

**Ozone (Dentistry towards the greenery) – A Review****Chirag M. Raiyani\***, Ruchi Arora and Deepak P. Bhayya*Department of Pedodontics and Preventive Dentistry, Darshan Dental College and Hospital, Udaipur – 313001, Rajasthan, India***\*Correspondence Info:**

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E-mail: [drchiragpedo@gmail.com](mailto:drchiragpedo@gmail.com)**Abstract**

This article markedly emphasizes the nuances of ozone in dentistry. Electronic search of scientific papers was carried out using PubMed, Scopus and Wiley Inter Science. The use of ozone in dentistry became popular after the Second World War, despite the low level of technological comfort offered by the ozone-producing devices. Minimal invasive procedures a part of recent trends in dentistry have demanded the use of ozone. Its wide array of use in multifactorial dental infections without any known several side effects have led to its importance. Ozone gas is immunostimulating, potent analgesic, detoxicating, antimicrobial, bio-energetic and has biosynthesis properties as it causes activation of the metabolism of carbohydrates, protein and lipids. The use of ozone, which has no effects on environment also, is future of green dentistry for greener tomorrow.

**Keywords:** Antibacterial, caries, dentistry, ozone**1. Introduction**

Ozone is a natural gaseous molecule made up of three oxygen atoms[1] and molecular weight is 47.98g/mol.[2] 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. 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.[1] Ozone has been used in dental treatment for over 3½ years by 4,000 dentists with no reports of side effects. In addition, in clinical studies in over 2,000 patients, no adverse effects have been reported.[3]

There are four different systems for generating ozone gas:

- i. **Ultraviolet system:** Produces low concentrations of ozone. It is used in esthetics, saunas, and for air purification.[2]
- ii. **Corona Discharge system:** Produces high concentrations of ozone. It is the most common system used in the medical/dental field.[2] Electrical sparks are passed through an oxygen

rich environment, e.g. lightning or any electrical device, which produces sparks. Many room air purifiers frequently use this method.[4]

- iii. **Cold plasma system:** Used in air and water purification.[2] An ionic flow is induced in a glass cathode tube filled with a noble gas, which is highly electrified. This unit is enveloped in a second tube, usually 316 L grade steel, through which pure oxygen is passed. This is the second electrode, which acts only as a ground and does not receive any direct current. The flow of plasma within the tube induces the oxygen to reform as O<sub>3</sub>. [4]
- iv. **Electromagnetic:** This method used quartz glass tubes through which oxygen flows, with copper wire wound around the inner and outer tubes. A high frequency voltage is passed through the coils, producing a strong electromagnetic field.[4]

**2. History**

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.[1] In

1896 Nikola Tesla patented the first ozone generator in the U.S.[5]

Ozone gas was used for treating gaseous post-traumatic gangrene, infected wounds, burns and fistulas in German soldiers during World War I.[2] Ozone therapy was accepted as an alternative medicine in the U.S.A. from 1880. German dental physician E.A. Fisch (1889-1966) was the first dentist who uses ozone in his dental practice.[1]

### 3. Ozone in dentistry

A Zurich dentist named Fisch, who used ozone for the treatment of chronic periodontal infections, first investigated ozone for dental applications in 1933 and oral wounds.[6] Main use of ozone in dentistry is relays on its antimicrobial properties.

#### 3.1 Caries

The ozone is used as an antimicrobial agent, since the application of ozone during 20 seconds leads to the destruction of 99.9% of microorganisms in the carious lesion. Due to the reactive potential of the ozone gas and its high ability of oxidation, it is able to destroy bacterial membranes.[7]

##### 3.1.1 Incipient caries

Baysan and Beighton (2007) conclude that the 40-second application of ozone gas to non-cavitated occlusal lesions failed to significantly reduce the numbers of viable bacteria.[6] Huth et al., (2007) ran a split mouth clinical trial to assess the effect of a single 40-second application of gaseous ozone on non-cavitated fissure caries in permanent molars. Forty-one patients with 57 pairs of lesions were recruited. The ozone-treated teeth showed

reduced caries progression when compared to the untreated control lesions in these same patients.[6]

##### 3.1.2 Cavitated carious lesions

Clinical application of gaseous ozone appears attractive for the treatment of cavitated occlusal and root caries lesions in cases where restorative treatment is not possible, e.g. anxious children.[8]

Dahnhardt *et al* (2006) completed a controlled clinical study on 28 children contained 82 carious lesions and for each child in which a lesion was treated with ozone, a control lesion was left untreated. He reported that 94% of the children were treatable and the vast majority "lost their dental anxiety".

##### 3.1.3 Root caries

Ozone therapy can be considered as an alternative management strategy for root caries.[9] Baysan *et al*(2000) assessed antimicrobial effect of Heal ozone on primary root caries lesions (PRCL) and evaluated the efficiency of ozone. As a result, ozone exposure to either 10 or 20 s under experimental conditions reduced the total levels of micro-organisms in the PRCLs to < 1 % of the control values.[10] Holmes (2003) observed effect of Kavo Heal ozone device on PRCL followed by professionally - applied remineralising solution. Treatment was applied to 89 patients. After 18 months, 100 % of ozone-treated PRCL's had improved.[10]

##### 3.1.4 Pit and Fissure Caries

A number of published studies have reported on the efficacy of ozone on pit and fissure caries. Representative studies and their findings are presented in the table-1.[11]

**Table-1: Treatment of Pit and Fissure Caries: Summary of Representative Studies**

Author	No. of Patients	No. of Teeth	Success*	Duration of Study month)
Megighianetal. 2003"	60	200	90	1
Holmes. 2003'	193	579	99	4
Abu-Naba'a et al. 2003*	90	258	88	12
Stinson et al, 2003^	98	279	99	12
Holmes, 2003'''	376	2,364	99	12
Johnson etal. 2003"	105	114	81	1
Morrison and Lynch, 2003'-	145	240	89	3
Morrison and Lynch, 2003"	108	186	81	3
Hamid. 2004'-'	184	184	87	3
Hulhctai. 2005'^	41	114	80	3

\*Based on a statistically significant improvement in clinical measures at  $p < 0.05$

### 3.2 Ozone in Prosthodontics

The wearing of removable dentures is not as common but there is certainly widespread use of acrylic removable orthodontic appliances. Ozone has been suggested as a disinfectant for acrylic appliances. Oizumiet *al* (1998) suggested that direct exposure to gaseous ozone could be useful for disinfection of dentures. Arita *et al* (2005) found no significant differences in the antimicrobial activity of ozonated water and commercially available denture cleaners.[6]

### 3.3 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. Denture stomatitis can be controlled by topical application of ozonated oil over tissue surface and over denture surface.[1]

Murakamiet *al* (2002) found that the use of ozone as denture cleaner is effective against methicillin-resistant *S. aureus* and viruses. Arita *et al* (2005) reported that the application of ozonated water might be useful in reducing the number of *C. albicans* on denture plates.[1]

### 3.4 Bonding strength of restorative materials

As ozone has been suggested for use as a cavity preparation disinfectant, an important consideration is whether the application of ozone affects the bonding strength achieved by restorative materials. Schmidlinet *al.*, (2005) found that gaseous ozone application had no effect on the shear bond strength of composite resin to bovine enamel and dentine samples.[6]

Polydorou *et al*(2006) found that 40s application of ozone was found to reduce significantly the numbers of *Streptococcus mutans*, but not to extend of other treatments.[10] Onisor *et al* (2007) found that surface treatment with ozone might significantly decrease marginal quality of class V resin restorations in dentine without negatively influencing marginal quality in enamel.[6]

### 3.5 Periodontics

Ozone has been proposed as an adjunct antiseptic in periodontitis therapy. *P. gingivalis*, *T. forsythia* and *P. micra* could be eliminated by 2% CHX or by ozone gas at 53 gm-3. Nagayoshi *et al.*, (2004) tested the efficacy of ozonated water on survival and permeability of oral micro- organisms and dental plaque. They confirm that ozonated water (0.5–4 mg/l) was highly effective in killing of both microorganisms. Huth *et al* (2006-2007) in their

study declared that the aqueous form of ozone, as a potential antiseptic agent, showed less cytotoxicity than gaseous ozone or established antimicrobials under most conditions.[10]

### 3.6 Endodontics

Ozone gas in a concentration of ~4 g m<sup>3</sup> (HealOzone; KaVo, Biberach, Germany) is being used clinically for endodontic treatment.[12] Nagayoshi *et al* (2004) found that ozonated water was inferior to 2.5% sodium hypochlorite in antimicrobial action against *enterococcus faecalis* and *streptococcus mutans* in bovine dentin in vitro.[6]

Estrela *et al* (2007) studied antimicrobial effects of ozonated water, gaseous ozone and antiseptic agents in infected human dental root canals. All these substances had no antibacterial effect against *Enterococcus faecalis* over a 20-minute contact time in the infected root canals.[10] Cardoso *et al* (2008) reported that ozonated water did not neutralize endotoxin, but was reported to be effective against *candida albicans* and *enterococcus faecalis* in the root canal system.[13]

### 3.7 Bleaching

Crown discoloration is a major aesthetic problem, especially in anterior teeth. After placing the bleaching agent, the crown is irradiated with ozone for minimum of 3-4 minutes. This ozone treatment bleaches the tooth within minutes and gives the patient a happy and healthier-looking smile.[14]

Azarpazhooch *et al* (2008) Ozone has been suggested as having applications in tooth bleaching. However, there is no published evidence of bleaching efficacy of teeth by ozone. Manton *et al.*, (2008) found the application of ozone with carbamide peroxide solution did not significantly affect bleaching effectiveness compared with peroxide alone.[6]

### 3.8 Ozone therapy in oral and maxillofacial surgery

Filippi (1995) was observed the influence of ozonized water on the epithelial wound healing process in the oral cavity. It was found that ozonized water applied on the daily basis can accelerate the healing rate in oral mucosa.[10] Agapov *et al.*, (2001) In patients with chronic mandibular osteomyelitis, it was observed that medical ozone exposure reducing the incidence of complications. Petrucci *et al* (2010) 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.[1]

### 3.9 Ozonated water in decontamination of avulsed teeth before replantation

Ebensberger *et al*(2002) was observed two-minute irrigation of the avulsed teeth with non-isotonic ozonated water provides mechanical cleansing and decontaminate the root surface.[1] Stubinger *et al*(2006) found non-isotonic ozone water has been shown to not have any negative effects on the root surface at an exposure time of less than 2 minutes.[6]

### 3.10 Uses in oral medicine

Soft tissue lesions like Herpes, Aphthae, Cheilitis, Candidiasis and Cysts can be treated with either Ozonated water or oils.[15] Clavo *et al*(2004) concluded that the ozone therapy can produce an improvement in blood flow and oxygenation in some tissues and appears to have had some positive effect during the treatment of patients with advanced head & neck tumors. Macedo and Cardoso(2005) described a case report of the application of ozonated oil on herpes labialis and mandibular osteomyelitis and demonstrated faster healing time than conventional protocols.[16]

### 3.11 Ozone for treatment of Peri-implantitis

Karapetian *et al*(2007) Ozone, a powerful antimicrobial kills the microorganisms causing peri-implantitis. 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.[1]

### 3.12 Decontamination of toothbrush

Ozone application was found to remove the toothbrushes bristles microbiota following conventional brushing.[1]

### 3.13 Cracked tooth syndrome

According to the clinical situation and symptoms, a conservative attempt can be used with ozone application. After revealing the crack and evaluation of the case apply ozone gas for 60-120 seconds and restore with a long-term temporary filling, i.e., glass ionomer cement. Put the tooth slightly offocclusion and reassess periodically.[17]

### 3.14 Hypersensitive teeth

Ozone removes the smear layer, open up the dentinal tubules, broadens their diameter and calcium and fluoride ions flow easily, deeply and effectively to plug the dentinal tubules. Thus, ozone can effectively terminate the root sensitivity problem within seconds and also result last longer than those by conventional method.[18]

### 3.15 Use of topical ozone to treat recurrent aphthous ulceration

Recurrent aphthous ulceration is a common mucosal disorder. This case report demonstrates the beneficial use of topical application of ozone using the Heal ozone appliance in a patient with long-standing aphthous ulceration involving the lateral border of the tongue. The topical application of ozone provided an effective means of producing resolution of clinical symptoms related to aphthous ulceration for this patient.[19]

## 4. Application of ozone in dentistry

Three basic forms of application to oral tissue are:

- i. Ozonated water: Ozonated water is commonly in root canal therapy.
- ii. Ozonated olive oil: Ozonated olive oil is mostly used after periodontal and surgical procedure for healing. For the treatment of dry socket, periapical sinus, denture sore mouth, lip herpes, mouth and tongue ulcer ozonated oil is used and
- iii. Oxygen/Ozone gas: Oxygen/Ozone gas is generally use to treat dental caries and aphthous ulcer.[18]

## 5. Indications/contraindications

### 5.1 Indications:

- Prophylaxis and prevention of caries.
- Remineralization of caries.
- Bleaching of discolored teeth.
- Endodontic treatment.
- Desensitization of external sensitive tooth necks.
- Soft tissue pathoses.
- Dry socket.[18]

### 5.2 Contraindications

- Pregnancy.
- Glucose-6-phosphate-dehydrogenasedeficiency (favism).
- Severe anemia.
- Acute alcohol intoxication.
- Hemorrhage from any organ.
- Ozone allergy.[16]

## 6. Advantage/disadvantages

### 6.1 Advantages

- Non-invasive / minimal intervention technique.
- Induction of a friendly ecologic environment.
- Improves metabolism of infected tissues by means of its oxidizing effect.[17]

### 6.1 Disadvantages

- Theproblem of maintaining the ideal tightness between the cap and the ozoned tooth.

- The device does not administer ozone when there is a risk of untightness.
- More time (may be even 10 minutes) needed for a proper preparation of the cap.[17]

## 7. Ozone toxicity

Known side effects are epiphora, upper respiratory irritation, rhinitis, cough, headache, occasional nausea, vomiting, and shortness of breath, blood vessel swelling, poor circulation, heart problems and at times stroke. Because of ozone's high oxidative power, all materials that come in contact with the gas must be ozone resistant, such as glass, silicon and Teflon. However, in the event of ozone intoxication the patient must be placed in the supine position and treated with vitamin E and n-acetylcysteine.[16]

## 8. Conclusion

The ozone therapy has been more beneficial than any other present conventional therapeutic modalities with great benefits to the patients. In comparison with other treatment modality, ozone therapy is quite inexpensive with less time consuming. The potent antimicrobial of ozone makes it a therapeutic agent of choice in the treatment of infectious oral diseases. Further research is needed to standardize treatment procedures of ozone therapy.

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