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Recommendations for Management and Mitigation of Aerosol Generated by the Use of High-Speed Rotary Instruments During the COVID-19 Epidemic: An Integrative Review

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Abstract

Objective: To systematize the bibliographic production on the recommendations for management and mitigation of aerosol generated by high-speed rotary instruments in times of COVID-19 epidemic. **Material and Methods:** A bibliographic search was carried out on Brazilian and international electronic bibliographic databases (Lilacs, SciELO, MEDLINE and PubMed). After applying criteria for inclusion and exclusion of articles, 21 studies were selected to carry out the review. **Results:** A proposal was designed with recommendations to reduce contamination during aerosol-generating procedures with high-speed rotary instruments. **Conclusion:** It is recommended to use complete personal protective equipment, including N95, FFP2, FFP3 or similar respirators, mechanical barriers, suction through high volume evacuator, constant renewal of the ambient air through exhaust systems or workroom pressurization, and careful cleaning and disinfection of the work environment after each patient.

Keywords: Aerosols, coronavirus infection, oral surgery

Introduction

On March 11, 2020, the World Health Organization (WHO) officially declared the SARS-CoV-2 pandemic. This new coronavirus is responsible for the infectious disease called COVID-19.[1] Its transmission can occur directly, through close contact with people infected by the inhalation of respiratory bioaerosols produced when a person speaks, coughs or sneezes, or by indirect transmission through contact with surfaces contaminated with SARS-CoV-2 that is taken to the eye, nose or mouth mucosa.[2,3,4,5,6]

Since the beginning of the pandemic, health professionals have been warned about high occupational risk.[7,8] According to the WHO, aerosol-generating procedures are associated with an increased risk of coronavirus transmission.[9] The formation of these aerosols can be divided into: aerosols induced by the patient, as in irritating procedures that cause coughing or sneezing, or mechanically induced aerosols during intubation, cardiopulmonary resuscitation, bronchoscopy, non-invasive ventilation, continuous positive airway pressure, and use of high frequency rotary instruments such as drills, saws and ultrasound devices.[10]

These aerosols, if contaminated by SARS-CoV-2, pose a risk to professionals and patients treated.[6,11] In this occupational risk group, dental surgeons are at the top of the list, but other surgical specialties in medicine such as otolaryngology, head and neck surgery, neurosurgery and plastic surgery, use techniques that demand the use of high-speed rotary equipment in regions with high viral load, in addition to remaining very close to the patient's face during surgery.

Many of these interventions are considered elective, and because they represent a high risk of SARS-CoV-2 transmission, the WHO has advised their postponement in periods of epidemic outbreak.[9] However, it is estimated that we will need to deal with the presence of coronavirus for a time that may extend until 2022.[12] During this period, we will live with moments of stabilization in the number of cases and possible new epidemic outbreaks.[12] Thus, it is important to improve aerosol management and mitigation measures when elective surgical interventions are resumed. Biosafety protocols are part of the routine of these health teams, but in the face of a new disease without an effective treatment, it is essential to increase care during the visits.

This article aims to carry out an integrative review in order to identify, analyze and synthesize the results on practices and recommendations for the mitigation and management of aerosol mechanically generated by high-speed rotary instruments, thus contributing to a possible reduction of the occupational risk of SARS-CoV-2 infection.

Material and Methods

Our research question in this integrative review was: what are the recommendations for management and mitigation of aerosol generated in procedures that use high-speed rotary instruments in times of COVID-19 epidemic?[13] The methodology for the integrative review had the following phases: (1) definition of the research question; (2) search for relevant studies; (3) selection of studies based on pre-established inclusion criteria; (4) data analysis and preparation, and (5) summary and communication of information.

The search was carried out on May 17, 2020, on the databases: Regional Portal of Biblioteca Virtual em Saúde (VHL), which incorporates Lilacs, SciELO, MEDLINE and other types of information sources, such as open educational resources, internet sites, scientific events, and PubMed. The search strategy employed included: **"aerosol" AND "COVID-19".** The search was restricted to publications between 2015 and 2020, regardless of country, and carried out through the title, abstract and keywords. The following inclusion or exclusion criteria were used: **a) inclusion***:* documents that presented measures for handling and or mitigating mechanically generated aerosol from the use of rotary instruments in medicine and dentistry in times of COVID-19; **b) exclusion***:* articles that addressed the risk of cross-contamination in aerosol-generating procedures not induced by rotary instruments; articles that analyzed clinical aspects and COVID-19 treatment or documents not available in Spanish, Portuguese or English.

With the search strategy adopted, 206 studies were identified. Of these, 14 were excluded due to duplicity between the bases. Two reviewers read the remaining 192 abstracts. After applying the exclusion criteria to the 192 remaining articles, 21 were selected for this review.[14]

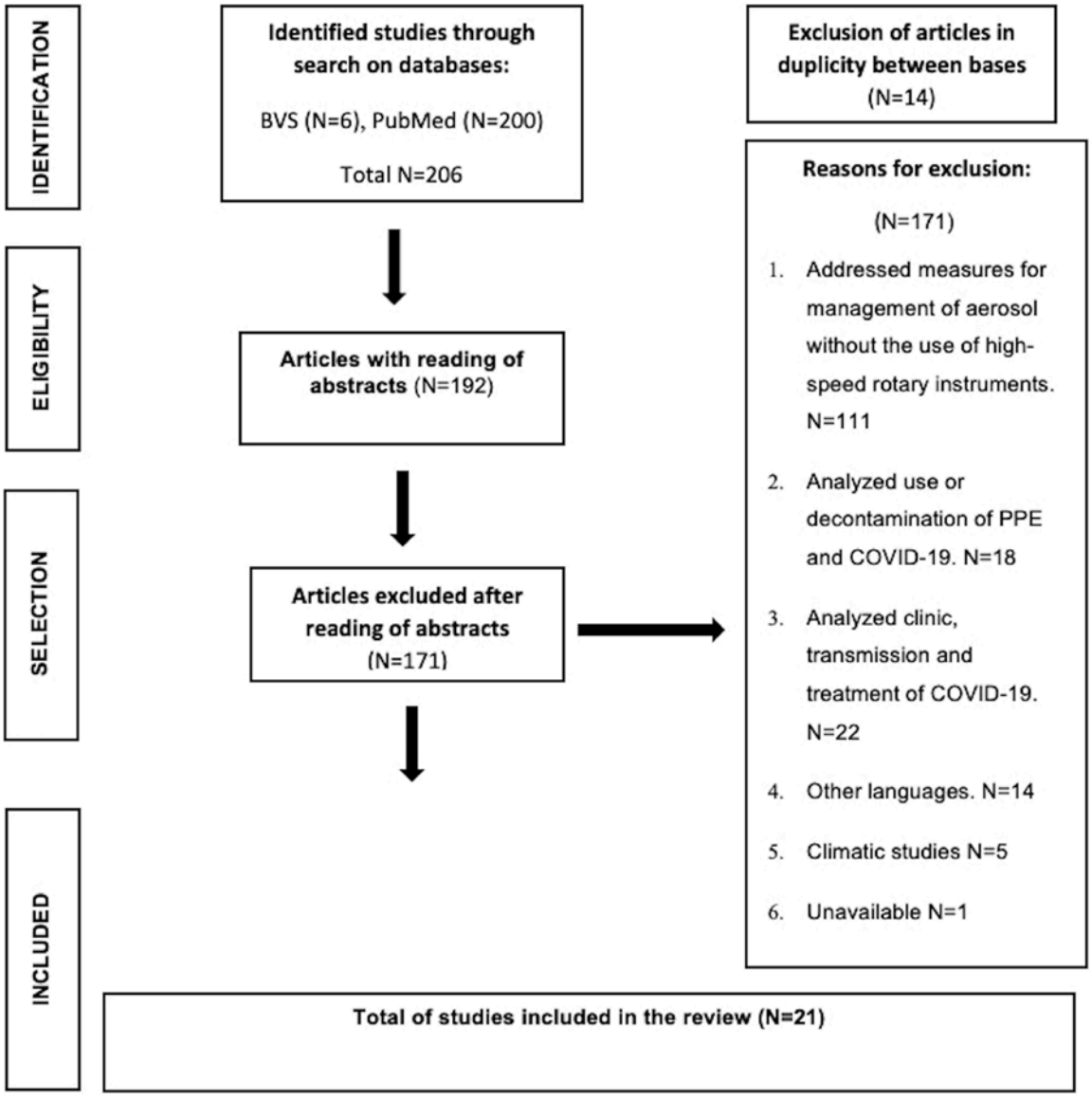

Figure 1. Flowchart of identification and selection of articles for review

Results

There was consensus on the recommendation to perform only urgent and emergency procedures, as well as, whenever possible, the replacement of techniques that require the use of rotary instruments during the COVID-19 epidemic period.

There was an understanding in the studies found on the need for personal protection, through the use of respirators, long-sleeved waterproof gowns, gloves, cap, and eye protection. For respiratory protection, there was agreement in the indication of N95, FFP2, FFP3 or equivalent respirators, due to their superior filtration and sealing capacity.[15-22] The use of respirators with an exhalation valve is not recommended.[15,16,23] In longer surgeries, the use of air-purifying respirators has been suggested.[17,23,24] The use of double gloves was mentioned in two documents[23] and the use of waterproof shoes or shoes protectors was recommended in 4 studies.[16,19,25,26] Eye protection was also widely recommended through the use of goggles[16] and a face shield,[15,16,18,20,22,25,27] which also protects the respirator from splashes and aerosol.[17]

Concerning the recommendations for management of aerosol generated by rotary instruments in dentistry, we found guidelines for the offices to maintain good ventilation[15,16,19,20,28,29] and for such procedures to be scheduled for the end of the day.[19] Volgenant *et al*.[15] indicated consultations in offices with negative pressure, but recognized that natural ventilation in the offices is the possible reality for most establishments. It was expressly recommended to use a room with differential pressure in surgeries performed in a hospital operating room.[17,12,25,27,30]

As regards aerosol clearance time, it is suggested that after the procedure, negative pressure rooms must remain empty and closed for fifteen[27] to twenty[22] minutes before terminal cleaning. In neutral rooms, without the use of a pressure differential, they must remain empty and closed to the internal environment and the windows open to the outside from thirty minutes[15] to one hour before disinfection is carried out.[22]

About room cleaning and disinfection, it was proposed that it be done on all surfaces and equipment between each patient, as well as at the end of the day. The use of oxidizing substances was cited, such as 0.1-0.5%sodium hypochlorite,[15,16,22,28] 1% povidone iodine,[22] chloroform,[16] 0.1%[15], 0.5% and 7%[17,22] hydrogen peroxide, and lipid solvent disinfectants such as ether,[16] 62-75% alcohol,[15,16,19,22,28] peracetic acid,[16] phenols,[19] and quaternary ammonium compounds..[19]

Concerning practices for mitigating aerosol generated by rotary instruments, we find in dentistry: the use of absolute isolation with a rubber dam,[15,16,19,28] high volume evacuator,[25,28-30] and preprocedural mouth-rinse with hydrogen peroxide solution.[15,16,28] The need to develop and use new forms of barriers in aerosol-generating procedures was pointed out.[15,26] Amongst the measures adopted to mitigate aerosol in medicine, the design and use of different types of barriers was the most reported measure.[17,18,29,31-34]

Table 1 shows the author(s), year of publication, country(ies) where the study took place, the specialty involved, methodology and objective of the articles and the measures for mitigation and management of procedure-generated aerosol from high speed rotary instruments, which guided the presentation of the results of this work.

Table 1. Articles identified in the review on mitigation and management measures of aerosol generated during procedures with rotary instruments

Author, year, specialty, country	Methodology, objective of the study	Suggested Actions
Ağalar C and Engin DÖ.[22] 2020. Infectious Diseases Turkey	Literature review. To submit recommendations on biosafety care under COVID-19.	Use of complete PPE*, service in well-ventilated isolation rooms or rooms with negative pressure. Wait 20 minutes before cleaning in negative pressure rooms and one hour in neutral pressure rooms, keeping them open. Cleaning and disinfection of surfaces.
Basso T *et al*.[18] 2020. Orthopedics Belgium	Literature review. To systematize the recommendations for the use of high-speed rotary instruments.	Use of N95, FFP2 or FFP3 respirators and face shield. Avoid pulsed lavage, minimize the use of rotary instruments and high speed saws, use of waterproof drape as containment barriers.
Chan DYC *et al*.[31] 2020. Neurosurgery Hong Kong	Letter to the editor. To describe concern about the risk of contamination by SARS-CoV-2 in neurosurgeries using rotary instruments.	Previous testing for COVID-19 in suspected cases, rational use of complete PPE* with upper respiratory protection only for patients with a positive test or when testing is not possible. Preferential use of hand tools during the epidemic period.
Chen JX *et al*.[34] 2020. Otorhinolaryngology USA	Experimental study. To present a technique to mitigate aerosols generated by rotary instruments during mastoidectomy.	Previous testing for COVID-19 and use of barrier drape to reduce aerosol dispersion. Use of surgical drape fixed to the microscope was an efficient method to reduce contamination caused by aerosol during mastoidectomy.
David AP *et al*.[30] 2020. Otorhinolaryngology USA	Literature review. To address the use of a viral isolation drape to reduce the risk of aerosol.	Use of N95 respirator or powered air-purifying respirator, fluid-resisting gown, eye protection and negative pressure barriers to reduce aerosol dispersion during endoscopic surgeries with transoral or endonasal access.
Howard BE.[23] 2020. Otorhinolaryngology - Head and Neck Surgery USA	Literature review. To evaluate the forms of respiratory protection during performance of mechanically induced AGP*.	Procedures with extended duration, proximity to the airway, and the use of energy devices may require heightened levels of respiratory PPE, with the use of respirators with 99- to 100-level filters or powered air-purifying respirator.

Izzetti R *et al*.[35] 2020. Dentistry Italy	Literature review. To discuss the risks of COVID-19 related to dental practice and current recommendations for dentists.	Avoid using rotary and ultrasonic devices. Use of complete PPE*, surgical suction system, waiting 15 minutes after treatment for air change, air renewal through natural ventilation, disinfection of all surfaces.
Li Y *et al*.[28] 2020. Dentistry. China	Literature revision. To submit recommendations for care during the COVID-19 epidemic outbreak.	Indicate patients screening with rapid testing. Use of complete PPE*, good ventilation in the clinic setting and a powerful aspiration system. Strict and regular cleaning and disinfection of surfaces with alcohol or chlorine.
Lo Giudice R.1[6] 2020. Dentistry Italy	Informative article. To propose a protocol with recommendations on dental treatment in time of COVID-19 outbreak.	Use of FFP2 or FFP3 respirators, goggles or face shield for the entire health team. Recommends the use of barriers in equipment, cleaning, and disinfecting surfaces.
Martins-Filho PR *et al*.[19] 2020. Dentistry Brazil	Communication. To provide recommendations for dental care in the period of epidemic outbreak.	Use of complete PPE*. Schedule aerosol-generating procedures for the end of the shift. Cleaning and disinfection between consultations with quaternary ammonium-based, phenol-based, and alcohol-based products, and terminal disinfection after care. Proper disposal of contaminated waste.
Odeh ND *et al*.[26] 2020. Dentistry Saudi Arabia and Jordan	Communication. To submit recommendations for dental care during the COVID-19 outbreak.	Use of complete PPE*, give preference to manual instrumentation. Need for research to develop barriers with negative pressure.
Ozturk CN *et al*.[17] 2020. Plastic Surgery Turkey	Literature review. To provide guidance on surgical procedures during COVID-19 outbreak.	Prior screening patients for COVID-19. Use of complete PPE*. Perform the procedures in negative-pressure airflow room.
Raghavan R *et al* [25] 2020. Orthopedics United Kingdom	Informative article. To describe the current practice adopted to reduce aerosol production during surgery in a period of COVID-19 epidemic.	Use of complete PPE* and waterproof shoes. Perform surgeries in negative pressure environment. Use a powerful suction system. Preferably use percutaneous accesses and techniques that reduce aerosol. Carry out irrigation with a syringe to avoid pulse lavage.
Thamboo A *et al*.[24] 2020. Otorhinolaryngology Head and Neck Surgery Canada	Literature review. To identify different PPE* and provide evidence-based recommendations.	High-speed devices are high-risk procedures. Using level 3 PPE* is recommended, which includes: air-purifying respirators, N99/FFP3 respirators, if N95 is not available. Eye protection. Perform procedures in negative pressure rooms.
Tomasi SO *et al*.[32] 2020. Neurosurgery Austria	Letter to the editor. To share the experience of biosafety measures during the COVID-19 epidemic.	Testing patients for COVID-19 who are candidates for neurosurgical procedures that require the use of rotary instruments. Use complete PPE*.
Turkistani KA.[20] 2020. Dentistry Saudi Arabia	Literature review. To systematize guidelines for carrying out AGP* during the COVID-19 outbreak.	Use of complete PPE*. Maintain adequate ventilation in the operatory and waiting room, cleaning, and disinfection of surfaces.
Umer F *et al*.[21] 2020. Dentistry Pakistan	Literature review. To evaluate the type of respiratory protection indicated in AGP* in COVID-19 times.	Indicates the use of N95 or FFP2 respirators to the detriment of surgical masks in dental care. In times of supply crisis, prolonged use is permitted as long as the respirator maintains its safety properties.
Volgenant CMC *et al*.[15] 2020. Dentistry Netherlands	Literature review. To provide suggestions for measures to control COVID-19 infection during dental care.	Perform rapid tests prior to elective care. Use of complete PPE*. Use negative pressure rooms, where this is not possible, keep the environment well ventilated. Wait at least 30 minutes between patients, keeping the rooms ventilated before cleaning, and rigorous disinfection of surfaces.
Williams M et al.[29] 2020. Orthopedics United Kingdom	Case report. To present a technique to contain the aerosol generated during orthopedic surgeries.	Recommends the adaptation of a kidney dish with a hole as a low cost and efficient option for mitigating aerosol secondary to power-tools.
Workman AD *et al*.[33] 2020. Otorhinolaryngology USA	Experimental study. To simulate aerosolization events in the presence or absence of barriers during the use of high-speed drills.	The use of a high-speed drill produced significant aerosol contamination in all conditions tested, confirming the high risk for the surgeon. The use of a barrier significantly reduces aerosol spread.
Zimmermann M and Nkenke E.[27] 2020. Oral and Maxillofacial Surgery and Traumatology Austria	Literature review. To provide recommendations for carrying out procedures in OMFST* during the COVID-19 epidemic.	Previous testing of patients. Use of complete PPE*. Perform surgeries in negative pressure rooms. Prioritize extraoral approaches, avoid aerosol-generating instruments and electric cautery. Do not allow people to enter and leave the operating room. Wait 15 minutes for cleaning and disinfection of room.

*Complete PPE - Personal Protective Equipment with N95, FFP2 or FFP3 respirators, waterproof gown, cap, gloves and face shield. *OMFST : Oral and maxillofacial surgery and traumatology. *AGP – Aerosol-Generating Procedures.

Discussion

Much of the publications so far sought to guide the different health specialties on the necessary adjustments for care during the outbreak of the COVID-19 epidemic.[35] In many countries, elective procedures are being resumed and knowing such care is essential to prevent new outbreaks.

The risk of transmission by aerosols mechanically generated by the use of high-speed instruments such as drills, saws and ultrasound devices is still scantily discussed.[35] This aerosol generated can be droplets, also known as splashes and droplet cores consisting of saliva, body fluids and organic debris.[37] Droplets larger than 100 μm settle quickly on surfaces in the immediate vicinity of the source, whereas droplet cores smaller than 10 μm are lighter and can remain in the air for hours before settling on a surface.[37]

The possibility of airborne transmission during aerosol-generating procedures implies the need for superior respiratory protection.[23,33] N95, FFP2 and FFP3 respirators are the most commonly used, with recommendation of disposal after the procedure. In shortage scenarios, elastomeric respirators are an alternatives to disposable FFRs as they can be can be repeatedly reused after cleaning and disinfection.[23] Powered air-purifying respirators are also reusable PPE alternatives that provide a higher protection factor as compared to other respirators.[17,23,24] However, the device limits the use of a microscope and headlight and is expensive.[23]

The adequacy of ambient air treatment of offices and rooms in surgical suites seems to be a problem to be faced considering that many offices and operating rooms are not equipped with differential pressure treatment, with highly efficient particle filtering system and controlled direction of air flow as recommended.[9,38,39,40] Thus, the recommendation of maintaining neutral rooms with good ventilation during or after care must be understood as an emergency measure to reduce viral spread, but not definitive in the medium term. This is because such condition can compromise the ideal maintenance of temperature in the operating rooms (19-24 °C), important not only for the comfort of patients and surgical staff, but also in the prevention of environmental conditions that favor the growth and transmission of microorganisms, in addition to entrance of vectors.[41]

Regarding clearance time of generated aerosol, in experimental laboratory conditions, the presence of SARS-CoV-2 in aerosols was found in up to 2.64 hours,[42] which raised many doubts about the safe time interval between procedures. The time interval between procedures will depend not only on the clearance time, but also on ventilation and air change inside the room. Rooms with negative pressure with 10 to 12 air changes per hour will need an average of 20-30 minutes to reduce contamination to less than 1%.[40] It is estimated that a single air change removes 63% and that after 5 air changes, it is believed that less than 1% of the original air contamination remains.[40] Thus, the determination of the time required for aerosol clearance until 99.9% of the air is changed must be planned by the hospital engineering team, as this calculation takes into account specific characteristics of each setting.[43] On the other hand, neutral rooms, without the use of pressure differential, must remain empty and closed to the internal environment and windows open to the outside for one hour. However, further clinical studies need to be carried out to evaluate the safety of this indication.[40]

After this aerosol is cleared, SARS-CoV-2 can remain infectious on some surfaces for hours.[42] As a result, cleaning and disinfection measures widely recommended among the studies found are considered crucial for the prevention of COVID-19 cross-contamination.[15,16,19,20,22,27,28] Cleaning of critical areas is necessary before and after each surgical procedure and at the end of each day. It should be noted that these precautions must also be observed in non-critical areas, such as reception room, toilets and ventilation systems.[44,45] The WHO recommends cleaning surface dirt with soap and water followed by disinfection by a friction process with 70% ethyl alcohol, 0.5% sodium hypochlorite (equivalent to 5000 parts per million) and quaternary ammonium compounds.[9] After cleaning, critical and semi-critical rotary instruments and equipment must be sterilized.[46]

The use of preprocedural antiseptic mouth-rinses with 0.5% or 1% hydrogen peroxide for one minute was mentioned by four authors in this review.[15,16,28,35] It was believed that its use could reduce the microbial load before dental care, but there seems to be controversy regarding its effectiveness.[47] However, there is still no scientific evidence proving its effectiveness in maintaining the decrease in this viral load as the salivary glands will continue to secrete contaminated saliva.[48] Chlorhexidine, commonly used as an antiseptic mouthwash, has not been effective in decontaminating surfaces infected with SARS-CoV-2.[42]

The mitigation of generated aerosol is a challenge to be overcome. The creation of barriers to contain aerosol and the use of high volume evacuator during procedures were measures adopted in the different specialties that use high speed rotary instruments. We found the tendency to indicate that patients should be tested for COVID-19 prior to procedures while the epidemic continues.[17,27,28,31,32] Such measures combined can significantly reduce the risk of cross-contamination (Table 2).

As with any scientific work, the present one has limitations. Some of them are due to the reduced number of publications that evaluate aerosol mitigation measures produced by high-speed rotary instruments. In addition, more robust clinical trials are not available to assess the safety

of recommended measures related to SARS-CoV-2. Finally, as it is a new virus, it is expected that new publications will point to evidence that will require adjustments in the recommendations for health professionals.

Conclusions

Among the recommendations found for handling and mitigating aerosol generated by high-speed rotary instruments during the SARS-CoV-2 epidemic period, the following stand out:

- Correct use of all PPE, including respirator N95, FFP2, FFP3, air purifying respirator or equivalent, disposable waterproof gown, gloves, cap and face shield;
- Use of high volume evacuator during procedures;
- The indication of carrying out the procedures in controlled environments with negative pressure or with good ventilation; setting a time interval that allows aerosol to settle according to hospital engineering guidelines, followed by cleaning and disinfection of the enviroment.
- The development of barriers to contain aerosol is a trend that can be promising, and testing patients for COVID-19 prior to care adds greater safety for health professionals.

Table 2 . Recommendations for performing aerosol-generating procedures by high-speed rotary instruments

Recommendations for performing aerosol-generating procedures
Screening prior appointments to identify suspicious cases (phone calls, messaging applications or video conferencing). Consider testing patients for COVID-19 in advance.
Schedule patients considering the time needed for air exchange and cleaning of the work environment.
Use of disposable PPE at each visit: N95, FFP2, FFP3 respirator or equivalent, waterproof gown, gloves, cap and face shield.
Minimize spraying through mechanical barriers (absolute isolation in dentistry, isolation drapes, aerosol boxes, among other devices).
Constant aspiration with high power suction (vacuum pump).
Ensure constant air renewal, preferably through air conditioning units with exhaust or pressurization of the work room (negative pressure rooms). In environments without a purification system, consider keeping the windows open for natural ventilation during care.
Waiting time between appointments will be defined by Hospital Engineering by calculating the work area and air purifier capacity.
Cleaning and disinfection of all surfaces after each patient.

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