Review Article

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Ozone in Dental Therapy: A Review of Literature

Ashmika P. Wade[1*] Poonam D. Rai[2] Devanand Shetty[3]

[1]PG Student, Department of Periodontics, D. Y. Patil University, School of Dentistry, Nerul, Navi Mumbai, India.
[2]Professor and Guide, Department of Periodontics, D. Y. Patil University, School of Dentistry, Nerul, Navi Mumbai, India.
[3]Professor and Head, Department of Periodontics, D. Y. Patil University, School of Dentistry, Nerul, Navi Mumbai, India.

ABSTRACT

Background: Three oxygen atoms constitute to form a tri-atomic molecule of ozone.. It has an internal steric hindrance that prevents it from forming a triangular structure**.** Ozone is derived from the Greek word "Ozein" which means odorant. As it is naturally in the atmosphere and it surrounds the earth at an altitude between 50,000 and 100,000 feet it has defensive role in earth's ecological harmony . It protects the living organisms from ultraviolet rays. Dentist Dr. Fish ,a Swiss dentist used ozone either as gas or ozonated water in his practice to aid in disinfection and wound healing in dental surgeries. The main Antimicrobial properties of the ozone is the main reason for its use in dentistry. Ozone is almost used in all aspects of dentistry. There are enough evidence of ozone biocompatibility, and effectiveness in removing the microorganisms from dental unit water lines, the oral cavity, and dentures. Ozone therapy is more in contrast to the present conventional therapeutic modalities as it is a minimally invasive and conservative approach, quite inexpensive, painless therapy which increases the acceptability and compliance of patient with minimal adverse effects. Ozone therapy has a wide range of applications in almost every field of dentistry. Its unique properties includes biosynthetic actions,antimicrobial, detoxicating, immunostimulant, analgesic, antihypnotic and bioenergetic.

Keywords: Dental therapy, ozone, periodontal disease.

INTRODUCTION

Ozone is derived from the Greek word "Ozein" Ozein means odorant . Ozone (O_3) consists of three oxygen atoms so it is a triatomic molecule, it is a higher energetic form of atmospheric oxygen. The stratosphere layer of atmosphere contains abundance of ozone [5] . In the stratosphere when an oxygen molecule is stroked by high energy ultraviolet radiation , it splits in to two free oxygen molecules , leading to production of ozone [1] . As it is naturally in the atmosphere and it surrounds the earth at an altitude between 50,000 and 100,000 feet it has defensive role in earth's ecological harmony [4]. It protects the living organisms from ultraviolet rays. Ozone falls downward to the earth from such high altitudes as it is heavier than any pollutant, when ozone that it comes in contact with any pollutant it combines and gets cleansed. It is earth's natural way of self cleansing [6]. O_3 is a blue gas that is present in large quantity in stratosphere with a concentration of 16–20 mg/m. It quickly gives up nascent oxygen molecule to form oxygen gas, and so is considered as an unstable gas. Because of this instability, it has the highest oxidation potential, approximately 150% greater than that of chlorine when used as an antimicrobial agent. [1] Ozone is shown to be effective against Gram- negative and Gram-positive bacteria, fungi, and viruses [7]. It decrease bacterial, fungi, virus and protozoa loading. antimicrobial, analgesic and bio-stimulants are its effects. The concentration of ozone varies between 1 and 100 µg/ml (0.05%–5%) [1].

HISTORICAL BACKGROUND

Since more than a century medical grade ozone has been used as one of the non-medication methods of treatment. It was first used in 1840 by German

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***Correspondence Dr. Poonam D Rai.**
Department of Periodontology and Oral Implantology, Dr. D. Y. Patil School of Dentistry & Hospital, Nerul, Mumbai, India.
Email: drpoonamm.singh@gmail.com

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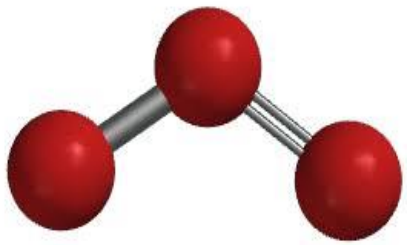
Chemist Christian Friedrich Schonbein , of university of basel in Switzerland . He is the father of ozone therapy. The first ozone generator was developed by werner Von Siemens in 1857 in Germany and also was first applied in medical field by Dr. C. Lender in 1870 for purifying blood in test tubes. The scientific community did not study ozone seriously until 1936 when the first dentist Dr. Fish [8] ,a Swiss dentist used ozone either as gas or ozonated water in his practice to aid in disinfection and wound healing in dental surgeries. The main Antimicrobial properties of the ozone is the main reason for its use in dentistry. A german physicist Joachim Hansler and a german physician Hans Wolff in 1957 developed the very first ozone generator for medical use**.** However, it was only at the end of 1980s, medical ozone became subject of dental research and practice. Following to this, it was used progressively for medical and dental purposes.[1] Ozone therapy can be defined as a versatile bio-oxidative therapy in which oxygen/ozone is administered via gas or dissolved in water or oil base to obtain therapeutic benefits. [9]

STRUCTURE

Three oxygen atoms constitute to form a tri-atomic molecule of ozone.. It has an internal steric hindrance that prevents it from forming a triangular structure**.** [10] Beacuse of this, each oxygen atom forms a single bond with the another oxygen atom instead of forming the expected double bonds resulting in a negative charge throughout the ozone molecule. [5]



Goals of ozone therapy [7]:

(i) inactivation and elimination of pathogens,
(ii) immune system stimulation and improves circulation,
(iii) reduction of inflammation and pain,
(iv) stimulates humoral anti-oxidant system,
(v) proper oxygen metabolism restoration,
(vi) stroke damage and shock prevention,
(vii) Inducing a friendly ecological environment,
(viii) brain function and memory improvement.

EFFECT ON BACTERIA, VIRUS, FUNGUS, PROTOZOA

BACTERIA

Ozone basically acts on bacterial cell membranes, by oxidation of their lipid and lipoprotein components. Also there is evidence for interaction with proteins as well.[11, 12] It seems to render the spores defective in germination, perhaps because of damage to the spore's inner membrane.[13]

VIRUS

All the viruses are susceptible to ozone but their susceptibility differs widely[14]. Lipid-enveloped viruses are more sensitive to ozone.[15,16] In Analysis of viral components damage to polypeptide chains and envelope proteins impairing viral attachment capability, and breakage of viral RNA was seen[14].

FUNGAL AND PROTOZOA

cell growth is inhibited at certain stages.[17]

Effect on blood cells

Ozone reduces or eliminates clumping of RBCs and restores its flexibility[18]. There is a provokation of glutathione peroxidase, catalase, and superoxide dismutase production which acts as free radical scavengers.[19]

Effect on leukocytes

Ozone behaves as a weak cytokine such as tumor necrosis factor-α (TNF-α), interleukin-2, interleukin-6, interleukin-8, transforming growth factor-β [TGF-β]) inducer[20-23].

Platelets

H_2O_2 generated by blood ozonation activate phospholipase C, phospholipase A2, cyclo-

oxygenases , thromboxane synthetase and lipooxygenases, allowing a step increase of intracellular Ca_2, release of prostaglandin E2, prostaglandin F2a, and thromboxane A2 along with irreversible platelet aggregation.[25-27]

OZONE PRODUCTION

Under the influence of factors such as ultraviolet radiation and electrical discharges oxygen molecules from the air combines . Production of ozone in nature is due to intense physical stress on water.[28]Ozone Generators a highly specific gazettes are used for production of ozone for medical use. Medical grade oxygen is made to flow through high voltage tubes with outputs ranging from 4000 V to 14000 V.Ultra-violet light lamp, Corona discharge / Cold plasma are the three principles on which the ozone generators work.[29-31]

MECHANISM OF ACTION:

a. Antimicrobial action:[32]

- Ozone leads to destruction of bacteria, fungi, and viruses
- The mechanism of action includes firstly the damage to the cytoplasmic membrane of cells as a consequence to ozonolysis of dual bonds and secondly modification of intracellular contents because of oxidation of protein loss of organelle function that is led due to secondary oxidant effect
- The human body cells are not damaged and the action remains non-specific and selective to microbial cells due to the antioxidant ability.
- As a result of few-seconds-application of ozone stops all vital functions
- Gram-positive bacteria are more sensitive to the action of ozone than Gram-negative bacteria.

b. Immunostimulating effect:[32,33]

- The immunoglobulin synthesis and immunocompetent cell proliferation is stimulated as an influence of ozone to humoral and cellular immune system .
- The function of macrophages is activated due to which sensitivity of microorganisms to phagocytosis is increased.
- This further leads to production of cytokines as a consequence other immune cells are activated .
- Biologically active substances such as interleukins, prostaglandins, and leukotrienes, which helpin reduction of inflammation and wound healing are synthesized by ozone.
- High or low concentration of ozone causes immunodepressive or immunostimulating effect, respectively.

c. Anti-hypoxic effect:[33]

- Ozone results in change of cellular metabolism by raising partial pressure of oxygen in tissues and improving the transportation of oxygen in blood Certain enzymes such as dehydrogenase, superoxide dismutases, glutathione peroxidases and catalases are activated by repetitive low doses of ozone.
- Ozone increases oxygenation and reduces local inflammatory processes, thus improving the metabolism of inflamed tissues.

d**. Biosynthetic effect**

- protein synthesis mechanism is activate with increased amount of ribosomes and mitochondria in cells that causes regeneration potential and elevation of functional activity of tissues and organs.[33]

e. ozone secretes Vasodilators like nitric oxide that are responsible for dilatation of venules and arterioles.[33]

f. Ozone intensifies remineralization potential when acting on the organic substance of mineralized tooth tissues.

g. Also enables the diffusion of calcium and phosphorus ions to the deeper layers of carious cavities by opening of the dentinal tubules.[34]

ROUTES OF OZONE ADMINISTRATION:

Ozone gas application[2]

Ozone generator is an equipment that converts oxygen to ozone. The ozone is then led to a hand piece that is fitted with a silicone cup. There are different shapes of silicone cups available that corresponds to various teeth and their surfaces. This helps in close contact between silicone cup and the carious area of the tooth and prevents ozone escape. The ozone is led for a minimum of 10 s. The ozone in the silicone cup is reconverted to oxygen by the apparatus.

Ozone aqueous solution

It has been shown to be efficacious against Gram-positive and Gram-negative oral

microorganisms as well as bacteria in plaque biofilm. In comparison to other chemical cleaners, it appears to be less expensive[35].Gaseous ozone may be used as a dental disinfectant if applied for 3 min and is considered more effective microbicide than the aqueous form.[36] If ozone gas is inhaled into the respiratory tract[37] it has toxic effects, hence to control oral infections and various pathogensozonated water may be useful.[38] Commercially available as ultra-pure, tripple ozone treatment system.

Ozonized oil [2]

Ozonated oils, through which pure oxygen and ozone are passed are of pure plant extracts. plant extracts forms a thick, viscous oil, or, a petroleum jelly-like product by undergoing a chemical reaction. The final products contain ozonides. This is a harmless method of external application.

DENTAL APPLICATIONS:[2]

Ozone therapy presents great advantages when used as a support for conventional treatments and is indicated for use in a wide range of dental specialties.

Ozone and oral pathogens

Microorganisms plays a major role in oral lesions and are caused by various etiological factors; Eliminating these microbial pathogens is an effective dental treatment. Various bacteria have been studied in relation to ozone treatment. It has been reported that an exposure of about 60 s exhibited 99.9% killing efficiency against cario-genic bacteria (Actinomyces naeslundii, Streptococcus mutans and Lactobacillus casei). However, exposure for such a long period showed degradation of salivary proteins and hence 10 s–30 s of exposure was proven to be effective in killing a significant number of bacteria[3]. Considering the medium for the survival rates of S. mutans and L. casei the salivary medium depicted greater survival than the saline medium[39]. Estrela et al.[40] demonstrated the effectiveness of ozone addition to an ultrasonic cleaning system against Staphylococcus aureus in infections of the oral cavity. Numerous studies have observed the effect of ozone on a wide variety of microorganisms involved in the formation of biofilm : A. naeslundii, Veillonella dispar, Fusobacterium nucleatum, Streptococcus sobrinus, Streptococcus oralis and Candida albicans[41], S. mutans[42] and Lactobacillus aci-dophilus[43], Streptococcus sanguis, Streptococcus salivarius, Porphyromonas gingivalis, Porphyromonas endodontalis and Aggregatibacter actinomycetemcomitans.[42]Some investigators reported a reduced number of bacteria and fungi after in vivo treatment using ozonized water. In contrast, others reported no significant success of ozone treatment in reducing the microbiota.In fact, it was found that exposure to 2 mg/ liter ozone for 120 s was ineffective in completely eliminating C. albicans. Kshitish et al. [44]evaluated the effectiveness of ozone and chlorhexidine against certain bacteria, viruses and fungi. They recorded a 25% reduction in A. actinomycetemcomitans and no antimicrobial effects in relation to P. gingivalis or Tannerella forsythensis after application of ozone or chlorhexidine. The antifungal effect of ozone has been found to exceed that of chlorhexidine. However, no antiviral effects against Herpes simplex virus (HSV-1 and 2), Human Cytomegalo-virus (HCMV) and Epstein Bar virus (EBV) has been reported. Bezirtzoglou et al.[45] isolated various species of Streptococcus species, Aerococcus viridians, C. albicans, S. aureus and Staphylococcus epidermidis from toothbrushes of children and found that maximum decontamination efficacy of ozone treatment against toothbrush bristles microbiota was observed after 30 min while exposure for short time periods seems to be ineffective.

Ozone and oral tissues

Ozone application has many beneficial effects on the oral tissues. Huth et al.[37]evaluated the biocompatibility of gaseous and aqueous forms of ozone in relation to the established antimicrobials. They reported that ozone is a potential antiseptic agent and the aqueous form showed less cytotoxicity than gaseous ozone or established antimicrobials (chlorhexidine digluconate 2%, 0.2%; sodium hypochlorite- 5.25%, 2.25%; hydrogen peroxide 3%) under most conditions. hence, aqueous form of ozone fulfills cell biological characteristics for biocompatibility and in terms of biocompatibility

Filippi [46]observed the effect of ozonated water on epithelial wound healing process in oral cavity. It was found that when applied daily it fastens the healing rate in oral mucosa. In addition to these, various oral mucosal lesions such as Herpes, Aphthous ulcers, Candidiasis, Denture stomatitis also show marked resolution owing to the healing capacity of ozone. [3]

Ozone in treatment of dental caries :

Dental caries is caused by an ecological niche of caries producing organisms. Much has been reported in the literature regarding the effectiveness of ozone in the elimination of cari-ous lesions. This is attributed not only to the marked anti microbial properties of ozone but also to the fact that ozone oxidizes the pyruvic acid produced by the cariogenic bacteria to acetate and carbon dioxide.

Management of pit and fissure caries

Some short term invitro studies showed significant reduction in the no. of microorganisms of ozone on pits and fissures caries[48] and primary root caries[49-52]. Non-cavitated lesions showed a greater reduction in number of microorganisms than larger lesions , and lesions close to gingival margin after application of ozone. This suggests that reversal of carious lesions depend on size and localization[49]. Ozone removes the smear layer leaving behind the exposed dentin that is occluded by the remineralizing agent applied. Ozone application improves non-cavitated initial fissure caries in patients at high caries risk over a 3- month period as quoted by huth et al. [48]It has been shown that the infusion of ozone into noncarious dentine prevented biofilm formation in vitro from S. mutans and L. acidophilus over a 4-week period [43].

Prophylactic ozone treatment for restorative treatment :[3]

Corroborated evidence from in vitro studies indicates that the ozone can be used as a prophylactic antimicrobial agent prior to etching and placement of restorations.

Restorative dentistry

Evidence gathered from studies testing the efficacy of ozone on dental materials justifies the use of ozone prior to the placement of etchant and sealant. There was no alteration observed on the physical properties of enamel, dentin including knoop surface microhardness or contact angle and adhesive restorative materials.[53]When applied for prolonged duration; ozone gas has a strong bactericidal effect on microorganisms within the dentinal tubules of deep cavities, consequently improving the clinical success of restorations.[52]Crown discoloration of non-vital teeth is treated after placing bleaching paste in the pulp chamber followed by ozone exposure for 3–4 min by the virtue of its oxidation property.[47]

Endodontics

Ozone has immense potential to be used as an antimicrobial in endodontics [54] . Ozone is effective when it is prescribed in adequate concentration, time and delivered correctly into root canals after the traditional cleaning, shaping and irrigation has been completed. Ozone will not be effective if too little dose of ozone is delivered or it is not delivered appropriately. The potential use of ozone gas, ozonated water and ozonized oil in endodontic therapy has been repeatedly reported in the literature[55,56]. Intra canal gas circulation of ozone at a flow rate of 0.5–1 l/min with net volume of 5 gm/ml for 2–3 min showed encouraging results against pathogenic microbes in the root canal. Ozonated water can be used as an intracanal irrigant and in infected necrotic canals, ozonized oils can be used as an intra-canal dressing reducing the marked anaerobic odor emanating from infected teeth. Ozone encourages tissue regeneration and bone healing is encouraged when ozone is used as an irrigant**.** Also when a root canal was disin-fected by ozone water with sonification, the antimicrobial efficacy was comparable to 2.5% NaOCl [57]. in vitro studies[35,58] showed that ozone was effective over most of the bacteria found in cases of pulp necrosis.Hence in periapical infections, ozone therapy can increase the scope of non-surgical management of these lesions[3].

Hypersensitive teeth:

Dentin hypersensitivity (DH) is an exaggerated response to sensory stimuli that usually causes no response in a normal, healthy tooth [95].Ozone application has been found to effectively reduce sensitivity of not only exposed enamel and dentin

but also in cases of root sensitivity. 40–60 s application of ozone is found to instantly reduce pain in these sensitive teeth. Ozone initiates removal of the smear layer, opens the dentinal tubules and widens them. On applying remineralizing agent; calcium & fluoride ions enters the dentinal tubules easily, readily and completely, preventing the fluid exchange from these tubules. Hence, termination of sensitivity occurs following ozone application within seconds and also lasts longer than those by conventional methods.[60]

Ozone in periodontics:

Mechanical therapy is usually the first mode of treatment recommended for most periodontal infections. After adequate time to evaluate healing response, the patient must be reevaluated to determine if further mechanical, adjunctive pharmacological, and/or surgical treatment is indicated.[96] Ozonated water had strong bactericidal activity against bacteria in plaque biofilm**[2].**

The effect of ozone water irrigation on the proliferation of cells in the periodontal ligament adhering to the root surfaces of avulsed teeth was shown by Ebensberger et al [61]. They concluded that avulsed teeth when irrigated with ozonized water for 2 min showed effective mechanical cleansing and root surface decontamination with no adverse effects on the periodontal cells on the tooth surface. One study concluded that the addition of ozone to a ultrasonic cleaning system containing different experimental solutions resulted in antibacterial activity against staphylococcus aureus. Ozonated water has an excellent anti-inflammatory capacity[37,62,63].

In a study by Nagayoshi et al.[42] dental plaque samples were treated with 4 mL of ozonated water for 10 s. It was seen that both gram negative and gram positive and oral c. albicans were killed by ozonated water**.** This reflects its potential to control infectious micro-organisms in dental plaque.

Efficacy of three different concentrations of ozone water (0.5, 2, and 4 mg/ml in distilled H_2O) on the time-dependent inactivation of cariogenic, periodontopathogenic and endodontopathogenic microbes in culture and in bio-films was tested by Nagayoshi et al [35]. They confirmed that ozonated water was highly effective in killing both gram positive and gram negative micro-organisms. Gram negative being more sensitive as compared to gram positive bacteria.

Ramzy et al.[64] used 150 ml of ozonized water to irrigate the periodontal pockets for a duration of 5–10 min once weekly for four weeks in patients suffering from aggressive periodontitis. He achieved highly significant improvement regarding pocket depth, plaque index, gingival index and bacterial count.

Ozone has also been successfully used as a pretreatment rinse to irrigate periodontal pockets prior to performing scaling and root planing. Also ozonated oils have showed improvement in patients with acute necrotizing ulcerative gingivitis [3]. use of ozone effectively sterilizes the surfaces of both the bone and implant, and also initiates the reparative mechanisms that allows tissue regeneration around implant surface is supported by published research**.**[65,66]

Oral medicine

Holmes et al treated patients with oral lichen planus by tissue insufflation, injection, cupping and ozonated oil applications. The therapy outcomes were encouraging in these patients with no markable adverse effects unlike more traditional pharmacological approaches[67]. Several soft tissue lesions i.e. aphthous ulcers, herpes labialis[47] have been reported to be effectively treated using ozone therapy. This applicability is attributed to the accelerated healing properties of the ozone[68].

In patients suffering from carinomatous lesions, chemotherapy and radiotherapy are routinely administered and it invariably causes mucositis. Ozone therapy applied in both aqueous and gaseous forms in cases of mucositis has shown positive results, enabling the patient to eat normally, and improves the quality of life during oncological therapeutic interventions[69]. ozone has been proven to be one of the most powerful oxidants we can use in dentistry.

Prosthodontics:

Dentures are commonly inhabited by several micro-organisms especially C. albicans. Denture stomatitis is routinely encountered in clinical practice which is

a manifestation of plaque accumulation on the surface of the denture and hence effective denture plaque control should be initiated to prevent such outcomes[3]. One successful method to do so is the use of ozone as denture cleaner. It is effective against various microbes adhering on the denture surface including C. albicans[70] methicillin-resistant S. Aureus and viruses[71]. It has also been reported that ozone can be applied for cleaning the surface of removable partial denture alloys without compromising the physical properties of the alloy such as reflectance, surface roughness, and weight[72].

Patients suffering from periimplantitis were investigated by Karapetian et al.[73] They compared the effectiveness of conventional, surgical and ozone therapy methods to cure periimplantitis. They reported that the main challenge seems to be the decontamination of the implant surface, its surrounding tissue and the prevention of recolonization with periodontal pathogenic bacteria. And the most effective bacterial reduction was recorded in the ozone-treated patient group[3].

Oral surgery

Ozone is known to encourage wound healing a well as control opportunistic infection [74].

Ozone therapy has a vast range of applications in oral surgery; be it a simple extraction procedure or a severe jaw infection or osteotomy procedures. Ozone enhances wound healing, improves several properties of erythrocytes and facilitates oxy-gen release in the tissues. This causes vasodilatation and hence improves the blood supply to the ischemic zones. Therefore, it can be successfully used in cases of wound healing impairments following surgical interventions like tooth extractions or implant dentistry.[75] Kazancioglu et al. evaluated the effect of ozone therapy on pain, swelling and trismus following third molar surgery and concluded that ozone application effectively reduced postoperative pain; however it had no effect on swelling and trismus.[76] In a study which compared the use of ozonated oil in an experimental group to a control group in which antibiotic therapy was used in the treatment of alveolitis, it was found that patients treated with ozonated oil healed more quickly[77]. Ozone was used in the treatment of avascular osteonecrosis of the jaw. There was complete healing of the lesions with the disappearance of symptoms.[78-81]

Exposure to medical grade ozone promotes more complete and rapid normalization of nonspecific resistance and T-cellular immunity[82]. Hence it shows rapid clinical cure and reduced incidence of complications in patients when used in patients with chronic mandibular osteomyelitis. When surgical removal of bone sequestra is carried out, ozone can be used as an alternative to hyperbaric oxygen therapy owing to its extensive oxidation property and on the fact that ozone contacted bacteria can be more easily recognized and destroyed by granulocytes and the complement system. It also increases the phagocytosis performance of polymorphonuclear cells[83].Also after performing osteotomies against infections ozonated water has shown better clinical outcomes when used for pro-phylactic applications[3].

Hammuda et al have documented successful use of ozone in cases of temporomandibular joint arthrocentesis and concluded that it is an effective conservative procedure in the treatment of internal derangement[84]. Ozone has also been recommended as a therapeutic treatment in cases of bisphosphonate related osteonecrosis of jaw[78].

Pedodontics

The applications of ozone therapy in a pediatric practice is mainly dependent on the fact that its application is a very effective, east, quick and especially a painless procedure. Attaining a positive rapport with a child patient is the key to a successful pediatric treatment which can be very effectively accompanied by using ozone therapy. These aspects not only enhances the operator efficiency but also effectively improves the patient compliance and tolerance to the treatment[3]. The frequently encountered cases in a pediatric practice are those of trauma to the teeth. A high level of bio-compatibility of aqueous ozone on human oral epithelial cells, gingival fibroblast cells, and periodontal cells has been observed[37,61]. Ozonated water is indicated in replantation of avulsed tooth with no harmful effect on periodontal cells. Dahnhardt et al.[85]treated open carious lesions with

ozone in anxious children. There was near total reduction (93%) of dental anxiety.

Orthodontics

Teeth that are bonded with bonding material are reported to have been affected by some form of enamel opacity after orthodontic treatment; diffuse opacity being the most common type identified. Also visible white spot lesions have been seen to develop within 4 weeks of orthodontic treatment. Although enamel-bracket interface is the most susceptible area for white spot lesion formation, microleakage can invade beneath the bracket area. Thus, enamel prophylaxis is of great importance in orthodontics.[3]

On the other hand, due to its strong oxidizing effect, ozone might have negative effects on resin tooth adhesion related to the oxygen inhibition of polymerization. In a recent study, Cehreli SV et al.[86] studied the effects of prophylactic ozone pretreatment of enamel on shear bond strength of orthodontic brackets bonded with total or self-etch adhesive systems. They concluded that enamel pretreatment with ozone did not affect the shear bond strength of adhesive systems used for bracket bonding. Moreover, shear bond strength values of the ozone pretreated specimens were somewhat higher.

Ozone toxicity

When ozone is administered of 0.05 ppm for 8 h it is not toxic. A maximum concentration of ozone in oral cavity amounts to 0.01 ppm, during ozone therapy. Certain side-effects are cough, nausea, vomiting, headache, epiphora, rhinitis, upper respiratory irritation, shortness of breath, and heart related problems.[87]

Contraindications [1]

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

Ozone Intoxication[1]

- Patient must be placed in supine position
- Vitamin E
- Ascorbic acid
- Inhale humid oxygen
- N-Acetylcysteine.[77]

Ozone and dental unit water lines

Dental unit water line (DUWL) contamination has become a concern.[88.89] Water becomes stagnant when the units are not in use. Detachment of microorganisms, splatter, and aerosols from dental procedures may possibly infect health care personnel[89]. Szymanska[90] identified moulds, bacteria, and yeasts in biofilms which are hazardous to the health care worker and other patients during treatment. Opportunistic pathogens were cultured from the mains water.[91] Another study suggested that DUWL biocides may adversely affect adhesion of resin to enamel.[92] Ozone has been used for purification of water due to its efficiency and lack of side effects. Kohno et al [92] published their results that indicated acidic electrolyzed water could be applied as an appropriate measure against bacterial contamination of the DUWL. Montebugnoli et al [93] concluded that dental manufacturers should be invited to design dental units that incorporate automated devices to disinfect DUWLs. Ozone achieved a 57% reduction in biofilm and a 65% reduction in viable bacteria in model dental unit water lines in spite of being used in a very low dose and with a short time of application.

CONCLUSION

Ozone is almost used in all aspects of dentistry. There are enough evidence of ozone biocompatibility, and effectiveness in removing the microorganisms from dental unit water lines, the oral cavity, and dentures. Ozone therapy is more in contrast to the present conventional therapeutic modalities as it is a minimally invasive and conservative approach, quite inexpensive, painless therapy which increases the acceptability and compliance of patient with minimal adverse effects. It is toxic when inhaled, and in intravenous administration. It used in dentistry in 3 forms, gas, oil, and with water.

Ozone therapy has a wide range of applications in almost every field of dentistry. Its unique properties includes biosynthetic actions, Antimicrobial, Detoxicating, Immunostimulant, Analgesic,

Antihypnotic and Bioenergetic. However, further research is still needed.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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