

Ozone Therapy In Pediatric Dentistry: An Alternate Approach

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Abstract

The use of ozone in dentistry is gaining its place in every day dental practice and is used in almost all dental applications. The undisputed disinfection power of ozone over other antiseptics makes the use of ozone in dentistry a very good alternative and/or an additional disinfectant to standard antiseptics. Minimally Invasive Dentistry is now the new Standard of Care in all disciplines of dentistry, most importantly in preventive and operative dentistry. So far, arresting and reversing the process of tooth caries without invasive treatment are unpredictable and rely very much on patient's compliance. Recent research and clinical studies on the use of ozone in treating early tooth caries without cavitations are very promising and are showing that it is now possible to arrest and reverse these lesions in a predictable and repeatable way without invasive intervention. These findings are establishing a paradigm shift, a revolution in dentistry.

INTRODUCTION

Ozone (O₃) is a gas with a characteristic, penetrating odour that is present in small amounts in atmospheric air. Ozone molecules are composed of three oxygen atoms and present naturally in the upper layer of atmosphere.^{1,2} It is one of the most powerful antimicrobial agents available in gaseous and aqueous forms.

There is no doubt that oral hygiene forms the fundamental basis for the prevention of dental caries. Research suggests that the process of decay, in which, establishment of an acid-based niche environment where demineralisation exceeds remineralisation, starts in the microbiological coating over the surface of the tooth, called plaque. Plaque consists of food debris, bacteria normally present in the oral cavity and various proteins. Plaque needs to be disrupted and removed on a regular basis to prevent infection and damage. A lot of times, tooth morphology makes oral hygiene difficult. The use of ozonated water reduces unattached bacteria, micro-organisms in plaque, found around and on tooth surfaces.³

ANTIMICROBIAL EFFICACY OF OZONE IN CARIES

Ozone is one of the most powerful antimicrobial agents that is currently used in dentistry. Dental caries is caused by an ecological niche of caries producing organisms and eliminating these cariological organisms provide a tremendous clinical and long term preventive advantage for

patients. Research has shown, application of ozone for a period of 10sec was capable of reducing the numbers of *Streptococcus mutans* and *Streptococcus sobrinus* in vitro due to the antimicrobial effectiveness of ozone, as a gas and in the form of ozonated water.⁴

Polydorou et al.⁵ studied antibacterial effect of KavoHealozone device on *Streptococcus mutans* in comparison with the already proven activity of two dentin-bonding systems. Their findings show that an 80 s application of ozone is a very promising therapy for elimination of residual micro-organisms in deep cavities and therefore of potentially increasing the clinical success of restorations. A 40 s application of ozone was found to reduce significantly the numbers of *Streptococcus mutans*, but not to extend of other treatments. A longer period of ozone activity could be advantageous as a result of its anticariogenic effect.

Nagayoshi et al.⁶ 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 gram positive and gram negative micro-organisms. Gram negative bacteria, such as *Porphyromonas endodontalis* and *Porphyromonas gingivalis* were substantially more sensitive to ozonated water than gram positive oral streptococci and *Candida albicans* in pure culture. Furthermore ozonated

water had strong bactericidal activity against bacteria in plaque biofilm. In addition, ozonated water inhibited the accumulation of experimental dental plaque in vitro.

In dental unit water lines, ozone achieved a 57 percent reduction in biofilm and a 65 percent reduction in viable bacteria in spite of a very low dosage and short time of application.⁷ In addition, a high level of biocompatibility of aqueous ozone on human oral epithelial cells, gingival fibroblast cells and periodontal cells has been published.

MANAGEMENT OF PIT AND FISSURE CARIES

Ozone allows the tooth surface to remineralise, encouraged by the patient's saliva, mouthwashes and dentifrice and, where the caries are already established, it halts their growth and allow the area to 'heal' without amputation of tooth material to remove what we consider to be infected, without the need for anaesthesia. Three to four month recall studies have shown, not a single lesion identified as a carious lesion being progressed; the majority of lesions showed remineralisation.⁸

Ozone treatment of enamel caries lesions within pits and fissures in caries active situations should be cleansed of caries within the fissures, prior to ozone treatment. This permits the ozone to readily access the caries and after the ozone treatment, sealing of the clean fissures should be encouraged.

Baysonetal,⁹ used only ozone to treat non-cavitated caries involving the middle third of dentin. They did not fully clean the fissures. Not surprisingly, they reported that Ozone treatment of non-cavitated occlusal lesions for 40 seconds failed to significantly reduce the numbers of viable bacteria in infected dentin beneath the de-mineralized enamel. Clinical recommendations involve opening the lesions and caries removal leaving only up to 1mm of caries on the pulpal floor prior to ozone treatment and subsequent restoration

Ozone application is known to significantly improve non-cavitated initial fissure caries in patients at high caries risk over a 3- month period.¹⁰

Dahnhardt et al study¹¹ treated open carious lesions with ozone in anxious children. In fact the children who will not get treatment of a very early stage of dental caries are most likely the ones who can be the most anxious and not cooperative during routine dental procedures. With ozone treatment "94 percent of the children were treatable and 93

percent lost their dental anxiety. The hardness values improved significantly in the ozone-treated test lesions after 4, 6 and 8 months compared with baseline, while the control lesions had no significant change in hardness at any recall interval". It is important to note that hardness of dental caries is our best clinical tool to reflect the activity of dentine caries.

A study investigated the effect of ozone pretreatment on the microleakage and marginal integrity of pit and fissure sealants on freshly extracted human molars. It showed, ozone pretreatment significantly reduced the extent of microleakage and favorably affected the marginal sealing ability of the fissure sealants.¹²

When ozone is used during caries treatment with resin restorations, bond strength can be compromised by the release of oxygen. The use of antioxidant agents neutralizes the free oxygen. A study was done, to evaluate the effects of ozone and sodium ascorbate on resin-dentin microtensile bond strength (µTBS) and it was seen that, the application of ozone decreased the µTBS of the dentin-composite resin interface.¹³ Though, the application of ozone does not impair the composite-to-composite bond.¹⁴

MANAGEMENT OF ROOT CARIES

Ozone is most effective when it has the ability to penetrate shallow lesions which were about 1mm deep at the maximum. The ozone cap must be held against the caries lesion allowing the ozone to penetrate the decay and biofilm (Fig 1). In the case where there is a cavitated 4mm deep, root caries lesion adjacent to the gingival margin simply using ozone treatment would probably not be effective. To manage this kind of a situation the outer caries must first be removed, leaving about 1mm of caries over the cavity floor. Then ozone treatment followed by routine restoration is indicated.¹⁵

Ozone can reverse and arrest shallow non-cavitated root caries lesions when used as part of a full preventive care regimen. This process includes reducing the frequency of consumption of fermentable carbohydrates, increased use of fluoride-containing products and improved oral hygiene.¹⁵

Ozone is used in the treatment of hypersensitive dentin. The effect of ozone, with or without the use of desensitizing agents, on patency and occlusion of simulated hypersensitive dentin has been investigated. The use of ozone gas is a viable adjunct to fluoride-containing desensitizers in enhancing tubular occlusion, but is not effective with oxalate

desensitizers.¹⁶

ROOT CANAL THERAPY IN DECIDUOUS TEETH

Ozone is highly indicated in root canal therapy due to its strong disinfection property and absence of cytotoxicity. During the canal shaping and irrigation, ozonated water is highly recommended to be used as a disinfectant and irrigant.

Nagayoshi and colleagues,¹⁷ found nearly the same antimicrobial activity (against *E. faecalis* and *Streptococcus mutans*) and a lower level of cytotoxicity of ozonated water as compared with 2.5% NaOCl. They stated, "Ozone is known to act as a strong antimicrobial agent against bacteria, fungi, and viruses.

Ozonated water was examined against *Enterococcus faecalis* and *Streptococcus mutans* infections in vitro in bovine dentin.¹⁸ After irrigation with ozonated water, the viability of *E. faecalis* and *S. mutans* invading dentinal tubules significantly decreased. Notably, when the specimen was irrigated with sonication,

ozonated water had nearly the same antimicrobial activity as 2.5% sodium hypochlorite (NaOCl). The cytotoxicity against L-929 mouse fibroblasts between ozonated water and NaOCl was compared. The metabolic activity of fibroblasts was high when the cells were treated with ozonated water, whereas that of fibroblasts significantly decreased when the cells were treated with 2.5% NaOCl. These results suggest that ozonated water application may be useful for endodontic therapy.¹⁷

Ozonized oils can also be used as a temporary root canal dressing in infected necrotic cases. In peri-apical lesions, ozone gas infiltration contributes in the non-surgical management of these lesions. Siqueira and colleagues¹⁹ evaluated the antibacterial activity of the ozonated oil and calcium hydroxide pastes against bacterial species commonly associated with the etiology of periradicular diseases. Of the tested medicaments, ozonated oil was the most effective against the evaluated bacterial species.

PERIODONTAL TREATMENTS IN CHILDREN

Ozonated oil is used as a safe therapeutic alternative in patients with Acute Necrotizing Ulcerative Gingivitis. Healing and bactericidal properties make it useful as a subgingival irrigant.²⁰ Ozone accelerates the healing of soft tissue conditions, i.e. aphthous ulcers, herpes labialis, ANUG and other gum infections.²¹

Huth KC et al²² reported, there was no significant difference in the antimicrobial effectiveness of gaseous/aqueous ozone, in comparison with that of the established antiseptic chlorhexidine digluconate, against periodontal microorganisms.

HEALING OF WOUNDS

Ozone reduces the post-extraction healing time by forming a pseudo-membrane over the socket, so protecting it from any physical and mechanical insults. Ozone therapy was found to be beneficial for the treatment of the refractory osteomyelitis in the head and neck in addition to treatment with antibiotics, surgery and hyperbaric oxygen. In alveolitis, there is accelerated healing by irrigation with ozonated water after removal of the necrotic pulp & debris under antibiotic coverage.²¹

BLEACHING

Ozone is used to lighten the discoloration in root canal treated teeth. Crown discoloration is a major aesthetic problem, especially in anterior teeth. Conventional walking bleaching requires much more time and results are not often satisfactory. Also, capping the tooth with ceramic crown is not always a good idea. Ozone can also be successfully used for lightening the yellowish tinge of tetracycline-stained rat incisors, as reported by Tessier J and colleagues²³ in their experimental study.

COMMERCIALLY AVAILABLE OZONE SYSTEMS

Medical Ozone is made when medical grade oxygen is electrically activated (using an Ozone Generator) to form ozone.²⁴ It is a mixture of the purest oxygen and purest ozone. According to its application, the ozone concentration may vary between 1 and 100 µg/ml (0.05-5%).²⁵ Ozone is an unstable gas and it quickly gives up nascent oxygen molecule to form oxygen gas. The release of nascent oxygen has beneficial effects on every part and organ¹ due to its extremely strong oxidant property.

KaVo produces the HealOzone (Fig 2) which has had almost a decade of clinical study, research and development. It has been shown to be very safe when used in the oral cavity.

A slightly different approach is offered by TherOzone (Santa Monica, USA) (Fig. 3). This unit provides ozonated water for disinfection purposes.

OZONATED WATER

Ozone is approximately 10 times more soluble in water than

oxygen. Mixed into aqua bidestillata (pyrogen free) water, the half life of ozone is nine to ten hours (at pH 7 and 20C); and at 0C, it is doubled. Ozonated water finds applications in dental surgery where it is reported to promote hemostasis, enhance local oxygen supply and inhibit bacterial proliferation. Applied following tooth extraction or during dental surgery, it may also be rinsed in conditions such as thrush and periodontal disease.²⁶

THE BENEFITS OF OZONE TREATMENT

Ozone treatment is excellent as a preventative measure against future decay and dental work needed to correct the damage caused by bacteria. Benefits include

OZONE TOXICITY

Ozone inhalation can be toxic to the pulmonary system and other organs²⁷. Complications caused by ozone therapy are infrequent at 0.0007 per application. Known side-effects are epiphora, upper respiratory irritation, rhinitis, cough, headache, occasional nausea, vomiting, shortness of breath, blood vessel swelling, poor circulation, heart problems and at a 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.^{2, 28}

Figure 1

Figure 1: An Adapted silicone cap for Ozone disinfection in root caries.



Figure 2

Figure 2: Healozone Unit



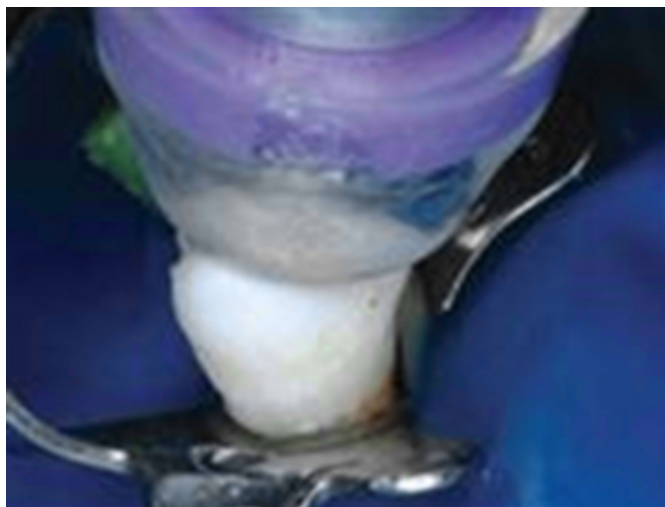
Figure 3

Figure 3: TherOzone Unit



Figure 4

Figure 4: Disinfection with Ozone gas using a silicone cap of Healozone Unit for pit and fissure caries.



DISCUSSION

Ozone is clinically easier, less expensive and faster when compared with other antimicrobial and oxidant caries treatments. Ozone should not be compared to conventional drilling and filling approaches. Since ozone is the most powerful antimicrobial and oxidant that can be used in dentistry thus fairly obvious that ozone should be used in combating the microorganisms associated with dental caries. Since aqueous ozone exhibits the highest level of biocompatibility compared to commonly used antiseptics, it should be considered for extensive use in this area of dentistry.²⁹

Ozone should be considered an adjunct to existing treatment and preventive methods rather than an isolated treatment modality. The vast majority of the dentists that are using ozone therapy treatments today use the treatment in conjunction with plaque and diet control, chemotherapeutic approaches such as fluoride or chlorhexidine, sealants, and stepwise excavation. It is thus clear that clinical dentistry has adopted ozone to be used in conjunction with other clinical approaches, not as an alternative.⁶

The new Caries Elimination System, based on ozone (O₃) gas, is delivered through a hose and handpiece into a polymer cup that is placed around the tooth surface to be treated. The ozone penetrates through the decayed tissue, eliminating any bacteria, fungi and viral contamination. It also denatures the acid metabolites of the bacteria when delivered in 10-second bursts, ozone gas at a concentration of 2,200 ppm can eliminate 99 per cent of the micro-flora, and so halt the decay process. (Fig 4)

The solubility of ozone in water (50 ml ozone in 100 ml water at 0°C) is tentimes greater than that of oxygen. The half-life of ozone ranges from 1 hour at 22°C²⁸ to approx. 3 hours at 4°C, when double-distilled water is used as a solvent.

CONCLUSION

Ozone has a place in 21st century oral health care: its proven powerful antimicrobial efficacy and undoubtedly potent oxidant ability, reduces cariogenic microorganisms and provide beneficial effects against organic acids in lesions, in conjunction with existing management strategies for dental caries to tip the “caries balance.”

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