

# Radiation safety in dental radiography



Dental Radiography Series

The goal of dental radiography is to obtain diagnostic information while keeping the exposure to the patient and dental staff at minimum levels.

While some exposure to radiation is acceptable in medical practice, it should be understood that levels of radiation exposure to patients, dental staff, and other nearby occupants should be kept to **As Low As Reasonably Achievable (ALARA)** to reduce health risks from ionizing radiation.

Any methods that can reduce patient and area radiation exposures without major difficulty, great expense or inconvenience, should be practiced. Practitioners must always consider the risk of patient exposure with the benefit of diagnosis.

# Radiograph guidelines

One way to do this is with the use of radiographic patient selection criteria.

Guidelines for the prescription of dental radiographs have been developed by an expert panel of dentists sponsored by the public health service.

A free brochure is available from Carestream Health, Inc. (see last page for ordering information)

publication N-80A "Guidelines for prescribing dental radiographs." The guidelines are voluntary and are intended only as a decision-making aid for the dental practitioner. They are used only in conjunction with a carefully taken medical and dental history and a clinical examination.

Patient Category	Child	Adolescent	Adult
	Essential for diagnosis of dental caries and pulpitis	Essential for diagnosis of dental caries and pulpitis	Essential for diagnosis of dental caries and pulpitis
New Patient*	Essential for diagnosis of dental caries and pulpitis	Essential for diagnosis of dental caries and pulpitis	Essential for diagnosis of dental caries and pulpitis
Recall Patient*	Essential for diagnosis of dental caries and pulpitis	Essential for diagnosis of dental caries and pulpitis	Essential for diagnosis of dental caries and pulpitis

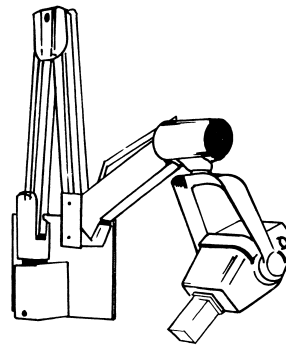
# Radiation safety considerations

In any case, once the decision has been made to prescribe x-rays, every reasonable effort must be made to minimize exposure to the patient and dental office personnel.

Interestingly, the same safety procedures that minimize exposure for both patient and operator can also increase the quality of the radiographic images.

There are many factors that determine the level of radiation received by the patient during a radiographic examination. These include:

- The selection of the x-ray machine
- The use of technique factors that result in low patient exposure
- The use of fast films and screen/film combinations
- Adherence to correct film processing methods
- The use of digital sensors
- The use of collimators and filtration
- The use of lead aprons and thyroid collars to protect the patient from unnecessary radiation exposure



All x-ray equipment, regardless of date of manufacture, is subject to state and federal x-ray equipment regulations.

Although proper filtration is not usually a problem with modern equipment, older x-ray machines should be tested by a radiation physicist or qualified technician to verify the presence of the correct amount of filtration.

The kilovoltage or kVp setting is one of the most important factors that determines the image contrast, as well as dosage to the patient. In the 60-80 kVp range, biological risk estimates from dental radiology are essentially the same and, therefore, the diagnostic need should be the determining factor for which kVp setting to use. Settings below 60 kVp are not recommended for routine dental radiography because of higher patient exposures.

## Exposure

Typical Radiation skin entry exposures and effective dose equivalents are outlined in the table below:

Typical patient doses from dental x-ray exams

Exam	Skin Dose (mR)	Effective Dose (mrem)
Full mouth (18 exposures)	2,300-3,100	1.5
Bite-wing	200	0.4
Panoramic	700-950	1.1

To keep the effective dose equivalent in perspective; in 1991, a research team at the Academic Center for Dentistry in Amsterdam made an elaborate series of measurements of dose to all areas of the head and neck during bite-wing radiography using a plastic "head phantom." They found an effective dose for the bite-wing of 0.4 mrem. To put this in perspective, background radiation from naturally occurring radionuclides in our environment and from cosmic rays delivers almost a thousand times as much radiation every year (approximately 300 mrem).

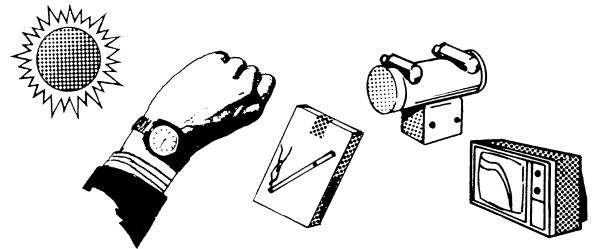
The benefits of the use of x-rays in dentistry outweigh the risks when proper safety procedures and considerations are followed.

The dentist or registrant of the x-ray producing equipment is responsible for all aspects of radiation safety in the dental office.

## Consideration

The dentist selects the patient who needs radiographs, determines which radiographs are needed, takes or supervises the exposure of the films and interprets the images.

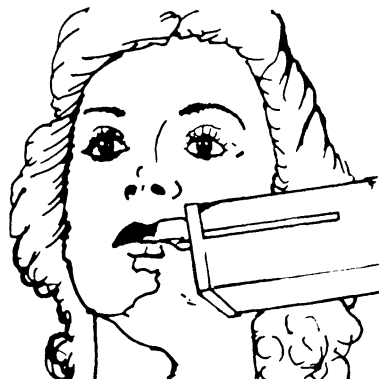
An important method for keeping patient exposure as low as reasonably achievable is the appropriate prescription of radiographs.



## Rectangular collimation

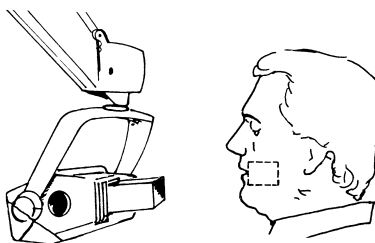
Collimators, when installed properly, serve to limit the size and shape of the useful x-ray beam reaching the patient. This will not only reduce dose, but may also improve image quality.

The American Dental Association (A.D.A.) and the American Academy of Oral and Maxillofacial Radiology recommend the use of a shielded, open-ended, position-indicating device, or PID, preferably with rectangular collimation.



This is an example of a rectangular collimator that restricts the beam to the size and shape of the dental film. Round collimators can be converted to a rectangular shaped opening by using an insert available through a manufacturer of dental radiographic products (see last page for suggested resource). This technique significantly reduces the volume of tissue exposed during intraoral radiography.

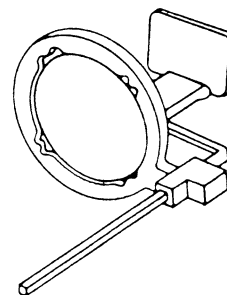
Rectangular collimators reduce patient exposure by restricting the beam size to that of the film used. These devices will increase subject contrast by reducing excessive scatter radiation.



The area and volume of tissue exposed to the primary x-ray beam should not exceed the minimum coverage required to image the anatomical area in question. Periapical radiographs should, in general, demonstrate 1/4-in of alveolar bone beyond the apex of each tooth, 1/8- to 1/4-in margin between the crowns of the teeth and the edge of the film; the occlusal plane should be straight or slightly curved upward toward the distal.

In bite-wing views, the occlusal plane should be straight or slightly curved upward toward the distal. There should be equal distribution of maxillary and mandibular crowns and maxillary and mandibular alveolus, and the interproximal spaces should be open. These criteria can be met successfully by careful execution of correct periapical and bite-wing techniques.

Film holding devices are recommended for intraoral radiography to eliminate the need for the film to be held in place by the patient's finger. These film holding devices also provide for the film to be placed parallel to the teeth, resulting in a less distorted image. The holders recommended today incorporate beam guiding devices which make PID alignment a simpler task.



The A.D.A. and the Academy discourage the use of short, closed, pointed plastic cones because of the increased scatter radiation and unnecessary radiation close to the face and surrounding areas of the patient. As shown in the drawing, the rectangular collimator restricts the x-ray beam to an area just slightly larger than the intraoral film itself.

It is estimated that the radiation dosage from use of both F-speed film and rectangular collimation is minimal, less than one-fifth that from D-speed film and round beams. On the other hand, beam energy ranging from 60 to 80 kVp, and short cone (20cm or 8 inches) versus long cone (40cm or 16 inches) make little difference in patient exposure.

## Image density

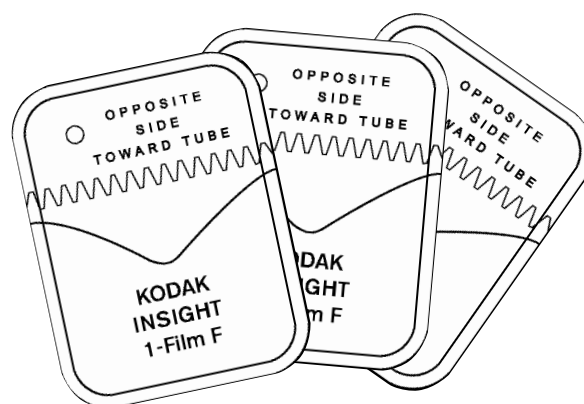
A significant factor contributing to image density is the quantity of x-rays reaching the film. This is controlled by combining milliamperage and exposure time as milliamperere-seconds or mAs. Correct mA and timer settings are established using a technique chart such as the exposure guidelines for Kodak intraoral dental films (publication N-412).

Unnecessary radiation exposure to patients results when films need to be retaken due to faulty radiographic or processing techniques.

The speed, or sensitivity, of dental x-ray film is another important factor responsible for controlling patient exposure.

The two speeds used for intraoral radiography are group D and group F.

Kodak InSight dental film, an F-speed film is up to 60% faster than Kodak Ultra-speed dental film. Its increased speed makes it ideal for long cone paralleling techniques and for use with x-ray equipment designed for short exposures.



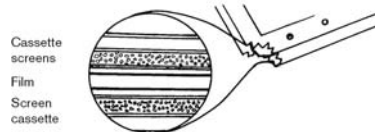
## Film cassettes

Film cassettes are used for extraoral techniques such as panoramic and cephalometric radiography.

Cassettes serve as lighttight film holders and are equipped with two intensifying screens that convert x-ray energy to light energy. This feature enables image formation to occur with less exposure than is possible with direct x-rays alone. Patient exposure can be reduced by up to 100 times when compared to direct exposure film techniques.



To minimize the needs for retakes, it is important to utilize the proper film/screen combination with a cassette that provides pressure uniformity and lighttight integrity.



Film/screen combinations are used to image the mandible, the maxilla, the temporomandibular joint and the orofacial complex.

Since different film/screen combinations result in various speed systems, the practitioner can choose the speed system that will allow the patient to be exposed to the least amount of radiation while still providing the diagnostic information required.

## Minimal exposure

Kodak Lanex regular front screens are used with a green sensitive film, such as Kodak T-Mat G/RA dental film. Exposures are usually one quarter to one half those needed with the earlier generation blue-light emitting phosphors. Beside dose reduction, the newer phosphors maintain excellent image detail, help eliminate motion blur by the use of shorter exposure times, and produce less wear on the x-ray tube.

Kodak Ektavision extraoral imaging system also provides a similar exposure reduction, while providing a further increase in sharpness resulting from new film and screen technology.

Proper exposure and processing of film is another factor in keeping exposure as low as reasonably achievable. Errors can result in the need for additional radiographs and increased exposure.

Quality assurance is any systematic action to ensure that a dental office will produce consistently high-quality images with minimal exposure to patients and personnel. When operators are presented with clear guidelines for quality assurance, patient exposure is dramatically reduced.

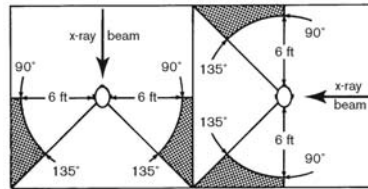
Besides diagnosis, films are used for insurance claims, teaching, patient referrals and legal purposes. The use of duplicate radiographs reduces patient x-ray exposure because the need to re-expose patients is eliminated. When duplicate radiographs are needed, there are several methods available to produce them. We also offer duplicating film in a variety of film sizes that range from size 2 to an 8 x 10-in size.

We also offer two-film dental packets that contain two separate intraoral dental films together for producing two identical radiographs with one exposure. The two-film packet requires no adjusting or resetting of equipment or additional exposure to the patient. The same double loading technique can be done with extraoral film by using a combination of Kodak T-Mat H/RA dental film and Lanex regular screens.



## Exposure protection

Even though the thyroid gland may be out of the primary beam path when rectangular collimation is used, exposure of that gland may be significant when the round positioning device is used. Lap aprons are available with thyroid collars attached. Separate thyroid collars are also available.

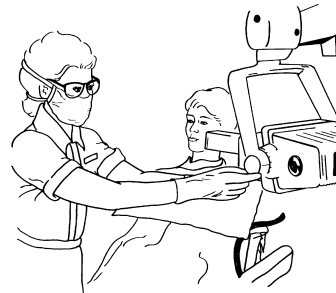


The most commonly used leaded aprons cover the entire chest and lap, effectively reducing scatter radiation reaching underlying tissues. Lap aprons and thyroid collars should be used for all dental radiographic procedures.

The best way of limiting the possibility of occupational exposure is the establishment of radiation safety procedures that apply the basic principles of radiation safety.

## Basic principals of radiation safety

The goal of radiation safety is to keep all radiation exposures **As Low As Reasonably Achievable (ALARA)**. This means that even if exposures are acceptable, if there is a reasonable way to reduce the exposure even further, those controls should be utilized. While there are many components to an effective radiation safety program, there are consistently three basic principals to minimize radiation exposure:



- **Time** – minimize time duration working with x-ray sources
- **Distance** – increase distance between the source of radiation and yourself
- **Shielding** – Shielding of a suitable density to attenuate x-ray

## Additional radiation safety controls commonly utilized for dental facilities

### Administrative controls

- Warning signs and postings
- Safety procedures
- Radiation film badge dosimeters

### Engineering controls

- Shielding (lead, thick drywall, concrete, barriers, etc.)
- Operating controls placed outside of or at an increased distance from patient area

Perhaps the most important factor in reducing personnel exposure to radiation is for the operator to stand behind a radiation barrier during the exposure. This is usually accomplished by installing the exposure button in a location outside the dental operator.

If a protective barrier is not available, the operator should be positioned at least six feet from the x-ray tube head at an angle from 90 degrees to 135 degrees to the central ray of the x-ray beam. Six feet (2 m) is considered safe as long as the operator is not positioned in the path of the primary x-ray beam.

The proper installation of x-ray equipment and safety of operational procedures can be certified by a radiation physicist. Some states require a plan for review of an office before the installation of any x-ray equipment. This plan would include the location of x-ray equipment, the exposure button and composition of wall materials for radiation barriers.

The operator or patient should never hold films in the mouth during radiographic procedures. Unnecessary health risk and injuries may occur. Film holders used in modern dental radiography preclude the need for dental personnel or patients to hold films with their fingers.

Depending on the radiation levels of the clinical setting, practitioners may elect to use radiation dosimeters (film badges) to monitor long-term radiation doses to employees working with x-ray units. The use of the film badge may also be required by local regulations. **Even when not required by regulation, occupational dose monitoring with film badges may be beneficial to the clinic to ensure safe practices and proper risk management.**

Radiation dosimeters should be used properly in accordance with the dosimetry providers and all regulatory requirements. Use only dosimeters accredited by the **National Voluntary Laboratory Accreditation Program (NVLAP)**.

Neither the operator nor the patient should stabilize the x-ray tube head during the procedure; rather the operator should make any adjustments prior to making exposures. Additional exposure may occur while attempting to stabilize the tube head during exposure. Slight amounts of radiation leakage occur through all x-ray tube heads and, therefore, contact with the tube housing during exposures must be avoided. Any instability of the tube head should be corrected by proper adjustment of the suspension arm.

## Summary

With proper use of modern film and equipment, required diagnostic information from dental x-rays can be obtained while minimizing patient exposure. Conversion from D-speed to F-speed film alone, with no other changes, reduces exposure by 60%. When F-speed film is combined with the use of rectangular collimation, dosage is less than one-fifth that from D-speed film and round collimators. Other practices, such as the use of open-ended parallel projection collimation, maintaining source-to-skin distances of at least 20 cm (and preferably 40 cm), and using 60-80 kVp tube voltage settings, also minimize the level of patient dose.

Radiation doses to the patient from dental radiography, assuming optimum technique and state-of-the-art technology, are relatively small when compared to doses from other medical procedures and environmental sources. Thus, clinical need rather than patient dose should determine which radiographic examination, if any, is to be prescribed for a patient.

From the selection of patients for radiographic examination, through the exam itself, to the interpretation of the results, the dentist has a professional obligation to control radiation exposure in the dental office. The dentist must eliminate any unnecessary exposure and keep all necessary exposure **As Low As Reasonably Achievable**.

## References

Technical Report of the Commission on Dental Products: Recommendations for radiographic procedures. International Dental Journal, June 1989.

White, S.C. 1992 Assessment of radiation risk from dental radiography. Dentomaxillofacial Radiology, 1992, V.21, Aug. 118-26.

The Benefits of Dental X-Ray Examinations, American Dental Association W138, 2000.

To obtain a free copy of any of the publications referred to in this pamphlet, please visit [www.kodakdental.com](http://www.kodakdental.com)

To obtain assistance in converting to the F-speed films mentioned in this pamphlet, or to obtain further information on other Kodak dental film products or recommendations:

- In the U.S. or Canada, please call 1-800-933-8031

## Other Publications in the Dental Radiography Series:

Exposure and Processing for Dental Film Radiography  
N-413 CAT No. 832 8788

Quality Assurance in Dental Film Radiography  
N-416 CAT No. 141 3772

Guidelines for Prescribing Dental Radiographs  
N-80A CAT No. 809 9392

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