An update on radiographic practices: information and recommendations

ADA COUNCIL ON SCIENTIFIC AFFAIRS

This article provides guidelines intended to aid dental professionals in promoting the safety and efficacy of dental diagnostic radiology. Previous ADA guidelines for radiographic practices were published in 1988.[1] The guiding principle for use of diagnostic radiology in dentistry is to enhance the diagnostic benefits of dental radiographs and minimize the associated radiation risks to patients and staff. The overriding principle behind reducing radiation risk is to use exposures that are as low as reasonably achievable—that is, the ALARA principle.[2-4]

The following guidelines address the use of dental radiographs, beam collimation and filtration, beam quality, lead aprons and collars, image receptor positioning devices, operator protection, infection control, film processing, darkroom procedures, quality assurance, image viewing, digital radiography and continuing education. In addition to these guidelines, dentists should be aware of federal and state regulations applicable to radiographic practices.

USE OF DENTAL RADIOGRAPHY

Published in 1989, the guidelines of the U.S. Food and Drug Administration, or FDA,[5] direct dentists to exercise professional judgment when prescribing diagnostic radiographs for dental patients and to determine the type, frequency and extent of each radiographic examination. These guidelines for the prescription of dental radiographs have been demonstrated as effective in maintaining an appropriate risk:benefit ratio.[6-9] However, although the FDA guidelines specify radiographic examination types for children, adolescents and adult patients and for both the initial dental examination and recall visits, they are not meant to be considered as practice standards. For the initial dental examination, the nature of the radiographic examination is tailored to the patient's age, dental status and dental history. The concept of risk of developing caries and periodontal disease is incorporated into the recommended intervals for taking recall radiographs outlined in the FDA guidelines. Dental radiographs for pregnant patients may be prescribed according to usual and customary radiographic selection criteria, as abdominal exposure during dental radiography is negligible.[10,11] This is consistent with the FDA's recommendation for the use of leaded aprons as described below. Furthermore, usual and customary radiographic selection criteria should be applied for patients who have received radiation therapy to the head and neck for medical purposes. Radiation doses in dental radiography are insignificant when compared with those used for therapeutic purposes.[10,12] Patients in this population also are at high risk of developing dental diseases and should receive necessary diagnostic radiographs.

Diagnostic radiography should be used only after clinical examination, consideration of the patient's history and consideration of both the dental and the general health needs of the patient. Routine use of radiography as a part of periodic examinations of all patients is an inappropriate practice. Because each patient is different from the next, radiographic examination should be individualized. The nature and extent of the diagnosis required for patient care constitute the only rational basis for determining the need, type and frequency of radiographic examinations. Administrative radiographs are defined as those taken for reasons other than diagnostic examination of individual patients—for example, those taken to document treatment

performed, to meet insurance requirements or to test students as part of a board examination or for teaching purposes.

Previous radiographic records of a patient should be made available for patients seeking care from a new dentist, as these films are useful in providing information about a patient's dental history and treatment. A facility may maintain radiographic records and also fulfill the transfer of records by means of duplicate radiographs.

SELECTING IMAGE RECEPTORS

The basis for selecting film types, film-intensifying screen combinations and other image receptors is to obtain the maximum sensitivity (speed) consistent with the image quality required for the diagnostic task. For periapical and bitewing radiographs, only films of American National Standard Institute Speed Group "E" or faster are recommended. Since there are minimal diagnostic differences between the various intraoral films available today, the use of faster films (E- or F-speed) is preferred because they reduce the radiation dose by more than 50 percent compared with D-speed film.

For extraoral radiography, use of the fastest film-intensifying rare-earth film/screen system combination that is appropriate for the diagnostic task is indicated. For panoramic radiography, rare-earth screens are the fastest available and are compatible with most modern panoramic radiographic machines. To successfully use these screens, older panoramic equipment can be retrofitted with additional filters, if necessary, to reduce radiation exposure to patients and staff. The use of such high-speed receptors, however, may involve exposure times that are too short for some X-ray equipment, which results in poor image quality.

COLLIMATING THE X-RAY BEAM

The tissue area (and volume) exposed to the primary X-ray beam should not exceed the minimum coverage consistent with meeting diagnostic requirements and clinical feasibility. Proper collimation restricts the amount of primary radiation to the patient. For periapical and bitewing radiography, rectangular collimation should be used whenever possible because a round field beam (as produced by open, round collimators) used with a rectangular image receptor produces segments of the beam circle that are not used in receptor exposure, which causes unnecessary radiation exposure to the patient. Round collimation delivers three to four times the absorbed radiation of rectangular collimation.[10,13] Moreover, the position-indicating device, or PID, should be shielded and open-ended to further approximate beam size to the size of the image receptor and thus limit radiation exposure to patients and staff. Rectangular collimation of the beam can be obtained by replacing the round PID with a rectangular one, attaching a special rectangular collimating plate to the end of the round PID or using a film holder that incorporates a metal shield to block radiation beyond the edges of the film. Individual state regulations stipulate the maximum size of the X-ray beam. Supplemental beam collimation may be used to contain the size of the beam to that of the dental film or digital receptor.

BEAM FILTRATION

Beam filtration should comply with federal and state regulations. The most judicious use of filtration involves selective filtration of excessively high-energy and excessively low-energy radiation. A kilovoltage best suited to the diagnostic purpose should be used. The range of 70 to 100 kilovolt peak, or kVp, is suitable for most purposes. A kVp below 70, however, can deliver unnecessarily high radiation doses. Within this range, lower kilovoltages are associated with higher-contrast images, shorter grayscale, higher entrance skin doses, lower deep-tissue doses and lower levels of scattered radiation. Higher kilovoltages, associated with lower-contrast images but longer grayscale, enable a better separation of objects of different densities. Higher kilovoltages also provide lower entrance skin doses, higher deep-tissue doses and higher levels of scattered radiation.

In the United States, X-ray machine manufacturers are required to install internal aluminum beam filters in all X-ray units. Rare-earth beam filters may be added for supplemental use to further remove higher energy radiation from the beam and reduce patient exposure.

USE OF LEADED APRONS AND COLLARS

Although radiation exposure to the gonads and thyroid glands may be negligible in properly conducted radiographic examinations, radiation dose to the thyroid is considered the largest component of the effective dose in dental radiography. As such, leaded collars

should be used whenever practical to minimize any unnecessary radiation exposure. Leaded thyroid collars are strongly recommended for use with pediatric patients, because children's thyroid tissue is highly susceptible to X rays. However, these collars should not be used with panoramic radiography because they interfere with the primary beam. The beam in panoramic radiography is projected at a minus angle; therefore, a thyroid collar could prevent the imaging of mandibular teeth.

Although scatter radiation to the patient's abdomen is extremely low, leaded aprons should be used to minimize patient's exposure to radiation.

RECEPTOR HOLDERS

Receptor/film holders that position the receptor to coincide with the collimated X-ray beam should be used. A number of specialized holders are designed for periapical and bitewing radiography. Some holders also block the primary beam beyond the plane of the receptor, a feature that reduces radiation exposure even further. To prevent irradiation of the fingers and bending of the film, which can result in inaccurate image geometry, radiographic film should not be held in the oral cavity by the patient or the dental professional.[14]

OPERATOR PROTECTION

Unless protective shielding is provided for the operator, the installation should be arranged so that the operator can stand at least six feet from the patient and in a location that is not in the path of the X-ray beam during exposure. Workloads of more than 1,800 milliampere seconds per week may require use of an additional barrier. Barriers should contain a leaded glass window to enable staff to view the patient during exposure. Information on shielding design, including determination of barrier requirements, can be obtained from the National Council on Radiation Protection and Measurements.[14] Practitioners should consult state government regulations regarding the protection of staff members subject to occupational exposures; they also should consult state radiologic health personnel or other qualified experts regarding the proper design of radiographic facilities. Monitoring the radiation exposure of dental personnel, particularly women of childbearing age, is desirable and, in fact, mandatory in many states. Dosimetry badges are available from several commercial sources for this purpose.

EXPOSURE AND FILM PROCESSING

Exposure settings should be established for optimal image quality. Practitioners should be aware of the appropriate exposure ranges for the techniques being used. Overexposure accompanied by underprocessing is not recommended, as this practice exposes the patient and office personnel to unnecessary radiation and may result in loss of image quality and important diagnostic information. As many states maintain exposure guidelines (milliamperage and time settings) for intraoral radiography, it is prudent to contact the state radiation protection agency for this information.

Film processing should be performed under the manufacturer-recommended conditions with proper processing equipment and a darkroom with safelights. Alternatively, an automatic processor with an appropriate safelit hood may be used. The length of time that film can be exposed under particular conditions of safelighting should be established by a safelight test.[15] All exterior light should be excluded from a darkroom to prevent fogging of films, and it should be noted that faster, more sensitive films are more vulnerable to darkroom light leaks than slower-speed films. Darkrooms should be checked routinely for light leaks.

DARKROOM PRACTICES

Proper radiologic darkroom practices should be followed.[15] These include (among others) maintaining a darkroom with adequate ventilation, avoiding repeated skin contact with processing chemicals and avoiding microbial contamination in handling film packets.

INFECTION CONTROL

To minimize the potential for cross-contamination, the general principles of asepsis should be applied consistent with the infection guidelines for dental radiography from the American Academy of Oral and Maxillofacial Radiology.[16] The guidelines include the following:

- Apply universal precautions, treating each patient as potentially infectious and taking appropriate measures to protect patient and provider.
- Wear gloves during all radio-

graphic procedures and when handling contaminated packets, supplies and instruments.

- Heat-sterilize nondisposable instruments (such as intraoral film holders, beam-aligning devices and bite blocks) between patient uses. Alternatively, use new disposable devices for each patient, discarding contaminated items after patient use.
- Disinfect or barrier-protect ear rods, chin rests, head positioners and digital radiography sensors between patients.
- Disinfect or cover work surfaces and other contact areas (such as the hand-operated exposure switch and cone) between patients. During radiographic procedures and subsequent film processing, minimize contact between contaminated gloves and environmental surfaces; for example, perform chair adjustments in advance, use a single standard head position for maxillary and mandibular periapical radiographs, and obtain all necessary supplies before seating the patient. Disinfect between patient visits any environmental surfaces that become contaminated.
- Use barrier-protected film when possible to greatly minimize infection-control procedures. After exposure, the protective surface coverings are removed from the film packet, and the uncontaminated film can be managed without gloves or other precautions.
- If barrier-protected film is not used, use a disposable container (such as a paper cup) to transport contaminated film packets to the darkroom. With gloved hands, open film packets and allow the film to drop onto a clean, covered surface. This allows the film to be processed with ungloved hands. Likewise, do not wear gloves when receiving and mounting radiographs.
- When using a daylight loader, contamination is difficult to avoid. If barrier packets are not used to protect film from contamination or are not removed before using the daylight loader, remove gloves and wash hands before using the loader. Lift the cover of the daylight loader and place clean gloves and the contaminated film packets inside. Close the lid, then slide hands through the loader's sleeves and into the unit. Don the gloves before handling the film packets; remove gloves before hands are withdrawn from the loader.

QUALITY ASSURANCE

A quality assurance program should be established to ensure high-quality radiographic images. This includes routine monitoring of X-ray generators, processing equipment and processing conditions.[13,17] Maintenance should be performed at regular intervals. For more information on specific areas of quality assurance, contact the FDA Center for Devices and Radiological Health, 5600 Fishers Lane, Rockville, Md. 20857.

IMAGE VIEWING

Radiographic images should be viewed under proper conditions with an illuminated viewer to obtain maximum available information. A variable-intensity viewer is desirable, as high-density areas of an image require more light intensity than low-density areas for optimal viewing. The region around the film being viewed should be masked to prevent glare; minimal extraneous room light is recommended to avoid excessive reflections. In some cases, magnification may be helpful in viewing radiographic images.

DIGITAL RADIOGRAPHY

The objective of maxillofacial radiography is to achieve images of high diagnostic quality in a short time with a minimal dose of radiation to the patient. Digital radiography, a relatively new technology, offers a means to these ends. The concept has been applied to two types of systems: those using imaging sensors based on charged-coupled devices, or CCD, and those using photostimulable storage phosphor, or PSP, sensors. Because image acquisition is more rapid with CCD systems than with PSP systems, the former may be more useful when instant radiographs are desirable (for example, oral surgery, endodontics or implant placement). However, PSP systems—because of the added time and steps they require for image acquisition—may be more appropriate in general radiographic practices, where the need for instant images may not be as essential.

A CCD imaging system, which has an intraoral sensor the size of intraoral films, connects to a computer with a wire. A reusable sensor is placed at the desired position in the oral cavity and exposed to the X-rays. A radiographic image appears on the computer screen almost instantaneously. With digital imaging, the amount of radiation needed to create an image is reduced by 50 to 90 percent, depending on the system.

PSP systems use a filmlike sensor plate with a storage phosphor on one of its surfaces. Once exposed, the sensor is placed in a scanning device, and the image appears on the computer screen in approximately one or two minutes. Exposing the plates to strong light (for example, placing them on a view-box) for approximately one minute eliminates the original image, allowing the plate to be reused repeatedly. Storage phosphor systems use an amount of radiation comparable to that used in CCD-based systems.

CCD and PSP systems produce images of similar quality, and an array of computer-assisted modifications are available for both to allow image rotation, inversion, colorization, measurement and contrast changes, as well as an array of other modifications. These images also can be printed on photo-quality paper or on transparent sheets using any number of standard printers.

Advantages of digital radiography include rapid image delivery, the ability to electronically transmit information to a consulting peer, and expeditious enlargement or other modification of radiographic images for enhanced diagnostic capabilities and patient education. In addition, digital radiography eliminates the need for a darkroom as well as the cost and stocking of film and processing chemicals.

While digital imaging systems provide high-quality images, they may not provide the same level of exchange capabilities. Proprietary formats may limit the opportunities for sharing digital images, unless a common format is used. The Digital Imaging and Communications in Medicine, or DICOM, standard is the result of efforts by medical and dental professionals to develop a common format for exchanging images and information. With the ultimate goal of total interconnectivity among medical and dental imaging devices, the DICOM standard is becoming widely accepted throughout the health care industry.

CONTINUING EDUCATION

Practitioners should stay informed of new information on radiation safety issues, as well as developments in equipment, materials and techniques, and adopt appropriate items to improve radiographic practices.[5,12-15] Dentists and dental auxiliaries should participate in continuing education in the many aspects of diagnostic radiology and technology. ADA.org provides access to a continuing education course listing (compiled twice a year) to assist dental professionals seeking information on continuing education programs. ■

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