

Research & Reviews: Journal of Dental Sciences

OZONE – A BOON IN THE FIELD OF CONSERVATIVE DENTISTRY AND ENDODONTICS

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Review Article

Received date: 28/07/2015

Accepted date: 28/09/2015

Published date: 05/10/2015

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Keywords: Ozone in Conservative Dentistry, Ozonated Water, Ozone in Endodontics

ABSTRACT

This review on ozone elaborates on the different uses in the field of conservative dentistry and endodontics. It has been successfully used in since many years owing to its oxidizing property, making it an excellent antimicrobial agent. Moreover its potent anti-inflammatory property along with favourable cellular and hormonal immune response makes ozone an effective therapeutic agent. Also its ability to arrest and reverse carious lesions in a predictable way, opened up a new chapter in minimal intervention dentistry. It has been shown to stimulate remineralization of recent caries-affected teeth and is used as a preventive therapy in caries, root caries, and along with intracanal irrigants in endodontic treatment. Its been the choice of treatment in dentistry because it is non invasive and non toxic.

INTRODUCTION

The word ozone originates from the Greek word “ozein”, which means odour and which was first used by the German chemist Christian Friedrich Schonbein, [1799-1868], who is the father of ozone therapy, in the year 1840. Ozone was first used in the medical field for treating post traumatic gangrene in German soldiers in world war I^[1]. In the 1920's, Dr Edwin Parr, a Swiss dentist, started to use ozone as part of his disinfection system. Ozone, a naturally found gas in the upper atmosphere, filters potentially damaging ultraviolet light from reaching the earth's surface^[2]. Ozone is an extremely strong oxidant that oxidises nearly all metals to the highest oxidation stage. Ozone reacts with numerous inorganic and organic compounds. It is an unstable gas which releases nascent oxygen, which is a strong oxidant, rendering multiple beneficial effects like an effective antimicrobial agent, disruption of tumour metabolism, metabolic & immune modulation, sterilization of medical & dental equipment, purification of drinking water^[3]. It is also bacteriocidal. Other uses of ozone is that, it is used to purify drinking water and water in dental equipment and for sterilizing instruments for medical use. Ozone has been used to treat infections for so many years now. Today ozone therapy has been extensively used in dental and medical field. Ozone therapy can be defined as versatile bio oxidative therapy in which oxygen or ozone is administered via gas or dissolved in water or oil base to obtain therapeutic effects^[4].

Ozone is administered on patients for therapeutic purposes in various forms like ozone gas, as an aqueous solution, oil or as ozonated water.

Modes of Ozone Administration [2,4]

1. Ozone Gas: An Ozone generator produces ozone by passing air through high voltage in a polyurethane console. Some of the commercially available ozone units for medical use are: HealOzoneTEC3 (Curozone,USA). Prozone(W&H), O3 ozicure ozone device. The generated ozone is applied to the patient through hand piece which gets adapted to teeth through a silicon cup and is exposed for a minimum period of 10 seconds. The used ozone is passed through a reducing agent to convert back to oxygen

and then led back to the generator.

2. Ozone aqueous Solution: Useful for disinfection and sterilization. It displays hemostatic effect, in cases of hemorrhage. It was found to accelerate wound healing as it improves oxygen supply and supports metabolic processes.

3. Ozone Oil: Useful for external application. Ozone is passed through plant extracts to form a thick gel containing ozonides.

4. Ozonated water: Studies have shown that ozonated water increased metabolic activity of L29 mouse fibroblast cells and improved lipopolysaccharide induced inflammatory response. It also had strong bactericidal activity against plaque biofilm 4 which is very beneficial.

Effect on Bacteria

Ozone acts on bacterial cell membranes, by oxidation of their lipid and lipoprotein components. There is evidence for interaction with proteins as well ^[2,3]. Ozone seems to render the spores defective in germination, perhaps because of damage to the spore's inner membrane.

Effect on Viruses

All viruses are susceptible to ozone; yet differ widely in their susceptibility. Lipid-enveloped viruses are especially sensitive to ozone ^[5]. Analysis of viral components showed damage to polypeptide chains and envelope proteins impairing viral attachment capability, and breakage of viral RNA.

Effect on Protozoa and Fungus

Ozone inhibits cell growth at certain stages ^[1].

Effect on blood

Ozone reduces or eliminates clumping of red blood cells and its flexibility is restored, along with oxygen carrying ability ^[8]. There is a stimulation of the production of glutathione peroxidase, catalase, and superoxide dismutase which act as free radical scavengers ^[6,7].

Effect on white blood cells

Ozone behaves as a weak cytokine such as tumour necrosis factor- α (TNF- α), interleukin-2, interleukin-6, interleukin-8, transforming growth factor- β [TGF- β] inducer ^[10-13]. Ozone reacts with the unsaturated fatty acids of the lipid layer in cellular membranes, forming hydrogen peroxides (H₂O₂), one of the most significant cytokine inducers ^[8].

Effect on platelets

Hydrogen peroxide generated by blood ozonation activate phospholipase C, phospholipase A₂, cyclo-oxygenases and lipoxygenases, and thromboxane synthetase, allowing a step increase of intracellular calcium, release of prostaglandin E₂, prostaglandin F_{2a}, and thromboxane A₂ with irreversible platelet aggregation ^[9,10].

Uses of Ozone in Conservative Dentistry and Endodontics

Ozone in treatment of caries

Ozone in gaseous or aqueous phase has been shown to be powerful and reliable antimicrobial agent against bacteria, fungi and viruses ^[6]. Ozone has a severe disruptive effect on cariogenic bacteria. Resulting in elimination of acidogenic bacteria. The strongest naturally occurring acid produced by acidogenic bacteria during cariogenesis is pyruvic acid. Ozone can demineralise this acid to acetic acid. It has been shown that remineralisation of carious lesions can be enhanced due to the production of acetic acid ^[11]. Treatment with ozone gas significantly reduced caries progression, remineralize and arrested carious lesions in patients with high risk. It was also seen that ozone dentistry being least invasive, should induce least state of anxiety in patients compared to traditional dentistry. Non cavitated lesions were more likely to reverse than cavitated lesions ^[12,13].

Ozone therapy is used as an atraumatic treatment modality in dental practice. Some of the in vitro studies with short-term follow-up assessed the effect of ozone on pit and fissure caries ^[14,16] and primary root caries with results showing significant reductions in the number of microorganisms in the carious lesions. In small, non-cavitated, lesions showed a greater reduction in number of microorganisms after the application of ozone than did larger lesions, and lesions closer to the gingival margin also showed less reduction in the number of microorganisms ^[15,16]. This suggests that the reversal of carious lesions depend on the size and localization ^[17]. Noncavitated lesions were more likely to reverse than cavitated lesions. However in established carious lesions, ozone therapy has to be done along with restorative therapy and patient has to be educated about the maintenance phase of caries treatment involving oral hygiene maintenance and balanced diet. Also immediately after ozone treatment, it is advisable to apply a remineralizing agent. Proximal carious lesions are readily diagnosed with bite-wing X-rays unlike occlusal ones. Depending on the depth and speed onset of the lesions, a decision is made on whether to open and access the lesion or to use a non-invasive treatment. As a general rule, in non-cavitated low speed onset lesions confined in enamel or at the dentino-enamel junction, a non-invasive protocol should be used first. If the lesion extends in dentin, the final judgment should be based

on the caries risks assessment of the patient. In cavitated lesions, restoration is a must. By increasing exposure time of ozone from 10 sec to 20 sec, ozone changed its antimicrobial effect from disinfection to sterilization^[18,19]. Application of ozone for 40 seconds significantly reduced *S.mutans* count, whereas 60 sec exposure almost eliminated cariogenic species like *S.mutans*, *L.casei* and *A.naeslundii* in carious lesions in roots^[20]. However if proximal lesion of the caries is not visible on bitewing x-ray, but gives a diagnodont reading up to 25, a minimal intervention protocol needs to be followed with 40 second ozone exposure and air abrasion or sealing the lesion.

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 placement of sealant with no negative impact on sound enamel physical properties including knoops surface hardness or contact angle^[21-23]. The longer exposure to ozone gas has a strong bacteriocidal 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.

Ozone in Treating Dentin Hypersensitivity

Non-cariou hypersensitivity is due to many contributing factors among which are erosion, abfraction, bite pressure, recessed gingiva, etc. 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^[22]. This desensitization of dentine lasts for longer period of time. 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 lasts longer than those by conventional methods.

Ozone Therapy in Endodontics

Ozone has a great potential to be used as an antimicrobial agent in endodontics^[18]. Micro organisms are one of the major causes of failure on root canal treatment. Ozone is the most powerful antimicrobial agent with numerous advantages to reduce the number of micro organisms in the root canal due to its oxidative potential ,especially it is effective against *Mycobacteria*, *Streptococcus*, *Pseudomonas aeruginosa*, *Escherichia coli*, *Staphylococcus aureus*, *Peptostreptococcus*, *Enterococcus faecalis*, and *Candida albicans*. Ozone is effective, when it is prescribed in sufficient concentration, used for adequate time and delivered correctly into root canal after cleaning and shaping and irrigation. Studies have proved the potential use of ozone gas, ozonated water and ozonised oil in endodontics^[21,22].

The introduction of ozone has enabled the clinician to ozonate sodium hypochlorite (NaOCl), the most ubiquitous of the endodontic irrigants^[23,24]. Ozonated sodium hypochlorite releases hypochlorous acid which reacts with insoluble proteins to form soluble polypeptides, amino acids and assorted by-products. It acts as an organic and fat solvent, degrading fatty acids and transforming them into fatty acid salts and glycerol thus reducing the surface tension of the residual solution. The chloramines produced interfere in cell metabolism and cause destruction of cell walls and cytoplasmic membranes of micro-organisms^[25,26]. Ozonation of NaOCl in a negative pressure differential environment as created by Heal Ozone should enable one visit root canal^[26] therapy in cases where the literature suggests the need for multiple visit treatment^[27,28].

Ozone in Bleaching

In root canal treated teeth, crown discolouration is a major aesthetic problem, especially in anterior teeth. Conventional walking bleaching requires much more time and results are not often satisfactory. The bleaching effect with ozone is seen when the bleaching agent is placed in the access cavity and crown is exposed to ozone for a minimum of 3-4 minutes. This ozone treatment bleaches the tooth within minutes and gives the patient a happy and healthier-looking smile.

Ozone Toxicity^[29-30]

Ozone inhalation can be toxic to the pulmonary system and other organs. Complications caused by ozone therapy are infrequent at 0.0007 per application. Known side-effects are epiphora, upper respiratory irritation, rhinitis, cough, headache, occasional nausea, vomiting, shortness of breath, blood vessel swelling, poor circulation, heart problems and at times even stroke. Because of ozone's high oxidative power, all materials which come in contact with the gas must be ozone resistant, such as glass, silicon, and Teflon. In case of ozone intoxication, patient must be placed in the supine position, and treated with vitamin E and n-acetylcysteine^[2].

Contraindications in Ozone Therapy

The following are contraindications for the use of ozone therapy:

Pregnancy, Glucose-6-phosphate-dehydrogenase deficiency, Hyperthyroidism, Severe anaemia, Severe myasthenia, Acute alcohol intoxication, Recent myocardial infarction, Haemorrhage from any organ, Ozone allergy.

CONCLUSION

Scientific researches suggest ozone therapy has great potential in the treatment of various conditions encountered in the field of conservative dentistry and endodontics and its implementation in clinical field practice looks promising. 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 diseases.

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