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OZONE- A NEW REVOLUTION IN DENTISTRY

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ABSTRACT

Ozone therapy has successfully being used in the medical field for treatment of various diseases for more than 100 years. The versatility of ozone therapy, its unique properties, noninvasive nature, absence of side effects or adverse reactions were responsible for its wide spread use. This review of literature is an attempt to summarize its therapeutic potential in dentistry and its possible clinical application in future.

KEYWORDS

Ozone, Ozone therapy, Application in dentistry, Contraindications of Ozone.

Number of Figures : 4 **Number of References :45**

INTRODUCTION

Ozone is a natural gaseous molecule made up of three oxygen atoms. 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 (Bayson A *et al*.,2004) The word ozone originates from the Greek word ozein, which means odor and was first used by German chemist Christian Friedrich Schonbein, father of ozone therapy (1799-1868) in 1840. The first application of ozone in medical field seems to have been for treating gaseous, post-traumatic gangrene in German soldiers during the 1st world war (Bocci V 2004) However a big step forward was the invention of a reliable ozoniser for medical use by the physicist Joachim Hansler (1908-1981). The idea to use ozone in medicine developed slowly during the last century and it was stimulated by the lack of antibiotics and the disinfectant properties of ozone. Ozone, which is used for medical purposes, is a gas mixture comprised of 95 to 99.95% oxygen and 0.05 to 5% pure ozone. Due to proven therapeutic advantages of ozone, many fields in dentistry could benefit from ozone therapy. The first dentist who used ozone was Edward Fisch in 1950 for treating Austrian surgeon Ernst Payr for a gangrenous pulpite and thereby inspired him to begin a line of investigations dedicated to ozone use in health care.

OZONE GENERATION

The first ozone generator for medical use was developed by German physicians named Joachim Hansler and Hans Wolff. Their design continues to be the basis for modern equipment. Medical grade ozone is a mixture of pure oxygen and pure ozone in the ratio of 0.05% to 5% of O3 and 95% to 99.95% of O2. Due to the instability of the O3 molecule, medical grade ozone must be prepared immediately before use. After preparation with in less than an hour, only half of the mixture is still ozone while the other half is transformed into oxygen. As a result, it is impossible to store ozone over long periods of time. In order to control the decomposition of O3 into oxygen it can be associated with a vehicle with aqueous properties to promote the conversion more quickly or with a vehicle with more viscous properties to retard the conversion. There are three different systems for generating ozone gas: Ultraviolet System produces low concentrations of ozone, used in esthetics, saunas, and for air purification. Cold Plasma System: used in air and water purification. Corona Discharge System: produces high concentrations of ozone. It is the most common system used in the medical/ dental field. It is easy to handle and it has a controlled ozone production rate. Commercially available ozone generator: CurOzone USA Inc. (Ontario, Canada) developed the HealOzone, which is now distributed by KaVo Dental (KaVo, Biberach, Germany), for use in dentistry. Mode of delivery: The route of ozone administration is topical or locoregional in gaseous or aqueous form or as ozonated olive or sunflower oil.

Fig 1: Ozonytron X

Mechanism of action

Ozone has been shown to possess unique properties and has potential applications to the clinical practice of dentistry and medicine. There are several known actions of ozone, such as antimicrobial (bactericidal, viricidal, and fungicidal), immunostimulating, immune modulatory, antiinflammatory, biosynthetic (activation of the metabolism of carbohydrates, proteins, lipids), bioenergetic, antihypoxic, analgesic, haemostatic, etc. Ozone oxidizes bio-molecules, disrupts microbial cell structures and metabolism. Ozone disrupts microbial cell walls in seconds, leading to immediate cell lysis. An ozone application of 10 – 20 second has been reported to eliminate more than 99% of the microorganisms found in the dental caries and associated biofilms – and a 40 second treatment time covers all eventualities (Lynch and Baysan, 2001.). It was reported that ozone at low concentration of 0.1 ppm, is sufficient to inactivate bacterial cells including their spores. (Broadwater WT *et al.*, 1973).

APPLICATION OF OZONE IN DENTISTRY

The use of ozone has been proposed in dentistry because of its antimicrobial, disinfectant, biocompatibility and healing properties. Ozone has been applied for treatment of early carious lesions, sterilization of cavities, root canals, periodontal pockets, enhancing epithelial wound healing such as ulcerations and herpetic lesions, Bleaching of discolored root canal treated teeth, Desensitization of extremely sensitive teeth, treatment of periimplantitis, and as a rinse for the avulsed teeth or as a denture cleaner and decontamination of used tooth brush. Ozone in Prevention of Dental caries **(** Hickel R *et al*.,2004, Celiberti P *et al*.,2006, Baysan A *et al*.,2000, Baysan *et al*.,2007, Abu-Nab'aL *et al.*, 2003) Ozone can be used to kill bacteria present in carious lesion, painlessly and even without anaesthetic. Ozone is applied to the carious lesion in a controlled manner, safely killing bacteria that have caused caries, thus requiring minimal of physical intervention and just a few seconds. In cases of incipient caries, ozone can kill bacteria in the demineralized part and this demineralized tooth structure then, can be remineralized using a special remineralization kit, containing Calcium, Fluorine, Phosphorus and Sodium, all in their ionic forms. Ozone in Endodontic treatment**(** Nogales CG *et al*.,2006, Nagayoshi M *et al*.,2004, .Estrela C *et al*.,2007)**.**

Ozone oils can be used to sterile the root canal systems and to clear the canals of necrotic debris by virtue of ozone's bactericidal and effervescent properties. Ozone oils are ozonated sunflower oil or olive oil or groundnut oil. This ozone oil irrigation is more quick and efficient in canal sterilization than that conventional irrigation by the sodium hypochlorite and sodium peroxide combination.Ozone in Healing wounds **(**Valacchi G *et al*., 2011.) Ozone has been reported to accelerate the healing of soft tissue conditions, i.e. aphthous ulcers, herpes labialis, Acute necrotizing ulcerative gingivitis (ANUG) and other gum infections. It also reduces the post-extraction healing time by forming a pseudo-membrane over the socket, so protecting it from any physical and mechanical insults. Ozone therapy was 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. In alveolitis , there is accelerated healing by irrigation with ozonated water after removal of the necrotic pulp & debris under antibiotic coverage. Ozone in Bleaching **(**Tessier J *et al*.,2010) In root canal treated teeth, crown discoloration is a major aesthetic problem, especially in anterior teeth. Conventional walking bleaching requires much more time and results are not oftenly satisfactory. Also, capping the tooth with ceramic crown is not always a good idea. But, now, ozone has the answer to all these questions. Ozone can be successfully used for lightening the yellowish tinge of tetracycline-stained rat incisors. Ozone in Desensitization of sensitive root necks ,Quick and prompt relief from root sensitivity has been documented after ozone spray for 60 seconds followed by mineral wash onto the exposed dentine in a repetitive manner. This desensitization of dentine lasts for longer period of time. Smear layer present over the expose root surface prevents the penetration of ionic Calcium and Fluorine deep into the dentinal tubules. Ozone removes this smear layer, opens up the dentinal tubules, broadens their diameter and then Calcium and Fluoride ions flow into the tubules easily, deeply and effectively to plug the dentinal tubules, preventing the fluid exchange through these tubules. Thus, ozone can effectively terminate the root sensitivity problem within seconds and also results last longer than those by conventional methods.

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. (Huth KC *et al*., 2006, Ebensberger U *et al*.,2002). 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.(Ebensberger U *et al*.,2002).

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. Ozonated water strongly inhibited the accumulation of dental plaque. Ozonated oil is used as a safe therapeutic alternative in patients with Acute Necrotizing Ulcerative Gingivitis. Healing and bactericidal properties makes it useful as a subgingival irrigant. The antimicrobial property of ozone is not only effective in reducing the number of cariogenic bacteria, but also causes significant reduction in themicro organisms present in the root canal. However it was not successful in completely eliminating these bacterias embedded in the biofilm. (Polydorou O *et al*., 2011, Knight GM *et al*., 2008, Nagayoshi M *et al*.,2004, Bezrukova IV *et al*.,2005, Johanson E *et al*.,2009) Ozonated water is effective in killing grampositive, 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. (Fukuizumi T *et al*.,2004, Kshitish Detal., 2010) Ozone may be considered as an adjunctive to conventional treatment strategy due to its powerful ability to inactivate microorganisms

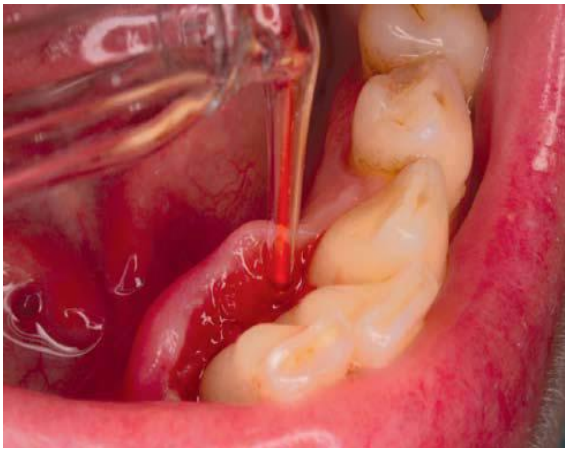

Fig 2:Ozone treatment in periodontitis

Ozone effects on bacterial organisms.

Werner von Siemens developed the first ozone generator in 1857. Viebahn R 2007 Esentially, this consisted of an oxygen chamber subjected to an intense electrical field. Kleimann, shortly thereafter, carried out the first bacteriological studies on pathogenic bacteria Rilling S *et al*.,1987 Pioneering clinical applications first came during the First World War when externally-applied ozone/oxygen mixtures were administered to battlefield wounds. Ozone fought infections, and via its vasoactive properties, encouraged wound repair. Equipment failures, however, due to ozone oxidative action on rubberized treatment envelopes, impeded progress in this area until the development of ozone-resistant plastics many decades later. Today, there are over 3000 ozone-based municipal water purification systems worldwide, a constantly growing number. This represents a clear testimony to ozone's potent antimicrobial properties. Exposed to ozone, all bacterial species fare poorly. Bacterial envelopes are composed of invaginating multilayers whose components are ozone-reactive. Surrounding

the bacterial cytoplasm is a phospholipid proteinaceous cytoplasmic membrane, itself englobed by a structurally-stabilizing peptidoglycan shell. In acid-fast bacteria (e.g.,*mycobacterium tuberculosis*), up to one half of the capsule contains complex lipids. Ozone acts on bacterial cell membranes via the oxidation of their lipid and lipoprotein components, whose multiple chemical bonds then assume new angular configurations incompatible with viable bacterial architecture. There is evidence for interaction with proteins as well .(Mudd JB *et al*.,1969) In one study exploring the effect of ozone on E. coli, ozone penetrated through cell membranes, reacting with cytoplasmic contents, cleaving the circular plasmid DNA, thus impairing bacterial procreation (Ishizaki K *et al*.,1987) Higher organisms have developed mechanisms for protecting DNA and RNA, and for repairing them when disrupted, which could provide a partial explanation for why, in clinical treatment using ozone at doses prescribed, ozone is toxic to pathogens and not to the patient. (Cech T *et al*.,1986) Given adequate time of exposure and intensity of concentration, any and all bacterial species – except perhaps the super hardy *Deinococcus radiodurans* and similar organisms - invariably succumb to ozone action, a fact that endows ozone therapy with one of its most solid scientific foundations.

Ozone's antiviral actions

Viruses are parasites at the genetic level, separated into families based on their structures, types of nucleic genome,and modes of replication. Recently, there has been ever increasing interest in ozone's potential for viral inactivation in vivo. Long established is ozone's in vitro neutralization of viruses and it stands to reason that this capacity would be studied in living systems. In vivo ozone applications, however, present special challenges. All viruses are susceptible to ozone; yet differ widely in their susceptibility. In one study, poliovirus resistance was 40 times that of coxsackievirus (Roy D *etal.*, 1982) Analysis of viral components showed damage to polypeptide chains and envelope proteins impairing viral attachment capability, and breakage of viral RNA. Other researchers suggested that, in ozonation, it is the viral protein capsid that sustains damage. (Riesser V *et al*.,1977) Viruses, unlike mammalian cells, have no enzymatic protection against oxidative confrontation. Lipid-enveloped viruses are especially sensitive to ozone challenge, implicating that lipid alteration is a salient mechanism for their viral death. Viruses containing lipid envelopes include the Hepadnaviridae (Hepatitis B), the Flaviviridae (hepatitis C, West Nile virus, yellow fever); the Herpesviridae, a large family grouping the Simplex,Varicella-Zoster, Cytomegalovirus, and Epstein-Barr viruses; the Orthomyxoviridae (influenza); the Paramyxoviridae (mumps, measles); the Coronaviridae (SARS); the Rhabdoviridae (rabies); the Togaviridae (Rubella, encephalitis); the Bunyaviridae (Hantavirus); the Poxviridae (smallpox); the Retroviridae (HIV), and the Filoviridae (Ebola, Marburg), among others. Indeed, once the virion's lipid envelope becomes fragmented, its DNA or RNA core cannot progress in its life cycle. Viruses that do not have an envelope are called "naked viruses."

Made of a DNA or RNA nucleic acid cores, and a nucleic acid protein coat, or capsid, they are generally more resistant to ozone challenge than lipid-coated virions. Some naked viruses include: Adenoviridae (respiratory infections), Picornaviridae (poliovirus, coxsackie,echovirus, rhinovirus, hepatitis A), Caliciviridae (hepatitis E, Norwalk gastroenteritis), and Papillomaviridae (Molluscum contagiosum). Ozone interacts with the viral proteins of naked viruses, forming protein hydroxides and peroxides, leading to viral demise.

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. (Karapetian VE *et al.*, 2007).

Fig 3:Ozone application in Perimplantitis

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.(Arita M *et al.*,2005) The use of ozone as denture cleaner is effective against methicillin-resistant S. aureus and viruses.(Murakami H *et al.*,2002) 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.(Suzuki T *et al.*,1999) 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.(Oizumi M *et al.*,1998) There is also some evidence on the effectiveness of aqueous ozone application in adjunct to aminoalcohol for decontamination of the implant surfaces.(Nagayoshi M, *et al.*,2004).

Ozone therapy in oral and maxillofacial surgery

Ozone has a positive influence on bone metabolism and reparative process of the bone (Sanseverino ER *et al.*,1989) 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 (Agapov VS *et al*.,2001). 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. (Steinhart H *et al*.,1999). 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 (Vescovi P *et al*., 2010).

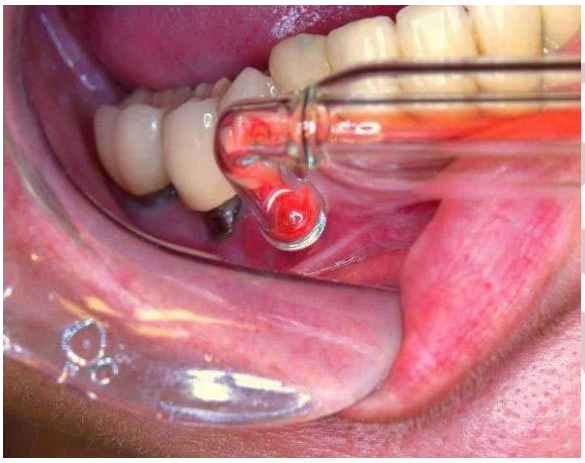

Fig 4: Ozone Application During Implantology

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.(Petrucci MT *et al*.,2010) 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.(Agrillo A *et al*.,2007) 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. (Agrillo A *et al*.,2006).

Ozones in Prosthodontics**;**

Ozone gas can be applied as a prophylactic treatment prior to etching and the placement of sealant with no negative impact on sound enamel physical properties, including knoop surface microhardness, 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 to adhesive restoration. 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. Gaseous ozone is used to disintegrate smear layer and to disinfect the prepared tooth. Denture stomatitis can be controlled by topical application of ozonated oil over tissue surface and over denture surface. Decontamination of tooth brush: Ozone application was found to remove the toothbrushes bristles microbiota following conventional brushing.

CONTRAINDICATIONS OF OZONE

The following are contraindications of ozone therapy

1. Pregnancy
2. Glucose- 6- phoshate dehydrogenase deficiency (favism)

3. Hyper thyroidism
4. Severe anemia
5. Severe myasthenia
6. Active

Prolonged inhalation of ozone can be deleterious to the lungs and other organs but well calibrated doses can be therapeutically used in various conditions without any toxicity or side effects.(Bocci V *et al.*,2009). The European Cooperation of Medical Ozone Societies, warns that direct intravenous injections of ozone/oxygen gas should not be practiced due to the possible risk of air embolism.

CONCLUSION

The ozone therapy has been more beneficial than present conventional therapeutic modalities that follow a minimally invasive and conservative application to dental treatment. The exposition of molecular mechanisms of ozone further benefits practical function in dentistry. Treating patients with ozone therapy lessens the treatment time with an immense deal of variation and it eradicates the bacterial count more specifically. In future, the focus should be on well designed double blind randomized clinical trial and establishment of safe and well defined parameters to determine the precise indications and guidelines for routine use of ozone in the treatment of various dental pathologies.

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