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REVIEW ARTICLE

# Ozone Therapy in Dentistry

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## ABSTRACT

Ozone is a component of the upper layer of atmosphere and is an allotropic form of oxygen, which has been effectively used in the treatment of different diseases for more than 100 years. Ozone gas, discovered in the mid-19th century, is a molecule consisting of three atoms of oxygen in a dynamically unstable structure due to the presence of mesomeric states. Although ozone has dangerous effects, yet researchers believe it has many therapeutic effects also. Its effects are proven, consistent, safe, and with minimal and preventable side effects. Ozone gas has a high oxidation potential and is effective against bacteria, viruses, fungi, and protozoa. It also has the capacity to stimulate blood circulation, platelets, and immune response. Ozone is used in dentistry in various forms like gaseous, ozonated water, and as ozonated oils.

Ozone was shown to be biocompatible and is used in all aspects of dentistry. It has been shown to stimulate remineralization of recent caries-affected teeth and is used as a preventive therapy in caries, root caries, and intracanal irrigants in endodontic treatment. It has been used in treatment of alveolitis, avascular osteonecrosis of the jaw, and herpes virus infection, and as an adjuvant in periodontal surgical and maintenance phases. Owing to its beneficial biological properties including antimicrobial and immunostimulating effects, ozone therapy has opened new vistas in treatment modalities of different dental pathologies for patients of all ages. The objective of this article is to review the literature available on applications of ozone in dentistry.

**Keywords:** Antimicrobial, Dentistry, Immunostimulant, Ozone.

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## INTRODUCTION

Atmospheric air is composed of nitrogen (71%), oxygen (28%), and other gasses (1%) including ozone. It is a natural gaseous molecule, discovered in the mid-19th century, and is made up of three oxygen atoms in a dynamically unstable structure due to the presence of mesomeric states.[1] The stratosphere layer of the atmosphere contains plenty of ozone, and it protects the living organisms from the ultraviolet rays by surrounding the earth at altitudes of 50,000 to 100,000 ft.[2] Air is lighter than ozone and thus, ozone falls downward to earth from such high altitudes.[3] It cleanses the air by combining with any pollutant it comes in contact with. This is the earth's natural way of self-cleansing.[4]

Ozone, also known as trioxygen or triatomic oxygen, is derived from the Greek word "Ozein" which means odor.[5] Ozone is a colorless gas, acrid in odor, and explosive in liquid or solid form. It has a half-life of 40 minutes at 20°C and about 140 minutes at 0°C.[6] Ozone rapidly gives up nascent oxygen molecule to form oxygen gas, so it is considered as an unstable gas. As ozone is an unstable gas, it has the highest oxidation potential, approximately 150% more than that of chlorine when used as an antimicrobial agent.[5] It also induces blood circulation and the immune response.[7] Ozone used in the medical field is a mixture of the purest oxygen and purest ozone and according to its application, the ozone concentration may vary between 1 and 100 µg/mL (0.05–5%).[8]

Ozone therapy can be defined as a versatile bio-oxidative therapy in which oxygen/ozone is administered via gas or dissolved in water or oil base to obtain therapeutic benefits.[9] The complete dosage of ozone is determined by the ozone therapist according to the medical/dental indication and condition of the patient.[8] It has been widely used in the medical field due to its strong oxidizing property that oxidizes almost all the surfaces to the highest oxidation stage.[10] Ozone, being a gas, can penetrate easily even into such tissues and spaces that are not accessible.[7] Introduction of ozone therapy has truly changed the way dentistry was before.[11]

## HISTORY

In 1785, researchers discovered an odor when electric sparks passed in an electrostatic machine and in 1840, the substance was named as Ozone by Christian Friedrich Schonbein, the father of ozone therapy.[12] Because of the bactericidal and antimicrobial effects of the substance, the ozone generator was first useful in industrial applications and disinfection of water. In 1857, first ozone generator

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was developed for medical use by Joachim Hensler, a German physicist and Hans Wolf, a German physician. It was effective in making a mixture of ozone and oxygen at therapeutically variable dosages. In 1870, C Lenderin therapeutically used ozone to purify blood. During the First World War, it was also used for treating gaseous, posttraumatic gangrene in German soldiers. Before 1983, many Swiss dentists had also been known to use ozone in dentistry.[11,12]

## STRUCTURE

A triatomic molecule of ozone is composed of three oxygen atoms. They are bounded together by equal oxygen–oxygen bonds at an angle of 116°C. The internal structure of ozone has steric hindrance that prevents it from forming a triangular structure.[13] Thus, instead of forming double bonds, each oxygen atom forms a single bond with the other oxygen atom resulting in a negative charge throughout the ozone molecule.[2]

## OZONE GENERATORS

There are three types of systems for generating ozone gas[14]:

1. *Ultraviolet system*: It manufactures ozone in low concentrations. It is used in esthetics, saunas, and air purification.
2. *Cold plasma system*: This system is used for air and water purification.
3. *Corona discharge system*: It manufactures high concentrations of ozone. This system is most commonly used in medical/dental fields.
4. *Electromagnetic system*: In this method, quartz glass tubes are used through which oxygen flows with copper wire wound around the inner and outer tubes. A strong electromagnetic field is produced by passing a high frequency voltage through the coils.

## MECHANISM OF ACTION

Ozone therapy has a wide range of applications in treating various diseases because of its special properties including antimicrobial, immunostimulant, antihypoxic, biosynthetic, and, to a limited extent, bioenergetic, and detoxicating actions.

### Antimicrobial Effect

Deactivation of bacteria, viruses, fungi, yeast, and protozoa are caused by ozone. It causes disruption of the integrity of the bacterial cell envelope by oxidation of phospholipids and lipoproteins. Low concentration (0.1 ppm) of ozone is sufficient to deactivate bacterial cells including their spores.[15] Ozone inhibits cell growth of fungi at certain stages, especially the budding cells.[16] In viruses, ozone causes destruction of the viral capsid and upsets the reproductive cycle by disrupting the virus-to-cell contact with peroxidation.[6]

### Stimulation of Oxygen Metabolism

The red blood cell glycolysis rate is increased by ozone therapy. As a result, it causes stimulation of 2,3-diphosphoglycerate leading to an increase in the amount of oxygen released to the tissues. Ozone causes activation of the Kreb's cycle by inducing oxidative carboxylation of pyruvate thus, stimulating production of adenosine triphosphate. It also causes a marked decrease in nicotinamide adenine dinucleotide and helps to oxidize cytochrome C. Ozone activates production of enzymes, which act as free radical scavengers and cell-wall protectors: Glutathione peroxidase, catalase and superoxide dismutase and prostacycline, a vasodilator.[1]

### Immunostimulating Effect

Cellular and humoral immune systems are influenced by ozone. It increases the proliferation of immune-competent cells and production of immunoglobulins. It also causes activation of macrophages and increases sensitivity of microorganisms to phagocytosis.[1] As a result of this activation, the immune cells produce special messengers called cytokines. These molecules, in turn, activate other immune cells of the body, setting off a cascade of positive change throughout the immune system, which is stimulated to resist diseases. Therefore, the application of medical ozone is very useful for immune activation in immune-compromised patients.[17] Ozone causes the production of biologically active substances, such as interleukins, leukotrienes, and prostaglandins, which are essential in reducing inflammation and wound healing.[1] High concentrations of ozone cause immune-depressive effect whereas in low concentrations, it causes immunostimulating effect.[18]

### Antihypoxic Effect

The organisms are protected against the actions of oxygen free radicals through a complex enzymatic system. These include superoxide dismutase, catalase, dehydrogenase, and glutathione peroxidase. Repeated low doses of ozone stimulate these enzymes and thus, protect the cells from oxidative damage. Ozone increases the partial pressure of oxygen in tissues and improves transportation of oxygen in blood. As a result, it stimulates the aerobic processes like glycolysis, Kreb's cycle, and beta oxidation of fatty acids. Ozone prevents aggregation of erythrocytes by

stimulating circulation and increases their contact surface for oxygen transportation. The blood cell elasticity of inflammed tissues are changed because of ozone, which changes the cell membrane structure of erythrocytes and increases the negative charge. Thus, the blood flow in the capillary vessels is increased due to decrease in the rolling of the blood cells. Ozone also reduces the local inflammatory process.[19]

### Biosynthetic Effect

Protein synthesis mechanism is activated by ozone with increased amount of mitochondria and ribosomes in cells that leads to increase in functional activity and regeneration potential of tissues and organs.[1]

- Vasodilators (nitric oxide) that are responsible for dilatation of arterioles and venules are released by ozone.[1]
- Ozone, when acting on the organic substance of mineralized tooth tissues, intensifies remineralization potential.[20]

## APPLICATION OF OZONE THERAPY IN DENTISTRY

Ozone therapy has various advantages when applied as a support for conventional treatments, and is used in a wide range of dental specialties.[21]

### Ozone and Oral Pathogens

Various etiological factors are responsible for oral lesions; microorganisms play a major role for the same.[22] Elimination of these microbial pathogens is essential for effective dental treatment. It has been found that 99.9% cariogenic bacteria, such as *Actinomyces naeslundii, Streptococcus mutans*, and *Lactobacillus casei* are killed when ozone is exposed for 60 seconds. However, salivary proteins showed degradation when ozone is exposed for such a long period and, hence, 10 to 30 seconds of exposure was proven to be effective in killing a significant number of bacteria.[23]

### Ozone and Oral Tissues

Application of ozone has various useful effects on the oral tissues including remission of various mucosal alterations, increase in wound healing, and also increase in turnover rate of oral cells. Huth et al[24] reported that ozone is a potential antiseptic agent and the aqueous form of ozone showed less cytotoxicity than gaseous ozone or established antimicrobials (chlorhexidine digluconate, 2, 0.2%; sodium hypochlorite, 5.25, 2.25%; hydrogen peroxide, 3%) under most conditions. Therefore, optimal cell biological characteristics in terms of biocompatibility for oral application is fulfilled by aqueous ozone.[4]

It has been found that the healing rate of oral mucosa can be accelerated when ozonized water is applied on the daily basis.

### Ozone in Treatment of Dental Caries

Many studies have proved that the application of ozone therapy is effective in the treatment of pit and fissure caries, root caries, and interproximal caries. The mechanism of action is because of its antimicrobial properties and its ability to oxidize the bacterial cell wall. This treatment can be used as an alternative therapy to routine drilling and filling for noncavitated deciduous carious lesion. Biofilm formation is prevented when ozone is infused into noncarious dentin. Some studies have reported that ozone when applied for 40 seconds is sufficient to kill different concentrations of *S. mutans* and application of 60 seconds has almost completely eliminated *S. mutans, L. casei* and *A. naeslundii*. Ozone is also effective against the microflora associated with primary root caries lesions. Ozone is effective to treat root caries in medically compromised patients and elderly people.[25]

### Role in Endodontics

The main purpose of conventional root canal therapy is to achieve a clean root canal that facilitates the placement of an adequate root filling. However, there may be multiple canals linked by a "web" of accessory canals. They are known as "apical delta" and lateral canals. Still now, dentists depend on irrigants reaching these areas to disinfect and dissolve organic debris where it is not possible to introduce the instrument mechanically. In endodontic treatment, ozonated water can be used for irrigation instead of using irrigation chemicals (NaOCl). Ozone is effective against endodontic pathogenic microorganisms like *Enterococcus faecalis, Candida albicans, Peptostreptococcus micros*, and *Pseudomonas aeruginosa* disinfecting of root canals and dentinal tubules. The distinctive anaerobic odor associated with some chronically infected teeth is also eliminated by ozone. Before filling, a slow insufflation (45–60 seconds) with moderate/high concentration of ozone gas is done into each canal because insufflation of ozone electrochemically passes into the lateral canals and dentinal tubules thus, killing the microbes. Ozone can also pass through the apical foramen and enter into the surrounding bone, enhancing healing and regeneration of bone.[26]

Crown discoloration is a major esthetic problem in root canal-treated teeth, especially in anterior teeth. Ozone gas can be used for whitening the teeth due to its strong oxidizing properties.[26]

### Hypersensitive Teeth

Common factors like attrition, erosion, abfraction, bite pressure, and gum recession are responsible for non-carious hypersensitivity. The penetration of ionic calcium and fluorine deep into the dentinal tubules is prevented by smear layer present over the tooth surface. The smear layer is removed by ozone; thus, it opens up the dentinal tubules, broadens their diameter, and allows calcium and fluoride ions to flow into tubules easily, and effectively to plug dentinal tubules, preventing the fluid exchange through these tubules. It has been documented that quick relief is achieved from root sensitivity after ozone spray for 60 seconds followed by mineral wash onto the exposed dentin in a repetitive manner.[27]

### Ozone in Periodontics

It was found that after the application of ozonated water (4 mL/L for 10 seconds), no viable bacterial cells were found.[28] Ozone has an antimicrobial effect against both Gram-positive as well as Gram-negative bacteria, along with fungi and viruses.[29] It was found that Gram-negative anaerobes like *Porphyromonas endodontalis* and *Porphyromonas gingivalis* were more sensitive to ozonated water than Gram-positive oral *Streptococci* and *C. albicans*.[30] When the roots of teeth were irrigated with ozonated water for 2 minutes and the periodontal cells of these teeth studied immunohistochemically to mark the proliferating cell nuclear antigen, it was found that the teeth irrigated with ozone has a higher labeling index.[31] Hence, it was concluded that the avulsed teeth when irrigated with nonisotonic ozonated water for 2 minutes leads to mechanical cleansing and decontamination with no negative effect on the periodontal cells remaining on the tooth surface.

In terms of pocket depth, plaque index, gingival index, and bacterial count in aggressive periodontitis cases, significant improvement was observed when 150 mL of ozonated water was used to irrigate periodontal pockets for 5 to 10 minutes once weekly for 4 weeks.[32] Aqueous form of ozone have shown less cytotoxicity as compared with conventionally used antimicrobials like chlorhexidine (0.2, 2%), sodium hypochlorite (2.25, 5.25%), and hydrogen peroxide (3%).[24]

### Ozone in Oral Medicine

Ozone therapy has shown effective results in treating several soft tissue lesions such as apthous ulcers and herpes labialis. It is also very helpful in treating patients with oral lichen planus by tissue insufflation, injection cupping, and ozonated oil application.[4] Healing of these lesions is due to the disinfectant and healing effects of ozone.[33]

Chemotherapy and radiotherapy are routinely administered in patients suffering from carcinomatous lesions and it invariably causes mucositis. Ozone therapy when used in both aqueous and gaseous form has shown positive results in treating mucositis, thus enabling the patient to eat normally and improve the quality of life during oncological therapeutic intervention.[4]

### Ozone in Prosthodontics

Denture stomatitis, mainly due to *C. albicans,* is a common occurrence found in full denture wearers. It can be treated by topical application of ozonated oil over the tissue surface and over denture surface. Ozone is also used to clean denture due to its disinfecting action. The patient is asked to soak dentures in ozonated water for at least 10 minutes after removal and rinse them before inserting into mouth.[34]

### Ozone in Oral Surgery

Ozone helps to increase the healing of the wound. After extraction or any surgical procedure, the area is immediately irrigated with ozone, which promotes faster healing without complications. Ozone therapy is essential for the treatment of the refractory osteomyelitis in the head and neck in addition to treatment with antibiotics, surgery, and hyperbaric oxygen.[33,35]

### Ozone in Implantology

Ozone helps in bone regeneration. During implant placement, the socket is prepared and ozone is bubbled into the prepared socket for about 40 seconds followed by placement of implant into the socket. This prevents infection and accelerates bone regeneration.[10]

### Ozone and Dental Unit Water Lines

Due to stagnation of water, dental unit water lines (DUWL) have been found to be a source of microorganisms. In a study, it was found that ozone achieved 57% reduction in biofilm and 65% reduction in viable bacteria in DUWL.[36]

## CONTRAINDICATIONS OF OZONE THERAPY

Ozone therapy is contraindicated in pregnancy, glucose-6-phosphate dehydrogenase deficiency, hyperthyroidism, severe anemia, severe myasthenia, ozone allergy, recent myocardial infarction, hemorrhage from any organ, and acute alcohol intoxication.[14]

## OZONE TOXICITY

Inhalation of ozone can be toxic to the pulmonary system and other organs. Complications that are caused

by ozone therapy are infrequent at 0.0007 per application. The common side effects are upper respiratory irritation, rhinitis, cough, headache, occasional nausea, vomiting, shortness of breath, blood vessel swelling, poor circulation, heart problems, and epiphora.[8] Well-calibrated doses can be therapeutically used in various conditions without any toxicity or side effects, but prolonged inhalation of ozone can be deleterious to the lungs and other organs.[37] The intravenous injections of ozone gas is prohibited by the European cooperation of medical ozone societies due to risk of air embolism.[33]

## CURE FOR OZONE INTOXICATION

The patient should be placed in the supine position. The patient should be treated with vitamin E, ascorbic acid, and *n*-acetylcysteines along with inhalation of humid oxygen.[26]

## CONCLUSION

Ozone therapy has a wide range of applications in almost every field of dentistry. Its unique properties include immunostimulant, analgesic, antihypoxic, detoxicating, antimicrobial, bioenergetic, and biosynthetic actions. Its atraumatic, painless, noninvasive nature and relative absence of discomfort increase patient's acceptability and compliance. Contraindications of this controversial method should not be forgotten. Further research is needed to regulate indications and treatment procedures of ozone therapy.

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