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Guidelines for oral and maxillofacial imaging: COVID-19 considerations

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Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), the virus causing the current coronavirus disease 2019 (COVID-19) pandemic, is not only highly infectious but can induce serious outcomes in vulnerable individuals including dental patients and dental health care personnel (DHCPs). Responses to COVID-19 have been published by the Centers for Disease Control and Prevention and the American Dental Association, but a more specific response is required for the safe practice of oral and maxillofacial radiology. We aim to review the current knowledge of how the disease threatens patients and DHCPs and how to determine which patients are likely to be SARS-CoV-2 infected; consider how the use of personal protective equipment and infection control measures based on current best practices and science can reduce the risk of disease transmission during radiologic procedures; and examine how intraoral radiography, with its potentially greater risk of spreading the disease, might be replaced by extraoral radiographic techniques for certain diagnostic tasks. This is complemented by a flowchart that can be displayed in all dental offices. (Oral Surg Oral Med Oral Pathol Oral Radiol 2021;131:99–110)

Although aerosols and airborne contamination are created by commonly used dental equipment such as ultrasonic scalers, high-speed dental handpieces, air/water syringes, air polishing, and air abrasion,¹ techniques used in oral and maxillofacial radiology (OMR), particularly intraoral radiography, can also produce aerosols. The control or reduction of such aerosol-generating procedures is a principal strategy in the global response to the current coronavirus disease 2019 (COVID-19) pandemic.¹ As dental health care personnel (DHCPs) return to practice following the prolonged lockdown provoked by this pandemic, they encounter an entirely changed world, requiring new systems of work. The American Dental Association (ADA) has fully adopted the Centers for Disease Control and

Prevention (CDC) recommendations and applied them to almost every aspect of dental care in its “Return to Work Interim Guidance Toolkit,”^{2,3} but the guidelines are still limited with regards to radiography. Although the first peer-reviewed report on this matter reflected the widespread confinement of radiography to extraoral projections⁴ because of the possible production of an aerosol by coughing and gagging during intraoral radiography, a letter to the editor advised the appropriate use of intraoral radiography when necessary.⁵

The death of a dental colleague in March due to COVID-19 reverberated throughout the dental world. The CDC COVID-19 response team reported that 37% of health care workers who died were 65 years of age and over.⁶ Furthermore, males, those with underlying health conditions, and those of minority ethnicities are particularly vulnerable to developing COVID-19 symptoms and, more important, developing a severe outcome, which includes death (Table I).^{7,8} In the absence of a widely-used vaccine of proven efficacy, identification of our vulnerable colleagues is a priority.

The purpose of this article is to (1) review the background of the COVID-19 pandemic and what is currently known about this disease, including signs and symptoms of infection and mechanisms of transmis-

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Statement of Clinical Relevance

The practice of oral and maxillofacial radiology has been severely constrained by the current COVID-19 pandemic. An infection control strategy based on current best practices and science and the use of extraoral in place of intraoral imaging techniques are discussed.

Table I. Conditions that render dental health care personnel vulnerable to COVID-19

Vulnerability	Details
Age	Each decade from the 50s carries almost a doubled risk of death
Sex at birth	Males are at least twice as likely to die of COVID-19
Underlying conditions	Diabetes (either type 1 or 2) poses an increased risk, even more so in complicated cases Obesity, particularly if the body mass index exceeds 35 Cardiovascular disease, namely, angina, previous myocardial infarction, stroke, or other cardiac intervention; for example, bypass or pacemaker surgery. <i>Note.</i> Heart failure further enhances that risk Pulmonary disease, including asthma Malignancy, where patients with active disease are more vulnerable over those in remission Rheumatic diseases Immunosuppressant treatment.
Ethnicity	Front-line health care personnel from ethnic minorities are more likely to die than their Caucasian counterparts

Main sources: Guzik et al.⁷ and Strain et al.⁸

sion; (2) list tactics with which DHCPs can minimize the risk of transmission of the disease between themselves and patients, with emphasis on preparing radiology equipment and accessories; and (3) consider how the prescription of radiographic techniques might be changed to provide the desired diagnostic information with minimal risk.

The CDC defines DHCPs as “all paid and unpaid persons serving in dental healthcare settings who have the potential for direct or indirect exposure to patients or infectious materials, including: Body substances, contaminated medical supplies, equipment, surfaces and air.”¹

THE BACKGROUND OF THE COVID-19 PANDEMIC

SARS-CoV-2 spreads “through direct, indirect, or close contact with infected people through infected secretions such as saliva and respiratory secretions or their respiratory droplets, which are expelled when an infected person coughs, sneezes, talks or sings. Respiratory droplets are $>5\text{-}10\mu\text{m}$ in diameter whereas droplets $\leq 5\mu\text{m}$ in diameter are referred to as droplet nuclei or aerosols.”⁹ An aerosol (an abbreviation of *aero-solution*), is a suspension of fine solid particles or liquid droplets in air or another gas.¹⁰ “The virus has been shown to persist in aerosols for hours, and on some surfaces for days under laboratory conditions.”¹ Death results not only from acute respiratory distress syndrome but also from organ failure.¹¹

The main signs and symptoms of COVID-19 are fever or chills, cough, shortness of breath or difficulty breathing, fatigue, muscle or body aches, headache, new loss of taste or smell, congestion or runny nose, nausea, vomiting, and diarrhea.¹² Identification of these manifestations in patients who are entering the clinic for radiographs permits the dentist to accomplish the first decision point in patient management: whether or not the patient has or is being investigated for this disease (Figure 1). It distinguishes between 2 separate groups of patients: those with or suspected of having COVID-19 and those with no

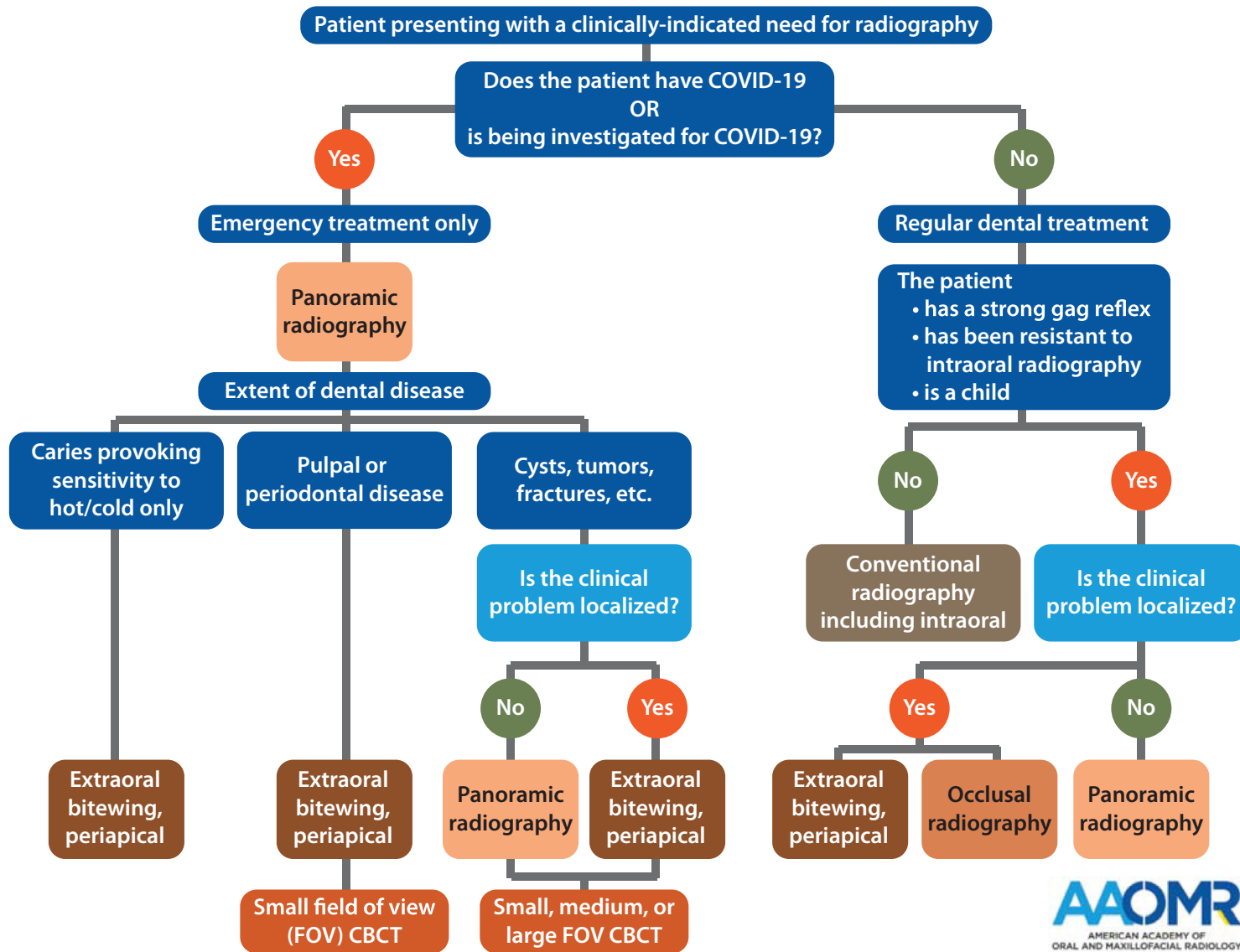
evidence or suspicion of the disease. This is the point where the dentist will decide to modify his or her radiographic activities (“Yes” in the decision tree) or proceed as normal (“No” in the decision tree). The early and prompt detection and isolation of patients diagnosed with or suspected of having COVID-19 is advised in order to minimize exposure of colleagues and other patients.¹³ However, the CDC warns that “COVID-19 may be spread by people who do not show symptoms.”¹² Considering the nature and presentation of the disease and the possibly serious outcomes for those infected with the virus, DHCPs should institute a clearly defined regimen to reduce the risk of transmission, as stated in Table II. The table is derived from the CDC’s updated “Guidance for Dental Settings.”¹ In the first instance, a colleague developing the above signs and symptoms should not report for work or, if developing them in the office, should be sent home or to another destination specified by state or local health departments. Immediate emergency medical attention should be sought if a colleague or patient displays the following signs: trouble breathing, persistent pain or pressure in the chest, new confusion, inability to wake up or stay awake, and bluish lips or face.¹² Because this list is not exhaustive, any other severe clinical manifestation should, of course, provoke similar urgency.¹²

TACTICS TO MINIMIZE THE RISK OF TRANSMISSION OF COVID-19

Education and provision of personal protective equipment for DHCPs

Each DHCP should be educated in how SARS-CoV-2 can infect people and be trained in and have practiced the appropriate use of personal protective equipment (PPE) before caring for patients. Further details included in recent CDC documentation^{1,14} are summarized in Table II.

- To protect patients and co-workers, DHCPs should wear a face mask at all times while they are in a



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Fig. 1. Flowchart for decision making in managing patients in the time of the COVID-19 pandemic with respect to oral and maxillofacial radiology.



Table II. General steps to be taken by dental office personnel during the COVID-19 pandemic

Stages	Elements	Activity/activities
Preparatory	Pre-patient care education and training of DHCPs and other staff	Education and training on prevention of transmission of SARS-CoV-2 Identify vulnerable colleagues (Table I) Appropriate use of PPE to prevent contamination of clothing, skin, and the environment during the process of doffing the equipment
	Maintain proper PPE EPA-standard supplies	Understand the office's PPE and EPA-standard inventory and its utilization and supply rates because these directly affect the degree and continuity of dental services provided
	Signage	The acquisition and/or production and appropriate siting of such signage to facilitate the correct conduct of all DHCPs, patients, and visitors within the dental office
	Waiting room	Remove magazines, coffee machines, toys, and other frequently touched materials Arrange furniture in waiting area to ensure social/physical distancing
Triage and physical admission of patient to the office	Teledentistry and triage protocols to be applied to the patients before presenting	Telephone screen patients for COVID-19 Telephone triage to determine whether patients need to be seen in a dental setting Advise patients to minimize the number of accompanying visitors and inform them that all must wear face masks/covering and will be subject to screening for fever and symptoms
	Physical (in-person) screening and triage of patients at entry into the dental office	Ensure that everyone complies with respiratory hygiene (wear face masks/coverings) and applied cough etiquette and hand hygiene (ABHR) Take temperature (fever is equal to or greater than 100°F) Inquire as to whether the patient has already been asked to self-quarantine Install physical barriers at reception areas Direct COVID-19-confirmed or suspected patients to the operator for their emergency treatment and NOT to the waiting room
Operatory	Avoid or minimize aerosol-generating procedures	Aerosol-generating procedures are commonly created in dentistry by ultrasonic scalers and high-speed dental handpieces, air/water syringes, and air polishing and abrasion, but also by patients when gagging and/or resisting intraoral radiography and by children Figure 1 and Table III
	Airborne infection isolation rooms	Single-patient rooms at negative pressure relative to surrounding areas with a minimum of 6 air changes/hour.* The operatory door should be closed except upon entry. Exhaust air directly to the outside or filtered through a HEPA filter
	HEPA positioning	Should be close to the patient's head but NOT such that any DHCP gets between it and the patient. This is relevant when the DHCP is placing intraoral sensors in the mouth
	After the patient has left	"DHCP should ensure that environmental cleaning and disinfection procedures are followed consistently and correctly after each patient." ¹ Use the appropriate EPA-standard cleaning materials. See Table IV

DHCP, dental health care personnel; PPE, personal protective equipment; EPA, Environmental Protection Agency; ABHR, alcohol-based hand rub; HEPA, high-efficiency particulate air.

*Air changes per hour: the ratio of the volume of air flowing through a space in a certain period of time (the airflow rate) to the volume of that space (the room volume). This ratio is expressed as the number of air changes per hour.

health care facility because this offers both source control and protection from exposure to splashes and sprays of infectious material from others.

- DHCPs working in areas with minimal to no community transmission should continue to use eye protection or an N95 or higher-level respirator. Universal

use of a face mask for source control is recommended for DHCPs.

- The DHCP in charge or the dental office owner should ensure that PPE of the appropriate quality (e.g., N95 or higher-level respirators, disposable-after-single-use isolation gowns) is available for the

clinical team in the proper quantities. Face cloths are not PPE and should not be used in the care of COVID-19 (or suspected) patients. Other PPE includes protective eyewear. Because the gaps between the glasses and the face do not protect the eyes from all splashes, sprays, and aerosols, face shields are required to guard against them.¹⁴

- A separate system of work will need to be created for radiographic procedures, which includes patient preparation, observing time intervals between patients, and cleaning and decontamination after the patient has departed from the facility.

PPE requirements when treating patients diagnosed with or being investigated for COVID-19

In addition to ensuring that all DHCPs have the required PPE and are utilizing it properly, it is important to consider the PPE requirements for patients who have or are suspected of having COVID-19 to manage the risk these patients pose to the dentist and clinical team members who receive all patients (emergency and nonemergency) in the dental office (Table II).

- If emergency dental care is medically necessary for a patient who has or is suspected of having COVID-19, the DHCP should follow the CDC's interim document for health care settings.¹⁴ In such a setting, patients should wear all recommended PPE including a face mask or cloth face covering to contain secretions and should be covered with a clean sheet.
- After arrival at their destination, the receiving radiology personnel and the transporter (if assisting with transfer) should perform hand hygiene and wear all recommended PPE.

PPE requirements when treating patients who are asymptomatic/not suspected of having COVID-19

The potential for asymptomatic SARS-CoV-2 transmission underscores the importance of applying prevention practices to all patients, including social distancing, hand hygiene, surface decontamination, and having patients wear a cloth face covering or face mask while in a health care facility.

Preparing radiology equipment and accessories

- DHCPs should limit clinical care to one patient at a time whenever possible.
- Set up operatories so that only the clean or sterile supplies and instruments needed for the dental procedure are readily accessible. Any supplies and equipment that are exposed but not used during the

procedure should be considered contaminated and should be disposed of or reprocessed properly after completion of the procedure.

- A limited amount of evidence exists regarding the clinical effectiveness of preprocedural mouth rinses before intraoral radiography to reduce aerosol generation and thereby SARS-CoV-2 transmission. There is some evidence, however, that whereas ethanol-based preprocedural mouth rinses (perhaps with essential oils) reduce the viral load, chlorhexidine does not. Povidone-iodine and hydrogen peroxide show some promise.¹⁵ Nevertheless, it must be appreciated that “there is currently insufficient high-quality evidence to suggest that oral rinses are effective against SARS-CoV-2.”¹⁵ Therefore, oral rinses should not be used as alternatives to high-quality PPE and rigorous infection control.¹⁵

How COVID-19 may cause changes in the prescription of radiographic techniques

In light of COVID-19, the ADA has provided interim guidance for DHCPs, recommending the avoidance or reduction of intraoral radiography during the COVID-19 crisis.¹⁶ As mentioned earlier, the virus can persist for long periods of time in aerosols. A potential source of aerosol production in intraoral radiography is gagging and coughing. In one study, the overall frequency of gagging during intraoral radiography was 13% but the frequency differed significantly between patients radiographed by trained radiographers (frequency of 9%) and by students (frequency of 26%).¹⁷ Although gagging occurred when positioning intraoral receptors in all sites, the most common site was the maxillary molar area.¹⁷

Recommendations of the ADA for radiographic prescription for common dental tasks (selection criteria) were first published in 1982; the most recent guidelines appeared in 2012.¹⁸ The broad thrust of these recommendations is still pertinent in the COVID-19 era; the prescription of every radiograph must arise from a particular clinical indication.¹⁸ However, the constraints that COVID-19 imposes upon dental practice might limit the hitherto free use of intraoral radiography, mainly due to the increased risk of producing a virus-laden aerosol.

These problems prompt us to consider different technologies, such as dental panoramic radiographs (DPRs) and cone beam computed tomography (CBCT), to accomplish the goals of intraoral radiography, particularly in those cases where an aerosol is most likely to be generated by gagging or coughing (see Figure 1). The hitherto almost routine full-mouth survey (FMS) may have to become less routine. Indeed, OMR educators teach that the word *routine* has no place in the

Table III. Comparison of imaging modalities available in dental offices

Feature	Intraoral radiography	Dental panoramic radiography	Cone beam computed tomography
Availability	Most dental offices	Most dental offices	Few dental offices
Spatial resolution (fine detail)	Highest	Moderate	Lowest
Diagnostic efficiency	Best for most studies of individual teeth	Adequate	Best when cross-sectional information is required
Reduced compliance	Children, gaggers, and those prone to coughing	Because most require patients to stand or sit vertically, may not be ideal for elderly and ill patients	
Aerosol production risk	Highest because of gagging and coughing	Least because nothing enters the oral cavity	
Movement artifact	Minimal risk	Moderate risk	High risk
Metal artifact	None	None, provided the patient is properly prepared and positioned	Greatest, because of beam hardening
Cross-sectional display	None	None	Best
Optimal indications	Examinations requiring fine detail: Detection of caries and periodontal bone loss, endodontic procedures in single-rooted teeth, etc.	Examinations requiring wide view of maxillo-mandibular anatomy: Large and/or multiple lesions, impacted teeth, status of developing permanent dentition, etc.	Examinations requiring 3-D images and/or extensive views of the oral and maxillofacial anatomy: Orthodontic diagnosis, implant site assessment, complex endodontic procedures, postoperative complications, large and/or multiple lesions, impacted teeth, etc.
Effective radiation dose ^{38,39}	Least (~2 μ Sv per exposure)*	Moderate (~14-24 μ Sv) [†]	Highest (~5-1073 μ Sv) [‡]

*Assuming the use of photostimulable phosphor digital imaging or F speed film and rectangular collimation.

†Assuming the use of a solid-state digital panoramic system.

‡Depending on factors including field of view and exposure parameters.

OMR vocabulary in accordance with the ADA selection criteria of 2012.¹⁸

The flowchart in [Figure 1](#) guides the prescription of radiographic procedures during the recovery phase of the COVID-19 pandemic. It is organized as a broad overview covering patients who are known or suspected to have COVID-19 and those who are not. [Table III](#) compares the strengths, limitations, and radiation burdens of intraoral radiography, DPR, and CBCT.

Before returning to [Figure 1](#), it is important to reveal why intraoral radiography, the workhorse of radiography in dentistry, has been so compromised by COVID-19. As we have seen, intraoral radiography is potentially an aerosol-generating procedure.

Before a review of radiographic technologies, it is important to emphasize that these do not replace a thorough clinical examination and history taking. Although the most frequent reason for intraoral radiography, particularly bitewings, is the detection of caries, particularly proximal caries, it was revealed that

“when diagnostic observations were translated into clinical management decisions using the rule that a

noncavitated lesion should be treated nonoperatively and a cavitated lesion operatively, . . . visual-tactile method alone was the superior strategy, resulting in most correct clinical management decisions and most correct decisions regarding the choice of treatment.^{19,”}

Because of the relative antiquity of most bitewing-and-caries studies (now at least 3 decades old) and because CBCT can be accurate for displaying cavitation in proximal caries, Wenzel has suggested that new studies are required in both child and adult populations. Bitewing radiography remains the state of the art for the diagnosis of proximal caries.²⁰ The utilization of bitewings and periapical radiography in the current COVID-19 pandemic will now be discussed.

Intraoral radiography

Before the current COVID-19 emergency, an authority identified that such an infection would reveal the Achilles’ heel of digital dental intraoral radiographic equipment: it cannot be sterilized.²¹ The CDC’s recent

update on the pandemic for DHCP¹ referred to their 2003 document.²² Unfortunately this document was written just when digital radiography was entering mainstream dental practice and therefore was only able to offer limited advice. Because the most widely used system of sterilization in dentistry is autoclaving, which would destroy the sensors, barrier protection of the sensors or a return to analog film imaging is being considered. However, now that most dental offices in North America have converted to some form of digital radiography, the use of film is not a realistic option. With regards to photostimulable phosphor sensors (also called storage phosphor plates), the best practical solution is to decontaminate them between patients with 70% alcohol wipes (or other CDC-approved disinfectant solutions) and then insert these sensors into sealable plastic envelopes before their next use. These steps have been shown to provide adequate protection for storage phosphor plate systems.²³ Consideration of scanner contamination was not part of that report and should be taken into account in the current pandemic.

The charge-coupled device and complementary metal oxide semiconductor solid-state sensors, used for direct capture of intraoral radiographs, and the cables that link the sensors to the computer present a significant infection control problem that so far has defied a practical solution. Choi tested the integrity of a number of barriers for solid-state sensors after clinical use.²⁴ The perforation rate of intraoral barriers was reduced when a double-barrier method was used; a latex finger cot enveloped both the plastic barrier-covered sensor and the sensor positioning device (such as a Rinn holder).²⁴ A study comparing different solid-state sensors concluded that the wireless sensor may be preferable to others because of the absence of a wire connecting it to the computer. The absence of a wire makes this type of solid-state sensor ideal for use at the present time.²⁵

A letter to the editor by Dave et al.⁵ regarding an article by Meng et al.⁴ on the challenges to dental practice posed by COVID-19 advised that any necessary intraoral radiography be undertaken by 2 DHCPs. Further details were acquired through a communication with the corresponding author of that letter. One radiographic technician/radiographer (the “clean” one) sets the exposure factors and exposes the patient. The other (the “unclean” one) places the sensors (phosphor plates) in the patient’s mouth and handles the now-contaminated sensors (Professor Keith Horner, University of Manchester, UK, personal communication).

Dental panoramic radiography

The over half-century existence of DPR has seen it evolve in complexity of movement and from analog to

digital technologies. Its principal advantages are delivery of a 2-D panoramic display of the maxillomandibular complex in adequate detail with a comparatively low radiation dose. The DPR has traditionally been used to overview patients new to dental care, particularly those with disease obvious on clinical examination. After the completion of a thorough examination, its use as a supplemental investigation in a consecutive case series of over 6000 digital DPRs made on symptom-free new patients requesting only a dental exam or dental hygiene revealed at least one incidental finding that could require treatment in approximately one-third of the patients.²⁶ Although the majority of incidental findings were impacted teeth, 1% had areas of sclerosing osteitis associated with teeth that were likely nonvital and should be reevaluated by clinical reexamination.²⁶

Furthermore, the patient-friendliness of the DPR has made it the first imaging modality for those patients with variable degrees of dental anxiety. In an investigation of dental anxiety among adult patients, only a DPR complementing the clinical examination revealed the source of dental pain, which was found to affect over three-quarters of patients with dental anxiety.²⁷

Further potential displacement of intraoral radiography by the DPR was suggested nearly 2 decades ago. Farman remarked that a reversal of the usual comparison of the DPR to bitewings as the gold standard to the assumption of DPR as the gold standard “might well turn out that the intraoral or bitewing series with its disadvantages of technical clumsiness, time consumption, additional dose, additional cost and infection control problems adds surprisingly little to the [DPR].”²⁸ The last, infection control problems, precisely resonates with the current COVID-19 pandemic. Indeed, DPR is well-suited for patients diagnosed with or suspected to have COVID-19 because, with the exception of the bite block in dentate patients, there is nothing to enter the mouth that would provoke gagging or coughing and thus produce an aerosol. Although a DPR alone may not be adequate for the diagnosis of proximal caries for the entire dentition, it was shown in one investigation to be effective when used in combination with anterior periapical radiographs and bitewings, producing results similar to an FMS.²⁹ This alternative to the FMS avoids the disadvantages indicated above by Farman²⁸ by limiting gagging induced particularly by the maxillary molar area.¹⁷

In addition, DPRs in one study displayed periapical lesions of the second and third maxillary molars better than periapical radiographs.³⁰ DPR has already not only substantially displaced intraoral radiography with regards to the preoperative assessment of third molars; it can produce 3 radiographic signs that indicate a risk of postoperative sensory impairment.³¹ Any

subsequent preoperative CBCT may have little effect on the outcome of surgery.³²

The recommendations for the use of the DPR alone for periodontal bone loss have varied between studies³³ and may reflect the DPR's magnification and slightly rostrally angled central ray.

Extraoral bitewing radiography

Generation of sectional images in DPR has been possible for nearly 3 decades as a component of some panoramic devices. Perhaps the most used and useful of these sectional views is the extraoral bitewing (EBW). EBW radiographs revealed significantly more caries and crestal bone loss in comparison to intraoral bitewings, with high-to-excellent sensitivity in one investigation, but produced more false positives for these lesions, possibly in part because of reduced interproximal overlapping.³⁴ That study did not use Wenzel's gold standard for radiologic diagnosis of caries by histologic confirmation.³⁵ However, earlier studies that employed the gold standard provided conflicting evidence, with one paper reporting high specificity (and therefore few false positives) for EBW,³⁶ and another confirming the increased likelihood of false positives for one of the units tested.³⁷ These findings reemphasize the need for careful clinical examination to confirm radiologic findings.

Cone beam computed tomography

CBCT differs from medical computed tomography in that it produces images with better spatial resolution and lower radiation dose, occupying a smaller footprint in the operatory (similar to that of a DPR) and with fewer installation specifications (no floor strengthening or high-tension electricity supply required).²¹ Nevertheless, the radiation dose is still greater than that of any conventional dental imaging technique and varies between different manufacturers and models.^{38,39} CBCT is broadly divided into den-toalveolar CBCT, namely, focused (small) and medium field-of-view (FOV) CBCT confined to the tooth-bearing jaws, and craniomaxillary CBCT, using FOVs in excess of 8 × 8 cm. Larger FOVs generally impart more radiation to patients than smaller FOVs.³⁹

Focused or small field-of-view cone beam computed tomography

The advantage of the focused FOV is that it can be used with the highest spatial resolution (image detail) for that unit precisely for the area of clinical interest, thereby permitting a reduction in overall radiation dose. Although in pre-COVID-19 times an intraoral radiograph could have sufficed, this now has to be

balanced against the likelihood of inducing gagging or coughing. Nevertheless, a focused FOV CBCT may be indicated, particularly when evaluating a tooth for a periapical lesion, missed root canal, complex anatomy, or vertical root fracture.⁴⁰ Although CBCT was proved to be superior to conventional radiography by changing not only the diagnosis but also the treatment plans of such cases, it also played a role in the assessment of root resorption and calcified root canals.⁴⁰

Although the diagnosis of caries has been mediated by conventional radiography, namely, bitewings and periapicals, the use of CBCT to diagnose caries, particularly primary caries in a minimally restored mouth where image disruption by metal artifacts will be minimal, is an unprecedented concept for most dentists. Nevertheless, in view of the current COVID-19 pandemic and the fact that some high-quality work has already been published, albeit *ex vivo*, it should be considered during the current pandemic when obtaining intraoral radiographs is not a viable task. CBCT not only obviates the aforementioned false-positive problem of bitewings³⁷; it is superior for caries detection, estimation of lesion depth, and detection of cavitation.³⁷ Two of the major downsides of using CBCT for primary caries diagnosis is the higher radiation dose, particularly in children, who are more vulnerable to the effects of radiation, and cost in comparison to conventional radiography. Another problem for children undergoing fixed-appliance orthodontics is the effect of the appliances themselves. An *ex vivo* study reported that these devices prevented diagnosis of non-cavitated caries.⁴¹

Although CBCT has also been used to assist in the diagnosis of secondary (recurrent) caries, its usefulness has been compromised by the artifacts produced by metal restorations. These artifacts are the spray (white lines) and beam-hardening (black bands) artifacts caused by the interaction of x-ray photons and metal restorations. CBCT performed better in the detection of recurrent caries when assessing composite restorations.⁴²

CBCT has already been used widely in the assessment of periodontal disease. An extensive systematic review by Haas et al. on the use of CBCT to assess periodontal bone defects reported that although CBCT could be useful for furcation-involved periodontal cases, it should only be used in cases where the information acquired by clinical and conventional radiographic evaluation is insufficient for treatment planning.⁴³ Although the spatial resolution of CBCT is inferior to that of intraoral radiography, its ease of use and patient-friendly attributes complement its superior volumetric display of the dental apparatus. Contrast resolution is still limited but CBCT "allows the distinction between tissues with minor differences and to

display them with different gray density levels.”⁴⁴ Its early detection of crestal alveolar bone loss and display of the potentially complex patterns of bone loss, such as intrabony and cortical plate defects and molar furcation involvement, enhance the quality of diagnosis.⁴³ A systematic review “showed a high accuracy of CBCT in visualizing periodontal structures and demonstrated the usefulness of CBCT in regenerative periodontal surgery of maxillary molars.”⁴⁵ CBCT appears to be an accurate method to describe vertical periodontal bone loss because it agreed better with the clinical measurements with fewer deviations than periapical radiographs.⁴⁶

Anomalies, such as impacted teeth, that affect the anatomically complex maxillary sinus are optimally investigated by cross-sectional imaging. Furthermore, CBCT is invaluable in the discernment of the more complicated root pattern of maxillary molars not only for endodontic purposes⁴⁰ but also for presurgical planning that contemplates extraction. Observation of severe external root resorption of the maxillary second molar by the impacted third molar often resulted in the removal of the former and retention of the latter.⁴⁷ CBCT of impacted maxillary canines should be evaluated by both multiplanar reconstruction and “curved” reconstructions and not just by one.⁴⁸ CBCT has now been extensively applied to a wide range of lesions arising within or affecting the jaw bones.^{21,49,50}

Large field-of-view cone beam computed tomography

CBCT imparts a larger radiation dose to the patient than conventional radiography, including panoramic radiographs. This larger dose has been displayed for a wide range of manufacturers of CBCT devices. This is of particular importance to the child patient. Horner et al. advised that “CBCT should only be used when adequate conventional radiographic examination has not answered the questions for which imaging was required.”⁵¹

Postimaging room cleaning

The CDC recommends that the “DHCP should ensure that environmental cleaning and disinfection procedures are followed consistently and correctly after each patient (however, it is not necessary that DHCP should attempt to sterilize a dental operatory between patients).”¹ The CDC¹ further recommends that this be done in accordance with the CDC’s 2003 guidelines.²²

- To clean and disinfect the radiology operatory after a patient without suspected or confirmed COVID-19, it is recommended to wait 15 min after completion of clinical care and the exit of each patient to begin cleaning and disinfecting room surfaces to allow for droplets to fall from the air. Therefore, DHCPs should delay entry into the operatory until a sufficient time has elapsed for enough air changes to remove potentially infectious particles.^{13,52}
- Air changes per hour is the ratio of the volume of air flowing through a space in a certain period of time (the airflow rate) to the volume of that space (the room volume). Though ideally this should be 12 air changes per hour, particularly in new construction or recent renovations, a minimum of 6 is acceptable. Patients should be scheduled at intervals 20 to 30 min apart to allow for this and for disinfection of the room.¹⁴
- In addition to ensuring sufficient time for enough air changes to remove potentially infectious particles, DHCPs should clean and disinfect environmental surfaces and equipment before the room is used for another patient.
- DHCPs must perform a standard antiseptic wipe-down of equipment, including lead/lead-equivalent aprons, using quaternary ammonium/alcohol impregnated wipes or other US Environmental Protection Agency (EPA)-approved disinfectants as listed in Table IV.⁵³ Ensure that the lead/lead-equivalent apron and the thyroid collar are stored correctly. The apron should not be folded because this not only

Table IV. Cleansing materials and solutions derived from EPA List N: Disinfectants for use against SARS-CoV-2²⁵

EPA reg. no.	Active ingredient	Product name	Contact time	Formulation type	Surface types
10492-4	Quaternary ammonium; isopropanol (isopropyl alcohol)	Discide Ultra Disinfecting Towelettes	0.5 min	Wipe	Hard nonporous
10492-5	Quaternary ammonium; isopropanol (isopropyl alcohol)	Discide Ultra Disinfecting Spray	0.5 min	Ready-to-use	Hard nonporous
10324-93	Quaternary ammonium	Maquat 64-PD	10 min	Dilutable	Hard nonporous
11346-4	Quaternary ammonium	Clorox QS	2 min	Ready-to-use	Hard nonporous

EPA, Environmental Protection Agency.

cracks the lead/lead-equivalent material, which reduces its radiation protection, but also may crack the surface, which makes it more difficult to disinfect.

Alternative methods of sterilization

- Preventive steps to curtail aerosols, such as the use of specially designed high-efficiency particulate arrester filters equipped with ultraviolet (UV) light, have also been advocated. Although the use of UV-C light to inactivate the original SARS viruses has been reported,⁵⁴ the CDC has remained silent since 2008, when it commented on UV's lack of efficacy and "one epidemic of UV-induced skin erythema and keratoconjunctivitis in hospital patients and visitors."⁵⁵
- The efficacy of alternative disinfection methods, such as ultrasonic waves, high-intensity UV-C radiation, and light-emitting diode (LED) blue light against COVID-19 virus is not known. The EPA currently cannot confirm whether, or under what circumstances, such products might be effective against the spread of COVID-19.⁵² Nevertheless, because of the gravity of the current COVID-19 pandemic, these modalities should be revisited for use in a dental context.

CONCLUSIONS

This article offers a strategy for the practice of oral and maxillofacial radiology during the COVID-19 pandemic. Although some of the evidence has been derived ex vivo rather than clinically, particularly with regards to caries and CBCT use, these serve as pointers to their possible application in the appropriate clinical situation. As the current COVID-19 pandemic continues to unfold, so will the need to develop and reconfigure our current technologies. This could have the effect of, at least, inspiring the manufacturers of devices used in radiology, particularly those of CBCT, to design and develop their products to meet additional needs, particularly by continuing to drive down radiation dose. However, the CDC advises that we "(s)tay informed. Consult regularly with your state or local health department for region-specific information and recommendations. Monitor trends in local case counts and deaths, especially for populations at higher risk for severe illness."⁵⁶

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