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# Dental aerosol: the ultimate super spreader in a dental environment

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## Abstract

Aerosol science is an enormous subject, both in scope, breadth and depth, with many prestigious peer-reviewed journals presenting on an incredible array of fields, genres and minutiae, linked, somehow, by the word 'aerosol'. The worldwide COVID-19 pandemic has dramatically transformed the day-to-day life upside down especially in the dental world. Health care services are adapting to the COVID-19 pandemic, yet oral health care and dentistry are particularly affected due to the proximity to the patient and the generation of aerosols through common treatment procedures. The current most critical concern in a dental environment is the aerosol transmission of SARS-CoV-2. Devices such as ultrasonic scalers generate a large amount of aerosol that are enough to remain airborne for extended periods before settling on environmental surfaces or making its way into the respiratory tract. This makes it necessary for the dentists to upgrade their knowledge on specifics of the aerosols before the ghastly virus slinks its loathsome way into our lungs. Hence, this review aims to cognizance the importance of aerosol transmission and clarify the pathway for identification and correction of negligence in daily dental practice. Covid era will encompass many alterations in infection control procedures and dental armamentarium which will be scrutinized by the extent and the severity of evidence validated.

**Keywords:** Aerosol, Splatter, Dental Aerosol, Bioaerosol, Airbone Disease, Aerosol Transmission

## Introduction

The worldwide COVID-19 pandemic has dramatically transformed the day-to-day life upside down especially in

the dental world. Broadly speaking, dentists were facing the darkest of the days where they were persuaded from not providing routine and non-emergent care during the pandemic. Health care services are adapting to the COVID-19 pandemic, yet oral health care and dentistry are particularly affected due to the proximity to the patient and the generation of aerosols through common treatment procedures. The SARS-CoV-2 (severe acute respiratory syndrome coronavirus 2) virus seriously disrupts routine dental procedures around the world. The reports, analyses and recommendations emerging with first-hand experience from dental settings in China are alarming.[1] The risks of infection for oral health personnel, cross-infection between patients and anyone in the dental care setting are high.[2]

The current most critical concern in a dental environment is the aerosol transmission of SARS-CoV-2. Devices such as ultrasonic scalers generate a large amount of aerosol that are enough to remain airborne for extended periods before settling on environmental surfaces or making its way into the respiratory tract. This makes it necessary for the dentists to upgrade their knowledge on specifics of the aerosols before the ghastly virus slinks its loathsome way into our lungs. Hence, this review aims to cognizance the importance of aerosol transmission and clarify the pathway for identification and correction of negligence in daily dental practice.

**Background**

A novel human coronavirus—now named severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2)—emerged from Wuhan, China, in late 2019 and is causing the pandemic.[3] Coronaviruses are enveloped RNA viruses with particles ranging from 60 to 140 nanometers (0.06 to 0.14 micrometers), with an average of 0.125 microns, and have typical spikes of 9 to 12 nanometers that appears like “coronas” around the sun. Cell death is observed 96 hours after inoculation on surface layers of human airway epithelial cells.[4] SARS-CoV-2 is a novel virus that is considered to be a recent strain that has not been previously identified in humans. Coronavirus mainly causes illness that varies from the common cold to more Severe Acute Respiratory Syndrome. Common clinical signs of the infection include respiratory symptoms in the form of fever, cough, shortness of breath and breathing difficulties. In more severe cases, infection can be fatal as it results in pneumonia, severe acute respiratory syndrome, kidney failure and even death.[5]

**Viral Dosimetry**

With the emergent of the novel coronavirus, there is a requirement to explore the dose-dependent response between viral load and the severity of the disease. One study demonstrated 60 times higher viral loads in the nasopharyngeal swabs from patients with severe form of COVID-19 when compared to the mild form.[6] Another study demonstrated the potential for saliva to be a noninvasive specimen type for the diagnosis and viral load monitoring of SARS-CoV-2. Because saliva can be provided by patients without any invasive procedures, the use of saliva specimens will reduce the risk of nosocomial transmission of SARS-CoV-2 and is ideal for situations in which nasopharyngeal specimen collection may be contraindicated.[7] Particles from cough or sneeze can potentially travel across far greater distances, with estimates up to 20 feet, from an infected person and then incite secondary infections elsewhere in the environment. These aerosolized droplet nuclei can endure in an area or even be floating in air, even after the person who emanated them has left and this can be posed as a deadly threat to the health-care workers. Here are some examples of the longevity of COVID-19 in various places:

• The virus is viable up to 72 hours after application to plastic and stainless steel surfaces.

• The virus is viable up to 24 hours on cardboard surfaces.

• The virus is viable up to nine hours on copper surfaces.

• The virus is viable in suspended aerosols up to three hours.[8]

**Transmission and Diagnosis**

It is believed that the novel coronavirus occurs through interpersonal transmission mainly via respiratory droplets and contact transmission. Besides, there may be a risk of fecal-oral transmission, as researchers have identified SARS-CoV-2 in the stool of patients.[1] Although symptomatic COVID-19 patients being the major contributor of transmission, recent observations hinted that asymptomatic patients and patients in their incubation period can be potential carriers of SARS-CoV-2.[9] This epidemiologic feature of COVID-19 has made its control extremely challenging, as it is difficult to identify and quarantine these patients in time, which can result in an accumulation of SARS-CoV-2 in communities.[1]

The diagnosis of COVID-19 can be based on a combination of epidemiologic information (e.g., a history of travel to or residence in affected region 14 days prior to symptom onset), clinical symptoms, CT imaging findings, and laboratory tests (e.g., reverse transcriptase polymerase chain reaction [RT-PCR] tests on respiratory tract specimens).[1] So far, there has been no evidence from randomized controlled trials to recommend any specific anti- CoV treatment, so the management of COVID-19 has been largely supportive. Currently, the approach to COVID-19 is to control the source of infection and lower the risk of transmission; and provide early diagnosis, isolation, and reliance on general supportive care, antiviral treatment, and immune modulation for affected patients.[10]

**Aerosol differentiation**

Aerosol science is an enormous subject, both in scope, breadth, and depth, with many prestigious peer-reviewed journals presenting on an incredible array of fields, genres and minutiae, linked, somehow, by the word 'aerosol'. It is human nature to start going down the proverbial rabbit hole; one fascinating article leading to another, yet another followed by still another.[11] Aerosols are differentiated based on particle size: spatter (> 50 μm), droplet (≤ 50 μm), and droplet nuclei (≤ 10 μm). In dental settings, 90% of the aerosols produced are extremely small (< 5 μm). Spatter, being the larger particle, will fall until it contacts other objects (e.g., door, countertop, sink, bracket, table, computer, patient or operator). Droplets remain suspended in the air until they evaporate, leaving droplet nuclei that contain bacteria related to respiratory infections. Droplet nuclei can contaminate surfaces in a range of three feet and may remain airborne for 30 minutes to two hours. If inhaled, the droplet nuclei can penetrate deep into the respiratory system.[12] Furthermore, the susceptibility of developing an infection is influenced by virulence, dose and pathogenicity of the microorganisms, along with the host's immune response.[13]

When a person coughs, sneezes, laughs, or talks, large (>5 μm diameter) and small (≤5 μm diameter) droplets or aerosols are generated. Due to gravity, larger droplets fall to the ground quickly; therefore, droplet transmission requires close physical proximity between an infected individual and a susceptible individual. On the other hand, small droplets or small particle residues of evaporated droplets have a low settling velocity, so they may remain in the air for a longer time and travel further before they can enter the respiratory tract or contaminate surfaces.[14] Results from some studies have shown that aerosols from highly virulent pathogens like SARS-CoV can travel more than six feet.[15]

**Aerosol generating procedure in dental setup**

Excessive heat due to the friction between the tooth and rapidly rotating bur when used without a coolant could cause substantial damage to dental tissues. Therefore, to

counteract the excessive heat, it is a universal consensus to use a water coolant when performing dental procedures, including tooth preparation, oral prophylaxis, and oral surgery.[16] The stumbling block associated with this water coolant is that it generates aerosols. When amalgamated with bodily fluids in the oral cavity including blood and saliva, bioaerosols are created which are commonly contaminated with bacteria, fungi, and viruses, and have the potential to remain aloof in the air for a considerable amount of time and be inhaled by the dentists or other patients.[17]

Dental aerosols are not one thing, they are at least three groups.

- Type 1 − Respiratory aerosols: Breathing produces a complex continuum of respiratory secretion droplets from the large to the aerosolized droplets.
- Type 2 − Clean Water Anthropogenic aerosols: The plume of spray from the well-adjusted, high-speed handpiece, the mist surrounding the tip of ultrasonic scaler or the haze coming from the 3 in 1 airway syringe.
- Type 3 – 'Mixed' aerosols: complex result of clean water combination of high velocity water flow, individual multi-sized droplets and aerosol impacts on the structures of the oral cavity.[11]

**Contamination of Different Areas During Dental Practices**

Dental environment can be regarded as a hub for cross-contamination in which the dentist's face being at the top for high-risk infection transmission. Comparing prosthetic and periodontal procedures, it has been proved that the latter caused more contamination. This could be owing to the greater bleeding and soft-tissue irritation during the usage of ultrasonic scalers.[18] It has been a proven fact that the most intensive aerosol and splash production occurs during the work of an ultrasonic scaling unit and high-speed handpiece.[19] In all of the restorative procedures, and the first ultrasonic scaling, the highest counts were detected on plates positioned on the subject's chest.[20]

The areas around nose and inner corner of eyes are significantly at higher risk of contamination and zygoma being the least contaminated area. This may be in the view of the fact that the dentist's position and his direct view during operation on mandibular jaw. Also, it is more strenuous to cope with the saliva during working on mandible. Since the dentist gets in the direction of the affected patient to have a clearer view, it is predictable to have more contamination in central areas of the face. Equal contamination on both sides of the face has been noted.[19] The assistant zone was found to be having the maximum aerosol contamination followed by the operator zone. The arms, chest and inner surface of the mask of the operator as well as the assistant were shown as contamination zones. [21]

Fluorescent dye in aerosols showed penetration in single layered face masks behind the face shields to enter the nose. Lone use of face shields were substantially inferior to masks in preventing penetration of airborne debris, because of their lack of peripheral fit. The long term use of face shield has less of a protective barrier effect since the smaller particles tend to flow around it and accumulate over time. The reasoning being they are better able to travel around the face shield and be inhaled when used in a cough simulator model. The use of a face shield reduced the fraction of the virus that deposited in the outer layer relative to the inner layers, which suggests that the aerosol reaching the respirator had a smaller average size.[22]

In the multi-chair dental clinic, the concentration of total circulating bacterial aerosols was lower at the end of the day compared to the beginning of the day. This may indicate a buildup of bacterial aerosols overnight when ventilation systems are not working. There was no

significant change in the concentration of total bacterial aerosols according to position within the clinic.[23] The aerosol was found to be hanging in the operatory for 30 minutes following the procedure. [21] Another study reported that the peak of aerosol concentration dissipates within 10—30 min with scaling procedures.[24]

Recent studies on aerosol contamination identified the distribution of splatter and aerosol along with their respective settling time after dental proceedures in an open plan clinic. They concluded that cross infection can be reduced drastically when bays are ≥ 5m apart in an open plan clinic and contamination is likely to minimal in these areas. Dental suction positively had an impact on the dilution effects from instruement water spray. 10 minutes was the observed settling time after which environmental cleaning may be appropriate.[25] Another study revealed that most of the aerosol and splatter were generated by the high speed air-turbine inspite of the assistant-held suction. They suggested that it might be safer to lessen the time taken between dental aerosol generating procedures with 6.5 air changes per hour to 30 minutes.[26]

**Mandatory Precautionary measures in Dental Setting**

Because of these inherent dangers to dentists, team members, and patients, the Occupational Safety and Health Act (OSHA) just released a new report called "Guidance on Preparing Workplaces for COVID-19." This document categorizes occupational risk as very high, high, medium, and lower risk and occupations involving aerosol production fall into the category of very high risk, according to OSHA. Since dentistry constitute itself in the very-high-risk category, the section "Implement Workplace Controls, Engineering Controls" recommends performing aerosol generating procedures in a dental setup installed with negative-pressure rooms or airborne infection isolation rooms.[27]

**Precautions in dental emergency during COVID-19 outbreak**

1. Patient screening: Routine medical history from each patient and rechecking the health status at every recall visit. Targeted screening questions including personal, travel, and epidemiological history should be asked. Temperature and lower respiratory tract symptoms should be closely monitored.

2. For patients whose infections are dental in origin, emergency treatments could be performed following standard dental emergency regimen.

3. For suspected or confirmed medically stable cases of COVID-19, laboratory assessments and multidisciplinary consultations should be performed. To clinch on the safety of patients and dentist, the patient should be rescheduled after the outbreak if required. In case of urgent dental treatment, highest level of personal protection should be implemented along with mechanical ventilation which should commence before treating the next patient.

**Precautions in routine practice**

**Waiting area:** Display a cough etiquette instruction at the entrance of the waiting room and ensure that all patients cover their nose and mouth using a mouthmask. Patients should be placed in an adequately ventilated waiting area. For rooms with natural ventilation, 60 L/s per patient is considered adequate ventilation. Social distancing as a minimum of 1 m ought to be maintained among patients.[28]

**Drape the Operatory:** The flat surfaces and cabinets around the dental chair should be draped as is customary in a medical operating room. Only the instruments that will be used on the current patient should be exposed to aerosols and spatter. The fronts of cabinets, flat surfaces (such as tray tables and Mayo stands), and equipment (such as radiography units and scanning devices) should be draped. It would be best if these drapes were replaced after each patient, but plastic drapes could be wiped down

with disinfectants. Equipment including blood pressure cuffs and thermometers should be cleaned and disinfected with 70% ethyl alcohol after every use.

**Hand hygiene:** There is a growing awareness of the importance of handwashing in the prevention of acute respiratory infections. During the outburst of SARS, several epidemiological studies suggested that handwashing with soap and 70%–90% alcohol-based hand rubs was effective in curbing SARS transmission.[29] As suggested by WHO, hand hygiene should be carried out before touching a patient, before cleaning of surfaces, before aseptic procedure is going to be performed, after exposure to body fluid, after touching a patient, and after touching a patient's surroundings.[14]

**Personal protective equipment:** Personal protective equipment (PPE) can form an effective barrier against most hazards of aerosols generated from the operative site.

1. Protective eyewear and face shields: It is clinically evident that COVID-19 may also be transmitted through contact with the mucous membranes in eyes, as infectious droplets could easily contaminate the human conjunctival epithelium.[30] To protect eyes from aerosols and debris created during dental procedure, protective eyewear or face shield should be always worn throughout the treatment and during disinfection between patients.

2. Face masks: To steer clear of contamination, snugly fitting face masks are recommended as the contaminants can bypass the filtering effect of these masks. The relation between pore size of surgical mask and bacterial filteration efficiency has revealed that the smallest pore size mask has the maximum bacterial efficiency. Studies have shown that fit of the mask, proper positioning of the mask, movement by the wearer, length of facial hair and voice level while speaking all have a direct bearing on bacterial filtration efficiency.[31]

At minimum, a medical mask (surgical or procedure mask) should be used if working at a distance of less than 1 m from the patient. When performing aerosol generating procedures (using highspeed handpiece, air-water syringe, and ultrasonic scaler), a particulate respirator that is at least as protective as a National Institute for Occupational Safety and Health (NIOSH)-certified N95, European Standard Filtering Face Piece 2 (EU FFP2), or equivalent, should be used. When implementing emergency dental treatment with suspected COVID-19 cases, a exaggerated level of respiratory protection should be taken into consideration, such as EU FFP3 respirators conforming to European Standard 149 (EN149). [14]

**Preprocedural mouth rinse:** Preprocedural mouth rinse is one of the most efficacious ways of diminishing the proportion of microorganisms in oral aerosols. A meta-analysis provided evidence that the use of preprocedural mouth rinse, including chlorhexidine (CHX), essential oils, and cetylpyridinium chloride (CPC), resulted in a mean reduction of 68.4% colony-forming units in dental aerosol.[32] About 0.12% CHX has gained maximum popularity as a preprocedural mouth rinse. Patients with mucosal irritation or other side effects such as tongue stain, 0.05% CPC could be an acceptable alternative.[33] The reduction from the viral load from mouth rinses will be transitory as most of the SARS-CoV-2 virus reservoirs have been found in nasopharynx and salivary glands. It would be ideal to have the patient rinse multiple times in between the procedure especially where there is involvement of the ultrasonic scalers and high speed handpieces.

**Removal/filter of contaminated air:** High Volume Evacuator (HVE) filter is a suction device that helps eliminate air at a rate of up to 2.83 m per minute. It is the most effortless way to eradicate dental aerosols as they are generated and could effectively reduce contamination by

90%.[34] The distance between the device and the active ultrasonic tip should be approximately 6–15 mm. However, the issue with the HVE is that without a dental assistant, clinicians might struggle in operating it using one hand. There have been modifications in HVEs to overcome this problem.

HEPA filter is an air filtration device that can remove 99.97% of the particles measuring 0.3 μm in diameter. One disadvantage is that the filter may become a source of microbes if the retained microorganisms proliferate and enter back into the filtered air.[35]

A update on the systematic review arguing about the efficacy of aerosol reducing procedures in dentistry summarises three major approaches. They include rubben dam application, pre-proceedural mouth rinses and high vaccum evacuation. High vaccum evacuation was regarded as the obligatory requirement to reduce aerosol.[36]

**SAFE dentistry:** There is no dental service concept for disaster preparedness or response that might be applied.Similarly, pathways to care provision in a post-pandemic future are missing. Safe Aerosol-free, Emergent Dentistry (SAFE Dentistry) as one approach to dental services during and emerging from pandemics. The concept's starting point is the identification of the most common patient needs followed by replacement of common treatments relating to the most common needs with alternative interventions with less infection risk because they do not generate aerosols. SAFE Dentistry is innovative, safe, and responds to the requirements of a pandemic and post-pandemic emergence where the risk of disease transmission remains high. SAFE Dentistry thereby ensures continuity of dental services while protecting providers and patients from infectious pathogens. Moreover, SAFE Dentistry allows dental service providers to remain operational and generate income even under pandemic conditions.[2] These would decrease the hospital visits for common dental ailments and thus reducing the burden of hospital personnel, infrastructure and resources. It also allows the dentists to provide a safe and hygienic environment which in turn nourish and strengthen the trust of a patient especially in these kind of pandemic situations.[37]

**Conclusion**

In the current trajectory of Covid era, it is important to update our previous knowledge base regarding aerosols and dentistry, as the field of aerosol science has expanded drastically but remains a jigsaw puzzle, pieces still missing. Aerosol science is an enormous subject, both in scope, breadth and depth, with many prestigious peer-reviewed journals presenting on an incredible array of fields, genres and minutiae, linked, somehow, by the word 'aerosol'. The post Covid era will encompass many alterations in infection control procedures and dental armamentarium which will be scrutinized by the extent and the severity of evidence validated. In routine dental practice the health and safety of dentists, dental hygienists and other team staff should be given top priority.

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