

OZONE - A NEW REVOLUTION IN DENTISTRY.

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ABSTRACT

OZONE an allotropic form of oxygen has successfully being used for treatment of various diseases since more than 100 years. The versatility of ozone therapy, its unique properties, non invasive nature, absence of side effects or adverse reactions were responsible for its wide spread use. It is highly valued for various effects, such as antimicrobial, antihypoxic, analgesic, immunostimulating etc. on biological systems. These mechanisms of action supported with a lot of case reports and scientific studies allow using it in different fields of medicine. This review of literature is an another attempt to summarize its therapeutic potential in dentistry and its possible clinical applications in future.

KEYWORDS: antimicrobial, antihypoxic, analgesic, immunostimulating.

INTRODUCTION

The word **OZONE** originates from Greek word **OZEIN**, which means odor and was first used by German chemist **Christian friedrich schonbein** father of ozone therapy (1799-1868) in 1840. Ozone is also known as **TRIATOMIC OXYGEN** and **TRIOXYGEN O₃**, molecular weight 47.8g/mol. It's a naturally occurring compound consisting of three oxygen atoms. It's found in nature in the form of gas in the stratosphere in a concentration of 1-10ppm, being continually created from and destroyed into molecular O₂.^[1] Ozone in stratosphere has a critical role in both the thermal structure of the stratosphere as well as the ecological framework for life on the Earth's surface. It's one of the most important gases in

the stratosphere due to its ability to filter UV rays. This protective layer can be seen as a blue colored sky.^[2] Ozone therapy is one of the modern non-medication methods of treatment. It is being used for more than 100 years. Medical reports on successful application of ozone in therapy of different diseases and studies of its effects caused a rapid growing interest in it. Some other factors were responsible for its wide spreading, such as simplicity of performance, good tolerance by patients, absence of side-effects or adverse reactions and high medical-social and economic efficiency. Even though ozone therapy is still being ignored by most of medical establishment because of facts that gaseous ozone is quite toxic and has strong oxidative properties.^[3]

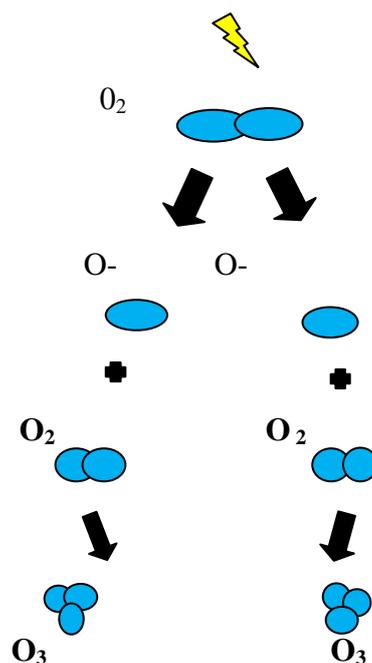
The ability of ozone to destroy toxic or noxious industrial impurities (phenols, cyanides, tetraethyl lead among others) and to inactivate bacterial contaminants in sewage has made it an attractive alternative to chlorination. In 1901 Wiesbaden, Germany became the first city to use ozonation for purification of its drinking water, followed by Zurich, Florence, Brussels, Marseille, Singapore and Moscow (the largest installation in the world), among others. The history of ozone's medical applications has nebulous and anecdotal beginnings. The names A. Wolff, Payr and Aubourg will always be linked with pioneering research, especially in the field of locally applied medical ozone.^[4]

Although relatively simple as regards application forms and active mechanisms, the use of ozone in dental medicine developed very modestly. As mentor, we must here mention the Swiss therapist A. Fisch, who himself acquainted Payr with ozone, and who presented a doctoral thesis (1952) and first publication on the use of ozone in dental medicine in 1935.^[5] It was not until the end of the 1980s, though, that medical ozone once more became a subject of dental research (Kirschner, Filippi).^[5] and dental practice (Lynch).^[6]

CREATION OF OZONE

In nature ozone is created by the combination of O₂ in the air under the influence of such factors as **ultraviolet radiation (from the sun) and electrical discharges (lightening)**.

Electrical discharge or UV rays.



An electrical discharge splits an O_2 molecule into two oxygen atoms (electrical discharge also referred to as corona discharge). These unstable O_2 atoms combine with each other oxygen molecules. This combination forms ozone.

It's also created in areas where there is intense physical stress on water such as waterfalls and ocean waves crashing onto rocks. Where natural concentration of ozone in the air can reach up to 0.5ppm, a point when its characteristic odor can be detected.^[7]

GENERATING SYSTEMS OF OZONE

1. There are three different systems for generating ozone gas:
2. **ULTRAVIOLET SYSTEM:** It produces low concentration of ozone. It's used in esthetics, saunas and for air purification.
3. **CORONA DISCHARGE SYSTEM:** It produces high concentration of ozone. It's the most common system used in the medical / dental field. It's easy to handle and it has a controlled ozone production rate.
4. **COLD PLASMA SYSTEM:** It is used in air and water purification.^[2]

HISTORIC BACKGROUND

The word ozone was first used by German chemist **Christian freidrich schonbein**, father of ozone therapy (1799-1868) in 1840.^[8] In 1785, Dutch chemist **Martinus Van Marun** was conducting experiment involving electrical sparking above water when he noticed an unusual

smell, which he attributed to the electrical reactions, failing to realize he had in fact created ozone. A half century later, Christian Friedrich Schönbein noticed the same pungent odor and recognized it as smell often following a bolt of lightning. In 1839 he succeeded in isolating the gaseous chemical and named it 'ozone'.^[9] The first ozone generator was developed by **Werner von Siemens** in 1857 and in 1870 there is first report of ozone being used therapeutically to purify blood by C. Lender in Germany.^[8] There is evidence of use of ozone as a disinfectant from 1881, mentioned in a book of diphtheria. In 1893, the world's first water treatment plant using ozone was installed in Ousbaden, Holland. During World War I, ozone was used medically to treat wounds and other infections.^[1,8]

In dentistry, Dr. E.A. Fisch (1889-1966) was the first dentist to use ozonated water in his practice and introduced it to the German surgeon Dr. Erwin Payr (1871-1946) who used it from that time in surgery and reported his results at the 59th congress of the German Surgical Society in Berlin in 1935.^[10]

PROPERTIES OF OZONE

Ozone is colorless or slightly bluish gas (blue when liquefied) slightly soluble in water and much more soluble in inert non-polar solvents such as carbon tetrafluoride and fluorocarbons where it forms a blue liquid. At 161K (-112°C; -170°C), it condenses to form a dark blue liquid. It is dangerous to allow this liquid to warm to its boiling point, because both concentrated ozone and liquid ozone can detonate. At temp. below 80K it forms a violet black solid. Most people can detect about 0.01 μmol/mol of ozone in air where it has a very specific sharp odor somewhat resembling chlorine bleach. Exposure of 0.1-1 μmol/mol produces headaches, burning eyes, irritation to the respiratory passage. Even low concentration of ozone in air are very destructive to organic materials such as latex, plastic and animal lung tissues.^[9]

Ozone is dependent on systemic conditions like temperature, pressure and decomposes to pure oxygen with a short half life. At room temperature ozone is a blue gas with a characteristic smell that can be noticed in air at a concentration of 2 ppm. Ozone is thermodynamically highly unstable compound which on decomposition produces molecular oxygen, atomic oxygen which is highly reactive. Oxidizes all non-noble metal immediately and attacks numerous organic compounds as a radical. This makes ozone apart from fluorine, one of the strongest oxidants. When dissolved in water, ozone is relatively unstable and decomposition rate depends on quality of water and systemic conditions.^[11]

MECHANISM OF ACTION OF OZONE

Ozone can react with blood components (RBC, WBC, PLATELETS, ENDOTHELIAL CELLS AND THE VASCULAR SYSTEM) and possibly affect oxygen metabolism, cell energy, the immunomodular property, antioxidant defense system, and microcirculation. Ozone the gaseous or aqueous phase, has been shown to be a powerful and reliable antimicrobial agent against bacteria, fungi, protozoa and viruses. It is generally accepted that the oxidant potential of ozone induces the destruction of cell walls and cytoplasmic membranes of bacteria and fungi. During this process ozones attaches glycoproteins, glycolipids and other amino acids and inhibits and blocks the enzymatic control system of the cell.^[12]

This results in increase in membrane permeability, the key element of cell viability , leading to immediate functional cessation. The ozone molecules can readily enter into the cell and cause the microorganisms to die.

By oxidizing the biomolecules featured in dental diseases, ozone has severely disrupted effect on cariogenic bacteria resulting in there elimination. Pyruvic acid is the strongest naturally occurring acid produced by acidogenic bacteria during cariogenesis. Ozone can decarboxylate pyruvic acid to acetic acid.^[13] This also help in buffering plaque fluid.

Enteroviruses, rotaviruses, hepatitis A and HIV viruses are more ozone sensitive than poliomyelitis and coxackieviruses. The main anti-viral actions of ozone are the change of the capsid and irreversible destruction of viral DNA. In bacterial cultures, E.Coli, and candida albicans are by far more ozone sensitive than staphylococci. Ozone inhibits their metabolic activity, and the cell walls of the bacteriaare primarily damaged . Bacteria can completely destroyed by ozone –produced antibodies.^[14]

USES OF OZONE IN DENTISTRY

The use of ozone in dentistry is gaining its place in every day's dental practice and is used in almost all dental applications. The undisputed disinfection power of ozone over other antiseptics makes the use of ozone in dentistry a very good alternative and/or an additional disinfectant to standard antiseptics. Due to safety concerns, O₃ gas was not recommended for intra-oral use. Only dissolved ozone in water and ozonated oils were and are still commonly used in different fields of dentistry. With the development of a foot pedal-activated dental

handpiece with a suction feature, O₃ gas can now be used safely in situations where diffusion is an important factor, i.e. dental hard tissues.

According to German dentist Fritz Kramer.^[15] ozone, such as in the form of ozonated water, can be used in the following ways.

1. As a powerful disinfectant.
2. In its ability to control bleeding
3. In its ability to cleanse wounds in bones and soft tissues.
4. By increasing the local supply of oxygen to the wound area, ozone can improve healing.
5. Ozonated water can increase temperature in the area of wound , and this increase the metabolic processes related to wound healing.

Dr. Kramer points out that ozonated water can be used in a number of different ways:

1. As a mouth rinse especially in the cases of gingivitis, periodontitis, thrush or stomatitis;
2. As a spray to cleanse the affected area , and to disinfect oral mucosa, cavities and in general dental surgery;
3. As a ozone /water jet to clean cavities to teeth being capped, receiving root canal therapy, and in treating painful gingivitis and stomatitis.

The application of ozone in dentistry comes as a result of physico-chemical properties: There are several known actions of ozone on human body, such as immunostimulating and analgesic, antihypoxic and detoxicating, antimicrobial, bioenergetic and biosynthetic (activation of the metabolism of carbohydrates, proteins, lipids) etc.^[16]

BIOLOGICAL ACTIONS

1. Antimicrobial effect

Ozone works destructively against bacteria, fungi, and viruses. This effect is a result of its action on cells by damaging its cytoplasmic membrane due to ozonolysis of dual bonds and also ozone induced modification of intracellular contents because of secondary oxidants effect. This action is non-specific and selective to microbial cells; it does not damage human body cells because of their major antioxidative ability. Ozone is very efficient in antibiotics resistant strains. Its antimicrobial activity increases in liquid environment of the acidic pH. In viral infections the ozone action lies in the intolerance of infected cells to peroxides and change of activity of reverse transcriptase, which takes part in synthesis of viral proteins.

Gram +ve bacteria are more sensitive to the action of ozone than Gram – ve bacteria. Among cariogenic bacteria streptococcus mutans and s.sorbinus are most sensitive.^[16]

2. Immunostimulating effect

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.^[16] As a response to this activation through ozone, the body's immune cells produce special messengers called cytokines. These molecules in turn activate other immune cells, setting off a cascade of positive change throughout the immune system, which is stimulated to resist diseases. 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.^[17] Ozone causes the synthesis of biologically active substances such as interleukins, leukotrienes and prostaglandins which is beneficial in reducing inflammation and wound healing.^[16] Ozone in high concentration causes immunodepressive effect whereas in its low concentration immunostimulating effect.

3. Antihypoxic effect

ozone brings about the rise of pO_2 in tissues and improves transportation of oxygen in blood, which results in the change of cellular metabolism - activation of aerobic processes (glycolysis, krebs cycle, β -oxidation of fatty acids) and use of energetic resources. Repeating low doses of ozone active enzymes: super oxide dismutase, catalases, dehydrogenase, and glutathione peroxidases. They are part of complex enzymatic systems which protect organisms against the action of oxygen-free radicals. It also prevents formation of erythrocytes aggregates and increases their contact surface for oxygen transportation. Its ability to stimulate the circulation is used in the treatment of circulatory disorders and makes it valuable in the revitalizing organic functions.^[16]

4. Biosynthetic effect

it activates mechanism of protein synthesis, increases amount of ribosomes and mitochondria in cells. These changes on the cellular level explain elevation of functional activity and regeneration potential of tissues and organs.^[16]

5. Ozone causes secretion of vasodilators such as NO, which is responsible for dilatation of arterioles and venules.^[16]

6. Ozone when acting on the organic substance of mineralized tooth tissues intensifies their remineralization potential. At the same time, it is capable of "opening" dentinal tubules, which enables the diffusion of calcium and phosphorus ions to the deeper layers of carious cavities.^[18]
7. A high concentration of ozone kills bacteria very quickly and is thousand times more powerful than other bacterial killing agents. The average concentration of ozone used in treatments is 25 gm of ozone /ml of oxygen/ozone gas mixture that translates into 0.25 parts of ozone to 99.75 parts of oxygen. Evidence based research has shown that at this concentration ozone effectively kills bacteria, fungi, viruses, and parasites.^[19]
8. One molecule of ozone is equal to between 3000 to 10,000 molecules of chlorine and kills pathogenic organisms 3,500 times faster.^[19]
9. According to many authors, a 10sec application of ozone causes the destruction of 99% bacteria, and a 20sec application even of 99.9%. In this way ecological niche appears.
10. During ozone therapy a maximum concentration of ozone in oral cavity amounts to 0.01ppm.^[20,21]

CLINICAL APPLICATIONS OF OZONE IN DENTISTRY

Ozone has therapeutic applications in various dental treatment modalities. Ozone therapy presents great advantages when used as an adjunct to conventional treatments.

Ozone in the management of caries

Ozone, in gaseous or aqueous phase, has been shown to be a powerful and reliable antimicrobial agent against bacteria, fungi, protozoa and viruses.^[16]

Ozone has a severely disrupted effect on the cariogenic bacteria, resulting in elimination of acidogenic bacteria. The strongest naturally occurring acid, produced by acidogenic bacteria during cariogenesis is pyruvic acid. Ozone can decarboxylate this acid to acetic acid.^[13] It has been shown that remineralization of carious lesions can be encouraged when the production of acetic acid, or other high pKa acids found in resting plaque, buffers plaque liquid.^[22]

Treatment with ozone gas significantly reduced carious progression, remineralised and arrested carious lesions in patients at high caries risk. It was also observed that ozone

treatment being noninvasive provoked least state of anxiety compared to traditional dentistry. Non cavitated lesions were more likely to reverse than cavitated lesions. Initial studies have indicated that an application of ozone is capable of clinically reversing leathery root carious lesions.^[23-27]

Ozone in management of hypersensitivity

Clinical trials documented gaseous ozone reduces pain immediately after treatment and on application of ozone, desensitization of dentine lasts for longer period of time. Smear layer present over the exposed root surface prevents the penetration of calcium and fluoride ions deep into the dentinal tubules. Ozone removes this smear layer, opens up the dentinal tubules, broadens their diameter and allows the Calcium and Fluoride ions to flow into the tubules easily, deeply and effectively to plug the dentinal tubules, preventing the fluid exchange through these tubules. Thus, ozone can effectively reduce the root sensitivity problem immediately and also lasts longer.^[28,29]

Ozone therapy in endodontics

Ozone has great potential to be used as an antimicrobial in endodontics. Micro organisms are one of the causes in the failure of root canal therapy. Ozone is one of the most powerful antimicrobial agents with enormous advantages to reduce the number of microorganisms in the root canal. Ozone is effective when it is prescribed in sufficient concentration, used for an adequate time and delivered correctly into root canals after the traditional cleaning, shaping and irrigation has been completed. Studies have proved the potential use of ozone gas, ozonated water and ozonised oil in endodontic therapy.^[30]

The aim of conventional root canal therapy is to provide a clean, shaped, root canal that facilitates the placement of an adequate root filling. There may be multiple canals, frequently linked by a "web" of accessory canals. There is the so-called "apical delta" and the common lateral canals. Until recently, the dental profession relied on irrigants reaching these areas to disinfect and dissolve organic debris where it is impossible to instrument mechanically. In this situation, current procedures can again be modified, as with whitening, to greatly improve the quality of treatment for patients. When irrigating with the 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. In cases where previous root canal treatment has failed, *Enterococcus faecalis* seems particularly prominent and especially difficult to eradicate. Ozone will eliminate this

bacterial type.^[31] It is also postulated that ozone will penetrate through the apical foramen, and enter into the surrounding and supportive bone tissue. The effect of ozone on these tissues will be to encourage healing and regeneration.^[32]

Ozone in Restorative dentistry

Studies that assessed the efficacy of ozone in restorative dentistry and its effect on dental materials concluded that ozone gas can be applied prior to etching and the placement of sealant with no negative impact on sound enamel physical properties, including Knoop surface micro hardness or contact angle. 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 of adhesive restoration.^[30]

Antibacterial Effect of Ozone on Plaque biofilm

Both caries and periodontal disease are caused primarily by plaque biofilm. Ozone might be useful to control oral infectious microorganisms in dental plaque. The antimicrobial property of ozone is not only effective in reducing the number of cariogenic bacteria, but also causes significant reduction in the micro organisms present in the root canal. However it was not successful in completely eliminating these bacteria embedded in the biofilm. Ozonated water is effective in killing gram-positive, gram-negative bacteria and oral *Candida albicans* causing periodontal disease. Ozonated water had nearly the same antimicrobial activity as 2.5% sodium hypochlorite and also the metabolic activity of fibroblasts was high when the cells were treated with ozonated water. The aqueous form of ozone, as a potential antiseptic agent, showed less cytotoxicity than gaseous ozone or established antimicrobials like chlorhexidine digluconate, sodium hypochlorite or hydrogen peroxide under most conditions. Therefore, aqueous ozone fulfils optimal cell biological characteristics in terms of biocompatibility for oral application. Ozone may be considered as an adjunctive to conventional treatment strategy due to its powerful ability to inactivate microorganisms.^[30]

Ozone therapy in oral and maxillofacial surgery

Ozone has a positive influence on bonemetabolism and reparative process of the bone. In patients with chronic mandibular osteomyelitis, it was observed that medical ozone exposure promoted more complete and rapid normalization of nonspecific resistance and T-cellular immunity, thus accelerating clinical cure and reducing the incidence of complications.^[33]

Ozone therapy is also found to be beneficial for the treatment of the refractory osteomyelitis in the head and neck in addition to treatment with antibiotics, surgery and hyperbaric oxygen.^[34]

Ozone therapy in the management of bone necrosis or in extraction sites during and after oral surgery in patients treated with Bisphosphonates may stimulate cell proliferation and soft tissue healing. When a combination therapy of a course of antibiotics, surgery and ozone therapy was given to patients with Osteo necrosis of jaw in patients with multiple myeloma there was a decrease in both the incidence of osteoradionecrosis of the jaw and the extent of lesions. It has been documented that dental extraction becomes possible in a patient with avascular bisphosphonate-related jaw osteonecrosis or in those who received pyrophosphate analogous when treated with ozone therapy. Compared with other therapeutic choices like antibiotics, surgical treatment, the new treatment protocol recommends the use of ozone therapy as therapeutic support in the treatment of bisphosphonate related osteonecrosis of the jaws.^[30]

Ozone for treatment of periimplantitis

For the prevention of periimplantitis an adequate and steady plaque control regimen must be ensured. Ozone, a powerful antimicrobial kills the microorganisms causing periimplantitis. In addition ozone shows a positive wound healing effect due to the increase of tissue circulation. Gasiform ozone or ozonized water shows an increased healing compared to wound healing without ozone therapy.^[35]

Effect of ozone on wound healing

The impact of ozone on epithelial wound healing in the oral cavity was observed by Filippi. It was found that ozone-water can be used daily to speed up the healing rate in the oral mucosa. This effect can be seen in the first two postoperative days. The comparison with wounds without treatment showed that daily treatment with ozone water accelerates the physiological healing rate. Patients under ozone therapy healed more quickly and without the need for systemic medication, compared to the control group. Application of ozone after tooth extraction reduced the post-extraction complications.^[30]

Use of ozonated water in decontamination of avulsed teeth before replantation

A high level of biocompatibility of aqueous ozone on human oral epithelial cells, gingival fibroblast cells, and periodontal cells has been found. Two-minute irrigation of the avulsed

teeth with non-isotonic ozonated water not only provides mechanical cleansing, but also decontaminate the root surface, with no negative effect on periodontal cells remaining on the tooth surface before replantation.^[36]

Antimicrobial efficacy of ozone as denture cleaners

Microbial plaque accumulating on the dentures is composed of several oral microorganisms, mainly *C. albicans*. Denture plaque control is essential for the prevention of denture stomatitis. The application of ozonated water may be useful in reducing the number of *C. albicans* on denture plates. The use of ozone as denture cleaner is effective against methicillin-resistant *S. aureus* and viruses. Ozone can be applied for cleaning the surface of removable partial denture alloys with little impact on the quality of alloy in terms of reflectance, surface roughness, and weight. Direct exposure to gaseous ozone was a more effective microbicide compared with ozonated water. Therefore gaseous ozone can be clinically useful for disinfection of removable prosthesis. There is also some evidence on the effectiveness of aqueous ozone application in adjunct to aminoalcohol for decontamination of the implant surfaces.^[30]

Role in periodontics

Studies found that ozonated water (0.5-4mg/L) strongly inhibited the formation of dental plaque and was highly effective in killing of both gram +ve and gram -ve microorganisms.^[37] Ozonated water can be used in the ultrasonic water reservoir, also as a pre treatment rinse before scaling, root planning and the sulci, pockets are irrigated using syringe and canula in non surgical pocket curettage. This process will reduce the initial pathogenic load on the patient locally and systemically. After treatment, each pocket & sulcus is insufflated with ozone gas which directly goes into tissues, sterilising the area.

Role in prosthodontics

A common occurrence found in full denture wearers is denture stomatitis, mainly due to *Candida albicans*. This can be controlled by topical application of ozonated oil over tissue surface and over denture surface. The disinfecting action of ozone is also used to clean denture. Advice patients to soak dentures in ozonated water for atleast 10min after removal and also rinse them before inserting into mouth. Ozone therapy in implantology helps in bone regeneration. The socket is prepared conventionally and ozone is bubbled into the socket for about 40sec, followed by placement of implant into the socket. This prevents infection and

enhances bone regeneration. Matsamura K et al treated implants with ozone and found that there was regeneration of periodontal cells similar to that around natural teeth.^[38]

Use of ozone therapy in child patients

Most of the child patients have fear and anxiety towards dental treatment. Dahnhart JE et al evaluated the anxiety level of children (and their parents) treated with ozone and found that all children & parents reported significant anxiety prior to ozone treatment. However, following the treatment, the children reported they would be pleased to return for future treatments.^[39]

DENTAL OZONE GENERATORS

Heal Ozone

The ozone unit for dental use was initially developed by CurOzone Inc. (Canada) and subsequently manufactured under license and distributed by KaVo-Dental GmbH & Co. (Germany) under the name 'HealOzone'. Its use has been pioneered by Professor Edward Lynch and his team at Queen's University in Belfast, Northern Ireland.

The HealOzone procedure

The HealOzone procedure consists of a package which includes:

1. The application of ozone gas.
2. The use of remineralizing agents.
3. A patient kit.
4. Information on oral hygiene.

The HealOzone device comprises

1. An air filter.
2. A vacuum pump.
3. An ozone generator.
4. A hand piece fitted with a sealing silicone cup and a flexible hose.

Ozone is delivered through a hand piece, which is equipped with a silicon cup. The cup is applied directly to the tooth so that it forms a tight seal at the application site. The procedure usually takes between 20 and 120 seconds per tooth. Immediately after ozone application the tooth surface is treated with a remineralizing solution (reductant) containing fluoride, calcium, zinc, phosphate and xylitol dispensed from a 2-ml ampule. Patients are also supplied

with a patient kit, which consists of toothpaste, oral rinse and oral spray, all containing fluoride, calcium, zinc, phosphate and xylitol, and aims to enhance the remineralisation process. HealOzone application for the treatment of non-cavitated lesions is usually repeated at 3 and 6 months.

Advantages

1. HealOzone treatment of dental caries removes the requirement for physical removal of diseased tissue and promotes remineralisation.
2. Extremely time efficient.
3. Provide pain free treatment for patients.
4. Pedodontist can thus provide the most modern and most natural treatment available to their patients without fear that they may cause any physical or mental trauma.

EQUIPMENT USED

OZONE DELIVERY SYSTEM

In this study, a novel ozone delivery system (HealOzone, CurOzone U.S.A) was employed. The ozone delivery system is a portable apparatus with an ozone generator for the treatment of caries and delivers ozone at a concentration of 2,100 ppm [10%. The vacuum pump pulls air through the generator at 615 cc/min to supply ozone to the lesion and purges the system of ozone after ozone treatment. A disposable removable silicone cup (diameters ranging between 5 and 8 mm), attached to the handpiece, is provided for receiving the gas, and exposing a selected area of the tooth to the gas. The tightly fitting cup seals the selected area of the tooth to prevent escape of ozone. The ozone is drawn out of the sealing cup through an ozone neutraliser that converts the ozone to oxygen. A suction system then removes any possible remaining ozone whilst the cup is still applied to the PRCLs (the suction system passed the gas from the delivery system through manganese (II) ions). The system then draws a liquid reductant through the sealing cup to further neutralise any residual ozone.

THE ELECTRICAL CARIES MONITOR

The ECM III (Lode Diagnostics BV, Groningen, The Netherlands) was used to measure the electrical resistance of each carious lesion. The ECM measures the electrical resistance of a site on the tooth during controlled drying. By drying the surface, the resistance is determined by the tooth structure, and short-circuiting to the soft tissues caused by the surface liquid (saliva) is avoided. The electrical resistance was measured at 23.3 Hz and 0.3 mA whilst drying the tooth for 5 s at an air flow rate of 5 L min⁻¹.

THE DIAGNODENT

The DIAGNOdent (Kavo, Germany) was used to detect and quantify the severity of PRCLS. This device measures laser fluorescence within tooth structure. As the laser light is propagated into the carious lesion, the two-way handpiece optics allows the unit to quantify the reflected laser light. A tooth surface that is sound exhibits little or no fluorescence, resulting in very low scale readings on the display. However, carious lesions show some levels of fluorescence, proportional to the severity of the lesions, resulting in elevated scale readings on the display. The DIAGNOdent system records the instant and peak values. The instant reading indicates the real time value that the probe tip is measuring, whilst the peak value refers to the highest level scanned on the tooth. The DIAGNOdent device was turned on by pressing the grey ring on the handpiece. Calibration was performed before each session according to the manufacturer's instructions. The peak value was subjected to statistical analysis.^[40]

CONTRAINDICATIONS^[3]

- Pregnancy.
- Glucose-6-phosphate dehydrogenase deficiency (favism).
- Recent myocardial infarction.
- Hyperthyroidism.
- Severe anemia.
- Severe myasthenia.
- Active hemorrhage.
- Acute alcohol intoxication.

OZONE TOXICITY

Even though ozone has certain benefits like non-invasiveness, simplicity, less time consumption and elimination of dental phobia, the inhalation of ozone can be toxic to pulmonary system and other organs. Known side-effects are epiphora and upper respiratory irritation, rhinitis, cough, headache, occasional nausea, and vomiting. However, complications caused by ozone therapy are infrequent at 0.0007 per application. 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.^[9]

CONCLUSION

Dentistry is changing as we are now using modern science to practice dentistry. Ozone therapy provides a treatment modality with considerable benefits for dental patients of all ages. In the era of advancement in the methodologies of treatment Ozone therapy has evolved with success. This is one of the most minimally invasive treatment methods. The treatment time is reduced and according to some studies bacterial count is reduced precisely. It is absolutely painless procedure which increases patient acceptability and compliance with minimal adverse effects. Scientific support demonstrated by various studies shows Ozone therapy as a potential therapy in field of medicine and dentistry. In comparison with classical medicine modalities such as antibiotics and disinfectants, ozone therapy is quite inexpensive, and according to many case reports and scientific studies it is very promising. Contraindications of this controversial method should not be forgotten.

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