

## REVIEW

# The Debate: What Are Aerosol-Generating Procedures in Dentistry? A Rapid Review

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**Abstract: Introduction:** This article aims to review the current national and international dental guidance produced during the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) pandemic to identify the level of consensus on aerosol-generating dental procedures (AGDPs). The outcomes intend to encourage increased collaboration with respect to dental guidelines in relation to the SARS-CoV-2 pandemic, as well as to improve decision making and safety for dental patients and staff.

**Methods:** This rapid review was conducted by 2 authors (MKV and KD), with the support of a third author (SD), to assess current guidelines related to dental AGDPs. This streamlined review approach allowed synthesis of data in an efficient manner in the rapidly evolving environment associated with the SARS-CoV-2 pandemic.

**Results:** The findings identified 1) a lack of consistency in reporting which procedures were deemed an AGDP; 2) that high-speed handpieces, air-water syringes, and mechanical scalers were consistently considered high-

risk AGDPs; 3) a lack of consensus on the risk of coronavirus disease 2019 (COVID-19) transmission with the use of slow-speed handpieces; 4) a general agreement, when described, that rubber dam and high-volume evacuation can significantly reduce aerosol production; and 5) a lack of consistency in reporting whether procedures constitute a low, moderate, or high risk of COVID-19 transmission. The findings are discussed in relation to the guidance and future recommendations.

**Conclusion:** It is recommended that future published guidance should indicate the risk stratification (low/moderate/high) of each procedure/exposure in a standardized international approach.

**Knowledge Transfer Statement:** The results of this rapid review can be used by clinicians to increase their awareness of international guidance on aerosol-generating procedures in dentistry. It will also encourage those publishing future guidance to provide an internationally standardized, risk-stratified approach to describing aerosol-generating procedures.

Currently, it allows clinicians to consider aerosol-generating procedures as a risk spectrum.

**Keywords:** dental equipment, dental research, occupational dentistry, evidence-based dentistry, coronavirus, coronavirus infections

## Introduction

On January 8, 2020, a novel coronavirus, severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), was officially announced by the Chinese Centre for Disease Control and Prevention as the causative agent of coronavirus disease 2019 (COVID-19). It was first identified in Wuhan, China, and reported to the World Health Organization (WHO) in December 2019. By January 30, 2020, the WHO had declared the outbreak a Public Health Emergency of International Concern, and on March 12, 2020, COVID-19 was officially declared a global pandemic (World Health Organization 2020a).

Respiratory tract infections, including COVID-19, are primarily transmitted from person to person by respiratory droplets, such as in exhaled breath



(Huynh et al. 2008) and during coughing (Lindsley et al. 2010). To counter the growing number of COVID-19 cases worldwide, countries introduced social distancing measures to increase distance between potentially infected persons and limit the spread of the virus. Evidence soon emerged that both symptomatic and asymptomatic individuals were able to transmit COVID-19 (Peng et al. 2020) and that, at 60 to 140 nm, SARS-CoV-2 particles are small enough to travel effectively in an aerosol (Rothe et al. 2020). This has implications for undertaking certain medical and dental procedures that generate aerosol, as well as for appreciating that there is a risk in COVID-19 transmission while talking (particularly loudly), coughing, and sneezing at close proximity.

An *aerosol-generating procedure* (AGP) has been defined as a medical or dental procedure that results in the production of respirable airborne particles (Proffitt 2020). AGPs are therefore considered a significant risk for the transmission of COVID-19 (Scottish Dental Clinical Effectiveness Programme 2020). The term first came into widespread use during the SARS pandemic in 2002 to 2004. At that time, the term AGP mainly referenced *aerosol-generating medical procedures* (AGMPs) (Howard 2020). AGMPs can be separated into those that stimulate a cough reflex and those that mechanically disrupt the contents of the respiratory tract, such as endotracheal intubation. As these procedures are typically undertaken on individuals who are experiencing active disease, the aerosols generated contain a high number of pathogens (high bioload) and are deemed a particularly high-risk procedure (Kumar and Subramanian 2020). AGPs specific to dentistry, such as those created when the “wet” oral environment is aerosolized by high-speed instrumentation, are termed *aerosol-generating dental procedures* (AGDPs).

More recently, the term *aerosol-generating exposure* (AGE) has been introduced to take account of the varying COVID-19 transmission risk

attributable to modifying factors, such as the procedure duration and the patient’s medical status. AGE also considers the risks posed by aerosols in exhaled breath and those produced during coughing and sneezing (Centre for Evidence-Based Medicine 2020). To mitigate risks posed by AGDPs and AGEs, the Chief Dental Office (CDO) suspended all routine dentistry in the United Kingdom on March 25, 2020. The guidance from Public Health England on appropriate personal protective equipment (PPE) to manage the risk of potential exposure during treatment has been based on whether the intervention generates an aerosol or not (GOV.UK 2020). Therefore, identifying which treatments constitute an AGDP is of great significance, as this has repercussions for PPE, as well as disinfection protocols, such as fallow times between procedures to allow for air exchange.

Many guidance bodies have released documents aimed at managing dental procedures in a safe and effective manner. For example, the CDO of England recommended dental practices reopen from June 8, 2020 (Office of the Chief Dental Officer 2020). With this in mind, a precise and consistent answer to the question “Which dental procedures are AGDPs?” is ever more pressing. Unfortunately, despite many documents being published, both in the United Kingdom and internationally (CoDER Working Group 2020) with the aim of supporting dentists’ return to safe practice, uncertainty and confusion remain, particularly when it comes to classifying which procedures should be classified as “aerosol generating” and the risk stratification of each procedure (low/moderate/high).

This review has been conducted with the aim of collating current national and international guidance on what constitutes an AGDP to identify areas of agreement and disagreement and to encourage research in areas where there is little or no consensus. Ultimately, this will enable safer treatment for clinicians and patients by using appropriate PPE and infection control protocols.

## Methods

### Types of Studies

A rapid review of the literature was performed with the aim of identifying and collating guidance documents that detail what dental procedures should be considered an AGDP. The review focused on dental procedures and exposures that are likely to occur within the dental setting. Exposures in the medical setting are outside the scope of this review. The further matter of PPE was not assessed directly.

### Search Methods for Identification of Studies

#### Electronic Searches

Electronic database searches were carried out in June 2020 on Medline via Ovid and Embase. A search strategy was designed with the assistance of the University of Bristol Library and used a combination of keyword search terms, Boolean operators, and medical subject headings (MeSH). The Cochrane Database was also searched for relevant publications.

Two main search streams were used. The first included the following search terms: *aerosol generating procedure* or *aerosol generating procedures* or *aerosol-generating procedure* or *aerosol-generating procedures* or *AGP* or *aerosol generating exposure* or *aerosol generating exposures* or *aerosol-generating exposure* or *aerosol-generating exposures* or *aerosol producing procedure* or *aerosol producing procedures*, *aerosol-producing procedure* or *aerosol-producing procedures*, AND *dent\**, OR *dentistry* (MeSH terms).

The second search was as described above but also included the search term *aerosol\**. This broadened the search to articles about aerosol production in dentistry that were published before the term *aerosol-generating procedure* and others were introduced. This search was also conducted using the limitation “COVID-19.” The abbreviation AGE was not used as this generated a very high

number of results, many of which were not applicable.

No restriction on publication type or publication date was applied. As comparison of international sources was an important part of the review, no language restriction was applied. Translation of foreign-language sources identified was undertaken using Google Translate.

#### Searching Other Resources

The full text was obtained for all relevant documents, and the reference lists of the applicable articles were searched for additional guidance documents.

### Data Collection and Analysis

#### Selection of Studies

The title and abstract were assessed for relevance to aerosol production in dental procedures. In order to maintain a clear and narrow focus, the literature search aimed to identify guidance that states whether or not a dental procedure is to be considered aerosol generating and what level of transmission risk is given, if any. Both review authors (MKV and KD) independently assessed all abstracts resulting from these searches. Full texts of the relevant and potentially relevant documents were compiled. Both reviewers independently assessed full-text articles. If the following inclusion criteria were met, the article was included:

1. Describes dental procedures
2. Describes whether or not these were an AGDP or the associated procedural COVID-19 transmission risk

Irrelevant articles were excluded and the reason for exclusion was recorded.

#### Data Extraction and Management

Two review authors undertook data extraction independently, and where discrepancies existed, these were addressed by reaching a consensus between the 2 authors MKV and KD, as well as SD for a final decision if required.

The results of the searches were saved to a reference manager and duplicates identified and removed.

#### Presentation of Main Results

A summary of findings table was developed for the main outcome of this review. The table included the following categories:

- Non-AGDP
- Low-risk AGDP
- Moderate-risk AGDP
- High-risk AGDP
- AGDP (Non-risk stratified)

### Results

The majority of the evidence considered by the authors was published in April to July 2020. Most of the guidance documents were published by national governing bodies. Guidance articles that were published by professional bodies, such as dental associations, were found to be more detailed in their stating of which procedures constituted an AGDP and the relative COVID-19 transmission risk of individual procedures.

The main results of this article have been collated in the Table. This table has been formatted to present the wide range of ways in which different publications describe AGDPs and/or their risk of COVID-19 transmission. While some publications simply describe AGDP/non-AGDP, others give an intermediate description, ranging from explicit low- to high-risk stratification to AGDP with modifying factors. The middle column in the Table has been designed to present this wide range of “intermediate” description.

The main area of consensus in both guidance and nonguidance documents is that the use of high-speed handpieces, air-water syringes, and powered scalers creates the greatest amount of biological aerosol (secretions, saliva, and blood) and therefore poses the highest risk of transmission. In most documentation, these are classified simply as AGDPs and are not stratified according to risk level. This finding stems from the research

undertaken during the first SARS outbreak (Săndulescu 2020).

There is less consensus that other procedures, such as air abrasion, polishing of teeth, and the use of a surgical handpiece, constitute an AGDP (Bizzoca et al. 2020; Jamal et al. 2020; Li et al. 2004; Shi et al. 2020). These procedures have been classified differently depending on the guidance document (Fig.).

The majority of guidance recommends the use of high-volume evacuation (HVE) and rubber dam to help mitigate aerosol production (Alharbi et al. 2002; Li et al. 2004; Bizzoca et al. 2020; Careddu et al. 2020; Jamal et al. 2020; Long et al. 2020; Meng et al. 2020; Passarelli et al. 2020; Peng et al. 2020; Shi et al. 2020). Evidence has demonstrated that rubber dam use greatly reduces the spread of droplets and aerosols (by around 70%) (Bizzoca et al. 2020), and HVE has been shown to remove 97% of aerosols within the surrounding area (Long et al. 2020).

Those documents that recognize AGEs also advise care when using intraoral devices such as impressions and radiographs in those patients with a sensitive gag reflex. However, this advice was not uniform across the documents.

### Discussion

#### Main Findings

The COVID-19 pandemic has refocused international attention on the transmission of pathogens in aerosols. This review has looked at a wide range of international dental guidance documents and position statements. We found that, frequently, the evidence on AGDPs and AGEs within dentistry was interpreted in different ways, with this reflecting a general lack of consensus and ambiguity across the documents. Occasionally, these differences were subtle, but often they were pronounced. For example, there is a clear lack of agreement about which dental procedures and/or exposures should be considered aerosol generating and also a lack of consistency as to how these procedures are categorized. This is often reflected in whether the

**Table.**

Documents Assessed and Included.

Publication	Non-AGDP	Low Risk of Transmission	Moderate Risk of Transmission	High Risk of Transmission	AGDP (Non-Risk Stratified)
		Or Non-AGDP/AGDP with Modifying Factors			
Office of Chief Dental Officer (England)	<ul style="list-style-type: none"> <li>- Remote consultations</li> <li>- Examination</li> <li>- Hand scaling</li> <li>- Simple extraction</li> <li>- Caries removal with hand instruments or SSHP using HVE</li> <li>- Restorative material placement</li> <li>- Removable denture stages (normal gag reflex)</li> <li>- SS crown placement</li> <li>- Orthodontic txt</li> <li>- Inhalation sedation</li> </ul>	- Removable denture stages (non-normal gag reflex)			<ul style="list-style-type: none"> <li>- HSHP</li> <li>- Surgical handpiece</li> <li>- Ultrasonic/mechanized scaler</li> <li>- Air-water syringe</li> </ul>
Link	<a href="https://www.england.nhs.uk/coronavirus/wp-content/uploads/sites/52/2020/06/C0575-dental-transition-to-recovery-SOP-4June.pdf">https://www.england.nhs.uk/coronavirus/wp-content/uploads/sites/52/2020/06/C0575-dental-transition-to-recovery-SOP-4June.pdf</a>				
Office of Chief Dental Officer (Wales) Welsh De-escalation Plan	<ul style="list-style-type: none"> <li>- Examination</li> <li>- Hand scaling using HVE</li> <li>- Simple extraction</li> <li>- Caries removal with hand instruments or SSHP</li> <li>- Delivery of LA</li> </ul>	<ul style="list-style-type: none"> <li>- Examination</li> <li>- Simple extraction</li> <li>- E/O and I/O radiographs</li> <li>- Temporary restorative material placement</li> <li>- Minimally invasive restorative procedures (without HSHP)</li> <li>- Removable denture stages</li> <li>- ST lesion management (e.g., biopsy)</li> <li>- I&amp;D</li> <li>- Fitting of crown/bridgework (previously constructed)</li> <li>- Perio care (hand scalers)</li> <li>- Orthodontic txt</li> <li>- Fluoride varnish application</li> <li>- Delivery of LA</li> </ul>	NA	NA	<ul style="list-style-type: none"> <li>- HSHP</li> <li>- Surgical handpiece</li> <li>- Ultrasonic scaler</li> <li>- Air-water syringe</li> <li>- SSHP for polishing and brushing</li> <li>- Air abrasion and polishing</li> </ul>
Link	<a href="http://www.dental-referrals.nhs.wales/wp-content/uploads/2020/06/2020-06-10-Standard-Operating-Procedures-for-AGPs-on-non-Covid-19-patients-FINAL.pdf">http://www.dental-referrals.nhs.wales/wp-content/uploads/2020/06/2020-06-10-Standard-Operating-Procedures-for-AGPs-on-non-Covid-19-patients-FINAL.pdf</a> <a href="https://gov.wales/sites/default/files/publications/2020-06/wales-de-escalation-pandemic-plan-for-dentistry.pdf">https://gov.wales/sites/default/files/publications/2020-06/wales-de-escalation-pandemic-plan-for-dentistry.pdf</a>				
Scottish Dental Clinical Effectiveness Programme	<ul style="list-style-type: none"> <li>- Examination</li> <li>- Hand scaling using HVE</li> <li>- Simple extraction</li> <li>- Caries removal with hand instruments or SSHP</li> <li>- Removable denture stages</li> </ul>	- Hand scaling without HVE			<ul style="list-style-type: none"> <li>- HSHP</li> <li>- Surgical handpiece</li> <li>- Ultrasonic scaler</li> <li>- Air-water syringe</li> </ul>
Link	<a href="http://www.sdcep.org.uk/wp-content/uploads/2020/05/SDCEP-Resuming-General-Dental-Services-Following-COVID-19-Shutdown-250520.pdf">http://www.sdcep.org.uk/wp-content/uploads/2020/05/SDCEP-Resuming-General-Dental-Services-Following-COVID-19-Shutdown-250520.pdf</a>				

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Publication	Non-AGDP	Low Risk of Transmission	Moderate Risk of Transmission	High Risk of Transmission	AGDP (Non-Risk Stratified)
		Or Non-AGDP/AGDP with Modifying Factors			
Health and Social Care Board— Reestablishment of General Dental Practices (Republic of Ireland)	<ul style="list-style-type: none"> <li>- Examination</li> <li>- Hand scaling using HVE</li> <li>- Simple extraction using HVE</li> <li>- I/O radiographs (following risk assessment)</li> <li>- Temporary restorative material placement (fluoride-releasing GI)</li> <li>- Caries removal with hand instruments or SSHP</li> <li>- Removable denture stage (following risk assessment)</li> <li>- Adjustment of dentures, removable orthodontic appliances (disinfected)</li> <li>- ST lesion management (e.g., biopsy)</li> <li>- I&amp;D</li> <li>- SS crown placement</li> <li>- Fluoride varnish/fissure sealant application</li> <li>- Temporary overdentures</li> <li>- Inhalation/intravenous sedation</li> <li>- Delivery of LA</li> <li>- Air-water syringe with good moisture control (using rubber dam or cotton wool/gauze and dry guards)</li> </ul>	Phase 3 step considerations (reduction of AGDP)			<ul style="list-style-type: none"> <li>- HSHP</li> <li>- Surgical handpiece</li> <li>- Ultrasonic/mechanized scaler</li> <li>- Air-water syringe</li> <li>- Air abrasion and polishing</li> <li>- Air-driven SSHP with coolant spray</li> </ul>
Link	<a href="https://facultyofdentistry.ie/images/News/20200515_HPSC_guidance_on_Covid-19.pdf">https://facultyofdentistry.ie/images/News/20200515_HPSC_guidance_on_Covid-19.pdf</a>				
Faculty of General Dental Practitioners (United Kingdom)	NA	<ul style="list-style-type: none"> <li>- Examination (avoiding cough reflex) without air-water syringe</li> <li>- Hand scaling using HVE</li> <li>- Simple extraction</li> <li>- E/O radiography and CBCT</li> <li>- I/O radiography without a cough reflex</li> <li>- E/O photography</li> <li>- Temporary restorative material placement without HSHP and with isolation</li> <li>- Removable denture stage</li> <li>- Adjustment of dentures and removable orthodontic appliances (disinfected)</li> <li>- I&amp;D using HVE</li> <li>- Fitting of crown/bridgework (previously constructed) with isolation</li> <li>- Restoration/repair of implant prosthesis without HSHP</li> <li>- Endodontic access of broken tooth with hand excavation</li> <li>- Fissure sealant application with isolation</li> <li>- Orthodontic txt (debond or repair) without HSHP</li> </ul>	NA	<ul style="list-style-type: none"> <li>- Examination (inducing cough reflex)</li> <li>- Ultrasonic scaler</li> <li>- I/O radiography (inducing cough reflex)</li> <li>- Full-mouth PAs</li> <li>- I/O photography (inducing cough reflex)</li> <li>- Surgical extraction</li> <li>- Definitive restoration with HSHP using HVE and rubber dam</li> <li>- Removable denture stages (poorly tolerated)</li> <li>- Definitive crown cementation</li> <li>- Restoration/repair of implant prosthesis using HSHP</li> <li>- Surgical implant placement</li> <li>- Endodontic access with HSHP using HVE and rubber dam</li> <li>- Orthodontic txt (debond or repair) using HSHP or extensive air-water syringe use</li> </ul>	NA
Link	<a href="https://www.fgdp.org.uk/sites/fgdp.org.uk/files/editors/FGDP%20CGDent%20Implications%20of%20COVID-19%20for%20the%20safe%20management%20of%20general%20dental%20practice%2016%20June%202020%20ed1.1.pdf">https://www.fgdp.org.uk/sites/fgdp.org.uk/files/editors/FGDP%20CGDent%20Implications%20of%20COVID-19%20for%20the%20safe%20management%20of%20general%20dental%20practice%2016%20June%202020%20ed1.1.pdf</a>				

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Publication	Non-AGDP	Low Risk of Transmission	Moderate Risk of Transmission	High Risk of Transmission	AGDP (Non-Risk Stratified)
		Or Non-AGDP/AGDP with Modifying Factors			
<b>British Dental Association</b>	<ul style="list-style-type: none"> <li>- Remote consultations</li> <li>- Examination</li> <li>- Hand scaling</li> <li>- Simple extractions</li> <li>- Caries excavation with hand instruments or SSHP using HVE</li> <li>- Restorative material placement</li> <li>- Removable denture stages (normal gag reflex)</li> <li>- SS crown placement</li> <li>- Orthodontic txt</li> </ul>	<ul style="list-style-type: none"> <li>- Air-water syringe when water used, followed by gentle air, using HVE</li> </ul>			<ul style="list-style-type: none"> <li>- HSHP</li> <li>- Surgical handpiece (with irrigation)</li> <li>- Ultrasonic/mechanized scaler</li> <li>- Air-water syringe (air and water simultaneously)</li> <li>- Endodontic handpieces (rotary)</li> <li>- Endosonic handpieces</li> <li>- Air abrasion and polishing</li> <li>- Sandblasting</li> </ul>
<b>Link</b>	<a href="https://www.bda.org/advice/Coronavirus/Pages/returning-to-work.aspx">https://www.bda.org/advice/Coronavirus/Pages/returning-to-work.aspx</a>				
<b>British Orthodontic Society</b>	<ul style="list-style-type: none"> <li>- Examination (without air-water syringe)</li> <li>- Hand scaling</li> <li>- E/O and I/O photographs (without mirrors)</li> <li>- Impressions</li> <li>- I/O scanning</li> <li>Orthodontic txt:                             <ul style="list-style-type: none"> <li>- SEP (without air-water syringe) for bracket placement</li> <li>- Band cementation using HVE</li> <li>- Archwire tie-in</li> <li>- Bracket and band removal</li> <li>- Adhesive removal with pliers or Mitchell's trimmer</li> <li>- Placement of retainer, removable appliance, or aligner</li> <li>- Adjustment of cribs</li> <li>- Adjustment of retainer or aligner with scissors</li> <li>- IPR with manual strips</li> <li>- TAD placement with manual driver</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>- Air-water syringe with HVE</li> <li>- I/O photographs (with mirrors)</li> <li>- Adhesive removal with SSHP and HVE</li> </ul>			<ul style="list-style-type: none"> <li>- Air-water syringe without HVE</li> <li>- Ultrasonic scaler</li> <li>- Tooth prophyl with SSHP</li> <li>- Mechanical prophylaxis</li> <li>- Sandblasting</li> <li>- Etch, wash, dry</li> <li>- Adhesive removal with HSHP</li> <li>- Adhesive removal with SSHP, not using HVE</li> <li>- Adjustment of retainer, removable appliance, or aligner with handpiece</li> <li>- IPR with HSHP or SSHP</li> <li>- TAD placement with handpiece</li> </ul>
<b>Link</b>	<a href="https://www.bos.org.uk/Portals/0/Public/docs/Advice%20Sheets/COVID19%20FACTSHEETS/Recovery%20Phase%20Advice/AGP/Table%20of%20AGP-Non%20AGP%20v7.pdf">https://www.bos.org.uk/Portals/0/Public/docs/Advice%20Sheets/COVID19%20FACTSHEETS/Recovery%20Phase%20Advice/AGP/Table%20of%20AGP-Non%20AGP%20v7.pdf</a>				

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Publication	Non-AGDP	Low Risk of Transmission	Moderate Risk of Transmission	High Risk of Transmission	AGDP (Non-Risk Stratified)
		Or Non-AGDP/AGDP with Modifying Factors			
British Society of Periodontology	- Examination (without air-water syringe)	- E/O radiography - OHI - Smoking cessation advice - Plaque, bleeding score	- I/O radiography - I/O OHI - Removal of PRF with SSHP - Prophylaxis with SSHP - Subgingival hand debridement - I&D - Surgical periodontal treatment (no powered instruments)	- Removal of PRF with HSHP - Ultrasonic/mechanized scaler - Air abrasion and polishing - Subgingival debridement (powered instrument) - Surgical periodontal treatment (powered instrument)	NA
Link	<a href="https://www.bsperio.org.uk/userfiles/BSP-Back-to-work-version-2-Risks-associated-with-steps-of-treatment-07.06-2020.pdf">https://www.bsperio.org.uk/userfiles/BSP-Back-to-work-version-2-Risks-associated-with-steps-of-treatment-07.06-2020.pdf</a>				
British Society of Restorative Dentistry	- Remote consultations - Remote prescribing (analgesia and antimicrobials)	- Examination (without air-water syringe) - E/O and I/O radiography (tolerant patient) - Photography - Simple tooth extraction - Temporary restorative material placement - Provisional crown recementation - Removable denture stage - Adjustment and repair of dentures (disinfected) In a COVID-19-positive patient: - HSHP or SSHP - Air-water syringe	- Examination (with air-water syringe) - I/O radiography (intolerant patient) - Surgical tooth extraction - Definitive restoration/crown cementation - Impressions - Fixed prosthodontic stages - Restoration of a dental implant - Endodontic procedures - Hand scaling and subgingival debridement - Surgical procedures (no powered instruments) In a COVID-19-positive patient: - HSHP or SSHP - Air-water syringe	- Surgical handpiece - Ultrasonic/mechanized scaler - Surgical periodontal treatment (powered instrument) In a COVID-19 -positive patient: - HSHP or SSHP - Air-water syringe	NA
Link	<a href="https://www.bsrd.org.uk/Index.aspx">https://www.bsrd.org.uk/Index.aspx</a>				
Royal College of Surgeons (Faculty of Dental Surgery) Recommendations for Oral Surgery	- Simple extractions - ST lesion management (e.g., biopsy/ intralesional injections/ cryotherapy) - Intravenous sedation	- Inhalation sedation (awaiting clarity)			- Surgical handpieces
Link	<a href="https://www.rcseng.ac.uk/dental-faculties/fds/coronavirus/">https://www.rcseng.ac.uk/dental-faculties/fds/coronavirus/</a>				
Australian Dental Association	- Examination - Hand scaling - Simple extractions - Caries removal with hand instruments or SSHP - Removable denture stage - Orthodontic txt - Fluoride varnish/fissure sealant application - Medical management of ST - TMJD management	- Restorative procedures using HSHP with the use of rubber dam			- HSHP use without a rubber dam - Surgical handpiece - Ultrasonic scalers
Link	<a href="https://www.ada.org.au/Covid-19-Portal/Cards/Dental-Professionals/Guidelines-and- Risk- Factors/Practical-Advice-for-stepping-back-to-Level-2-Rest">https://www.ada.org.au/Covid-19-Portal/Cards/Dental-Professionals/Guidelines-and- Risk- Factors/Practical-Advice-for-stepping-back-to-Level-2-Rest</a>				

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Publication	Non-AGDP	Low Risk of Transmission	Moderate Risk of Transmission	High Risk of Transmission	AGDP (Non-Risk Stratified)
		Or Non-AGDP/AGDP with Modifying Factors			
Dental Council of New Zealand	NA	Use of HVE, rubber dam, and preprocedural M/W to reduce aerosol risk			<ul style="list-style-type: none"> <li>- Electric or air-driven rotary handpieces (with or without water)</li> <li>- Ultrasonic scalers</li> <li>- Air-water syringe</li> <li>- Air abrasion and polishing</li> </ul>
Link	<a href="https://www.dcnz.org.nz/assets/Uploads/COVID/Guidelines-atAlert-Level-2-final.pdf">https://www.dcnz.org.nz/assets/Uploads/COVID/Guidelines-atAlert-Level-2-final.pdf</a>				
College of Dental Surgeons of Saskatchewan (Canada)	<ul style="list-style-type: none"> <li>- Examinations</li> <li>- Hand scaling</li> <li>- Simple extractions</li> <li>- Removable denture stages</li> <li>- Fitting of crown/bridgework (previously constructed)</li> <li>- Orthodontic txt</li> <li>- Fluoride varnish/fissure sealant application</li> <li>- ST lesion management (e.g., medical/biopsy)</li> <li>- TMJD management</li> <li>- Perio procedures</li> </ul>	Rubber dam use with endodontic/restorative/pediatric restorative procedures to reduce aerosol risk			<ul style="list-style-type: none"> <li>- HSHP</li> <li>- SSHP</li> <li>- Surgical handpieces</li> <li>- Ultrasonic instruments</li> <li>- Air-water syringe</li> <li>- Polishing/prophy with air and water</li> <li>- Laser instrumentation</li> <li>- Dental implant placement</li> <li>- Inhalation sedation</li> </ul>
Link	<a href="https://media.oralhealthgroup.com/uploads/2020/04/20200427_CDSS_IPC_Interim_Protocol_Update.pdf">https://media.oralhealthgroup.com/uploads/2020/04/20200427_CDSS_IPC_Interim_Protocol_Update.pdf</a>				
American Dental Oral Surgeons (United States)	<ul style="list-style-type: none"> <li>- Hand scaling</li> <li>- Minimally invasive atraumatic procedures (hand instruments)</li> </ul>	Rubber dam use to reduce aerosol risk			<ul style="list-style-type: none"> <li>- Dental handpieces (nonspecified)</li> <li>- Ultrasonic scaler</li> <li>- Air-water syringe</li> </ul>
Link	<a href="https://www.cdc.gov/coronavirus/2019-ncov/hcp/dental-settings.html">https://www.cdc.gov/coronavirus/2019-ncov/hcp/dental-settings.html</a> <a href="https://success.ada.org/~/media/CPS/Files/Open%20Files/ADA_Return_to_Work_Toolkit.pdf">https://success.ada.org/~media/CPS/Files/Open%20Files/ADA_Return_to_Work_Toolkit.pdf</a>				
Consejo General de Dentistas (Spain)	NA	NA	NA	NA	<ul style="list-style-type: none"> <li>- HSHP</li> <li>- Ultrasonic devices</li> <li>- Surgical handpiece</li> <li>- Air-water syringe</li> <li>- Hard tissue lasers</li> <li>- Air abrasion</li> <li>- Orthodontic txt (e.g., removal of brackets and polishing)</li> </ul>
Link	<a href="https://www.consejodentistas.es/comunicacion/actualidad-consejo/notas-de-prensa-consejo/item/1783-plan-estrategico-de-accion-para-clinicas-dentales-durante-el-periodo-de-desescalada.html">https://www.consejodentistas.es/comunicacion/actualidad-consejo/notas-de-prensa-consejo/item/1783-plan-estrategico-de-accion-para-clinicas-dentales-durante-el-periodo-de-desescalada.html</a>				
Direção-Geral da Saúde (Portugal)	NA	NA	NA	NA	<ul style="list-style-type: none"> <li>- Dental handpieces (nonspecified)</li> <li>- Air-water syringe</li> <li>- Polishing</li> <li>- Root canal treatment</li> </ul>
Link	<a href="https://www.dgs.pt/directrizes-da-dgs/orientacoes-e-circulares-informativas/orientacao-n-0222020-de-01052020-pdf.aspx">https://www.dgs.pt/directrizes-da-dgs/orientacoes-e-circulares-informativas/orientacao-n-0222020-de-01052020-pdf.aspx</a>				

(continued)



**Table.**  
(continued)

Publication	Non-AGDP	Low Risk of Transmission	Moderate Risk of Transmission	High Risk of Transmission	AGDP (Non-Risk Stratified)
		Or Non-AGDP/AGDP with Modifying Factors			
Ordre National des Chirurgiens-Dentistes (France)	NA	NA	NA	NA	- Dental handpieces (nonspecified) - Ultrasonic scaling - Air-water syringe - Polishing
Link	<a href="http://www.ordre-chirurgiens-dentistes.fr/uploads/media/COMMUNIQUE_30AVRIL-EXTRAIT_RECO.pdf">http://www.ordre-chirurgiens-dentistes.fr/uploads/media/COMMUNIQUE_30AVRIL-EXTRAIT_RECO.pdf</a>				
Österreichische Zahnärztekammer (Austria)	NA	NA	NA	NA	- HSHP - Ultrasonic scalers - Polishing
Link	<a href="https://stmk.zahnaerztekammer.at/fileadmin/content/steiermark/Corona/Empfehlungen_fuer_zahnaerztliche_Ordinationen_300420.pdf">https://stmk.zahnaerztekammer.at/fileadmin/content/steiermark/Corona/Empfehlungen_fuer_zahnaerztliche_Ordinationen_300420.pdf</a>				
Conseil de l'Art Dentaire (Belgium)	NA	NA	NA	NA	- HSHP - Ultrasonic scalers - Air-water syringe
Link	<a href="https://organesdeconcertation.sante.belgique.be/fr/documents/tableau-de-reprise-des-activites-de-lart-dentaire">https://organesdeconcertation.sante.belgique.be/fr/documents/tableau-de-reprise-des-activites-de-lart-dentaire</a>				
Helsedirektorat (Norway)	NA	NA	NA	NA	- HSHP and contra-angle handpiece - Ultrasonic scalers - Air polishing
Link	<a href="http://www.helsedirektoratet.no">www.helsedirektoratet.no</a>				
Sundhedsstyrelsen (Denmark)	NA	NA	NA	NA	- HSHP - SSHP - Ultrasonic cleaning - Air-water syringe
Link	<a href="https://www.sst.dk/dah">https://www.sst.dk/dah</a>				

Examinations include oral health assessment, prescribing, and preventative advice in a face-to-face manner. Countries with a publication(s) on COVID-19 implications on dental practice but without specific description of what constitutes an AGDP include the following: Germany (<https://www.idz.institute/publikationen/sonstiges/system-von-standardvorgehensweisen-fuer-zahnarztpraxen-waehrend-der-coronavirus-pandemie.html>), Switzerland (<https://www.sso.ch/home/coronavirus.html>), Netherlands ([https://www.knmt.nl/sites/default/files/2020-04-21-leidraad\\_mondzorg\\_corona\\_def.pdf](https://www.knmt.nl/sites/default/files/2020-04-21-leidraad_mondzorg_corona_def.pdf)), Malta ([https://deputyprimeminister.gov.mt/en/health-promotion/covid-19/Documents/mitigation-conditions-and-guidances/Guidance-for-Dental-Practices\\_06Jun20.pdf](https://deputyprimeminister.gov.mt/en/health-promotion/covid-19/Documents/mitigation-conditions-and-guidances/Guidance-for-Dental-Practices_06Jun20.pdf)), and India (<http://www.dciindia.gov.in/Admin/NewsArchives/Dental%20Clinics%20Protocols%20Final.pdf>).

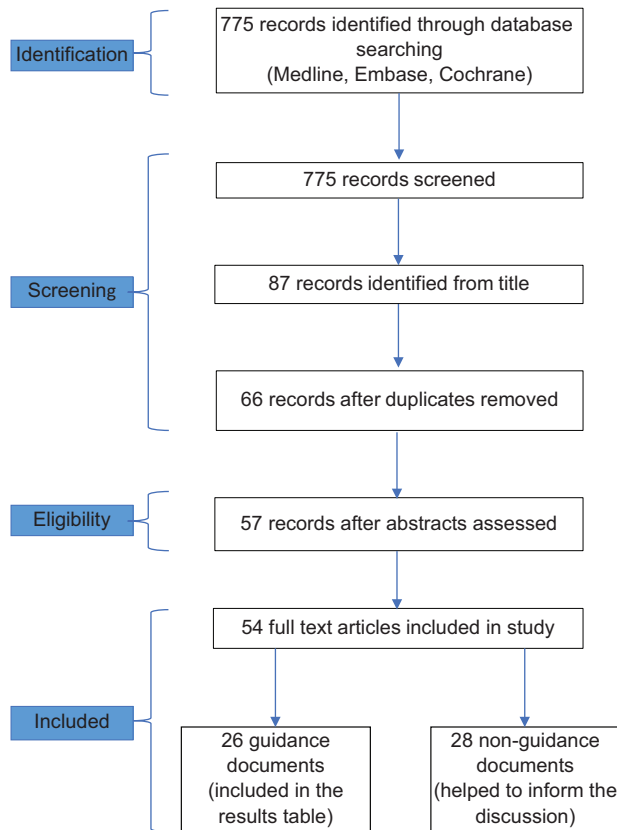
AGDP, aerosol-generating dental procedures; CBCT, cone beam computed tomography; COVID-19, coronavirus disease 2019; E/O, extraoral; GI, glass ionomer; HSHP, high-speed handpiece; HVE, high-volume evacuation; I&D, incise and drain; I/O, intraoral; IPR, interproximal reduction; LA, local anesthesia/anesthetic; M/W, mouthwash; NA, not applicable; PA, periapicals; Perio, periodontal; PRF, plaque retentive factors; OHI, oral hygiene instruction; SEP, self-etch primer; SSHP, slow-speed handpiece; SS, stainless steel; ST, soft tissue; TAD, temporary anchorage device; TMJD, temporomandibular joint dysfunction; txt, treatment.

document separates procedures into AGDP/non-AGDP (17/26 of the guidance documents) or whether they are categorized by COVID-19 transmission risk (4/26). Guidance documents that were published by government bodies, typically at an earlier stage of the pandemic (April/May), tended to specify only whether or not procedures were deemed an AGDP, whereas professional bodies, who typically published

guidance later (June), tended to be more descriptive by also categorizing the risk of COVID-19 transmission attributable to each procedure. Those bodies using the transmission risk approach did not use consistent categories to describe that risk. As well as official guidance documents, our literature search also returned published nonguidance journal articles. These articles followed a similar pattern to the guidance documents, in that there

was wide variation in the inclusion of procedures and, when named, a lack of consensus as to which procedures did or did not constitute an AGDP (Alharbi et al. 2002; Li et al. 2004; Zemouri et al. 2017; Ather et al. 2020; Bizzoca et al. 2020; Careddu et al. 2020; Jamal et al. 2020; Long et al. 2020; Martins-Filho et al. 2020; Meng et al. 2020; Passarelli et al. 2020; Peditto et al. 2020; Peng et al. 2020; Pethani et al. 2020; Ren et al. 2020;

**Figure.** Identification of relevant documents. A flowchart to outline the rapid review process undertaken to identify guidance and nonguidance documents relating to dental aerosol-generating dental procedures (AGDPs). The rapid review involved electronic database searches of Medline via Ovid, Embase, and the Cochrane Library. In total, 775 records were identified and screened for their appropriateness. Following removal of unrelated and duplicated articles, 57 articles were considered eligible for inclusion. Owing to the unavailability of 3 articles, 54 were ultimately included in the study. Twenty-six of these were guidance documents and/or position statements, while 28 were nonguidance published articles. The guidance documents were scrutinized and tabulated in the Table. Nonguidance articles were reviewed for relevant information on AGDPs, which was used for comparison with the guidance documents, in the discussion.



Săndulescu 2020; Shi et al. 2020; Suri et al. 2020; Turkistani 2020).

Twenty-one of 26 guidance documents agree that procedures that do not involve the use of rotatory instruments or induce the gag reflex can be considered non-aerosol generating. However, 11 of 26 do not state exactly which procedures do not constitute an AGDP. Those documents that do provide some clarification present their information in different ways; some make allowances for whether a patient has tested COVID positive or negative (British Society for Restorative Dentistry 2020), while others

advise the use of adjuncts to mitigate risk, and others do neither. Guidance from the UK Faculty of General Dental Practitioners (FGDP) (Faculty of General Dental Practitioners 2020), the British Society of Periodontology (BSP) (British Society of Periodontology and Implant Dentistry 2020), and the British Society of Restorative Dentistry (BSRD) (British Society for Restorative Dentistry 2020) appear to be the first documents to clearly separate procedures by risk of COVID-19 transmission, specifying low, moderate, and high risk. However, there are still inconsistencies across these

documents, such as the classification of procedures that induce a gag reflex. One notable area of contrasting advice surrounds the use of the slow speed handpiece. Several British guidance bodies, as well as the Australian government guidance document, state that a slow speed handpiece, used in a dry field with high-volume evacuation, represents a low to moderate COVID-19 transmission risk (9/26). However, 4 of 26 guidance documents have so far regarded the use of the slow speed handpiece as an AGDP at high risk of COVID-19 transmission, including some European countries and Canada (Alharbi et al. 2002; Li et al. 2004; Jamal et al. 2020).

### Evolving Evidence

The WHO's stance in March 2020 was that aerosol transmission of COVID-19 was not a concern, with the virus primarily transmitted through respiratory droplets and contact routes (World Health Organization 2020b). At that time, no strong evidence existed about how long saliva droplets stay in the air (physical decay), whether the droplets remain infectious (biological decay), or if they can be acquired by another person (Xu et al. 2020). In March 2020, Liu et al. published an article in which they assessed 35 aerosol samples taken from 2 Wuhan hospitals and concluded that levels of SARS-CoV-2 in aerosol were low or undetectable (Liu et al. 2020). However, research recently published in June 2020 has demonstrated that SARS-CoV-2 can remain in aerosol and infectious for considerably longer than most respiratory infectious diseases, including both SARS and Middle East respiratory syndrome (Fears et al. 2020). Interestingly, recent research has pointed to dental unit water lines, rather than saliva, as the main source of the microbiota present in dental aerosols. Studies have looked at the microbiota present in dental aerosols, which has been shown to be remarkably homogeneous across patients and highly similar to those identified in dental unit water lines. The same is true for the bioload identifiable in dental aerosols

from a range of AGDPs. The small degree of variability in pathogen and bioload is likely to be due to factors such as the number of carious teeth and the presence of periodontal disease (Kumar and Subramanian 2020).

In light of the changing evidence, WHO recently changed its stance on aerosol transmission of COVID-19 and announced a planned update to its guidance on modes of transmission. With evidence emerging and changing at such a pace, it is, perhaps, unsurprising that there is not a wider consensus on both what constitutes an AGDP/AGE and how these events may correlate to COVID-19 transmission risk.

### Current Knowledge

When we assimilate this current knowledge and its impact on dental staff and patient safety, it becomes clear that the picture is neither simple nor well defined. Our review has shown that despite determined, worldwide efforts to clarify the aerosol-producing nature of dental procedures and exposures, an obvious answer is not readily available, not least because of the novelty of the SARS-CoV-2 virus and the continually emerging research on it.

Critical gaps in our knowledge still exist, such as what constitutes an AGDP, the true presence and formation of the bioload associated with a range of AGDPs, and the risk of transmission of COVID-19 for each dental procedure. In light of this, perhaps a more realistic and adaptable approach to categorizing procedures/exposures in dentistry is to expand upon the “AGE” model—that is, to recognize that in the complex environment of the dental practice, the risk of COVID-19 transmission of procedures/exposures is best assessed as a continuum, rather than in a binary manner. For simplicity, a low/moderate/high-risk model is proposed, which is flexible enough to take account of the type of AGDP, the environment, and any predisposing risk factors for both the patient and the dental team. Importantly, the model should be inherently flexible, such that a particular procedure can be

readily upgraded or downgraded with regard to its COVID-19 transmission risk, depending on such factors as a patient’s medical history, as well as the publishing of newly emerging evidence.

### Recommendations

Currently, there is much uncertainty within the literature as to which dental procedures should be considered aerosol generating. There is also a lack of evidence as to how effectively the SARS-CoV-2 virus transmits through aerosol, although this continues to change rapidly. Further research is required to clarify the risk of each dental procedure/exposure, enabling dentists to plan a working environment that is as safe as possible for staff and patients.

The current knowledge base and emerging evidence would suggest that categorizing dental procedures solely as aerosol generating or not aerosol generating is overly simplistic. In line with the FGDP (Faculty of General Dental Practitioners 2020), BSP (British Society of Periodontology and Implant Dentistry 2020), and BSRD (British Society for Restorative Dentistry 2020) approach, procedures and exposures can be best thought of as being on a spectrum of risk, which is affected not just by the procedure itself. Risk stratification should take a holistic approach with consideration given to the type of dental procedure, the use of water from dental water lines (Kumar and Subramanian 2020), the use of risk mitigating factors such as HVE and rubber dam, the working environment (ventilation), the duration of exposure, the proximity of the clinician to the aerosol, the manipulation of high viral-load tissue such as the oropharynx (Lindsley et al. 2010), and the medical and social history of the staff and patient.

An example of how such a model might work in practice may look like this: the use of the high-speed handpiece might be considered at high risk of COVID-19 transmission. As a short procedure, with the use of HVE (Long et al. 2020), rubber dam (Bizzoca et al. 2020), and excellent ventilation (Office

of the Chief Dental Officer 2020), it may be possible to downgrade this risk to moderate. If that procedure was undertaken on a healthy, young patient by a healthy, young dentist (Centers for Disease Control and Prevention 2020) who was wearing full PPE, including an FFP3 mask (Estrich et al. 2020), there may be scope to downgrade the risk further still. However, if evidence emerged that manipulation of certain oral tissues (Lindsley et al. 2010) or a certain salivary bioload (Kumar and Subramanian 2020) was at particularly high risk of COVID-19 transmission, there would be scope within the model to again upgrade the procedure.

### Conclusion

Despite there being plentiful national and international guidance available, there remains ambiguity as to what constitutes an aerosol-generating dental procedure. It is recommended that future published guidance should stratify the COVID-19 transmission risk (low/moderate/high) of each procedure/exposure in a standardized international approach that can be readily updated and that allows flexibility for patient and environmental factors. When giving advice on the level of PPE or fallow time required between dental procedures, any relevant modifying factors should, where possible, be stated.

### Author Contributions

M.K. Viridi, K. Durman, contributed to conception, design, and data analysis, drafted and critically revised the manuscript; S. Deacon, contributed to conception and design, critically revised the manuscript. All authors gave final approval and agree to be accountable for all aspects of the work.

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