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INVITED MEDICAL REVIEW

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Aerosol transmission for SARS-CoV-2 in the dental practice. A review by SIdP Covid-19 task-force

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Abstract

Current evidence suggests that SARS-CoV-2, the virus that causes COVID-19, is predominantly spread from person to person. Aim of this narrative review is to explore transmission modality of SARS-CoV-2 to provide appropriate advice to stakeholders, in order to support the implementation of effective public health measures and protect healthcare workers that primary face the disease. "In vivo" and "in vitro" studies from laboratories and hospitals confirmed the presence of surface contamination and provided insight of SARS-CoV-2 detection in the air, particularly in indoor settings with poor ventilation where aerosol-generating procedures were performed. Measures for aerosol reduction, in conjunction with other effective infection control strategies, are needed to prevent the spread of SARS-CoV-2 in dental setting.

KEYWORDS
aerosol, COVID-19, dental practice, SARS-CoV-2

SIdP—Italian Society of Periodontology and Implantology Covid-19 task-force is a group of SIdP members and external consultants aimed to identify and monitor the evidence regarding COVID-19 spread and possible implications for clinical practice.

1 | INTRODUCTION

The novel coronavirus disease (COVID-19), caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), represents the most significant public health emergency that the world has faced in the last century. The outbreak started in Wuhan, China, with animal-to-human transmissions, followed by sustained human-to-human transmissions (Zhu et al., 2020). The latter is promoted through the ACE2 cell receptors that are detectable in the respiratory tract (Wit et al., 2016), (Zhou et al., 2020). SARS-CoV-2 has been found in the saliva of over 90% of infected individuals by viral culture method (To et al., 2020), and significant viral load in oral fluids (predominantly saliva) was confirmed using a highly sensitive SARS-CoV-2 RdRp/Hel assay (Chan, Yip, et al., 2020; Chan, Yuan, et al., 2020). Moreover, nasal and throat viral titers were found to be similar in both asymptomatic and symptomatic patients (Zou et al., 2020).

Understanding transmission modality of emerging infectious disease is essential to give appropriate advice to stakeholders, in order to implement effective public health measures and protect healthcare workers that primary face the disease. Among different working categories, dental practitioners are the workers facing the greatest risk of possible contagion of virus and bacteria from patient oral cavity and respiratory tract (Laheij et al., 2012), (Petti, 2016). The close contact between the mouth of the patients and the dental operators clearly plays a fundamental role in the exposure with infected secretions, such as saliva and respiratory secretions or corresponding droplets (Szymańska, 2007; Zemouri et al., 2020). Moreover, the risk may significantly increase by several dental interventions performed with instruments that rotate, vibrate, or expel compressed air (Zemouri et al., 2017). These procedures may potentially spread infection creating aerosols, in conjunction with possible emission during breathing, speaking, sneezing, and coughing (Judson & Munster, 2019). In the dental community, there is the concern that aerosol-generating procedures (AGPs) could facilitate the transmission of SARS-CoV-2, exposing to the contagion both dental staff and patients. Therefore, the aim of this review is to evaluate the transmission route of SARS-CoV-2 and elaborate on AGPs and aerosol transmission in the dental practice.

2 | MATERIAL AND METHODS

In order to review the literature regarding the transmission route of SARS-CoV-2 in a dental setting and elaborate on aerosol production during dental procedures, an electronic search was conducted on PubMed (Supplementary file 1). Additionally, recommendations from Italian (ISS), European (ECDC), American (CDC), and global (WHO) health organizations were considered for additional information. Relevant articles from literature revisions/commentaries/letters were also searched.

All the studies in English or Italian language reporting direct evidence about transmission risk of SARS-CoV-2 in dental practice were considered. Furthermore, indirect evidence from "in vivo" and "in vitro" studies for any setting was used if direct evidence was not available.

3 | TRANSMISSION ROUTE OF SARS-CoV-2

The classification systems of routes of respiratory disease transmission are based on the dichotomy of respiratory droplet emissions into "large" and "small" droplets, firstly published in the 1930s by W.F. Wells focusing on tuberculosis transmission (Wells, 1934). Large droplets (or respiratory droplets: >5 μm) remain airborne only briefly before settling because of gravity, contaminating surfaces in the immediate vicinity (<1 m) of the infected individual (Anfinrud et al., 2020; Barker & Jones, 2005). Conversely, small droplets (or droplet nuclei: 1-5μm) can stay airborne for hours because they are too small to settle because of gravity. They are carried by air currents and dispersed by diffusion and air turbulence, contaminating surfaces over long distances (> 1m) (ASHRAE, 2014).

This classification system, adopted by the WHO and other agencies (such as the Centers for Disease Control and Prevention—CDC), categorizes host-to-host transmission of respiratory diseases as droplet (direct or indirect contact modes) and aerosol transmission as the main possible modes of transmission routes (WHO, 2014).

According to the WHO (2020), SARS-CoV-2 is primarily transmitted between people through exposition of mucosae (mouth and nose) or conjunctiva (eyes) to direct or indirect (fomites) contact of respiratory droplets (Burke et al., 2020), (Chan, Yip, et al., 2020; Chan, Yuan, et al., 2020), (Huang et al., 2020), (Li, Guan, et al., 2020; Li, Pei, et al., 2020). Initially, the WHO advised also that transmission through the air over time and distance could occur, but only when aerosol-generating procedures are performed. These partly included: positive pressure ventilation, tracheal intubation, airway suctioning, nebulizer treatment, and bronchoscopy (Tran et al., 2012).

A very recent experimental study by Van Doremalen et al. (2020) evaluated the stability of SARS-CoV-2 and SARS-CoV-1 in five environmental conditions (aerosols, plastic, stainless steel, copper, and cardboard) and estimated their decay rates. The authors revealed that SARS-CoV-2 was more stable on plastic and stainless steel (up to 72 hr) than on copper (up to 4 hr) and cardboard (up to 24 hr). Moreover, they observed that SARS-CoV-2 remained viable in aerosols throughout the duration of the experiment (3 hr). Since the experimental nature of the study may not reflect normal human conditions, the authors concluded that both aerosol and fomite transmissions of SARS-CoV-2 are plausible, since the virus can remain viable and infectious in aerosols for hours and on surfaces up to days (Van Doremalen et al., 2020).

A recent study aimed to determine distribution of SARS-CoV-2 RNA in hospital wards in Wuhan, China, testing air and surface samples. The authors observed that contamination was greater in intensive care units than general wards but aerosol distribution characteristics in the general wards indicate that the transmission distance of SARS-CoV-2 might be 4 m (Guo et al., 2020).

Another very recent study by Liu, Liao, et al. 2020; Liu, Ning, et al. 2020 measured SARS-CoV-2 RNA in several aerosol samples in different areas of two hospitals in Wuhan, China. The authors found the highest concentration of virus in temporary single toilet room without ventilation, concluding that SARS-CoV-2 may have the potential to be transmitted via aerosols and indicating that room ventilation, open space, and proper use and disinfection of toilet areas can effectively limit the concentration of SARS-CoV-2 RNA in aerosols.

Given the high transmissibility of SARS-CoV-2, a plausible hypothesis is that airborne transmission may be present also in the absence of aerosol-generating procedure and that a face-to-face conversation with an asymptomatic infected individual, even if both individuals take care not to touch, might be adequate to transmit the virus (Meselson, 2020).

Studies on flow physics demonstrated that a number of particles are emitted during breathing and speech (Anfinrud et al., 2020). Apart from large particles, breathing and talking also produce smaller and numerous ones, known as aerosol particles (Duguid, 1946), (Papineni & Rosenthal, 1997), (Morawska & Cao, 2020), Somsen et al., 2020). Certain persons called "*superspreaders*" produce many more aerosol particles than other persons (Asadi et al., 2019). This suggests that a susceptible individual inhaling aerosol may become infected.

Different authors (Chan, Yip, et al., 2020; Chan, Yuan, et al., 2020), (Zou et al., 2020), and (Hu et al., 2020) reported also the existence of asymptomatic individuals who tested positive for the SARS-CoV-2, and from very recently studies, there is evidence that many infected individuals who transmit SARS-CoV-2 are either minimally symptomatic or not symptomatic at all. An epidemiological study in China (Li, Guan, et al., 2020; Li, Pei, et al., 2020) calculated that about 86% of infections in Wuhan, China, were "undocumented" individuals, those with "mild, limited, or no symptoms" who accordingly were never tested. The asymptomatic incubation period for individuals infected with SARS-CoV-2 has been reported to be ~1–14 days, and it was confirmed that those without symptoms can spread the virus (Rothe et al. 2020).

Airborne transmission between asymptomatic individuals might be associated with the pandemic nature of the disease and the super rapid-spreading event. Some outbreak reports during choir practice (Hamner et al., 2020), in restaurants (Lu et al., 2020), or in fitness classes (Jang et al., 2020) have suggested the possibility of aerosol transmission in specific indoor locations, such as crowded and inadequately ventilated spaces (Leclerc et al., 2020). Despite the detection of RNA in environmental samples based on PCR-based assays is not indicative of viable virus that could be transmissible, results from these studies suggest that SARS-CoV-2 airborne transmission may be possible in confined spaces and in specific circumstances and settings. To date, the WHO, together with the scientific community, has been actively discussing and evaluating whether SARS-CoV-2 may also spread through aerosols in the absence of aerosol-generating procedures, particularly in indoor settings with poor ventilation.

4 | AEROSOL-GENERATING PROCEDURES AND AIRBORNE TRANSMISSION IN THE DENTAL PRACTICE

Aerosol-generating procedures are usually performed in the human mouth by dental professionals, and the oral mucosa has been recognized as a potentially high-risk route of SARS-CoV-2 infection (Xu et al., 2020), Peng et al., 2020). An aerosol cloud of particulate matter and fluid often is clearly visible during the use of rotary instruments, ultrasonic scalers, air polishers, and air abrasion units (Micik et al., 1969). Each of these instruments removes material from the operative site that becomes aerosolized by the action of the rotary instrument, ultrasonic vibrations, or the combined action of water sprays and compressed air.

Using the bacterial growth method, the ultrasonic scaler has been shown to produce the greatest amount of airborne contamination, followed by the air-driven high-speed handpiece, the air polisher and various other instruments such as the air–water syringe and prophylaxis angles (Bentley et al., 1994, Legnani et al., 1994, Gross et al., 1992, Harrel, 1996). Interestingly, low level of aerosol production was also observed after dental extraction and oral examination (Hallier et al., 2010).

A study from Rautemaa et al. (2006) found a higher bacterial load in the aerosols at 1.5 meter from the oral cavity of the patient than in the aerosols within 1 meter from the patient. Chuang et al. (2014), based on a preliminary study from two patients, showed that bacterial aerosols contamination could spread a horizontal distance of 100 cm and a vertical distance of 50 cm from a patient's oral cavity, and remain airborne suspended for 20 min. Another study (Dutil et al., 2009) reported that aerosols production return to baseline 2 hr after the dental treatment, with a potential for an airborne contaminant to enter the ventilation system and spread elsewhere.

Despite the actual absence of data on SARS-CoV-2 spreading in dental offices, very recent publications from general hospital and laboratory setting confirm surface contamination and provide initial evidence on whether the SARS-CoV-2 can be detected in the air, mostly in areas where aerosol-generating procedures are performed. Results emphasized the importance of preventing or reducing microbial aerosols in the dental setting, in order to avoid cross contamination and guarantee a safe working environment.

5 | PREVENTIVE MEASURES IN THE DENTAL PRACTICE

Different preventive measures have been described to reduce risk of infection for dental professionals during the outbreak of COVID-19. The WHO strongly recommend a precheck triage (questionnaire and temperature measurement) to early recognize possible patients with COVID-19. Specifically, the patient should also be asked, or temperature taken as the case may be, if he or she is running a fever (> 37.5 °C) or suffering from flu-like symptoms, myalgia, unproductive cough, or diarrhea. Once a SARS-CoV-2 case is suspected, the dentist must immediately inform the health authorities. However, assuming that also presymptomatic or asymptomatic patients may be infective, other strategy should be used to minimize the risk of infection to dental personnel. Special precautions should be taken to minimize droplet and aerosol production, including the prevention of the gag, cough, or vomiting reflexes leading to aerosols (Li et al., 2004).

Due to SARS-CoV-2 vulnerability to oxidation, preprocedural mouth rinse containing oxidative agents such as 0.5% povidone is recommended in order to reduce its salivary load (Bidra et al., 2020).

Whenever possible, handpieces and ultrasonic instruments should be avoided. Since no differences exist in the efficacy of manual or mechanical non-surgical periodontal procedures (Tunkel et al., 2002), manual instruments should be used.

In order to virtually eliminate all contamination arising from saliva or blood, Barnum (1864) described the use of a rubber dam. When a rubber dam can be used, aerosol composition is limited to the tooth material and any organisms contained within the tooth itself (Samaranayake et al., 1989), (Cochran et al., 1989), Samaranayake & Peiris, 2004). However, in some aerosol-producing dental procedures (subgingival restorations, final steps of crown preparation) the use of a rubber dam is not possible. In these cases, high-volume vacuum suction/evacuator (HVE) can reduce 90% of aerosol production if correctly positioned near the handpiece and close to the mouth (Harrel & Molinari, 2004). Moreover, the 4-handed technique and anti-retraction dental handpiece with specially designed anti-retractive valves or other anti-reflux designs are useful for controlling infection, so they are strongly recommended as an extra preventive measure for cross-infection.

With the aim of reducing airborne SARS-CoV-2 presence, room ventilation is strongly recommended, mostly in areas where aerosol-generating procedures are performed.

It must be emphasized that the dental team should not rely on a single precautionary strategy or device to minimize the risk of infection to dental personnel and other patients completely. Controlling dental aerosol is only one single step to reduce the risk of infection by a certain percentage. Further steps are clearly needed in order to reduce the remaining risk.

6 | CONCLUSIONS

In the absence of direct evidence on transmission of SARS-CoV-2 in dental practice, indirect evidence from clinical and laboratory settings suggests that:

- Transmission routes of SARS-CoV-2 are the direct droplet spread, indirect contact spread, and airborne spread, confirming that dental professionals are at high risk of infection.
- Either minimally symptomatic or not symptomatic infected persons transmit SARS-CoV-2, suggesting to considerate each patient in dental setting as a potential spreader.
- Aerosol reduction and other effective infection control strategies are needed to prevent the spread of SARS-CoV-2. In dental setting, these may be:

  a. preprocedural mouth rinse containing 1% hydrogen peroxide or 0.5% povidone, in order to reduce virus viability,
  b. using manual instruments for periodontal treatment, in order to avoid aerosol production,
  c. using a rubber dam, a high-volume vacuum suction/evacuator, and the 4-handed technique, in order to reduce aerosol production,
  d. room ventilation, in order to limit virus concentration in the air.

  Other steps are needed to prevent the spread of SARS-CoV-2.

CONFLICT OF INTEREST

The authors have nothing to disclose.

AUTHOR CONTRIBUTION

Marco Clementini: Conceptualization; Writing-original draft. **Mario Raspini:** Conceptualization; Writing-original draft. **Luigi Barbato:** Writing-review & editing. **Francesco Bernardelli:** Writing-review & editing. **Giovanni Braga:** Writing-review & editing. **Claudio Di Gioia:** Writing-review & editing. **Crisitiano Littarru:** Writing-review & editing. **Francesco Oreglia:** Writing-review & editing. **Eugenio Brambilla:** Supervision. **Ivo Iavicoli:** Supervision. **Vilma Pinchi:** Supervision. **Luca Landi:** Validation; Writing-review & editing. **Nicola Marco Sforza:** Validation; Writing-review & editing. **Raffaele Cavalcanti:** Writing-review & editing. **Alessandro Crea:** Writing-review & editing. **Francesco Cairo:** Conceptualization; Validation; Writing-review & editing.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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