Aerosols in Dentistry: A Review

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Abstract

This review examines the risk of infection transmission in dental settings through aerosols, particularly in light of the COVID-19 pandemic. Dental procedures, particularly those involving high-speed instruments, produce aerosols containing saliva, blood, and microbes. These aerosols pose a significant risk of transmission, especially in close contact situations. Measures such as high-volume evacuation, barrier protection (masks, gloves, eye protection), and preprocedural rinses with antiseptic mouthwash can help reduce aerosol contamination. However, the effectiveness of these measures varies, and more research is needed to fully understand and mitigate the risk. The review also discusses the legal and regulatory considerations surrounding aerosol contamination in dental practices.

Ultimately, adherence to recommended protocols from organizations like the CDC and ADA is crucial for minimizing aerosol-related infection transmission in dental settings, particularly in the context of the ongoing COVID-19 pandemic.

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Introduction

Bioaerosols are defined as airborne particles of liquids or volatile compounds composed of organisms or their toxic products. Bioaerosols have been recognized as a result of certain dental procedures and represent a potential mechanism for the spread of infection.[1] Aerosols consist of many microorganisms and its toxic byproducts are hazardous in several occupations and people in these jobs are at high risks of these occupational infections in comparison to general population due to continous exposure to those bioaerosols generated. [2-5]

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In health care workers, dental professionals and the patients are at higher risk of exposure to the dental aerosols created by turbine burs, water air sprays and other aerosol forming instruments during treatments. The aerosols in environment of dental offices consists of microbial component of These aerosols contain plaque, tartar, Saliva, Blood, dental materials , Nasopharyngeal, and Inadequately Disinfected Dental Unit Water Lines (DUWL). [6,7] Bacterial species such as Pseudomonas aeruginosa, Pseudomonas cepacia, Legionella pneumophila and Mycobacterium chelonae and few species of yeast have been identified in biofilms. Total bacterial aerosol concentration is positively correlated with clinical working time in dental practice.[7]

Dental aerosols and droplets are listed as high risk by The US Centers for Disease Control and Prevention (CDC) in equivalence to those aerosols produced during medical procedures. These aerosols are highly hazardous especially

while handling asymptomatic or minimally symptomatic individuals. [8,9] Aerosols fabricated in dental settings during close contact, exposure to bodily fluids, and indirect handling of as well as indirectly from handling sharp equipment and polluted dental surfaces cause dental health care personnel (DHCP) and their patients to experience mind distress.[10-14] As per literature, DHCP are exposed to the microbes transmitted from oral cavity and respiratory tracts of patients in from dental aerosols during the dental procedures.[15-22] The current review aims at assessing the risk caused by transmission in dental setups by dental aerosols and evaluate the measures taken for transmission and infection control.

There are three major doubts that need to be taken into consideration including the difference or equivalence of dental aerosols to those produced during other medical procedures.[23] Dental procedures include use of water and air sprays that leads to dilution of toxic products and microbes. Other precautions, such as evacuation techniques and rubber dam use further reduce the risk of exposure to microbes.[24] Other points taken into consideration include whether dental aerosols truly consist of infectious viral load and whether dental treatments cause spread of respiratory infections. According to CDC guidelines, the spread of SARS-CoV-2 through contact with surfaces is not a major route of viral transmission and furthermore, estimation of risk of aerosols and surface contamination must depends on recovery of viable virions, not just only on PCRtesting.[10, 24]

Dental Procedures Associated with Aerosols; Dental aerosol, droplets and splatter; andDental aerosol contents

Aerosol is less than 50 micrometers in diameter that stays in air for a longer period of time before it enters respiratory tract after inhaling through air even after a while. However, splatter and droplets are larger than 50 micrometer in size and have the potential to stay airborne for less amount of time. Microbial strains such as mycobacterium tuberculosis have the potential to stay viable in droplets. As droplets evaporate, they become smaller in size and have the potential to become airborne and thus may be able to produce infections during dental procedures. Micik and colleagues in dentistry defined the terms aerosols and splatter[25-27].

By definition, aerosols are fine liquid droplets or solid particles that are suspended and able to move through the air. Droplets are larger in size and tend to fall on surface due to the ballistic behavior . [28, 29]

Dental aerosols are mixture of saliva, blood, yeasts and molds, various microbes such as multi- resistant Staphylococcus aureus, influenza, legionnaire's disease, pneumonia; viruses such as mumps, chicken pox, cytomegalovirus infection, hepatitis B and C virus infection, herpes simplex virus Types 1 and 2 infection, human immunodeficiency virus; fungal elements such as mycotoxins, molds, yeasts and spores and dead cells. [30,31,32] Oral cavity harbors over 700 types of micro organisms including those from respiratory tract, nasopharynx and lungs. Body fluids including saliva, blood and gingival crevicular fluid consists of debris that could be aerosolized and contribute to transmission of infection. [33, 34]

Dental procedures include high speed instruments that involve high speed as well as slow mechanical action tools responsible for producing the dental aerosols during the process. The instruments produce aerosols by kinetic energy. [35-37] A recent study investigated how ultrasonic scaling can transmit particle aerosols up to 2 meters away, and these particles can remain suspended for 35 minutes to hours without airflow. [38] If airborne particles are larger than 10 microns, these particles can be deposited by gravity on surrounding surfaces, such as the patient and adjacent clinical areas, at ranges of up to 2 meters.[39] During these dental procedures, various dental devices such as dental handpieces, air water syringes, ultrasonic scalers and air polishing units are known to produce colonization units via the produced bioaerosol.[40] During dental procedures with high speed handpieces, excessive heat is generated due to friction between the teeth and the rapidly rotating bur. Without coolant, the heat can damage the hard dental tissue and cause pathological changes in the pulp. Therefore, it is general consensus to use water coolants to prevent heat build-up during dental procedures, including tooth preparation, oral prophylaxis, and oral surgery. [41]

In addition to the aerosols generated naturally when a patient breathes, speaks, sneezes, and coughs, aerosols can also be generated through health-care procedures, which

is commonly known as aerosol-generating procedure (AGP). AGPs generate both small and big droplets each with a dissimilar composition and pattern. As a result, it is not advisable to use the term "AGP" interchangebly and presume that all AGPs provide the same concerns or demand the same level of PPE (i.e. AGP does not necessarily denote to a high-risk procedure) The classification of AGP as a high-risk operation should be based on evidence.[22,24] Also, the conclusion that aerosol generation causes infection is erroneous. The notion that aerosol-generating medical procedures (AGMP) and aerosol-generating dentistry procedures (AGDP) are equivalent is likewise incorrect . Aerosol compositions also vary widely among AGMPs. For example, one particular AGMP produces an aerosol by stimulating a patient's cough. Coughing has been shown to release up to 1000 times more droplets than normal breathing.[42,43]

Dental aerosols have been examined for more than a half of a decade. Fluids and Oral tissues are full of viruses and bacteria.[44-46] Aerosols of these microorganisms are unavoidable when the oral cavity is exposed to rotating, vibrating, or compressed air-blasting instruments.[44] Additionally, it is generally known that using High Volume Evacuation (HVE) selectively can minimize dental aerosols no less than 90%.[47] It needs to be noted that the majority of hospital suction units are categorized as small capacity. The majority of dental aerosol droplets discharged by HVE touch the patient's face and body without harm.[48] Depending on the treatment room's airflow parameters, a small portion of these droplets form a "dental aerosol" that remains in the air for 10 to 30 minutes.[47] Numerous research has looked at the relative infectiousness of dental aerosols and the possibility of cross-contamination risks in dental settings. The majority of these research were produced in response to recent or recurrent illnesses like tuberculosis, HIV/AIDS, hepatitis B, SARS-CoV-1, etc.[48] These papers, in general, consist of phrases suggesting the potential/possible infectiousness caused by dental aerosols of infected individuals. [47]

Can splatter from dental procedures spread disease?

Miller *et al.* have concluded that bio-aerosols can contain millions of bacteria per cubic foot of air.[19] King *et al.* said that aerosols he collected from patients from a distance of 6 inches showed a significant reduction in colony forming units by the aerosol reduction system. [33]

Contamination from surgical sites

Mechanical instruments used during dental treatments generally produce airborne particles. The most obvious aerosols are produced by ultrasonic scalers, air ablation instruments, dental handpieces, and air polishers. Each of these devices eliminate surgical site material that has been atomized by the combined action of compressed air and water sprays, ultrasonic vibrations, and rotating instruments. This airborne material was distributed at a minimum distance of 18 inches from the surgical site. Despite the droplet volume and diffusion distance, no visible aerosols were detected during use of the ultrasonic scaler and could only be detected as droplets settled on the surrounding surface.[49,50]

Possible Transmission Routes of SARS-CoV-2 in Dental Practice

There is an indication that SARS-CoV-2 may spread from person to person directly through the exchange of droplets and indirectly through bacterial carriers.[51,52] Asymptomatic individuals have been discovered to shed the virus for up to 14 days during the asymptomatic prodromal phase, with possible viral shedding lasting up to 24 days. Live SARS-CoV-2 virus has been recovered from the saliva of infected people, and it has been demonstrated in some instances that saliva has virus concentrations that are much higher than those found in nasopharyngeal test swabs. It is not unexpected that the epithelium of airways and salivary ducts is abundant in ACE2+ cells.[53] In the SARS epidemic caused by SARS-CoV-1 in the early 2000s, salivary duct epithelial cells were an early target for viral contamination.[53]

The close interpersonal contact between those involved and the nature of the procedures carried out while providing dental treatment make the dental setting more conducive to SARS-CoV-2 transmission. Direct contact with conjunctival, nasal, or oral mucosal tissues or droplets carrying pathogensput both DHCPs and patients at higher risk.[8] SARS-CoV-2 can also persist on hard surfaces for 4-72 hours, which means that touching them could lead in indirect exposure.[53] The viral load of the infected person and the host person's susceptibility may affect the likelihood of such transmissions.[53] Dental aerosols, direct contact, surface contamination, droplet

transmission, and fomites are possible SARS-CoV-2 transmission pathways in dental offices.

Contamination from the operative site

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Dental Aerosols and COVID-19

Currently, all evidance indicate to droplet transfer as the main method of SARS-CoV-2 transmission.[54-60] Contact transmission is a minor factor.[61, 62] Yet, there is concern that under some circumstances, viruses might turn into aerosols and raise the risk of airborne infection. Because there is a sizable proportion of asymptomatic or prewar affected patients, this worry is especially crucial in dentistry.[63-66]

These people can not be diagnosed with the aid of using habitual screening questions or temperature checks. Theconcern, treating an asymptomatic/presymptomatic patient with AGDP may endanger the health of dental staff, office staff, or other patients.

Dental Aerosols are Not Infectious[42]

Practitioners routinely produced aerosols in patients with pathogen infections, whether they did it consciously or not. Besides contained in many other past diseases, dental aerosols may also be found in the SARS-CoV-2 virus following the COVID 19 outbreak in 2020. There is no proof that the dental aerosols found in the SARS-CoV-2 are more infectious than the ones contained in the previous pathogens. Evidence addressing the transmission of COVID through dental aerosols has been restricted as a result of the use of PPE and other protective measures during normal dental operations. The recent dental office closures were about “social distancing” and not about dental aerosols. It had to be said during the last pandemic (H1N1, 2009), Neither Ontario nor Quebec regulatory agencies impose restrictions on dental aerosols. Instead, preoperative screening and hand hygiene came into focus. [54]

Certain medical procedures can produce highly dangerous aerosols. This awareness was made crystal clear by the tragic infecting and passing away of medical personnel during the SARS and Ebola outbreaks. When performing medical operations involving infectious COVID-19 sufferers, the use of heightened PPE and other airborne measures is entirely appropriate.[54]

There are possibilities of Two main concerns in the current regulatory environment: Not knowing well enough about dental aerosol mitigation. In non-clinical areas, sustained conversations and even coughing and sneezing can produce higher viral loads, and there is certainly no benefit to mass evacuation, perhaps without masks. Protocols aimed to keep safe patients and medical staff in rooms with no direct observable symptomps in the dental offices are thus necessary. Another issue is the false assumption that going to the dentist is risky. Due to a bad perception of dental installations as a harmful and contaminated region, patients are anxious about dental visits. However, there is no denying that dentist office are safer than the majority of other public places. Yet the public's dental health will unavoidably worse if they perceive that going to the dentist offices is dangerous.[54]

Safer aerosol-free emergent (safer) dentistry[69]

Safer Aerosol-Free Emergent Dentistry (SAFERDentistry) are being adviced for dental procedures. This is based on avoiding aerosol producing processes. Such procedures exist and may replace possibly hazardous“standard” therapies in an emergency context with airborne pathogens such as SARS-CoV-2. This practice focuses on priorities of most common patient needs and ethically proven procedures that do not require aerosol generating instruments. With the protocol to avoid aerosol generating procedures, SAFER dentistry prioritzes emergency and needful procedures needed for the patients. SAFER dentistry comprise the following:

1. Teledentistry: to avoid direct contact and is when performed in person, this includes antiseptic mouthrinse andvisual and/or tactile inspection without intraoral radiographyfor diagnosis.

2. Absolute emergency cases involving Swelling, Acute pain, or infection: depending on the diagnosis, antibiotic therapy (acute inflammation), pulp devitalization/temporary filling (pulpitis), and/or local anesthesia andtooth extraction are provided.

3. Toothache due to caries without pulpal involvement: glass-ionomer sealants/Atraumatic Restorative Treatment (ART), fluoride varnish/gel, silver-diamine-fluoride application (SDF), and/or tooth brushing with high fluoride-containing toothpaste (HFT, 5,000 ppm fluoride).

4. Pain and swelling due to Acute periodontitis: metronidazole/amoxicillin and hand scaling combination for 1 week.

5. Denture repair/reline, lost crown or orthodontic bracket, ororthodontic wire: denture repair with soft re-line, and wire adjustment, crown and bracket re-cementation, repair, orremoval as well as removal of stiches from previous surgery.

SAFER dentistry provides realistic, effective and harmless treatment protocols. These protocols provide a practical approach to the dental procedures in the pandemic situation of COVID 19 and SARS-COV-2

Package	Intervention options without aerosol risk	Conventional optionswith aerosol risk
Examination	• Teledentistry– remote triage, examination and counseling • Pre-examination antiseptic mouthrinse • Visual examination • Examination with instruments • Probing, • percussion test • Pulp vitality testing (ice-pellet/heated gutta-percha/electric testing) • Extraoral X-ray if available and required (OPG)	•Intraoral x-ray (risk of avulsion & coughing) •Temperature test with cold air blow (saliva splatter) •Tactile examination/palpation

Table 1. SAFER Dentistry Packages and intervention options[69]

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
Influeza	Apparently associated with coughing but may require direct contact with the patient
Legionnaires' Disease	Aerosolization of Legionella pneumophila has been assosciated with air conditioning systems and hot tub spas
Severe Acute Respiratory Syndrome	Spread by direct contact and aerosolized droplets

Table 2. Disease known to be spread by droplets of aerosols[70].

Methods of reducing airborne contamination

Treatment of DUWLs and sterilization of instruments should be followed according to ADA's recommendations. Dental procedures produce contaminated aerosols that visible.[67,68] During routine dental treatment, there is a strong possibilty that aerosolized material include viruses, blood, and plaque organisms.. The potential for the spread of infection via an almost invisible aerosol, however, must be recognized and minimized or eliminated tothe greatest extent feasible within a clinical situation. The danger posed by splatter and droplets coming from the work site will be significantly reduced by using protective gear, such as masks, gloves, and eye protection.[69] However, any infectious substance released as an aerosol has the ability to pass through mask leaks and come into contact with mucous membranes by diffusing around safeguarding equipments like safety glasses. After a procedure, a true aerosol and droplet nuclei may linger for up to 30 minutes in the air of dental setups.[70]

Using the rubber dam as a protective habit can almost minimize any contamination brought on by saliva or blood. The only source of airborne contamination, then, comes from dental treatments. Thus, only airborne tooth material and microbes in the tooth will be the factors left behind. Aerosol contamination is more of a concern when rubber dam application is not possible in procedure such as treatment of periodontium. Here, Ultrasonic instruments will cause the production of aerosols.[68]

Ultrasonic and Sonic Scalers	Considered the greatest source of aerosol contamination; use of a high-volume evacuator will reduce the airbone contamination by more than 95 percent
Air Polishing	Bacterial counts indicate that airbone contamination is nearly equal to that of ultrasonic scalers; available suction devices will reduce airbone contamination by more than 95 percent
Air-Water Syringe	Bacterial counts indicate that airbone contamination is nearly equal to that of ultrasonic scalers; high-volume evacuator will reduce airbone bacteria by nearly 99 percent
Tooth Preparation With Air Turbine Handpiece	Minimal airbone contamination if a rubber dam is used
Tooth Preparation With Air Abrasion	Bacterial contamination is unknown; existensive contamination with abrasive particles has been shown

Table 3: Dental Procedures and Devices that cause airborne contamination[35]

Removing the contaminated material from the working area is one of the effective methods to follow. The most frequently used methods of removing airborne contaminationfrom the air of the treatment room are the use of a high efficiency particulate air(HEPA) filter and the use of ultraviolet radiation and chambers in the ventilation system. However, they are somewhat expensive; the UV system is cost prohibitive for most dental offices at this time. Both approaches have the shortcomings of an extended period for the air in the treatment room to cycle through the filter or UV treatment system.[68]

DEVICE	ADVANTAGES	DISADVANTAGES
Barrier Protection-Masks, Gloves and Eye Protection	Part of "standard precautions," inexpensive	Masks will only filter out 60 to 95 percent of aerosols, subject to leakage if not well-fitted, do not protect when mask is removed after the procedure
Preprocedural Rinse With Antiseptic Mouthwash Such as Chlorhexidine	Reduce the bacterial count in the mouth, saliva and air; inexpensive on a per-patient basis	Tends to be most effective on free-floating organisms such as plaque, subgingival organisms, blood from the operative site or organisms from the nasopharynx
High-Volume Evacutor	Will reduce the number of bacteria in the air and remove most of the material generated at the operative site such as bacteria, blood and viruses; inexpensive on a per-patient basis.	When an assistant is not available, it is necessary to use a high-volume evacuator attached to the instrument or a "dry field" device; a small-bore saliva ejector is not an adequate substitute
High-Efficiency Particulate Air Room Filters and Ultraviolet Treatment of Ventilation System	Effective in reducing numbers of airbone organisms	Only effective once the organisms are already in the room's air, moderate to expensive, may require engineering changes to the ventilation system

Table 4. Methods of reducing airborne contamination[35].

Legal concerns of dental aerosols:

The ADA and CDC have recommended that all blood-contaminated aerosols and splatter should be minimized.[71] Occupational Safety and Health Administration regulations stated, all procedures involving blood or other potentially infectious materials shall be performed in such a manner as to minimize generation of droplets of the these substances.[72,73] The recommendations and protocols were retained in the guidelines for infection control by the CDC. The use of rubber dams and HVEs are considered to be "appropriate work practices"—precautions that always should be followed during dental procedures.[74,75] Table 4. lists the available methods of reducing aerosols and splatter contamination, as well as their relative effectiveness and costs.

Conclusions

Dental procedures involve high speed instruments that produce body fluids and microbes derived aerosols. These aerosols are hard to study due to the dilution factor. However, it is well studied the droplets and aerosols during close contact with infected patients has a high risk of transmission. Thus, pertaining to the outbreak of COVID 19, it is reasonable to follow the protocols recommended by CDC and ADA to reduce aerosol contamination and exposure.

Declaration of Interest

The authors report no conflict of interest.

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