

AIR DISINFECTION PROCEDURES IN THE DENTAL OFFICE DURING THE COVID-19 PANDEMIC

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ABSTRACT

The outbreak of coronavirus disease 2019 (COVID-19) generated a huge pressure on health care systems worldwide and exposed their lack of preparation for a major health crisis. In the times of a respiratory disease pandemic, members of the dental profession, due to having a direct contact with the patients' oral cavity, body fluids and airborne pathogens, are exposed to a great occupational hazard of becoming infected with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). The authors carried out a systematic literature search using the main online databases (PubMed, Google Scholar, MEDLINE, UpToDate, Embase, and Web of Science) with the following keywords: "COVID-19," "2019-nCoV," "coronavirus," "SARS-CoV-2," "dental COVID-19," "dentistry COVID-19," "occupational hazards dentistry," "ventilation," "air disinfection," "airborne transmission," "hydrogen peroxide disinfection," "UV disinfection," "ozone disinfection," "plasma disinfection," and "TiO₂ disinfection." They included publications focused on COVID-19 features, occupational hazards for dental staff during COVID-19 pandemic, and methods of air disinfection. They found that due to the work environment conditions, if appropriate measures of infection control are not being implemented, dental offices and dental staff can become a dangerous source of COVID-19 transmission. That is why the work safety protocols in dentistry have to be revised and additional methods of decontamination implemented. The authors specifically advise on the utilization of widely accepted methods like ultraviolet germicidal irradiation with additional disinfection systems, which have not been introduced in dentistry yet, like vaporized hydrogen peroxide, non-thermal plasma and air filters with photocatalytic disinfection properties. Due to its toxicity, ozone is not the first-choice method for air decontamination of enclosed clinical settings. *Med Pr.* 2021;72(1):39–48

Key words: occupational hazards, dentistry, airborne transmission, COVID-19, SARS-CoV-2, air disinfection

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INTRODUCTION

In December 2019, a new outbreak of a coronavirus disease took place in China and it soon became a serious global threat [1]. Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is responsible for a severe lower respiratory tract infection. The majority of infected people are either asymptomatic or develop a mild form of coronavirus disease 2019 (COVID-19). Unfortunately, it is estimated that 15–20% will suffer from a severe form of the disease and approx. 3.7% will die [2,3].

The basic reproduction number (R_0) of a virus is one of the key values that can predict whether a given infectious disease will spread into the population or die out [4]. For SARS-CoV-2 in the primary phase of the outbreak, R_0 was estimated to range 2.24–3.58 [5]. However, predicting the dynamics of COVID-19 cannot

be definitely obtained [6]. It has to be assumed that due to the highly contagious nature of the virus, it has an enormous potential for rapid spread in the global society. The countries which are currently fighting with COVID-19 are trying to reduce the surge of new cases, which creates a huge pressure on their health care systems [7]. A better understanding of the nature of SARS-CoV-2 is extremely important in the development of control measures, which will eventually stop the spread of this infection [1].

Dental staff is exposed to viruses, bacteria and fungi inhabiting the oral cavity and respiratory tract of the treated patients. Given the specificity of dental procedures, which involve prolonged and direct face-to-face dentist-patient and dental assistant-patient contacts, the risk of contracting COVID-19 is the highest from among all professions [8]. Due to the direct exposure to patients' pathogens and indirect contact with

microorganisms present both on surfaces and in the air of the dental office after aerosol generation procedures (AGPs) [9], if appropriate measures of infection control are not being implemented, dental staff and dental offices can become a dangerous source of COVID-19 transmission.

The aim of this review was to collect and analyze information regarding air disinfection procedures, which could be potentially utilized in the dental setting during the COVID-19 pandemic. Wearing face masks reduces the risk of airborne infections in healthy individuals; therefore, the World Health Organization advises on wearing them. However, the size of SARS-CoV-2 is 0.06–0.14 μm and filtering face piece (FFP) respirators assure efficient protection against particles which are $\geq 0.3 \mu\text{m}$ in diameter. For this reason, face masks are insufficient to provide full protection from the virus in the air [10]. One needs to bear in mind that the airborne transmission of the novel coronavirus, though not yet proven, poses a great potential occupational hazard to all medical professionals working in enclosed spaces.

METHODS

The authors carried out a systematic review of scientific literature related to air disinfection. Key articles were retrieved mainly from PubMed, Google Scholar, MEDLINE, UpToDate, Embase, and Web of Science. In all electronic databases, the following search strategy and key words (in the title/abstract) were used: “COVID-19,” “2019-nCoV,” “coronavirus,” “SARS-CoV-2,” “dental COVID-19,” “dentistry COVID-19,” “occupational hazards dentistry,” “ventilation,” “air disinfection,” “airborne transmission,” “hydrogen peroxide disinfection,” “UV disinfection,” “ozone disinfection,” “plasma disinfection,” and “TiO₂ disinfection.” To ensure literature saturation, the authors scanned the reference lists of the included studies or relevant reviews identified through the search. They analyzed all full text reports and decided whether they met the inclusion criteria. Only publications focusing on COVID-19 features, occupational hazards for dentists during the COVID-19 pandemic, and methods of air disinfection utilized in the clinical setting were eligible for the inclusion. The majority of the included scientific publications were published in January 1, 2016–May 11, 2020. Few earlier publications were also used because of their impact on the understanding of the nature of the procedures or because there were no recent relevant scientific works regarding the concerned topics.

RESULTS

Characteristics of SARS-CoV-2

The phylogenetic analysis revealed that SARS-CoV-2 is a new member of the *Coronaviridae* family. Coronaviruses (CoV) are a group of positive-sense, single-stranded RNA viruses of zoonotic origin. They can be further divided into 4 genera: α -CoV, β -CoV, γ -CoV, and δ -CoV. Notably, SARS-CoV-2 belongs to the β -CoV subgroup, together with severe acute respiratory syndrome coronavirus (SARS-CoV) and Middle East respiratory syndrome related coronavirus (MERS-CoV) [11]. The nucleotide sequence similarity between SARS-CoV-2 and SARS-CoV is 79%, and between SARS-CoV-2 and MERS-CoV about 50% [1]. The highly identical genome was previously isolated from the intermediate horseshoe bat (*Rhinolophus affinis*), which indicates that it might be the SARS-CoV-2 natural host. All coronaviruses have ≥ 4 structural proteins: S (spike), E (envelope), M (membrane), and N (nucleocapsid). Protein S is responsible for the fusion between the virus and the host cell during the infection. The SARS-CoV-2 diameter is approx. 0.125 μm [12], which allows the virus to penetrate through pores of most personal protective equipment (PPE) masks [13].

Ways of virus transmission

It is considered that viral respiratory infections spread by direct contact, such as touching an infected person or the surfaces and fomites that the person has either touched or on which large virus-containing droplets expired by the person have landed. The virus can remain stable for days. The droplets can also be deposited directly on another person. Another way of spreading is airborne transmission. After the droplets are expired, the liquid content starts to evaporate, and some droplets become so small that transporting by an air current affects them more than gravitation. Such small droplets are free to travel in the air and carry their viral content meters away from where they originated. So far, there has been no clinical evidence that for SARS-CoV-2 spreads this way, but it is known that SARS-CoV-1 did. That is why this possibility should definitely be taken into account [14].

Risk of COVID-19 in the dental office

Dentistry is based on AGPs like the use of dental handpieces, ultrasonic scalers, air abrasion, air-polishing, air-brushing, or 3-in-1 syringe tools. These devices emit significant amounts of the water-air spray which mixes with patients' secretions. The particles of the virus

get into the air, where they can stay up to 3 h before settling on the surface [15]. The period of time when the virus can stay alive on a given surface is determined by the type of material. It has been proven that SARS-CoV-2 can survive up to 5 days on metal, 4–5 days on paper, up to 4 days on glass, up to 4 days on plastic, 2–3 days on steel, up to 4 h on copper, up to 8 h on latex gloves, and up to 2 days on medical aprons [7,16].

The importance of disinfection of the clinical setting was demonstrated in a study from Singapore, where viral RNA was found on almost all tested surfaces (pens, light switches, a bed and handrails, and a sink) in the patient's room before routine cleaning. The patient demonstrated only mild symptoms of COVID-19 [17]. That is why dental staff can become infected by pathogens transmitted by direct contact with the patient's saliva droplets, indirectly through surfaces and instruments, which were in contact with the patient, and by inhalation of airborne microorganisms [14].

The guidelines on infection control of dental offices during the COVID-19 pandemic according to the American Dental Association (ADA) and the Center for Disease Control and Prevention (CDC)

In order to prevent unnecessary patient contacts, a complete telephone assessment should be undertaken to determine the need for a face-to-face appointment. It has been recommended that dentists should perform only urgent and emergency procedures [18,19]. Visits in the dental office should be planned in advance to avoid patient-patient contact. The procedures should be brief and the equipment required should be prepared before the patient's arrival to minimize the contamination of the dental environment. Appointments should be spaced in a way to ensure thorough decontamination of the dental office and air exchange. When entering the dental office, patients should be asked to wear face masks and disinfect their hands. The next step should be to perform a non-contact body temperature measurement and to submit a mandatory epidemiological declaration [10,19].

Appropriate PPE should be provided for all medical personnel. While performing a non-AGP on a non-COVID patient, disposable gloves, a disposable plastic apron, a fluid resistant surgical mask, goggles and a visor are required. When conducting an AGP, regardless of whether they are dealing with COVID or non-COVID patients, members of dental staff should be equipped with disposable gloves, a fluid resistant gown, a FFP3

respirator, goggles and a visor [20]. The proper doffing and donning of PPE are also important to prevent the infection of medical personnel.

In order to reduce the number of microbes, which are released into the clinical environment, a preprocedural antimicrobial mouth rinse for the patient is recommended. A 1% solution of hydrogen peroxide or a 0.2% solution of iodopovidone can be utilized [10]. An additional implementation of rubber dam isolation and high-volume suction can help to minimize the production of saliva and blood contaminated aerosol or spatter. The most important single method of preventing transmission of any infectious agent, including SARS-CoV-2, is hand washing and appropriate hand care [19,21].

Disinfection procedures for objects and flat surfaces should be executed in the following order: firstly, cleaning with disposable wipes moistened with a disinfectant, so as not to raise the spray, and secondly, spraying the surface and wiping it once more [10]. Chemicals that can be used to eliminate the virus include 62–71% ethanol, 0.5% hydrogen peroxide or 0.1% sodium hypochlorite, when applied for 1 min [16,22]. In addition, it has been shown that the virus lasts longer in rooms with 30–50% relative humidity, so it is important to keep the dental office dry [15,16].

Neither CDC nor ADA have provided any specific recommendations reading air disinfection during the COVID-19 pandemic. Only the utilization of upper-room ultraviolet germicidal irradiation (UVGI) and portable high efficiency particulate air (HEPA) units as an adjunct to higher ventilation and air exchange rates have been mentioned [19].

Ventilation and air-conditioning of the dental office

Due to the fact that there has been no evidence that live SARS-CoV-2 contaminates heating, ventilation and air-conditioning (HVAC) systems in buildings potentially exposed to this disease, CDC does not provide guidance on the decontamination of these systems. However, their recommendations regarding the proper maintenance of ventilation systems assume that such systems should provide air movement in a clean-to-less-clean flow direction. The filtration efficiency should be increased to the highest level, especially through the HVAC system, and the utilization of demand-controlled ventilation during occupied hours should be limited.

Dental offices should have adequate ventilation to remove infected air from the room and replace it with fresh air. This ensures that the right air composition,

temperature and humidity are maintained [23]. Ventilation systems can effectively help to control the transmission of infectious diseases in enclosed spaces [24]. When admitting a patient who is not suspected of being infected with COVID-19, the standard ventilation rate of ≥ 1.5 air change/h, both during and after the visit, should be provided. When a patient is suspected of being infected with COVID-19, mechanical ventilation with a constant 6 air change/h, both during and after the visit, is recommended [24]. The use of air purifiers with HEPA14 filters or higher, where the filtration efficiency is $\geq 99.995\%$, for particles $\geq 0.01 \mu\text{m}$, is highly recommended [10], especially while the patient is undergoing, and immediately after, an AGP [19].

Many dental clinics have air-conditioning systems. Poorly maintained ventilation and air-conditioning systems can be a potential source of fungal and other microbial organisms. Air-conditioning systems could, therefore, act as a vehicle for the transmission of microorganisms in the dental clinic. Some viral aerosols remaining in the dental clinic, after a working day and once the air-conditioning system is shut down, could also be recirculated again the next working day [25]. That is why air-conditioning systems should be periodically cleaned and disinfected, especially during the COVID-19 pandemic. A good method for air-conditioning disinfection is fogging [26]. It is also essential to establish a routine of opening the windows and exchanging the air between patients and after the working hours of the dental office.

Disinfection by fogging with hydrogen peroxide

Fogging is a widely used method of disinfection, which involves dispersing the disinfectant, together with an airstream, in the form of microscopic particles. The room is then filled with a mist (depending on the formulation) of various biocides. Hydrogen peroxide is a widely recommended agent for daily use in enclosed areas, like incubators, medicine trolleys, laboratory cabinets, rooms and pharmaceutical areas, operating rooms, isolation rooms, intensive care units and general medical wards [26,27]. It has been successfully used in room decontamination processes, either under the form of hydrogen peroxide vapor, vaporized hydrogen peroxide or aerosolized hydrogen peroxide [28]. It uses air particles in the room for spreading the disinfectant.

The solution of hydrogen peroxide, which is based on pure water and is activated by plasma, coats the surfaces in the room and acts as an oxidizing and disinfecting

agent, producing reactive oxygen species (ROS) that attack essential cell components such as DNA, lipids and proteins [28]. The product exhibits bactericidal, fungicidal, virucidal and sporicidal activity. Hydrogen peroxide is a more effective antimicrobial agent in the gaseous form, in comparison with the liquid form [27]. It is relatively safe for humans and the environment, because it easily degrades into water and oxygen, and no residue is usually found [26,28]. It is also safe for medical materials and devices. Importantly, it reaches places that are hard to get to, so that all objects in contact with the air are disinfected. In addition, these devices are easy to use and portable [29].

The disadvantage of this method is the fact that rooms have to be vacated and pre-cleaned to remove the visible dirt. Vapors must be moved around as they are irritating to the eyes, mucous membrane and skin. They may also cause lung irritation if inhaled. For these reasons, a disinfected room cannot be immediately occupied by the patient and the medical staff. The fumigation device should be operated by a trained personnel. This procedure is both time-consuming and expensive [27].

There is no data on the use of such a disinfection method in the dentistry setting. However, due to the decades of a successful use of vaporized hydrogen peroxide in other clinical settings, this method can certainly be recommended as an effective way to meet the new hygienic demands in dentistry.

Use of UVGI

Ultraviolet (UV) radiation has been used for almost half a century to annihilate airborne microorganisms in hospitals, laboratories, and dental offices. All bacteria and viruses tested so far react more or less to UV disinfection [30]. While the susceptibility of SARS-CoV-2 to UV has not been fully investigated yet, studies of other coronaviruses, including SARS-CoV and MERS-CoV, have proven their liability to this type of radiation [31,32]. The International Ultraviolet Association [30] has reported that UV disinfection may play an important role in reducing the transmission of COVID-19.

Generally, UV belongs to the electromagnetic wave radiation. It can be divided into UV-A with a length of 315–380 nm, UV-B with a length of 280–315 nm, and UV-C with a length of 100–280 nm [33]. Research conducted by Darnell et al. [32] has shown that only the UV-C light can exterminate viruses by disrupting their DNA base pairing and halting their reproductive capability.

Germicidal lamps are the source of UV-C radiation. They are designed to increase the effectiveness of manual chemical disinfection, which can leave residual impurities on the surface, and to reduce the risk of airborne infections. Nonetheless, if an object comes in line with the light, anything in its created shadow is not subjected to the germicidal effect of UV-C radiation. The further away from the source of UV-C the object is situated, the lower the light efficacy [34].

In UV-C flow germicidal lamps, the contaminated air is drawn through a filter into the disinfection chamber. It gives a possibility of intensive disinfection of the air in the presence of people. The UV-C direct radiation tubes provide an option of direct disinfection of the whole room when the personnel or patients are not present. The dual-function UV-C flow germicidal lamps combine these 2 options [35].

The effectiveness of UV-C flow germicidal lamps depends on the intensity of radiation, air movement, the amount of aerosol passing through the device per unit of time, the duration of action, the particle size, and humidity of the penetration barrier. When a virus enters the air during sneezing or coughing, it forms the nucleus of an aerosol droplet, as a result of which the virus is more resistant to UV radiation than its isolated form [36].

The evidence-based perioperative infection control protocol in the dental office should imply thorough cleaning between patients with the addition of UV-C radiation for 20–30 min [37]. There are also attempts on reprocessing PPE using UV radiation, but no explicit protocol has been established yet [38]. During the COVID-19 pandemic, UV-C lamps are an important aspect of the infection control protocol.

Ozone generators

Ozone generators are a group of medical devices, which are classified as IIb class and are certified in the European Union (CE – Conformité Européenne). They are used to disinfect enclosed spaces. Ozone is a gas that occurs naturally in the Earth's atmosphere. Being one of the strongest oxidants, it violently reacts with organic compounds. It is an effective bactericidal, fungicidal and virucidal agent [39].

The disinfection mechanism is based on the denaturation of viral envelope proteins which impair cell adhesion, the oxidation of unsaturated fatty acids, and which also form the lipid envelope, and the destruction of single-stranded RNA. Research by Hudson et al. [39,40] has shown the inactivation of influenza viruses, herpes

simplex viruses, coronaviruses, rhinoviruses and polioviruses after exposure to 100 ppm of ozone for 30 min.

Ozone can be easily produced from oxygen or air. It decomposes with the formation of oxygen, thus leaving no harmful by-products that would need to be eliminated. It has the ability to easily penetrate into all areas of the room, furniture and other objects, which is its significant advantage [39,41]. However, ozone causes some materials (e.g., natural rubber) to corrode. Also, for it to be effective, considerable humidity of the environment is necessary [42]. According to research by Sato et al. [43], for the virus to be inactivated, $\geq 80\%$ air humidity is required.

Considering that ozone is toxic for humans, ozonation can only be carried out in a sealed room, without any people inside. Effective ventilation systems and measurements of the concentration of ozone are necessary for the safe use of the room after the disinfection procedure, in order to check whether any residual ozone was efficiently removed or has decomposed. The U.S. Occupational Safety and Health Administration has set a standard of the safe ozone concentration for humans as 0.1 ppm for 8 h or 0.3 ppm for 15 min [39].

The construction of ozone generators includes humidifiers and sensors that control the level of humidity and ozone concentration. They provide the possibility to set the concentration of generated ozone and the working time of the device. It is believed that a concentration of 100 ppm for 10–15 min, or 20–25 ppm for 20–30 min is efficient enough. The optimal virucidal effect is obtained by increasing the ozone concentration to 25 ppm for 15 min, maintaining this concentration for 10 min, and then increasing the relative humidity to 95% and leaving it for additional 5 min [40,41].

Ozone therapy has proven successful in dentistry with managing wound healing in the oral cavity, oral lichen planus, gingivitis and periodontitis, halitosis, osteonecrosis of the jaw, post-surgical pain, dental caries, plaque and biofilms, root canals, dentin hypersensitivity, temporomandibular joint disorders and teeth whitening. Even though ozone has been used for disinfection of operating rooms since 1856 [44], today it is not the first-choice method.

Plasma

There are following states of matter: solid, liquid, and gas. If enough energy is applied to a gas, it becomes an ionized gas, known as plasma, which represents the fourth fundamental state of matter [45]. A state of plasma could be typically classified according to temperature.

The gas temperature of high-temperature plasma and thermal plasma is too extreme for treating living organisms. The gas temperature of non-thermal plasma remains low, making it suitable for biological applications. Electrical discharge methods used for non-thermal plasma generation in biological applications are generally categorized into 1 of the following: corona discharge, dielectric barrier discharge, glow discharge, microhollow cathode discharge, atmospheric pressure plasma jet, pulse discharge, or high/low-frequency discharge [46]. Plasma contains many charged particles (OH^- , H_2O^+ , electrons), activated and non-activated particles, UV photons (UVB, UVC), intense electric field, as well as ROS, including hydroxyl radical, hydrogen peroxide, singlet oxygen and ozone, and reactive nitrogen species (RNS), including nitric oxide, activated nitrogen and peroxyxynitrite [47,48].

Non-thermal plasma, generated in low-atmospheric pressure conditions, has biomodulating, stimulating, disinfecting and sterilizing properties [45]. It can be used in wound disinfection, the sterilization of tools, and the purification of air, water, sewage and food. Such a wide spectrum of non-thermal plasma applications is associated with its ability to inactivate biological agents such as viruses, bacteria, spores or fungi, with little impact on the structural integrity of the disinfected surfaces [47]. Their activity includes the oxidation of lipids and membrane proteins, which results in the disruption of the proper function of the cell membrane, eventually leading to cell disintegration. Electrostatic forces also have great influence on the integrity of the cell membrane. Charged particles generated by plasma accumulate outside the membrane, thus leading to its destruction. The disruption of cell surface structures may also be the result of the process of electroporation. This phenomenon is associated with an increase in the number of existing micropores induced by a pulsed electric field.

Reactive compounds can interfere with intra-cellular transport and induce DNA decomposition. Ultraviolet photons present in the plasma can change the structure of nucleic acids, leading to the formation of nitrogen base dimers and impaired DNA replication capacity [49]. However, ROS and RNS are probably the main contributors to the inactivation of viruses via non-thermal plasma [50]. It is currently suggested that UV radiation plays a minimal role in the plasma sterilization process [45]. Many studies have confirmed the biocidal effect of plasma, but the exact molecular mechanism of this action is yet to be established [47]. Plasma is successfully used in several devices applied for air

disinfection [51,52]. The non-thermal plasma disinfection method is environmentally friendly as it does not generate waste or toxic by-products, and does not use toxic chemicals. It is also easy and safe in handling [50].

Photocatalytic disinfection

Disinfection with the UV-C light may not always be effective due to its too low penetration depth. That is why there is a growing interest in the use of photocatalytic properties of titanium dioxide for disinfecting air, water and surfaces [53]. Oxidation processes involving titanium dioxide are stimulated by UV radiation and cause the formation of hydroxyl and peroxide radicals. These radicals cause various processes leading to oxidative stress and destruction of microorganisms [54]. The titanium dioxide-based photo catalyst has a great potential for inactivating pathogens. The titanium dioxide disinfection property is primarily attributed to the surface production of ROS, as well as the formation of free metal ions. It is worth noting that fresh titanium dioxide has strong biocidal activity even without UV irradiation [55].

Notably, titanium dioxide acts on a wide range of Gram-negative and Gram-positive bacteria, fungi, protozoa and viruses. Research conducted by Han et al. [56] showed the effectiveness of photocatalytic disinfection with titanium oxide against SARS-CoV-1, which also gives a high probability of the virucidal effect on SARS-CoV-2. The inactivation of viruses is initiated by the adsorption onto the catalyst nanoparticles, followed by the attack on the virus protein capsid and RNA [53]. Titanium dioxide activity can be increased thanks to the presence of copper or silver [56].

Filters made of silver and titanium dioxide activated by the UV light are a very interesting alternative for air disinfection. Such filters can be utilized in various ventilation or air-conditioning systems [54]. However, the fact that the efficiencies of photocatalytic oxidation (PCO) air purifiers depends on the design of the device and the indoor air properties, such as relative humidity, temperature and the composition of contaminated air, needs to be taken into consideration. With high relative humidity, water particles occupy the active surfaces of photocatalytic filters, where the radicals are produced, which decreases the effectiveness of these devices. Mohamed and Awad [54] conducted a study in which a self-made silver/titanium dioxide nanoparticle-based filter quartz system with an inside volume of 0.78 m^3 was designed and constructed. During the photocatalytic disinfection, the number of microorganisms was significantly declined and reached up to 0 colonies after 300 min.

In another research conducted by Chotigawin et al. [57], PCO air purifiers utilized in a 8 m³ laboratory chamber for 121 min also induced 100% air purity. The second phase of the experiment was conducted in a renal unit of a 800-bed public hospital. A PCO air purifier was located in a renal dialysis room with a capacity of 259.2 m³, which is more relatable to the conditions of a dental office. The experiment revealed that the disinfection properties of the PCO device decreased with the distance. After 90 min of the air purification, the rate of removed microorganisms was 63.5%, 23.9% and 28.2% for a distance of 2 m, 6.5 m, and 8 m respectively.

The surface coating with a thin layer of titanium dioxide nanoparticles can also be utilized in the dental setting, where UV radiation is often used for surface disinfection. This procedure significantly increases the effectiveness of decontamination and contributes to a radical improvement in the hygienic conditions. It is advised to apply ceramic wall tiles coated with a layer of titanium oxide [58]. Based on the obtained information, the authors suggest that other surfaces, for example, made of metal (dental handpieces, instruments) or rubber (gloves or rubber dams), and surfaces of medical sluice, could also be potentially covered with a thin layer of titanium dioxide nanoparticles. Photocatalytic oxidation occurring on surfaces coated with titanium dioxide can be a useful additional method of disinfection, but it is still under research and development.

CONCLUSIONS

Dental professions predispose to exposure to COVID-19 and many other infectious diseases. Repeated disinfection of air-conditioning systems in dental offices and frequent air exchange with mechanical ventilation are the key strategies to ensure occupational safety during the current pandemic. Following CDC's recommendations and on the basis of information included in this review, the authors believe that UV-C flow germicidal lamps and devices with HEPA filters provide additional useful methods of air disinfection. Devices which utilize disinfection by plasma and fogging with hydrogen peroxide can also be applied in the clinical dental setting. Due to its toxicity, ozone is no longer the first-choice method for air decontamination of enclosed medical spaces. Finally, photocatalytic disinfection (especially coating surfaces with a thin layer of titanium dioxide nanoparticles) is an interesting method of disinfection, but its practical benefits are yet to be established.

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