

Role of Ozone Therapy in Minimal Intervention Dentistry and Endodontics - A Review

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ABSTRACT

Ozone has been successfully used in medical field since many years owing to its oxidizing property making it an excellent antimicrobial agent. Moreover its potent anti-inflammatory property along with favorable cellular and humoral 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. Furthermore its efficacy in curbing resistant poly microbial root canal flora appears very promising. This article is based on information through valid textbooks, peer reviews, journals and medline/pubmed search.

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Introduction

Ozone is a natural allotrope of oxygen found in upper layer of atmosphere protecting living organisms on earth from U.V. Radiation. 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 few¹. Ozone can arrest white spot lesions and reverse early caries process thus leading to a promising future in minimal intervention dentistry.

History

Ozone was first observed by a German chemist Christian Friedrich Schonbein 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 use².

1870 – Lender first used Ozone in Medical field for purifying blood in test tubes.

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.

2004 – Prof. Edward Lyrich Published “Ozone – The Revolution in Dentistry”.

Biological actions:

Effect on Bacteria, Virus, Fungus, Protozoa:

Ozone damages the bacterial cell membranes by ozonolysis and oxidates intra cellular proteins leading to loss of organelle function³. This action is selective to microbial cells and thus does not affect human body cell as the later have good antioxidative ability. Ozone is very effective in antibiotic resistant strains with accelerated efficiency in acidic PH environment⁴.

Viruses: Ozone makes the infected cell intolerant to peroxides and changes the activity of reverse transcriptase⁵ thus hampering viral protein synthesis.

Fungal & Protozoa: Ozone inhibits cell growth at certain stages.

Cellular and Humoral Immune system:

It reactivates the immune system through macrophage activation and Cytokine release which inturn boost immune system⁶ which makes it useful in patients with low immune status and immunodeficiency.

Anti-inflammatory:- Ozone Stimulates release of interleukins, leukotrienes and prostoglandins⁵ thus reducing inflammation and promoting wound healing.

Effect on Micro-circulation:

Ozone causes secretion of nitrous oxide which is a vasodilator and hence dilates arterioles & venules. It prevents clumping of red blood corpuscles' and increases their contact area for oxygen transportation. It also activates aerobic processes like glycolysis and krebs cycle at cellular level thus stimulating circulation⁷ of blood and hence used in treatment of circulatory disorders.

Pharmacodynamics:

Ozone, a powerful biocide takes only 10sec to kill 99% of bacteria, fungi & viruses. 25 micro grams of Ozone per ml of Oxygen¹ is the amount of ozone used in treatments and this translates into 0.25 parts of Ozone to 99.75 parts of Oxygen. The potency of one molecule of Ozone equalizes to 3000 to 10,000 molecules of chlorine and thus is 3500 times more pathogenic to microbes with no side effects of chlorine.

Modes of Ozone Generation in Dentistry: The most common methods of ozone production used for therapeutic purposes are given below.

1. Ultra-Violet System: Useful for purifying air but generates less concentration of ozone.
2. Cold Plasma System: Useful for purifying water and air.
3. Corona Discharge System: most popular systems in medical field and dentistry. It has controlled production rate and easily generates high ozone concentration.

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.

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 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.

Applications:

Primary Pits & Fissures Caries Lesions:

Ozone shows encouraging results in treating early tooth carious lesions thus promising a painless dentistry in future. Ozone can be used along with diagnodent to assess the caries risk in the earliest stages and thus delivered according to the severity of the lesion⁸.

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.

Proximal Caries Lesions and root caries:

Similar protocol of pit and fissure caries has to be followed and it is important to emphasize on a noninvasive protocol for non cavitated lesions which are confined to enamel. However cavitated lesions need to be restored. Increasing exposure time of ozone from 10sec to 20sec, changed its antimicrobial effect from disinfection to sterilization^{9,10}. Application of ozone for 40 seconds significantly reduced S.mutans count, whereas 60sec exposure almost eliminated cariogenic species like S.mutans, L.casei and A.naeslundii in carious lesions in roots^{11,12}. Proximal caries lesions are generally diagnosed with Bite-Wing X-Rays unlike occlusal one. However if proximal lesion of the caries is not visible on bitewing x-ray, but gives a diagnodent reading up to 25, a minimal intervention protocol needs to 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.

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

Hyper – Sensitive Teeth:

Enamel and Dentine loss occurring due to multiple factors like attrition, abrasion, erosion, trauma from occlusion may cause hyper sensitivity and diagnosis of etiology is vital. After elimination of cause 40 to 60 sec application of

ozone is found to instantly reduce pain in these sensitive teeth⁸.

Ozone removes the smear layer, opens the dentinal tubules and broadens their diameter. Thus when a remineralizing agent is applied, calcium & fluoride ions flow into dentinal tubules

and plug them preventing fluid exchange thus terminating sensitivity.

Effect of ozone on enamel and Dentine:

Ozone did not alter the physical properties of enamel¹³ and also had no effect on its sealing ability. Thus ozone can safely be applied over intact and prepared enamel during restoration¹⁴. Application of gaseous form of ozone does not affect the modulus of elasticity and vickers hardness of dentin. Thus application of ozone does not alter the micromechanical properties of substrate, nor the sealing ability of bonding system¹⁵⁻¹⁷.

Cracked Tooth Syndrome:

After exploration of the crack, assess the prognosis and tooth is exposed to ozone for 60 – 120 sec and seal the tooth with an intermediate restoration like GIC⁸. The tooth needs to be periodically assessed and restored.

Necrotic root canals & Peri-apical Lesions:

Polymicrobial infections complicate cases of apical periodontitis. A study evaluated the effect of intra canal medicament comparing ozone oil, calcium hydroxide with paramonochlorophenol and glycerine (HPG) with periapical lesions¹⁸. The radiological, histopathological and bacteriological studies showed no significance among groups. However Ozone showed effectiveness over most of bacteria found in cases of pulp necrosis but not when bacteria are organized in biofilm¹⁹. Ozone demonstrated anti-microbial action against bacterial strains such as mycobacteria, staphylococcus, Pseudomonas, enterococcus, e-coli, peptostreptococcus, e-fecalis & Candida albicans in invitro research models²⁰. In infected necrotic canals, ozonized oils can be used as an intra-canal dressing. Also when a root canal was

disinfected by ozone water with somification, the anti-microbial efficacy was comparable to 2.5% NaOCl²¹. Hence in periapical infections, ozone therapy can increase the scope of non-surgical management of these lesions.

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.

Bleaching:

After root canal treatment, crown discolouration is a major aesthetic problem. Ozone was successfully used for lightening the yellowish tinge on rat incisors²². The bleaching effect with ozone is seen when the bleaching agent is placed in the access cavity & crown is exposed to ozone for a minimum of 3 to 4 minutes with marginal success.

Dental Unit Water Line Disinfection:-

Multiple pathogenic bacteria were constantly found in randomized control trials. Ozone achieved 57% reduction in biofilm and 65% reduction in viable bacteria²³ and hence due to absence of any side effects it became an accepted water line disinfectant.

Ozone Toxicity:-

Ozone gas should not be inhaled as the bronchial pulmonary system is very sensitive to ozone. Ozone should not be administered I.V as there would be a risk of air embolism²⁴. Other side effects include epiphora, upper respiratory irritation, rhinitis, cough, nausea, vomiting, shortness of breath, blood vessels swelling, heart problem and at times stroke. However in the event of ozone intoxication patient must be placed in

supine position and treated with vitamin- E and N-acetyl cysteine.

Contraindications:-

1. Pregnancy
2. Glucose 6 phosphate dehydrogenase deficiency
3. Hyperthyroidism
4. Severe anemia
5. Severe Myasthenia
6. Acute alcohol intoxication
7. Recent Myocardial Infarction
8. Haemorrhage from any organ
9. Ozone allergy

Conclusion:

Ozone offers a painless alternative to conventional treatment for tooth decay and has proven to halt primary root caries, primary pit and fissure decay and clinically reverse the lesion. Its anti microbial action on endodontic flora is quite promising. However further research is required to investigate efficacy and cost benefits of this treatment morality. Recent Cochrane review²⁵ elucidated requirement of large randomized controlled trials of at least two years duration to substantiate the data.

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