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MIRACLE OF OZONE IN DENTISTRY: AN OVERVIEW

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ABSTRACT

Ozone which is being used for more than 100 years in its different forms, is one of the extensively used alternative method of treatment for various diseases/condition. It is gaining popularity in the present era because of its simplicity in its application, well accepted by the patients with no deleterious effects and is economically efficient. This review of literature is an attempt to discuss the evolution of oxygen and its biochemical interactions and applications through various modalities/ routes in medicine in general and dentistry in particular.

KEYWORDS: Ozone therapy, Dentistry, Periodontitis, Cosmetics.

INTRODUCTION

Scientific data indicates that there was no oxygen when the world came into existence. Oxygen first started to form as a waste product of anaerobic organisms approximately 3 billion years ago and started to increase with synthesis by photosynthetic organisms 1 billion years later.[1] Oxygen is the primary requisite for life. It helps in the growth and development of humans. It enhances wound healing by vascular proliferation and cell multiplication.[2] Oxygen is essential for all aerobic organisms and contributes to the formation of fundamental organic molecules together with hydrogen, carbon, nitrogen and sulphur.[3] Continuous supply of oxygen to the tissues through microcirculation is vital for the healing process and for resistance to infection. External factors have been shown to significantly decrease the peripheral oxygen supply. Adequate delivery of oxygen to the wound tissue is vital for optimal healing and resistance to infection.

Oxygen plays a critical role in the formation of collagen, the growth of new capillaries and the control of infection. The restoration of a damaged tissue is mainly by the oxygen in circulation which produces the granulation tissue. Basic scientific studies have clarified how oxygen and blood flow influences healing. Since time immemorial research has focused on treating wound and infection with different molecules of oxygen such as Hyperbaric oxygen and Ozone therapy.[4]

The concept of hyperbaric oxygen therapy can be traced back to 1600, but as a therapy, HBO began to be given in 1943. HBO treatment utilizes the two-atom O_2 molecule while ozone treatment uses the three-atom O_3 molecule.[4] Hyperbaric oxygen therapy is defined as administration of 100% oxygen to a patient who has been placed inside a chamber which has been pressurized to greater than one atmosphere at sea level.[2] The effects of HBO are based on the gas laws, and physiological and biochemical effects of hyperoxia.[5] The side effects and complications of HBO treatment may lead to central nervous system toxicity characterized by convulsion. Other adverse effects include dental problems, hypoglycemic seizures, transient myopia and barotrauma that can especially present as pneumothorax due to lung barotrauma.

Though, the advantage of Ozone was known since time immemorial, it has gained popularity in the field of medicine. Ozone therapy is used to disinfect and treat diseases by limiting the effect of bacteria, viruses, fungi, yeast and protozoa.

Ozone (also known as triatomic oxygen and trioxygen) is an allotropic form of oxygen occurring naturally in the Earth's atmosphere. It surrounds the Earth at an altitude of between 50,000 and 100,000 feet.[6] This article discusses the application of ozone in dental uses.

HISTORY

The word ozone was first used by Christian Friedrich Schonbein in 1840. He subjected oxygen to electrical discharges and noted "the odour of electrical matter". Schonbein concluded that odour was due to a gas which he named ozone, from the Greek ozein (odorant), and described several of its properties.[7] Ozone therapy originated in Germany about 100 years ago. It is now routinely used in Europe, Germany, Russia, Italy, France, and India.

Hansler developed one of the first reliable models of medical ozone generators. Dr. Albert Wolff successfully treated putrescent wounds, suppurating bone fractures, fulminating inflammations (phlegmons) and abscesses during the First World War, publishing his results already in 1915. This field then received a major impulse through the work of the surgeon and ozone therapist Erwin Payr, who presented his epoch-making publication, entitled "Ozone Treatment in Surgery" (Über Ozonbehandlung in der Chirurgie) at the 59th Meeting of the German Surgical Society (Deutsche Gesellschaft für Chirurgie) in 1935. This can be called the real beginning of ozone therapy.[7]

Properties of Ozone[8]

Medical grade ozone is a mixture of pure O2 and O3 in the ratio of 0.1% to 5% of O3 and 95% to 99.5% of O_2. Depending on the conditions like temperature and pressure, ozone is highly instable compound with half- life of 40 mins at 20^0C,

Principle

Oxygen molecule is stroked by high energy ultraviolet (UV) radiation, it splits into two free oxygen atoms, further these free oxygen atoms collide with oxygen molecules leading to the production of ozone. That can be used for treating various diseases.[9]

$$O_2 + UV \longrightarrow O + O$$

$$O + O_2 \longrightarrow O_3$$

Ozone treatment follows the principle of administration of an oxygen/ozone mixture at a specific ratio (minimum oxygen 95%, maximum ozone 5%) to body cavities or the circulatory system. The blood is then returned to the person (autotransfusion). This procedure is called major autohemotherapy. It is assumed that the increased partial oxygen pressure in the blood treated with the oxygen/ozone mixture has no therapeutic effect as this relative condition created in a very small amount of blood will become insignificant following dilution with the autotransfusion procedure. The physical and chemical effects of ozone, therefore, seem to play a direct role in this therapeutic effect. The H_2O_2 formed as a result of the reaction between ozone and biomolecules is accepted to be a second molecule acting as a mediator for ozone treatment effects.[4]

Mechanism of Action

Ozone therapy as a non-surgical alternative form of the medical treatment may help to reduce clogging of blood cells, detoxify the liver, decrease uric acid in the body, improves circulation and oxygen supply, kill viruses, fungi, and bacteria, also increase the activity of WBCs.[8]

Ozone reacts with bio-molecules producing one molecule of reactive oxygen species (ROS) mainly hydrogen peroxide and two molecules of lipid oxidation product (LOP). ROS react with erythrocytes in the blood and disappears. This is called early phase reaction and it is short lived. LOPs distributed to tissues and act on receptors at the different location on the body. They undergo marked dilution under circulation system. This is called late phase reaction and it lasts longer.[10]

$$R\text{-}CH{=}CH\text{-}R + O_3 + H_2O \rightarrow R\text{-}CH{=}O + R\text{-}CH{=}O + H_2O_2$$

a. Antimicrobial action: bacteria, fungi, and viruses are destroyed with O_3 application. The ozonolysis of dual bond of the outer cytoplasmic membrane and modification of intracellular content because of secondary oxidative effect leads to oxidation of proteins.
b. Immunostimulating effect: ozone stimulates the cellular and humoral immune system and hence proliferation of immunocompetent cells and immunoglobulin synthesis. Sensitivity of microorganisms to phagocytosis is increased due to activation of macrophages. This further leads to production of cytokines such as interleukins, prostaglandins, and leukotrienes, which help in reduction of inflammation and wound healing are synthesized by ozone
c. Anti‑hypoxic effect: Ozone results in change of cellular metabolism by raising partial pressure of oxygen in tissues and improving the transportation of oxygen in blood.
d. Biosynthetic effect: Ozone causes activation of protein synthesis mechanism with increased amount of mitochondria and ribosomes in cells that leads to elevation of functional activity and regeneration potential of tissues and organs.
e. Vasodilators (nitric oxide) that are responsible for dilatation of arterioles and venules are secreted by ozone.
f. Ozone intensifies remineralization potential when acting on the organic substance of mineralized tooth tissues.[9]
g. Also enables the diffusion of calcium and phosphorus ions to the deeper layers of carious cavities by opening of the dentinal tubules.[9]

Goals of Ozone Therapy[6]

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

Routes of Administration of Ozone[1,8,10]

1. Auto Hemotherapy: Around 250ml of blood collected in anticoagulant solution, it is ozonized outside the body then slowly infused back into the animal's body in over 15 min by the intravenous route. This maintains homeostasis of the body.
2. Insufflations: Insufflation of ozone gas is practiced through body spaces like Rectal, Vaginal and Ear canal. Rectal Insufflations are most commonly practiced.
3. Ozone Bagging: In this method, O_2-O_3 mixture is pumped into an ozone resistant bag, which is then placed around the area to be treated. Ozone is absorbed through the skin and superficial lesions are treated.
4. Ozonated Oil: Ozone is used with oil as ozone carrier. In oils like olive oil, sesame or sunflower oil. Ozone is bubbled until it forms the gel like consistency.
5. Ozone Blanket: It is used to treat several local and systemic conditions. In this method, Ozonated Silicon blanket is placed around the whole body of the animal.
6. External Administration of ozone: Use of Ozonated antiseptics, saline, Ozonated ointments, Ozonated vegetable oil etc.
7. Parenteral methods: Subcutaneous Ozone injections, Paravertebral Intramuscular Injections, Intravenous Infusions are taken.
8. Enteral Method: This route includes Intake of ozonated distilled water, Intestinal irrigation with Ozonated distilled water.
9. Steam Sauna: Bathing with Ozone or steam mixture is called as Steam Sauna. It cleanses the skin, pores and Lymphatic system.
10. Body Suit: The patient first opens off the pores of the skin by taking a warm or hot shower, after which they immediately enter the body suit. Bodysuit must be sealed at the ankles and wrists to reduce leaking of ozone.

Generators of Ozone

Since ozone is very unstable, it has to be generated only when needed and used at once.[7] The first ozone generator was developed by Werner Von Siemens in Germany in 1857.[11] There are three different systems to produce therapeutic grade ozone.[6] They are:

1. Ultraviolet system: Produces low concentrations of ozone. It is used in esthetics, saunas and for air purification.
2. Corona discharge system: Produces high concentrations of ozone. Most common system used in medical and dental field. It is easy to handle and it has a high controlled ozone production. These type of generators produce ozone of concentration 3-6%. Nitrous oxide is the byproduct produced in this process.[7]
3. Cold plasma system: Used in air and water purification.[6,11]

Appliances producing ozone for dental use[6,9]

HealOzone by KaVo: It is an air‑based system in which gas is applied in a closed circuit.

OzonyTron by MYMED Gmb H. - Oxygen activation generator (OzonytronX—Biozonix, München, Germany) uses the power of high frequency and voltage 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 and H: Prozone is easy to use and safe to apply as the tissue compatible dosages can be preset according to the indication areas of endodontics and periodontitis. A hygienic procedure is ensured during the gassing of the pockets as the plastic attachments (Perio tips or Endo tips) are exchangeable.

Ozotop: It is a compact, easy to use table top unit having a free flow ozone delivery system which utilizes corona discharge. Root canals and periodontal pockets could be easily penetrated

Customized thermoformed dental appliance: For application of ozone gas hard‑ or medium‑soft thermoformed dental appliance could be prepared which extends 2–3 mm beyond the affected gingival area and a free space for gas circulation is left. Indicated areas where such an appliance is hard to use or uncomfortable to the patient, polyvinylchloride (PVC) or silicone cap might be used.

Irrigation with ozonated water: As ozone water is highly effective in killing of both Gram-positive and negative micro-organisms, areas affected during and after scaling, root planing and non-surgical pocket curettage might be irrigated with ozone water. In plaque biofilm, the bactericidal activity of ozone water against bacteria is strong.

Ozone Nano bubble water: If protected against UV rays exposure, the oxidation ability of NBW3 is retained as aqueous ozone for more than 6 months. NBW3 is used as an adjunctive antiseptic in periodontal treatment due to its bactericidal efficacy and usability. The bactericidal activity of NBW3 is more potent against periodontopathic bacteria than an established oral antiseptic, 0.2% chlorhexidine digluconate.

In-office and home use of ozonized olive oil: A blunt 25-G needle or any other appropriate tip can be used to fill pockets with ozonized olive oil and the application can be repeated once a week.

Ozone in surgical and medical management

Ozone therapy is used to treat following clinical conditions[7, 8]:

1. Lumbar disc herniation[12]: oxygen-ozone therapy is a minimally invasive treatment for lumbar disk herniation. A reduction in disc volume occurs on intradiscal administration of medical ozone, as disc shrinkage may reduce nerve root compression.
2. Aging[8]: Early and premature aging is treated by Ozone therapy.
3. Geriatric condition[13]: Ozone has general revitalizing capacity when used as a complementary therapy. Can be used for poor concentration, general reduction in mental and physical performances.
4. Infected wound[7,13]: Disinfection property of ozone helps in healing of infected wound, external ulcers and skin lesion.
5. Circulatory Disorders[13]: Ozone Therapy gives very good results in arterial circulatory disorders, which are characterized by a sensation of heaviness and coldness and pain in legs while walking.
6. Macular Degeneration[13]: Ozone is used to improve weak eyesight due to age-related Retinal detachment.
7. Intestinal Conditions[13]: Inflammatory conditions of the large intestine and small intestine, fistulas are treated by rectal insufflation of Ozone.

8. Cancer[8]: Ozone is antineoplastic. This means that Ozone inhibits the growth of new tissue because rapidly dividing cells shift their priorities away from producing the enzymes needed to protect themselves from the ozone. Cancer cells are rapidly dividing cells and are inhibited by Ozone.
9. Atherosclerosis and Ischemic heart disease[14]: Ozone has been found to be the hypolipidemic effect. It activates antioxidant defense system, the eliminating lipoprotein toxicity, decreasing their capacity to penetrate the vessel wall. Hence, ozone can treat Atherosclerosis and IHDS.
10. Diabetes mellitus[14]: Ozone improves the penetration of cellular membranes for glucose. This is achieved by stimulating pentose phosphate pathway and aerobic glycolysis is that in case of Diabetes mellitus.
11. Parkinson's disease[14]: Ozone therapy useful in Parkinson"s disease for tremor, bradykinesia, postural disturbance and gait disturbance.
12. Lung diseases[8]: Ozone is used in the treatment of lung diseases such as bronchial asthma and chronic obstructive pulmonary disease.
13. Cosmetology[8]: Ozone therapy used in cosmetology to treat skin, hair related problems, Acne, pimple etc.

Other medical specialities where ozone therapy is used are

Gerontology, Infectiology, Orthopedics, Gastroenterology, Hepatology, Rheumatology, Dermatology, Gynecology, Stomatology, Dentistry, Intensive therapy, Pneumology, Cosmetology, Neurology, Urology, Cardiology, Oncology, Angiology.

Uses of Ozone In Dentistry[8,11]

Conservative dentistry- Ozone causes opening of the dentinal tubules by removing the smear layer, which allows the calcium and fluoride ions into the tubules resulting in plugging of the Dentinal tubules. Thus preventing the fluid exchange through these tubules. The root sensitivity problem can be effectively terminated by ozone within seconds. Enamel cracks, Tooth whitening, Dentinal hypersensitivity, abscess, granuloma, remineralization of pit and fissure caries, root and smooth surface caries, bleaching of discolored root canal treated teeth, Sterilization of cavities, Root canals.

Oral surgery- After a tooth is extracted or any surgical procedure the area is irrigated and insufflated with ozone promotes faster healing without complications. Ozone therapy is found

to be beneficial for the treatment of the refractory osteomyelitis in the head and neck in addition to treatment with antibiotic, surgery and hyperbaric oxygen.[15]

Oral medicine: Soft tissue lesions like Herpes, Aphthae, Removable denture ulcers, Cuts, Cheilitis, Candidiasis, Cysts and Traumatic wounds can be treated with either Ozonated water or oils. The disinfectant and healing properties help in the healing of these lesions.[15]

Prosthodontics - Gaseous O_3 is proved to be clinically useful for disinfection of dentures.[15]
Orthodontics and orthopedics- Application of ozone in water and gaseous form into the TMJ dysfunctions or for myoarthropathy can cause relaxation of muscles. Not much of data is available, still research needs to be done.

Facial esthetics: ozone steam moisten the skin texture, whitens and purifies the skin. It promotes easy blood circulation and accelerates skin metabolism (source- google, still research needs to be done).

Ozone therapy in periodontics

Ozone is a very good alternative and/or an additional disinfectant to standard antiseptics due to its undisputed disinfection power over other antiseptics.

Periodontitis being multifactorial disease process in the mouth has the role of microorganisms, host response, in its etiology. The undisputed disinfection power of ozone over other antiseptics makes the use of ozone in treatment of periodontitis, gingivitis, peri implantitis, surgical cuts, Prophylaxis, a very good alternative and/or an additional disinfectant to standard antiseptics.[11] Repeated application of ozone spray for 60s followed by mineral wash on the exposed dentine provides quick and prompt relief from root sensitivity. Gaseous or aqueous form of ozone may be used in cases of peri‐implantitis. The abutment is fully covered by cutting an appropriate length of PVC or silicone cap. The gingival borders around the implant should be properly sealed. Ozone gas infiltrations can also be used in this situation. During debridement and curettage, irrigation is done with ozonated water. On the treated areas, 3–4 times daily application of ozonized oil can also be advised.[6]

According to Krammer, a German dentist, aqueous ozone can be used:

1. As a powerful disinfectant

2. To control bleeding
3. To cleanse wounds in bones and soft tissues
4. To improve healing by increasing the local supply of oxygen to the wound area
5. To increase the metabolic processes related to wound healing as ozonated water can increase the temperature in the wound area.

Ozonated water: It has been shown to be efficacious against Gram‑positive and Gram‑negative oral microorganisms as well as bacteria in plaque biofilm. It may be used as a mouth rinse in cases of gingivitis, oral thrush or stomatitis, as a spray to cleanse the affected area and to disinfect oral mucosa, as a water jet in treatment of painful gingivitis and stomatitis.[6,9]

Ebensberger et al., 2002 found that 2 min irrigation with ozonated Water (4mg/l) leads to mechanical cleansing, decontaminates the root surface, no negative effect on periodontal cells remaining on the tooth surface.[9]

Similarly Ramzy et al., 2005 found that patients suffering from aggressive periodontitis were irrigated with 150 ml of ozonized water over 5‑10 min once weekly using a blunt tipped sterile plastic syringe showed significant improvement regarding pocket depth, PI, GI and reduction in bacterial count reported in sites treated with ozonized water.[16]

Hayakumo et al., 2013 found that subgingival irrigation with NBW3 is valuable adjunct to periodontal treatment.[17] Since ozone has a half-life of 20 mins, to overcome this disadvantage ozone nano bubble water (NWB3) was developed using nano-bubble generating technology.

Gaseous form: Most frequently used in restorative dentistry and endodontics. It is a non-invasive therapy for treatment of dental caries and may be used as a disinfectant before the placement of a direct restoration and also as therapy for hypomineralized teeth.[9]

Ozonized oil: It is competitive antimicrobial agent due to wide accessibility of sunflower oil. It is found efficacious against Streptococci, Enterococci, Staphylococci, Pseudomonas, Escherichia coli and especially Mycobacteria and is used for the cure of fungal infections.[6,9]

Shoukeba et al in 2014 found that ozonated olive oil gel could be a promising adjunct to SRP in treatment of aggressive periodontitis.[18]

Huth et al., 2006 found that aqueous ozone is less cytotoxic than gaseous ozone or established antimicrobials.[9]

K.L Vandana et al in 2015 found that CHX, PI (povidone iodine) and ozone showed similar effects in reducing aerobic and anaerobic CFU'S and can be used as pre procedural agent, considering its beneficial effect.[19]

Ozone Toxicity: Despite proponents for ozone use and the potential applications, toxicity can occur even at environmental levels and may be related to cardiac, respiratory, and neurologic events.[20] Certain side-effects such as cough, nausea, vomiting, headache, epiphora, rhinitis, upper respiratory irritation, shortness of breath, and heart-related problems.[9]

Ozone Intoxification[11]

Administration of 0.05 ppm for 8 h ozone is not toxic. A maximum concentration of ozone in oral cavity amounts to 0.01 ppm, during ozone therapy. 0.01 ppm concentration of ozone can be used in oral cavity during ozone therapy.[9]

In case of ozone toxicity, patient must be placed in supine position and made to inhale humid oxygen. Oral intake of Vitamin E is beneficial to the chronic ambient exposure. Budesonide has been shown to inhibit the airway neutrophilic inflammatory response although it does not prevent functional impairment of the airway.[20]

Future Directions To Ozone Therapy: With the wide range of possible applications and toxicity that can occur at environmental levels from within a home, research on ozone use and toxicity is likely to increase in the future.[20]

The recent discovery that ozone is produced in vivo as a fundamental immunological defense against pathogenic organisms opens exciting conceptual and research directions for the clinical use of ozone in medicine and dentistry.[7] Further research is needed to standardise protocol for treatment procedures with ozone.

CONCLUSION

Dentistry is changing as we are now using modern science to practice dentistry. Various research shows that in comparison with classical medicine modalities such as antibiotics and disinfectants, ozone therapy is quite inexpensive, and very promising. This article provides a brief review on the evolution of oxygen and its use in medicine, ozone therapy and its mechanism, different routes of administration as well its uses in medicine and dentistry.

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