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Review Article

OZONE - A REVIEW

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ABSTRACT

Ozone (O_3) gas discovered in the mid-nineteenth century is a molecule consisting of three atoms of oxygen in a dynamically unstable structure due to the presence of mesomeric states. Ozone therapy has been utilized and heavily studied for more than a century. Its effects are proven, consistent, safe and with minimal and preventable side effects. Medical O_3 is used to disinfect and treat disease. Mechanism of actions is by inactivation of bacteria, viruses, fungi, yeast and protozoa, stimulation of oxygen metabolism, activation of the immune system. Medication forms in a gaseous state are somewhat unusual, and it is for this reason that special application techniques have had to be developed for the safe use of O_3. In local applications as in the treatment of external wounds, its application in the form of a transcutaneous O_3 gas bath has established itself as being the most practical and useful method, for example at low (sub-atmospheric) pressure in a closed system guaranteeing no escape of O_3 into the surrounding air. Ozonized water, whose use is particularly known in dental medicine, is optimally applied as a spray or compress. Diseases treated are infected wounds, circulatory disorders, geriatric conditions, macular degeneration, viral diseases, rheumatism/arthritis, cancer, SARS and AIDS.

KEYWORDS: Allodynia, autohemotherapy, lipid ozonation products, ozone.

INTRODUCTION

Ozone (O_3) is an unstable gas, it breaks down into oxygen very quickly. Hence, we cannot store the ozone. Whenever needed it can be generated. The half life of ozone at 68 F is around 40 minutes; half life means the time taken to reduce to half of its original volume.

Ozone is generated basically in four ways:

1) Ultraviolet radiation: The ozone present in the earth's atmosphere is synthesized naturally. The exposure of ultra violet radiation of sun to the oxygen in atmosphere produces ozone. Ozone can also be produced synthetically. In industries ultraviolet bulb was used for generating ozone, but it produces low concentrations of ozone in comparison to other methods. The major disadvantage of this method is that the bulb will lose its efficacy very quickly. However, the advantage of this method was that it can generate ozone without producing nitric oxide, if the input air is clean and without pollutants. The ozone itself is nontoxic in low concentrations; it becomes poisonous only when combined with other gases. Unfortunately ozone was represented as toxic gas synonymous to smog. Because of its easy measurement in comparison to other smog components

2) Corona discharge: Electrical sparks are passed through an oxygen-rich environment, e.g. lightning or any electrical device, which produces sparks. This method is often misleadingly called, cold spark, as the sparks are far from cold. Many room air purifiers frequently use this method. Sparks are discharged between two metallic electrodes, through which a fan passes air. This method is not suitable for medical ozone generation because 1) in ambient air, nitric oxide is formed and 2) minute amounts of metal ions, produced by sparks arcing between the electrodes, are released into the oxygen flow, making it

unsuitable for medical purposes. For room air purification, however, these units may be suitable for the nitric oxide breaks down rapidly within several feet and the metal ions dissipate rapidly. To avoid this problem, some units use plasma tubes.

3) Cold plasma: In this method Glass cathode tube was used for ionic flow induction. The glass cathode tube was initially filled with a noble gas which is highly electrified. This unit will be enveloped in a second tube, usually 316 L grade steel, through which pure oxygen is passed. This is the second electrode and serves only as a ground. It does not receive any direct current, and avoids arcing further metal ion pollution. The flow of plasma within the tube induces the oxygen to reform as O_3.

4) Electromagnetic: In this method quartz glass tubes were used. Oxygen flows through it, copper wire was wound around the inner and outer tubes. A high frequency of voltage was passed through the coils, it produces a strong electromagnetic field (EMF). This method can generate heat and which may destroy ozone. Fan or heat sink were required for dissipating the heat. Quartz glass was more useful, it can prevent the contamination caused by heat in comparison to other glasses. Further investigations are required for the possible side effects caused by EMF.

Cold plasma method is more effectively used for medical applications. This method can produce high concentrations of ozone without contamination from generators components. Due to minimal voltage requirement and low temperatures, quartz glass is not essential for this method. The major problem in manufacturing instruments for ozone use in medical purpose, is due to its powerful oxidizing effect which may react with substances used in instruments. Ozone generators may allow some foreign substances to pass through the output gas. To avoid this, the tubes should be made of surgical steel. Use of non-reactive substance such as high silica glass in the generation tubes, still the output gas must pass through some type of tubing, humidifier, and cannula or syringe, which may oxidize or release minute amounts of foreign molecules into the output gas. Ideally, for this reason, non-reactive substances such as 316 L steel, Norprene tubing, borosilicate glass humidifiers, steel or glass spargers (diffusers) and Teflon or Kynar fittings are used. Cost is a major factor in ozone generator construction. It's better to use ozone treatment whenever needed. Because, the requirement of instrument during surgery may not exceed a very few minutes. So the foreign substances in the output gas may be very few in number which may not cause health hazards.

However, it is desirable that the ozone generating chambers should be made of the highest-grade materials available. Contact of ozone with aluminum and nylon should be avoided. For medical use contact with PVC and low grade steel should be avoided. Polypropylene humidifiers are non-reactive with ozone at room temperature (below 114° F.). Also, certain gases are vented from many plastics even without exposure to ozone. Regardless the safety measurements there are chances for the adverse effects. Extreme care should be taken during purchase of instruments.

Ozone Concentration

The measurement of ozone concentration is challenging. There are at least six variables affecting output, and application. These variables are:

1) Voltage applied, including cycles per second.

2) Flow rate of the input gas through the generating tubes.

3) Humidity of the input gas.

4) Temperature of the input gas.

5) Concentration of oxygen in the input gas.

6) Pressure, including barometric pressure.

Thus, the output of ozone may vary accordingly. A simple example can be quoted for variation in ozone output: at sea level the ozone output may vary vastly different from produced in the swiss alps. Usually manufacturer may measure the ozone produced on a given day at a given temperature, humidity, flow rate, oxygen concentration and voltage, then extrapolate to estimate intermediary positions according to the voltage and flow meters. Bottled oxygen is used during medical application, it increases accuracy. There is disadvantage even with use of bottled oxygen it may affect ozone output. Its mainly because, the oxygen released from generating chambers expands and cools at different rates in different climates and at different barometric pressures, thus affects ozone output.

Testing of German hansler units with ozone analyzer revealed that, it provides an erratic concentration of ozone and the output of ozone is declined markedly after 10minutes of constant operation. To avoid this, United States has developed new plasma units. The out of ozone with this instrument is steady and reliable. The concentration may not decrease with continuous use during surgery. The ozone production will vary depending upon various barometric pressures. Conversion Charts are available for various barometric pressures. Addition of a built-

in memory chip into which the current barometric pressure and other variables are entered, the accuracy can be brought to within 5% of the true concentration, assuming a perfectly accurate flow meter is used. Most flow meters aren't accurate below .5 Liters per minute (LPM) and below, the range most often used in medical application. The use of a pediatric regulator, calibrated from 1/16 - 1 LPM, increases the accuracy.

APPLICATIONS:

The most common methods of administration of ozone are:

1) Inhalation: a) Ambient room air purifiers

b) Filtered through oil

2) Ingestion: a) Ozonated water

b) Ozonated oil

3) Sauna/Body suit: Absorbed through the skin

4) Topical: a) Ozonated oil

b) Localized application

5) Insufflation: a) Rectal

b) Vaginal

c) Auricular

6) Injection: a) Minor autohemotherapy

b) Major autohemotherapy

c) Direct injection into vein

d) Hemorrhoidal vein

e) Directly into tumor

CONTRAINDICATIONS:

Most physicians caution against the use of ozone therapy in the following conditions:

1) After recent heart attack

2) Pregnancy

3) Recent internal bleeding including menses

4) Hyperthyroidism

5) Cramping or spasms

6) Thrombocytopenia

7) Alcoholic intoxication

8) Allergy to ozone

During the usage of ozone, if pressure is felt in the lungs the ozone should be stopped immediately. The pressure will dissipate shortly without harm. Co administration of other medicines with ozone may become dangerous should be used carefully. Ether never should be combined with ozone due to its explosive nature. Ozone treatment can only be carried out under a physician's guidance.[1]

Caries should be considered as an infection, and as such should be managed in very different way to the traditional drill and fill or tissue amputation. Infections can be managed with a pharmaceutical approach, and the quest for many researchers in this field has been to find a product that is effective, safe, easy to apply and predictable. The obvious benefit to the patient is that little or no tissue has to be removed, thus ending the cycle of tissue destruction and repair which the profession know has a limited life-time.

According to the niche environment theory a bacterial niche will be developed in carious lesion. Bacteria are far from the simple bugs as they are often referred to. For the growth of these bacteria, it may take help from the surrounding colonies. Protein coatings, Plaque and debris form a protective coat and helps in developing these colonies. These coatings also reduce the action of pharmaceutical agents, which were mainly used to eradicate these bacterial colonies.

From the past few decades the concept of dental caries has changed. Investigations have disclosed the complex mechanism of effects of physiological demineralization and remineralization that takes place daily in oral hard tissues by their interaction with saliva. The dental profession shares today a completely new vision of an old pathology. Decay start as a metabolic imbalance, shifted towards acidity and demineralization. Dental plaque is the medium in which this process develops. In such an environment acidophilic and acidogenic bacteria develop this ecological niche and new methods of diagnosis need to be found[1-8]. At an ear a stage in the development of a carious lesion, when enamel and dentine are dematerialized and dentine has not been denatured by proteolysis, these dynamics can be reversed, and remineralization occurs. When the bacterial ecological niche is eliminated remineralization occurs.

Acidigonic bacteria release acid as metabolic by product. This product may breakdown the mineralized structure of tooth and

can progress carious lesions. Equilibrium can be achieved if the mineral loss equals the mineral gain. Ozone can attain equilibrium, mainly of its oxidizing property. It is bactericidal and also causes the oxidation of biomolecules which allows the niche to survive and expand. It severely disrupts the bacterial population in carious lesions and destroys the cariogenic bacteria and their ecological niche. There by it promotes the re mineralization, further no acid attacks are seen in lesions. Acid pyruvate, one of the naturally occurring strongest acid manufactured by bacteria, and implicated in the progression of caries, is oxidized by ozone to acetate acid and carbon di-oxide. Acetate acid is less acidic than pyruvate, and this de-carboxylation reaction leads to mineral uptake due to the more alkaline conditions in a carious lesion. As soon as ozone therapy has taken place, and the patient licks the treated surface, the lesion will become populated with normal mouth commensals. These do not produce the aids associated with the progression of caries.

Ozone has been shown to be safe[9] and clinically to be effective n the management of root carious lesions [10-14]. Treatment of lesions in the elderly patients is difficult, because of the associated medical problems. With the use of ozone therapy, such lesions are easily treated. Ozone unit simplified the treatment in domiciliary setting, the clinician does not require carrying a range of restorative materials on such visits. Dentists while using ozone units, advice their patients to use a fluoride and mineral containing mouthwash. It increases the ozone efficacy by promoting remineralization.

Ozone treatment became the primary approach for several dental caries. It completely removes several potential stress factors, such as no need for local anesthesia, no use of the drill and no packing of restorative material. It even reduced the time period for caries management. General dental practitioners can therefore provide the most modern and most natural treatment available to patients with fear that they cause any physical or mental trauma. All the potential sources of stress for the surgeon in restorative treatment of the carious lesion are removed and yet the GDP 'S are providing the very best in dental care.

Treatment of deciduous teeth lesions

Ozone and mineral releasing glass ionomers were used for managing these patients. Caries is filled with fuji VII (GC Japan), which will supply long term fluorine and mineral release. It also prevents the ingress of food debris and further re-establishment of the acid niche environment. Firstly the loose debris should be cleaned, until leathery base reaches. It can be done with hand instruments. Then ozone is applied, the lesion wetted with the curozone remineralising wash and then the glass ionomer can be applied. This modified ART technique has been reported by Holmes J

Treatment of permanent teeth lesions.

Fissure sealants technique was commonly used for eruption of permanent dentition and prophylaxis in population at risk of rampant carious lesions. But in the current scenario it is replaced with ozone treatment [15-16]. It's because the use of bristly brush and pumice to clean the oclussal surfaces of teeth prior to sealing in the fissure sealant technique. The bristles were not too small enough to clean the depths and food debris, bacteria may remain at depths of fissures. Leading to large carious cavity.

***Antimicrobial activity of ozonated water*[17]**

To examine antimicrobial activity, oral microorganisms were exposed to several concentrations of ozonated water. The cell viability of S. mutants decreased to 58% after exposure to 0.5 mg/l of ozonated water for 10 s, and S. mutants was killed instantaneously in ozonated water (2 and 4 mg/l). The cell viabilities of S. sobrinus, S. sanguis and S. salivarius were very similar to that of S. mutants when the cells were exposed to ozonated water.

Ozonated water was dose-dependently toxic to C. albicans. However, C. albicans was not completely killed in 2 mg/l of ozonated water for 120 s. To compare the antimicrobial activity of ozonated water and commercially available disinfectants, povidone iodine and benzalkonium chloride were tested in this study. When S. mutans was exposed to ozonated water (4 mg/l), povidone iodine (2.3 mg/ml), or benzethonium chloride (40 lg/ml) for 10, 30, or 60 s, no viable cells were detected. Although ozonated water and povidone iodine each had a remarkable antimicrobial effect on C. albicans, a few thousand viable cells were still detected when candida albicans were exposed to benzalkonium chloride at 10, 30, and 60 seconds.

Effect of storage temperature on the concentration and bactericidal activity of ozonated water

It is well known that the concentration of ozonated water decreases with time. We examined the effect of storage temperature and time on the concentration and bactericidal activity of ozonated water against S. mutants. When ozonated water was maintained at 22_C for 180 min, the concentration and bactericidal activity decreased remarkably with time. When

ozonated water (4 mg/l; 22_C) was stored on ice, bactericidal activity was maintained for 180 min. In addition, the concentration of ozone was reduced to one-half its initial value when ozonated water was stored on ice for 120 min.

Microscopic examination of S. mutans exposed to ozonated water

To detect total counts of S. mutans exposed to ozonated water, they stained bacterial cells with LIVE/DEAD BacLightTM Bacterial ViabilityKit.

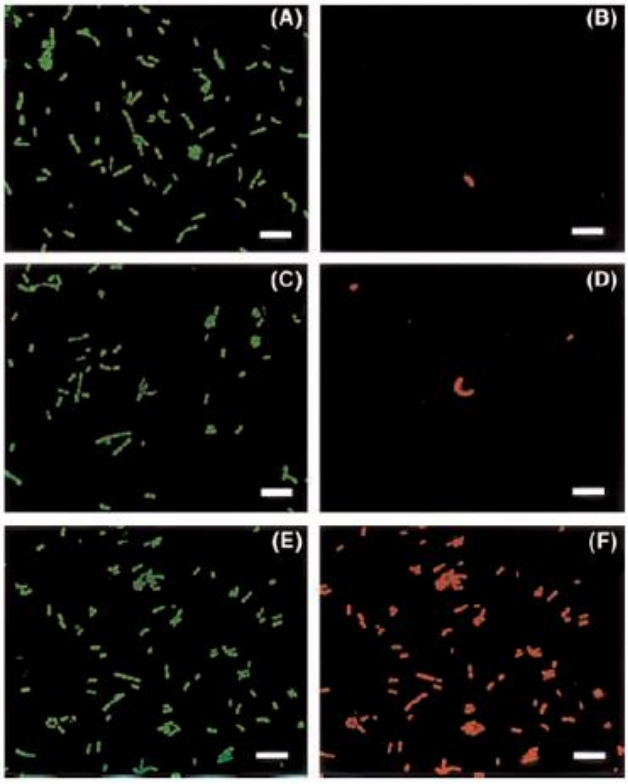

Figure 1. Fluorescence observation of *S. mutans* exposed to ozonated water.

As shown in Figure 1, fluorescence microscopic analysis revealed that almost all S. mutants cells were killed by ozonated water (4 mg/ l). On the other hand, only a few dead S. mutants cells were detected when treated with culture medium or distilled water.

The morphologic change in S. mutants exposed to ozonated water was examined by scanning electron microscopy. Treatment of medium or distilled water had no effect on the morphology of S. mutants. The disruptions of cells were found when S. mutants were treated with ozonated water (4 mg/l) (Figure 2).

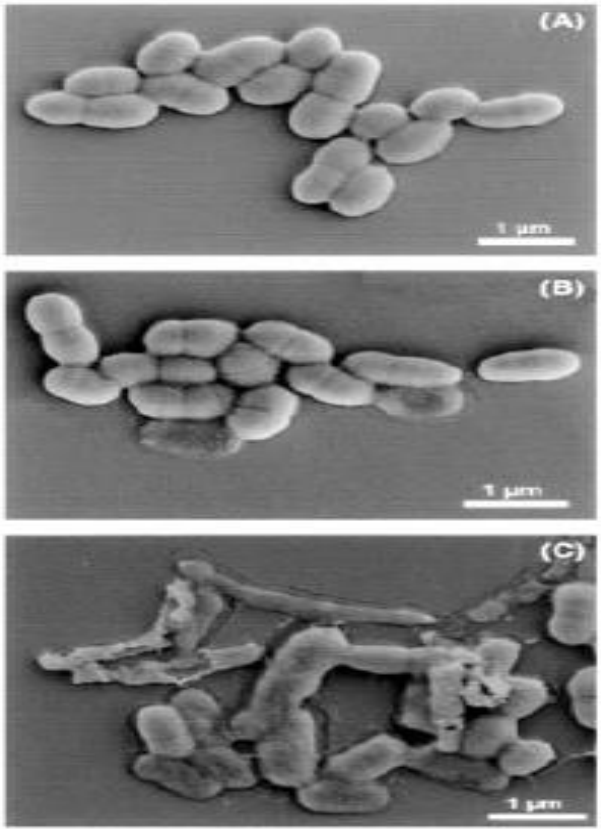

Figure 2. Scanning of electronic microscopic observation of *S. mutans* exposed to ozonated water.

Ozone in Endodontics

The major goals with conventional root canal therapy are to provide a clean shaped root canal, which can facilitate the placement for adequate root filling. In certain situations there may be multiple canals, which are linked by a web of accessory canals. There are apical delta and the common lateral canals. Dental professionals commonly use irrigants to disinfect dissolved organic debris in these areas. In this situation, while irrigating with usual irrigant solution for example sodium hypochlorite, ozone can be applied to the hypochlorite solution in the root canals. This technique allows the root canal system to be thoroughly disinfected and possibly be sterilized. Failure to treatment for root canal is due to enterococcus faecalis which is very difficult to eradicate. Use of ozone will eliminate this bacterial type (18). It is also postulated that ozone will penetrate through the apical foramen and enter into surrounding and supportive bone tissue. The effect of ozone on these tissues will be to encourage healing and regeneration. [19]

The ozone generating systems

The kent ozone system

Kent ozone system sprays a high pressure stream of water mixed with ozone gaps. It completely cleans the teeth from all nocks and corners. It gives long lasting freshness, healthier & white teeth and freedom from dental disease.

The HealOzone system

The HealOzone unit is made by CurOzone and distributed by KaVo Dental Limited. It delivers a 10-second burst of ozone gas at a pre-set concentration, through a hose and hand piece, into a polymer cup that is placed around the tooth surface to be treated (Figure 3).

Figure 3. Heal Ozone delivers ozone gas through a base and handpiece into a polymer cup that is placed around the tooth surface to be treated.

To fulfil health and safety regulations, a seal must be achieved around the tooth surface, which protects against the contraindications of high ozone exposure. Without this seal, the HealOzone unit will not produce ozone gas. At the end of the 10-second ozone exposure, the unit vacuums any residual ozone backthrough a catalyst that converts this ozone back to oxygen. This takes just 10seconds. To complete the treatment, the HealOzone unit then pumps a reductant fluid/mineral wash onto the treatment site, to kick-start the remineralisation process. This only takes a further five seconds. So, in just 25 seconds we can eliminate the micro flora that cause decay and start the' healing' process of a carious lesion.

CONCLUSION

In comparison to several other therapies in dentistry for caries and lesions, ozone therapy is considered to be more beneficial. It is suitable for all age groups. It is useful for intra oral hard and soft tissues. Treatment of carious lesions with ozone becomes more effective and much more acceptable.

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