ABSTRACT
Most people possess a fear toward dentistry. On account of this fear, they avoid the dental treatment. In fact, people fear injections and drills that are used in dental clinics. But in recent time, dentistry has been experiencing a period of dynamic changes and growth, perhaps like no other time before. The use of ozone in dental treatment is the result of this dynamics and growth. Ozone (O₃) 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 O₃ has dangerous effects, yet researchers believe it has many therapeutic effects. Ozonized water, whose use is particularly known in dental medicine, is optimally applied as a spray or compress. Incorporation of ozone in dental clinic setup would eradicate the feeling of pain during dental treatment and also cut off the treatment time significantly. Scientific support, as suggested by demonstrated studies, for ozone therapy presents a potential for an atraumatic, biologically based treatment for conditions encountered in dental practice.

Keywords: Bleaching, Caries, Dentistry, Ozonated oil, Ozone.


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Conflict of interest: None

INTRODUCTION
Ozone (O₃), a natural 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. The gas is colorless, 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.¹⁻³ The word ozone originates from the Greek word ozein, which means odor and was first used by German chemist Christian Friedrich Schonbein, father of ozone therapy (1799–1868) in 1840 when, working with a voltaic pile, he noticed the emergence of a gas with an “electric and pungent smell” that could be a sort of “super-active oxygen.”⁴ Industrial ozone generators are used for industrial application and disinfection of water, after it was shown the potent and broad bactericidal activity of ozone. The first medical application seems to have been the use of ozone for treating gaseous, posttraumatic gangrene in German soldiers during the First World War.⁵ However, a big step forward was the invention of a reliable ozonizer for medical use by the physicist Joachim Hansler (1908–1981). The idea to use ozone in medicine developed slowly during the last century and it was stimulated by the lack of antibiotics and the disinfectant properties of ozone. Ozone, which is used for medical purposes, is a gas mixture comprising 95 to 99.95% oxygen and 0.05 to 5% pure ozone.⁵ Its basic function is to protect humans from harmful effects of UV radiation.⁵ It is one of the most important gases in the stratosphere due to its ability to filter UV rays which is critical for the maintenance of biological balance in the biosphere. It has been used in human medicine since the beginning of 20th century. Today, ozone is used not only to disinfect wounds and improve blood circulation, but also as a treatment for carcinomas, leukemia, rheumatism, and multiple sclerosis. In dentistry, nowadays, ozone has got its own role. It is used in a safe and controlled manner to remove caries painlessly followed by remineralization of that demineralized tooth structure.⁶

WHAT IS OZONE
Ozone is a gas composed of three atoms of oxygen and present naturally in the upper layer of atmosphere in abundance. It has got the capacity to absorb the harmful ultraviolet rays present in the light spectrum from the Sun. Thus ozone filters the light spectrum high up in the atmosphere and protects the living creatures from the ultraviolet rays. Ozone is an unstable gas and it quickly gives up nascent oxygen molecule to form oxygen gas. Due to the property of releasing nascent oxygen, it has been used in human medicine since long back to kill bacteria, fungi, to inactivate viruses, and to control hemorrhages. Medical grade ozone is made from pure medical oxygen because oxygen concentration in the atmospheric air is variable. Atmospheric air is made up of nitrogen (71%), oxygen (28%), and other gases (1%) including ozone which is altered by processes related to altitude, temperature, and air pollution.⁷

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There are three different systems for generating ozone gas:

1. Ultraviolet system: Produces low concentrations of ozone, used in esthetics, saunas, and for air purification.
2. Cold plasma system: Used in air and water purification.
3. Corona discharge system: Produces high concentrations of ozone. It is the most common system used in the medical/dental field.

**CASE REPORT**

Christian Friedrich Schönbein, a German chemist, is considered to be the father of ozone therapy (1840). When he passed an electrical discharge through water, a strange smell was produced, which he called ozon, from the Greek word ozein (odor). Edward Fisch was the first dentist to use ozone in 1950. He used ozone to treat Austrian surgeon Ernst Payr who then became an ozone enthusiast and began a line of research dedicated to its use in healthcare. Ozone therapy has been in use since the 1800s and in 1896 the genius Nikola Tesla patented the first O₃ generator in the United States, later forming the “Tesla Ozone Company.” During the First World War (1914–1918) doctors familiar with O₃’s antibacterial properties and with few other medical resources available to them applied it topically to infected wounds and discovered O₃ not only remedied infection, but also had hemodynamic and anti-inflammatory properties. In the late 1980s, reports had emerged that German physicians were successfully treating HIV patients with O₃-AHT (Autohemotherapy). Medical grade ozone is a mixture of pure oxygen and pure ozone in the ratio of 0.05 to 5% of O₃ and 95 to 99.95% of O₂. Due to the instability of the O₃ molecule, medical grade ozone must be prepared immediately before use. Within less than an hour after preparation, only half of the mixture is still ozone while the other half is transformed into oxygen. As a result, it is impossible to store ozone over long periods of time. In order to control the decomposition of O₃ into oxygen, it can be associated with a vehicle with aqueous properties to promote the conversion more quickly or with a vehicle with more viscous properties to retard the conversion.

**MECHANISM OF ACTION**

- **Inactivation of bacteria, viruses, fungi, yeast, and protozoa:** Ozone therapy disrupts the integrity of the bacterial cell envelope through oxidation of the phospholipids and lipoproteins. In fungi, O₃ inhibits cell growth at certain stages. With viruses, O₃ damages the viral capsid and upsets the reproductive cycle by disrupting the virus-to-cell contact with peroxidation. The weak enzyme coatings on cells which make them vulnerable to invasion by viruses make them susceptible to oxidation and elimination from the body.

- **Stimulation of oxygen metabolism:** Ozone therapy causes an increase in the red blood cell glycolysis rate. This leads to the stimulation of 2,3-diphosphoglycerate which leads to an increase in the amount of oxygen released to the tissues. Ozone activates the Krebs cycle by enhancing oxidative carboxylation of pyruvate, stimulating production of ATP. There is a stimulation of production of enzymes which act as free radical scavengers and cell-wall protectors.

- **Activation of the immune system:** Ozone administered at a concentration between 30 and 55 μg/cc causes the greatest increase in the production of interferon, tumor necrosis factor, and interleukin-2. The production of interleukin-2 produces subsequent immunological reactions.

**MODES OF OZONE ADMINISTRATION**

Ozone therapy in dentistry contains a multiplicity of protocols to deal with dental infection. The three fundamental forms of application of ozone to oral tissue are:

- **Ozonated Water**
  - It is commonly used in root canal therapy. The following properties of ozone are used in this case:
    - Hemostatic effect
    - Disinfectant and sterilization effect
    - Accelerated wound healing, improved oxygen supply, and support of metabolic process.

- **Ozonated Olive Oil**
  - Mostly used in periodontal and surgical procedure for healing. Also used for the treatment of dry sockets, periapical sinus, denture sore mouth, lip herpes, mouth, and tongue ulcer. Ozonated oils are pure plant extracts, through which pure oxygen and ozone are passed. The final products contain ozides. This method of external application is harmless.

- **Ozone Gas**
  - Ozone gas is generally used to treat dental caries and aphthous ulcer. Ozone-generating equipment converts oxygen to ozone. The ozone is then led to a handpiece fitted with a silicon cup over the tooth for minimum of 10 seconds.

**APPLICATIONS OF OZONE IN DENTISTRY**

The use of ozone has been proposed in dentistry because of its antimicrobial, disinfectant, biocompatibility, and healing properties. Ozone has been applied for the treatment of early carious lesions, sterilization of cavities, root canals, periodontal pockets, enhancing epithelial wound healing, such as ulcerations and herpetic...
lesions, bleaching of discolored root canal treated teeth, desensitization of extremely sensitive teeth, treatment of peri-implantitis and as a rinse for the avulsed teeth or as a denture cleaner and decontamination of used toothbrush.

In Caries Prevention\textsuperscript{17,18}

Ozone can be used to kill bacteria present in carious lesion, painlessly and even without anesthetic. Ozone is applied to the carious lesion in a controlled manner, safely killing bacteria that have caused caries, thus requiring minimal of physical intervention and just a few seconds. In cases of incipient caries, ozone can kill bacteria in the demineralized part and this demineralized tooth structure can then be remineralized using a special remineralization kit, containing calcium, fluorine, phosphorus, and sodium all in their ionic forms.

In Endodontic Treatment\textsuperscript{19}

Ozone oils can be used to sterile the root canal systems and to clear the canals of necrotic debris by virtue of ozone’s bactericidal and effervescent properties. Ozone oils are ozonated sunflower oil or olive oil or groundnut oil. This ozone oil irrigation is more quick and efficient in canal sterilization than that conventional irrigation by the sodium hypochlorite and sodium peroxide combination.

In Periodontal Treatment\textsuperscript{20}

Ozonated water strongly inhibited the accumulation of dental plaque. Ozonated oil is used as a safe therapeutic alternative in patients with acute necrotizing ulcerative gingivitis. Healing and bactericidal properties make it useful as a subgingival irrigant.

In Healing Wounds\textsuperscript{21}

Ozone has been reported to accelerate the healing of soft tissue conditions, i.e., aphthous ulcers, herpes labialis, ANUG, and other gum infections. It also reduces the postextraction healing time by forming a pseudomembrane over the socket, so protecting it from any physical and mechanical insults. Ozone therapy was found to be beneficial for the treatment of refractory osteomyelitis in the head and neck in addition to treatment with antibiotics, surgery, and hyperbaric oxygen. In alveolitis, there is accelerated healing by irrigation with ozonated water after removal of the necrotic pulp and debris under antibiotic coverage.

In Bleaching\textsuperscript{22}

In root canal treated tooth, crown discoloration is a major esthetic problem, especially in anterior teeth. Conventional walking bleaching requires much more time and results are not satisfactory. Ozone can be successfully used for lightening the yellowish tinge of tetracycline stain.

In Desensitization of Sensitive Root Necks\textsuperscript{23}

Quick and prompt relief from root sensitivity has been documented after ozone spray for 60 seconds, followed by mineral wash onto the exposed dentin in a repetitive manner. This desensitization of dentin lasts for longer period of time. Smear layer present over the expose root surface prevents the penetration of ionic calcium and fluorine deep into the dentinal tubules. Ozone removes this smear layer, opens up the dentinal tubules, broadens their diameter, and then calcium and fluoride ions flow into the tubules easily, deeply, and effectively to plug the dentinal tubules. It prevents the fluid exchange through these tubules. Thus ozone can effectively terminate the root sensitivity problem within seconds.

In Prosthodontics\textsuperscript{23}

Ozone gas can be applied as a prophylactic treatment prior to etching and the placement of sealant with no negative impact on sound enamel physical properties. The longer exposure to ozone gas has a strong bactericidal effect on microorganisms within the dentinal tubules of deep cavities, which could result in increasing the clinical success of restorations with no negative impact on dentin and enamel shear bond strength to adhesive restoration. Ozonated oil can be applied topically in denture stomatitis and also for cleaning the surface of removable partial denture.

Decontamination of Toothbrush\textsuperscript{23}

Ozone application was found to remove the toothbrushes bristles micro biota following conventional brushing.

CONTRAINDICATIONS OF OZONE\textsuperscript{24,25}

The following are the contraindications of ozone therapy:
\begin{itemize}
  \item Pregnancy
  \item Glucose-6-phosphate dehydrogenase deficiency
  \item Hyperthyroidism
  \item Severe anemia
  \item Severe myasthenia
  \item Active hemorrhage
  \item Acute alcohol intoxication
  \item Ozone allergy.
\end{itemize}

ADVANTAGES OF OZONE THERAPY\textsuperscript{24}

\begin{itemize}
  \item Noninvasive or minimal intervention technique
  \item Induction of a friendly ecologic environment
  \item Improves metabolism of infected tissues by means of its oxidizing effect.\textsuperscript{26}
\end{itemize}
DISADVANTAGES OF OZONE THERAPY

The problem of maintaining the ideal tightness between the cap and the ozoned tooth.

- The device does not administer ozone when there is a risk of untightness.
- More time (up to 10 minutes) needed for a proper preparation of the cap.

RECENT DEVELOPMENT

Ozone was effectively used as an antibacterial agent to treat oral infections caused by Actinomyces naeslundii, Lactobacilli casei, and Streptococcus mutans. Exposure of about 60 seconds exhibited 99.9% killing efficiency, but exposure for such a long period showed degradation of salivary proteins. So, exposure of 10 to 30 seconds was proved effective in killing significant number of bacteria. O₃ was also observed to regulate the expression of the genes that play vital role in onset and maintenance of allodynia.

CONCLUSION

In contrast with traditional medicine modalities, such as antibiotics and disinfectants, ozone therapy is quite economical; it will markedly reduce both medical cost and invalidity. Dentistry is varying with induction of modern science to practice dentistry. The ozone therapy has been more beneficial than present conventional therapeutic modalities that follow a minimally invasive and conservative application to dental treatment. The exposition of molecular mechanisms of ozone further benefits practical function in dentistry. Treating patients with ozone therapy lessens the treatment time with an immense deal of variation and it eradicates the bacterial count more specifically. The treatment is painless and increases the patient’s tolerability and fulfillment with minimal adverse effects. In future, the focus should be on randomized clinical trial for routine use of ozone in the treatment of various dental pathologies.

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