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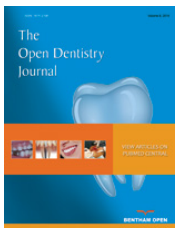

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REVIEW ARTICLE

COVID-19 in Dental Practice: Transmission Risk, Infection Control Challenge, and Clinical Implications

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Abstract:

Objective:

The COVID-19 pandemic has become a worldwide, significant public health challenge. Dental care providers are at high risk due to the nature of their profession, which necessitates close proximity to the patient's oropharyngeal region and the use of droplet and aerosol-generating procedures.

Methods:

A review of the evolving literature on the COVID-19 pandemic was conducted. Published articles addressing SARS-CoV2 transmission modes and risks, and infection control procedures required in the dental office to protect dental patients and health care providers were assessed. Also, clinical guidelines on the management of dental patients during the pandemic were reviewed.

Results:

The established modes of transmission of SARS-CoV2 appear to be through respiratory droplets and through close contact with either symptomatic or asymptomatic patients. In addition to standard precautions of infection control widely followed in dental practices, extra precautionary measures are needed to control the spread of this highly infectious disease. Dental treatment during the pandemic is limited to emergent and urgent cases after a meticulous patient risk assessment and dental needs are triaged to minimize the risk of COVID-19 transmission and avoid cross-contamination.

Conclusion:

Dentists should be aware of the recently updated knowledge about COVID-19 modes of transmission and the recommended infection control measures in dental settings. Effective management protocols to regulate droplet and aerosol contamination in the dental clinic should be implemented to deliver dental care in a safe environment.

Keywords: Coronavirus disease 2019, Dentistry, Dental clinical guidelines, Infection control, Personal protective equipment, Aerosol.

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1. INTRODUCTION

The COVID-19 pandemic first originated in Wuhan, China, in December 2019. It has been identified as a public health emergency of international concern by the World Health Organization (WHO) and by the 29th April 2020, it reached 2954222 confirmed cases worldwide [1 - 3]. It was first identified in samples of bronchoalveolar lavage fluid in patients with pneumonia on the 3rd January 2020, and found to be typical of a lineage B beta coronavirus, following which, it was termed novel Coronavirus (2019-nCoV) [1]. On the 11th February 2020, the International Committee on Taxonomy of Viruses (ICTV) announced "severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2)" as the name of the new virus as it was genetically related but different to the coronavirus responsible for the SARS outbreak of 2003. Moreover, the WHO named the disease caused by this virus as "COVID-19" [4].

2. MODES OF TRANSMISSION OF SARS-COV-2 VIRUS

Several studies were performed to determine the modes of transmission of SARS-CoV-2, which confirmed that it is mainly transmitted through respiratory droplets and direct

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contact. The primary mode of transmission is thought to occur from droplet spread in which large droplets (≥5-10 μm) carry virus particles. Droplet transmission occurs when a person is in close contact (within one and a half meters) with a patient having respiratory symptoms (*e.g.*, coughing or sneezing) and therefore, they risk exposing their oral and nasal mucosae and eyes to the potentially infective respiratory droplets [5 - 7]. Another study highlighted the transmission of SARS-CoV-2 through the ocular surface and speculated that the virus enters the tears through droplets, which may pass through the nasolacrimal ducts and then into the respiratory tract [6].

The infection control guidelines established to avoid such infection, recommend supplementing standard precautions with droplet (transmission-based) precautions. The core element of standard precautions is hand hygiene using soap and water for at least 20 seconds, especially when hands are visibly dirty and after touching any surface, coughing, sneezing or blowing the nose [8]. In circumstances where no soap and water are available, hand hygiene with alcohol-based hand rub (ABHR) containing ethanol (80% v/v) or isopropanol (75% v/v) is used. Alcohol denatures proteins and inactivates enveloped viruses, including coronaviruses and thus ABHR is recommended by the WHO that declared its marked virucidal effect against SARS-CoV and MERS-CoV [9, 10]. As diseases transmitted by respiratory droplets require certain proximity of people, droplet precautions recommended by health agencies during this COVID-19 pandemic include cough etiquette and social distancing. Cough etiquette was clarified by Harte 2010 as covering the mouth and nose during coughing and sneezing, using tissues to cover respiratory secretions and quickly disposing them of in a closed area, offering a surgical mask to people with respiratory symptoms to decrease contamination of the surrounding environment and performing hand hygiene after contact with respiratory secretions [11]. At the level of the community, social distancing is designed to reduce interactions between individuals where unidentified infected persons may exist [12].

Among health care workers, personal protective equipment (PPE) includes face masks, respirators, gloves, and goggles or face shields, that are advised to protect from droplet infections. Face masks are used to avoid respiratory droplets and spray of body fluids on the face and also used by patients as source control to prevent the spread of pathogens to others [13]. Respirators are used to protect from respiratory aerosols and if properly fitted, they may provide better protection against respiratory infections than a standard face mask. Gloves are also used to prevent hand contamination by body fluids, including respiratory secretions. Additionally, goggles and face shields are used to protect against the transfer of respiratory pathogens into the eyes from contaminated hands and other sources [14, 15].

The other documented COVID-19 mode of transmission is through contact, where the immediate environment around the infected person (*e.g.*, chair, glass window in the room, etc.) or objects used by the infected person (*e.g.*, door handle, light switches, elevator buttons and faucet taps, etc.) could act as a potential medium to transmit infection by indirect contact [16 - 18]. Environmental contamination is attributed to aerosol transmission in a relatively closed environment exposed to high concentrations of aerosols for a long time as well as under certain circumstances that generate aerosols. These circumstances include endotracheal intubation, bronchoscopy, open suctioning, administration of nebulized treatment, manual ventilation before intubation, turning the patient to the prone position, disconnecting the patient from the ventilator, non-invasive positive-pressure ventilation, tracheostomy, and cardiopulmonary resuscitation. During these maneuvers, the aerosols with virus particles being less than 5μm in diameter can remain in the air for long periods of time, transmitted to others over distances greater than one meter and thus become airborne, increasing the risk of spread [5, 7].

To verify environmental contamination around patients with COVID-19, different surfaces were experimentally exposed to the SARS-CoV-2 virus isolated in tissue culture form. Reported results showed that no infectious virus was recovered from printing and tissue papers after a three-hour (hs) incubation and from wood or cloth on day two. In contrast, SARS-CoV-2 was more stable on smooth surfaces and could not be detected from treated glass and banknote surfaces on day four or from stainless steel and plastic on day seven. More surprisingly, a detectable level of the infectious virus could still be present on the outer layer of a surgical mask on day seven [19]. Another study examined SARS-CoV-2 in aerosol form concluded that the virus could remain viable and infectious in aerosols for three hours and on surfaces for days (depending on the inoculum shed). This study proved that the virus is more stable on plastic and stainless steel (72 and 48 hs, respectively) than on copper (4hs) and cardboard (24hs) although the virus titer was greatly reduced [20].

The infection control guidelines established to avoid COVID-19 infection through contact with environmental surfaces recommend supplementing standard precautions with contact (transmission-based) precautions. Health Care Workers (HCWs) should wear a clean, non-sterile, long-sleeved gown and gloves whenever in contact with the patient or potentially contaminated areas surrounding the patient, with appropriate doffing and disposal of all PPE and hand hygiene after patient care. A new set of PPE should be donned when care is administered to another patient [21]. Equipment should be single-use and disposable, if possible. In case of shared equipment, proper cleaning, disinfection and sterilization should be confirmed with care during transportation to a central sterilization service department. For the disinfection of environmental surfaces, the WHO recommends the use of disinfectants that are active against enveloped viruses, which includes the SARS-CoV-2 virus. These disinfectants include 70% ethyl alcohol for disinfecting reusable dedicated equipment as well as any small areas in use and sodium hypochlorite at 0.5% (equivalent to 5000 ppm) for disinfecting surfaces in healthcare settings [22]. All health care wastes produced during the care of COVID-19 patients should be collected safely in designated containers and bags and then safely disposed of, with all who handle the waste, wearing appropriate PPE (boots, apron, long-sleeved gown, thick gloves, mask, and goggles or a face shield) and performing appropriate hand hygiene straight after [10].

Hoffmann, *et al*. [23], highlighted that Angiotensin-Converting Enzyme 2 receptors (ACE2) are highly concentrated in salivary glands and could also be used for host cell entry and infection. This was later supported by the detection of SARS-CoV-2 RNA in the saliva of 25 COVID-19 patients where salivary samples were collected by drooling technique or with a pipette to ensure exclusion of sputum and oropharyngeal secretions from the specimens [24]. However, it remains to be shown whether SARS-CoV-2 levels in saliva are high enough to be infectious [25]. SARS-CoV-2 RNA has also been detected in 7 of 10 stool samples from infected subjects raising the likelihood of fecal-oral transmission [26].

3. TRANSMISSION RISK IN DENTAL OFFICES

In dental practices, COVID-19 transmission is expected *via* droplets and aerosols generated during clinical procedures especially when using drills or ultrasonic devices that cause aerosol release [27]. Based on previous reports on COVID-19 patients undergoing endotracheal intubation, aerosol transmission in an environment exposed to high concentrations of aerosols for a long time led to the spread of SARS-CoV-2 [1, 5, 28]. Furthermore, splatters created during oral surgery procedures, like aerosols, are also contaminated by respiratory pathogens [29]. Another important potential mode of transmission in dental practice could be contact with contaminated environmental surfaces.

During various dental procedures, aerosols and splatter can be produced by either patient, dental unit waterlines (DUWLs) or instruments used. For patients, microorganisms present in their mouth and respiratory tract may be transported in the generated aerosol; the amount of contamination is dependent on the amount of saliva, nasal and throat secretion, blood, dental plaque, periodontal infection, and the presence of any dental infection. The contamination of DUWL with very adherent organisms may be precipitated by the design of narrow lines, water stagnation, heating of dental chair unit and anti-retraction valve failure. Microorganisms may shed to the oral cavity during the use of DUWLs in dental procedures and can lead to the spread of infection [30, 31]. Instruments that can produce dental aerosols include ultrasonic and sonic scalers, air-water syringe and air turbine handpiece used for tooth preparation [32, 33].

Aerosols are defined as a combination of both liquid and solid particles (of less than 50 μm in diameter) and when the liquid evaporates, solid particles form droplet nuclei of 0.5 to 10 μm composed of saliva, dried serum and microorganisms. These droplet nuclei can reach pulmonary alveoli carrying bacteria and viruses and transmitting various infectious diseases such as SARS-COV-2 and *Mycobacterium tuberculosis,* or it can remain afloat in the air for several hours. Splatters consist of a mixture of air, water and / or solid substances, which are of 50 μm to several millimeters in diameter and are visible to the naked eye. Due to the mass, splatters are able to have the kinetic energy to move in a ballistic manner and settle atop objects due to gravitational forces with limited penetration into the respiratory system [34, 35].

The infection control guidelines to minimize the risk of dental aerosols emphasize on the use of PPE *i.e*. gloves, face masks and protective eyewear, pre-procedural rinsing, use of focused spray ultrasonic inserts; and disinfection of dental unit waterlines by chemical or non-chemical means [36]. Given that the incubation period of COVID-19 ranges from 1-14 days, (most commonly around five days) [7], recent evidence suggests that a non-symptomatic person can spread COVID-19 with high efficiency [37], also patients can spread high amounts of the virus and infect others even after recovery from the acute illness, therefore, the use of N95 masks is advised to ensure the safety of healthcare workers during COVID-19 outbreak [38]. Protective eyewear with side shields or face shields for dentists, not only protects from aerosols and spatter that transmit infection, but also from debris projected from the mouth, and from injuries caused by sharp instruments [39]. Guidelines also advised the use of High Volume Evacuators (HVE) with low volume saliva ejector as this will ensure removal of the water deposited in the floor of the mouth with no air removal. HVE also has a large bore evacuator tip with a diameter of 8 mm or more and thus, it can remove air at the rate of 100 cubic feet per minute, reducing aerosol and splatter by 93“96% [33, 40].

Due to the high risk of COVID-19 spread *via* dental practice, the dental healthcare community needs to take urgent action to protect patients and dental health care providers alike from infection. As of March 18th, the American Dental Association (ADA), and the U.S. Centers for Disease Control and Prevention (CDC) have urged all dentists to cancel, or at least postpone, all elective and non-urgent dental visits and thus routine dental practice has been suspended in several countries [41]. However, although patients diagnosed with COVID-19 are not recommended to receive dental treatments, dental emergencies are difficult to avoid, and consequent close contact is unavoidable. Thus, a timely and major reassessment of dental care practices is essential [27, 42].

4. DENTAL CONSIDERATION IN THE MANAGEMENT OF COVID-19 PATIENTS

The American Dental Association (ADA) has published interim guidance for the management of emergency and urgent dental care to assist dentists in making informed decisions concerning patient evaluation and treatment during the COVID-19 pandemic [43]. In addition, many other international and local regulatory bodies have published guidelines and protocols for urgent dental treatment during the COVID-19 pandemic [44 - 46].

Dentists are advised to review their local governance recommendations regarding dental management during the pandemic. However, all guidance highlights the importance of screening patients prior to their dental appointments. The purpose stated for the screening is to identify patients with possible COVID-19 infection and to minimize the chance of exposure to Dental Care Providers (DCP), staff and to other patients. During the screening call, patients should be asked whether they have a fever (above 38°C) or if they are experiencing any respiratory symptoms like sore throat, cough, or difficulty of breathing. Additionally, ADA recommended obtaining a travel history (to any of the affected countries

during the last 14 days) as well as the history of contacts with a diagnosed or suspected case of COVID-19. Subsequently, the dental condition of the patient and the urgency of their dental treatment needs are assessed. The list of emergency and urgent dental care conditions that require immediate treatment is presented in Table **1** and adopted from ADA interim guidance [43].

Table 1. List of emergent and urgent dental care adopted from ADA intern guidance (2020).

Dental Emergency	Cellulitis, extra or intraoral swelling compromising airways
	Facial trauma
	Uncontrolled bleeding
Urgent Dental Needs	Dental pain due to pulpal inflammation
	Pericoronitis
	Dry socket
	Localized dental abscess (periapical or periodontal)
	Tooth fracture causing pain
	Dental trauma, avulsion or luxation
	Suture removal
	Denture repair due to injury to soft tissue or prior to medical care
	Soft tissue injury form orthodontic wire/ appliance
	Dental treatment prior to medical care *e.g.* radiation therapy
	Biopsy of abnormal tissue
	Replacement of lost temporary filling or cementation of permanent bridges if the temporary prosthesis is broken

Guidelines from CDC stated that patients reporting dental pain should be evaluated for the level of pain and whether it is controlled by pain medications or not. According to these guidelines, patients with facial trauma, uncontrolled bleeding or cellulitis affecting the airways should be referred to the emergency department. A localized dental abscess, dental pain due to pulpal inflammation or dental trauma, causing avulsion or luxation of the teeth should be seen and managed based on the best recommended treatment guidelines. Other non-urgent dental care should be postponed until further notification from the CDC [47].

4.1. Dental Treatment of Patients with a Confirmed COVID-19 Infection

ADA guidance does not allow their examination in dental settings and recommends that emergency dental treatment to be limited to control pain and infection in consultation with the medical team. Accordingly, if a dental procedure must be performed, it should be done under rigorous standards, limited contact, and airborne precaution in a negative pressure room [48]. When infection control measures were strictly followed, none of the dental staff in the School and Hospital of Stomatology in Wuhan University was found to be infected by COVID-19 [49].

4.2. Pharmaceutical Management of Pain and Infection

Prescription of pain medication or antibiotics might be needed to treat mild pain or localized infection. There has been a number of reports that Nonsteroidal Anti-Inflammatory Drugs (NSAIDs) may exacerbate symptoms in COVID-19 patients. Ibuprofen use has been found to be associated with increases in Angiotensin-Converting Enzyme-2 (ACE2) receptor expression, which may facilitate infection with COVID-19 [50]. However, the literature does not provide any conclusive evidence against the use of NSAIDs in COVID-19 patients [50, 51]. The World Health Organization has published a scientific brief regarding the use of NSAIDs in COVID-19 that concluded a lack of evidence of severe adverse events as a result of NSAIDs use in COVID -19 patients [52]. Therefore, prescribing NSAIDs in combination with acetaminophen to manage dental pain, is appropriate until further evidence emerges.

Asymptomatic patients without known exposure to COVID- 19 cannot be assumed to be free of the SARS-COV-2 virus [37]. Therefore, recommendations are given that all aerosol-generating dental procedures should be done in isolated and adequately ventilated rooms or in a negative pressure room (when available). The use of the highest PPE available, including eye protection and face shield, is essential as is the use of fitted N95 respirators or FDA approved N95 equivalent masks for both the dentist and the dental assistant [53]. For none-aerosol generating procedures, the use of a surgical mask and a face shield is required (if N95 masks are unavailable/ in limited supply); however, there is a moderate risk of infection and professional judgment regarding patient treatment that must be exercised [48]. The SARS-CoV-2 virus is viable in aerosol for three hours [20], which emphasizes the importance of following the correct sequence of wearing and removal of PPE as recommended by the CDC [54]. Special recommendations to minimize the risk of disease transmission during dental procedures in those patients are presented in Table **2** [55 - 57].

For patients with resolved COVID-19 infection, it remains to be established when dental treatment can be safely performed. The duration of immunity to SARS-CoV-2 is also not known yet, however, it is unlikely that patients get re-infected after recovery, but the evidence on the immune response and the possibility of re-infection is lacking in the literature [58]. As with any newly emerging infectious disease, the patient must be presumed as infective until counter-evidence is presented, so resolved patients should be managed with the same precautions as asymptomatic patients.

5. PRESENT SITUATION AND FUTURE CONSIDERATIONS

Dental healthcare has been significantly affected by the COVID-19 pandemic. Limitation of dental care to emergency treatment and postponing elective procedures not only challenged the current treatment protocols but also resulted in a significant financial loss to many dental practices [59, 60]. However, this limitation has created telecommunications and online consultations that emphasize patient-education and follow up for early recognition and management of dental problems and hence avoiding life-threatening dental emergencies [61].

The risk of COVID-19 infection to the dental care provider

and potentially infecting patients during emergency dental treatment is significant. Data form the top five affected countries estimated that 15-20% of HCWs were infected with COVID-19 [62]. Factors like lack of understanding of the virus and its mode of transmission, the limited availability and inadequate use of PPE, limited diagnostic tests and psychological stress are contributing to the increased rate of COVID-19 infection among HCW [62].

Table 2. Special recommendations to minimize the risk of disease transmission during dental procedures.

General	Limit the number of individuals in the treatment room to the absolute minimum requirement.
	Use proper PPE.
	Follow the correct sequence of putting and removing PPE.
	Wait 15 min after patient dismissal before cleaning and disinfecting the room [55].
Minimize Gag, Cough and Vomit Reflex	Proper patient positioning and utilizing effective suction.
	Avoid the use of topical spray anesthesia.
	Avoid intra oral radiograph and use extra oral radiograph/ CBCT imaging.
Reduction of Droplet/Aerosol Generation	Pre-procedure mouth washes like 1% hydrogen peroxide or 0.2% povidone solution [56, 57]. Pediatric patients who are unable to rinse, cotton rolls socked in the mouth wash can be used.
	Minimizes the use aerosol-generating instruments like three-way syringe, ultrasonic devices and high-speed handpieces.
	Rubber dam when a high-speed handpiece use is necessary.
	Use the high-volume suction in addition to the saliva ejector.
	Use anti-retraction high-speed handpiece to reduce the backflow of oral microbes into the tubes of the dental units.
Restorative Treatment	Chemical caries removal and atraumatic restorative techniques are recommended.
Periodontal Treatment	Manual (hand) scaling and brushing are used.
	Use resorbable sutures following surgical procedures.
Prosthodontic Treatment	Handle dental impressions and prosthesis using the necessary PPE. Transport Specimen to the dental lab in a leakproof sealed bag .
Dental Waste	Should be disposed of according to the requirement of medical wastes.

CONCLUSION

To ensure the safety of dental staff during the outbreak, the US Occupational Safety and Health Administration (OSHA) has recommended regular testing DCPs for COVID-19, daily self-assessment for symptoms of COVID-19 and temperature check for all dental personals including dental assistants, hygienists, receptionists and dental technicians. Dental staff education is essential for protecting staff and patients from further spread of COVID-19, with an emphasis on the progression of the disease, its mode of transmission, clinical presentation and prevention methods, proper training in hand hygiene, the use of PPE and infection control methods according to the updated protocols form CDC and WHO [63].

A better understanding of the present situation will allow for the prediction of future dental needs as dental services may grow in the post-COVID-19 period. Health agencies should be coordinated to implement comprehensive prevention and control measures in future dental care [64]. New safety procedures, air purification systems, or additional infection control measures will be developed as our understanding of COVID-19 infection evolves. As the information on this pandemic is continuously changing, it is vital that dental professionals stay updated on the emerging research to be able to continue providing dental treatment in a safe environment.

LIST OF ABBREVIATIONS

WHO	=	World Health Organization.
ABHR	=	Hand hygiene with Aalcohol-Based Hand Rub
PPE	=	Personal Protective Equipment
HCWs	=	Health Care Workers
DUWLs	=	Dental Unit Waterlines
HVE	=	High Volume Evacuators
DCP	=	Dental Care Providers
ADA	=	American Dental Association
CDC	=	Centers for Disease Control and Prevention
ACE2	=	Angiotensin Converting Enzyme-2
NSAIDs	=	Nonsteroidal Anti-inflammatory Drugs

CONSENT FOR PUBLICATION

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CONFLICT OF INTEREST

The author declares no conflict of interest, financial or otherwise.

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