Stomatologija. Baltic Dental and Maxillofacial Journal, 22: 35-8, 2020

Coronavirus Disease-2019 and dental practice: A project on the use of ozonized water in the water circuit of the dental armchair

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SUMMARY

A novel coronavirus (2019-nCoV) is associated with human-to-human transmission. From its beginning in December 2019, the coronavirus disease 2019 (COVID-19) outbreak has spread globally from Wuhan and is now declared a pandemic by the World Health Organization (WHO). The person-to-person transmission routes of 2019-nCoV includes direct transmission, such as cough, sneeze, droplet inhalation transmission, and contact transmission, such as the contact with oral, nasal and eye mucous membranes. The participants in dental practice are exposed to a severe risk of 2019-nCoV infections because of the face-to-face communication and the exposure to saliva, blood, and other body fluids. Dental professionals play great roles in preventing the transmission of 2019-nCoV. Since ozone has a proven anti-viral action, we present a project on the use of ozonized water in the water circuit of the dental armchair, in order to lower the viral load during dental practice in dental clinics and hospitals.

Key words: COVID-19, ozone, dentist, decontamination.

INTRODUCTION

The current ooutbreak of the novel coronavirus strain (2019-nCoV) constitutes a public health emergency of global concern (1). Symptoms of coronavirus disease 2019 (COVID-19) include fever, cough, and acute respiratory disease, with severe cases leading to pneumonia, kidney failure, and even death. The severe respiratory illness caused by the COVID-19 was first detected in Wuhan, Hubei, China, and the infection has spread worldwide (2). Although patients with symptomatic COVID-19 have been the main source of transmission, recent observations suggest that asymptomatic patients and patients in their incubation period are also carriers (1, 2). This epidemiologic feature of COVID-19 has made its control extremely challenging, as it is difficult to identify and quarantine these patients in time. Besides, it remains to be proven whether patients in the recovering phase are a potential source of transmission (1, 2). Dental professionals play great roles in preventing the transmission of 2019. In addition to the infected patient's cough and breathing, dental devices such as high-speed dental handpiece or ultrasonic instruments, using high-speed gas, can spread the patient's secretions, saliva, or blood to the surroundings.

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INFECTION CONTROL DURING DENTAL PROCEDURES

Because of the unique characteristics of dental procedures, where a large number of droplets and aerosols could be produced, the standard protective measures in daily clinical work are not effective enough to prevent the spread of COVID-19, especially when patients are in the incubation period, are unaware they are infected, or choose to conceal their infection. Particles of droplets and aerosols are small enough to stay airborne for an extended period before they settle on environmental surfaces or enter the respiratory tract. Thus, the 2019-nCoV has the potential to spread through droplets and aerosols from infected individuals in dental clinics and hospitals (1, 2).

Infection prevention and control during health care is recommended when COVID-19 is suspected. According to relevant guidelines and research, dentists should take strict personal protections and avoid or minimize operations that can produce droplets or aerosols (1, 2). Meng *et al.* described the recommended measures for dental practice, from the dental environment to the evaluation of the patients, till the treatment (2). During the dental treatment, the use of personal protective equipment, including masks, gloves, gowns, and goggles or face shields, is recommended to protect skin and mucosa from (potentially) infected blood or secretion. Because the respiratory droplets are the main routes of 2019-nCoV transmissions, particulate masks (FFP2-standard masks set by the European Union) are recommended for routine dental practice. The use of rubber dams and saliva ejectors with low or high volume can reduce the diffusion of droplets and aerosols (2-3).

High-speed rotating instruments, such as a dental turbine handpiece, which has a maximum rotation capability of 400 000 revolutions per minute when used for tooth trimming, create contaminated splatters and particulate mists. Dentists and oral healthcare workers are frequently exposed to microbial pathogens, because such splatters contain oral fluid and tissue debris (4). When high-speed instruments are used, oral bacteria can be detected 2 metres away from patients. Thus, the risk of pathogen transmission from patients is not contained within a limited distance of the treatment site and staff as well as other patients in the general vicinity may have a risk of inhalation of oral microbes when high speed instruments are used (4). Effective infection control strategies are needed to prevent the spread of 2019-nCoV through these contact routes.

PROJECT ON THE USE OF OZONIZED WATER IN THE DENTAL UNIT WATERLINES (DUWL)

Dental unit waterlines (DUWL) are highly contaminated during dental practice. Microorganisms enter dental unit delivered by incoming municipal water and from the oral cavity of patients undergoing dental treatment. In this last case, they can be transmitted directly by projection on skin and membranes or they can be disseminated by aerosol spray created from dental hand-pieces and air/water syringe [5]. Bio-aerosol could be detected at a horizontal distance of 1 meter and at a vertical distance of 50 cm from the patient's oral cavity, remaining in suspension for twenty minutes (5-6). In addition, many Authors demonstrated the presence of a medium-low level of bacterial and fungal contamination in the air of dental offices (5-6). Although dental units disinfection systems and anti-retraction valves have been created in the past years, the new COVID-19 emergency requires new strategies to protect subsequent patients and dental staff during dental care (7). It is therefore needed to investigate highly effective disinfection methods to tackle pathogens such as 2019-nCoV (2).

Ozone

Ozone (O3) is a very strong oxidant and it has been widely used as a disinfectant and germicidal agent, both for food industry and medical purposes. Ozone has strong oxidizing properties and has long been used for disinfecting drinking water (8). Many studies reported that disinfection is achieved rapidly and it appears that the inactivation effect of ozone is more efficient than that of disinfectants such as chlorine, chloramines and chlorine dioxide (ClO2); moreover, ozone can also oxidize and degrade organic substances in water (9). The concentration of ozone needed

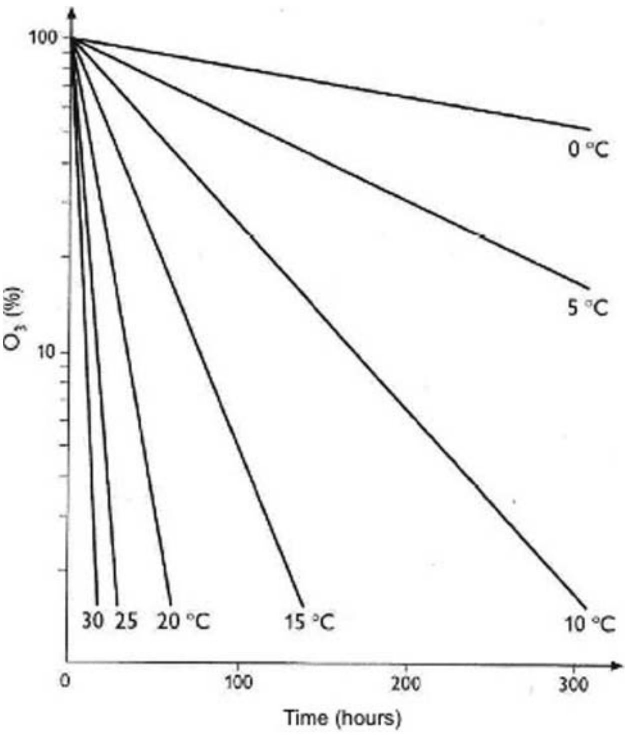

Fig 1. 1 Ozonized water decay according to the temperature (Guidelines of the Italian Oxygen – Ozone therapy Society – 22/4/2013)

to disinfect drinking water is extremely low: effective disinfection can be achieved with ozone application of 0.4 mg/L for 4 min (10). These findings indicate that ozone has a very broad profile as a water disinfectant. Oxidation treatments of food, water and human diseases by ozone showed a high effectiveness and safety profiles and they are relatively inexpensive. Toxicity by oxidation represents a broad spectrum of action against pathogens. Due to its strong oxidation properties, ozone is likely to be effective on an extremely wide range of microorganisms, including viruses that have not been studied yet. The anti-viral action of ozone was assessed in 1982 by Bolton *et al.*, who found out that ozone exposure rapidly inactivated the enveloped vesicular stomatitis virus (VSV) in bovine cell cultures, even at low-concentration (11). A study conducted by Zaky *et al.* on patients with chronic hepatitis C virus (HCV) demonstrated that ozone treatment in the form of major auto-hemotherapy (MAH) significantly improved patient general health, normalizing hepatic enzymes and reducing HCV RNA load (12). A recent study on poliovirus by Jiang *et al.*, demonstrated that ozone inactivates poliovirus type 1 (PV1), primarily by disrupting the 5′-non-coding region (5′-NCR) of the PV1 genome. Their study also revealed that ozone specifically damaged the 80-124 nucleotide region in the 5′-NCR and recombinant viral genome RNA infection models confirmed that PV1 lacking this region was non-infectious (13). Some authors suggested that viral inactivation may be associated with capsid protein damage (14). It seems that ozone primarily degrades protein capsid into subunits and liberates RNA; naked RNA may be secondarily inactivated by ozone itself, being the destruction of the viral nucleic acid by ozone the main reason for virus

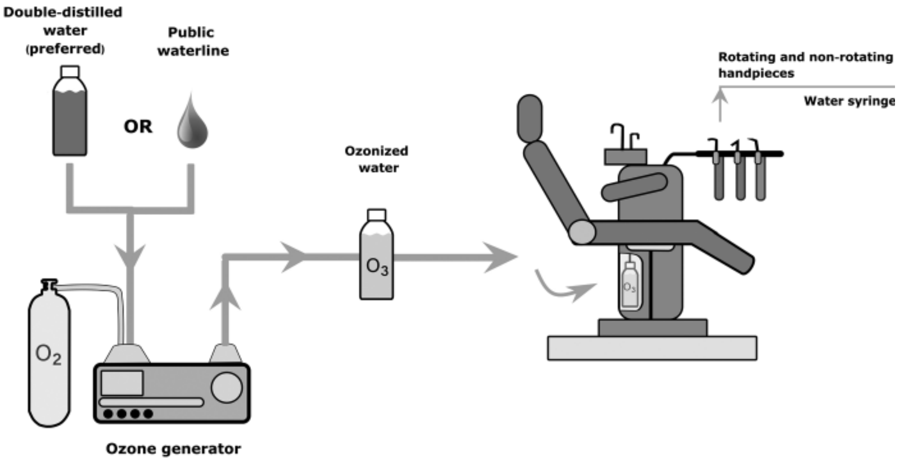

Fig 2. Project on the insertion of ozonized water into the dental unit to supply rotating and non-rotating handpieces and air/water syringe

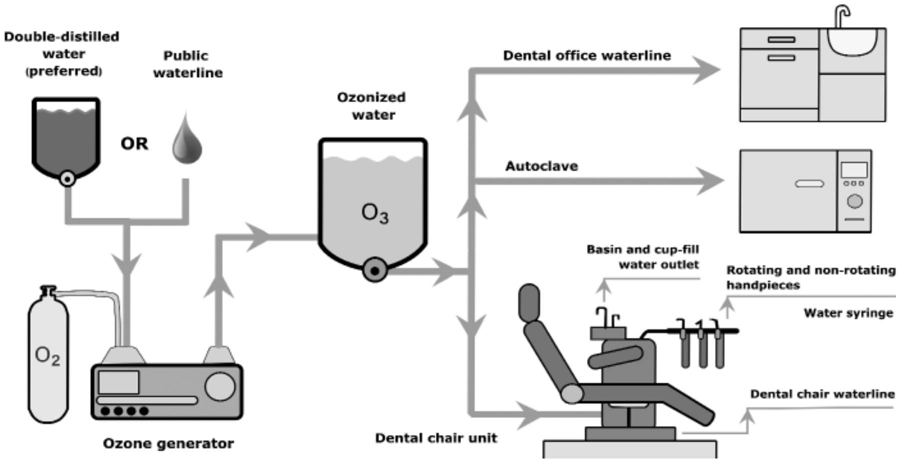

Fig 3. Project on the insertion of ozonized water in DUWL and all dental clinic water circuit

inactivation(14-15). Rowen *et al.* recently reported the effective use of ozone in Africa for the treatment of Ebola epidemic, where ozone was administered by systemic (direct intravenous gas and oral ozonized water assumption) and local methods (rectal ozonized water irrigation) (15). Within the limitations of a small sample size, ozone therapy has proven to reduce the severity, the duration of the disease course and to strongly reduce death and complication rates (15). Ozone is effective against fungi, bacteria and viruses and shows a broad oxidative biocide effect. Some viruses are much more susceptible to ozone's action than others. It has been found that lipid-enveloped viruses are more susceptible to ozone action than naked viruses (16). 2019-nCoV, SARS and MERS are all enveloped viruses. The possible mechanisms of antiviral action of ozone that have been suggested are: denaturation of virions through direct contact, peplomer alteration, lipid and protein peroxide formation, rapid activation of humoral and cell-mediated immunity, host-specific autovaccine creation, and anti-oxidant enzymes enhancement (12).

According to a Chinese experimental study, ozone kills Severe Acute Respiratory Syndrome (SARS) virus inoculated in experimental model cells, with a killing rate of 99%. Ozone as a disinfectant solution was tested at different concentrations for the inactivation of SARS virus, resulting in the inactivation of the SARS virus either at low (4.86 mg/L) and medium (17.82 mg/L) concentration and an extremely rapid inactivation at high concentration (27.73 mg/ L in 4 min) (17).

Researchers found that the novel coronavirus is over 80% similar to the SARS virus in their genome sequences (1-2). It is thus reasonable to predict that ozone is equally effective in preventing and controlling the new coronavirus. In fact, the Italian Scientific Society for Ozone Therapy (SIOOT) has recently released both a short communication that encourages ozone therapy on COVID-19 patients and a report of the first promising results in a small sample of treated patients (18).

The use of ozonized water (OW) in the water circuit (especially dental hand pieces and air/water syringe) of the dental armchair could contribute to break down viral load. Below we present a project of a water circuit of the dental armchair operating with ozonized water.

Project design

We present a project on the basis of the available medical ozone generator devices. For our purpose, we considered OZO2PLUS – Alnitec s.r.l., Cremosano (CR), Italia. This device (bubbler) can produce ozonized water with a concentration from 1 to 100 μg/ml and it is equipped with a spectrophotometric technology through which ozone concentration is precisely dosed and monitored. This device requires the oxygen to be supplied by a pure medical oxygen tank, instead of ambient air, thus providing an extremely efficient conversion index. Ozone is produced by corona discharge effect and immediately conveyed into water. The ozone generator should be filled with water (maximum capacity 3000 ml). Double-distilled water should be preferred over distilled or tap water, as it absorbs a greater concentration of ozone, about 20 to 25% of the total amount of the available gaseous ozone produced. The ozone generator could be regulated at 40 μg / mL of ozone gaseous concentration. This way, double-distilled water reaches ozone saturation within 5 minutes of bubbling, the final ozone concentration in double-distilled water being 8.0 μg/mL, which is currently the most suitable concentration according to the available Literature. A recent *in vitro* study compared OWs with different concentrations: 2 μg/mL, 5 μg/mL and 8 μg/mL and concluded that 8 μg / mL was the most efficient concentration (19). At the end of the preparation procedure, the ozonized water should be extracted and put in a glass bottle. OW can be stored in the refrigerator at about 4°C, since its half-life depends on the temperature (Fig.1).

For an immediate use, 1000 ml of double-distilled water can be promptly bubbled and OW can be manually inserted in the water tank of dental unit (Fig 2).

The maximum OW quantity prepared by this ozone generator is 3 liters. After the 3 liters has been stored or connected to the dental unit, the ozonization lasts for about 4-5 hours before the ozone decays occurs; at room temperature (20-25°C), O3 percentage in the water remains between 80 and 100%, enough to maintain its antiviral properties. In the future, the device could be modified to be connected at the start of dental unit water circuit. This way, OW could be steadily prepared and provided and it could directly reach not only hand-pieces but also all dental office units, sinks, autoclave, spittoons and glasses (Fig.3).

Medical ozonized water is safe for long-term use and has no effect on most of the dental unit materials such as silicone, stainless steel 304/316, brass and PTFE (20). However, some elements such as polyamide water pipes and aluminum components may be damaged by prolonged use of ozone. Therefore, it is always recommended to verify the specific ozone compatibility of all the materials before applying ozone to the dental office waterline. Should such systems spread in the future, ozone-resistant construction materials should be preferred.

We must be constantly aware of infectious threats that may challenge the current infection control regimen, especially in dental practices. When novel microorganisms with high infectious potential appear, additional precautions for airborne infection are required. Educational information and infection control procedures for these occupational risks are important and should be provided to all staff. Hopefully, specific new protocols advising the best suitable concentrations and exposure settings will shortly be available. The possibility to have a simple, fast, not expensive device able to reduce the viral load aerosol-related allows a high level of security for dental staff, patients and, consequently, to the whole population.

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Received: 01 06 2020
Accepted for publishing: 24 06 2020