Feb. 2008

The Dental Learning Network

Radiographic Technique Review

4 Homestudy Credit Hours

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Radiographic Technique Review

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Objectives

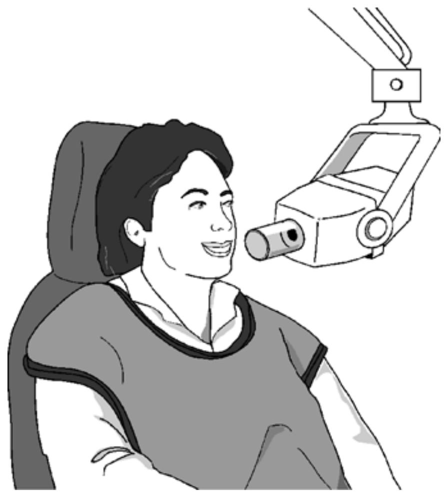
At the completion of this course, the student will be able to:

- Describe the properties and characteristics of x rays.
- List proper infection control protocol for the treatment room and the darkroom.
- Describe proper placement for each film in a Full Mouth X-ray Survey using the paralleling technique.
- Describe the proper processing techniques for exposed film.
- List all the qualities of an "excellent" x-ray.
- List the common errors in x-ray technique and ways to avoid them.

Introduction

Good x-ray technique leads to excellent and diagnostic x-rays, less retakes, a happier patient and employer, and a smoother day at the office.

The goal of this course is to refresh your memory of the x-ray techniques you learned in school. Depending on when you graduated, it may be entirely new material or simply a review. Now that you have had clinical experience, it may surprise you how much more practical those formerly foreign looking diagrams have become. We also hope to answer some of the difficulties encountered in "the real world" that may not have been addressed in school, and offer some practical suggestions for organizing the x-ray procedure to give you control over this area of your practice.



The History of X-rays

A Bavarian physicist named Wilhelm Conrad Roentgen discovered x rays. He was working with some sealed glass vacuum tubes that contained a cathode and an anode. During his experiments, he applied voltage to these tubes and noticed that a screen near the tubes was glowing. He blocked the path of these newfound rays to see what would prevent the screen from glowing. When he placed his own hand there, he could see the outline of his bones on the screen. This historic discovery on November 8, 1895 dramatically changed diagnostic procedures for both medicine and dentistry.

X-ray Characteristics

Bremsstrahlung Radiation

X rays are part of the electromagnetic spectrum that includes sound and light. They can penetrate matter, produce a latent image, make some materials fluorescent, and produce ionization of some materials. X-ray photons travel at the speed of light and interact with all the matter they contact. Bremsstrahlung radiation results when an electron passes near the nucleus of an atom and the positive charge emitting from the nucleus changes its course. The result is a photon of radiation. The x-ray tube head produces this kind of radiation.

Kilovoltage and Milliamperage

The x-ray machine takes energy from an electrical source (usually a 220V outlet) and converts it to a powerful enough electrical impulse to create the x rays (measured in kilovolts or kV). The most common settings for dental x-ray units are 70 kVp (kilovoltage peak) or 90 kVp. The adjustable settings depend on the density of the area being x-rayed. A 15% increase in kilovoltage will double the density on the radiograph. Cut the exposure time in half to keep the same density on the film. The kilovoltage is responsible for the quality of the x ray beam. Milliamperage (mA) is responsible for the quantity or number of rays produced. For dental use, the normal range for milliamperage is between 7 and 15 mA.

The X-ray Tube

The dental x-ray tube contains a cathode made up of a tungsten filament and a focusing cup. Across from the cathode is an anode. The focusing cup focuses the negatively charged electrons generated by the cathode and directs them to the positively charged anode. The generated x rays escape the housing through an aluminum filter at the opening of the tube head. A vacuum-sealed glass enclosure houses all these components. A casing of lead or some other metal and a layer of oil dissipates the heat generated by the x rays. There is a collimator at the opening to restrict the x-ray beam to less than 2 1/4 inches at the patient's skin surface. A lead-lined cone collimates the beam further.

According to federal guidelines, a chart with the settings for time (seconds or impulses), kVp, and mA for the techniques most commonly used must be posted near the control panel of each x-ray unit in the office.

Effects of Radiation

It is very important that you understand how x rays and the radiation produced by them effect living organisms, especially you and your patient. There are three ways x-rays interact with organic matter: Classical Scattering, the Compton Effect, and the Photoelectric Effect.

A photon may come into contact with an atom and interact with an electron. If the photon does not have enough energy to actually displace the electron from the atom it gives its energy to the electron. The electron then produces another photon with the same energy as the other and sends it off in a different direction. This is called *Classical Scattering*.

If the photon has enough energy it will displace the electron from its orbit around the atom. The electron, called a recoil electron, is lost from the atom. The atom absorbs the energy from the photon, but is now missing one electron. This atom will now have a net positive charge and is called an ion. This is called the *Photoelectric Effect*.

If the photon collides with an atom and has enough energy to displace it, but does not transfer all of its own energy to the atom or the electron, it will continue on weaker as scattered radiation. This is called the *Compton Effect*.

These three reactions in themselves are not life threatening. The molecular interactions of these altered atoms can result in breaking molecules into smaller pieces, disrupting molecular bonds, and forming new bonds within or between molecules. Radiation can also interact with the water or oxygen in cells to disturb their delicate balance and damage DNA molecules.

High doses of radiation to the entire body can cause acute effects. Long term or chronic effects come from repeated exposure to radiation. The body attempts to repair the damage but cannot keep up if the exposures are regular enough or strong enough.

Operators of x-ray devices should monitor the amount or radiation they are exposed to by using a film badge. These badges are worn while at work and then sent in to a company at regular times to be evaluated for radiation exposure. Operators should step behind a lead barrier when exposing films. If no barrier is available, stand at least 6 feet away and between 90 and 135 degrees to the primary beam. Operators should never hold the film for a patient during exposure.

Radiographs should not be taken unless the benefit for the patient outweighs the risk of the radiation exposure. This is the main reason for using an excellent technique in radiology: less retakes means less exposure. Lead aprons must be used on all patients, and a thyroid collar during intraoral films.

Radiation exposure varies according to the film speed, the technique used, the kilovoltage used, and the amount of collimation used. The paralleling technique using a "long cone" provides the least amount of radiation and the best quality radiograph. Rectangular collimation reduces the area of tissue exposed to the x-ray beam by 60 to 70%.

The fastest film, at least speed "D" film, should be used for bitewings and periapicals. The clinician should also use the least number of films possible that will accurately represent the area in question.

An x-ray beam with the lowest possible kilovoltage should be used, at least 60 kVp. Filtration equivalent to 2.5 mm of aluminum should be used for 70 kVp or more. Those units operating below 70 kVp should have the equivalent of 1.5 mm of aluminum.

A patient would have to have 25 complete mouth series in a short time to significantly increase his or her risk of skin cancer. The benefit of detecting disease that may not be otherwise detected far outweighs the risk of radiation in the small doses used for dental radiography.

Infection Control

Review the patient's medical history before starting to take x-rays. Wear a clean pair of gloves and a mask for each patient. Disinfect the exposure button and tube head or cover with a fresh protective barrier for each patient. Anything touched during the procedure should be disinfected. The instruments must be sterile and stored in a closed container. As soon as the film is placed in the patient's mouth, it is contaminated. If the film is touched with contaminated gloves or instruments, it is contaminated. Contaminated films should be placed in a cup behind the barrier. When the series is complete, assemble all contaminated instruments in the sink then transport them to the sterilization area. Remove the gloves and wash your hands. Transport the film to the darkroom. Use a clean pair of disposable gloves in the darkroom to open the packets. Remove the film from the packets without touching them (the powder from the gloves will leave an imprint on the final film). Collect contaminated packets on a disposable paper towel. When all films are out of the packets, discard the towel and the packets and remove the gloves. After washing hands, process the films as usual, and the darkroom equipment will not be contaminated. The film packets could also be decontaminated by wiping them with bleach before taking them into the darkroom.

Intraoral Film Placement Technique

Intraoral films are those taken with the film inside the mouth. They include periapical films, bitewing films, and occlusal films. Periapical radiographs are for diagnosis of the teeth, bone, lamina dura, and periodontal ligament. The film must include at least 3 to 4 millimeters beyond the apex of the tooth being x-rayed. Bitewing x-rays are used to diagnose problems of the crowns and interproximal areas. Decay, calculus, overhanging margins, and interproximal bone loss are best detected in bitewing x-rays because the teeth are not overlapped as in some periapical images. Occlusal films are used to diagnose disorders of the jaw or palate.

Radiographic Surveys

The two most common series of x-rays taken in the dental office are Bitewing Surveys and Full Mouth Surveys. The bitewings consist of a premolar view and a molar view for each Side of the mouth taken in occlusion (4 films). The Full Mouth Survey consists of a series of x-rays that properly represent every tooth in the patient's mouth (with 3 to 4 millimeters of surrounding bone) and all other tooth bearing areas of the mouth even if edentulous (no teeth are present). Usually, bitewing x-rays are taken to examine the contact areas of the premolar and molar regions, and periapicals for the other teeth and edentulous areas.

Paralleling Technique for Periapical X-rays

The paralleling technique results in good quality x-rays with a minimum of distortion and is the most reliable technique for taking periapical x-rays. The film is placed parallel to the long axis of the tooth in question and the central x-ray beam should be directed perpendicular to the long axis of the tooth. It is critical to remember to take the root anatomy into consideration when planning an x-ray. Also the patient's maxillary occlusal plane should be parallel to the floor. The chair should be positioned high enough so that you can easily see the occlusal surfaces of the maxillary teeth first. When you are finished with the maxillary films, lower the chair for the mandibular views. Look at every patient's mouth before inserting the film. Observe the contact areas. Check for any sores that might be exacerbated by the films. If there are large apthous ulcers, consider altering the technique to avoid touching them. Look for partials and dentures.

Film holding devices (like the RINN holder) are used in the paralleling technique. They provide a superior reference for aiming the x-ray beam and correct film placement so that the tube head is perpendicular to the film.

For maxillary periapicals, the film should be placed near the midline of the palate, not placed against the palatal aspect of the teeth. Improper film placement will result in foreshortening, bent film, or an excellent view of the crowns of the teeth but not the apices. Mandibular periapicals are often challenging because of the tongue and floor of the mouth. Mandibular films must be placed between the tongue and the mylohyoid ridge. Instruct the patient to relax the floor of his or her mouth and tongue. Guide the film to displace the tongue and slide it in to place, using your index finger as a "bumper" so the film doesn't scrape the mylohyoid ridge. Then (after removing your finger) tell the patient to slowly close. This is usually the least comfortable x-ray, but if the patient's musculature remains relaxed it is easier. The horizontal placement of the film is very important in either arch. The film must be placed so the x-ray beam is directed between the contacts of the teeth in question so there is no overlapping.

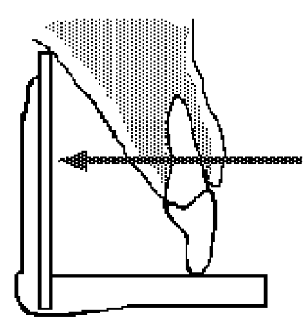
Start the Full Mouth Series with anterior views because beginning with easy placement will help establish your credibility with the patient. Then he or she is more relaxed as the molar films are placed. The recommended order for taking a Full Mouth Series is:

	MAXILLARY ARCH		MANDIBULAR ARCH
1	Central Incisors	10	Central Incisors and Lateral Incisors in same film
2	Right Lateral Incisors	11	Right Cuspid
3	Right Cuspid	12	Right Bicuspid
4	Right Bicuspid	13	Right Molars
5	Right Molars	14	Left Cuspid
6	Left Lateral Incisors	15	Left Bicuspid
7	Left Cuspid	16	Left Molars
8	Left Bicuspid	17	Bitewings
9	Left Molars		

Remember to place the film gently but confidently. As soon as it is correctly positioned, tell the patient to hold still while you move behind the protective barrier and expose the film.

Maxillary Central Incisors

Begin the full mouth series with the maxillary central incisor region. Patients usually tolerate this film easily. The film is inserted into the holder in a vertical orientation. The beam should pass perpendicular to the film plane and the film should be at a 90º angle to the interproximal area of the maxillary central incisors. The film is placed well into the palatal region, in the area of the second bicuspid. If it is too close to the teeth, the image will be distorted.



Maxillary Lateral Incisors

For the maxillary laterals, the film is placed in the holder in a vertical orientation. The same beam angle as the maxillary incisor area is used (refer to the diagram for Maxillary Incisor), but the film is centered behind the lateral incisor, perpendicular to the long axis of the lateral incisor and near the center of the palate. This view will also contain the central incisor and the cuspid.

Maxillary Cuspid

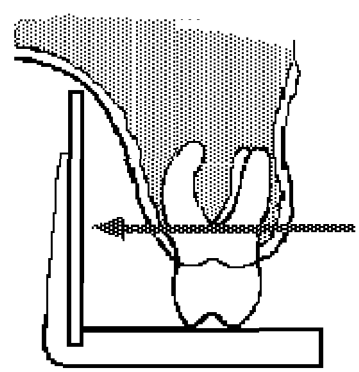
For the maxillary cuspids, the film is placed into the holder in a vertical orientation. The cuspid is centered on the film and it is placed well into the palate. The central x-ray beam is perpendicular to the film and at a right angle to the long axis of the tooth. The mesial contact should be open, but often the distal contact is unavoidably overlapped. The next film will display the distal contact area.

Maxillary Bicuspid

For the maxillary bicuspids, the film is placed in the holder in a horizontal orientation. The contact between the first and second premolar is centered on the film with the central x-ray beam perpendicular to the film. The contacts for the distal of the canine through the distal of the second premolar should be open. Sometimes, a cotton roll will need to be placed between the bite block and the mandibular teeth opposing in occlusion. This will stabilize the bite and keep the block from rotating because of the occlusion of the canine.

Maxillary Molars

For the maxillary molars, the film is placed in the holder in a horizontal orientation. The second molar is centered on the film with the central x-ray beam perpendicular to the film. The contacts of the first, second, and third molars should be open. The third molar region should be included in this film even if the tooth is not present.

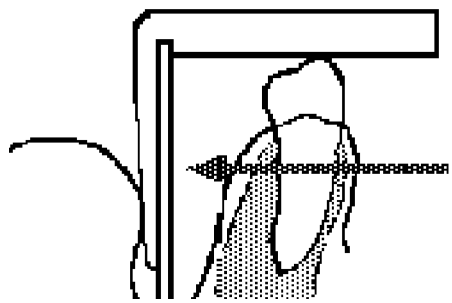


Mandibular Anteriors

For the mandibular anteriors, the film is placed in the holder in a vertical orientation. The mandibular central incisors are centered on the film with the central x-ray beam perpendicular to the film. The contact between the two central incisors should be open. The film should be placed as far into the patient's mouth as possible without causing discomfort, usually as far back as the second premolar. The tongue is moved back and must not be in between the film and the teeth or it will show on the radiograph. The lateral incisors should be visible in this film as well. Two smaller films may be used if the patient's mandible is unusually narrow.

Mandibular Cuspid

For the mandibular cuspids, the film is placed in the holder in a vertical orientation. The mandibular canine is centered on the film with the central x-ray beam perpendicular to the film. The mesial contact of the lateral and the distal of the first premolar should be present in this film, with the mesial and distal contact of the canine open. The tongue should be mildly displaced so the film can be inserted into the floor of the mouth and far enough away from the teeth so that the film doesn't bend.

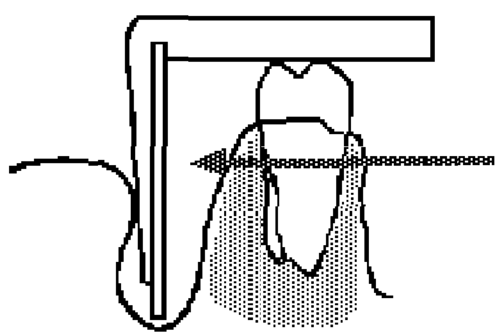


Mandibular Premolars

For mandibular premolars, the film is placed in the holder in a horizontal orientation. The contact between the second premolar and the first molar is centered on the film. The central beam should be perpendicular with the long axis of the tooth. The film should contain the distal of the canine through the mesial of the second molar, with the contacts of the premolars open. The film should be placed as far into the patient's mouth as his or her anatomy will allow.

Mandibular Molars

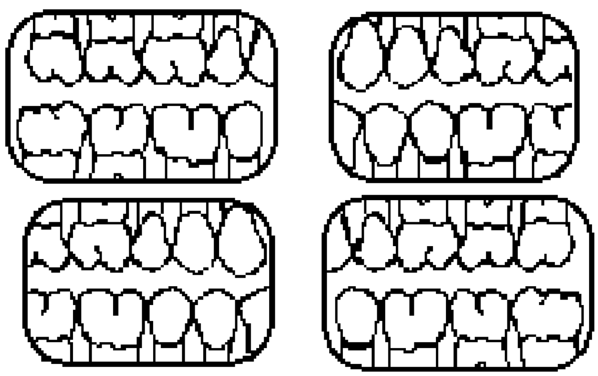
For the mandibular molars, the film is placed in the holder with a horizontal orientation. The second molar is centered on the film with the central beam perpendicular to the film. The contacts between the molars should be open and the distal of the third molar region should be visible even if there is no tooth present. Be careful about the placement of this film because the sharp edge can be uncomfortable in the sensitive floor of the mouth. If the patient is instructed to gently close rather than "bite" the film holder will be more secure and more comfortable.



Bitewing X-rays

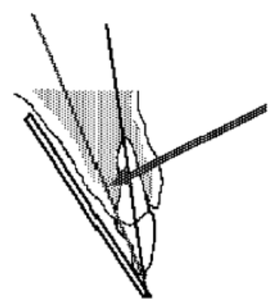
The final section of the Full Mouth Survey will contain bitewing x-rays. The bitewings show open contacts for the teeth from the distal of the canine to the third molar region. Usually, four films will be adequate to show the premolar and molar regions.

The first bitewing should show the distal of the canine and the premolars. The operator must look at the contact areas to correctly position the film. The film must be perpendicular to the contact areas being shown. The cone head is perpendicular to the film (parallel with the contacts). The second bitewing shows the mesial of the first molar through the third molar region. The film again must be perpendicular to the contact areas so they will be open in the film. If teeth are misaligned or if for any other reason you expect some areas to overlap, take an additional x-ray view of the area that will open up the contact.



Bisecting the Angle Technique

The bisecting the angle technique is not recommended for full mouth series because of the wide margin for error. It is used mainly for unusual anatomy, endodontic films, and possibly small children because it does not require the use of film holding devices. Instead of placing the film away from the tooth being x-rayed as in the paralleling technique, the film is placed directly against the tooth. The film touches the teeth at the incisal edge or the lingual-occlusal surface and then the rest of the film is angled dependent on the anatomy of the area. The x-ray beam is directed perpendicular to the bisecting line between the angle of the long axis of the tooth and the angle of the film. The cone is placed 7 or 8 inches from the patient's face and parallel with the horizontal plane of the film.



Occlusal Radiography

A large size 4 film is used for occlusal radiography and it is placed in the mouth horizontal to the occlusal plane between the arches. It is used to view objects in a three dimensional way; to locate teeth that are not easily seen on the other views; to locate pathology in the jaw, palate, salivary ducts, or sinus; to diagnose fractures; and other specific circumstances.

Two standard angulations used in this technique are the topographic view and the cross-sectional technique. In the topographic view, the arch in question is parallel to the floor. The x-ray beam is directed perpendicular to the line bisecting the angle of the long axis of the anterior teeth and the film, which is parallel with the occlusal plane and the floor. In the cross-sectional technique, the central ray is aimed 90º to the film.

Radiographs for the Edentulous Patient

X-rays should be taken on an edentulous patient, even though the x-rays will not be used for caries detection. A full mouth series may reveal pathology, may be needed for implants, and can show the sinuses in relation to the alveolar ridge crest. Normally 10 to 14 periapical films will adequately survey the edentulous patient. No bitewings are necessary. The paralleling technique can be used by modifying the instruments to account for the lack of tooth occlusion. Cotton rolls can be affixed to the underside of the bite block with rubber bands. The exposure time is reduced by 1/4 to make sure the films are not overexposed.

Endodontic Radiographs

The paralleling technique is recommended for endodontically involved teeth and teeth that are in the process of root canal treatment. A good endodontic film will have the tooth being treated in the center of the film, at least 5 mm of bone beyond the apex of the tooth, and an anatomically correct image. The points and rubber dam may make it impossible to use the x-ray instruments. The film can be positioned parallel to the tooth by inserting a cotton roll between the tooth and the film, or it can be held by a hemostat or Snap-A-Ray.

Introduction

Patients often view x-ray procedures with disdain. They may have had previous bad experiences and children are sometimes overwhelmed by the technology. Confidence and compassion on the part of the operator can do wonders for patient compliance.

Gag Reflex

Gagging is a common problem when taking x-rays. Gagging is really caused by the patient's fears (real or imagined) even though it is a physical reaction. Start the series with anterior or premolar films to show the patient successful film taking. This will establish you as the authority. Don't leave the film in the patient's mouth for any longer than absolutely necessary. Set up the machine and do everything else necessary before putting the film in the patient's mouth. Instruct the patient to breathe through his or her mouth while placing the film. Set the film in place with confidence and don't move it around. If the patient gags anyway, try to reassure them that it is a common survival instinct and that you know just what to do to help them control it.

There are mouthwashes and throat lozenges available to anesthetize the mouth. Some practitioners swear by salt on the tongue. Others instruct the patient concentrate on an object or picture in the room. Caution should be used if spraying topical anesthetic because the patient might aspirate it. The interesting common thread running through these techniques is that the operator insists that it is common procedure and has worked for many other patients. Since the reflex is triggered by psychological factors, any way that occupies the concentration skills of the patient is helpful. Try different techniques when the opportunity presents itself.

Complaining Patients

Patients will sometimes refuse x-rays for a variety of reasons. Many will say they do not want to be exposed to the radiation. Explain to the patient that the doses of radiation are small in comparison to the benefit of the diagnostic importance of the x-ray. "The doctor cannot give you a full examination without these." Also explain to the patient that every effort is made to expose them to the least amount of radiation possible to gain a good x-ray. If the patient has recently had x-rays for medical purposes, they may not want to be exposed again. Each case will be different, depending on the reason for the oral x-ray (routine or because of a problem). If the patient still refuses the x-rays, have the dentist speak to the patient. Every effort should be made on your part to explain the situation to the patient to establish your credibility.

The physician of a pregnant patient should be consulted before any x-rays are taken, especially in the first trimester. If the patient has a suspicion that they may be pregnant, it is wise to postpone routine x-rays until she is sure she is not pregnant. The lead apron should protect the reproductive area if the x-rays must be taken, but if the patient's physician recommends against it, postpone any x-rays until after the baby is born.

Panoramic X-rays are taken when a view of the whole dentition or the jaw is needed. The image is not clear enough to diagnose caries, especially in the interproximal areas because they are overlapped. Panoramic x-rays will show pathology in the bony areas not pictured in standard x-rays.

Film cassettes are used with the panoramic machines. Cassettes usually have a lead L and R to indicate the left and the right. Sometimes these letters are in the film holder on the machine. The film and two intensifying screens are inside the cassette. The screens each have a layer of phosphor that become fluorescent when x-rays strike it. This phosphorescence exposes the film in the cassette. The intensifying screens allow less radiation to be used. The patient is exposed to the least possible amount of radiation, but this picture has less resolution or detail than the periapical film.

The cassette is inserted into the film holder on the panoramic machine. The tube and cassette holder are connected and revolve around the patient while the x-ray beam remains pointed at the patient. Specific directions are available from the manufacturer of the different types of machines and should be followed carefully. The patient should be seated or standing straight, and a lead apron used that protects the back as well as the front. Most of the tube activity goes around the back of the patient's head. The patient's head must be straight with the midsagittal line perpendicular to the floor and the chin down slightly. An imaginary line from the orbit through the external auditory meatus is parallel with the floor. Usually the machine will have a chin rest to correctly position the patient's head.

The patient must remove any earrings, eyeglasses, hearing aids, metal hairpins, necklaces, and prosthetics or retainers before a panoramic x-ray. A short explanation about the actions of the machine is appropriate so the movements do not surprise the patient. The patient's teeth should be centered in the focal trough of the film according to the manufacturer's recommendations. The patient must place his or her tongue on the palate.

The most frequent panoramic positioning errors include:

- chin out of position,
- tongue not raised,
- patient not sitting upright,
- head tilted or rotated,
- lips open,
- too far forward,
- machine too high,
- and chin not in chin rest.

Introduction

Sometimes other extraoral radiographs will be needed to accurately diagnose the patient's problem.

Lateral Oblique Jaw Projections

Panoramic units are not available in all offices because they are expensive. A useful view of large areas of the jaw can be accomplished with the lateral oblique jaw technique. The patient is seated in a chair with teeth occluding. The patient's occlusal plane is parallel to the floor with the midsagittal plane perpendicular to the floor. The cassette (5X7 or 8X10) is placed in a holder or the patient can hold it resting on his or her shoulder and his or her hand supporting the film at the cheek level. At least one inch of the film is below the mandible. The patient's chin is then tilted up slightly and the long axis of his or her head is moved about 15 degrees toward the cassette. The central x-ray beam is directed at a vertical angle of -10 to -15 degrees with the cone head perpendicular to the film. The area in question should be generally centered on the film.

Cephalometric Projections

Cephalometric radiographs are used (especially by orthodontists) to measure and assess the patient's profile. This film must be a very accurate representation of the head without distortion. A head positioning device called a cephostat is used with an 8X10 film. The patient's midsagittal plane is parallel to the cassette and the left side of the head is against it. The source of the beam is 60 inches away from the patient, directed perpendicular to the cassette and through the long axis of the ear rods.

The soft tissues of the patient's profile must be visible on the film. Place a thin lead or copper filter in the x-ray source, use a wide-latitude, low-contrast film, place an aluminum filter over the cassette, or use a special cassette especially made to capture the patient's profile. Sometimes, the dentist will require a posterioanterior view as well as the normal side view. The patient faces the cassette and the central ray is directed at the level of the external occipital protuberance.

Temporomandibular Joint (TMJ) Views

Standard panoramic views will show the TMJ, but not always the glenoid fossa. Check the panoramic machine manual for explanations of repositioning the patient with the specific machine. A submentovertex or basilar projection will show the TMJ and other structures from underneath the chin. A tomograph is another type of x-ray for TMJ diagnosis. The radiologist takes a submentovertex view and then sets the tomographic unit to measurements from the submentovertex view. Arthrography images the soft tissue of the joint by using radiopaque dye. A dentist may ask for these views or a special combination of others depending on the area of concern.

Introduction

After the films have been exposed, they need to be processed. Even with the best placement technique, a cooperative patient, and the highest quality x-ray machine, a film can be rendered undiagnostic during processing.

Film

X-ray film consists of a plastic base covered in an emulsion. The emulsion contains gelatin and silver halide crystals. The silver halide crystals are energized by radiation exposure. When the film is exposed to x rays, the energy reacts with the crystals and creates a "latent image" depending on the different densities that the x-rays have passed through. Where there is a filling in the tooth, the crystals have very little stored energy because the metal blocks out almost all the x-ray beam. Conversely, interproximal spaces let most of the radiation through, so the crystals in that area are full of stored energy. The ability for different tissue densities to absorb radiation is called attenuation. Over time the latent image will disappear, so it is best to process the film as soon as possible after exposure. The film should be stored in a refrigerator to slow attenuation if immediate processing is not possible.

When the x-ray is immersed in the developer chemicals, it soaks into the gelatin and reacts with the silver halide crystals. The energized crystals then form metallic silver and bromide. The silver is deposited onto the film and causes the darker areas. The crystals that were not energized are simply washed away by the fixer and that area of the film remains white. So the developer reacts with the energized crystals to make the black areas and the fixer removes the unenergized crystals and leaves those areas white. If the film comes out too dark, it is because it is overexposed (too much radiation) or overdeveloped. If the film is too light, it is underexposed, underdeveloped, or over fixed.

Manual Processing

Most offices have an automatic processor and tanks for quick processing. At some time in your career you may be called upon to manually develop x-rays. The chemicals and theory are the same in an automatic processor.

The most important factors to consider for developing are the temperature of the chemical and the amount of time the film is allowed to be in contact with the chemical. The higher the temperature of the solution, the less time needed. The preferred condition for manual processing is 4 1/2 to 5 minutes at 68ºF (20ºC). Keep a nonmercury thermometer and a timer accurate in minutes and seconds in the darkroom to check your solution.

The film is submerged in the developer for the proper amount of time and then must be rinsed in clean, circulating water for 30 seconds. Then the film is submerged in the fixer for at least 10 minutes. The film is rinsed in a compartment with clean, running water for at least 20 minutes to remove all the chemicals and silver. Then the film can be hung to dry or a commercial drying machine or product can be used.

Make sure to keep the chemicals in the darkroom in the same order, developer in the left tank, water bath in the center, and fixer in the right tank. The fixer will have a strong vinegary smell. Stir the solutions before submerging the x-rays to mix and distribute the temperature evenly. Use different instruments to stir the developer and the fixer so the two aren't mixed. Make sure the liquid levels are adequate to cover the films as they are dipped, and add the appropriate chemical if necessary. The best temperature for the chemicals is between 65ºF and 75ºF (18ºC to 24ºC). Adjusting the temperature of the incoming water can regulate this temperature. Given time, the chemicals will be the same temperature as the water. The patient's name and date of exposure should be secured somewhere on the rack. Make sure to turn off the overhead white light and use the safe light. Clip the films firmly to the hanger. Use a timer, don't rely on your memory. Rinse in between the solutions. The final wash should be 20 to 30 minutes. If the films are in the water for more than an hour, the emulsion may begin to wash off. If the films are left in water overnight, they will be clear in the morning.

The chemicals should be checked every day before they are needed. The best way to check the quality is to use a control film and compare it to a newly developed one. A step wedge is an instrument used to show various gradients of x-ray exposure. The simplest method of making a "home made" step wedge is to take a tongue depressor and tape six pieces of lead foil (from inside the x-ray packs) in descending order. Tape two pieces of lead foil to the end of the tongue depressor. Tape two more pieces overlapping the first but 1/4 inch from the end of the depressor. Finally take the last two pieces and overlap them 1/2 inch away from the end of the depressor. The tip of the depressor should have two layers of lead foil, 1/4 inch from the tip should have 4 layers of lead foil, and 1/2 inch from the tip should have 6 layers of lead foil. Similar devices are available for purchase through dental supply companies.

Make a control film by placing the step wedge on a film and exposing it to x rays. Process this film in fresh chemicals that are at the proper temperature for the proper time. Each day expose one film with the step wedge on it and process it with an unexposed film. The unexposed film should be clear. The step wedged film should be identical in shading as the control. If there is a visible difference, the problem must be identified and corrected before any patient films are processed.

Chemicals should always be handled according to the manufacturer's directions. The chemicals must be checked every day, and replenished as needed. Every day, 6 ounces of the developer should be removed and replaced with 6 ounces of fresh developer. Stir the solution to mix well. The fixer should be replenished daily by removing 3 ounces and replacing it with 3 ounces of fresh solution. The chemicals must be completely changed according to the manufacturer's directions. Factors will alter when this is necessary, such as how many x-rays are developed, exposure to air, and the amount of water dilution. The daily checker film will be a good indicator of when to change the solutions.

Darkroom

The darkroom should be kept clean. The chemical fumes could affect the emulsion of the film so store unused film in another room. There should be plenty of room to work, especially next to the processing tanks. The best internal temperature is 70ºF to 80ºF (21ºC to 26ºC) at 70% humidity. It should be a totally dark room with no cracks in the door where light might sneak in. To check for light leaks, enter the room and close the door with the lights turned off. After your eyes have adjusted (2 or 3 minutes) look around for light. If you see any light leaks, they must be sealed because it could effect the films during processing.

There should be hot and cold running water near the tanks with mixing valves so the temperature can be regulated. A white light source and a good quality safe light should be available at least 4 feet away from the working surface.

Automatic Film Processing

Automatic film processors develop radiographs more quickly than manual processing with consistently good results if the chemicals are maintained. A series of rollers are inside the unit to guide the film through the chemicals. The processor uses a heating element to keep the solutions at a constant temperature, usually 85ºF to 105ºF (29ºC to 40ºC). This higher temperature shortens the time needed for processing. The action of the rollers helps to disperse the chemicals evenly over the film. A special roller at the end of each tank squeezes off most of the chemical so there is no mixing or diluting of the chemicals.

The two most frequent causes of failure in automatic processors are dirty rollers and expired chemicals. The chemicals should be replenished at the beginning of the day. After four full mouth surveys or panoramic films, the chemicals will need 4 to 6 ounces of new solution. The rollers should be washed once a week with warm running water and soaked for 10 to 15 minutes. Two large extraoral films should be run through the machine to clean the rollers.

Depending on the rate of use, the solutions should be changed every 2 to 6 weeks. Follow the guidelines and use the solutions recommended by the manufacturer. Empty all the chemicals in an orderly manner so they don't mix.

Follow the manufacturer's recommendations carefully regarding lubrication, maintenance schedules, and general use. The cover should be kept slightly ajar when the machine is not in use to let fumes disperse and keep moisture from accumulating on the motor. Feed films in at the recommended rate. Feeding too fast can cause them to stick together.

Film Duplication

X-ray films may need to be duplicated when the patient moves, is referred to a specialist, for preauthorization of insurance, or any other time a record of the x-rays needs to be sent outside the office. The originals stay in the patient's chart as a permanent record for the office. The operator can use double films (the type with two films in the same packet) for x-rays that will be sent out. They yield two good quality films while exposing the patient to the same amount of radiation.

Film duplicators can also be used, especially when originals have already been taken. The duplicating film is sensitive to light and becomes lighter when exposed. Regular x-ray film becomes darker when exposed to light.

The duplicating procedure takes place in the darkroom with safelights on. The radiographs to be copied are mounted in a special mount designed for duplication with the embossed (raised) dot side down for optimal contact with the duplicating film. Then these radiographs are placed on the duplicator and the duplicating film is placed on top with the emulsion side against the radiograph originals. Expose according to the manufacturer's recommendations. The film is processed in the same way as regular x-rays.

Qualities of Excellent Radiographs

Diagnostically useful radiographs have specific visual qualities. The x-ray image is a combination of black, white, and shades of gray. Contrast is the difference between the colors and shows definition of the items contained in the picture. The denser an object is, the more it blocks the x-ray beam, and it appears white on the x-ray picture. The contrast depends on the type of film used, the processing of the film, and the density of the film. Extraoral films have their own inherent contrast. Incorrect developing can ruin the contrast of a film by lightening or darkening the subtle shades of gray. Overdevelopment will make the film too dark, and underprocessing will make the film too light. A film with good contrast will show the darkness of soft tissue, the lightness of amalgam, and the subtle shades of gray in the nerve canal and trabecular bone.

The contrast in the film is determined by:

- thickness of the patient,
- the density of his or her hard tissue, and
- the anatomic number of the tissue of the subject

in comparison to the kilovoltage used. The operator should consider these variables and adjust the kilovoltage to compensate if necessary.

Density is another important characteristic of an x-ray. The density is dependent on the amount of radiation that penetrates the tissues and reaches the film, the distance from the x-ray tube head to the patient, the subject thickness, and the way the film is developed. The higher the amperage and the longer the film is exposed, the darker it will be. The higher the voltage peak the more energy is produced and the darker the film will be. The farther the source of the x-ray beam is from the patient, the less intense the x-ray beam.

The quality of detail on a radiograph is called resolution. The x-ray has good resolution if objects are easily recognized with no overlap, distortion, or blurriness. Films can be blurry if the patient or film moves during exposure. Tubehead movement will not cause blurry distortion.

A good radiograph will contain the following characteristics: (From "Radiographic Imaging for Dental Auxiliaries" by Miles, Van Dis, Jensen, and Ferretti)

Periapical Radiographs:

- The correct anatomic area should be represented.
- At least 3-4 mm (1/4 inch) of alveolar bone should be visible beyond the apex.
- The image should not be elongated or foreshortened.
- The radiograph should have acceptable density.
- The radiograph should be free of film-handling or processing errors.
- The interproximal contacts should not overlap.
- There should be no cone cuts.
- The embossed (raised) dot should appear at the incisal or the occlusal edge.
- In a complete mouth radiograph series, the apex of each tooth should be visible at least once, preferably twice.

Bitewing Radiographs

- The interproximal contacts should not be overlapped from the distal surface of the canine to the mesial surface of the third molar.
- The crowns of the maxillary and mandibular teeth should be centered in the image from top to bottom.
- The crest of the alveolar bone should be visible with no superimposition of the crowns of the adjacent teeth.
- The occlusal plane should be as horizontal as possible.

Operator Errors

Operator errors in film placement and angulation of the tubehead often result in undiagnostic x-rays. X-rays that are undiagnostic are useless to the dentist and must be retaken. Every effort should be taken to minimize the following errors, because each retake exposes the patient to more radiation.

Film Placement

Correct film placement is critical for success with x-rays. If the correct technique is followed every time, positioning errors will be minimized. In all premolar views, the distal of the cuspid is visible. All molar views should contain the third molar region even if the tooth is not present in the mouth. When focusing on a specific tooth, it should be centered on the film.

The film must be placed high enough in the palate or low enough in the floor of the mouth to clearly show the apex of the tooth in question and 3 to 4 mm of bone.

Films should not be bent if possible, but if the patient is uncomfortable with the edge, try gently reshaping the edge and repositioning the film in the mouth. Asking the patient to "gently" close often decreases the discomfort especially in the floor of the mouth.

Before placing an x-ray film in a patient's mouth, check to make sure that it is not backwards. The lead foil will leave an artifact on the exposed x-ray and it will be confusing to mount.

Make sure that exposed films are not mixed up with unexposed ones.

Angulation Of The Tubehead

Errors of angulation of the tubehead are common. When using an instrument, make sure that the tubehead is aligned correctly, parallel with the indicator rod and aligned with the ring. Film positioning devices are so helpful that (when used correctly) they virtually eliminate the errors of angulation. When the patient's anatomy alters the usefulness of the instrument, compensation may be necessary. For example, if the patient has a shallow palate and the instrument will not allow the film to be parallel with the long axis of the tooth, the cone can be compensated to a more shallow angulation and the image will not be foreshortened.

Overlapping is another common error of angulation. If the cone is not perpendicular to the film, the contacts will be overlapped. Some offices routinely use a size 3 film for a bitewing view that contains all the teeth from premolar to molar. Due to the curve of the arch, some area is bound to be overlapped. It is better to position two size 2 films in a premolar view and then a molar view so all contacts will be opened.

Cone cutting is another common error of angulation. The film will be cone cut when the tubehead is not covering the whole area of the film. The best way to avoid this is by looking at the film in the patient's mouth and aiming the cone head directly toward the film instead of guessing from extraoral landmarks.

If the patient moves, the film will be affected. Watch the patient as you expose the film to make sure they don't move. The patient should be instructed to hold very still and not swallow until he or she is told it is OK.

Correct film processing procedures were previously discussed in the section on film processing, but the following table summarizes common film processing errors, the results, and possible solutions.

ERROR	RESULT	SOLUTION
Developer temperature too low	Film too light	Check and adjust temperature
Developing time not long enough	Light film	Use a timer
Developer solution too old or diluted	Films too light Yellow or brown film	Keep a schedule of chemical maintenance Run checking film
Developer too warm	Film too dark	Check and adjust temperature
Developing time too long	Film too dark Foggy film	Use a timer
Light leak in processing	Film too dark Foggy film	Check processor and darkroom
Film exposed to light before processing	Film too dark Foggy film	Don’t open film until safety light is turned on and other lights are off Check safety light for leaks
Films exposed to radiation after exposure	Foggy film	Take exposed films out of room when exposing other radiographs
Fixer too old or contaminated	Yellow or brown film Green film	Check with checking film Replenish and maintain on schedule
Incorrect rinsing between developer and fixer	Streaking	Follow proper protocol for rinsing between chemicals
Chemicals exhausted Incorrect or insufficient washing	Streaking Green film	Run checker film every day Wash longer after fixer
Dirty rollers, fingerprints	Artifacts or Streaking	Clean rollers, handle films by edge
Films sticking together	Green Film	Refix and rinse
Bending films	Lines on film	Don’t bend films
Static electricity	Lightning marks on film	Humidify environment, use Static Guard
Water drops on film	White spots	Don’t put film in water after removing it from its wrapper
Developer splash on film	Black spot	Make sure countertop is dry after changing chemicals

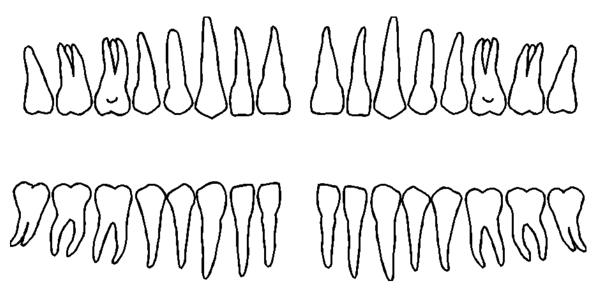
Mounting Films

Films must be mounted consistently and correctly. The x-ray mount should have the full name of the patient, the date of exposure, and the name of the person taking the radiographs.

In the standard method of mounting, the raised dot is oriented upward. This dot is always facing the tube head so on the resulting films the right is the right side of the patient and the left is the left side of the patient. Always orient the dot at the occlusal or incisal edge of periapicals so that the dot will not interfere with periapical anatomy.

When the radiographs are dry, take them with the mount to an area with a view box. Turn all the films so the dots are facing up. Take all maxillary films and group them together. Put the bitewing x-rays to the side. Face all mandibular films (dot still up) with the incisal edges and the occlusal surfaces up and all the maxillary films with the incisal edges and the occlusal surfaces down. Mount the x-rays from the facial aspect (from the outside in) as if you are standing in front of the patient. The films representing the left side of the patient are mounted on your right side. Sort the anterior films and mount them. Then mount the premolars then the molar views. Mount the bitewing films. Empty frames on the film mount should be blocked with an opaque film blank. Check that the dots are all on the same side and that objects and restorations on the periapicals match the same areas on the bitewings. Check the root curvatures to make sure they are all towards the distal. The general curve of the occlusal edges should be upturned at the ends, like a smile.

The most common orientation is with the dot raised (pimple), but some practitioners prefer to view x-rays with the dot oriented downward (dimple). The "correct" way to mount x-rays is according to the direction of the dentist who will be using them.



Legal Aspects

A licensed dentist or a properly supervised dental student must determine the number and types of x-rays. Taking radiographs based on a predetermined timetable (every year or every 6 months) is not considered an acceptable standard of care. The needs of each patient should be evaluated clinically before the decision of taking x-rays is made.

The dentist is responsible for keeping the equipment in good working condition. The dentist is also legally responsible to use licensed personnel for taking x-rays.

The patient must give documented informed consent. The patient should have a full explanation of the benefits and the risks of exposure to radiation and they must specifically express his or her permission to have them taken. A written, signed consent form is the easiest way to document the patient's approval.

Digital imaging is the newest and most promising technology in dental radiography. Researchers are finding limitless possibilities for imaging technologies.

Modern digital imaging systems include:

- a detector to convert the transmitted light of a conventional radiograph or the remnant x-ray beam into an electronic signal.
- a converter to convert the electronic signal into a form the computer can understand, and
- a computer to receive, store, process, and retrieve the images.

A sensor replaces the film normally used for traditional radiographs. The most common type of Intraoral sensors are solid-state electronic devices called “charged-coupled devices” (CCD). The x-ray photons interact with the material in the sensor and create an electric charge. This signal is converted to data that can be understood by the computer.

A radiograph is composed of shades of gray spanning from black to white, and is known as a "continuous tone" image. This means that the shades of gray blend together with no noticeable interruptions. To convert data from the sensor into digital form, the image is converted into individual pieces of information by an analog to digital or “A to D” converter. This information describes the light intensity (brightness) and its location in relation to the picture as a whole. Each small piece of information is called a pixel. The computer reassembles the pixels in the correct order and brightness to build a digital image. Manufacturers of current image processor equipment use a standard 12 bit or 4096 levels of gray for the images. Newer processors use 16 bit or 65,536 levels of gray. Increasing the number of bits representing the brightness expands the gray scale so that the digital image more closely resembles the original image. The higher the number of pixels used to define the image the closer we approach the spatial appearance of the original image. This means that a properly displayed digital image will be identical to the original to an observer. The more pixels and bits of information involved in the pictures require more memory of the computer for processing and storage.

A typical imaging system is composed of a video camera, a framegrabber with A/D and D/A converter, a host computer with optical disk storage and image processor software or hardware and a video monitor. Once the image is in the computer, it can be manipulated, enhanced, enlarged, filtered, and compared to other images. The technique of capturing the image must be reproducible so two images of the same area taken at different times can be accurately compared. [1]

One alternative to capturing the radiograph digitally is to scan a standard radiograph and convert it into a digital image. For example, software from Televere Systems called

[1] S. Brent Dove ddsweb@uthscsa.edu Dental Diagnostic Science Copyright UTHSCSA 1995 All right reserved

TigerView will take the images from the scanner and automatically arrange them in proper orientation and order. These images can be manipulated, rotated, and enhanced. Zoom, contrast, brightness, and orientation are also variable.

Digital images can be transmitted via modem in only seconds. Images can be inserted into a word processing document (like treatment plans) and printed on an office printer with good (although not diagnostic) results.

Radiographs in current patient files can be scanned and stored on magnetic media rather than in physical form, taking up much less room than conventional files. Electronic files can be submitted to insurance companies or for specialist referrals. Radiographs can be displayed in a magnified form for patient education.

Scan inactive patient records, maintaining an electronic storage of these old records. Software like TigerView allows complete contents of patient records (charts and radiographs) to be scanned and digitally stored on removable disk media. The disks hold a large amount of data and can be stored off site. Digital records are easy to retrieve. The physical records can be stored in a low-cost dead storage area rather than on site. Once archived digitally it is not recommended that the originals be destroyed.

TigerView has been granted FDA 510(k) approval as a Class II medical device guaranteeing that diagnostic quality will be preserved when scanning film into digital form. Zoom capabilities allow close up of the radiograph or an area on the radiograph. Brightness and contrast can be adjusted to enhance details during clinical diagnosis.

Radiographs can be displayed on a large-screen monitor for patient education. Enhances patient understanding of treatment plans. Duplicates films easily. Any digital image can be printed on paper instead of using the standard film duplication process.

Conclusion

X-rays are important for the proper diagnosis of caries and pathology that may not be seen by a visual exam. X-rays should be taken wisely to avoid exposing the patient to unnecessary radiation. A good, standard technique should be used every time an x-ray is taken.

Please mark only one **best** answer to the following questions on the one page answer sheet.

This test contains 20 questions. Please mark your answers in spaces numbered 1 through 20 on your answer sheet.

1. The discoverer of x-rays was:

    a. Wilhelm Conrad Roentgen
    b. Conrad Bremsstrahlung
    c. Wilhelm Compton
    d. Conrad Wilhelm

2. The dental x-ray tube contains:

    a. a cathode
    b. an anode
    c. a focusing cup
    d. all of the above

3. If a photon comes in contact with an atom and gives it's energy to the atom, then the atom produces another photon and sends it off in another direction, it is called:

    a. Bremsstrahlung radiation.
    b. The Compton Effect.
    c. classical scattering.
    d. the photoelectric effect.

4. An assistant may hold the film in place for the patient during exposure.

    a. True
    b. False

5. Which of the following should be sterilized or covered with a clean cover for each patient?

    a. The chair
    b. The tube head
    c. Instruments used in the patient's mouth
    d. b and c

6. Radiographs should be taken on all patients every 6 months.

    a. True
    b. False

7. Periapical radiographs are for diagnosis of:

    a. the teeth
    b. the bone and lamina dura
    c. the periodontal ligament
    d. all of the above

8. Bitewing x-rays show:

    a. the apex of a tooth.
    b. the TMJ.
    c. crowns and interproximal areas of the premolar and molar regions.
    d. soft tissues of the face in relation to the bone of the head.

9. In the paralleling technique, the x-ray beam is directed perpendicular to the bisecting line between the angle of the long axis of the tooth and the angle of the film.

    a. True
    b. False

10. In the paralleling technique, the central x-ray beam passes ________ to the film plane.

    a. Horizontal
    b. perpendicular
    c. vertical
    d. at a 25º angle

11. The gag reflex is usually caused by the patient's fears.

    a. True
    b. False

12. In the bisecting the angle technique, the film is placed:

    a. directly against the tooth.
    b. at a 45º angle to the tooth.
    c. at a 90º angle to the tooth.
    d. about 6 inches away from the tooth.

13. An occlusal radiograph is used to view:

   a. objects in a three dimensional way.
   b. the occlusal plane of the teeth.
   c. the interproximal areas of the teeth.
   d. the apex of an anterior tooth.

14. X-rays should be taken on an edentulous patient to diagnose caries.

   a. True
   b. False

15. Patients are __________ for panoramic x-rays.

   a. draped across the front only with a lead apron
   b. draped with a lead apron that protects the back as well as the front of the patient
   c. not draped
   d. draped across the lap only with a lead apron

16. Patients should remove earrings, eyeglasses, hearing aids, and other metal items before a panoramic x-ray is taken.

   a. True
   b. False

17. In the lateral oblique jaw projection technique, the central x-ray beam is directed at a vertical angle of:

   a. 10 to 15 degrees
   b. 90 degrees
   c. -10 to -15 degrees
   d. 45 degrees

18. A film that comes out of the processor too dark has been:

   a. overexposed
   b. overdeveloped
   c. over fixed
   d. a or b

19. A good periapical film will:

    a. represent the correct anatomic area and at least 3-4 mm of alveolar bone beyond the apex.
    b. show the image in correct dimension, not elongated or foreshortened
    c. be free of film handling and processing errors.
    d. not be cone cut.
    e. all of the above.

20. The most common radiograph mounting orientation is with the dot raised (pimple), but some practitioners prefer to view x-rays with the dot oriented downward (dimple). The "correct" way to mount radiographs is according to the direction of the dentist who will be using them.

    a. True
    b. False

(end of test)

Glossary

Adapted from Miles, Van Dis, Jensen, and Ferretti: Radiographic Imaging for Dental Auxiliaries, Second Edition, 1993

Absorb: To take into the skin or body tissue.

Absorption: A process whereby the intensity of a beam of radiation is reduced because some (or all) of the particles (or photons) of the incident beam are eliminated or reduced in energy by interactions with matter.

Acid: A solution containing more hydrogen ions than water. Its pH is less than 7. The hydrogen ions can be replaced by a base to form salts.

Actinic Radiation: Radiation that can produce photo chemical effects, such as the production of a latent image in a film emulsion by visible light or x rays.

Actual Focal spot: The area of the target (tungsten) that is always larger than the effective focal size. It is the area of the anode upon which the electrons strike.

Acute Exposure: Radiation exposure of short duration; usually refers to radiation of relatively high intensity.

Age Fog: Mottled or uniform fogging owing to outdated film or films stored under conditions of excessively high temperature and humidity.

Alternating current: A flow of electrons in one direction followed by a flow in the opposite direction.

Aluminum Filter: Any of various thicknesses of aluminum used as filtration in an x-ray beam to absorb the longer-wavelength, less-penetrating radiation.

Ampere: The unit of intensity of an electric current produced by 1 volt acting through a resistance of 1 ohm.

Anatomic Landmark: An anatomic structure whose image may serve as an aid in the localization and identification of the regions to be radiographed or the regions in a radiograph.

Angulation: The direction of the primary beam of radiation in relation to object and film.

Anion: An ion carrying a negative charge.

Anode: The positive terminal of an x-ray tube; a tungsten block embedded in a copper stem and set at an angle to the cathode (*q.v.*) The anode emits x rays from the point of impact of the electron stream from the cathode. An anode that rotates constantly during x-ray production to present a changing focal spot to the electron stream and to permit use of smaller focal spots or higher tube voltages or currents without overheating is called a Rotating Anode.

Anteroposterior Position: An examination in which the film is placed at the posterior (for example the back of the head), with the x rays passing from the anterior to the posterior direction. Abbreviated: A-P.

Area Monitoring: Routine monitoring of the level of radiation in any particular area, building, room, or equipment.

Artifact: 1) A substance or structure not naturally present in living tissue, but which produces an authentic image appearing in a radiograph. 2) A blemish or an unintended radiographic image resulting from faulty manufacture, manipulation, exposure, or processing of an x-ray film.

Atom: The smallest part of an element that is capable of entering into a chemical reaction. It consists of a positively charged nucleus and an extranuclear portion composed of electrons equal in number to the nuclear protons.

Atomic Number: The number of electrons outside the nucleus of a neutral atom. It is also the number of protons in the nucleus.

Background Radiation: Background implies radioactivity arising from nature. This includes cosmic rays (*q.v.*) and radioactive elements in the earth and air.

Backscatter: Radiation deflected by scattering processes at angles greater than 90 degrees to the original direction of the beam of radiation.

Barrier, Protective: A barrier of radiation-absorbing material, such as lead, concrete, or plaster, used to reduce radiation hazards. Primary Protective Barrier: A barrier sufficient to reduce the useful beam to the permissible dose rate. Secondary Protective Barrier: A barrier sufficient to reduce the secondary or scatter radiation to the permissible dose rate.

Base: A solution containing fewer hydrogen ions than water. Its pH is greater than 7. Bases can react with acids to form salts.

Beam: An emission of electromagnetic radiation or particles. Central Beam: The center of the beam of x rays emitted from an x-ray tube. Usually called the central ray. Useful Beam: In radiology, that part of the primary radiation that is permitted to emerge from the tubehead assembly of an x-ray machine, as limited by the tubehead port and accessory collimating devices.

Beam Guiding Instrument: Instrument used during radiography to facilitate correct alignment of the central ray.

Binding Energy: The energy needed to eject an electron from the atom.

Bisecting Angle Technique: A technique for the radiographic exposure of intraoral films whereby the central axis or central ray of the x-ray beam is directed at right angles to a plane determined by bisecting the angle formed by (1) the long axis of the tooth or teeth being radiographed and (2) the plane in which the film is positioned behind the teeth.

Bitewing Radiograph: The x-ray shadow images of the crowns, necks, and coronal thirds of the roots of both upper and lower teeth, so called because the patient bites on a cardboard tab or "Wing" placed in the center of the film packet.

Block: In intraoral radiography, a block is a film holder that the patient bites on to provide stable retention of the film packet or orientation of tooth position. In panoramic radiography, a block is a tooth positioner that provides correct orientation of the dentition within the image layer.

"Boiling Off" Electrons: Heat or incandescence of the filament of the x-ray tube, which produces a source of free electrons by thermionic emission.

Bound Electron: An electron that is close to the nucleus. For example, the K shell electron.

Bremsstrahlung Radiation: A spectral distribution of x rays ranging from very low energy photons to those produced by the peak kilovoltage applied across an x-ray tube. Bremsstrahlung means "braking radiation", referring to the sudden deceleration of electrons as they interact with highly positively charged nuclei.

Calcium Tungstate: A chemical substance in crystal form used to coat radiographic intensifying screens; the screens fluoresce when struck by x rays.

Carcinogen: A substance having the ability to produce cancer.

Cassette: A light-tight container in which x-ray films are placed for exposure to x radiation; usually backed with lead to reduce the effect of backscattered radiation (*q.v.*) Screen Type Cassette: A film holder, usually made of metal with the exposure side made of a low atomic number material such as Bakelite, aluminum, or magnesium; the cassette contains intensifying screens between which a "screen type" film is placed for exposure.

Cathode: A negative electrode from which electrons are emitted. In x-ray tubes, the cathode usually consists of a helical tungsten filament behind which a molybdenum reflector cup is located to focus the electron emission toward the target of the anode.

Cathode Ray: A stream of electrons passing from the hot filament of the cathode to the target or anode in an x-ray tube.

Cathode Ray Tube: A tube cathode containing a spirally wound filament that becomes incandescent, producing electrons when a low-voltage electric current is passed through it.

Cation: A positively charged ion.

Cell: A minute protoplasmic mass, which in the aggregate makes up organized tissue. The cell consists of a circumscribed mass that contains a nucleus and a surrounding cytoplasm.

Germ Cell: The cells of an organism whose function it is to reproduce an entity similar to the organism from which the germ cells originated. They are characteristically haploid, i.e., have a single set of chromosomes

Somatic cell: Body cells (any cells that are not germ cells); they are characteristically diploid, i.e., have two sets of chromosomes.

Centigrade (Cº): The metric temperature scale on which the freezing point of water is 0 and the boiling point of water is 100. The formula for the conversion of degrees centigrade to degrees Fahrenheit is Fº=9/5 Cº+32.

Central Ray: The theoretical center of the x-ray beam. The term is employed to designate the direction of the x rays in a given projection; the central ray may be considered to extend from the focal spot of the x-ray tube to the x-ray film.

Cephalometric Projection: Examination by means of film place to obtain lateral and Caldwell posteroanterior views of the head. Used in orthodontics, maxillofacial surgery, and, to some degree, in prosthodontics to measure and study maxillofacial growth and maxillary and mandibular relationships. The head is held in position by means of a holding device called a cephalostat.

Cervical: 1) Pertaining to the neck or cervical vertebrae. 2) Pertaining to the cementoenamel junction (CEJ) area of a tooth.

Characteristic (Discrete) Radiation: Electromagnetic radiation produced by electron transitions from higher energy orbitals to replace ejected electrons of inner electron orbitals. The energy of the electromagnetic radiation emitted is unique or characteristic of the emitting atom (element).

Chromosome Aberration: Any rearrangement of chromosome parts as a a result of breakage by radiation or other means.

Chronic Exposure: Radiation exposure of long duration, either continuous (protracted exposure) or intermittent (fractionation exposure); usually refers to exposure of relatively low intensity.

Clearing Agent: see Fixer.

Coherent Scattering: Sometimes called unmodified scattering. One of the four interactions that occur when photons (x rays) and atoms collide with each other. The low-energy x-ray photon collides with an inner-orbital electron, but its low energy cannot dislodge the electron. The electron may absorb the photon, which then sets the photon into vibration. This causes an electromagnetic wave that is the same as the incident (incoming) photon, but that travels in a different direction. This type of interaction is below the energy range useful in clinical radiology.

Collimation: Any device used for the elimination of the peripheral divergent portion of the useful x-ray beam, such as metal tubes, "cones," or diaphragms interposed in the path of the beam.

Collimator: A lead disc with an aperture of various size and shape. The diaphragm limits the size of the primary beam to the area of interest, thereby minimizing patient exposure to the primary beam.

Compton Scatter Radiation: Commonly called scatter radiation. The incident radiation has sufficient energy to dislodge a bound electron, but it attacks a loosely bound electron and dislodges it; the remaining radiation attacks a loosely bound electron and dislodges it; the remaining radiation energy proceeds in a different direction as scatter radiation.

Condyle: a rounded projection on a bone, usually for articulation with another bone (e.g., of the mandible).

Cone: A device on a dental x-ray machine that is designed to indicate the direction of the central ray and to serve as a guide in establishing a desired source-to-film distance (SFD)

Short Cone: A conical or cylindrical cone having as one of its functions the establishment of an anode-to-skin distance of up to approximately 18 cm.

Long Cone: A cylindrical or rectangular cone designed to establish and extended anode-to-skin skin distance, usually within the range of 27 cm to 36 cm.

Cone Cutting: Failure to cover or expose the entire area of a radiograph with the useful beam, thereby only partially exposing the film.

Cone Distance: The distance between the focal spot and the end of the cone, usually expressed in inches or centimeters.

Constant Potential Kilovoltage; see Kilovoltage

Continuous Spectrum: For electromagnetic radiation, a spectrum that exhibits a gradual variation of wavelength. Examples include the spectrum of light from an incandescent solid and an x-ray spectrum.

Contrast: The difference in image density appearing on a radiograph, representing various degrees of beam attenuation.

Film Contrast: A characteristic inherent in the type of film used.

Long-Scale Contrast: An increased range of grays between the blacks and whites on a radiograph. Higher kilovoltages increase this range.

Short-Scale Contrast: A reduced range of grays between the blacks and whites on a radiograph. Lower kilovoltages decrease this range.

Subject Contrast: The relative differences in density and thickness of the components of the radiographed subject, as evidenced by the varied radiographic densities caused by the differences in absorbing power of the different kinds of material traversed by an x-ray beam.

Cosmic Rays: Radiation of extremely short wavelengths that originates outside the earth's atmosphere.

Critical Tissues (Organs): Those tissues that either react unfavorably to radiation or, by their nature, attract and absorb specific radiochemicals.

Crookes' Tube: see X-ray Tube

Darkroom: A room that can be completely darkened so that photographic or x-ray film may be processed.

Daylight System: A method of loading, unloading, and feeding films into the processor in normal room light. This system entails the use of special equipment, with no need for a darkroom.

Definition (Image): The property of images pertaining to their sharpness, distinctness, or clarity.

Density (Photographic or Film): The degree of darkening of exposed and processed photographic or x-ray film.

Background Density: The density of a processed film owing to factors other than the radiation exposure received through the recorded objects or structures.

Inherent (Film) Density: The density of a processed film owing to such intrinsic factors in the film as the density of the film base and the emulsion gelatin.

Object (Tissue) Density: The resistance of an object to the passage of x rays.

Detail: A visual quality that depends on sharpness (definition). Factors that influence detail include 1) the size of the tube focal spot; 2) the source-to-film distance; 3) the distance of the object from the film; 4) the motion of the object or x-ray source; 5) the type of intensifying screens; and 6) the image contrast.

Developer: A chemical (potassium bromide) used in a developer to check the development of the unexposed silver bromide and to control the working speed of the developer with respect to the exposed silver bromide.

Directly Ionizing Particles: Charged particles having sufficient kinetic energy to produce ionization by collision.

Distal: Remote; farther from any point of reference; e.g., midline.

Distortion: An inaccuracy in the size or shape of an object as it is displayed in the radiograph.

Magnification Distortion: Proportional enlargement of a radiographic image. It is always present to some degree in oral radiography but is minimized with increased source-to-film distance or decreased object-to-film distance.

Vertical Distortion: Disproportional change in size, either elongation or foreshortening owing to incorrect vertical angulation or improper film placement.

Dose (Dosage of Radiation) The amount of energy absorbed per unit mass of tissue at site of interest.

Absorbed Dose: The amount of energy imparted by ionizing radiation to a unit mass of irradiated material at a place of interest. The unit of absorbed dose in the traditional system is the rad (100 ergs/g). The currently accepted unit of absorbed dose is the gray (Gy). (1Gy=1joule/kg.)

Cumulative Dose: The total dose resulting from repeated exposures to radiation of the same region, or of the whole body.

Depth Dose: The radiation delivered to a particular depth beneath the surface of the body; it is usually expressed as a percentage of surface dose.

Doubling Dose: The amount of ionizing radiation, absorbed by the gonads of the average person in a population over a period of several generation that will result in a doubling of the current rate of spontaneous mutations.

Erythema Dose: Antiquated approach to radiation measurement based on the amount of radiation to cause erythema (redness) of the skin.

Exit Dose: The absorbed dose delivered by a beam of radiation to the surface through which the beam emerges from an object.

Threshold Dose: The minimum dose that will produce a detectable degree of any given effect.

Tissue Dose: the radiation dose received by a tissue. In the case of x rays and gamma rays, tissue doses are expressed in rads. The rem is the generally accepted unit of tissue dose for other ionizing radiations.

Dose Equivalent: The product of absorbed dose and modifying factors (i.e., the quality factor, distribution factor, and any other necessary factors). The traditional unit of dose equivalence is the rem (rad X qualifying factors).

Dosimeter (Radiation Meter): An instrument used to detect and measure an accumulated dosage of radiation.

Double Exposure: Two superimposed exposures on the same radiographic or photographic film.

Effective Focal Spot: That apparent size and shape of the focal spot when viewed from a position in the useful beam; with the use of a suitable inclined anode face, it is smaller than the actual focal spot size. (See also Line Focus.)

Ektaspeed Film: Direct exposure film with a speed (*q.v.*) category of approximately 25 R^{-1}

Electrode: Either of the two terminals of an electric source, an anode or a cathode (*q.q.v.*).

Electromagnetic Radiation: The forms of energy propagated by wave motion as photons or discrete quanta. The radiations have no matter associated with them. They differ widely in wavelength, frequency, and photon energy and have strikingly different properties. Covering an enormous range of wavelengths (from 10^{17} to 10^{-6} angstroms), they include radio waves, infrared waves, visible light, ultraviolet radiation, x rays, gamma rays, and cosmic radiation.

Electromagnetic Wave: A wave produced by mutual induction of electric and magnetic fields.

Electron: A negatively charged elementary particle.

Electron Stream: Electrons moving from the cathode to the anode across a potential difference in a low-pressure gas tube or a vacuum tube.

Electron Volt: The kinetic energy gained by an electron falling through a potential difference of 1 volt.

Element: A pure substance consisting of atoms of the same atomic number, which cannot be decomposed by ordinary chemical means.

Elongation: A form of radiographic distortion in which the image is longer than the object radiographed.

Entrance Dose: Dose measured at the surface of an irradiated object. It includes both primary radiation and backscatter from the irradiated underlying material.

Epithelium: The cells lining all canals and body surfaces including those cells that are specialized for secretion.

Equivalent: The thickness of pure aluminum, concrete, or lead, which would afford the same radiation attenuation, under specified conditions, as any given material being considered.

Excitation: The addition of energy to a system, thereby transferring it from its ground state to an excited state.

Exposure: A measure of the ionization produced in air by x radiation or gamma radiation. It is the sum of the electrical charges on all of the ions of one sign produced in air when all of the electrons liberated by the photons in a volume element of air are completely stopped in air, divided by the mass of the air in the volume element.

Exposure Factors: Radiographic kilovoltage, exposure time, milliamperage, and source-to-film distance: The primary radiographic factors considered when making an exposure.

External Oblique Ridge: A ridge originating from the anterior border of the ramus of the mandible extending to the lateral body of the mandible in the molar region.

Extraoral Radiograph: An examination of the teeth and bones made by placing the film or cassette against the side of the head or face and projecting the x rays from the opposite side.

Filament: A coiled tungsten wire, which emits electrons when heated to incandescence.

Film: A thin, transparent sheet of cellulose acetate or similar material coated on one or both sides with an emulsion sensitive to radiation and light.

Direct-Exposure Film: Film that is highly sensitive to the direct action of x rays but that has low sensitivity to screen fluorescence (e.g., intraoral dental film).

Screen Film: A film that is sensitive to the fluorescent light of intensifying screens but not as sensitive to the direct action of x rays (e.g., panoramic film).

X-ray Film: 1) A film manufactured for use in radiography. or 2) A radiograph.

Film Badge: A metal container of radiographic film used for the detection and measurement of radiation exposure of personnel.

Film Base: The thin, transparent sheet of cellulose acetate or similar material that carries the radiation- and light sensitive emulsion of x-ray films.

Film Packet: A light-proof, moisture-resistant, sealed paper or plastic envelope containing x-ray film, used in making radiographs.

Film Processing: The process of converting a latent image to a visible image by immersion in developer and fixer, followed by rinsing in water and drying.

Film Speed: The amount of exposure to light or x rays (the latter in roentgens) required to produce a given image density. Film speed is expressed as the reciprocal of the exposure in roentgens necessary to produce a density of 1.0 above base and fog; films are classified in six speed groups, from A through F. (See Speed.)

Filter: The material (usually aluminum) placed in the useful primary beam of x radiation.

Fixer (Film or Hypo-): The solution in which the manifest image is fixed and hardened, removing the silver halide crystals from the exposed film that has been unexposed to or unaffected by the action of the x radiation.

Fluorescence: The emission of radiation of a particular wavelength by certain substances as the result of absorption of radiation of shorter wavelength. The emission occurs essentially only during the period of irradiation.

Fluorescent Screen: A sheet of material coated with a substance, e.g., calcium tungstate or zinc sulfide, which emits visible light when irradiated with x radiation.

Focal Spot: That part of the target on the anode of an x-ray tube that is bombarded by the focused electron stream when the tube is energized.

Focusing Cup: Along with the filament, the focusing cup determines the size and shape of the target (focal) spot. The cup is constructed of molybdenum.

Fog (Fogging): A darkening of the whole or part of a radiograph by sources other than the radiation of the primary beam to which the film was exposed.

Chemical Fog: Film darkening owing to imbalance or deterioration of processing solutions.

Light Fog: Darkening of a radiograph owing to unintentional exposure to light (to which the emulsion is sensitive), either before or during processing.

Radiation Fog: Darkening of a radiograph owing to radiation from sources other than intentional exposure to the primary beam (e.g., scatter radiation), or exposure of film during unprotected storage.

Foreshortening: A form of distortion in which the image is shorter than the object radiographed. In the angle bisecting technique it is caused by misdirecting the x-ray beam perpendicular to the plane of the film instead of to the plane of the bisector (i.e., the vertical angulation is too steep).

Gadolinium and Lanthanum: Phosphors that absorb more of the available x-ray photons and have a higher conversion efficiency to light than does calcium tungstate, the phosphor most commonly used in intensifying screens. Sometimes referred to as rare-earth elements.

Gamma Radiation: Short wavelength electromagnetic radiation of nuclear origin, within a range of wavelengths from about 10^{-8} cm to 10^{-11} cm.

Gelatin: A protein obtained from animal skin and hooves by boiling; used in x-ray film manufacture as a means of suspending the silver halide crystals in the film emulsion.

Gene: The fundamental unit of inheritance that determines and controls transmissible characteristics.

Genetic Effects (Radiation): Changes produced in the genes and chromosomes of all nucleated body cells. In customary usage, the term relates to the effect produced in the reproductive cells.

Geometric Unsharpness: Impairment of image definition owing tot he penumbra (shadow).

Gonad: An ovary or a testis, site of origin of oocytes or spermatozoa.

Gray: A unit of radiation measurement established in 1974 by the International commission on Radiation Units and Measurements. One gray (Gy) = 1 joule/Kg= 100 rad. The gray is a unit of absorbed dose and replaces the rad.

Grid: A device used to prevent as much scattered radiation as possible from reaching an x-ray film during the exposure of a radiograph.

H and D Curve: A characteristic curve of a photographic emulsion obtained by plotting film density against the logarithm of the exposure. Also called the Hurter and Driffield curve (named after the British scientists and founders).

Halides: Compounds of metals with halogen elements; bromide, chlorine, and iodine.

"Hard" Radiation: A slang term for x rays of short wavelengths and high penetrating power. In usage, the shorter the wavelength, the "harder" the radiation.

Impulse: The burst of radiation generated during a half cycle of alternating current.

Indirectly Ionizing Particles: Uncharged particles, which can liberate directly ionizing particles or can initiate a nuclear transformation.

Interpretation (X-ray Film): The study of a radiograph, the interpretation of that which is seen, and the integration of the findings with the case history, laboratory, and clinical examinations, to arrive at a diagnosis. The dentist does not "diagnose" the radiograph; rather, he or she studies and interprets its image.

Interproximal Radiograph (Bitewing Radiograph): A special type of intraoral radiograph for depicting interproximal features of the teeth and interdental bone crests, made on a film positioned by special (bitewing) tabs on which the patient's teeth are closed.

Intraoral Radiograph: Radiograph produced on a film placed intraorally to the teeth.

Inverse Square Law: A law that states that in either vacuum or matter, radiation intensity decreases with distance from the source. In the case of a true point source, the reduction is inversely proportional to the square of the distance from the source. In the case of sources of finite size, the decrease of intensity is less rapid, particularly in the vicinity of the source.

Inverse Square Law of Radiation: The intensity or exposure rate of radiation at a given distance from the source is inversely proportional to the square of the distance.

Ion: An atomic particle, atom, or chemical radical bearing an electrical charge, either negative or positive.

Ionization: The process or the result of a process by which a neutral atom or molecule acquires either a positive or a negative charge.

Ionizing Radiation : Electromagnetic radiation (e.g., x rays or gamma rays) or particulate radiation (e.g., electrons, neutrons, and protons) capable of ionizing air directly or indirectly.

K Electron: an electron having an orbit in the K shell, which is the first shell of electrons surrounding the atom's nucleus.

keV: The symbol for 1000 electron volts.

Kilo (k): a prefix representing 1000.

Kilovoltage (in x=ray machines): The potential difference between the anode and the cathode of an x-ray tube.

Constant Potential Kilovoltage: The potential formed by a constant voltage generator expressed as constant potential kilovolts (kVcp).

Kilovoltage Peak (kVp): The crest value (in kilovolts) of the potential difference of a pulsating-potential generator. When only half of the wave is used, the value refers to the useful half of the cycle.

Lamina Dura: The thin plate of dense or compact bone that lines the tooth sockets; it appears on a radiograph as a fine radiopaque line passing around the tooth.

Latent Image: The invisible change produced in a photographic or x-ray film emulsion by the action of x radiation or light, from which the visible image is subsequently developed and fixed chemically.

Latent Period: The period between the time of exposure of tissue to an injurious agent (e.g., radiation) and the clinical manifestation of a particular response.

Lateral Jaw Projection: An examination in which the film is placed adjacent to the ramus or the body of the mandible, with the rays directed obliquely upward from the opposite side and the central beam directed at the point of interest. The vertical angulation is such that it casts the image of the near mandible superior or anterior to the area of interest.

Lateral Skull Projection: An examination in which the film is placed parallel to the sagittal plane of the head with the rays directed at right angles to the plane of the film and the sagittal plane; the entire skull is shown.

Latitude, Film Exposure: The range between the minimum and maximum radiation exposures that yields diagnostically useful images of structures.

Latitude, Object: The range between the maximum and minimum object densities recorded on a radiograph.

Leaded Apron: A lead-impregnated rubber apron that provides protection for patients and personnel from radiation.

Leukemia: A disease in which there is great overproduction of white blood cells, or a relative overproduction of immature white cells, and great enlargement of the spleen. It can result from exposure to ionizing radiation.

Line Focus: A principle employed in the design of x-ray tubes, by which the effective focal spot (*q.v.*) is sharply reduced relative to the actual focal spot.

Localization: The making of a radiograph for the purpose of identifying a site in relation to surrounding tissues.

Magnification, Radiographic: The enlargement or distortion of a radiographic image recorded on film emulsion, minimized by reducing the object-to-film distance, and increasing the focus-film distance.

Maximum Permissible Dose (MPD): For radiation workers, 50 mSv per year is permissible. The MPD is the maximum dose of radiation that, in view of present knowledge, would not be expected to produce significant radiation effects.

Mesial: Toward the center of the dental arch.

Milliampere (mA): Electrically, the milliampere is 1/1000 of an ampere (*q.v.*). In radiography, milliamperage refers to the current flow from the cathode to the anode, which, in turn, regulates the intensity of radiation emitted by the x-ray tube and, hence, directly influences the radiographic density.

Milliampere-Seconds (mAs): The product of the x-ray tube operating amperage and exposure time, in seconds.

Millirad (mrad): One-thousandth of a rad.

Millirem (mrem): One-thousandth of a rem.

Milliroetgen (mR): One-thousandth of a roentgen.

Molecule: The smallest quantity of matter that can exist by itself and retain its chemical properties; it is composed of one or more atoms.

Monochromatic Radiation: Electromagnetic radiation of a single wavelength.

Mutation: A departure from the parent type, as when an organism differs from its parents in one or more heritable characteristics, as a result of genetic change.

Neutron: An elementary particle having no electrical charge. The neutron is a constituent of the nucleus of all atoms except hydrogen.

Nucleus, Atomic: The small central part of an atom containing the protons and neutrons; most of the atomic mass is concentrated here.

Object-to-Film Distance (OFD): Distance between the object or skin and the cassette or film.

Oblique: An angular view of a surface or object.

Occlusal Plane: The plane of the masticating surfaces of the molar and bicuspid teeth when the maxilla and mandible are closed.

Occlusal Radiograph: a radiograph made with a film designed for placement between the occlusal surfaces of the teeth, with the x-ray beam directed caudad or cephalad.

Orbital Electron: An electron that is moving in an orbit around the nucleus of an atom.

Osteoradionecrosis: Damage and death of normal bone, which may result from a curative dose of radiation used in the treatment of malignant or nonmalignant disease.

Overdevelopment: Permitting the film to remain in the developer beyond the normal or preset time. This decreases radiographic contrast and increases radiographic density.

Oxidation: A chemical reaction in which an electron is removed from an atom.

Pantomography: A method of radiography by which continuous radiographs of the maxillary or mandibular dental arches and their associated structures may be obtained.

Paralleling (Right-Angle) Technique: The production of a radiographic exposure of intraoral film whereby the plane of the film packet is made parallel to the long axis of the tooth being radiographed. The central beam axis or "central ray" of the x ray is directed at right angles to both.

Penetrability: The ability of a beam of x radiation to pass through matter; kilovoltage and filtration determine the degree of penetrability.

Penumbra: The secondary shadow that surrounds the periphery of the primary shadow; the term pertains to the shadow proper. a penumbra is the ill-defined margin or shadow produced by light. In radiography, it is the blurred margin of an image detail, also called geometric unsharpness.

Periapical Radiograph: A radiograph made by intraoral placement of film for recording shadow images of the outline, position, and mesiodistal extent of the teeth and surrounding tissue.

Photoelectric Effect: The ejection of bound electrons by an incident photon such that the whole energy of the photon is absorbed and transitional or characteristic x-ray emissions are produced.

Photoelectron: An electron emitted from a substance under a stimulus or other radiation of appropriate wavelength.

Photon: A quantum of electromagnetic radiation.

Position Indicating Device (PID): A device usually composed of a plastic ring through which a metal rod can be placed to assist in properly aligning the cone and film.

Preservative: A chemical that inhibits oxidation of the reducing agents by air. Sodium sulfite is the chemical usually employed as a preservative.

Projection: A term for the position of a part of the patient with relation to the x-ray film and the x-ray beam.

Protective Barrier: A barrier of radiation absorbing material(s) used to reduce radiation exposure.

Primary Protective Barrier: A barrier sufficient to attenuate the useful beam to the required degree.

Secondary Protective Barrier: Barrier sufficient to attenuate the scatter or secondary radiation to the required degree.

Proton: An elementary nuclear particle with a positive electric charge.

Proximal: Nearest; closest to a point of reference.

Quality Assurance: Maintaining optimal function and, therefore, results of an operation. In radiology this refers to mechanisms to assure continuously optimal functioning of both technical and operational aspects of radiologic procedures- to produce maximal diagnostic information while minimizing patient exposure to radiation.

Quality Factor (QF): The linear-energy-transfer-dependent factor by which absorbed doses are multiplied to obtain (for radiation protection purposes) a quantity that expresses the effect of the absorbed dose on a common scale for all ionizing radiations.

Rad (Radiation Absorbed Dose; Roentgen Absorbed Dose): A unit of measurement for the absorbed dose of any type of ionizing radiation in any medium. One rad is the energy absorption of 100 ergs (*Cf.* Gray).

Radiation: The emission and propagation of energy, in the form of waves or particles, through space or a material medium.

Radiation, Actinic: Radiation that can produce photochemical effects, such as the production of a latent image in a film emulsion by visible light or x rays.

Radiation Burn: A burn caused by overexposure to radiation energy.

Radiation Dermatitis: Inflammation of the skin resulting from a high dose of radiation. The reaction varies with the quality and quantity of radiation used and is usually transitory.

Radiation Sickness: A syndrome associated with exposure to ionizing radiation that may result in nausea, vomiting, and diarrhea; later symptoms include malaise, depression, epilation. purpura, hemorrhage, fever,and emaciation.

Radiobiology: That branch of biology dealing with radiation effects on biologic systems.

Radiograph: A visible image on a radiation-sensitive film emulsion to ionizing radiation that has passed through an area, region, or substance of interest.

Radiographic Survey: A series of radiographic projections constituting a study.

Radiography: The technical process of positioning, exposing, and processing radiographs.

Radiologic Health: The art and science of protecting humans from injury by radiation, as well as of promoting better health through beneficial applications of radiation.

Radiolucency: The appearance of dark images on film owing to the greater amount of radiation that penetrates the structures and reaches the film.

Radiolucent: Permitting the passage of x rays with relatively little attenuation by absorption.

Radiopacity: The appearance of light images on film owing to the lesser amount of radiation that penetrates the structures and reaches the film.

Radiopaque: A structure that strongly inhibits the passage of x rays.

Radiosensitivity: Relative susceptibility of cells, tissues, organs, organisms, or any substances to the injurious action of radiation.

Rare Earth: Commonly used to refer to intensifying screens that contain one or more of the rare-earth elements and that use the absorption and conversion features of these elements in x-ray imaging. May also refer to a screen-film system used for x-ray imaging. These systems are considered "fast" exposure systems.

RBE (Relative Biological Effectiveness): A factor used to compare the biologic effects of absorbed dosages of differing types of ionizing radiation in a particular organism or tissue. The standard of comparison is medium voltage x rays delivered at about 10 rad/min. The unit of RBE is the rem (q.v.).

Rectification: Conversion of alternating current to direct current.

Full-Wave Rectification: Conversion of the entire wave of an alternating current to a direct current.

Half-Wave Rectification: conversion of half of the sine wave of an alternating current to a direct current.

Self-Rectification: rectification of half of the sine wave of the alternating current across an x-ray tube as a result of the absence of electron emission at the anode.

Relative Risk: The ratio of the risk of biologic harm; in those exposed, to the risk, in those not exposed, to radiation.

REM (Roentgen-Equivalent-Man): A unit of dose of any radiation to body tissue, expressed in terms of its estimated biologic effects relative to an exposure of 1 roentgen of gamma or x radiation.

Resolution (Image): The discernible separation of closely adjacent image details. In optics to separate and make visible the parts of an image.

Reticulation: A network of corrugations in the emulsion of a radiograph as a result of too great a difference in temperature between any two of the three darkroom solutions.

Roentgen(R): An international unit of exposure based on the ability of radiation to ionize air,ions carrying 1 electrostatic unit of quantity of either positive or negative electricity. (2.083 billion ion pairs).

Roentgen, Wilhelm C.,: The discoverer of x rays on November 8, 1895; he observed that a Crookes' vacuum tube operating at high voltage caused a piece of barium platinocyanide lying a few feet away from the tube to glow in the dark. Dr. Roentgen, a physicist, is known as the "Father of X rays."

Safelight: Special lighting used in the darkroom that permits film to be transferred from cassette to processor without fogging.

Scattered Radiation: Radiation that during passage through a substance, has been deviated in direction. It may also have been modified by an increase in wavelengths. It is one form of secondary radiation (*q.v.*).

Secondary Ionization: Particles, usually electrons, ejected by recoil when a primary ionizing particle passes through matter.

Secondary Radiation: Particles or photons produced by the interaction of primary radiation with matter.

Sharpness (Image): The ability of an image to demonstrate an interface line as one-dimensional.

"Soft" Radiation: X rays of relatively long wavelength with relatively little penetrating ability.

Source: The point of emanation of gamma or x rays when used as an origin of radiation.

Spatial Resolution: The smallest distance between two points in an object that can be distinguished as separate detail in the image; generally indicated as a number of black and white line-pairs per millimeter.

Speed, Film: Speed in radiography refers to the relative amount of darkening produced on a film (with reference to film or screen characteristics) from a given amount of radiation. Speed and sensitivity may be used interchangeable. Officially, the speed of a film system is defined as the reciprocal of the exposure in roentgens required to produce a density of 1.0 above base plus fog density. The measurement unit of film speed is R^{-1}.

$$\text{Speed} = \frac{1}{\text{roentgens}}$$

Speed of Light: Light travels 186,000 miles/sec. All electromagnetic radiation travels at the speed of light.

Speed of X rays: X rays travel at the speed of light, 186,000 miles/sec, or at 3×10^8 meters per second in a vacuum.

Static Marks: marks on a radiograph resembling small streaks of lightening; they result from static electricity that occurs when the film is removed from the wrapper paper or when films are separated after being piled on top of one another.

Step-Down Transformer: This transformer produces a lower voltage output by stepping down the input voltage. Stepping down the voltage results in a step up in amperage because the power input is equal to the power output. The filament transformer of the x-ray circuit is a step-down transformer.

Step-Up Transformer: This transformer produces a higher voltage output than the input by stepping up the output voltage. Stepping up the voltage results in a step down in amperage because the power input is equal to the power output. The high-voltage transformer of the x-ray circuit is a step-up transformer.

Stop Bath: a solution of water and acetic acid used between the developer and the fixer that stops the development of the film.

Tank, Processing: Metal tanks used to hold processing solutions. Constructed of stainless steel to resist corrosion an permit rapid equalization of temperature control. The outside walls of the tanks are insulated to prevent condensation of moisture and maintain temperature control.

Target: The area on the anode subject to electron bombardment, usually consisting of a tungsten insert on the end face of a solid copper anode.

Target-Film Distance (TFD): This is the same as focal-film distance (FFD), in that it is the distance from the focal spot of the x-ray tube to the x-ray film.

Thermionic Emission: The release of electrons from the cathode filament by heating.

Timer: A switch mechanism used to complete the electrical circuit to produce x rays for a predetermined time.

Electronic Timer: A timer that functions through a mechanical clock mechanism.

Hand Timer: An attachment to or part of a timer that requires thumb or finger pressure to actuate the timing device.

Mechanical Timer: A timer operated by a spring mechanism.

Tissue: An aggregation of similarly specialized cells united in the performance of a particular function.

Tumor: 1) A swelling; a morbid enlargement of tissue. 2) A neoplasm; a mass of new tissue that persists and grows independently of its surrounding structure and that has no physiologic function.

Ultraspeed Film: Direct exposure film with a speed category of approximately 15 R^{-1}.

Umbra: A complete shadow produced by light, with sharply demarcated margins. In radiography, a sharply delineated image detail.

Underexposed: A condition of a radiograph in which the image displays insufficient silver deposits.

Volt: The unit of electrical pressure or electromotive force necessary to produce a current of 1 ohm.

Electron Volt: The kinetic energy gained by an electron in falling through a potential difference of 1 volt; 1.6 X 10-12 ergs.

Wave, Electromagnetic: Energy manifested by movements in an advancing series of alternating elevations and depressions.

Wavelength: The distance between the peaks of waves in any waveform, such as light, x rays, and other electromotive forms; also the distance from any point on a wave to the identical point on an adjacent wave. In electromagnetic radiation, the wavelength is equal to the velocity of light divided by the frequency of the wave.

Wetting Agent: A solution used in film processing, it follows the washing process to accelerate the flow of water from both film surfaces and to hasten the drying of radiographs.

Whole-Body Radiation: Exposure of the entire body to radiation.

X ray: A type of electromagnetic radiation characterized by wavelengths of 100 angstroms or less.

X-ray Beam: The radiation emerging from an x-ray generator or source.

X-ray Spectrum: A portion of the electromagnetic spectrum with photon energies greater than 100 eV.

X-ray Tube: An electronic tube in which x rays are generated.

Coolidge Tube: A vacuum tube in which x rays are generated when the target (integral with the anode) is bombarded by electrons emitted from a heated filament and accelerated toward the anode across a high potential difference.

Crookes' Tube: A vacuum discharge tube developed by Sir William Crookes in early experimental work with cathode rays. Wilhelm Roentgen first discovered that, in addition to the production of cathode rays, x rays were emitted during the operation of these tubes.

Gas Tube: An early type of x-ray tube in which electrons were derived from residual gases within the tube.