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Ozone therapy-new innovation in dentistry: A review article

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Abstract---Ozone has been used as a therapy since the 19th century. Christian Friedrich Schonbein demonstrated the changes in the properties of oxygen with the formation of the particular gas called ozone. Ozone (O₃) is naturally produced by the photo-dissociation of molecular oxygen (O₂) into activated oxygen atoms, which then react with further oxygen molecules. This transient radical anion rapidly becomes protonated, generating hydrogen trioxide (HO₃), which, in

turn, decomposes to an even more powerful oxidant, the hydroxyl radical (OH). 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, ozone has found to be effective against gram-positive and gram-negative bacteria, fungi, and viruses. Controlled ozone application has been found to be extremely safe, free from side effects and far free from most medications, including antibiotics. Ozone is a promising treatment modality for various dental problems in future. But, it has to be kept in mind that presently ozone is an adjunct to other conventional treatment modalities and should be used in combination until more research shows benefits in independent usage.

Keywords---ozone, oxygen, ozonated gas.

Introduction

Ozone has been used as a therapy since the 19th century. The first time, Dutch physicist Martin Van Marun in 1785, mentioned about ozone but it was Christian Friedrich Schonbein in 1840, a Professor in University of Basel, who demonstrated the changes in the properties of oxygen with the formation of the particular gas called ozone. Ozone (O₃) is also known as trioxygen or triatomic oxygen, a higher energetic form of atmospheric oxygen (O₂). It consists of 3 atoms of oxygen. The word ozone is derived from the Greek word "Ozein" which means odorant. Ozone (O₃) has a characteristic, penetrating odor and is present in small amounts in atmospheric air. It is present naturally in the upper layer of atmosphere i.e stratosphere in abundance.^(1,2) It surrounds the Earth at an altitude of between 50,000 and 100,000 feet and protects the living organisms from ultra-violet rays⁽³⁾ as it has got the capacity to absorb the harmful ultra-violet rays present in the light spectrum. It is a pale blue gas that condenses to a deep blue liquid at very low temperatures. Ozone (O₃) is naturally produced by the photo-dissociation of molecular oxygen (O₂) into activated oxygen atoms, which then react with further oxygen molecules. This transient radical anion rapidly becomes protonated, generating hydrogen trioxide (HO₃), which, in turn, decomposes to an even more powerful oxidant, the hydroxyl radical (OH). Ozone is often created by thunder and lightning and is also known for its interaction with industrial pollutants at ground level. As it falls downward to earth, being heavier than air, combines with any pollutant it comes in contact with and cleanses the air. This is earth's natural way of self-cleansing.

Ozone gas has a high oxidation potential and is 1.5 times greater than chloride when used as an antimicrobial agent. ⁽⁴⁾Ozone therapy became an inherent element of the treatment of infection in such fields as surgery, dermatology, cosmetics, and dentistry. The ozone concentration used may vary between 1 and 100gm/ml (0.05-5%) according to the medical/dental indication and the patient's condition. ⁽⁵⁾ 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, ozone has found to be effective against gram-positive and gram-negative bacteria, fungi, and viruses. Controlled ozone application has been found to be extremely

safe, free from side effects and far free from most medications, including antibiotics. It also stimulates blood circulation and the immune response. ⁽⁴⁾

There are three different systems for generating ozone gas. They are:

1. Ultra violet system: produces low concentrations of ozone, used in aesthetics & 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.

Ozone to be used medically is made from pure medical oxygen and is produced commercially in ozone generators, which sends an electrical discharge through a specially-built condenser containing oxygen. 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. As the O₃ molecule is unstable, it must be prepared immediately before use as within less than an hour after preparation, only half of the mixture is still ozone while the other half gets transformed into oxygen. Hence, it is impossible to store ozone over long periods of time. In order to control the decomposition of O₃ into oxygen, it is 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.

History

1. Christian Friedrich Schonbein (1840), a German Chemist, is regarded as the Father of ozone therapy.
2. In 1857, Joachim Hansler, a German physicist and physician, along with German physician, Hans Wolff, developed the first ozone generator for medical use.
3. The Institute for Oxygen Therapy- Healing was formed in Berlin and the man credited with founding naturopathy, Dr. Benedict Lust, began practicing in New York, and wrote many articles on ozone.
4. Dr. C. Lender in 1870- purified blood in test tubes by using O₃.
5. In 1881, it was used as a disinfectant in the treatment of diphtheria.
6. Dr. Charles Kenworthy, a Florida physician, in 1885, published the book which details on the use of ozone on therapeutic purposes.
7. In 1896, an Ozone generating system was patented by Nikola Tesla.
8. In early 20th century, Food and Drug Act, revised its use and effect in the field of medicine.
9. In 1920s, Dr Edwin Parr, a Swiss dentist, started to use O₃ as part of his disinfection system.
10. A German dentist, Dr. E.A. Fisch, in 1950, used ozonated water for dental procedures and pioneered its use in medicine.
11. In 1955, an Ozone machine called "Ozonosan" was patented by Dr. Joachim Hansler which formed the basis of the expansion in German ozone therapy.
12. In 1971, The International Ozone Institute (IOI), now known as International Ozone Association was founded.

Mode of administration of ozone

There are three basic forms of ozone application:

- Ozone gas
- Ozonated water
- Ozonated oil

Mechanism of action of ozone

Ozone in both gaseous and aqueous phase is a powerful and reliable antimicrobial agent against bacteria, fungi, viruses and protozoa.

Antimicrobial effect

According to microbiological research data, the ozone can kill all types of gram-positive and gram-negative bacteria, including the *Pseudomonas aeruginosa* and *Escherichia coli*, which are extremely resistant to antibiotics. The anti-microbial effect of ozone is due to either its action of ozonolysis on cells which damages the cytoplasmic membrane of microbes or ozone induced modification of intracellular contents because of secondary oxidants effects. This action is non-specific and selective to microbial cells so it does not damage human body cells.⁽⁶⁾ Thanomsuet *al.*⁽⁷⁾ demonstrated the effect of ozone treatment on cell growth and structural changes in bacteria such as *E. coli*, *Salmonella sp.*, *Staphylococcus aureus* and *Bacillus subtilis*. Its antimicrobial activity increases in liquid environment especially in acidic pH.

Immuno-stimulating action

Ozone influences cellular and humoral immune system. It stimulates proliferation of immunocompetent cells and synthesis of immunoglobulins. It also activates function of macrophages and increases sensitivity of micro-organisms to phagocytosis. ⁽⁸⁾ Satisfactory results have been reported from applying ozone therapy to patients at a concentration of 30-55 µg/cc causes the greatest increase in the production of interferon and the greatest output of tumor necrosis factor and interleukin-2. The production of interleukin-2 launches an entire cascade of subsequent immunological reactions. This means that the application of medical ozone is extremely useful for immune activation in patients with a low immune status and/or immune deficit. In 2003, it was discovered that ozone can be generated in vivo in activated neutrophils. ⁽⁹⁾ This discovery had the striking impact since it shows that ozone has a physiological role, not only as a bactericide agent but rather one that could form part of the physiological amplifying mechanisms of the inflammation and the activation of associated genes.

Anti-inflammatory & analgesic action

These effects seem to be due to its way of acting on diverse targets:

- It decreases the production of mediators of the inflammation.
- Inactivation of metabolic mediators of pain.

- Helps in the synthesis of biologically active substances such as interleukins, leukotrienes and prostaglandins, which is beneficial in reducing inflammation and pain.

The infection or inflammation is positively charged (acidic) and ozone is negatively charged (basic) so the chemistry of infection and inflammation attracts ozone to the area. A study done on anti-inflammatory effects of ozonated water in an experimental mouse model suggested that ozonated water has anti-inflammatory properties and is a potential therapeutic option for acute inflammation. ⁽¹⁰⁾

Anti-hypoxic action

The effects of ozone on the metabolism of oxygen can be explained from its promoting action of:

- Changes in the rheological properties of the blood.
- Increase in the speed of glycolysis of the erythrocyte.

Ozone brings about the rise of PO₂ in tissues and improves transportation of oxygen in blood, which results in change of cellular metabolism activation of aerobic processes (Glycolysis, Krebs cycle, B-oxidation of fatty acids) and use of energetic resources. Ozone acts as a super-oxygenator, bringing oxygen to tissues, assisting body in its natural healing process.

Goals of ozone therapy

- Elimination of pathogens.
- Restoration of proper oxygen metabolism.
- Induction of a friendly ecologic environment.
- Increased circulation.
- Immune activation.
- Simulation of the humoral anti-oxidant system.

Applications of ozone in dentistry

Bacteria are the cause of many problems in dentistry so a powerful agent is needed for effective elimination of these causative agents. In dentistry, Ozone is used as a chair side disinfectant because of its synergistic part of the treatment, both in eliminating bacteria and oxygenating chair side environment.

Role of ozone on dental caries prevention and management

Within the past few years, ozone therapy has been launched as a new method for treating caries. It has been suggested that the application of ozone to carious lesions will arrest or reverse these lesions and that the use of ozone will provide an alternative to conventional drilling and filling. A study conducted by Baysan proved that the number of bacteria in carious root lesions is considerably reduced by ozone therapy, and that the lesions clinically change to stages in which progression of the caries can be considered to have ceased. ⁽¹¹⁾

Role in periodontics

Both caries and periodontal disease are caused primarily by plaque biofilm. Ozone might be useful to control oral infectious microorganisms in dental plaque. Ozonated water strongly inhibits the accumulation of experimental dental plaque and 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.

Role in endodontics

Until recently, chemical irrigants are relied on for reaching the main and lateral canals to disinfect and dissolve organic debris where it is impossible to instrument mechanically. In endodontic treatment, instead of using irrigation chemicals (NaOCl), ozonated water can be used for irrigation. Ozone has been found effective against endodontic pathogenic microorganisms like *E. Faecalis*, *Candida albicans*, *Peptostreptococcus micros* and *Pseudomonas aeruginosa* for disinfection of root canals and dentinal tubules. Ozone also eliminates the distinctive anaerobic odor associated with some chronically infected teeth.

Role in bleaching

Ozone can be used for bleaching in discolored non-vital teeth. Once the bleaching agent is placed on the inner aspect of the root canal treated tooth, the crown is irradiated with ozone for minimum of 3-4 mins. This ozone treatment bleaches the tooth within minutes and provides good esthetic results. Tessier *et al.* conducted the first experimental study, to evaluate, in an experimental model of growing rats, the efficacy of using ozone to lighten tetracycline-stained incisors and it was demonstrated that ozone can be successfully used for lightening the yellowish tinge of tetracycline-stained rat incisors.^(1,2)

Role in desensitization of sensitive root

It has been documented that ozone spray for 60 seconds followed by mineral wash onto the exposed dentine in a repetitive manner results in desensitization of dentinal tubules which lasts for longer period of time. Smear layer present over the exposed root surfaces prevents the penetration of ionic calcium and fluoride deep into the dentinal tubules. Desensitization by ozone results due to removal of smear layer and opening up the dentinal tubules, which increases the tubular diameter and allow calcium and fluoride ions to flow into the tubules easily, deeply and effectively. This obliterates the dentinal tubules, and prevents the fluid exchange through these tubules. Thus, ozone is effective in terminating the root sensitivity problem within seconds and its results last longer than those by conventional methods.

Role in wound healing

Application of ozonated water and ozonated oil daily accelerate the healing rate thus effective in the treatment of alveolitis. Ozone forms a pseudomembrane over the socket and reduces the post extraction healing and thus protects extraction

socket from any physical and mechanical insults. After radiotherapy in the jaw, oxygen supply reduces considerably in the affected area due to the obliteration of intraosseous vessels. After surgical interventions such compromised bone heals slowly compared to healthy bone. Ozone might be successfully used to treat such wound healing impairments after radiotherapy.

Role in prosthodontics

Microbial plaque accumulates on the denture. It is composed of several oral microorganisms, mainly *C. albicans*. To prevent denture stomatitis plaque control is essential. Topical application of ozonated oil over tissue surface and over denture surface controls the deposition. The disinfecting action of ozone is also used to clean denture.

Appliances producing ozone for dental use

- HealOzone by KaVo is air-based and the application of the gas takes place in a closed circuit. Manganese ions sucked out and neutralise its surplus. The concentration of ozone in the cap adjacent to the tissue amounts to 2100 ppm. Perfect air tightness of the cap is necessary for the application of ozone. Therefore, the application is only possible on the surfaces where such air tightness can be provided.
- OzonyTron by MYMED GmbH - Oxygen activation generator (OzonytronX—Biozonix, Munchen, Germany) uses the power of high frequency and voltage. Activated oxygen (ozone) concentration can be adjusted in 5 levels via current strength. Inside the glass probe, which is formed by a double glass camera, is a noble gases mixture that is conducting and emitting electromagnetic energy. When the tip of the probe gets in contact with the body it emits energy around the treated area and splits environmental diatomic oxygen in singular atomic oxygen and ozone. The concentration of ozone in the operation field is 10 to 100 µg/ml (becomes a fungicide, virucide, and bactericide at the intensity of 1–5 µg/ml). There is no closed circuit here, therefore, ozone can be applied to the places that are difficult to reach, e.g. gingival pockets or root canals.
- Product photo (Prozone) by W&H - It is characterized by its ease of use and safety of application (preset tissue-compatible dosages in the indication areas of periodontitis and endodontitis). Prozone ensures a hygienic procedure during the gassing of the pockets due to its exchangeable plastic attachments (Perio tips or Endo tips).

Advantages of ozone

Simple, non-invasive, less time consumption eliminates dental phobia.

Ozone toxicity

When administered of 0.05 ppm for 8 hour, ozone is not toxic.

Contraindications

Acute alcohol intoxication, pregnancy, severe anemia, recent myocardial infarction, hyperthyroidism, active hemorrhage, and thrombocytopenia.

Side-effects

- Epiphora,
- Upper respiratory irritation
- Rhinitis
- Cough
- Headache
- Occasional nausea, vomiting
- Shortness of breath
- Blood vessel swelling
- Poor circulation
- Heart problems

Treatment of ozone toxicity

In the event of an ozone intoxication the patient must be placed in the supine position, inhale humid oxygen, and take ascorbic acid, vitamin E, and n-acetylcysteine. Because of ozone's highly oxidative power, all materials that come in contact with the gas must be ozone resistant, such as glass, silicon, and Teflon.

Conclusion

A recent Cochrane Review identified 3 randomised controlled trials (RCTs) and two of the three RCTs included in the analysis investigated the effect of ozone therapy on crown lesions, while the third investigated the effect on root lesions and it was concluded that these trials provide no evidence that the application of ozone arrests or reverses the decay process and also ozone and photodynamic therapy (PDT) had a minimal effect on the viability of microorganisms organized in a cariogenic biofilm. Hence, a systematic review of all relevant randomized controlled trials found that there is a fundamental need for more evidence of appropriate rigor and quality before the use of ozone can be accepted into the mainstream primary dental care or can be considered a viable alternative to current methods for the management and treatment of dental caries. Dentistry is changing as we are now using modern science to practice dentistry. Ozone therapy has been more beneficial than present conventional therapeutic modalities that follow a minimally invasive and conservative application to dental treatment. Ozone is a promising treatment modality for various dental problems in future. But, it has to be kept in mind that presently ozone is an adjunct to other conventional treatment modalities and should be used in combination until more research shows benefits in independent usage.

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