DENTAL RADIOGRAPHER STUDY GUIDE

History

Professor Wilhelm Conrad Roentgen was awarded the first Nobel Prize in Physics in 1901, for the discovery of the x-ray, November 8, 1895, in Germany.

Professor Roentgen was duplicating an experiment that consisted of passing an electric current through a vacuum tube to test its fluorescence on a piece of photographic plate. The room was darkened and the current was passing through the tube, when to his amazement, Professor Roentgen noticed that the photographic plate on the other side of the room was glowing. As he passed between the plate and the tube he could see his shadow upon the cardboard. He picked up the plate and noticed the shadow of his hand on its surface. The bones appeared much darker than the soft parts of the hand. These rays were remarkably different from cathode rays and he determined that they emanated from the point of impact of the cathode rays against the glass wall of the vacuum tube.

Roentgen, being unable to determine the exact nature of his new ray called it the x-ray, the letter "x" traditionally representing an unknown. Based on Roentgens discovery, this new ray or the x-ray has the following properties:

- Passes through opaque substances
- Travels in rectilinear straight lines
- Cannot be deflected by a magnet
- Lies outside the visible spectrum
- Can cause fluorescence on a photographic plate

General Principle

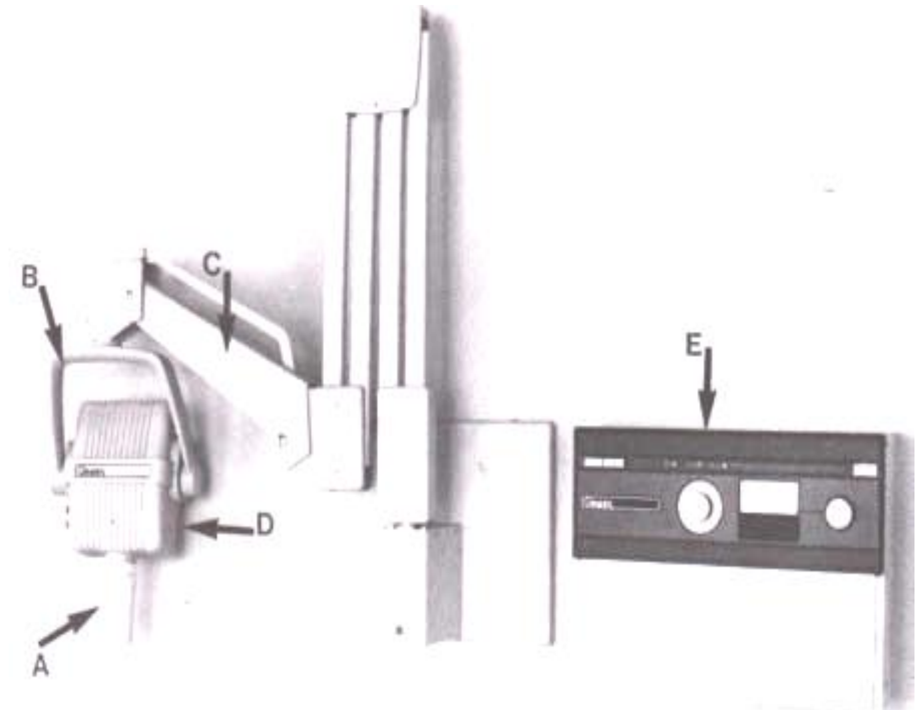
X-rays are produced when high speed electrons (cathode rays) are suddenly stopped. The cathode rays strike the wall, the glass tube, and give up their energy in the form of a completely new ray – the x-ray.

Equipment

X-ray Machine (see diagram on next page)

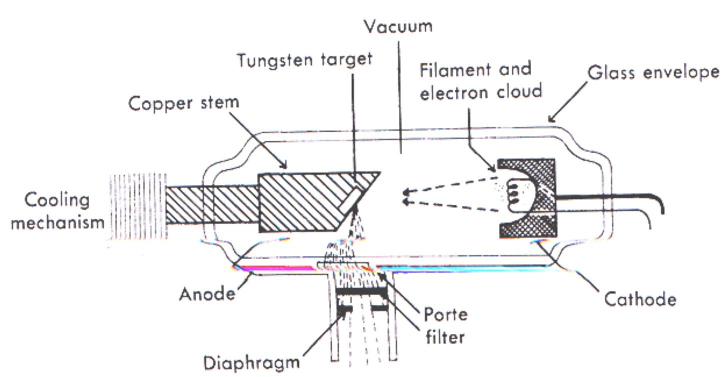
1. Control Panel – controls for the x-ray machine are located here.
    a. On/off switch – turns machine on/off and may control a light switch to indicate machine is turned on.
    b. Kilovolt peak selector (kVp) – determines the peak voltage at which the machine operates. Most machines are operated at settings of 65 – 90 kVp. As the setting increases, the penetrating power of the x-ray beam increases.
    c. Voltmeter – measures and indicates kilovolts during each exposure.
    d. Milliamperage (mA) control determines the amount of radiation produced during each exposure. Dental x-ray machines operate at 10 or 15 mA. More radiation is produced at 15 mA than at 10 mA.
2. Adjusting arm – allows large movements of the tube head.
3. Tube Head – produces the x-ray beam.
4. PID (position indicating device) – attached to the tube head assists in aiming the x-ray beam. PIDs may be round or rectangular and should be lead lined and open ended. Could be short or long.
5. Activation Button – may be located at the end of a cord or mounted in a lead lined wall outside the x-ray room. It must allow the operator to stand a minimum of 6 feet away from the patient.

DENTAL X-RAY MACHINE



Dental x-ray machine A, Position indicating device; B, Yoke; C, Arm; D, Tube head; E, Control panel

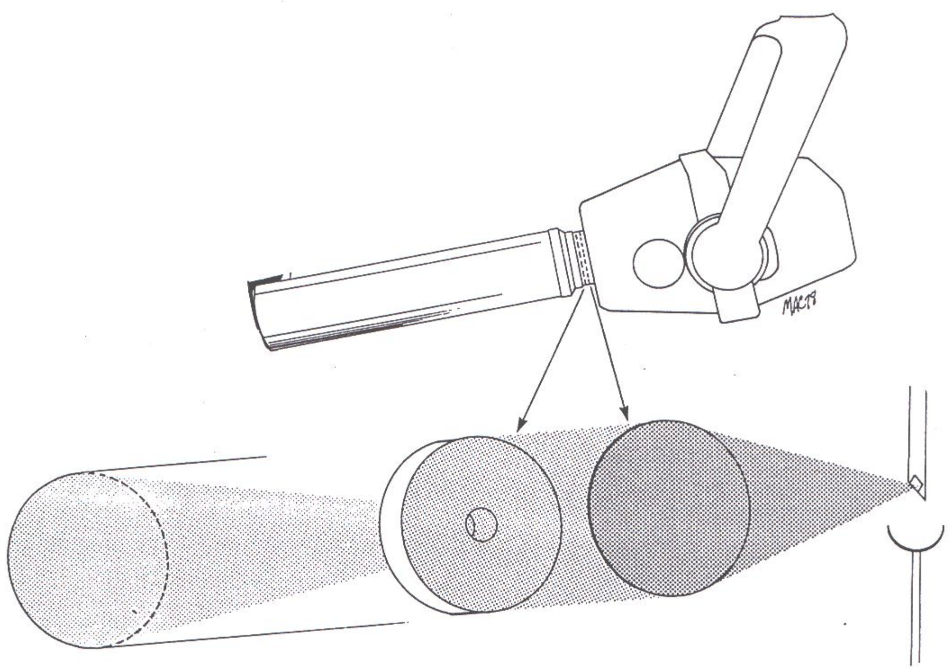
TUBE HEAD



X-ray Tube Head (see diagram on page 2)

1. Cathode (-) is a negative electrode. Electrons are produced at the cathode and used in the production of x-rays.
2. Tungsten Filament - a thin, coiled tungsten wire mounted on two wires and provide electricity. Electrons emitted from the filament are used in the productions of x-rays.
3. Focusing Cup – contains the tungsten filament and focuses its electrons into a narrow beam directed at the focal spot or target located on the anode.
4. Anode (+) – is a positive electrode. The energy of the electrons produced by the cathode are converted to x-ray and heat energy when they strike the target in the anode.
5. Tungsten Target - the area on the anode that the electrons strike. The target converts the kinetic energy of the electrons into x-ray energy. Less than 1 % of the kinetic energy is converted to x-rays and the rest becomes heat.
6. Aluminum Filter – an aluminum disk placed in the path of the x-ray beam to absorb low energy x-rays that do not have the penetrating power to pass through anatomic structures and reach the film. Without this filtration, these x –rays would remain and cause an increase in the amount of radiation absorbed by the patient. Federal regulation requires that the disks be 2.5mm thick.
7. Lead Diaphragm or Collimator – also reduces patient exposure to radiation by limiting the size of the area exposed. The device which collimates the x-ray beam in dental x-ray machines is the lead diaphragm, a flat lead disk with a small opening at its center through which radiation passes. It is located at the end of the PID that attaches to the tube head. It may be round or rectangular depending on the shape of the PID.

Aluminum Filter



Aluminum Filter – disk between tube head and PID. Illustrates the function of the filter and collimator. The entire beam passes through the aluminum filter to remove long, useless wavelengths of x-rays. Collimator then determines the size and shape of the beam.

Dental Radiographic Practice

Production of X-rays

1. X-rays are produced in the tube head in the following sequence. When the x-ray machine is turned on, electricity flows through the filament circuit, heating the tungsten target.
   Note: The amount of electricity flowing through the circuit is controlled by the milliamperage control knob**.** Dental x-ray machines operate at either 10 or 15 mA. At 15 mA, more current flows through the circuit than at 10 mA, and the filament becomes hotter.
2. When the filament is heated, it emits electrons by thermionic emission. Emitted electrons are replaced because the negative side of the high voltage circuit is connected to one of the filament mounting wires. The emitted electrons form a cloud around the filament.
   Note: At higher filament temperatures, more electrons are emitted. If there are more electrons, more x-rays will be produced. Therefore, milliamperage controls the temperature of the filament, the number of electrons emitted, and the number of x-rays produced.
3. When the activating button is pushed, the anode – cathode circuit is activated and the anode(+) and cathode (-) are charged. The amount of charge is controlled by the kilovoltage setting.
4. The negatively charged electrons are repelled from the cathode (-) and travel at high speeds across the x-ray tube.
5. The focusing cup directs the electrons in a narrow beam at the focal spot or target located on the anode.
6. When the electrons strike the anode(+) at the tungsten target, their kinetic energy is transformed into heat and x-ray energy.
   Note: The amount of charge to the anode and cathode is controlled by the kilovoltage setting. At higher settings, the charge is greater. The electrons travel at higher speeds and strike the target with more force, creating more powerful x-rays with shorter wavelengths.
7. The angle of the target projects the x-rays out of the tube through a thinner area of glass called the porte. The x-ray tube head is lead lined, preventing x-rays from exiting the tube head at any point except the porte.
   Note: The tungsten target is angled to project a smaller effective focal spot than the actual focal spot (the target) where the x-rays are produced. This enhances the sharpness of the image and allows the heat generated by x-ray production to be dissipated over a large area.
8. The aluminum filter removes low energy x-rays from the x-ray beam.
9. The lead diaphragm and PID collimate the x-ray beam, reducing the area exposed to radiation.

Quality

The quality or penetrating power of the x-ray beam is controlled by the kilovoltage setting. The x-ray beam must have sufficient power to demonstrate the different densities of objects on film. (enamel, decay, fillings)
It should pass through less dense objects while it is increasingly absorbed by objects of increasing density. At higher kilovoltage settings , the x-ray beam has more penetrating power. Settings from 65 to 90 kVp are used in dental radiography.

Dental radiographs are black and white images of dental structures. The varying shades of gray in the images demonstrate the scale of contrast of the film**.** Films exposed at lower kilovoltage settings do not demonstrate many variations in radiation absorption. They exhibit fewer shades of gray and therefore have a short scale of contrast**.** Films exposed at higher kilovoltage settings demonstrate many variations in radiation absorption by structures. They exhibit many shades of gray and have a long scale of contrast.

Quantity

The quantity of x-rays produced by the x-ray machine is controlled by the milliamperage and exposure time setting. As exposure time increases, the amount of radiation to which the film and patient are exposed increases. Since both exposure time and milliamperage control the quantity of radiation that is generated, they may be expressed in combination as milliampere-seconds (mAs). It is preferable to use a higher milliamerage setting with a shorter exposure time. This reduces the chances of film or patient movement during the exposure.

The amount of radiation reaching the film influences film density, which is the overall blackness of the film. It is measured by the amount of light which may be transmitted through the processed film. Density increases as the amount of radiation increases.

Radiation Biology

Biology

Ionization – the primary manner in which x-rays damage biological tissues is through the process of ionization.

Exposure - a measurement of the quantity of radiation to which an object or organism is subjected. Some of this radiation will be absorbed, and some will pass through the organism. Exposure is measured by identifying the amount of the ionization in air produced by x or gamma radiation.

Dose – The amount of energy absorbed per unit of tissue. The dose of ionizing radiation absorbed by human tissue is important in dental radiography because it is responsible for biological damage as a result of tissue exposure to radiation.

Units of Radiation Measurement

Roentgen (R) is a unit of radiation exposure. It should not be spoken of as a dose because radiation does not become a dose until it is absorbed.

Rad (rad) is the unit for absorbed dose.

Rem (rem) is the unit of dose equivalent and refers to the occupational dose received by radiation workers.

Types of exposure

Threshold exposure – the minimum exposure that will produce an effect on an individual.

Acute exposure – rapid delivery of radiation in one dose over several days or 2 –3 weeks.

Chronic exposure – repeated exposure over a long period of time – months or even years. This is the type of radiation that is the most concern to dental radiographers. Chronic exposure can be represented by a person who perhaps has a BWX series every six months for 30 years.

Localized Exposure vs. Total Body Exposure

A small volume of tissue can withstand much larger doses of radiation than total body exposure. For example **600R** may be given to a cancer patient on a specific body part to reduce a tumor size, but if given total body it is a lethal dose.

In dental radiography we use a collimator beam of 2 ¾in. - this is a very localized beam. Total body exposure of dental radiographs is 1/10,000 of the facial exposure.

Example: if an FMX gives a patient a localized dose of 3 R, their total body exposure equals 3/10,000 R.

Doses

The following are biological changes that can or will occur at a given dose:

Dose	Causes
50R	Temporary redness of skin
75R	Blood Changes
150R	Radiation sickness (total body exposure)
250R	Gonadal Sterility
400R	Lethal Dose (50% chance of death)
600R	Fatal to all humans (total body exposure)

Tissue Sensitivity

The amount of somatic and genetic biological damage that a human being suffers as a result of radiation exposure depends upon:

1. The quantity of ionizing radiation to which the subject is exposed. (acute vs. chronic)
2. The ability of the ionizing radiation to cause ionization of human tissue.
3. The amount of body area exposed (local vs. total body).
4. The specific parts of the body exposed (radiosensitive vs. radioresistant).

Radiosensitive	Radioresponsive	Radioresistant
blood cells	skin glands	muscle
reproductive cells	glands	nerve
young bone		mature bone

Concept: Young, rapidly dividing cells are the most radiosensitive.

X-ray Protection

Patient

1. Fast film – the use of fast film is considered the single most effective method of reducing the patient's exposure to x-rays.
2. Filtration – removes useless x-rays from the x-ray beam – these useless rays would contribute to the dose of radiation. Aluminum filters are placed over the beam's exit porte in the head of the machine. Proper filtration is 2.5mm.
3. Collimation – the collimator shapes and reduces the size of the beam and therefore, reduces the amount of tissue being irradiated. Rectangular collimators even further reduce the size of the beam. The average beam is collimated to a circular 2 ¾ " in diameter.
4. Shields - Thyroid or gonad shields should have the equivalent of .25 mm thickness of lead.
5. Film exposure technique – **may be the most important!!** – technical competence of the operator insures "first time" diagnostic quality of the film.

Operator

Sources of x-rays to which the operator may be exposed:

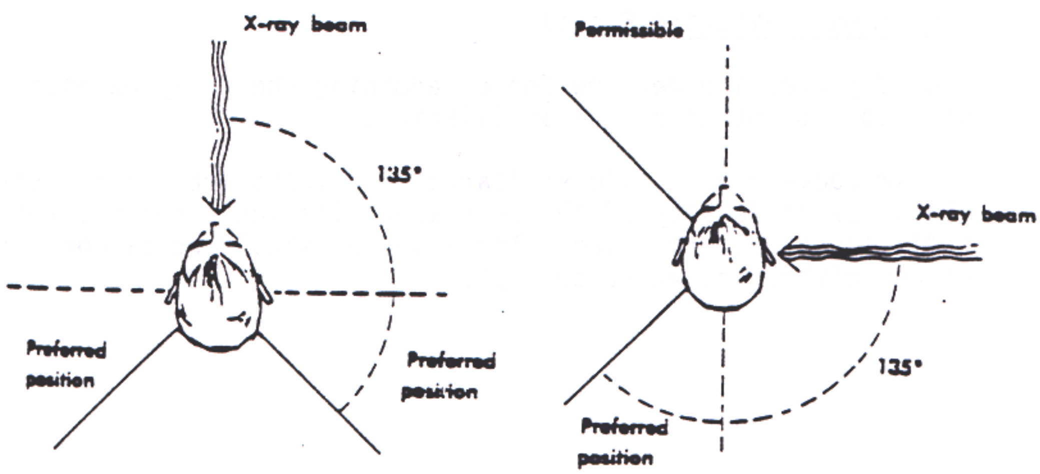
1. Primary x-ray – useful rays that pass through the metal housing at the windows before hitting matter.
2. Scatter radiation – that which results from the interaction with matter.
3. Leakage radiation (housing) – radiation that leaks through the metal housing – very slight.
4. Scatter from filters and cones.
5. Scatter from walls and furniture.

Distance

A minimum distance **<u>of 6 feet away</u>** from the major source of radiation is imperative.

Position

In addition to standing 6 feet away the operator may further reduce exposure by standing 90 – 135 degrees to the x-ray beam.



Positions of greatest safety for dental x-ray machine operators during exposure

Shields

The operator should stand behind a <u>1mm thick</u> lead shield wall to effectively stop all scatter radiation.

Environs

The patient should be positioned that the x-ray beam is aimed at a wall of the room and <u>not</u> through a door or other opening where people are located.

Surveys

The exposure of the environs to x-ray is best established through a radiation survey of these areas. People in adjacent rooms or corridors may be unnecessarily exposed if the x-rays are able to penetrate the walls of the operatory.

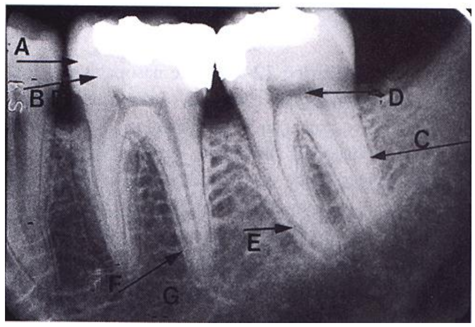
Radiation Monitoring Badges

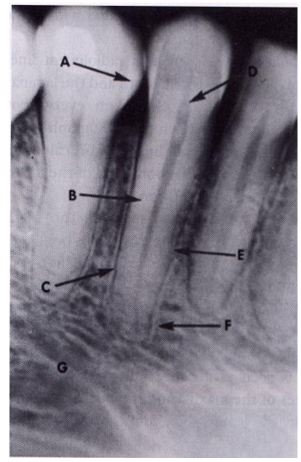
A good protective measure for determining the x-ray exposure of operators or other dental auxiliaries.

A film badge uses a film similar to the intra oral film – the blackness or density of the processed film indicates the amount of radiation it has received. These badges should be clipped somewhere around either the waist or hips.

Radiographic Anatomy

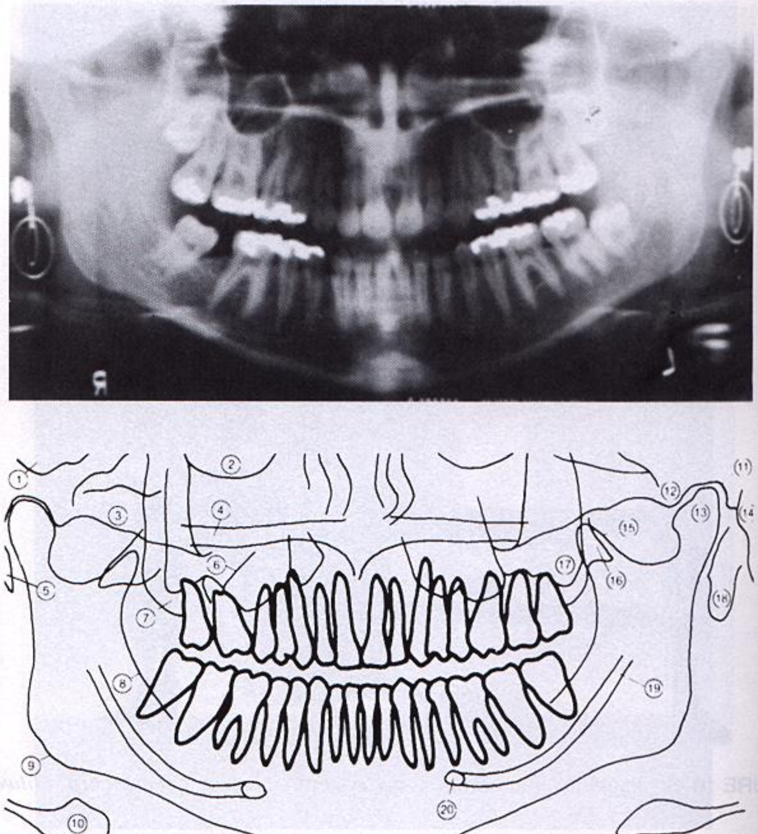
Tooth Structure





a. enamel
b. dentin
c. periodontal ligament
d. pulp cavity
e. cementum
f. bone

Radiographic anatomy of a panorex (NOT ON TEST)

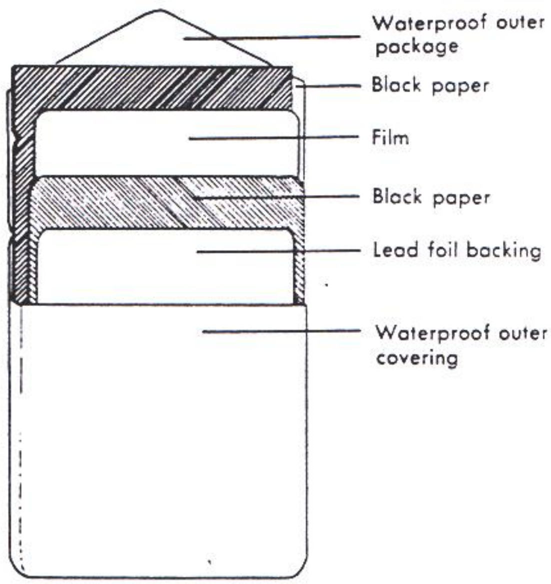


1. Middle Cranial Fossa
2. Orbit
3. Zygomatic Arch
4. Palate
5. Styloid Process
6. Septa in Maxillary Sinus
7. Maxillary Tuberosity
8. External Oblique Line
9. Angle of Mandible
10. Hyoid Bone
11. Glenoid Fossa
12. Articular Eminence
13. Mandibular Condyle
14. Vertebra
15. Coronoid Process
16. Pterygoid Plates
17. Maxillary Sinus
18. Ear Lobe
19. Mandibular Canal
20. Mental Foramen

Radiographic Film

Two Basic Types of Dental Film
1. Non-screen – intraoral (all intra oral film is non-screen) periapicals
2. Screen – Fluorescence – extraoral only (panorex)

Non-screen – Intraoral (Periapical)
Film is exposed directly by ionizing radiation.



Film Packet

a. Two black paper sheets which protect the film
b. Film backed by a thin sheet of lead. This lead acts to:
    1. absorb most of rays that pass through film.
    2. protect the patient.
    3. prevent fogging.
c. Waterproof outer package.

Three types of intraoral film

1. Periapical – shows crown, apex of tooth, and 3-4mm of surrounding bone.
2. Bitewing – commonly referred to as the cavity detecting x-rays. Shows the crowns and interproximal of premolar and molar teeth. Bitewings are also the most accurate radiograph for assessment of bone level.
3. Occlusal – shows large segments of an entire arch on one film.

Screen Film – Extraoral Cassettes (Panorex)

Requires much fewer x-rays to expose film because screens are much more efficient film in absorbing x-rays. The film is exposed by the fluorescing screen, not directly by x-rays.

Film Holders and Aiming Devices

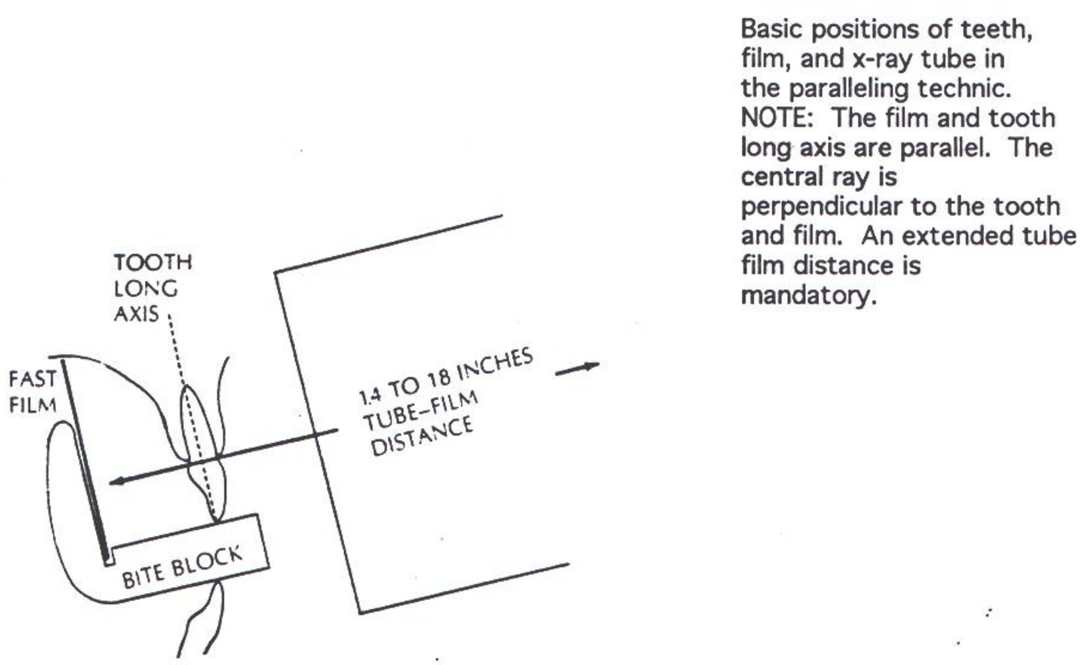
1. Rinn XCP Instrument – bite block with metal indicating arm and aiming ring. When used correctly, the Rinn XCP correctly aligns the film, teeth, and radiation beam for the parallel technique.

Advantages	**Disadvantages**
Autoclavable or disposable	May be assembled incorrectly
Parts may be purchased separately	
Reduces technical errors	

Radiographic Techniques

Paralleling

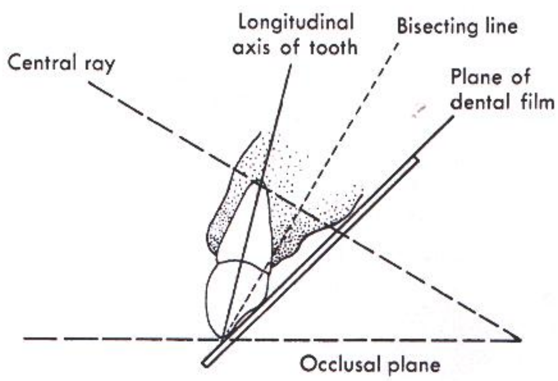
1. Film placed parallel to long axis of tooth.
2. Central ray of x-ray beam is perpendicular to the film (and long axis of tooth).



Paralleling technique

Bisecting Technique

The “rule of isometry” is applied to dental radiography and established that in periapical radiographs “ the central ray must be projected perpendicularly to a plane bisecting the angle formed by the longitudinal axis of the tooth and the plane of the film packet.



Relationship of central ray, tooth, and film packet in bisecting angle technique.

Basic Concepts of Radiographic Development

Latent Image

Radiographs, after having been exposed to ionizing radiation, but before development, contain a latent image. When a beam of x-ray passes through an object, some x-rays are absorbed by the object and some are allowed to pass through and reach the emulsion (which is silver bromide crystals). The silver bromide crystals are said to be sensitized when struck by an x-ray photon. These sensitized crystals are chemically altered to form a image.

Latent image – image on film **before** it is developed, **after** it has been exposed.

Development

The basic purpose of the developer is to act upon only those crystals that have been sensitized by radiation. The developer continues the precipitation of silver in these crystals effectively turning them from shades of gray to completely black – depending on the density of the object. For example, the area of emulsion opposite a gold inlay would receive no sensitization of the silver bromide crystals (no x-rays could pass through the gold, they were absorbed) and therefore no black metallic silver would be deposited in the crystal – they remain essentially undeveloped -essentially a white or clear area on the radiographs. On the other hand, the area of the silver bromide crystals opposite the pulp, would receive a great deal of sensitization, causing the developer to act upon these crystals and fill them with black metallic silver – essentially a dark area on the radiograph.

- Black – sensitized
- Gray – partially sensitized
- White – nonsensitized (not developed)

Fixing

The purpose of the fixer is to remove the unexposed (unsensitized), and therefore undeveloped, silver bromide crystals from the emulsion. The removal of these crystals creates the “white” areas on the film which is more accurately thought of as clear areas – the places on the emulsion where no radiation sensitized crystals. For example, all areas that correspond to silver amalgams appear white or clear, because x-rays were absorbed by the material and therefore, never reached the emulsion to sensitize the crystals.

Processing

Radiographic processing is a chemical reaction that transforms the latent image into a visible image. It may be done manually or automatically.

The Darkroom

1. Overhead white light – this is for illumination of the darkroom. But must be turned off while developing films.
2. Safelight – this is a light equipped with a low-watt bulb and a red or yellow filter to eliminate the blue-green part of the light spectrum to which x-ray film is sensitive. This light should be placed no closer than 3 – 4 feet from the work surface as to not expose the film.
3. Three process – these are usually Developer – Water - Fixer
4. Timer – an accurate timer must be used to determine the correct processing time based on the solution temperature..
5. Film hangers – used to hold films in the processing solutions.

Manual Processing

The time temperature method of film processing is used for manual film processing. The films are placed in the developer and fixer for the manufacturers recommended period of time.

1. Place the radiographs in developer, the films are then rinsed by moving the film up and down in the water bath. This removes the developer from the film and stops further development.
2. The films are next placed in the fixer solution. They will have cleared (lost their cloudy appearance) after being in the fixer.
   Note: Since the crystals can be energized by white light prior to clearing, always check for clearing under a safelight. After the films have been cleared, they may be read, if necessary. This wet reading must be followed by fixing for the remaining amount of time or the quality of the image will deteriorate over time.
3. After fixing, the films are placed in the water bath to remove any remaining fixer solution.
   Note: If the films are not thoroughly washed, residual fixer will stain the films brown over a period of time, reducing the quality of the image.
5. The films are next dried at room temperature or in a drier. They must be dried thoroughly before handling.

Automatic Processing

There are many different models of automatic processors. Simple models have containers of processing solutions and water that require regular maintenance and replenishing. Plumbing is required for more complex models which have constant water flow. Some models automatically replenish the solutions each time a film is processed. Before using an automatic processor, carefully read the manufacturer’s directions.

Automatic Processor Design

While the models may differ, the basic design of automatic processors is the same.

1. The transport system, usually rollers, moves the film along through the chemicals and water bath. Special rollers remove excess chemicals, reduce carry over from one solution to the next, and remove excess water prior to drying.
2. The heater maintains a constant temperature in the developer. Temperatures in automatic processing range from 74º to 105º F depending on the model used.
3. The dryer circulates warmed air around the film to speed drying.
4. The daylight loader attaches to the automatic processor and permits film loading in white light conditions. The top of the daylight loader is a filter similar to the safelight filter. Hands are inserted onto the loader through light tight sleeves. Film unwrapping and loading can be observed through the filter. The risk of cross-contamination is high with the use of daylight loaders. They should only be used with film wrappers that are removed before the films are placed in the daylight loader

Supplemental Techniques

Steps in mounting

1. Place all films with raised dot towards the operator.
2. Determine if radiograph is of maxillary or mandibular area.

Maxillary	Mandibular
Sinus	2 rooted molars
3 rooted molars	Border of mandible

2. Position films with apices of teeth pointed upward for the maxilla and downward for the mandible.
3. To identify right and left of maxillary or mandibular films, identify which lateral border of the radiograph is the mesial border and which is the distal border.
4. Determine whether the radiograph shows the incisor, cuspid, bicuspid, or molar region. From this you can tell right, left, mandible, and maxilla.
5. Place the film in its respective position in the film mount.

Infection Control

The following is a general guideline that includes procedures for optimal infection control for exposing and processing dental radiographs.

Getting the film

Dental films should be stored in wall-mounted dispensers or a film drawer. Be sure to use clean gloves before touching film supply.

Film Packets

1. After exposure of radiograph, carry radiograph in a cup to the darkroom.
2. With gloves on, open film packet in such a manner that you can "drop" the film onto a clean paper towel without touching it.
3. Remove gloves and wash hands.
4. Process films using standard technique.

Exposing the film

The head and cone of the x-ray machine should be covered with a thin sheet of plastic – usually a bag. This material should be changed between patients.

The control panel and/or exposure switch also should be covered with plastic.

Processing the film

Assuming you are using vinyl barriers, set the envelopes on a paper towel next to a new clean cup and wipe off any excess fluids. Open vinyl envelope with steady light pull – allow the film packet to drop out.

Do not touch the outside of the paper cup with your gloves on. Remove gloves, wash hands, and carry paper cup to the processor. Open packets in the dark and process the series.

Radiographic Film Errors (NOT ON TEST)

ERROR	CAUSES	REMEDY
MISSES APEX	1. Under angulation of vertical angle	1. Increase vertical angle
OVERLAPPING	1. Incorrect horizontal angle	1. Direct central ray between interproximal spaces
PARTIAL IMAGE	1. Cone-cut 2. Incompletely immersed in processing tank 3. Film touched other film or side of tank while processing	1. Cover area of interest with cone of radiation 2. Check level of developer 3. Keep film racks separate and away from walls and other films
BLURRED IMAGE	1. Film movement 2. Patient movement 3. Tube movement	1. Be sure film is stabilized in position 2. Instruct patient to keep still 3. Steady tube head before exposure
DOUBLE IMAGE	1. Film exposed twice to same or different area	1. Place exposed film in a cup after use
STRECHED APPEARANCE	1. Excessive bending of film to accommodate arch	1. Keep film as parallel as possible with minimal bleeding
FORESHORTENING	1. Excessive overangulation of vertical angle	1. Reduce vertical angle
ELONGATION	1. Underangulation of vertical angle	1. Increase vertical angle
CLEAR FILM/NO IMAGE	1. Film not exposed to x-radiation 2. Machine malfunction 3. Failure to turn on machine 4. Film placed in fixer before developer	1. Be sure film is radiated before developed 2. Have machine tested and repaired 3. Turn on machine 4. Review darkroom procedures
FOGGED FILM	1. <u>CHEMICAL FOG</u> a. Developer temp too high b. Overstrength developer c. Prolonged development d. Contaminated developer 2. <u>LIGHT FOG</u> a. Darkroom light leak b. Improper safelight c. Improper filter in safelight d. Turning on overhead light e. Prolonged exposure to safelight	1. Follow manufacturer's time/temp method 2. Check doors and walls for leaks. Check types of filters in safelight and check for cracks. Reduce exposure time of films to safelight.
DENSITY TOO DARK	1. Excessive exposure time/ mA too high 2. KvP too high 3. Developer too warm 4. Complete exposure to white light	1. Decrease mA 2. Decrease KvP 3. Decrease developer temperature 4. Practice good darkroom techniques
DENSITY TOO LIGHT	1. Underexposure a. Inaccurate timer b. Wrong setting time 2. Insufficient development 3. Solutions too cool 4. Use of old r poorly mixed solutions 5. Use of old film 6. Herringbone pattern	1. Have x-ray machine tested. Depress button completely and firmly. Use correct exposure time 2. Properly develop films 3. Regulate temperature of solutions 4. Change solutions and clean tanks 5. Do not use outdated films 6. Don not place film backwards
INCISAL OR OCCLUSAL EDGE/SURFACE MISSING	1. Overangulation of vertical angle	1. Use proper vertical angle
BLACK LINES/WHITE LINES	1. Crimping films	1. Do not crease film in attempt to accommodate oral cavity