O-Zone Dentistry: Minimally Invasive Dental Care for the Modern Practice
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Abstract
Ozone gas has a high oxidation potential and is effective against bacteria, viruses, fungi, and protozoa. It is highly valued for various effects, such as antimicrobial, analgesic, immune-stimulating 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 is an attempt to summarize different modalities of ozone application in dentistry. The exposition of molecular mechanisms of ozone further benefits practical function in dentistry. Further studies are necessary to standardize indications and treatment protocols of this promising medical agent.

Keywords: Ozone Therapy; Minimally Invasive Dentistry; Hyperbaric Oxygenation; Ozone/administration/dosage/chemistry/therapeutics; Reactive Oxygen Species/chemistry/metabolism.

Introduction
Heralding a new era in dentistry, ozone therapy has been established as a safe and effective method.1,2 Therapeutic use of ozone in medicine has been well known, and its use in dentistry is becoming more popular in the recent years.3,4 Ozone is a triatomic molecule, consisting of three oxygen atoms. Its molecular weight is 47.98g/mol. Ozone is thermodynamically highly unstable compound, dependent on system conditions like temperature, pressure and it decomposes to pure oxygen with a short half-life.5,6 It is one of the most important gases in the stratosphere, due its ability to filter UV rays which is critical for the maintenance of biological balance in the biosphere. This protective layer can be seen as the blue-colored sky.7,8 Ozone in the upper atmosphere filters potentially damaging ultraviolet light from reaching the Earth’s surface.9 It has many different applications in various fields; one of them is usage of ozone in medicine.

Ozone therapy is one of the modern non-medication methods of treatment and 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.10 Ozone has multiple medical effects:7,10,11

1. The elimination of microorganism’s disinfection from bacteria, viruses and fungi.
2. The oxygenation of tissue which improves healing.
4. An increase in cell energy by stimulating the Krebs cycle production of Adenosine triphosphate.
5. The stimulation of white blood cells and the immune system response production of cytokines: Tumour necrosis factor, Interleukin 2.
6. An increase in blood flow and the elasticity of erythrocytes.

Applications in Dentistry
Ozone has been successfully used in medicine because of its microbiologic properties for more than 100 years.12 Its bactericide, virucide, and fungicide effects are based on its strong oxidation effect with the formation of free radicals as well as its direct destruction of almost all microorganisms.6 Thus Ozone would be a wonderful adjunct to our arsenal of treatments.13

Ozone Therapy and Dental Caries
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 and primary root caries with results showing significant reductions in the number of microorganisms in the carious lesions. Ozone therapy was introduced as a conservative alternative in the treatment of primary caries when HealOzone an ozone-generating device, was used to apply ozone gas to carious lesions for a period of ten to 20 seconds in vivo resulting in the reduction...
of the number of microorganisms present in the lesions by 99%. Factors related to the reversal of carious lesions must include the size and localization. The total number of microorganisms in small, non-cavitated lesions showed a greater reduction 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.

Ozone Therapy in Oral Surgery
Ozone is known to encourage wound healing as well as control opportunist infection. It was shown that daily treatment with ozonized water accelerates the physiological healing rate. In a clinical survey Stübing & al. described the local effectiveness of ozone on infected intraoral wounds following high-dose radiotherapy. Ozone has a therapeutic effect that facilitates wound healing and improves the supply of blood. Guerra & al. compared the use of ozonated oil in an experimental group to a control group in which Alvogil and antibiotic therapy was used in the treatment of alveolitis. Patients treated with Oleozon healed more quickly without the need for systemic medication when compared to the control group. This finding suggests ozonated oil might be effective in the treatment of alveolitis. Irrigation of a surgical site with ozonated water will speed healing and help remineralize the bone. Thus, ozonated water would be helpful for extractions, cavitational surgery and implant surgery.

Ozone Therapy in Prosthodontics
Microbial plaque accumulating on the fitted surfaces of dentures is composed of several oral microorganisms, mainly Candida albicans. Denture plaque control is essential for the prevention of denture stomatitis. In an attempt to solve this problem Arita & al. assessed the effect of ozonated water in combination with ultrasonication on Candida albicans. Following exposure to flowing ozonated water 2 or 4 mg/l for one minute they found no viable C. albicans suggesting the application of ozonated water might be useful in reducing the number of C. albicans on denture bases.

Ozone Therapy in Pedodontics
Dental caries is a bacterially mediated disease characterised by demineralisation of the tooth surface, which may lead to cavitation, discomfort, pain and eventual tooth loss. Ozone is toxic to certain bacteria in vitro and it has been suggested that delivering ozone into a carious lesion might reduce the number of cariogenic bacteria. It has been proved to be efficient, easy and comfortable for the patient. It has proved to be an effective atraumatic treatment modality with potential interest for use in clinical pediatric dentistry. For the patient's perception, its elegant glass probes and virtually silent application when in use will help to calm the fears of those pediatric patients prone to anxiety during the treatment.

Ozone Therapy in Periodontics
Ozonated water inhibited the accumulation of experimental dental plaque in vitro. Ozonated water had strong bactericidal activity against bacteria in plaque biofilm. It was found that ozonated water 0.5-4 mg/L was highly effective in killing of both gram-positive and gram-negative microorganisms. Nagayoshi & al. examined the effect of ozonated water on oral microorganisms and dental plaque. Almost no oral microorganisms were detected after a ten seconds treatment with ozonated water. When the experimental dental plaque was exposed to ozonated water, the number of viable cells once again decreased. The ozonated water strongly inhibited the formation of dental plaque in vitro. These results suggest ozonated water may be useful in reducing infections caused by microorganisms present in dental plaque.

Ozone Therapy in Endodontics
The oxidative power of ozone characterizes it as an efficient antimicrobial agent and its indication for use in endodontic therapy seems quite appropriate. Its antimicrobial action has been demonstrated against bacterial strains such as: Microbacteria, Staphylococcus, Streptococcus, Pseudomonas, Enterococcus and Escherichia coli, Staphylococcus aureus, Velano & al., Enterococcus faecalis, and Candida albicans using in vitro research models. Nagayoshi & al. evaluated the effect of ozonated water on Enterococcus faecalis and Streptococcus mutans in bovine teeth. A significant intratubular decrease of these bacteria was observed in the teeth. In vitro studies showed that ozone was effective over most of the bacteria found in cases of pulp necrosis. Ozone works best when there is less organic debris remaining. Therefore, the recommendation is to use either ozonated water or ozone gas at the end of the cleaning and shaping process.
Discussion
Ozone therapy is proving to be a new therapeutic modality with great benefits for patients. The potent antimicrobial power of ozone, along with its capacity to stimulate the circulatory system and modulate the immune response, makes it a therapeutic agent of choice in the treatment of numerous medical pathologies among them are Hepatitis, Herpes simplex, Herpes zoster, circulatory system dysfunctions, immune diseases and others. The principle line of study has evolved using the HealOzone device to determine its effect on several kinds of caries pit and fissure, non-cavity, and primary root caries. The oxidative impact on this microbiota has been recognized in several studies. Bysan A et al.15 suggested that application of ozone gas for a period of ten to 20 seconds results in 99% of the microorganisms being destroyed. There are various modes of Ozone administration.31 The European Cooperation of Medical Ozone Societies warns from direct intravenous injections of ozone/oxygen gas that should not be practiced due to the possible risk of air embolism.10

A. Ozone gas: Ozone generating equipment converts oxygen to ozone. The ozone is thereafter led to a hand piece fitted with a silicone cup. Differently shaped silicone cups are available that correspond to the form of various teeth and their surfaces. This ensures close contact between the silicone cup and the carious area of the tooth so that the ozone does not escape. The ozone is led through the silicone cup over the tooth for a minimum of 10 s. The ozone in the silicone cup is collected again and reconverted to oxygen by the apparatus.

B. Ozone aqueous solution: The following properties of ozone are used in this case:
- Disinfectant and sterilizing effect;
- Hemostatic effect, especially in cases of hemorrhages;
- Accelerated wound healing, improved oxygen supply and support of metabolic processes

C. Ozone oil: Ozonated oils are pure plant extracts, through which pure oxygen and ozone are passed. The plant extracts undergo a chemical reaction to form a thick, viscous oil, or in some cases, a petroleum jelly-like product. The final products contain ozonides. This method of external application is harmless. Research in Cuba,

Europe, USA, India and South Africa concerning the anti-microbial efficacy of ozone has continued over the last twenty years and has conclusively shown the ability of both gaseous and dissolved ozone to eradicate a wide range of bacteria, bacterial spores and viruses.32

Conclusion
Ozone therapy presents a potential for an atraumatic, biologically-based treatment for conditions encountered in dental practice. The therapy has been more beneficial than present conventional therapeutic modalities that follow a minimally invasive and conservative application to dental treatment. Further research is needed to standardize indications and treatment procedures of ozone therapy.

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