The use of ozone in dentistry – a case study

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Ozone gas is a highly effective surface disinfectant for instruments, implants and prostheses. As a result of the spontaneous and catalyzed breakdown of the molecule, it is suitable for use in the mouth during surgical interventions; the positive biophysical properties mean that it promotes wound healing and epithelization and reinforces the natural antiradical principles of cells (by means of enzyme induction).

Ozone gas can also support professional prophylaxis. In part 2 of this series, the application will be presented in a severe case of Parodontitis marginalis in the frontal region of the upper jaw, which it was possible to clinically significantly improve by repeated application of ozone gas (Prozone). Ozone gas also demonstrably helps in the treatment of surface caries (fissure, occlusal and root caries). Initial results indicate that ozone may also be used in the treatment of periimplantitis and endodontal infections. It is more biocompatible and less cytotoxic than sodium hypochlorite.

Key words: Ozone – disinfectant – oral pathogenic microflora – co-cultures of micro-organisms and teeth – ozone gas application for fissure and root caries, periodontitis and periimplantitis – positive biophysical effects
Ozone as an antimicrobial principle in models of dental infections

Nagayoshi et al. have studied the efficacy of three different concentrations of ozone water (0.5, 2, and 4 mg/ml in distilled water) on the time-dependent inactivation of cariogenic, periodontopathogenic and endodontopathogenic microbes (Streptococcus, Porphyromonas gingivalis and endodontalis, Actinomyces actinomycetemcomitans, Candida albicans) in culture and in biofilms. Depending on the dosage, the oral microbes were inactivated after 10 seconds. Anaerobes were particularly sensitive to ozone. Candida was more resistant (approx. 90% reduction after incubation with the highest ozone concentration).

Baysan et al. have studied the antibacterial effect of ozone gas (HealOzone) on moist lesions of primary root caries (0.25% ozone in air with a gassing rate of 13.3 ml/sec.) in freshly extracted human teeth in vitro. 40 soft lesions were divided into two groups, in order to compare the efficacy of 10 and 20 seconds of exposure to ozone. Each lesion was first divided into two halves using a sterile blade; one half was exposed to ozone, the other half was left as a control. Both types of sample were then put in an anaerobic culture medium and incubated for 4 days at 37°C. In the samples treated with ozone gas, the microbe concentration was significantly and time-dependently reduced.

Nagayoshi et al. used dentin blocks from cows’ teeth to study the role of bacteria in endodontal infections and caries. Colonies of Enterococcus faecalis and Streptococcus mutans were co-incubated with sterilized dentin blocks for 6 days. The root canals of the infected dentin blocks were either irrigated with ozone water for 10 minutes or treated with ozone water plus ultrasound; as a control, they were also treated with distilled water with and without ultrasound. Sodium hypochlorite (NaOCl; 2.5%, i.e. the clinical concentration) was used as a reference disinfectant; it eliminated all living bacteria in the dentin. Ozone water reduced the amount of streptococci and enterococci in the dental tubules; when ozone was combined with ultrasound treatment, more than 90% of the bacteria were killed. From these results, the authors have concluded that ozone water can be considered to be a potential root canal disinfectant that is less cytotoxic than NaOCl. NaOCl can cause necrosis while ozone water is exceptionally biocompatible. Steier and Steier have suggested combining a less cytotoxic concentration of NaOCl (1.25%) with ozone.

The results of Nagayoshi et al. have been confirmed by Huth et al. (2008) in a root canal culture model (biofilm formation after incubation of teeth with Pseudomonas aeruginosa, Enterococcus faecalis, Peptostreptococcus micros and Candida albicans): Depending on the dose and species, ozone gas and/or ozone water reduce the amount of bacteria.

Lynch and Swift (2008) have acknowledged the published information on the role of ozone as an optional, complementary root canal disinfectant and concluded that "as ozone is the most powerful antimicrobial and oxidant we can use in endodontics, and as aqueous ozone revealed the highest level of biocompatibility compared with commonly used antiseptics, then
it is fairly obvious that ozone should be used to help combat the microorganisms associated with infected root canals”.

Clinical application of ozone in cases of caries

Baysan and Lynch\textsuperscript{16, 17} have investigated and clinically assessed the effect of ozone on 70 primary root caries lesions in 26 patients. Prior to the treatment, a biopsy was taken from the centre of the caries (half of the lesion) in order to determine the number of colony-forming bacteria as a reference value. After 10 or 20 seconds of treatment with ozone gas, the second half of the exposed lesion was removed in order to analyze the bacteria content. Treatment with ozone gas significantly reduced the number of micro-organisms in the primary root caries lesions in a time-dependent manner with no sign of side effects. Three months after the application of ozone, 33 out of 65 lesions (51\%) exhibited an increase in hardness, 27 exhibited a fall in the degree of severity from index 2 to index 1 (52\%) and 5 lesions remained unaffected. 51\% of the root caries lesions had become hard. From these observations, the authors reasoned that this new form of treatment could be considered as an alternative to the conventional procedure (“drilling and filling”).

The same authors (Baysan and Lynch)\textsuperscript{18} carried out a longitudinal study on the effectiveness and safety of ozone with and without sealing procedures (Seal and Protect, Dentsply, Konstanz /Germany) in root caries. 80 patients with 226 lesions were included. After 12 months, 47\% of the lesions had hardened and required no further treatment, while the lesions in the control group were unchanged.

Holmes\textsuperscript{19} performed a double-blind, randomized and controlled study of the treatment with ozone of non-cavitated leathery primary root caries in 89 adults (observation period of 18 months). The two lesions of each patient were assigned either to a control group (treatment with air) or the verum group which was treated with ozone gas (concentration of 2.1 ppm applied over 40 seconds at a rate of 615 cm\textsuperscript{3}/min). After the ozone treatment, remineralization solution was applied. The participants in the study were recalled for review after 3, 6, 12 and 18 months. After 18 months, 100\% of the lesions that were treated with ozone were in a satisfactory clinical state, while 37\% of the lesions in the control group had deteriorated. 54\% of the lesions in the control group remained leathery (unchanged). From these results, the authors reasoned that surface primary root caries lesions that have become leathery can be prevented from worsening or even improved by using ozone gas and sealing.

Huth et al.\textsuperscript{20} performed a controlled prospective study on the effect of ozone on non-cavitated fissure caries in permanent molars. Initial occlusal caries lesions on one half of the jaw were compared with a corresponding lesion on the contralateral half of the jaw. Forty-one patients with 57 pairs of lesions were included in the study. Ozone gas (HealOzone) was applied over 40 seconds to the test molars (without sealing). Exploratory data analysis
revealed that the lesions that had been treated with ozone exhibited a better healing tendency or delayed progression of the caries, compared to the untreated lesions. Ozone treatment was therefore able to improve non-cavitated initial fissure caries in patients with a high risk of caries. This form of treatment is ideally suited to uncooperative and anxious children with circumscribed surface caries lesions. 21

In a recent overview, Lynch and Swift (2008)22 stated that “ozone’s place is for us to use its proven powerful antimicrobial efficacy and potent oxidant ability, to reduce cariogenic microorganisms, and provide beneficial effects against organic acids in lesions, in conjunction with our existing management strategies for dental caries to tip the ‘caries balance’.”

Use of ozone in implantology

We have suggested (Baumgarten, 2006)23 using ozone to treat periodontitis in patients who are candidates for receiving implants, and in order to disinfect the mouth before surgical interventions, to disinfect drilling holes before the implantation, to disinfect implants before operation and to disinfect the operation site during and after operation, as part of the prophylaxis and treatment of periimplantitis. The use of ozone in dentistry and oral surgery is recommended due to its numerous positive biophysical properties (cf. table 2).

Conclusion

Ozone gas is an effective surface decontaminant. Ozone water reduces the level of microbial contamination, reduces organic material in biological media and facilitates wound healing after oral surgery as a result of positive biophysical properties (increased defence against radicals, induction of acute phase proteins, improved natural immunity, increased synthesis and release of growth factors, improved microcirculation, accelerated epithelial regeneration). Ozone dissolved in water is more biocompatible and less cytotoxic to oral cells than sodium hypochlorite. The application of ozone gas to surface caries lesions (with or without sealing) demonstrably improves clinical findings. The potential of ozone in the treatment of periodontitis, periimplantitis and endodontal infections needs to be investigated in further controlled studies.

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**Table 2: Positive biophysical properties of ozone**

Increase in antiradical potential through induction of antioxidant enzymes (e.g. SODs, GSH peroxidases and haem oxygenase-1)

Induction of the stress-reactive synthesis of acute phase proteins (e.g. CRP)
Activation of the “oxidative burst reaction” of neutrophiles
Increase in natural killer cell functions
Activation of key molecules that promote inflammation, e.g. NFkB Increased synthesis of inflammatory and anti-inflammatory cytokines
Increased synthesis of growth factors, e.g. TGFβ
Improved microcirculation and haemostasis as a result of NO synthesis
Reoxygenation of hypoxic tissues
Increased regeneration of epithelia
Recruitment of stem cells (see references no. 23 and 24)