Decoding Dental Aerosols

How conflation with medical aerosols in the age of COVID-19 has created an inaccurate and potentially dangerous argument in dentistry

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COVID-19 is a significant pandemic that has crippled society over the past few months. The shutting of economies and the introduction of "social distancing" was a necessary response to reduce the rate of new infections and prevent overloading of our health-care systems. As such, dental clinics, along with most other non-essential businesses, have been asked to cease operations to reduce social contacts and in turn, protect the public.

In North America, our collective efforts have largely been successful, paving the way for the phased re-opening of previously-shuttered businesses, including dental offices. It is at this critical juncture that a new controversy has risen to prominence – the dental aerosol and aerosol generating dental procedures (AGDPs). In the past few months some members of our dental community have expressed concern that AGDPs could facilitate the infective transmission of the SARS-CoV-2 virus and endanger dental staff and patients. This paper aims to be a rational, data-based evaluation of the research and available evidence.

Virus Transmission vs Disease Infection

SARS-CoV-2 is the virus, COVID-19 is the disease and Corona is the common "street" name. These terms are often used interchangeably, but it is important to distinguish between them. It is also important to clarify that transmission of a virus does not mean infection with the disease; in fact it usually will not [1, 2]. It is established that the SARS-CoV-2 virus can infect a host via droplet and contact transmission, whereas acquiring COVID-19 disease via airborne transmission remains unlikely [2-8].

The minimal infectious dose can be defined as is the minimum dose of viral particles that can initiate disease [1, 2, 9]. Each virus differs in its infective dose depending on host susceptibility and immune response. Furthermore, it has been shown that the probability of getting infected, as well as the severity of disease, are dose-dependent [1, 2, 9-11]. Accordingly, it is important to protect the susceptible portals of entry: the SARS-CoV-2 virus enters the human body through the mucus membranes: the nose, the mouth and the eyes [12-15]. Therefore, one should shield these areas with appropriate personal protective equipment (PPE).

Aerosols: Droplet Transmission and Airborne Transmission

Many of the following terms are often used interchangeably: "aerosols," "droplets," "droplet nuclei," "airborne," and "solid particulates." This semantic uncertainty makes it more difficult to draw recommendations on how to adapt clinical practice.

In general, "aerosols" are solid or liquid particles that are suspended in the air; while they can be visible, most often, they are not [9, 16, 17]. Aerosols can be divided into large droplets and small droplets; however, most researchers and clinicians tend to reserve the term "aerosol" only for small droplets. In this instance, they would use the term "droplet" for larger droplets and the term "aerosols" for smaller droplets. Large droplets behave ballistically and tend to be falling when they infect the recipient. This mode of transmission is known as "droplet transmission" [2]. Large droplets may also contaminate objects and be transferred to mucous membranes by way of touch. This is called contact transmission [18]. Small droplets stay suspended in the air for a variable amount of time, or they evaporate and change into a solid particulate "droplet nuclei" that float freely. The transmission of these small droplets is known as "airborne transmission" [16, 17, 19]. There is significant controversy regarding the cut-off point between small and large droplets [1, 2, 16, 17, 20].

Aerosol Generating Procedures (AGPs)

An aerosol generating procedure (AGP) is a medical or dental intervention that has the potential of creating aerosols in addition to those that patients naturally produce during breathing, speaking, sneezing and coughing [16]. AGPs produce both small and large droplets, and each AGP creates a different pattern and composition of aerosols. Therefore, the term AGP should not be used loosely, and one should not presume that all AGPs have the same risk or require the same level of PPE *(i.e. AGP does not indicate by default a high-risk procedure)*. The decision to categorize an AGP as a high-risk procedure should be based on evidence [16]. Furthermore, it is inaccurate to conclude that generating aerosols will cause infection. It is also inaccurate to grant equivalency between the aerosol generating medical procedures (AGMPs) and the aerosol generating dental procedures (AGDPs). The aerosol composition differs considerably even amongst AGMPs: for instance, certain AGMPs generate aerosols by inducing the patient to cough. It has been shown that coughing emits up to 1000 times the number of droplets compared to normal breathing [20].

Aerosol Generating Medical Procedures (AGMPs)

Generally, AGMPs can be divided into two categories: procedures that induce the patient to produce aerosols and those that mechanically create aerosols [16]. Medical procedures that agitate the airway (e.g. tracheal or bronchial intubation) may induce the patient to cough forcibly, thereby releasing aerosols filled with a high viral infectious dose [1, 2]. Indeed, both these procedures have been associated with a high-risk of SARS-CoV-1 transmission to health-care workers [2, 16]. For example, a retrospective cohort study reported an increased risk of being infected with SARS-CoV-1 in health-care

staff involved with intubation procedures [21]. It should be noted that while all health-care workers wore N95 masks, some of them did not have eye protection.

In contrast, AGMPs may also disperse aerosols mechanically through interventions such as ventilation, suctioning or nebulizer treatment. Despite the limited evidence, these procedures are generally considered less risky than the induction group described above [2, 16, 22, 23]. For example, a meta-analysis of three cohort studies concluded that nebulizer treatment had no significant increased risk in the transmission of SARS-CoV-1 to health-care workers [22].

Aerosol Generating Dental Procedures (AGDPs)

Dental aerosols have been studied for well over 50 years. The tissues and fluids of the oral cavity are replete with bacteria and viruses [24-26]. When the oral cavity is exposed to instruments that rotate, vibrate or expel compressed air, an aerosol of these microbes is inevitably created [26, 27]. It is also well established in the literature that the attentive use of high volume evacuation (HVE) will reduce dental aerosols by at least 90% [28-30]. *It is important to note here that most hospital suction units are not rated as high volume* [26]. The majority of dental aerosol droplets that escape HVE land innocuously on the patient's face or body [31]. A smaller percentage of these droplets constitute the "dental aerosol" that remain suspended in the air for 10-30 minutes, depending on the airflow characteristics of the operatory [24].

There are many studies examining the relative infectivity of dental aerosols as well as the risk of cross-contamination in dental settings. Most of these studies were written in response to a new or resurgent disease such as TB, HIV/AIDS, Hep B, SARS-CoV-1 etc. [32-38]. Generally, these articles all contain a phrase alluding to the *possible/potential* infectivity of dental aerosols generated from an infected patient.

To our knowledge, there is no evidence that general dental aerosol exposure has resulted in infection of dental health-care workers or other patients, provided that routine PPE/HVE protocols were in place. One must conclude that while general dental aerosols may be unpleasant to consider, they have not been shown to transmit disease.

Dental Aerosols and COVID-19

People are afraid, and it is understandable. All the evidence to date points to droplet transmission as the *primary* vector of infection by SARS-CoV-2 [2-7]. Contact transmission plays a minor role [18, 39]. However, there is concern that the virus could become aerosolized under specific conditions, thereby introducing the possibility of airborne transmission. In dentistry, this concern is particularly relevant since there is a significant percentage of infected people who are either asymptomatic or pre-symptomatic [14, 40-42]. These individuals cannot be identified by routine screening questions or temperature checks. The concern is that treating asymptomatic/pre-symptomatic patients with AGDPs could endanger the health of the dental health-care workers, clerical staff or other patients.

Because COVID-19 is a new disease, we will not have all the facts for quite some time, but we believe there is enough current and historical data to arrive at some reasonable conclusions.

Below are the points on which we have built our thesis:

- Dental aerosol transmissions have little to no history of infectivity when regular PPE/HVE is being practiced. This even applies to tuberculosis which, unlike COVID-19, is a known airborne disease [32-38];

- Six months of patient data have clearly established that COVID-19 is spread primarily by droplet transmission [2-7];

- The probability of infection from viral exposure in respiratory diseases is proportional to both *dose (viral load) and time (amount of time a susceptible host is exposed to the virus) [1, 2]*;

- The lowest rate of viral shedding occurs during nasal breathing [1, 10]; during dental procedures, patients generally do not speak, shout or sing. Therefore, the potential viral dose is already quite low. This situation is dramatically different during inductive AGMPs [16];

- Dogged contact tracing has established that asymptomatic spreaders can cause cluster infections in various settings: places of worship, cruise ships, family gatherings, nursing homes, restaurants, business conferences, meat processing plants, choir rehearsals, etc. Unquestionably, asymptomatic spreaders have also visited dentists this year. Yet there remain no documented cluster events linked to a dental office setting. We submit that this is because both dose and time are mitigated during traditional dental visits due to PPE, HVE and the brevity of social interactions.

Dental Aerosols are Not Infectious

In our rush to be cautious, we have lost track of this basic fact. Decades of precedent exist. Dentists have routinely (but unknowingly) generated aerosols in patients infected by pathogens. The dental aerosols of 2020 are only marginally changed from those of 2019 and before. Now they may also contain the SARS-CoV-2 virus in addition to the multitudes of previous pathogens. There is no evidence that the viral load of the 2020 dental aerosols is more infectious than that of those previously encountered.

The use of high volume evacuation and routine PPE has protected dentists, staff and patients from cluster infections. *If this were not the case, there would already be ample evidence to the contrary.*

The recent closure of dental offices was about "social distancing," it was never about dental aerosols. It bears noting that during the last pandemic (H1N1, 2009), neither the licensing bodies of Ontario nor Quebec mandated restriction of dental aerosols. Rather there was primarily an emphasis on pre-procedural screening and hand hygiene.

Aerosols from certain medical procedures can be extremely hazardous. Tragic infection and death of health-care workers during the SARS and Ebola outbreaks crystalized this awareness [16]. The use of

enhanced PPE and other airborne precautions is wholly appropriate for those medical interventions on infectious COVID-19 patients.

However, medically and dentally generated aerosols are not the same: in a regrettable rush to judgement, these very different interventions have been conflated.

What Are the Real Dangers?

We believe there are two primary concerns in the current regulatory environment:

1. Unfounded emphasis on dental aerosol mitigation is a "red herring," which might distract us from the real transmission risk in a dental office – the non-clinical areas. Non-clinical areas are where higher viral doses from sustained speaking (and perhaps even coughing and sneezing) may occur, possibly without masks, and certainly without the benefit of high volume evacuation. We believe it is imperative to enforce protocols designed to protect staff and patients in the non-clinical spaces of dental offices.

2. Unfounded emphasis on dental aerosol mitigation has created a false impression that visits to the dentist are dangerous. Patients are unquestionably safer in dental offices than in most other social settings. Yet if the public perceives visits to the dentist as a health risk, their dental health will inevitably suffer.

This paper is a call for the return of reason. We are concerned that leadership, while well-intentioned, is directing dentistry down a path that will ultimately neither enhance the public's dental health nor its safety.

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References

1. Tang, J.W., et al., *Factors involved in the aerosol transmission of infection and control of ventilation in healthcare premises.* Journal of Hospital Infection, 2006. 64(2): p. 100-14.
2. Wilson, N.M., et al., *Airborne transmission of severe acute respiratory syndrome coronavirus-2 to healthcare workers: a narrative review.* Anaesthesia.
3. World Health Organization (WHO). *Report of the WHO-China Joint Mission on Coronavirus Disease 2019 (COVID-19)* 2020 Feb 16-24]; Available from: https://www.who.int/docs/default-source/coronaviruse/who-china-joint-mission-on-covid-19-final-report.pdf.(Last accessed May 20, 2020)
4. World Health Organization (WHO). *Modes of transmission of virus causing COVID-19: implications for IPC precaution recommendations*. 2020 March 29]; Available from: https://www.who.int/news-room/commentaries/detail/modes-of-transmission-of-virus-causing-covid-19-implications-for-ipc-precaution-recommendations. (Last accessed May 20, 2020)
5. Centers for Disease Control and Prevention. *Interim Infection Prevention and Control Recommendations for Patients with Suspected or Confirmed Coronavirus Disease 2019 (COVID-19) in Healthcare Settings*. 2020 May 18]; Available from: https://www.cdc.gov/coronavirus/2019-ncov/hcp/infection-control-recommendations.html. (Accessed May 20, 2020)
6. Bitnunet, A., et al. *Evidence shows COVID-19 is almost exclusively spread by droplets*. 2020 May 9; Available from: https://www.thestar.com/opinion/letters_to_the_editors/2020/05/09/evidence-shows-covid-19-is-almost-exclusively-spread-by-droplets.html. (Last accessed May 20, 2020)
7. Wu, D., et al., *The SARS-CoV-2 outbreak: What we know.* Int J Infect Dis, 2020. 94: p. 44-48.
8. Rafiq, D., A. Batool, and M.A. Bazaz, *Three months of COVID-19: A systematic review and meta-analysis.* Reviews in Medical Virology, 2020: p. e2113.
9. Tellier, R., *Aerosol transmission of influenza A virus: a review of new studies.* Journal of the Royal Society Interface, 2009. 6 Suppl 6: p. S783-90.
10. Bromage, E. *The Risks - Know Them - Avoid Them*. 2020 6 May 2020]; Available from: https://www.erinbromage.com/post/the-risks-know-them-avoid-them. (Last accessed May 20, 2020)
11. Kowalik, M.M., et al., *COVID-19 - toward a comprehensive understanding of the disease.* Cardiology Journal, 2020.
12. Zhao, S., et al., *Anesthetic Management of Patients with COVID 19 Infections during Emergency Procedures.* Journal of Cardiothorac and Vascular Anesthesia, 2020. 34(5): p. 1125-1131.
13. Lu, C.W., X.F. Liu, and Z.F. Jia, *2019-nCoV transmission through the ocular surface must not be ignored.* Lancet, 2020. 395(10224): p. e39.
14. Meng, L., F. Hua, and Z. Bian, *Coronavirus Disease 2019 (COVID-19): Emerging and Future Challenges for Dental and Oral Medicine.* Journal of Dental Research, 2020. 99(5): p. 481-487.
15. Gengler, I., et al., *Sinonasal pathophysiology of SARS-CoV-2 and COVID-19: A systematic review of the current evidence.* Laryngoscope Investigative Otolaryngology.
16. Judson, S.D. and V.J. Munster, *Nosocomial Transmission of Emerging Viruses via Aerosol-Generating Medical Procedures.* Viruses, 2019. 11(10): p. 940.

17. Jones, R.M. and L.M. Brosseau, *Aerosol transmission of infectious disease.* Journal of Occupational and Environmental Medicine, 2015. 57(5): p. 501-8.

18. Ferretti, L., et al., *Quantifying SARS-CoV-2 transmission suggests epidemic control with digital contact tracing.* Science, 2020. 368(6491): p. eabb6936.

19. Nicas, M., W.W. Nazaroff, and A. Hubbard, *Toward understanding the risk of secondary airborne infection: emission of respirable pathogens.* Journal of Occupational and Environmental Hygiene, 2005. 2(3): p. 143-54.

20. Fiegel, J., R. Clarke, and D.A. Edwards, *Airborne infectious disease and the suppression of pulmonary bioaerosols.* Drug Discovery Today, 2006. 11(1-2): p. 51-7.

21. Fowler, R.A., et al., *Transmission of severe acute respiratory syndrome during intubation and mechanical ventilation.* American Journal of Respiratory and Critical Care Medicine, 2004. 169(11): p. 1198-202.

22. Tran, K., et al., *Aerosol generating procedures and risk of transmission of acute respiratory infections to healthcare workers: a systematic review.* PLoS One, 2012. 7(4): p. e35797.

23. Davies, A., et al., *A review of the risks and disease transmission associated with aerosol generating medical procedures.* Journal of Infection Prevention, 2009. 10(4): p. 122-126.

24. Bennett, A.M., et al., *Microbial aerosols in general dental practice.* British Dental Journal, 2000. 189(12): p. 664-667.

25. Gao, L., et al., *Oral microbiomes: more and more importance in oral cavity and whole body.* Protein & Cell, 2018. 9(5): p. 488-500.

26. Harrel, S.K. and J. Molinari, *Aerosols and splatter in dentistry: A brief review of the literature and infection control implications.* The Journal of the American Dental Association, 2004. 135(4): p. 429-437.

27. Szymańska, J., *Dental bioaerosol as an occupational hazard in a dentist's workplace.* Annals of Agricultural and Environmental Medicine, 2007. 14(2): p. 203-7.

28. Micik, R.E., et al., *Studies on Dental Aerobiology: I. Bacterial Aerosols Generated during Dental Procedures.* Journal of Dental Research, 1969. 48(1): p. 49-56.

29. Harrel, S.K., J.B. Barnes, and F. RiveraHidalgo, *Reduction of aerosols produced by ultrasonic scalers.* Journal of Periodontology, 1996. 67(1): p. 28-32.

30. Jacks, M.E., *A laboratory comparison of evacuation devices on aerosol reduction.* Journal of Dental Hygiene, 2002. 76(3): p. 202-6.

31. Bentley, C.D., N.W. Burkhart, and J.J. Crawford, *Evaluating spatter and aerosol contamination during dental procedures.* The Journal of the American Dental Association, 1994. 125(5): p. 579-84.

32. Laheij, A.M.G.A., et al., *Healthcare-associated viral and bacterial infections in dentistry.* Journal of Oral Microbiology, 2012. 4: p. 10.3402/jom.v4i0.17659.

33. Cleveland, J.L., et al., *Multidrug-Resistant Mycobacterium tuberculosis in an HIV Dental Clinic.* Infection Control and Hospital Epidemiology, 1995. 16(1): p. 7-11.

34. Volgenant, C.M.C. and J.J. de Soet, *Cross-transmission in the Dental Office: Does This Make You Ill?* Current Oral Health Reports, 2018. 5(4): p. 221-228.

35. Zemouri, C., et al., *A scoping review on bio-aerosols in healthcare and the dental environment.* PLoS One, 2017. 12(5): p. e0178007.

36. Samaranayake, L.P., *Re-emergence of tuberculosis and its variants: implications for dentistry.* International Dental Journal, 2002. 52(5): p. 330-336.

37. Faecher, R.S., J.E. Thomas, and B.S. Bender, *Tuberculosis: A Growing Concern for Dentistry?* The Journal of the American Dental Association, 1993. 124(1): p. 94-104.

38. Samaranayake, L.P. and M. Peiris, *Severe acute respiratory syndrome and dentistry: A retrospective view.* The Journal of the American Dental Association, 2004. 135(9): p. 1292-1302.

39. Gawande, A. *Amid the Coronavirus Crisis, a Regimen for Reëntry*. 2020 May 13]; Available from: https://www.newyorker.com/science/medical-dispatch/amid-the-coronavirus-crisis-a-regimen-for-reentry. (Last accessed May 20, 2020)

40. He, X., et al., *Temporal dynamics in viral shedding and transmissibility of COVID-19.* Nature Medicine, 2020. 26(5): p. 672-675.

41. Cheng, H.-Y., et al., *Contact Tracing Assessment of COVID-19 Transmission Dynamics in Taiwan and Risk at Different Exposure Periods Before and After Symptom Onset.* JAMA Internal Medicine, 2020.

42. Rothe, C., et al., *Transmission of 2019-nCoV Infection from an Asymptomatic Contact in Germany.* The New England Journal of Medicine, 2020. 382(10): p. 970-971.