone gas was injected into the superior joint space.²⁸ Ozone therapy has been shown to be more effective than medication for treating temporomandibular joint-related pain.²⁹

Teeth whitening

There are various ways to whiten teeth, whether it is with a home kit or at a dental office. However, it is more difficult to whiten severe stains, which can be caused by ingestion of tetracycline or other methods. Studies have shown that in animal models, the yellowish tinge of tetracycline-stained teeth were reduced in color.³¹ In a test conducted by Al-Omiri et



al.,³³ bleaching teeth with 38% hydrogen peroxide and ozone resulted in whiter teeth than bleaching teeth with only 38% hydrogen peroxide.

CONCLUSION

Ozone therapy is a growing industry that has much potential in many areas of dentistry. There are varying degrees of evidence for the efficacy of ozone therapy in dental medicine. There is generally good evidence for the results of ozone therapy for restorative dentistry, but conflicting or insufficient evidence for ozone therapy in oral surgery and endodontics. Nevertheless, the results that are provided by various clinical trials generally pose a positive alternative treatment method with little to no risks involved. Ozone therapy is valuable in the treatment of many disorders such as sensitivity, root canal therapy, and osteonecrosis of the jaw. More clinical studies with standardized trials are necessary to ensure greater knowledge about the use of ozone in dentistry.

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Author contributions

YS: Designed, organized, and wrote the review article; designed the outline; solved queries related to scientific publications from the journals. SP: Performed Medline searches, aided in writing the review article and critiqued the literature. KR: Critiqued and applied logical reasoning to the literature. JG: Critiqued and applied logical reasoning to the literature. GJ: Revised the article to add logical reasoning and corrected the literature. NLS: Formulated clinical concepts, reviewed the article, and corrected the references. SAK: Formulated clinical concepts, reviewed the article, and corrected the references. All authors have read and approved the manuscript provided.

Conflicts of interest

The authors have no conflicts of interest to declare.

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