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Guideline: Dealing with aerosol-borne pathogens in dental practices

Introduction: It is well known that droplets and aerosols may cause infections in dental staff [21]. Therefore adequate protective measures against pathogens transmitted via droplets or aerosols from the patients' oral cavity are of great importance in dental practices. Due to close contact between dental professionals and patients' oral cavity and the formation of droplets, spray mist and aerosols during dental interventions, hygiene and precautionary measures are used in dental practice to prevent the transmission of infectious diseases.

Methods: Relevant information regarding the SARS-CoV-2 and COVID-19 pandemic was obtained from electronic databases such as PubMed, Cochrane library, Web of Science, using the following search terms: "SARS-CoV-2" OR "COVID-19", "airborne transmission", "mouth rinse", "dental", "aerosol" OR "aerosol generating procedures", "droplet", "FFP2" OR "FFP3" OR "N95" OR "mask". Latest reports and guidelines from major health authorities such as the Robert Koch-Institut (RKI), Centers for Disease Control and Prevention (CDC), World Health Organization (WHO), as well as major national dental associations and health regulatory bodies were also referred.

Results: Protecting dental professionals and patients from infections while ensuring basic dental care for the population is of paramount importance. With that in mind, this guideline presents recommendations for dental practitioners during the COVID-19 pandemic.

Keywords: droplets; aerosols; infections; COVID-19 pandemic; prevention; dental practice

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Providing basic dental care and ensuring personal protection in dental practices

The World Health Organization (WHO) associates aerosol-generating medical procedures with increased risk of infection for medical staff from SARS-CoV-2 [53]. Depending on the current situation of the pandemic, it is recommended to avoid these procedures if possible. However, aerosols must not be equated with the spray mist that occurs in dentistry. It is generally known that spray mist can contain pathogens, but in a form that is strongly diluted with cooling water. The term aerosol basically defines a suspension of liquid and solid particles with a diameter of 5 µm, deposits and living or dead microorganisms in a gaseous medium [48, 49]. Spray is a droplet mixture of air, water, solids with particles and is visible to the naked eye. A rebound effect of spray occurs after the impact on the tooth or soft tissue, emerges like a bell from the oral cavity in the work area and, in addition to the spray mist, contains germs, abrasive particles, saliva and possibly blood [11, 14]. The transition from "droplets" to "aerosols" and vice versa is smooth and depends on the ambient conditions. Both aerosol and spray can contain transmissible pathogens [3, 23]. The word aerosol is often colloquially used for all of these potentially infectious media for the sake of simplicity. However, it can be assumed that aerosol-generating dental procedures are certainly less infectious than saliva or bronchial secretions due to the high proportion of cooling water. The present guideline explicitly refers only to the formation of spray and aerosols during dental work.

Even if the regional prevalence of SARS-CoV-2 is high, all dental treatments that alleviate the patients' symptoms or prevent an existing disease from worsening must be guaranteed. It is important to differentiate between healthy or asymptomatic patients and suspected or confirmed COVID-19 infected patients, who should only be treated in compliance with special protective measures.

Triage of suspected cases

Suspected cases should be screened by phone or via a notice on the door at latest prior to the start of any dental treatment, preferably before the patient even enters the practice. Typical symptoms of an infection with SARS-CoV-2 and questions regarding potential contacts with COVID-19 positive patients in the past 2 weeks should specifically be asked. The body temperature might be measured as part of the triage of suspected cases. However, a large number of false positive results must be assumed. In addition, false negative results may occur if SARS-CoV-2 infected people show no signs of fever or antipyretic agents have been used [43].

Entering the dental practice

When entering the practice, patients should be asked to wear a mask covering both mouth and nose until the start of treatment as well as afterwards. Consistent implementation of basic hygiene including hand hygiene is expected. When entering the practice, patients should be asked to wash or disinfect their hands. Depending on the epidemiological situation, magazines, toys and other expendable items might be dispensed within the waiting room [34, 38]. Since transmission via contact surfaces cannot be ruled out, in addition to basic hygiene, regular disinfection of contact surfaces should be carried out [34, 52].

In order to protect risk groups from infection with SARS-CoV-2, the dental treatment should be integrated into the daily routine in a way that there is as little contact as possible with other patients. Suspected and confirmed COVID-19 cases should preferably be treated in special centers, clinics or practices. If this is not possible in exceptional cases, necessary treatments should be carried out in the dental practice in strategic and or scheduled separation from the patients attending regular consultation, while ensuring all hygiene and safety measures specified for this purpose.

Distancing

Patients should be kept at a distance from staff by observing the minimum distance of 1.5 m for registration [34, 38]. Installing plexiglass shields at registration to further protect employees from droplets. The distance between patients from different households should be at least 1.5 m in order to minimize the risk of the infection being transmitted via droplets [34, 38]. Employees should wear surgical masks permanently, even outside treatment rooms, and maintain the minimum distance requirement, also during breaks and in changing rooms [2, 6, 50].

COVID-Testing

Personnel showing symptoms of a COVID-19 infection should be isolated immediately and tested for the presence of an infection using PCR. There is not enough reliable data to routinely test symptom-free employees in dental practices, but it might be useful in case of a heightened risk situation.

Patients who show symptoms of a COVID-19 infection should only be treated in case of emergency until a negative test can be produced. In the event of a dental emergency, emergency treatment should be carried out in compliance with special protective measures.

Dental emergencies in symptomatic and infected patients

If possible, all dental treatments for symptomatic patients or confirmed COVID-19 patients should be postponed to a later date. In case of a dental emergency treatment (pain, abscesses, infections, complications e.g. secondary bleeding, trauma, etc.), the measures as described in table 1. should be applied:

- strict spatial separation from all other patients,
- patients should wear a surgical mask until the start of treatment,
- where possible, schedule emergency treatment at the end of the day,
- maximum PPE
  - (1) safety glasses/face shield
  - (2) FFP2/FFP3 or N95 mask
  - (3) hygienic hand disinfection
  - (4) disposable gloves
  - (5) headgear and socks (to reduce self-contamination)
  - (6) long-sleeved liquid-repellent protective scrubs
- Final cleaning and disinfection of all surfaces with at least limited virucidal surface disinfectants.

Diameter of the droplet	0.3 µm	0.5 µm	1.0 µm	5.0 µm	10 µm
Volume of the droplet	0.014 μm^3	0.065 μm^3	0.52 μm^3	65.5 μm^3	523.6 μm^3

Table 1 Relationship between volume and diameter of droplets

Aerosol formation in dental practices, protection through surgical masks and treatment cautions

Emission from persons

Droplets are mainly produced by humans when they speak (sing), cough and sneeze. Droplets that are created when speaking, coughing or sneezing range between 1 and > 10 µm in size [54]. The emission of particles containing bacteria acts 400 : 7 : 1 when sneezing : coughing : talking [15, 32, 41]. Droplets larger than 8 µm in size sediment on surfaces immediately, and no later than following a maximum of 20 minutes. With a size of around 4 µm, droplets sediment within 90 minutes. Smaller droplets (aerosols) can remain in the air for up to 30 hours and can then be transmitted over greater distances by air currents [15]. Depending on the relative humidity, droplets can turn into aerosols [7]. When droplets float in the air, they lose water and become so-called droplet nuclei, which are the size of aerosols. In stagnant room air, the size of the droplets reduces from 12–21 µm to around 4 µm within about 10 minutes [51].

The dehydration of droplets can (depending on the respective microorganism) kill or inactivate bacteria and viruses contained in the droplet. Hence the transition from droplets to droplet cores (or the drying out of aerosols) does not necessarily result in further infectivity of the microorganisms contained. Depending on surrounding conditions, the statements of experimental studies on the detection of SARS-CoV-2 viruses in aerosol that are capable of reproducing differ. Virus particles have been found in aerosols in some studies [29, 52]. Whether and how quickly the droplets and aerosols sink or remain suspended in the air depends on the size of the particles as well as a number of other factors, including temperature and humidity [26]. From the studies up to date, no statement can be made regarding the infectiousness of the virus particles.

Emission from water-cooled dental instruments

With the introduction of high-speed dental preparation instruments, the need for effective cooling of work areas arose in order to avoid thermal damage to the pulp-dentin system. The required amount of liquid for this lies at approx. 50 ml per minute. The liquid is swirled around and partially reflected on various intraoral structures and the instrument itself. Spray mist rebound contains both large liquid droplets and aerosols. The majority of the spray mist rebound consists of droplets ≥ 10 µm [5]. Around 90 % of the larger particles in the dental spray mist with a size of approx. 20 µm fall on the patient‘s face or body surface [38]. When using a dental turbine at a distance of 10 cm from the oral cavity of the treated patient, the number of particles with a diameter between 0.3 µm and 0.5 µm increased by a factor of 100 and for particles with a diameter of 7 µm by a factor 3 [27]. The number of particles ≥ 10 µm only increased by a factor of 1.7 when the turbine was used at a distance of 20 cm above the oral cavity, as they sediment quickly. Aerosols and droplets that arise during dental treatments are described in the literature with particle sizes of 0.5–20 µm [35, 40]. Due to their low sedimentation speed, aerosols can float several meters away and also infect people in other rooms or people who are in the treatment room at a later point in time [18]. However, the number of virus copies present in liquids, droplets or aerosols is not to be equated with infectious viruses. The exact infection dose required in virus copies to trigger an infection with SARS-CoV-2 is currently unknown.

Droplets contain significantly more liquid and therefore more microorganisms than aerosols, hence the necessary infectious dose is reached much faster through ingestion of a droplet. The following calculation of the amount of liquid transported in particles of the corresponding size is clear.

Effectiveness of surgical masks and simple textile mouth and nose covers that protect against large particles, as well as “physical distancing” of 1.5 to 2 m as part of the COVID-19 preventive measures indicate that SARS-CoV-2 is mainly transmitted by droplet infections [9, 55]. Both measures only reduce droplets, but not aerosols. Transmission of SARS-CoV-2 by aerosols has also been observed but requires longer contact times with the aerosol (choir samples) with low air exchange and/or increased humidity (slaughtering businesses) in the room in order to achieve the necessary pathogen dose. In dentistry, occurrences of such “super spreading events” are completely absent.

In conclusion, the current evidence base is insufficient to confirm or exclude airborne transmission with SARS-CoV-2 in the context of dental treatments [8, 36]. As such, procedures for reducing the spray mist, consisting of droplets and small, floating particles, represent basic occupational safety measures for the dental team. Since even trained, ergonomically designed dental technology cannot completely prevent the emission of droplets and aerosols from the patients’ oral cavity, putting in place additional measures to minimize the transmission of infection becomes inevitable.

Protective effect of face masks

The recommendations of the Commission for Hospital Hygiene and Infection Prevention (KRINKO) at the Ro-

Type of mask	Minimum retention capacity of the filter with regard to NaCl test aerosol [*respectively Staphylococcus aureus*]	Maximum permissible total leakage on subjects
FFP 1	80 %	22 % [a]
FFP 2	94 %	8 % [a]
FFP 3	99 %	2 % [a]
NIOSH N 95	95 %	10 % [b]
NIOSH N 99	99 %	10 % [b]
NIOSH N 100	99.97 %	10 % [b]
Medical masks (*S. aureus*)	[95 %]	Not specified

Table 2 Comparison of the requirements for particle-filtering half masks and mouth-nose protection (MNS) [13]; [a] Specified for FFP masks with NaCl aerosol in accordance with DIN EN 149 [12]; [b] For NIOSH-N masks derived from the Assigned Protection Factor (APF) of 10 specified by NIOSH. This requires a passed qualitative or quantitative Occupational Safety and Health Administration (OSHA) fit test [19].
(Table 1 and 2: L. Jatzwauk)

bert Koch-Institute are considered state of the art in the prevention of infectious diseases in Germany. In case of respiratory infections or pneumonia caused by coronaviruses (SARS, MERS), the use of an FFP2 mask is recommended. For patients infected with seasonal influenza A or B, one MNS is sufficient. On the other hand, KRINKO recommends a respirator to prevent avian influenza. Patients with open pulmonary tuberculosis should be treated using an FFP2 mask. Patients with open pulmonary tuberculosis caused by multi-resistant Mycobacterium tuberculosis (multi-resistant tuberculosis, MDR-Tbc, or extensively resistant tuberculosis, XDR-Tbc) require the wearing of an FFP3 mask with the same pathogen and transmission path. This shows that the recommendations based on a risk analysis are not only influenced by the quality of the "face masks", but also the clinical consequences to be expected in the event of an infection. The physical and technical testing of respiratory masks is carried out in accordance with DIN EN 149 under practical conditions. Subjects are exposed to an NaCl test aerosol wearing a respirator. The median mass-related particle size of the aerosol is 0.6 micrometers. However, even within these test conditions there is no absolute protection against the inhalation of aerosols (table 2).

Whether this protective effect is also necessary for infectious diseases that are transmitted by much larger droplets from the respiratory tract or by dehydrated aerosols cannot be derived from these model studies.

Recommended use of masks and face shields

The additional use of face protection shields might further increase safety. Dental staff should wear FFP2/FFP3 or N95 masks if contact with patients with suspected or confirmed SARS-CoV-2 infection takes place. During treatment of patients, who are not suspected to be infected with SARS-CoV-2, dental staff should wear a surgical mask. The best possible barrier function is guaranteed through correct fit of the surgical mask (good adjustment in the nose area and maximum lateral tightness). There is currently no reliable data available for the general wearing of an FFP2/FFP3 or N95 mask for all dental activities using water-cooled instruments.

Reusing masks

In the event of supply shortages in connection with COVID-19, mouth-nose protection and FFP/N95 masks might be reused or reprocessed for specific persons. A reasonable approach to reusing masks might be to provide each employee with at least 5 masks and to use them alternately every day, since a possible SARS-CoV-2 contamination of the 4 unused masks is inactivated after 5 days at the latest (European Centre for Disease Prevention and Control). Alternatively, preparation of masks specific to individuals might be carried out. Reprocessing should take place in sterilizers (e.g. at 121 °C), as the method has proven to be effective and gentle on the material [10].

Treatment precautionary measures

Rinsing the mouth or gargling with mucosal antiseptics shortly before dental treatment could briefly reduce potential virus concentrations in the throat and mouth and thus in the spray and aerosol [24]. Clinical studies regarding the reduction of SARS-CoV-2 currently do not exist for any of the mouth rinses listed below. There are indications of limited virucidal effects (against enveloped viruses) for the following antiseptics:

- ≤ 0,1 % Octenidin®
- 1–1,5 % H_2O_2 [38]
- 0.2 % Povidone-Iod [16, 28, 33, 34]
- 0.2 % Chlorhexidin [4, 33, 37]
- 0.2 % Cetylpyridinium Chloride [31]
- ≤ 0.25 % Natriumhypochlorit [20]
- Dequonal® [33]
- Listerine cool mint® [33]

Just before procedures, patients should be asked to rinse their mouth for 30–60 seconds. Further measures to reduce potential virus contamination by droplets and aerosols should be applied in the context of the respective pandemic situation and are listed below. Spray mist extraction system on the treatment unit, used with an effective systematic extraction technique, reduces the spray mist rebound and aerosols by 2/3 [42]. During dental treatments of suspected and confirmed cases, it is recommended to apply all protective measures as listed below.

There are currently no adequate scientific studies on the effectiveness of room air extraction in combination with HEPA filters or disinfection systems to reduce the viral load in dental treatment rooms.

Precautionary measures

If possible, a rubber dam should be installed [1, 11, 34, 38, 47]. Consistent and high-volume evacuation should be guaranteed. Attention should also be paid to a diameter-optimized suction cannula (≥ 10 mm). If this is guaranteed, there is currently no reliable evidence with regards to effectiveness of any additional suction devices [1, 11, 22, 25, 30, 46]. Large-volume spray mist suction should also be used for treatment methods that are carried out without assistance, such as professional tooth cleaning. After treatments in which aerosols have formed, ventilation should be effective [34]. Almost all instruments rotating rapidly or vibrating at high or highest frequency in the dental practice require a cooling medium. Powder-water blasting devices also require a combination of air, liquids and powder to generate the cleaning jet, which is why all these instruments are inherent in the system with a pronounced spray mist formation [1, 34]. Therefore, their use should be avoided in COVID-19 suspected cases, if clinically possible.

Conflicts of interest

Markus Tröltzsch is the author of a book in Quintessence – "Medicine in the dental practice", published since 23.10.2020, it contains an article on the topic "Corona". The author Christian Graetz gives credit for having conducted research projects on spray mist/aerosol formation by means of industrial cooperation (study support by Dürr Dental SE, Bietigheim-Bissingen, D; Loser & Co, Leverkusen, D). The other authors declare that there is no conflict of interest as defined by the guidelines of the International Committee of Medical Journal Editors.

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