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## *Ozone Is the Most Effective Disinfectant for Dental Treatment Units: Results After 8 Years of Comparison*

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### *Abstract*

The method of disinfecting water in dental treatment units using ozone-containing water was first described 10 years ago. In an investigational period over the last 8 years, waters from the outlets of 14 treatment units were examined microbiologically in a total of 240 tests. Twelve of the treatment units, employing hydrogen peroxide/silver ion disinfection - after repeated sanitization - regularly exceeded the limits laid down in the regulations governing water purity, and *Pseudomonas aeruginosa* could be detected at 181 water outlets. However, germs could hardly be detected in any of the tests of waters sampled from the two treatment units using ozonated water disinfection.

### *Introduction*

At the water outlets (functional units) of dental treatment units, numbers of microorganisms are found which by far exceed the Limit and Guideline Values fixed at 100 colony-forming units per milliliter of water (CFU/mL) laid down by Federal German regulations for the treatment of drinking water (Borneff, 1986, Filippi, 1990, Gräf, 1983, Just and Michel, 1984, Metz and Sonnabend, 1984, Prucha and Tilkes, 1986, Schoenen and Wehse, 1988, Steinbock, 1990). In addition, problem organisms such as *Pseudomonas aeruginosa* or -- more rarely -- *Legionella* are frequently found (Borneff, 1986, Exner et al., 1981, 1982, Just and Michel, 1984, Metz and Sonnabend, 1984). In the past, various methods have been proposed for reducing the presence of germs, of which none have shown any satisfactory results up to the present (Borneff, 1986, Ciszewski, 1982, Exner et al., 1981, 1987, Hesselgren and Nedlich, 1981, Just and Michel, 1984, Metz and Sonnabend, 1984, Schoenen and Wehse, 1988). As a rule, preparations based on hydrogen peroxide with silver ion additives are nowadays employed. However, the concentrations of peroxide used (30-50 mg H<sub>2</sub>O<sub>2</sub>/liter of water) exceed the above-

mentioned limit values of the drinking water treatment regulations (0.1 mg/L) by a factor of many times -- a disadvantage of this process (Bundesministerium Für Jugend, Familie, Frauen Und Gesundheit, 1990, Filippi et al., 1991). But by reducing the concentration to the required limit, the disinfectant effect of H<sub>2</sub>O<sub>2</sub>/silver ion preparations becomes questionable (Institut Fresenius, 1985, Thofern and Exner, 1986).

A few years ago, the possibility of disinfecting water in dental treatment units with ozone was described (Filippi et al., 1991). In principle, this consists of an external enrichment of the water by means of passing an ozone/oxygen mixture through it in the form of miniature bubbles (Filippi, 1990, Häufele and Sprockhoff, 1973, Rilling and Viebahn, 1990). The ozonated water is fed into the treatment unit where it is kept available as a cooling and rinsing medium. Due to the rapid disintegration of ozone in water resulting from mechanical actions exerted on it when it leaves the unit (vortex action, atomization), no ozone can be found in the water any more (Filippi, 1990). Both from a toxicological viewpoint and in the context of regulations on the treatment of drinking water, the use of ozone as a water disinfectant is completely safe.

It was the aim of the present study to test the usefulness of disinfecting water with ozone in dental treatment units by examining the results of microbiological tests carried out on regularly taken water samples.

### *Materials and Methods*

At the Medical Centre for Dental, Buccal and Maxillary Treatment of the Justus-Liebig-University of Giessen (Germany), water samples were taken from 14 treatment units in different departments and examined microbiologically. The test involved 11 treatment units of the "Sirona M1" Type (Siemens, Bensheim, Germany), two of the "Varidul" Type (Emda, Offenbach, Germany), as well as an "Estetica 1042" unit (Kavo, Biberach, Germany). None of these units had any major differences as regards number of treatments and length of use per day. One each of the Siemens and Emda unit types were fitted with a water ozonization unit ("Cytoson", Hänsler, Iffezheim, Germany), the remainder had standard, integrated H<sub>2</sub>O<sub>2</sub> water disinfecting units. In this case, the "Dentosept PL" (Siemens, Bensheim, Germany) hydrogen peroxide/silver ion preparation was used as a disinfectant.

The taking of water samples and subsequent microbiological tests were carried out by the Institute for Hygiene of the Medical Centre for Ecology at the Justus-Liebig-University of Giessen, Germany. After first allowing it to run out for two minutes, samples of water were taken from all outlets of the dental treatment units concerned in the form of 100 mL fractions. The number of colonies was determined in accordance with regulations on the treatment of drinking water, by spreading 1.0 mL and 0.1 mL over an incubation medium and counting them after 48 hours (Bundesministerium Für Jugend, Familie, Frauen Und Gesundheit, 1990). The water samples were tested for *Pseudomonas aeruginosa* in accordance with the so-called membrane filter method (Bundesministerium Für Jugend, Familie, Frauen Und Gesundheit, 1990). The number of colony-forming units per milliliter water (CFU/mL) and the number of *Pseudomonas aeruginosa* per 100 mL water was determined.

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The study lasted in this way for 8 years. During this period, the 14 dental treatment units were examined microbiologically a total of 240 times at all seven outlets. Findings were recorded on a per outlet basis. Whenever microorganisms were found in the water, the entire unit received a basic disinfection with a 2% H<sub>2</sub>O<sub>2</sub>/silver ion solution, which had to remain inside the water system of the treatment unit for 24 hours (Thofern and Exner, 1986). A few days following this disinfection, a follow-up examination was carried out, which also included the drinking water used in the system.

### *Results*

At none of the water outlets were microorganisms found to be present in a total of 131 tests. The remaining 109 tests yielded the following results: in 176 water samples from separate outlets, numbers of microorganisms exceeding the limit of 100 CFU/mL laid down by the drinking water regulations; independently of this, *Pseudomonas aeruginosa* was found to be present at 181 outlets.

Dental treatment unit	Method of water disinfecting	Manufacturer	Number of water tests per unit	All unit outlets germ-free	Number of outlets > 100 CFU/mL	Number of outlets with <i>Pseudomonas aeruginosa</i>
1	H <sub>2</sub> O <sub>2</sub> /silver ion	Siemens, Germany	7	2	12	4
2	H <sub>2</sub> O <sub>2</sub> /silver ion	Siemens, Germany	10	0	11	20
3	H <sub>2</sub> O <sub>2</sub> /silver ion	Siemens, Germany	21	15	7	1
4	H <sub>2</sub> O <sub>2</sub> /silver ion	Siemens, Germany	25	9	8	13
5	H <sub>2</sub> O <sub>2</sub> /silver ion	Siemens, Germany	11	7	8	4
6	H <sub>2</sub> O <sub>2</sub> /silver ion	Siemens, Germany	24	15	31	30
7	H <sub>2</sub> O <sub>2</sub> /silver ion	Siemens, Germany	22	12	9	12
8	H <sub>2</sub> O <sub>2</sub> /silver ion	Siemens, Germany	24	13	22	14
9	H <sub>2</sub> O <sub>2</sub> /silver ion	Siemens, Germany	7	2	5	12
10	H <sub>2</sub> O <sub>2</sub> /silver ion	Siemens, Germany	17	7	7	31
11	H <sub>2</sub> O <sub>2</sub> /silver ion	Kavo, Germany	12	11	8	0
12	H <sub>2</sub> O <sub>2</sub> /silver ion	Emda, Germany	24	6	44	40
		<b>SUM</b>	<b>204</b>	<b>99</b>	<b>172</b>	<b>181</b>
13	Ozonated water	Siemens, Germany	15	14	1	0
14	Ozonated water	Emda, Germany	21	18	3	0
		<b>SUM</b>	<b>36</b>	<b>32</b>	<b>4</b>	<b>0</b>

Out of a total 204 tests, the *treatment units with hydrogen peroxide/silver ion disinfection systems* showed a total of 99 cases in which microorganisms were completely absent (i.e., findings were negative) in the water samples taken. All other findings resulted in microorganism counts above 100 CFU/mL and/or *Pseudomonas aeruginosa* at one or

several outlets. On an overall basis, no preference was shown by the organisms for any particular outlet.

By comparison, in a total of 36 tests, *the treatment units supplied with ozonated water* showed a complete freedom from microorganisms in 32 cases. At one outlet in each case, an increased number of germs was found at a maximum of 220 CFU/mL only in 4 of the cases tested; all other outlets showed a complete absence of microorganisms, i.e., negative results. *Pseudomonas aeruginosa* was not found in any single instance.

Investigation of the drinking water supplied to these units showed no microbial presence of any kind.

### Discussion

Disinfection with hydrogen peroxide/silver ion preparations frequently does not show satisfactory results at all outlets until a thorough disinfection of the entire system has been carried out. The deposit effect is slight; reinfestation with pathological microorganisms starts 15-39 hours after the last treatment (Ciszewski, 1982, Filippi, 1990). Where water is highly infested -- produced for example by extended intervals between treatment sessions -- hydrogen peroxide/silver ion preparations are not in a position to reduce the number of microorganisms to 0 CFU/mL (Ciszewski, 1982, Filippi, 1990). The principal reason for this lies in the fact that the inside walls of the water system are colonized by microorganisms living by a metabolic processing of the tube materials (Exner et al., 1982, Tuschewitzki et al., 1983). The organisms embed themselves in a fibrous, polysaccharide matrix capable of protecting them for the most part from hydraulic forces and disinfecting agents (Costeron 1980, Exner et al., 1981). When an infestation by microorganisms has been discovered, a basic disinfection of the entire system is undertaken with a 2% hydrogen peroxide/silver ion solution, which has to be kept in the water system of the treatment unit for 24 hours. During this period, dental treatment is not possible with the unit concerned. An increased concentration of hydrogen peroxide/silver ion preparation is not acceptable, as it exceeds by many times the limit of 0.1 mg/L laid down by the (German) Drinking Water Treatment Regulations (Bundesministerium Für Jugend, Familie, Frauen Und Gesundheit, 1990, Filippi et al., 1991).

By using ozone, it is possible to obtain a continuous freedom from microorganisms in dental treatment units. Although the deposit effect is hardly different to that of hydrogen peroxide/silver ion preparations (Filippi, 1990), no basic disinfection of the entire system is required, as the concentrations of ozone used were able to reduce the number of microorganisms to 0 CFU/mL, even after extended intervals between treatment sessions (Filippi et al., 1991). Thus, water tests conducted over a period of eight years confirm the efficacy of disinfecting the water in dental treatment units with ozone.

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*Key Words*

Ozone; Dental Treatment Units; Water Disinfection; Hydrogen Peroxide; Silver Ion; *Pseudomonas aeruginosa*;

*Résumé*

La méthode de désinfection de l'eau des unités de traitement dentaire par l'eau ozonée a été décrite pour la première fois il y a 10 ans. Au cours de la présente étude, qui a couvert les huit dernières années, un total de 240 échantillons d'eau prélevés sur 14 unités a été soumis à analyse microbiologique. 12 des unités, qui étaient désinfectés par le procédé combinant l'eau oxygénée et ions argent, ont régulièrement dépassé les limites fixées par la réglementation malgré des nettoyages complets et répétés; de plus, *Pseudomonas aeruginosa* a pu être détecté dans 181 rejets d'eau. Par contre, sur deux unités désinfectées par l'eau ozonée, presque aucune des analyses effectuées n'a pu détecter des germes dans les échantillons d'eau prélevés.

*Zusammenfassung*

Die Methode der Wasserdesinfektion zahnärztlicher Behandlungseinheiten mit ozoniertem Wasser wurde vor 10 Jahren erstmalig beschrieben. Im Untersuchungszeitraum von insgesamt 8 Jahren wurde das Wasser aus den Entnahmestellen von 14 Behandlungseinheiten insgesamt 240 mal mikrobiologisch untersucht. 12 Behandlungseinheiten mit Wasserstoffperoxid-Silberionen-Desinfektion überschritten - nach wiederholten Grundsanierungen - regelmäßig die Grenzwerte der Trinkwasser-verordnung und an insgesamt 181 Wasserentnahmestellen konnte *Pseudomonas aeruginosa* nachgewiesen werden. Im Gegensatz dazu konnten bei zwei mit ozoniertem Wasser desinfizierten Behandlungseinheiten in nahezu keiner der Untersuchungen Keime im entnommenen Wasser nachgewiesen werden.