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
Introduction.
It is an astonishing thought that 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. Oral surgeons and dentists used ozone to combat infectious complications in patients with implants. One pioneer of ozone treatment was Sandhaus in Zürich, who developed an ozonizer for the parallel application of ozone gas and ozonized water. In an important contribution to practical dentistry, he presented two patients with implants who were suffering from aggressive mucositis and palatinal empyema respectively. In the first case, Sandhaus used professional cleaning methods, irrigation with ozone water and a series of ozone gas applications. In the second case, he performed an incision in order to drain the empyema and rinsed the infected area of the submucosa with ozone water and ozone gas insufflations. These measures were repeated every day for a week. In both cases, infectious complications were successfully combated. Sandhaus considered the application of ozone to be better than chemotherapy.

A short summary of the use of ozone in practical implantology has been published by Koch. Between 1969 and 1974, 618 implants were used on 289 patients. Regular inspection revealed a long-term failure rate of 3.8%. All successful implants had had the benefit of pre-, peri- and post-operative application of ozone water. Koch suspected that the successful implant integration rate was due to the use of ozone. There is, however, no information about the failure rate in controls not using ozone.

Another pioneer of the use of ozone in both preservative and operative dentistry was Türk, who has published an extensive list of indications (see table 1). As a result of significant technological progress (e.g. OzonyTron, Mymed, Töging/Germany, HealOzone, KaVo, Biberach/Germany and Prozone, W&H, Laufen Obb./Germany), the use of ozone in dentistry has once again become popular in recent years.

Ozone as a disinfectant
Ozone has long been used as a water disinfectant due to its reliable oxidation quality with regard to chemical, organic and biological impurities. It is suitable for reducing bacterial contamination in dental water and in dialysis systems. If it is introduced at
regular intervals, it can prevent the formation of biofilms in tubes and hose systems. Further additives (e.g. hydrogen peroxide) are usually needed to increase the efficiency. A Europe-wide study of water quality in dental practices revealed that the recommended limit for microbe concentration (max. 200 colony-forming units/ml water, in accordance with the guidelines of the American Dental Association) was exceeded in 51% of all water supply systems tested (237 practices) (high proportion of opportunistic bacteria, e.g. Legionella pneumophila, Pseudomonas aeruginosa, mycobacteria and coliform species). This is an unfavourable situation, as these practices also treat patients with weak immune systems, for whom such bacterial contamination is dangerous.

As a result of its potency as an oxidizing agent (the third strongest oxidizing agent after fluorine and peroxysulphate) and because of its rapid metal ion-catalyzed breakdown with intermediate formation of oxygen and hydroxyl radicals, ozone is a suitable candidate for the reduction of bacterial, endotoxic and organic contamination in water systems. On a molar basis, ozone is several hundred times stronger as an oxidizing agent than hydrogen peroxide. In small concentrations, it reacts synergistically with hydrogen peroxide and readily destroys organic material. It is a self-limiting oxidizing agent as a result of its tendency to spontaneously break down into oxygen and highly reactive singlet oxygen (23 kcal/mol), that in turn reacts with water to form hydroxyl radicals and hydrogen peroxide. This process is accelerated by the presence of transition metal ion redox systems (Fe++, Cu++) or titanium. The ozone concentration in a biological medium is reduced by thiol reagents (e.g. reduced glutathione, GSH or cysteine), and by amino acids, proteins and other organic molecules; this significantly reduces the potency of the ozone in the organism. The solubility of ozone in water (50 ml ozone in 100 ml water at 0°C) is ten times greater than that of oxygen. The half-life of ozone ranges from 1 hour at 22°C to approx. 3 hours at 4°C, when double-distilled water is used as a solvent.

Most biological systems use di-oxygen as an electron acceptor. Oxygen is a weakly oxidizing bi-radical species. The electron uptake results in the formation of superoxide anion radicals (O²⁻). An example of this is the mitochondrial aerobic oxidation of substrates of the citrate cycle, which leads to permanent superoxide radical attack, which is detoxified by the action of superoxide dismutases (SODs). These enzymes detoxify superoxides by conversion into hydrogen peroxide. This is then converted into water and oxygen by catalases and GSH peroxidases. Oxygen radicals are also neutralized by small-molecular antioxidants such as vitamin E (tocopherol), β-carotene, reduced glutathione (GSH), cysteine and ascorbic acid.
Periodontitis and periimplantitis are associated with or caused by microbial pathogens; these include gram-negative anaerobic and gram-positive opportunistic aerobic bacteria\(^7\). These periodontopathogenic bacteria form bacterial biofilms (plaques) in the space between hard substances and soft tissues in the mouth or in dental water systems or dialysis systems. These biofilms render the bacteria they contain resistant to the host’s own defence mechanisms and systemically administered antibiotics. The challenge for the dentist and patient is therefore to combat, on a daily basis, bacteria that form biofilms, by means of mechanical measures and chemical disinfectants, as the only effective prophylactic principles for preventing the appearance and/or progression of periodontitis or periimplantitis.

Brauner\(^8\) has demonstrated that the combination of professional tooth cleaning and daily rinsing of the mouth with ozone water can improve clinical findings in cases of gingivitis and periodontitis. Plaque indices and a tendency to bleed, however, quickly return if the professional measures are interrupted. Rinsing the mouth with ozone water without any mechanical procedures for plaque reduction were unsuccessful.

Bibliography.

Table 1: Use of ozone in dentistry *

- Ozone-oxygen gas mixture:
  - preservative and surgical treatment
- Ozone water:
  - preservative and prosthetic treatment
- Disinfection of cavities
- Disinfection of root canals
- Use in periodontology and periodontal surgery
- Treatment of suppuration
- Treatment of difficult dentition
  - Use in upper jaw surgery
- Treatment of maxillary cavities
- Extensive disinfection of wounds
- Cooling of cutting and drilling attachments
- Rinsing of sources of bleeding for the purposes of haemostasis
- Disinfection of operation wounds

* modified according to Türk from the Ozone Handbook \(^3\)

Recruitment of stem cells (see references no. 23 and 24)