Role of Ozone in Conservative Dentistry and Endodontics – A Review

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Abstract: Use of ozone in dentistry is gaining its place in every day's dental practice and is used in almost all dental applications. 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 made 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. Ozone has a wide application in endodontics which includes treatment of carious lesions, root caries, hypersensitivity, root canal disinfection, bleaching to name a few. We can produce and utilize Ozone for the treatment of various dental diseases without any toxic effects. This article summarizes the noninvasive application of Ozone in the treatment of various dental diseases.

Key words: Ozone in Endodontics, Minimal Interventional Dentistry, Ozonated Water, Diagnodent, Air Abrasion.

INTRODUCTION
Ozone, a triatomic oxygen, is found as natural gas in the upper atmosphere that prevents earth from threatening UV light. It is an unstable gas quickly giving up nascent oxygen which is a strong oxidant rendering multiple beneficial effects like an effective antimicrobial agent, disruption of tumor metabolism, metabolic & immune modulation, sterilization of medical & dental equipment, purification of drinking water to name a few. Ozone, a powerful biocide takes only 10 sec to kill 99% of bacteria, fungi & viruses. Ozone has the advantage over other free radical producing agents in that normal human cells are protected from the oxidative stress effects of ozone if used in correct amounts, and, in addition, ozone appears to promote a stimulation and activation of the enzymes involved in peroxide and free radical scavenging (glutathione peroxidase, catalase and superoxide dismutase), thus enhancing immune responsiveness and a more rapid healing response. Medical grade ozone is a mixture of pure O2 and pure O3 in the ratio of 0.1%-5% of O3 and 95%-99.5% of O2.

HISTORY
Ozone was first observed by a German chemist Christian Friedrich Schönbein in 1840 when he detected an “Odorful Gas” on passing electrical discharge through water (Ozen = Odor). He is considered as father of Ozone therapy. 1857 – Joachim Hensler, a German physicist and Hans wolf German Physician developed first Ozone generator for medical use. 1870 – Lender first used Ozone in Medical field for purifying blood. 1881 – Used as therapeutic agent in treatment of diphtheria. 1883 – Dr. Charles Kenworthy published his Experiences with Ozone in Florida Medical Journal. 1885 – Dusbaden, in Holland used Ozone in its water treatment plant. World war I & II – Ozone was used to treat wounded soldiers in trenches. By early 20th century Ozone use got legalized in USA. 1950 – Dr E.A. Fiseh a German Dentist first used Ozone on regular basis in Dental Practice. 2001 – Dr. Sieg Fried wrote a text book about use of Ozone in Medicine.

MECHANISM OF ACTION OF OZONE
Ozone can react with blood components (erythrocytes, leukocytes, platelets, endothelial cells and the vascular system) and positively affect oxygen metabolism, cell energy, the immunomodular property, antioxidant defense system, and microcirculation. 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, ozone attacks glycoproteins, glycolipids, and other amino acids and inhibits and blocks the enzymatic control system of the cell. This results in increase in membrane permeability, the key element of cell viability, leading to immediate functional cessation. Then ozone molecules can readily enter the cell and cause the microorganism to die. Also, ozone can attack many biomolecules, such as the cysteine, methionine, and, histidine residues of proteins. By oxidizing the biomolecules featured in dental diseases, ozone has a severely disrupted effect on cariogenic bacteria, resulting in their elimination. Pyruvic acid, is the strongest naturally occurring acid produced by acidogenic bacteria during cariogenesis. Ozone can decarboxylate pyruvic acid to acetic acid. This also helps in buffering plaque fluid.

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

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: HealOzone TEC 3 (Curozone, USA). Prozone (W&H) O3 ozicure ozone device

The generated Ozone is applied to 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.

Key words: Ozonated Water, Diagnodent, Air Abrasion.
2. Ozone aqueous Solution:
Useful for disinfection and sterilization.
Displays hemostatic effect in cases of hemorrhage.
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 ozoneides.

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.

APPLICATIONS

1) Primary Pits & Fissures carious lesions
Dental caries is the most common cause of tooth ache and if left untreated can lead to loss of the tooth. The application of Ozone therapy in the treatment of dental caries is extensively studied and many studies have proved its effectiveness in the treatment of pit and fissure caries, root caries and interproximal caries. Ozone can be used along with diagnostod to assess the caries risk in the earliest stages and thus delivered according to the severity of the lesion. 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 remineralising agent. The following table is an aid in how to perform ozone therapy depending on clinical cases. Remember that the availability of minimally invasive diagnostic and operative equipment is of great value in conjunction with the use of ozone.

2) Proximal Caries Lesions
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 EDJ, 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.

Increasing exposure time of ozone from 10 sec to 20 sec, changed its antimicrobial effect from disinfection to sterilization. Application of ozone for 40 seconds significantly reduced S. mutans count, whereas 60sec exposure almost eliminated cariogenic species like S.mutans, L.caseiand A.naelundii in carious lesions in rats. However if proximal lesion of the caries is not visible on x-ray, then ozonation should be followed with 40 second ozone exposure and air abrasion or sealing the lesion. However if there is a carious lesions which can be detected on the x-ray, then ozone exposure has to be increased to 60-120 seconds and has to be followed by a restoration.

3) Hyper-Sensitive Teeth
Non-carious hypersensitivity is due to many contributing factors among which are erosion, abrasion, bite pressure, recessed gum, 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. 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.

4) Vital Root Canal Therapy
After effective biomechanical preparation, irrigation with Ozonated water significantly reduced the bacterial population in the root canal. Also 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.

5) Necrotic Root Canal Therapy
The oxidative power of ozone characterizes it as an effective antimicrobial. Its antimicrobial action has been demonstrated against bacterial stains, such as Micobacteria, streptococcus, Pseudomonas aeruginosa, E.coli, S. aureus, Enterococcus faecalis and candida albicans. In vitro studies showed that ozone was effective over most of the bacteria found in cases of pulp necrosis. In infected necrotic canals, ozonized oils can be used as an intra-canal dressing. Also when a root canal was disinfected by ozone water, the anti-microbial efficacy was comparable to 2.5%Naocl. Hence in periapical infections, ozone therapy can increase the scope of non-surgical management of these lesions.

6) Bleaching
In root canal treated teeth, crown discoulouration is a major aesthetic problem, especially in anterior teeth. Conventional walking bleachin bleaching requires much more time and results are not often satisfactory. The bleaching effect with ozone is 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
Ozone inhalation can be toxic to the pulmonary system and other organs. The known side effects are epiphora, upper respiratory tract irritation, rhinitis, cough, headache, occasional nausea and vomiting. However, complications caused by ozone therapy are infrequent. In the event of ozone intoxication, the patient must be placed in the supine position, inhale humid oxygen, and take ascorbic acid, Vitamin E and n-acetylcysteine. Further, because of its high oxidative power, all materials that come in contact with the gas must be ozone resistant such as glass, silicon and Teflon.

CONTRAINDICATIONS
The following are contraindications for use of Ozone therapy - Pregnancy, severe anaemia, hyperthyroidism, thrombocytopenia, severe myasthenia, acute alcohol intoxication, recent myocardial infarction, hemorrhage from any organ, Glucose-6-phosphatedehydrogenase deficiency and ozone allergy. 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. Direct intravenous injections of ozone/oxygen gas should not be practiced due to the possible risk of air embolism.

CONCLUSION
Since its introduction in 1840, ozone therapy is proving to be a new therapeutic modality with great benefits to the 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 medical pathologies and infectious oral diseases. Ozone offers a painless alternative to conventional treatment for tooth decay and has proven to halt primary root caries, primary pit and fissure caries and clinically reverse the lesion. Its anti microbial action on endodontic flora is quite promising. However further research in large scale is needed in this area to better validate its valuable therapeutic applications. Such research will surely pave way to the better future of dentistry.
### REFERENCES


<table>
<thead>
<tr>
<th>Caries Severity Index</th>
<th>Diagnodent Reading</th>
<th>Clinical Diagnosis</th>
<th>Radiographic Interpretation</th>
<th>Treatment Plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>&lt;10</td>
<td>May be a sound tooth</td>
<td>Normal</td>
<td>10 Sec O₃/Seal Fissures if indicated with GIC or flowable composite</td>
</tr>
<tr>
<td>2</td>
<td>10 - 16</td>
<td>White spot lesions</td>
<td>Normal (lesion not seen on x-rays)</td>
<td>40 sec O₃ and remineralisation therapy Air abrasion and/or seal fissures</td>
</tr>
<tr>
<td>3</td>
<td>20 - 24</td>
<td>Carious lesion at EDJ</td>
<td>May not be visible on x-rays</td>
<td>Air abrasion/etch/40 sec O₃ therapy and restoration with GIC/composite</td>
</tr>
<tr>
<td>4</td>
<td>25 - 29</td>
<td>Caries involving 1-2mm of dentin</td>
<td>May/may not be visible on X-rays</td>
<td>Remove infected dentin, leave affected dentin. Etching – 60 sec O₃ therapy and restore with GIC/composite/Light cure GIC</td>
</tr>
<tr>
<td>5</td>
<td>&gt;30</td>
<td>Caries involving &gt;2mm of dentin</td>
<td>Mostly visible on X-Rays</td>
<td>Remove infected dentin to leave affected dentin, ozone exposure for 60 sec. depending on remaining dentin thickness liner/base and restoration.</td>
</tr>
<tr>
<td>6</td>
<td>&gt;99</td>
<td>Deep carious lesion, may/may not involve pulp</td>
<td>Visible on X-rays and assessing pulp vitality</td>
<td>If vital, indirect pulp capping is advised. Expose O₃ for 120 sec and seal with GIC. After 1 month, reassess and If remineralisation is evident, it can be restored with a permanent restoration.</td>
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**Recommended ozone concentration (O₃):** 3.5-5 g/ml & flow rate: 0.5-1 L/min.

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