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OZONE IN DENTISTRY- EFFECTS & APPLICATIONS

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INTRODUCTION

The term ozone is derived from the Greek word 'ozein', (meaning to odor; named after its typical odor habitually perceived by human nose at 0.02 or 0.05 ppm.). It was first used by a German chemist named Christian Friedrich Schonbein (father of ozone therapy) in 1840. Ozone or O_3 is a natural gaseous molecule consisting of three oxygen atoms. The stratosphere is composed of plenty of ozone which safeguards the living organisms from the harmful ultraviolet rays (UV). Oxone being heavier than air, falls downward towards the earth from very high altitudes. O_3 purifies the air and conglomerates with any other pollutant and toxin that comes in contact with ozone. Thus, this proves to be earth's natural and biological method of self-cleansing. Ozone has been used as one of the non-medication approaches of treatment modality for more than100 years. EA Fisch (1990) was the first dentist to use ozone therapy in his practice to facilitate disinfection and wound healing during dental surgeries. Ozone therapy can be outlined as a multipurpose bio-oxidative healing process wherein, oxygen/ozone is directed to the patient either in gaseous form, dissolved in water or oil base status; to achieve therapeutic profits.[1]

Ozone or trioxygen (allotropic form of oxygen) is an unstable gas which occurs certainly by the action of UV rays on oxygen in the outer atmosphere. Ozone is an effective oxidizer with the capability to oxidize any known biological object.[2] The antimicrobial action on bacteria, virus, and fungi, along with other properties like immunomodulatory, anti-hypoxic,

biosynthetic, and anti-inflammatory effects are the fundamental characteristics of ozone.[3,4] These chemical reactions are thus catalyzed by extremely high frequency UV light from sunlight. Also, other detrimental B and C ultraviolet radiations in the stratosphere nearing the outer atmosphere from the sun are engrossed by ozone.[5] Consequently, the stratospheric ozone has a pivotal role in the thermal structure of the stratosphere and the environmental scaffold for life on the surface of the earth. On the contrary, troposhepric ozone is documented to be toxic for the pulmonary tract.[5]

In the troposphere (near to the earth's surface), ozone is created by the chemical reaction between air pollutants from vehicle, exhaust, gas vapors and other emissions.[6] Ozone level is maintained by the balance between the sunlight that produces ozone and the chemical reaction which destroys it. O_3 is generated when the oxygen is divided by sunlight into single oxygen atoms.[7] Ozone acts as a shelter to protect life on the earth, but direct contact with it is detrimental to both plants and animals. When mixed with CO, N_2O and traces of acid, O_3 becomes toxic for the pulmonary tract.[4]

History

In 1840, Ozone was first discovered by a German Chemist Christian Frederick Schonbein at the University of Basil in Switzerland. In 1870, it was first used in medicine by Landler. Ozone was not earnestly and genuinely considered by the scientific community, until Dr EA Fisch in 1932, (Swiss dentist) used ozonated water as a disinfectant to treat Austrian surgeon Ernst Payr who then turned out as an ozone fanatic and began a line of research committed to its use in medical field. It was in 1950 when ozone-resistant materials were manufactured and during that period, Joachim Hänsler and Hans Wolf (German physicist and physician) joined together to develop the first ozone generator for medicinal use.[8]

Various forms of ozone

The different forms of Ozone in which it is distributed are ozone gas, oil and aqueous solution. These types are utilized either in combination or individually for the treatment of dental disease. There are numerous methods for ozone gas generation wherein, Ultraviolet system creates a minimum concentration of ozone which is used for air purification and esthetics. Corona discharge system produces a large concentration of ozone which is the most predominant types in the medical/dental field. This system entails a measured and controlled rate of ozone production and easily handled. Another system is the Cold plasma system, which is used in the purification of water and air. A different form of Ozone exists as

ozonated oil which are naturally occurring plant extracts wherein pure oxygen and ozone are passed through them. Oleozone and Bioperoxoil are examples of ozonated oil that is efficient against Staphylococci, Streptococci, Enterococci, Pseudomonas, Escherichia coli, and especially mycobacteria. Aqueous form of ozone can be used as a disinfectant, sterilizing agent, irrigation solution and hemostatic agent. Werner von Siemens (Germany) developed the first ozone generator system in 1857, and the first report of it being used therapeutically was to purify the blood by C Lender in 1870.[9]

Producitn of ozone gas

Ozone is produced naturally by the following methods

- From electrical discharges subsequent to thunderstorms. Ozone is formed when an oxygen molecule gets an electrical discharge, splitting it into two oxygen atoms. An atom combines with another oxygen molecule to form an O_3 molecule.
- From UV rays discharged that help in the electrical discharge over oxygen present in the stratosphere, thus, producing the ozone layer which absorbs most of the UV radiation released by the sun.
- UV system produces low concentrations of ozone utilized in esthetics, saunas and also in air purification.
- Cold plasma system used in air and water purification.
- Corona discharge system produces high concentrations of ozone that is easily controlled.[10]

Biological actions of ozone

Ozone is a highly thermodynamically unstable compound that decomposes to pure oxygen depending under specific temperature and pressure conditions.[11]

a. **Antimicrobial effect:** The oxidant potential ozone stimulates the obliteration of bacterial cellular walls and cytoplasmatic membranes. Gram positive bacteria are more sensitive to ozone than gram negative. All viruses are prone to the effect of ozone yet fluctuate in their vulnerability. Viruses with lipid envelope are especially sensitive to ozone action.[12]
b. **Immunostimulating effect:** Cellular and humoral immune system are quiet influenced by ozone system which helps in instigating proliferation of immunocompetent cells and synthesis of immunoglobulins. O_3 triggers the function of macrophages and upsurges the sensitivity of microorganism to phagocytosis. O_3 produces certain biologically active substances (interleukins, leukotrienes and prostaglandins) which is advantageous in

decreasing inflammation and wound healing.[13]

c. **Antihypoxic effect:** Ozone helps in increasing the pO2 in tissues and recovers transportation of oxygen in blood, that causes change of cellular metabolism-activation of aerobic processes (Glycolysis, Krebs cycle, Beta-oxidation of fatty acids) and use of energetic resources. O_3 mends the metabolism of inflamed tissue by increasing their oxygenation and decreases the total inflammatory processes.

d. **Biosynthetic effect:** O_3 initiates the mechanisms of protein synthesis and escalates amount of ribosomes and mitochondria in the cells. These changes illustrate the elevation of functional movement and regeneration capacity of tissues and organs. Ozone can produce secretion of vasodilators (NO), that helps in dilatation of arterioles and venules and also stimulates angiogenesis with the increased level of 2, 3 Diphosphoglycerate (2, 3-DPG). It changes the conformation of erythrocytes that allows them to return oxygen in the inflamed tissue.[14]

Generators of ozone

There are vivid techniques for the production of therapeutic grade ozone. They are:-

- **Ultraviolet system:** helps to produce low concentration of ozone that is used in esthetics, saunas and for purifying air.
- **Corona discharge system:** Most common system producing high intensity ozone that is used in medical and dental field and is easy to handle and can have a controlled ozone manufacture.
- **Cold plasma system:** Medical grade ozone is a mixture of pure oxygen and pure ozone in the ratio of 0.05% to 5% of ozone and 99.95% of oxygen. Due to its instability, medical grade ozone should be prepared instantaneously before use. This is mostly used for air and water purification.[14]

Goals of ozone therapy

- Stops progression and remove pathogens
- Increase of immune system and maintains proper circulation
- Reduces the inflammation and pain
- Initiates humoral anti-oxidant system
- Maintains proper oxygen metabolism
- Avoid shock and stroke damage
- Creates friendly ecological environment

- Increases brain function and memory[15]

Applications of ozone in dentistry

Ozone on microorganisms:- Ozone has great antimicrobial effect that is available for use in medicine, and is of utmost importance in killing these pathogens. There are various research that has proved the antimicrobial efficiency of gaseous ozone and ozonated water. Few researches have shown that it acts on bacterial cell membranes, by oxidation of their lipid and lipoprotein constituents. Ozone appears to extract the spores defective in germination, possibly because of the damage to the spore's inner membrane. All viruses are vulnerable to ozone but differ in their receptiveness. Examination of viral constituents exhibited injury to polypeptide chains and envelope proteins damaging the viral attachment competence and damage of viral RNA.[8] Ozone might help to control the oral infectious microorganisms present in dental plaque. A high level of biocompatibility of aqueous ozone on human oral epithelial cells, gingival fibroblast cells, and periodontal cells has been found which is significant for cleansing of avulsed teeth prior to replantation. Also, gaseous ozone can be clinically useful for disinfection of dentures.[5]

Ozone in dental caries:- Ozone has a rigorously unsettling consequence on cariogenic bacteria that results in elimination of acidogenic bacteria. Pyruvic acid is the strongest naturally occurring acid formed by acidogenic bacteria during cariogenesis. O_3 can decarboxylate this to acetic acid and it is evident that remineralization of carious lesions can be exhilarated when the formation of acetic acid, or other high pKa acids of resting plaque is neutralized. Ozone also buffers the plaque fluid. Thus, treatment with ozone gas considerably decreases caries progression, remineralizes, and arrests carious lesions in highly susceptible patients. It is also witnessed that ozone treatment caused least state of anxiety compared to traditional dentistry due to the non-invasive technique. Non-cavitated lesions were more likely to reverse than cavitated lesions.[8]

Ozone in endodontics:- Baysan conducted a study to prove that the number of bacteria in carious root lesions is significantly decreased by ozone therapy and the lesions clinically ceases to progress further.[16] Its antimicrobial action has been established against bacterial strains such as *mycobacteria*, *streptococcus, pseudomonas aeruginosa*, *Escherichia coli, staphylococcus aureus, peptostreptococcuss, enterococcus faecalis* and *candida albicans*. Particularly, when the specimen was irrigated with sonication, ozonated water had the same antimicrobial activity as 2.5% NaOCl.[14] Intracanal gas circulation of ozone at a flow rate of

0.5-1l/min with net volume of 5 gm/ml for 2-3 min presented promising consequences against pathogenic microbes in root canal.[1]

Ozone in dental bleaching:- Discoloration of the crown in the anterior teeth is a major esthetic problem. Conventional walking bleach technique entails longer time and the outcomes are not pleasing and satisfactory. The canal is sealed tight at the level of cementoenamel junction after the filler material is removed from the pulp chamber. The chamber is then rinsed with sodium peroxide solution to eliminate any debris, cement particles and the smear layer, so that the dentinal tubules are opened up. After that a bleaching paste or a cotton pellet moistened in bleaching solution is filled in the chamber and the orifice is closed with the glass ionomer cement. The crown is irradiated with ozone for minimum of 3–4 min after that. This therapy bleaches the tooth within minutes and gives the patient a happy and satisfactory result with a bright smile.[17]

Ozone in dentin hypersensitivity:- Dentin hypersensitivity after surgery was usually managed with ozonized oil or with a combination calcium sodium phosphosilicate mineral wash and ozonized oil. After this treatment, ozone alone was not efficient, rather a combination with mineral wash was seen to be more efficient in decreasing dentinal hypersensitivity. Ozone is also used along with other remineralizing agents like fluoride, CPP-ACP, and CPP-ACP+ Fluoride; to treat hypersensitivity in molar incisor hypomineralization (MIH). CPP-ACP is thought to successfully used in the treatment of MIH, and ozone extended the effect of CPP-ACP. Ozone when combined with a fluoride dentifrice augments and improves tubular occlusion of dentin when compared to a mixture of ozone with oxalates, This is proposed to be an efficient and successful add-on in decreasing and eliminating hypersensitivity. However, certain authors have reported that ozone has no effect on tooth hypersensitivity following a precarious assessment of a placebo-controlled triple-blind trial.[3]

Ozone in prosthodontics:- The fitted surface of the dentures consists of microbial plaque comprising of several oral microorganisms, predominantly *Candida albicans*. This needs to be controlled to prevent denture stomatitis. Arita *et al.* evaluated the effect of ozonated water along with ultrasonification on *C. albicans*. After an exposure to ozonated water for 1 min, the authors observed the absence of *C. albicans*. Thus, the application of ozonated water could be beneficial in decreasing the number of *C. albicans* in the denture bases.[8] Few other authors have also observed that ozone gas on denture-related traumatic ulcer resulted in better

ulcer healing, decreased pain level, decrease in ulcer size, and duration.[18] There are studies that compared the microbicidal effect between gaseous ozone and ozonated water on dentures and observed that direct exposure to gaseous ozone was more effectual.[19]

Ozone in oral surgery:- A study was performed to evaluate the consequence of ozone gas in oral and maxillofacial surgery, where ozone therapy was seen to be advantageous for the management of the refractory osteomyelitis in the head and neck along with antibiotics, surgery and hyperbaric oxygen.[5] Dry socket was prevented by the use of ozone which was examined among 30 patients needing bilateral surgical extraction of impacted lower third molars. Ozone therapy after extraction ominously decreased the occurrence (3.3%) of dry socket when compared to controls (16.7%). Hence, it showed that ozone could diminish the incidence of dry socket and recuperate healing following surgical removal of third molars. The use of ozone along with antibiotic therapy over a period of 15 days was followed for the treatment of osteoradionecrosis of jaw subsequent to bisphosphonate treatment for multiple myeloma. Out of the twelve treated, eight had complete resolution and four had partial resolution.[3]

Ozone in pedodontics:- The purpose of ozone therapy in a pediatric practice may depend mainly on the fact that ozone application is extremely quick, efficient, easy and painless procedure to execute. These facets not only augment the operator efficiency but also efficiently advances the patient fulfilment and patience to the treatment procedure.[1]

Ozone in periodontology:- Periodontal disease affects the supporting structures of teeth. It typically commences as gingivitis and in few cases can progress to periodontitis. Nonetheless, it is eventually the response of the host, bacterial, genetic alteration which resolves the transition and severity of the disease. The action of 1 min exposure of ozone (gaseous or water chlorhexidine (CHX) or saline on periodontal pathogens exhibited greater antimicrobial effect against *Porphyromonas gingivalis*, *Tannerella forsythia*, and *Parvimonas micra* in planktonic compared to biofilm cultures. The antibactericidal activity of aqueous ozone (20 μg/ml) and ozone gas (≥4 mg [−3]) against periodontal-pathogens was substantially less compared to 2% CHX but were much effective than 0.2% CHX. Thus, none of the agents could significantly reduce the *Aggregatibacter actinomycetemcomitans* in biofilm cultures. The impact of ozone with photodynamic therapy and antiseptic agents (2% CHX, 0.5%, and 5% hypochlorite) on several organisms in a biofilm model was studied *in vitro*. Dental plaque being the primary causal factor for gingivitis, periodontal disease should

undergo thorough treatment by professional cleaning followed by daily rinse of ozonated water. This was seen to be successful in diminishing the gravity of gingivitis and periodontitis. Ozone also has biosynthetic action. This capability of ozone to multiply periodontal cells was studied by means of immunochemistry subsequent to ozone exposure for 2 min after extraction. Ozone-treated group conveyed less pain and better quality of life compared to graft alone, post-surgery.[3]

Ozone in Osseointegration and Periimplantitis:- Ozone has been used around implants which efficiently sterilizes the implant surface and bony surface and also begins the reparative mechanisms thus permitting tissue regeneration around the implant surface. Dental implant has turned out to be a typical fundamental procedure for replacement of the missing teeth. To aid in prevention of periimplantitis sufficient, tolerable and stable plaque control routine must be guaranteed. Ozone helps to kill the microorganisms triggering periimplantitis and exhibits positive wound healing effect because of the increase of tissue circulation. Gaseous ozone or ozonated water proves to have an increased healing compared to wound healing without ozone therapy. An in vivo study performed by El Hadary *et al.* has assessedand showed that short-term administration of cyclosporine A, when administered with topical ozonated oil may influence bone density and the quality of dental implant osseointegration. Therefore, topical ozonated oil may ininfluence bone density and the quality of osseointegration around dental implants.[13]

Contraindications of ozone therapy

- Severe myasthenia
- Acute alcohol intoxication
- Pregnancy
- Severe anemia
- Recent myocardial infarction
- Glucose 6 phosphate dehydrogenase deficiency
- Hyperthyroidism
- Ozone allergy[20]

Ozone toxicity

Ozone is a strong oxidizing agent and when inhaled is tremendously toxic to the bronchopulmonary system. It could lead to sore throat, dryness of mouth, coughing, potentiate asthma, and lung damage when inhaled. It can also demonstrate fatal outcomes

when exposed to a concentration of 0.3 ppm for 15 min or 0.06 ppm, 8 h a day for 5 days.[21] Thus, ozone has no safety threshold as it is a toxic gas and can disturb the respiratory system even at 120 ppb. Ozi-cure™ ozone delivery system is however, contemplated unsafe for dental use since the concentration of ozone was above the recommended levels; hence, Healozone™ ozone delivery system was seen to be safe to use.[22] Thus, bearing in mind the risk present, ozonated water is less cytotoxic when compared to gaseous ozone and other antimicrobials concerning oral epithelial cells and gingival fibroblasts.[23]

CONCLUSION

Ozone is the supposed to be the best thing requiring non-surgical, painless and successful treatments to mankind. The ozone therapy has proven to be more advantageous than present conservative treatment options that entails a negligibly invasive approach to dental treatment. The elucidation of molecular mechanisms of this particular compound further provides profits in dentistry. Treating patients with ozone therapy diminishes the treatment time with a gigantic deal of disparity and it eliminates the bacterial count more precisely. This painless treatment increases the patients' tolerability, acceptability and satisfaction with negligible unfavorable consequences. However; the contraindications of this debatable method should be taken into consideration also. Further research is desirable to control the indications and treatment procedures of ozone therapy. Hence, the efficient use of ozone in routine dental practice is not yet comprehensively and unanimously acknowledged due to deficiency of adequate information, training, and the contradictory proof in literature. Though the present review portrays a brief picture about the results of prevailing studies that are very encouraging promising and are putting ozone in the map of all-in-one and must have tools in dentistry. The preceding reports were all based on *in vitro* studies and few clinical trials with procedural flaws and errors, smaller duration of follow-up and less number of subjects. Thus, well-controlled and blinded randomized controlled trials, with fewer sample, with adequate follow-up period, standardized and regular measurements and well-established analysis, are needed to establish ozone therapy as a standard treatment modality in dental practice.

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