Dental Aerosols: A risk for spread of Covid-19 in dentistry

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Abstract:
The outbreak of 2019 novel coronavirus (2019- nCoV), has strongly impacted the immune system of health care professionals, which challenged the system as treatment was not available. This disease was characterized by severe acute respiratory syndrome-corona virus-2 (SARS-CoV-2) and rapidly developed into a public emergency worldwide with an increase in cases and deaths. In dentistry, most dental procedures generate significant amounts of droplets and aerosols, posing potential risks of infection transmission. Understanding the significance of aerosol transmission and its implications in dentistry can facilitate the identification and correction of negligence in daily dental practice. In addition to the standard precautions, some safety precautions that should be implemented during an outbreak have been raised in this review.

Keywords: Corona virus disease 2019 (COVID-19); Aerosol; Infection control, precautions.

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INTRODUCTION:

At the end of 2019, an epidemic disease pneumonia with unknown etiology occurred in Wuhan, China. The cases were mostly linked to a local seafood market where live animals are sold, and these were the sources to transform pathogens from animals to humans and later on from human to human. The pathogen was recognized and named 2019 novel coronavirus (2019- nCoV), and the disease is called coronavirus disease 2019 (COVID-19).

The COVID-19 pandemic has strongly impacted the immune system of health care professionals, which challenged the system as treatment was not available.[1]

During clinical work, dental professionals are exposed to high risks of infection by 2019 novel coronavirus due to contact with blood, saliva, and other body fluids, combined with the handling of sharp instruments and procedures that generate aerosols.[2]

The 6th Edition of COVID-19 Treatment Regimen published by the National Health Commission of the People's Republic of China (2020) states that the possible routes of COVID- 2019 transmission are mainly by direct contact and droplet transmission. Aerosols become a potential transmission route when exposed to high concentrations of aerosols in a relatively packed environment. There is a potential risk to dental care personnel and patients in routine aerosols generated during dental procedures.

Dental team should be alert and maintain a healthy environment for both the patients and themselves. Furthermore, to prevent this pandemic transmission, it is essential to understand aerosol transmission and its implications in dentistry. In addition to standard precautions, some other special precautions are implemented during this period.[3]

The aim of this review is to encompass the role of aerosols in the transmission of diseases and discuss all safety precautions to be taken by the practitioner along with enlisting techniques to reduce the generated aerosols during every dental procedure, to avoid infection of COVID 19.

AEROSOL

The terms aerosol and splatter were given by *Micik and colleagues*.[3] Particles that are less than 50 micrometers in diameter, which remain airborne for an extended period before they settle on environmental surfaces or enter the respiratory tract called "aerosol." Airborne particles larger than 50 µm in diameter called as Splatter.[4]

- **Aerosols significance in the transmission of diseases:**

Direct transmission of aerosol may happen through secretions or droplets from an infected person by the oral, nasal, and conjunctival mucosa when that person coughs, sneezes, laughs, or talks. SARS-CoV-2 is primarily transmitted through respiratory **droplets** (particles >5µm in diameter); recent findings suggest that virus transmission may be possible through aerosolized **droplet nuclei** (particles ≤ 5µm in diameter). **Droplet nuclei** may remain in the air for 30 min to 2 hr, and it can contaminate surfaces in a range of 3 feet.[5] Droplets quickly settle to the ground or surfaces as countertop, sink, bracket, table, computer, patient, or operator quickly due to gravity and travel to shorter distances. Therefore, droplet transmission requires close physical proximity between an infected and susceptible individual. **(Fig. 1).**[2]

Human corona-viruses, including SARS-CoV and the Middle East respiratory syndrome-coronavirus (MERS-CoV), do not survive on a dry surface, but few studies have reported that they can persist on a surface for a few days, particularly when suspended in human secretion and undergo onward transmission *(Otter et al., 2013)*.[6] The aerosols from highly virulent pathogens like severe acute respiratory syndrome-coronavirus (SARS-CoV) can travel more than six feet *(Kutter et al., 2018)*.[7]

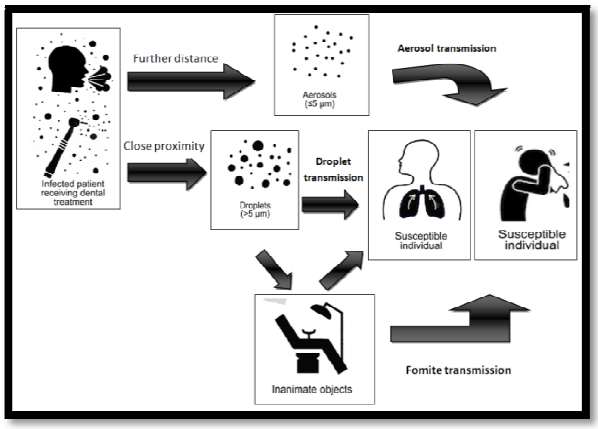

Fig 1: Different routes of transmission in dental setting via the aerosols.

Dental procedures performing with a high-speed handpiece, friction between the tooth and the rapidly rotating bur would create excessive heat. Without a coolant, the heat could cause damage to hard dental tissue and lead to pathological changes to the dental pulp. To overcome this heat gain, when performing dental procedures, the use of water coolant is necessary for procedures such as oral surgical therapies, prophylaxis, surgical extractions, tooth preparations, caries restorations, and access cavity preparation *(Farah, 2019)*.[8] The generated aerosols have shown in **Fig. 2**.

The water coolant generates visible and invisible aerosols.[4] Bio-aerosols that are commonly contaminated with bacteria, fungi, and viruses, have the potential to float in the air for a considerable amount of time and are inhaled by dentists or other patients. *(Jones and Brosseau, 2015)*.[9]

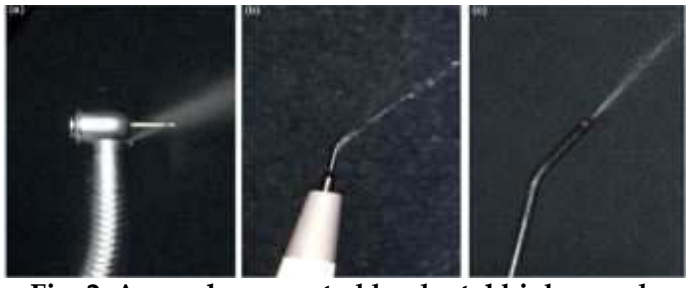

Fig. 2: Aerosols generated by dental high-speed handpiece (a), ultrasonic scaler (b), and air-water syringe (c)

❖ **Oral microflora associated with respiratory infections caused due to aerosols:**

More than 700 microbial species in the oral cavity are inhabited by fungi and viruses from the respiratory tract. Common inhabitants of the oral cavity include Streptococcus species, Actinomyces, Neisseria, Porphyromonas, Prevotella, Campylobacter, Capnocytophaga, and Fusobacteria. Oral biofilm resists antibiotics, antimicrobial agents, and the body's immune system. Removal of bacteria in dental biofilm is best achieved by physical disruption, so this process contributes to aerosol production.[10]

Generated aerosols consist of water, saliva, blood, debris, and microorganisms (e.g., bacteria, fungi, viruses, and protozoa), with their metabolites, such as lipopolysaccharides/endotoxins and other toxins.

❖ **Diseases known to be spread by droplets or aerosols**

COVID-19 disease includes the common cold, influenza, sinusitis, pharyngitis, pneumonia, tuberculosis, and severe acute respiratory syndrome. Through dental bioaerosols, nasal congestion, asthmatic episodes, and headaches have also been triggered.[9] The specific bacteria were likely to cause all the diseases, including **Legionella, Pseudomonas, and Nontuberculous mycobacteria. (Table 1)** Aerosolized bacteria and Dental treatments from waterlines can cause severe infections and even death.[4]

TABLE 1. DISEASES KNOWN TO BE SPREAD BY DROPLETS OR AEROSOLS[4]

DISEASE	METHOD OF TRANSMISSION
Pneumonic Plague	Patient to patient without the usual insect vector (flea); apparently by inhalation of the causative bacteria
Tuberculosis	Droplet nuclei expelled from the patient by coughing; once considered an occupational disease for dentists
Influenza	Apparently associated with coughing but may require direct contact with the patient
Legionnaires' Disease	Aerosolization of Legionella pneumophila has been associated with air conditioning systems and hot tub spas
Severe Acute Respiratory Syndrome	Spread by direct contact and aerosolized droplets

❖ **Precautions in dental practice from the generated aerosols:**

The outbreak and transmission of COVID-19 have undoubtedly shown that health professionals are at higher risk. The incubation period lasts up to 14 days; it is impossible to recognize the asymptotic carriers early or without testing. A report given by *Rothe et al. 2020,*[11] stated that the infection transmission from asymptomatic contact, implying that COVID-19 is contagious during the incubation period.

The cell receptor for COVID-19 infection is the angiotensin-converting enzyme II (ACE2) receptor which, is highly expressed in the oral cavity mucosa.[12] Markedly, this receptor is present in the epithelial cells of the tongue. These findings specify that the oral cavity is a potentially high-risk transmission of COVID-19 infection and will be used in future prevention strategies in the setting of clinical practice. The special precautionary measures targeted toward aerosol transmission should be taken to prevent and control the spread of this highly contagious disease. *(Xu et al., 2020).*[13]

Patient screening:

In routine, dentists should take a medical history thoroughly from each patient and confirm the health status. During this pandemic, must ask the targeted screening questions to patient related to COVID-19. These questions should include travel, personal, and epidemiological history.

If possible, strongly advised for tele-screening of the patients and record the COVID-19 symptoms, recent contact with confirmed COVID-19 patients, or disease epicenters. The confirmed non COVID-19 patient and recovered cases (≥30 day) should only be considered for dental treatment after coordination with the primary physician. Disease history and current stage should be meticulously evaluated. Suspected or confirmed COVID-19 patient's treatment should be postponed if possible or performed in airborne infection isolation rooms (AIIRs) or negative pressure rooms, ideally at a hospital setting.[14]

After the screening, patients are proposed to be divided into five groups **(Fig. 3)**:

A. Asymptomatic and unsuspected, unconfirmed COVID-19 case.
B. Symptomatic and/or suspected, unconfirmed COVID-19case.
C. Stable confirmed COVID-19 case.
D. Unstable confirmed COVID-19 case.
E. Recovered confirmed COVID-19 case.

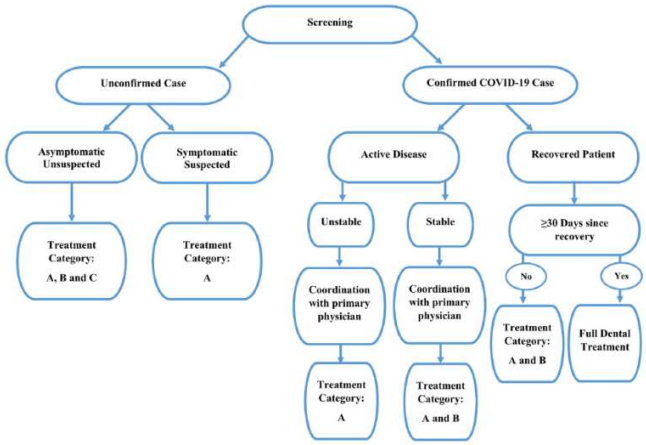

Fig. 3: The screening, patients are proposed to be divided into five groups[14]

D and E treatment category patient are non-urgent and elective so treatment can be postponed for the time being. **(Table 2)**

Table 2 Guidance table showing the categories of dental treatments and the variety of treatments that can be provided for the patient during the COVID-19 pandemic. Dental Treatments Categories[14]

A	B	C	D	E
Emergency	**Urgent conditions that can be managed with minimally invasive procedures and without aerosol generation**	**Urgent conditions that need to be managed with invasive and/ or aerosol-generating procedures**	**Non-urgent**	**Elective**
Unstable maxillofacial fractures that can compromises the patient's airway.	Severe dental pain (7≤) from pulpal inflammation that requires tooth extraction.	Severe dental pain (7≤) from pulpal inflammation that need to be managed with aerosol generating procedures.	Removable dentures adjustments or repairs.	Initial or periodic oral examinations and recall visits.
Diffuse soft tissue bacterial infection with intraoral or extraoral swelling that can compromises the patient's airway.	Severe dental pain (7≤) from fractured vital tooth that can be managed without aerosol generation.	Severe dental pain (7) from fractured vital tooth that need to be managed with aerosol generating procedures.	Asymptomatic fractured or defective restoration.	Aesthetic dental procedures.
Uncontrolled postoperative bleeding.	Dental trauma with avulsion/ luxation that can be minimally managed without aerosol generation	Dental trauma with avulsion/ luxation that need invasive/ Aerosol Generating Procedures	Asymptomatic fractured or defective fixed prosthesis.	Restorative treatment of asymptomatic teeth.
	Surgical postoperative osteitis or dry socket that can be managed without aerosol generation.	Deboned fixed prosthesis cleaning and temporary cementation.	Asymptomatic fractured or defective orthodontic appliance.	Extraction of asymptomatic teeth.
	Pericoronitis or third-molar pain that can be managed without aerosol generation.	Removable dentures adjustments for radiation/ oncology patients.	Chronic periodontal disease.	Orthodontic procedures other than those in category B/C
	Stable maxillofacial fractures that requires no intervention	Fractured or defective fixed prosthesis causing soft tissue injury.		Routine dental cleaning and preventive therapies.
	Localised dental/periodontal abscess that can be managed without aerosol generation	Acute periodontal disease.		Replacement of missing tooth/teeth with fixed or removable prosthesis
	Fractured or defective fixed orthodontic appliance causing soft tissue laceration.			Dental implant surgery.

❖ **Special precautions in routine practice from the aerosols:**

- **Hand hygiene**

Ethanol is widely used in gel form for hand rubbing, foams, and alcohol-based disinfectants are promising substances to protect healthcare workers against SARS-CoV-2. The mechanism of alcohol-based sanitizers is denaturing proteins so that enveloped viruses, including coronavirus, are removed using these sanitizers. Several epidemiological studies suggested hand-washing with soap and 70%–90% alcohol-based hand rubs (ABHRs) effectively controlled SARS transmission.[15]

The alcohol-based hand rubs contain at least 60% ethanol to provide adequate protection. Healthcare workers should consider hand rubbing in 5 moment's i.e.

1. Before touching a patient.
2. Before aseptic treatments.
3. After exposure to body fluids
4. After touching a patient.
5. After touching the patient's surroundings.[2]

- **Preprocedural mouth rinse**

In oral aerosols reducing the proportion of microorganisms is the most effective method. (Feres et al., 2010)[16] A meta-analysis showed that the use of preprocedural mouth rinse including chlorhexidine (CHX), Povidone-iodine (PV-I, 0.23-1%), cetylpyridinium chloride (CPC, 0.05-0.10%), and hydrogen peroxide (0.5-1.5%) resulted in a mean reduction of 68.4% colony-forming units in a dental aerosol. *(Marui et al., 2019)*[17]

According to *Chitguppi R. et al. 2020*,[18] only mouth rinse like Chlorhexidine, owing to their clinically significant substantivity, can be of clinical use in the prevention of COVID-19 spread and offer maximum protection to the healthcare workers. Mouth rinses like povidone-iodine and hydrogen peroxide that lack substantivity may kill the virus when they come in contact with it but offer little protection to healthcare workers and be of little use in the prevention of disease spread in the clinics & in community settings.[18]

For patients who develop mucosal irritation or other side effects such as tongue stain, 0.05% CPC could be a good alternative. Preprocedural mouth rinse can efficiently inactivate the SARS-CoV, MERS-CoV, and influenza virus A (H1N1) within 1 min. *(Feres et al., 2010)*[16]

Mouthwash containing chlorhexidine or CPC can prevent the biofilm adhesion and formation of viridans streptococci, Candida albicans, and proinflammatory effects.[17]

Since SARS-CoV-2 is vulnerable to oxidation, antiseptic mouthwash or gel containing broad-spectrum oxidative agents, such as hydrogen peroxide or PV-I, is recommended to reduce the oral microbiota and potentially SARS-CoV-2 as well. **(Table 3)**[17]

Table 3: Preprocedural mouth rinse[17]

Mouth rinses	Characteristics	Coronaviruses sensitive	Sources
Povidine iodine (PV-I, 0.23-1%	Reduce the number of oral microbiota. Inhibit the biofilm formation of viridancs streptococci and the adhesion, proinflammatory effects, and immune escape abilities of Candida albicans.	SARS-CoV, MERS-CoV and potentially SARS-CoV-2 sensitive.	Kariwa et. Al 2006; Eggers et al, 2015, 2018; Ardizzoni et. Al, 2018; Kampf et al, 2020; Li and Meng,2020
Cetylpyridinium chloride (CPC, 0.05-0.10%)	Reduce the number of oral microbiota. Inhibit the biofilm formation of viridancs streptococci and the adhesion, proinflammatory effects, and immune escape abilities of Candida albicans.	SARS-CoV, MERS-CoV sensitive. SARS-CoV-2 sensitivity is currently unknown.	Kariwa et. Al 2006; Eggers et al, 2015, 2018; Ardizzoni et. Al, 2018; Kampf et al, 2020; Li and Meng,2020
Hydrogen peroxide (H_2O_2, 0.5-1.5%)	Reduce the number of oral microbiota.	SARS-CoV, MERS-CoV and potentially SARS-CoV-2 sensitive.	Kariwa et. Al 2006; Eggers et al, 2015, 2018; Ardizzoni et. Al, 2018; Kampf et al, 2020; Li and Meng,2020
Chlorehexidine (CHX, 0.02- 0.05%)	Reduce the number of oral microbiota. Inhibit the biofilm formation of viridancs streptococci and the adhesion, proinflammatory effects, and immune escape abilities of Candida albicans.	0.02% CHX is ineffective against coronaviruses while 0.05% is SARS-CoV sensitive	Ardizzoni et al, 2018; Chin et al, 2020

- **Environmental surface disinfection**

Aerosol-generating procedures, droplets containing infective pathogens could be deposited on the surrounding surfaces. Cleaning and disinfection are important for frequently touched surfaces in patient care areas, especially those closest to the patient and most likely contaminated surfaces. (e.g., dental chair, desks, elevators, bathroom sinks, floor surface, cabinets, doorknobs, and all equipment close to the patient).[19] The 22 studies are analyzed revealed that human coronaviruses, like SARS and MERS, can persist on inanimate surfaces for up to 9 days. They can be efficiently inactivated by surface disinfects

within one minute. These surface disinfectants contain 62%–71% ethanol, 0.5% hydrogen peroxide, and 0.1% (1 g/L) sodium hypochlorite.[20]
Methods of disinfecting and cleaning are presented in (**Table 4).**[20]

Disinfecting non-critical surfaces in patient-care areas[20]			
Vaporized hydrogen peroxide		**Disinfectants**	
Types	**Virucidal efficacy**	**Hypochlorous acid (HOCl)**	**Other disinfectants**
Non-condensing vaporized hydrogen peroxide (VHP) technology (Steris) and condensing search hydrogen peroxide vapour (HPV) technology (Bioquell)	Limited evidence is available for the virucidal activity of condensing HPV systems. Recently, several studies have demonstrated the in vitro activity of condensing HPV systems against individual viruses, including feline calicivirus (FCV), adenovirus, lactococcal bacteriophages6, and MS2 coliphage	**Virucidal efficacy** • Virucidal ability of solutions containing a high amount of HOCl is better than those containing HCl • Reduction of efficacy after spraying from a distance more than 30 cm • Minimum concentration should be more than 40 ppm for effective virucidal effect • The 100 and 200 ppm concentrated solutions inactivated more than 99.9% of AIV directly after spraying, while the 50 ppm concentration required at least 3 min of contact	Alkalis, oxidizing agents, alcohols, and aldehydes

- **Personal protective equipment**

Personal protective equipment (PPE) can form an effective barrier against most hazards of aerosols generated from an operative site. In COVID-19, PPE recommendations are masks, respirators, gloves, goggles or face shields, and long gowns.
More body coverage leads to better protection. Donning and doffing PPE should be simple as the complexity of use leads to an increased risk of self-contamination, especially during doffing.[21]
The correct sequence of donning and doffing is depicted in **(Figs. 4, 5, 6, 7)**[20]

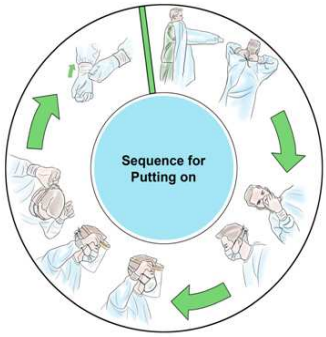

Fig. 4 Personal protection equipment donning

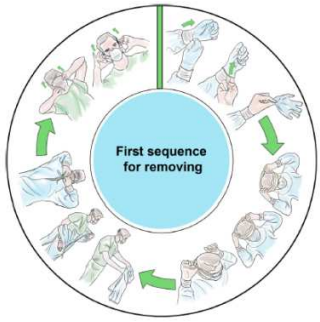

Fig. 5 Personal protection equipment first doffing

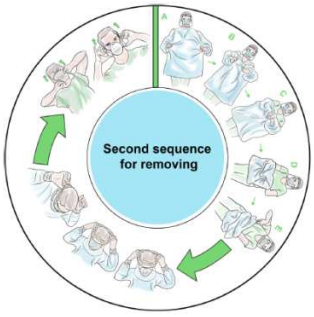

Fig. 6 Personal protection equipment second doffing order

Fig. 7 Personal protection equipment

- **Masks and respirators**

Waterproof surgical masks protect staff against both infected droplets and contact contamination by preventing the spread of respiratory droplets in the environment and reducing COVIID-19 contamination by at least 80%.

Filtering facepiece respirators (FFRs), including N95 respirators having a network of polypropylene microfibers and electrostatic charges, are protective and effective equipment infiltration. Powered air-purifying respirator (PAPR) is also recommended for protection against SARS-CoV-2.

Comparisons between different masks and respirators are given in **Table 5.**[20]

Table 5: A brief comparison between masks and respirators[20]

Mask type	Standard	Filtration effectiveness			Re-usability
Single-use medical masks	China: YY/T0969	3.0 microns: > 95% 0.1 microns: not effective			No
Surgical masks	China: YY 0469	3.0 microns: > 95% 0.1 microns: not effective			No
Surgical masks	USA: ASTM F2100	Level 1 3.0 microns: > 95% 0.1 microns: > 95%	Level 2,3 3.0 microns: > 95% 0.1 microns: > 95%		No
Surgical masks	Europe: EN 14683	Type 1 3.0 microns: > 95% 0.1 microns: > 95%	Type 2,3 3.0 microns: > 95% 0.1 microns: > 95%		No
Respirator masks	USA:NIOSH 42 CFR 84	N95 0.3 microns: > 95%	N99 0.3microns: > 99%	N100 0.3microns: > 99.97%	Yes (under especial conditions)
Respirator masks	Europe:EN 149:2001	FFP1 0.3 microns : >80%	FFP2 0.3 microns : >80%	FFP3 0.3 microns : >80%	Yes (under especial conditions)
Elastomeric respirators	USA:NIOSH 42 CFR 84			Yes	
PAPR	USA:NIOSH 42 CFR 84			Yes	

PAPR powered air-purifying respirator. APF assigned protection factor

For extended use mask, the CDC recommends up to 8 hr use of N95 respiratory mask, and should note that FFRs can be reused up to 5 times via the following strategies:

1) Mask rotation: The mask should be numbered and reused in turn. A used mask should be kept at least 72 hr, as the SARS-CoV-2 loses its viability. If a mask is used in the aerosol-generating process or is damaged, it should be discarded.

2) Reprocessing/decontamination: N95 models that do not contain cellulose, such as the 1860 model, can be reuse after decontamination with the hydrogen peroxide vaporization.

The other decontamination methods are moist heat (heating at 60–70 °C and 80–85% relative humidity), proper UV treatment of N95 masks, and the mask at 70 °C dry heating for 30 min decontamination. Among all, only the proper UV treatment of N95 masks is recommended for SARS-CoV-2. Correct way of putting on and removing a respirator mask. **(Fig. 8)**[20]

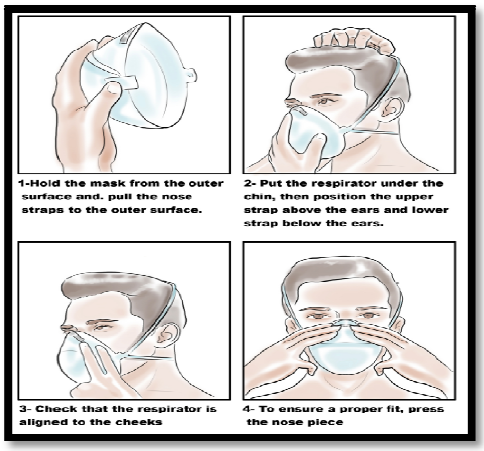

Fig 8: Correct way of putting on and removing a respirator[20]

- **Gowns**

Different qualities have been reported for gowns. Models of gowns mostly leave the neck exposed, which can be a route of contamination. The most protection is assigned to coverall followed by long gowns, gowns, and aprons, respectively.[2]

- **Gloves**

The risk of contamination can be reduced by adding tabs to the gloves for taking them off from the hands.

Donning three layers of gloves due to the complex doffing process is not suggested due to more risk of self-contamination. Gloves cleaning with quaternary ammonium or hypochlorite may decrease hand contamination except for alcohol-based hand rubs. Dentists should use arm-length surgical gloves. **(Fig.9)**[2]

- **Eye protectors**

The efficacy of face shields is to reduce contamination by breathing and coughing. The face shields are effective for large infectious particles to reduce exposure, but smaller particles can flow around a face shield and remain airborne to be inhaled. Face shields **(Fig 10)** are more bulky than goggles **(Fig 11)** and protect the entire face. Goggles give a standard eye protector by providing a full eye seal. *(Lindsley et al)*[21]

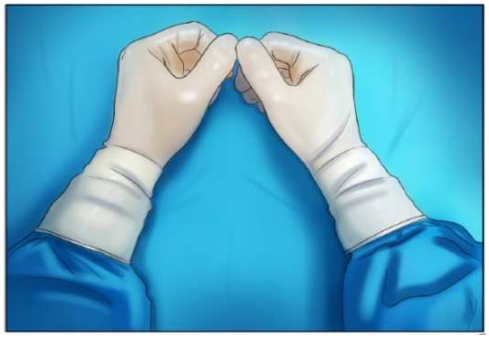

Fig 9: Arm-length surgical gloves that completely cover the wrist area[20]

Fig 10: Face shield

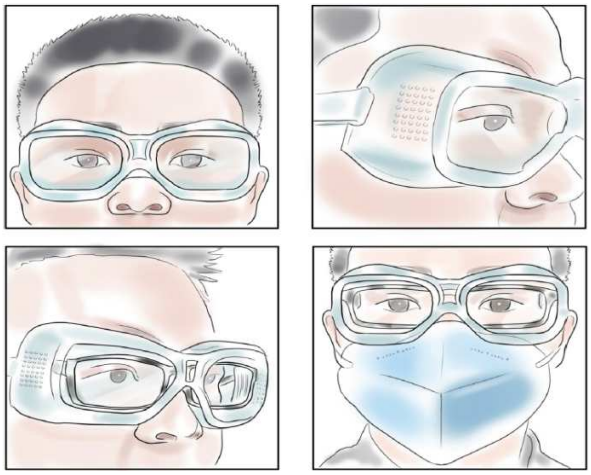

Fig 11: Standard eye protector[20]

- **Other methods to reduce generated aerosols**

Strategies to reduce aerosols generation in different dental disciplines **(Table 6)**

Table 6: Other methods to reduce droplet generation in different dental disciplines[2]

Dental discipline	Special precaution
Endodontics	Rubber dam must be applied during endodontic treatment. Root canal treatment usually requires a number of endodontic instruments and devices, therefore minimizing unnecessary hand contact with surfaces and equipment in the dental office to reduce possibility of fomite transmission.
Restorative dentistry and pediatric dentistry	Avoid using rotary instruments during cavity preparation. In selective cases, consider using chemochemical caries removal or atraumatic restorative techniques. If rotary instrumentation must be performed, rubber dam isolation should be applied.
Periodontics	Hand and ultrasonic instrumentation are equally effective in removing plaque and calculus deposits; if required, manual scaling and polishing are recommended (Krishna and de Stefano, 2016)
Prosthodontics	Salivary suction must be performed with care to avoid gagging. Select and adjust trays to the right size for impression taking to avoid cough reflex. For highly sensitive patients, consider applying oral mucosa anesthesia to the throat before impression taking. During fixed partial denture or single-crown preparation, treatment alternation may be considered to incorporate rubber dam application. For example, design supra-gingival margin for posterior bridge or use a split-dam technique (Li et al., 2004). During removable partial denture or complete denture try-in, avoid touching other objects in the dental office after contacting patients' saliva. Upon removal from patient's mouth, dental prosthesis, impressions, and other prosthodontics materials (e.g., bite registration) should be thoroughly disinfected by a disinfectant having at least intermediate level activity.
Oral-maxillofacial surgery	When performing simple extraction, treat the patient in a supine position to avoid working in the breath way of a patient

- **Removal/filter of contaminated air**

There are several methods to remove/filter contaminated air in treatment areas; the two most commonly used devices include the inexpensive High Volume Evacuator (HVE) and the expensive High-Efficiency Particulate Arrestor (HEPA) filters.

High-volume evacuation filter (HVE): It reduces more than 90% aerosol produced during ultrasonic instrumentation. *(Harrel et al., 1996)*[22] *(Jacks, 2002)*[23] Within a short period, HVE systems remove a large volume of air (up to 1003 feet of air/ minute) and typically have a large bore or opening on the tip (≥8 mm). *(Harrel and Molinari, 2004)*[4]

The inlet of the HVE attachment needs to be held close enough (10–20 mm) to the source of aerosols to evacuate those aerosols while avoiding contact of the HVE attachment with the ultrasonic instrument and the patient's intra-oral tissues. *(Mamoun, 2011)*[24] Without a dental assistant, clinicians might face difficulty to operate it with one hand.

Newer HVE devices currently available offer modifications, such as lighter weight, shorter length, angled configuration, and mirrored surfaces, which ease the use of the HVE by the sole practitioner. **Figure 12** illustrates several of these products.

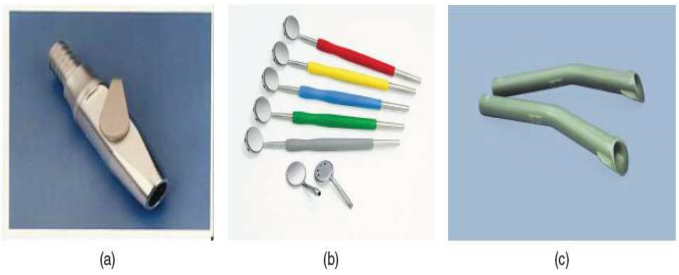

Fig 12: a) Bull Frog aluminum lightweight HVE hand piece – short; (b) mirror/suction device for HVE; (c) Pelotte angled evacuation tips.[25]

To reduce the aerosols that have escaped into the operatory air, the HVE suction should remain on continuously during the entire debridement procedure, even during momentary stops in instrumentation, and should be kept on for a few minutes after the procedure is completed.[24]

High-Efficiency Particulate Arrestor (HEPA filter): An air filtration device can remove 99.97% of the particles measuring 0.3 µm in diameter. Disadvantages are that the filter may become a source of microbes if the retained microorganisms proliferate and enter back into the filtered air, and soiled HEPA filters are difficult to clean, and these are expensive to replace. *(Day et al., 2018)*[26]

Device to reduce aerosol dispersion

A device with the aspiration and filtering system. *(Meng et al. 2020)*[27]

In dental clinics, the main purpose of this device is to reduce aerosol dispersion, isolating the operator 'external environment' and patient in an 'internal environment' through which access to perform the dental procedures while protected by a physical barrier.[28]

A variety of aerosol boxes have been proposed in the medical field *(Canelli et al. 2020)*[28], *(Cubillos et al. 2020)*[29], *(Francom et al. 2020)*[30] Earlier extra-oral dental suction systems have been proposed and commercialized, but no one is aware of the use of the aerosol box. Some devices to capture the aerosols under high negative pressure include a large clear cup-shaped acrylic plate to limit the dispersion of aerosol particles with no physical barriers.

The pre-existing devices may likely reduce but not prevent the aerosol dispersion in the air room and, therefore, may not completely prevent the contact of aerosol particles with the operator and their assistant. The cost for a device prototype is relatively less, and if it is produced on large numbers, the costs may be more reduced.

On the dental chair to fit the designed prototype, the device consists of a rigid translucent acrylic structure (methyl polymethacrylate) **(Fig. 13a)** covering the patient's chest, neck, and head. On the dental chair, the device is propped up, positioned simultaneously when the patient sits **(Fig. 13b).** For the aspiration and filtering of air, there is a piping system within the acrylic structure **(Fig. 13c)**, which provides a negative pressure inside the chamber. In the chamber, two hoses are strategically positioned for the aspiration system, and a suction unit is composed.

The working position of operator with the device is shown in **(Fig. 14a)**. Due to the use of the fluorescent dye, the simulations were carried out using an ultraviolet flashlight illumination in the working

field **(Fig. 14b**). The aspiration system aims to neutralize circulating microorganisms and toxic particles before the air returns to the external environment and forces the air to pass through an external box containing an antiseptic solution (2% NaOCl) **(Fig. 14c).**

Through three oval-shaped holes in the acrylic chamber, which provide access for the operator's hands, allowing for dental procedures, it can be performed seated in the 9 to 3 o'clock ergonomic positions. Translucent flexible polyvinyl chloride (PVC) films are covered to these orifices, on which small incisions are made. It allows the operator's hands and arms to reach inside the device while keeping the distance too short between the operator to the patient. Flexible PVC films should be used to seal the back of the device, which is open (no rigid acrylic structure). The PVC film protects the chair from contamination, and the patients can comfortably support themselves in the chair.[31]

Fig 13: Detailed images of the device: Translucent acrylic chamber (a); positioning of the acrylic chamber (b); and positioning of the aspiration piping (c) [31]

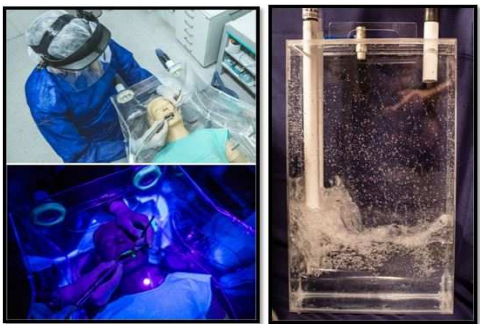

Fig 14: Images showing the work position of the operator (a). Ambient lights off and ultraviolet lights on to start the simulated dental procedure (b). (c) Image of the aspiration and filtering.[31]

Some limitations of the present device as, between patients the disinfection of the internal walls of the apparatus may be time-consuming, and the disinfection of the aspiration system piping is challenging. Presently, a 0.2% quaternary ammonium compound solution has been used for disinfection of the acrylic surfaces of the device in the service where the device is being tested. The internal walls of the piping system are being disinfected by aspiration of a 2% NaOCl solution.

Drawbacks with of this device are restriction to movement for patient and may experience anxiety, claustrophobic sensation. Difficulty in visualization of operative field by the operator and limitations regarding the communication between dentist and patient may occur.[31]

CONCLUSION

Dentists, by nature, are at high risk of exposure to infectious diseases. The emergence of COVID-19 has brought new challenges and responsibilities to dental professionals. Patients and practitioners are regularly exposed to tens of thousands of aerosols generated during procedures, and this exposure increases the potential for respiratory infections. To ensure patient and operator safety, oral health professionals should adapt the latest CDC guidelines and recommendations. This includes providing preprocedural mouth rinses, maintaining dental unit water quality, and wearing proper PPE. To reduce further risk, improve air quality, air cleaning systems and HVE or an isolation-and-evacuation device can be employed. Ultimately, combining multiple methods may be the most effective approach for managing dental aerosols.

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