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# Antibacterial Effect of Healozone in Caries Removal - A Literature Review

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**ABSTRACT:**

A trivalent, naturally occurring, odourless gas ozone is used in dentistry and medicine. Earlier the ozone was used in the treatment of inflammation, wound repair and abscess. Ozone has a good oxidative capacity when compared with chlorine and ozone exhibits antimicrobial properties against various bacteria, viruses, fungi and protozoan. Heal ozone is a device which is used in killing of bacteria in the decayed part of the tooth. Ozone intrudes the cell wall of bacteria and destroys them. It's proven that at such a lower concentration it is capable of inactivating the bacterial species. The ozone is available in the form of gas, ozonated water and ozonated oil.The activity of ozone is highly appreciable when there is less organic debris left. It is also effective when sufficient quantity and time duration of ozone can also enhance its activity. Importantly it will not be efficiently acting if the concentration is less and when the system has faults in producing it. Ozone plays a major role in removal of primary root carious lesion and in dentin bonding. It can also be used as a disinfecting agent before the placement of any restoration and any prosthesis. In the treatment of caries, ozone helps in removal of carious lesions and prevents the bacterial invasion further. Ozone is a painless, cheap minimal invasive procedure which has turned its attention towards caries removal. So this review will emphasize the importance of ozone and its application in removal of caries and in dentistry.

**KEYWORDS:**Antimicrobialeffect; Bacteria; Caries; Healozone; Ozone;

## INTRODUCTION:

The ozone molecule is a triatomic molecule which consists of three ozone atoms(Baysan and Lynch, 2005). The Ozone molecule is a highly stable one which depends on certain factors like temperature and pressure (Bocci, 2006). As it is an unstable gas, it can't be contained or stored and it must be used once at a time because of its half life which is 40 minutes at 20°C (Nogales *et al.*, 2008). It is a colourless gas which has an pungent how odour and the important property is it has high oxidation capacity when compared with Chlorine, it has 1.5 times potentially active oxidative property (Bocci, 2010). It is also used as an antimicrobial agent against bacteria, virus, fungi, protozoa. Ozone activity on blood cells results in reducing the red blood cells clumping and the originality of the cell would be restored and thus increases the oxygen carrying capacity.

This naturally occurring gas has a potential to kill microorganisms in conditions like caries removal also in the case of pulp necrosis (Janani, Palanivelu and Sandhya, 2020a). Earlier the discovery of ozone was done by introducing the electricity which produces the smell. The early use of ozone was in the treatment of inflammation (Teja, Ramesh and Priya, 2018a), fracture (Jose, P. and Subbaiyan, 2020) wound and abscess. In Endodontics study, ozone is considered to be an irrigating agent or intracanal medicament (M. Manohar and Sharma, 2018). The production of ozone was done by UV method with lesser concentration, those which were produced were also used in purification of air (Rickard *et al.*, 2004). The ozone molecules combine with UV radiation from the sunlight or by the electrical discharge. The intense stress over water also results in the formation of ozone gas. In medicine for the production of ozone, specific gazettes known as Ozone generators are used, which has the ability to produce ozone and works on three principles: UV light lamp, Corona discharge, and cold plasma. In dentistry, two widely used ozone units are ozone , ozotop(Davies *et al.*, 2003). The ozone is available in the form of gas, ozonated water and even oil form. The activity of ozone is highly appreciable when there is less

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organic debris left. It is also effective when sufficient quantity and time duration of ozone can also enhance its activity. Importantly it will not be efficiently acting if the concentration is less and when the system has faults in producing it.

Dental caries which is a multifactorial disease which is commonly caused by bacterial species. The treatment of caries involves the removal of various lesions and filling of the missing tooth structure with filling material. When the concept of minimal invasive technique was used there were many techniques used and one of them which has been commonly used in caries removal is healozone, widely being practised restorative dentistry. Healozone is an alternative method of treatment which has the ability to kill the bacteria in a tooth decay. It is sound treatment with less pain and it is potentially a good source of Antimicrobial property, where it interrupts the cell integrity of the bacterial cell wall. It results in the oxidation of bacterial cell walls which results in antibacterial properties. It is used as a support system in gum health in healing and treating periodontal disease. It is a useful method of pain-free caries removal in dentistry (Gupta and Boloor, 2016). The aim of the study is to determine the antibacterial property of heal ozone in caries removal by considering various factors.

Our team has rich experience in research and we have collaborated with numerous authors over various topics in the past decade (Arriga*et al.*, 2018; Basha, Ganapathy and Venugopalan, 2018; Hannah *et al.*, 2018; Hussainy*et al.*, 2018a; Jeevanandan and Govindaraju, 2018; Kannan and Venugopalan, 2018; Kumar and Antony, 2018; Menon *et al.*, 2018; M. P. Manohar and Sharma, 2018; Nandakumar and Nasim, 2018a; Nandhini, Babu and Mohanraj, 2018; Ravinthar and Jayalakshmi, 2018a; Seppan*et al.*, 2018; Teja, Ramesh and Priya, 2018b; Duraisamy*et al.*, 2019; Gheena and Ezhilarasan, 2019; Hema Shree *et al.*, 2019; Rajakeerthi and Ms, 2019; Rajendran *et al.*, 2019a; Sekar*et al.*, 2019; Sharma *et al.*, 2019; Siddique *et al.*, 2019a; Janani, Palanivelu and Sandhya, 2020b; Johnson *et al.*, 2020; Jose, Ajitha and Subbaiyan, 2020).

**Ozone activity on microbes:**

Ozone results in the killing of microorganisms like bacteria, fungi, and viruses. It interrupts the cell wall envelope of the bacteria by the oxidation of phospholipids and lipoproteins (Seidler *et al.*, 2008). Practically, 0.1 ppm at such a low concentration the ozone is capable of destroying and inactivating the bacterial cell. The mechanism of ozone when it enters the bacteria is to damage the cytoplasmic membrane and modification of intra cellular components because of oxidation which causes the loss of proteins (Loncar*et al.*, 2009). The important property which exists in human beings is antioxidative property due to which our cells aren't destroyed on the application of ozone (Azarpazhooh and Limeback, 2008). All the important functions of bacteria are arrested within a few seconds on the application of ozone. The gram positive bacteria are more susceptible than the gram negative bacteria to the action of ozone.

The studies have been reported that the ozone has the capacity of killing the 60s bacterial species in an accuracy of 99.9% (Lynch, 2004). Exposing the ozone for a longer period of time also results in degradation of salivary protein but 10 to 30 seconds of ozone exposure can kill a significant amount of bacteria. Some investigations have proved that there is a reduced bacterial and fungal count after an in vitro treatment by using ozonated water. When the antimicrobial effects of chlorhexidine (Noor, S Syed Shihaab and Pradeep, 2016) and ozone were evaluated against certain bacteria, fungi, virus, that antifungal and antimicrobial property was better to be in ozone (Laxman and Kshitish, 2010). The susceptibility of various organisms differ and the

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viruses are also susceptible to ozone. Especially the lipid enveloped virus are highly susceptible. In fungi, the inhibition of cell walls happens at various stages.

Certain species like streptococcus, candida albicans, Staphylococcus aureus which where isolated from the human brush of children were taken and then the efficiency of ozone was tested, where the exposing time period was found to be insufficient and didn't kill all the microbes. The ozone is also used to disinfect the cavity to have a reduced microbes associated in the treatment of caries removal. The endoactivator helps in removal of smear layer and organic debris and then application of ozone eliminates the microorganisms(Ramamoorthi, Nivedhitha and Divyanand, 2015).

**Methods of application of ozone on teeth:**

The ozone is found to be in gaseous form, ozonated water and ozonated oil where it can be applied over the teeth for caries removal. The gaseous form of ozone is topically administered by an open system or closed suction system which is used to avoid the toxic effect of inhalation of ozone gas. The gaseous form is more often practised in restorative dentistry and endodontics (Johansson *et al.*, 2007). This can be used to disinfect the cavity before placing any restoration of material or crown (Ravinthar and Jayalakshmi, 2018b) as it is one of the non-invasive therapy for treatment of carious lesions. This gaseous ozone which can be used as a disinfectant when it is applied for about three minutes and has more Antimicrobial effect than the aqueous form. These ozone producing equipment helps in the conversion of oxygen to ozone. Then the handpiece with a silicone cup is taken along with the ozone and there are different sizes of silicone cups available which enhances the tight area of contact between the carious tooth structure as well these cups so as to prevent the ozone gas escaping out. A proper CBCT imaging is required for the detection of the lesions and then application of ozone must be done (R, Rajakeerthi and Ms, 2019). The aqueous form of ozone is potentially against the gram positive and gram negative oral microbes which includes the bacteria in the plaque formation. It is quite inexpensive. This gas when inhaled, it can cause toxic effects and it is commercially available as ultrapure triple ozone treatment. The next available form of ozone is ozonated oil which is a sound antimicrobial agent and it is effective against streptococci, Enterococci ,Staphylococci and pseudomonas species. It is commercially available as Oleozone, Bioperoxoil.

These different forms of ozone can either be applied separately or can be used by the combination of any two (Saini, 2011). In the dental clinic, the ozone will be produced by the lightning effect and the electrical discharge field. First in the application of ozone, the isolation of the tooth is done then the application of gas on the affected area for about 40 to 60 seconds is done and that is potential to inhibit the bacterial growth further (Arora *et al.*, 2015). If not only the debris but also the residual biomolecules are removed then a window period of 3-4 weeks is given for the remineralisation of teeth which is done by normal salivary calcium and phosphate ions (Rajendran *et al.*, 2019b).

There are various applications of ozone which includes healozone by KaVo which is a closed system and the ozone concentration is about 2100 ppm and it has a perfect their tightness cap for the exposure ozone. Prozone, which is also another method which is easy to use and also safe to the tissues which is why it is widely being used for endodontitis and periodontitis. It is a safe, hygienic procedure where the tips which are used can be changed. Then the ozotop, it is easy to

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Received 16 February 2021; Accepted 08 March 2021.

use having a tabletop set up where the ozone is delivered by using Corona discharge. This is used in root canals (Teja and Ramesh, 2019), periodontal sockets as it can penetrate easily. The ozone water which has a high range of antibacterial effects can be used during and after sealing even in a route planning as the bactericidal activity of ozone is strong.

**Application of ozone in dentistry:**

Our institution is passionate about high quality evidence based research and has excelled in various fields ( (Pc, Marimuthu and Devadoss, 2018; Ramesh *et al.*, 2018; VijayashreePriyadharsini, SmilineGirija and Paramasivam, 2018; Ezhilarasan, Apoorva and Ashok Vardhan, 2019; Ramaduraiet *al.*, 2019; Sridharan *et al.*, 2019; VijayashreePriyadharsini, 2019; Chandrasekar *et al.*, 2020; Mathew *et al.*, 2020; R *et al.*, 2020; Samuel, 2021)

Ozone prevents the formation of dental caries by inhibition of the oral infectious microbes (Nagayoshi, Fukuizumi, *et al.*, 2004). This is potentially against an extended spectrum of bacteria and even the fungal species like Candida albicans (*Website*, no date). They are also used as disinfecting agents in the dentures against the Methicillin resistance S.aureus and E.coli (Murakami *et al.*, 2002). It is also a suitable disinfecting agent of the root canal when compared with sodium hypochlorite which is not indicated (Mohammadi*et al.*, 2017). The ozone is against the caries causing bacteria which is Streptococcus mutans(Polydorou, Pelz and Hahn, 2006). It can also control bleeding, and is used to cleanse the wounds on the soft issues and bones. It improves the healing of wounds by increasing the oxygen supply to the affected areas (Bhateja, 2012). The ozonated water was used over the epithelial wound in the oral cavity to check the wound healing properties. It was observed that the daily application of ozone can contribute epithelial wound healing in the oral cavity which was seen after the postoperative days (*The influence of ozonised water on the epithelial wound healing process in the oral cavity. Clinic of oral surgery, radiology and oral medicine*, no date).

Application of ozone in endodontics also plays a major role in killing bacteria. It was found that 0.5-4mg/L was enough to kill both gram positive and gram negative bacteria (Nagayoshi, Fukuizumi, *et al.*, 2004). Ozone potential was evaluated against Enterococcus faecalis and the study used both gaseous and aqueous form of ozone. The study revealed that the antibacterial activity against E.faecalis was successful when the duration of the ozone application was about 240 seconds (Hems *et al.*, 2005) studies have also shown that ozone was potentially against certain bacterias which causes pulp necrosis. Studies have shown that aqueous form of ozone exhibits strong antibacterial effects in plaque biofilm (Nagayoshi, Kitamura, *et al.*, 2004). The activity of ozone is highly appreciable when there is less organic debris left. So aqueous and gaseous form of ozone is suggested for the cleaning and shaping process. It is also effective when sufficient quantity and time duration of ozone can also enhance its activity.

This ozone in the aqueous forms can be used as a mouth rinse in the case of gingivitis, oral thrush. It is spayed over the affected area to disinfect the oral mucosa. It is used in Caries treatment, root canal treatment, dental hypersensitivity, enamel cracks (Nandakumar and Nasim, 2018b), tooth whitening, stomatitis, abscess and granuloma and even in pain, infection control, remineralisation of tooth structure, TMJ treatment, elimination of bacterial biofilm and also in tooth sensitivity. The unstable form of gas ozone lasts for about a few minutes whereas the aqueous form can last for about a few days.

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Received 16 February 2021; Accepted 08 March 2021.

**Ozone in management of root caries:**

In a study, the ozone efficiency was evaluated in the primary root canal lesion (Hussain*yet al.*, 2018b) in vitro method. Antibacterial effect of KaVohealozone device was assessed on the primary root canal lesions and the effect of ozone was noted on S.Mutans and S.sobrinus. The biopsy was first taken from half of the participants and from few patients after the ozone application. Then the microbial flora count was then evaluated and compared. It was reported that by the duration of 10 to 20 seconds of ozone application, it significantly reduced most of the microorganisms associated with the primary root canal lesions and it was also noted that there were no side effects which were observed between the intervals of 3 to 5.5 months of the trial (Baysan, Whiley and Lynch, 2000). The study concluded that the effect of ozone reduced the total levels of the microbial count for a time duration of 10-20 seconds.When the activity of ozone was doone for about 10 seconds it reduced the count of S.Mutans and S.sobrinus

In vitro study was done to evaluate the ozone potential where ozone is combined with the daily remineralising patient kit for those who have the clinical condition of non-capitated leathery primary root canal lesion in old people. It was concluded that the condition was able to reverse the lesion within 40 seconds of ozone application. The trial continued for about 18 months and the success rate was hundred percent in reversing and remineralisation of the tooth. Finally it was also told that it could be used as an alternative method rather than the normally practiced drilling and filling (Holmes, 2003).

Another study which was done to investigate the effect of Ozone on non-cavitated Initial occlusion fissure caries lesions by considering the patient risk in caries. When ozone treatment was done the area treated showed a significant reversal of the condition when compared with the untreated group with higher caries risk (Huth*et al.*, 2005). Most of the clinical study proves that the ozone is a very good active agent in the management and treatment of Caries removal.

**Effects of ozone in dentin bonding:**

Application of ozone on the Dentin and enamel can result in the decreased bond strength (Magni*et al.*, 2008). Studies have proven that ozone on disinfecting the cavity will not intrude the dentin enamel bond strength (Cadenaro*et al.*, 2009)) and also ozone has no influence on the mechanical properties of adhesives (Magni*et al.*, 2010) which includes Prime and Bond NT, silorane system adhesives.It is also proven that the pre-treatment of ozone when done, improves the marginal sealing ability of the pits and fissure sealant and it also improves the shear bond of root canal sealer is like AH 26,EX fill . But the ozone treatment didn't intrude with the shear bond strength of two self etch adhesives which were used on coronal and radicular dentin. The dentin bond strength of silorane based resin composite didn't affect significantly. Interestingly the gaseous form and aqueous form didn't reduce the effect of bond strength.

**Disadvantage of ozone treatment:**

The oxidant property of ozone results in irritation of eyes, mucosa of the respiratory tract. Gaseous form of ozone exhibits the cytotoxic effect to the human gingival fibroblast cell lines (Huth*et al.*, 2006). The side effects of ozone treatment could include rhinitis headache, poor circulation, stroke (Mohammadi and Azarpazhooh, 2015). The ozone therapy is highly contraindicated in myocardial infarction, pregnancy, alcohol intoxication. Most importantly it causes toxic effects when the gas is being inhaled and the long-term exposure would cause those above mentioned side-effects. If there is acute poisoning, ascorbic acid, vitamin K can be used as

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Received 16 February 2021; Accepted 08 March 2021.

an antidote which could be beneficial.Studies have shown that blood clotting is disturbed when there is a typical ozone poisoning.

**Contraindicated literatures:**

The natural occurring trivalent molecule is used in medicine and dentistry having a wide range of antibacterial properties. This is one of the conventional methods in treatment, prevention, management of carious lesions. When ozone activity was done over 60 clinical bacterial isolates, it was potential to kill all bacterial, yeast cells in a period of 30 seconds. The ozone water reduces the surface bacteria by 99.9% having the concentration of ozone up to 1500 ppm for the death of E. coli and S.aureus(Moore, Griffith and Peters, 2000). When the effects bonding agent were discussed , the ozone does not show any reduction of bond strength and the bond strength was comparatively higher in ozone when compared to chlorhexidine which had microleakage than ozone. Study when done on the gas form of ozone it didn't affect the modulus elasticity as well as Vickers hardness of dentin (Reddy *et al.*, 2012). The antimicrobial effects of ozone was done by using the ozonated water, gaseous ozone and 2% chlorhexidine and 2.5% of sodium hypochlorite. This was tested in the infected root canals and the study concluded that all these above mentioned substances were incapable of producing antimicrobial effect against E.faecalis in the infected canals (Estrela *et al.*, 2007).

The ozone which is available in gaseous,aqueous,oil forms a major role in the treatment of primary root carious lesions. But there were contraindications,when the study was conducted to evaluate the effects of ozone by comparing with cervitec protector on avoiding demineralization around brackets, there were development of white spot lesions during multibracket therapy even after the activity of ozone (Bezirtzoglou*et al.*, 2008). Another contraindicatory study where the effects of ozone gas and chlorhexidine (Siddique *et al.*, 2019b) where done done on bacteria in cavitated carious lesions in children where the application of both the agents over the bacterial species were not effective in reducing the microorganisms (Hauser-Gerspach*et al.*, 2009; Reddy *et al.*, 2012). So there are clinical studies which are reported to have promising activity of ozone and few contradictory methods in treating caries. This ozone is now experimented on mice when SC injection is given with ozone with a nerve injury, the sciatic nerve decreases the neuropathic pain (Fuccio*et al.*, 2009).

**CONCLUSION:**

Ozone which is a potent disinfectant and its therapy is economical and used in medicine and dentistry. This therapy is highly beneficial than the conservative method as it undergoes conservative approach and minimal invasive techniques . This treatment is significantly used to reduce the oral bacteria causing caries. This painless way of treatment is useful but the toxicity produced can be lowered which can indicate the extensive use for future purpose.

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