Review Article

The Covid Era And Aerosols In Restorative Dentistry

Mamatha Kumaraswamy,[1] Sheela N.V.,[2] H Murali Rao [3], B.S. Keshava Prasad[4]

[1]Postgraduate Student, Department of Conservative Dentistry and Endodontics, D.A.P.M.R.V. Dental College and Hospital, Bengaluru, Karnataka, India.

[2]Reader, Department of Conservative Dentistry and Endodontics, D.A.P.M.R.V. Dental College and Hospital, Bengaluru, Karnataka, India.

[3]Professor, Department of Conservative Dentistry and Endodontics, D.A.P.M.R.V. Dental College and Hospital, Bengaluru, Karnataka, India.

[4]Professor and Head, Department of Conservative Dentistry and Endodontics, D.A.P.M.R.V. Dental College and Hospital, Bengaluru, Karnataka, India.

Corresponding Author- **:** Dr. H Murali Rao,
Professor, Department of Conservative Dentistry and Endodontics, D.A.P.M.R.V. Dental College and Hospital, CA-37, 24th Main, JP Nagar, ITI Layout, 1st Phase, Bengaluru, Karnataka- 560078, India.
E-mail: drmuralihrao@yahoo.com,

ABSTRACT

Occupational hazards for dentists are the respiratory diseases caused by aerosol-generating dental procedures. This review describes the probable role of aerosols in restorative dentistry in transmitting the novel coronavirus disease and suggests a workflow based on triage categories. Four categories are suggested based on the severity of symptoms or on whether the treatment provided would be emergency or elective. Based on the categories, a workflow is designed to minimise the exposure to these droplets. Studies have shown that triaging helps to significantly reduce the risk of cross-infection, hence, standard operating procedures for disinfection and sterilization must be revised in the future.

Introduction:

Coronaviruses are zoonotic RNA viruses that cause diseases in both animals and humans (1). Severe acute respiratory disease (SARS) is a severe pneumonia disease caused in humans by the SARS-Coronavirus (SARS-CoV). It was first reported in November 2002 in China and had spread to 27 countries by 2003. Middle East Respiratory Syndrome (MERS) is another disease caused by Coronaviruses and the outbreak had occurred in 2012, in Saudi Arabia.

The ongoing pandemic is the Coronavirus disease (COVID-19) and is caused by SARS-CoV-2 (Severe Acute Respiratory Syndrome Coronavirus 2). The transmission of the disease is not yet certain but it is well-known that there are intermediate animal hosts and that human-to-human transmission occurs by droplets or aerosols (2). Also, SARS-CoV-2 disease is more infectious than the disease caused by SARS-CoV. This review aims to describe the role of aerosols in tooth preparations in restorative dentistry and techniques and alternate procedures to reduce the production of aerosols in a dental care setting.

Implications in restorative dentistry and endodontics

Dental professionals have always been at a risk of cross-contamination due to the type of work involved (3). The combination of saliva and high-speed equipment with water-coolant generates a large amount of spray comprising of droplets of various sizes (4). SARS-CoV-2 is found mainly in nasopharyngeal secretions and saliva (5) and thus, the disease has a massive potential to be transmitted to dental care providers through the spray production by instrumentation. Larger droplets settle quickly on various objects and can aerosolize due to movement of people and these new, smaller aerosols in turn remain suspended in the environment. Moreover, the virus's viability differs from surface to surface, the maximum persistence on a surface being 9 days. On plastic surfaces, the viability is 3 days, and on stainless steel surfaces, the viability is 2 days (3). Thus, considering the current scenario, the dental care provider should be the main decision-maker in performing risk-assessment (6) for treatments mandating immediate attention.

Methodology

MEDLINE (PubMed) and Google Scholar were scoured for clinical trials, randomized controlled trials, narrative reviews and systematic reviews, short communications, commentaries, and correspondences that are relevant to the objectives of this study.

Results and Discussion

1. Aerosol-producing procedures

Aerosols have been defined by Micik et al as, "particles that are suspended in the air for long periods of time and are invisible to the naked eye." These minute particles are less than 50 µm in size and can travel with air currents (7,8). The smaller particles, in particular, of an average size of 5 µm, have a hazardous potential to enter through the upper respiratory tract and settle in the alveoli in the lungs (7). Thus, they can be a route for transmission of infectious airborne diseases (9). Particles of these sizes are said to settle very slowly. Particles of even smaller sizes (less than or equal to 0.1 µm) behave as colloids and remain suspended indefinitely due to random, Brownian movement (7). Aerosols in a dental setup would comprise mainly of microorganisms, enamel and/or dentin debris, plaque, restorative material, and fluids. When combined with bodily fluids and microorganisms they are called 'bio-aerosols (9,10).'

Literature clearly suggests splatter to also be a source of infectious disease transmission (7,8,11). Particles are more than 50 µm in size and they settle quickly on objects as they are heavier than aerosols. Splatter can be clearly visible on nearby objects such as operatory lights, protective eyewear and other clear, plastic objects.

Aerosol-generating dental procedures are abbreviated 'AGDPs.' In descending order of the quantity of aerosols produced, these are (8):

1) Ultrasonic instrumentation
2) Air polishing
3) Air-water syringes or three-way syringes
4) Use of high-speed turbines
5) Lasers (4)
6) Use of air abrasion.

Most common diseases spread by aerosol or droplets are caused by Mycobacterium, H1N1 virus (influenza A), and Hepatitis B virus (8,12). Less common diseases are those caused by emerging coronaviruses (13) and Legionnaire's disease.

2. Viral load

Studies to quantify the SARS-CoV-2 viral load in aerosols and spatter in a dental setup were not available. Zou et al, in their study determining viral load in the upper respiratory tract of infected patients, have found that viral RNA is highest at the onset of symptoms (14). Viral load decreases from days 5 to 18 from the onset of the first symptom (15). It is also higher in the lungs than in the upper respiratory tract (16) possibly due to the high affinity of the novel coronavirus to ACE2 receptors present in the tracheobronchial epithelia and lungs (17).

Table 2 provides details of the viral load of SARS-CoV-2.

Table 2. Viral load of SARS-CoV-2

Authors	Situation/location	Viral load
Vuorinen et al (18)	At onset of symptoms	10^8 copies/mL
Wölfel et al (19)	Oral fluids/sputum	7×10^6 copies/mL
Liu et al (20)	Doffing area	0.02-0.04 copies/L of ai
Liu et al (20)	Toilets	0.02 copies/L of air
Chia et al (21)	Isolation rooms with air changes/circulation	1.8-3.4 copies/m^3

Stadnytskyi et al have estimated that an average viral load of 7×10^6/mL generates 1000 virus-filled droplet nuclei during loud speaking for 1 minute, provided the particles remain airborne for more than 8 minutes (22).

3. Emergency procedures

Elective treatment should be stopped and preference should be given to emergency procedures (23). A protocol must be followed for a smooth work-flow. Firstly, tele-screening or tele-triaging (24) should be done to screen out patients who do not require urgent treatment and whose symptoms can be managed through pharmacological therapy. Thorough travel and medical history should be taken in the tele-triage. Patients who require a face-to-face consultation and immediate treatment for relief from symptoms should be done so on an appointment basis with timed intervals to accommodate sterilization and disinfection of the working area. In case the patients have been a primary contact or reside in a Covid-containment zone, treatment should be deferred for 14 days (24).

Table 3. Summary of procedures that qualify for dental care (23,25–28) (29)

Triage: Category	Symptoms/Diagnosis	Procedure/Treatment
Emergency : A	Life-threatening head and neck infections, cellulitis obstructing airway, abscesses Trauma to facial bones Uncontrolled bleeding	Pharmacological therapy Refer to OMFS*
Urgent: B	Symptomatic irreversible pulpitis/symptomatic apical periodontitis	Pharmacological therapy Endodontic therapy
	Crown fracture with pulpal exposure	Vital pulp therapy or pulpectomy
	Intrusion/extrusion/lateral luxation	Repositioning and splinting of teeth
	Acute apical abscess	Incision and drainage Endodontic treatment Pharmacological therapy
Deferred: C	Reversible pulpitis	Treat the cause Pharmacological therapy, if required
	Deep caries lesions	Vital pulp therapy or pulpectomy
Elective: D	Aesthetic procedures	
	Routine recall visits	
	Restoration of asymptomatic teeth	
	Preventive/fluoride treatments	

1. Techniques to reduce the quantity of aerosols produced

It is almost impossible to completely eliminate the aerosols formed in restorative dentistry. Coronaviruses maintain virulence from 2 h to up to 9 days at room temperature and the virulence is higher at 50% humidity than at 30% humidity (30). No assumptions should be made that a patient is covid-free as research has proven the transmissibility of asymptomatic cases (3,31). These techniques should be employed to reduce the aerosols produced during treatment:

a. Four-handed dentistry: Ease of handling instruments, and suctioning around the operative tooth during treatment to reduce spatter and aerosol production is necessary, hence, four- or six-handed dentistry is advisable (23).

b. Pre-procedural mouth-rinse: Usage of 0.02% chlorhexidine mouthwash only weakly inactivates the coronavirus, but the combination of chlorhexidine with ethanol was suggested by Kelly et al to help reduce viral load (33). A more efficient method to reduce salivary viral load is to use 0.23% povidone-iodine (PVPI) mouthwash or 2% hydrogen peroxide for at least 15 s prior to the procedure. It is proven to inactivate coronaviruses like SARS-CoV-1 and MERS-CoV (34). Hydrogen peroxide is a strong oxidant and may cause damage to the SARS-CoV-2 virus (35).

c. Rubber dam: Barabari and Moharamzadeh, in their review stated that there is evidence that aerosols are reduced by 70% within 3-foot diameter of the operating field. The quantity of aerosols can be further reduced when the tooth of interest is disinfected using 0.23% PVPI, hydrogen peroxide (35) or sodium hypochlorite (36). An in-vitro study by Cochran et al confirmed that the number of colony-forming units (CFUs) when rubber dam and high-volume suction are used concurrently is reduced up to 99% (37). Contrarily, a study by Al-Amad et al revealed that a short, 30 minute procedure can be completed without the settling of aerosols on the head even when a rubber dam is not used (38).

d. Anti-retractive hand-piece (39): Ordinary hand-pieces cause backflow of saliva and other fluids into the dental unit water lines (DUWLs). They can later be ejected from the hand-piece and be a source of cross-contamination. To prevent this, anti-retractive hand-pieces with valve mechanism were specially designed (36,39). If this is not possible, high-speed airotors with reduced water or without water cooling can be used with tungsten-carbide burs (36).

e. Single-visit endodontics: Whenever possible, endodontic treatment should be completed in a single visit. This will reduce the number of appointments and also production of aerosols limited to one appointment (36). Intraoral radiography must be avoided as this can cause gagging or coughing in some persons (23,32).

f. High volume evacuators: High volume evacuators or suctions used with rubber dam isolation results in 99% reduction of the bio-aerosols produced (25).

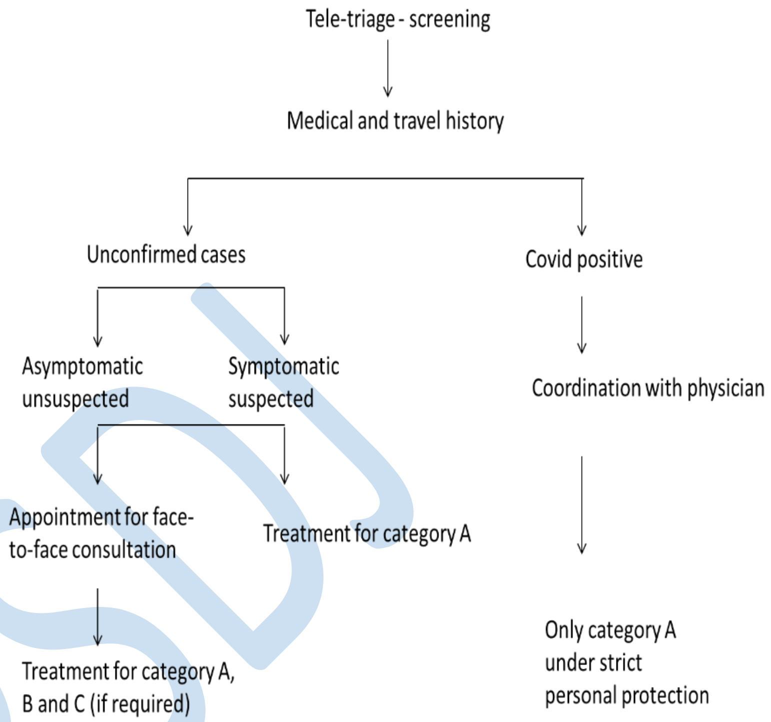
g. Chemo-mechanical caries removal: Manual excavation or atraumatic restorative techniques (ART) should be used whenever possible (39).

h. Adhesive restorative materials: Glass ionomer cements and bulk-fill composites must be used to reduce the clinical time required for treatment. Repair dentistry is advocated rather than replacing fractured restorations or crowns (39,40).

i. Surface disinfection: Surfaces that are frequently touched must be disinfected with a minimum concentration of 60% ethanol or 0.1% sodium hypochlorite (39).

j. Waste management: All contaminated disposables should be treated as infectious medical waste (39). Re-usable instruments and hand-pieces must be pre-treated, cleaned and sterilized (35).

Flowchart 1. Suggested workflow for patient-triaging



1. **Personal protection and air-purification (41)**

Wearing a Personal Protective Equipment prior to interacting with patients is a must (42) to prevent cross-infection and droplets from settling on personnel's clothes and skin (43). The PPE donned should preferably be a disposable one (44). Oral respirators (valved or non-valved) having a high filtering capacity like the N 95, N 99, or N100 must be used. Their filter capacities are 95%, 99%, and 99.97%, respectively (3). The clinic should have the minimum number of people necessary and also be equipped with exhaust vents and adequate ventilation either by natural or mechanical means. This must be done to avoid air re-circulation (45). Twenty-three minutes of 12 air changes per hour are required to filter the air with an efficiency of 99% (46). Air disinfection devices such as Ultraviolet Germicidal Irradiation (UVGI) have been shown to be effective against coronaviruses. Viral aerosols containing SARS-CoV-1 and MERS-CoV were inactivated with UV-C decontamination devices (45). Two most common methods to filter contaminated air are:

High-Volume Evacuator (HVE): They are suction devices held at approximately 6-15 cm from the operatory site and remove around 90% contamination contributed by aerosols (10). Some studies state that around 97% of these aerosols are removed by HVEs (25).

High Efficiency Particulate Arrestor (HEPA): This device essentially removes 99.7% of particulate matter of sizes 0.3 µm and above (47), thus protecting the dental worker from bio-aerosols. There are two main disadvantages of HEPA filters, i.e., they are expensive, and the filters themselves can be a site for growth of retained microbes which can re-enter the filtered air (10).

Conclusion and Future Perspectives

The pandemic has had a huge impact on dentistry and dental education. The current sterilization, hygiene, and personal protection protocols have been questioned. A small lapse in these procedures may trigger an unpredictable chain reaction. Although we have more knowledge about the SARS-CoV-2 disease presently, it is still insufficient to prepare us for the future (48). In the past, coronaviruses have been susceptible to public-health interventions but the recent outbreak of the novel coronavirus has proven otherwise. Therefore, more resources should be mobilized to improve public health care, diagnostics, and immunology related to these viruses. This review addressed the effect of the disease on providing routine and urgent endodontic and restorative treatment. Taking these challenges into consideration, dentists should rely on their knowledge and experience in taking adequate measures to prevent cross-infection and providing high-quality treatment.

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