DOCUMENT RESUME

ED 331 962 CE 057 840

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|---|---|
| TITLE | Dental Radiology I Student Guide and Instructor Guide . |
| INSTITUTION | Fox Valley Technical Coll., Appleton, WI. |
| SPONS AGENCY | Wisconsin State Board of Vocational, Technical, and Adult Education, Madison. |
| PUB DATE | 89 |
| NOTE | 130p. |
| PUB TYPE | Guides - Classroom Use - Instructional Materials (For Learner) (051) -- Guides - Classroom Use - Teaching Guides (For Teacher) (052) |
| EDRS PRICE | MF01/PC06 Plus Postage. |
| DESCRIPTORS | *Dental Technicians; *Dentistry; Measurement Equipment; *Radiologic Technologists; *Radiology; Study Guides; Teaching Guides; Two Year Colleges |

ABSTRACT

The dental radiology student and instructor guides provide instruction in the following units: (1) x-ray physics: (2) x-ray production; (3) radiation health and safety; (4) radiographic anatomy and pathology; (5) darkroom setup and chemistry; (6) bisecting angle technique; (7) paralleling technique; (8) full mouth survey technique--composition and film mounting; (9) special radiographs--extraoral radiographs, child patient, and edentulous patient; and (10) radiography practicum. Each unit in the student guide contains some or all of the following: an overview, a study guide, a lecture outline, and information sheets. The instructor's guide contains the following sections: (1) orientation; (2) course description; (3) course content outline; (4) course tasks and objectives list; (5) media list; and (6) a checklist for bias-free curriculum materials. (NLA)

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Dental Radiology I Student Guide

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# INTRODUCTION

## NOTICE OF COPYRIGHT

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**This Curriculum Is Bias Free.**

# STUDENT ORIENTATION

## Textbook and Learning Methods

Your text contains the majority of information you will be learning in the course. Course content is divided into major topic areas or **units**. Each unit contains an **Unit Overview**, which introduces and outlines the topic and identifies the learning objectives. A **Study Guide** is also provided, which lists each **learning activity** to be completed, and identifies related **resources**.

Be sure to read each unit overview carefully, and follow the study guide in the sequence described.

Learning activities include a variety of experiences, including presentations and demonstrations by the instructor, paper and pencil exercises, hands-on shop experience and various evaluation measures to check your progress. While some of the activities will be completed by you individually, the instructor will always be available to help. Just ask.

## UNIT OVERVIEW

**Task**

Recognize the characteristics of x-radiation and be able to relate that to the patient.

**Estimated Time**

3 hours

**Introduction**

In this unit, the student will be introduced to Dental Radiography, a brief history of x-rays, and a detailed look at what radiation really is. It will involve many new terms and an understanding of what wavelength, frequency, electromagnetic radiation, and ionization are.

**Outline**

1. History of X-Ray
2. Definition of Radiation and Terms Used in Radiography
3. Electromagnetic Radiation
4. Wavelength and Frequency
5. Characteristics of X-Radiation
6. Ionization
7. Rad-Rem and Roentgen

**Performance Objectives**

1. Define the different terms used in radiography.
2. Distinguish where x-rays are in the electromagnetic spectrum.
3. Recognize the many characteristics of x-radiation.
4. Compare the different methods of measuring x-radiation.

# STUDY GUIDE

| Completed √ | Activities | Resources |
|---|---|---|
| ____ | 1. Attend lecture | 1. Instructor |
| ____ | 2. Read | 2. <u>Radiology for Dental Auxiliaries</u>, pp. 1-14 |
| ____ | 3. Review | 3. Slide tape, "Introduction to X-Ray Physics," Box 238, Learning Lab |
| ____ | 4. Read | 4. Information Sheet 1, "Definitions in Radiography" Information Sheet 2, "Characteristics of X-Rays" |
| ____ | 5. Complete | Unit Exam 1 |



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# LECTURE OUTLINE

## X-ray Physics

I. Discoverer of x-rays

 A. First dental x-ray

 B. First intraoral radiograph

II. Effects of x-ray radiation

III. Terms

 A. Radiology

 B. Roentgenology

 C. Radiographs

 D. X-rays

 E. Film

 F. Exposure

IV. Production of x-rays

 A. Electrons

 B. X-rays are produced when high speed electrons are slowed or stopped suddenly.

  1. heat

  2. x-rays

V. Electromagnetic spectrum

 A. Radio waves - light waves - x-rays

 B. Crest of waves

 C. Travel at speed of light

 D. Wavelength = measured from the crest of one wave to the crest of the next wave

  1.

 E. Frequency = number of crests passing a fixed point per second

  1.

VI. Characteristics of x-rays

 A. High energy waves

 B. No mass

 C. No charge



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D. Travel at speed of light

E. Travel in straight line

F. Cannot be focused with a lens

G. Adversely affect living tissue

H. Affect photographic film

I. Cause fluorescence

VII. Ionization - measurement of x-rays

A. Ionization production of ions by removal of outer electrons

B. Each x-ray produces many ion pairs

1. A certain quantity of x-rays does produce a specific number of ions in a certain volume of air

VIII. Roentgen (R)

A. Milliroentgen (mR)

100 mR = 1R

B. Roentgen = amount of radiation which produces a specific number of ions or ion pairs in a standard volume of air

C. Roentgen is used to measure x-rays in air

IX. rad radiation absorbed dose

A. rad = a unit of absorbed energy per gram of absorbing material

B. Measures the effect of x-rays within the tissues

X. rem roentgen equivalent man

A. rem = dose of any ionizing radiation which produces the same effect in man as that from absorbing x-rays

B. Deals with different types of radiation and dose received over the whole body

XI. X-rays effect on body cells

A. X-rays may remove electrons from atoms in cell and kill it or change its function

## INFORMATION SHEET 1

### Definitions in Radiography

Roentgen Ray - This term is synonymous with x-ray.

Roentgenology - The study and use of radiation; synonym for radiology.

Roentgenogram - Synonym for radiograph which is the record of an image produced by the passage of x-rays through an object.

Ion - A charged particle (either positive or negative) resulting from the breakdown of atoms or molecules.

Ionization - The process of breaking atoms or molecules into ions.

Electric Current - A flow of electrons from one point to another.

Electron - A negatively charged particle.

Direct Current - A current of electricity which flows in one direction.

Alternating Current - A current of electricity which flows first in one direction and then reverses and flows in the opposite direction.

Cycle - One forward and one reverse flow of an alternating current.

Ampere - The unit of current flowing through a circuit.

Milliampere - One-thousandth (1/1,000) of an ampere (abbreviated ma).

Milliammeter - An instrument that measures milliamperage.

Milliampere-seconds (mas) - The number of milliamperes of electricity flowing around a circuit in one second.

Volt - A unit of measurement of electrical pressure which forces a current through a circuit. A kilovolt equals 1,000 volts.

Voltmeter - An instrument that registers voltage. In an x-ray unit, it registers the voltage of the current before that voltage is stepped up by the transformer.

Watt - A unit of measurement of electrical power. The voltage times the amperage equals the wattage. One volt times one ampere equals one watt.

Ohm - A unit of measurement of electrical resistance. It requires one volt to force one ampere through one ohm of resistance.

Primary Radiation - Primary radiation includes all radiation that comes directly from the anode. Except for the useful beam, it is absorbed by the tube housing.

Stray of Leakage Radiation - Stray radiation is any radiation that does not serve a useful purpose. This category includes radiation coming from the tube head through a crack or joint in the tube housing.

Secondary Radiation - Secondary radiation is that radiation emitted by any substance through which x-rays are directed or by any irradiated material.

Scattered Radiation - Scattered radiation is that radiation that has been deviated in direction during its passage through a substance. It may also have been altered by an increase or decrease in wavelength.

Radiolucency - An object through which radiation passes freely is called radiolucent. The area on the film corresponding to a radiolucent area receives more radiation than the surrounding area; therefore, after processing, the area corresponding to a radiolucent object is considerably darker. All soft tissue is radiolucent.

Radiopacity - The direct opposite of radiolucent is radiopaque. A radiopaque object or area is one which tends to absorb the radiation; therefore, the film is less exposed to radiation. These areas on a radiographic film appear light in contrast to the radiolucent areas. Bony structures are radiopaque areas. Due to the various densities in tooth structure, the radiographic film is exposed to varying degrees of radiation. The image is made of varying shades of light and dark areas corresponding to varying degrees of radiolucency and radiopacity.

Distance - As the distance increases, the radiation intensity at the object decreases. This is a particularly important factor when cones of different lengths are used.

Roentgen (R) - The unit of x-ray energy to which the patient is exposed and representing only the measurement of the ionization of a gas. One roentgen equals 2.095 X $10^9$ (Approximately 2 billion pairs). A roentgen does not describe what happens when the radiation enters the tissues or is absorbed.

Rad (Radiation Absorbed Dose) - A unit of measure of the amount of radiation energy absorbed by material such as tissue. One gram of tissue that has absorbed 100 ergs of energy in any form is said to have absorbed one rad of the particular radiation. With dental x-rays, one roentgen (R) is equivalent to one rad.

RBE (Relative Biological Effect) - The unit used to express the comparative biological effect on tissue irradiated by different forms of energy.

Rem - A unit of measure of the amount of absorbed radiation energy which takes into account the different relative biological effectiveness of different types of radiation. It is determined by multiplying the absorbed does (rad) by the relative biological effect (RBE) of the radiation used. For x-rays, one rem is equivalent to one rad.

Milliampere-Seconds (mas) - Radiation energy dosage to expose x-ray film is expressed as milliampere-seconds of electric current used to produce the x-rays. Milliampere-seconds can be converted to appropriate x-ray dosage at given distances from the x-ray tube target if the total filter equivalent, milliamperage, voltage of the current, and the exposure time are known. Dosages at other distances vary inversely with the square of the distance. This means that doubling the distance from the x-ray tube target reduces the amount of x-ray reaching a given area of tissue to one-fourth of its value. The mas is computed by multiplying the ma by the total number of seconds exposed.

Erythema - This is a redness of the skin much like that of sunburn. In extreme cases, there may be swelling and sloughing of the tissues.

Radiodermatitis - In this condition, the skin appears dry and flaky with scattered areas of brown pigmentation. The skin has a burning, tingling sensation. The fingernails become dry and brittle. Ulcerations may develop which later may become malignant.

Alopecia - Alopecia is loss of hair. If not due to extreme exposure, it is usually temporary. The hair follicles are sensitive to radiation.

Cataract - Cataract of the eye is a possible result of overexposure to radiation and usually appears long after the original exposure.

Sterility - Sterility may be caused by overexposure of radiation to the gonads. The possible mutations produced by overexposure to radiation can harm future generations.

Filter - Material placed in the useful beam to absorb the less penetrating radiations.

Inherent Filter - Filtration by the glass wall of the x-ray tube, by oil surrounding the tube, and by any permanent inclosure.

Added Filter - A filter added to the inherent filter.

Total Filter - Sum of inherent and added filters.

Lead Equivalent - Thickness of any material necessary to afford the same protection as a specified thickness of lead.

Personnel Monitoring - Systematic, periodic, or continuous check, by use of the film badge, of the radiation dose a person receives.

Protection Survey - Evaluation of radiation hazards to patients, personnel, and others in the vicinity of an x-ray installation.

Protective Barriers - Barriers of materials, such as lead, concrete, or plaster, used to reduce radiation hazards.

Protective Tube Housing - An x-ray tube inclosure that confines most of the radiation (emerging from the inclosure) to the useful beam.

Protective Tube Housing - See paragraph 11.

Diaphragms and Cones - As x-rays pass out from their source, they form a diverging beam. The only part of the beam useful for making radiographs is that which passes through the radiographic film. X-ray tube cones are radiopaque to absorb much of the useless radiation. In addition, radiopaque diaphragms are placed in the base of the x-ray unit cone to confine escaping radiation to a relatively narrow beam (collimation). These diaphragms have a center opening which determines the diameter of the escaping beam. Most of the more divergent rays are absorbed.

Aluminum Filters - X-rays of long wavelength, a result of low voltage, are absorbed by aluminum discs (varying from 1.5 to 2.5 mm of aluminum) placed in the path of the x-ray beam. With filter, the dose rate to the skin is reduced 50 to 70 percent. The filter cuts of the "soft," or less penetrating, rays and allows the "hard," or more penetrating, rays to pass. Soft rays contribute little to the exposure of the radiographic film and are apt to be absorbed and cause tissue damage.

Protective Screens and Booths - Protection is provided for the operator in Army dental clinics by either a protective screen or booth with a lead-equivalent thickness of at least 1/16 inch. The screen or booth is so located that radiation must be scattered at least twice before entering the protected area. The timer switch should be fixed to the protective side of the screen or booth to assure that the operator will be protected during the exposure.

Structural Shielding - Standards for dental x-ray rooms include a requirement for an equivalent thickness of 1/16 inch of lead on all inside walls and doors except those which the x-ray chair faces. When possible, the dental x-ray chair should be so positioned that the patient's back is turned toward an outside wall. This positioning causes most of the rays to be directed either toward the outside wall or the protected side wall.

## Faulty Radiographs

General - Errors in the techniques of exposing or processing dental films can produce several undesirable results, all of which can be avoided. The x-ray specialist should be familiar with the following common causes of faulty radiographs so that he can prevent them.

Too Light Image - An image that is too light may be caused by insufficient exposure, insufficient development, use of overused developer, or use of developer that is too cold.

Too Dark Image - An image that is too dark may be caused by overexposure, overdevelopment, or use of developer that is too warm.

Blurred Image - A blurred image is easily recognized by the appearance of more than one image of the object or objects on the film. It may be caused by movement of the patient, the film, or the tube during exposure.

Partial Image - Partial image may be caused by failure to immerse the film completely in the developing solution, contact of the film with another film during developing, or improper alignment of the central ray.

Distorted Image - Distorted image may be caused by improper angulation of the central ray of the film due to bending the film packet.

Fogged Film - Fogged film may be caused by exposure of film to light during storage; leaving film unprotected--outside the lead-lined box--in the x-ray room during operation of the x-ray machine before or after exposure; use of film that has been exposed to heat or chemical fumes; use of improperly mixed or contaminated developer; or defective safe light.

Stained or Streaked Film - Stained or streaked film may be caused by dirty solutions, dirty film holders or hangers, or incomplete washing.

Herringbone Image - Herringbone pattern is caused by placing the wrong side of the film toward the cone. This is not found in ultra-speed film.

Bleached Image - A bleached image is caused by leaving the film in a freshly mixed solution too long or at a temperature that is too high.

No Image - No image may result from no current passing through the tube at the time of exposure or from the film being placed in fixing solution before it is placed in developing solution.

Irregularly-Shaped Light Area - The presence of a foreign body in the point of the cone may cause light area. Care in the handling and routine cleaning of the inner surface of the cone will prevent the occurrence of such an area.

Reticulation - When this defect occurs the finished film has a net-like, or puckered, appearance resulting from swelling of the gelatin. Swelling is caused by sudden changes in temperature during processing, as in the transfer from a cool fixing bath to warm wash water or from a warm rinse water to a cool fixing bath.

## Anatomic Radiographic Landmarks

I. Normal Radiolucent Anatomic Landmarks Seen on Maxillary Radiographs

A. Antrum or Maxillary Sinus

The maxillary sinus is a very prominent structure partially seen in all periapical radiographs of the bicuspid-molar area. It occupies a large part of the body of the maxilla, varying greatly in dimension, but normally extending into the alveolar process adjacent to the apices of the posterior teeth.

B. Incisive Foramen

The incisive foramen is seen as a dark area located between and above the central incisors. In radiographs exposed from the region of the cuspid or lateral incisor, the incisive foramen may appear as a radiolucency at the apex of one of the incisors.

C. Greater Palatine Foramen

The greater palatine foramen is not often seen on radiographs. When seen it may appear as a dark spot above the lingual root of the first molar or it may appear mesial or distal to this position.

D. Median Palatal Suture

The median suture of the palate may appear as a radiolucent line extending posteriorly from the alveolar border in the sagittal plane of the maxillae.

E. Nasal Fossae

In a radiograph of the maxillary central incisors, the images of the paired fossae appear as somewhat elliptical radiolucent areas of various sizes separated by a radiopaque band representing the nasal septum.

F. Nostril Spots

Nostril spots are elliptical areas which may be seen on an anterior radiograph in the region of the lateral incisors. They a caused by rays passing readily through the nostril.

II. Normal Radiopaque Anatomical Landmarks Seen on Maxillary Radiographs

A. Coronoid Process of Mandible

The coronoid process of the mandible sometimes appears on maxillary molar films as a triangular opaque area located in the region of or distal to the maxillary tuberosity.

B. Hamular Process (Pterygoid Process)

The hamular process of the sphenoid bone is a hook-like process projecting from the internal pterygoid plate. Radiographically, it extends downward and backward from the maxillary tuberosity. Its position on a radiograph varies greatly according to the direction of the central ray employed in making the exposure. Occasionally, it may simulate a bone fragment.

C. Maxillary Tuberosity

The maxillary tuberosity is the convex distal border of the maxilla, curving upward from the alveolar process distal to the third molar. An extension of the maxillary sinus is occasionally seen within the tuberosity.

D. Zygomatic Process (Malar Bone)

The zygomatic arch commonly appears as a well-defined radiopaque area which may be superimposed over the molar roots. Additional radiographs are sometimes made at adjusted angulation to provide a better view of the molar root area.

E. Nasal Septum

The nasal septum is usually seen as a white ridge extending above and between the central incisors.

III. Normal Radiolucent Anatomic Landmarks Seen on Mandibular Radiographs

A. Mandibular Foramen

The mandibular foramen is seen on extraoral jaw films as a dark area on the mandibular ramus.

B. Mandibular Canal

The mandibular canal appears as a dark band with radiopaque borders running downward and forward from the mandibular foramen to the region of the bicuspid teeth. It may be seen below or superimposed upon the roots of the posterior teeth.

C. Mental Foramen

The mental foramen is seen as a dark area below and between bicuspids. Since it is not contiguous with either bicuspid, its relationship to these teeth appears different on radiographs made at different angulations.

D. Thinness of Bone Due to Physiologic Process

The bone in and distal to the area of the posterior teeth may appear dark as the result of normal thinning of the bone. If it occurs normally on one side, the same condition will appear on the opposite side.

E. Nutrient (Interdental Canals)

Nutrient canals appear as vertical dark lines in the region of the incisor teeth, often extending to the region of the bicuspids. They are also seen occasionally in the region of the maxillary anterior teeth.

IV. Normal Radiopaque Anatomic Landmarks Seen on Mandibular Radiographs

A. Border of the Mandible

The border of the mandible is seen as a heavy white line. A similar line does not appear on maxillary radiographs.

B. External Oblique Line

The external oblique line is a white line of variable density extending into the molar region as a continuation of the anterior border of the ramus of the mandible.

C. Genial Tubercles

Genial tubercles are seen as round white areas having dark centers located below and between the central incisors.

D. Mental Process (Mental Ridge)

The mental ridge appears as a dense white ridge extending from the anterior midline to the bicuspid region, usually located below the anterior teeth, but occasionally superimposed over the apices.

E. Mylohyoid Ridge (Internal Oblique Ridge)

The mylohyoid ridge appears as a white line of varying width extending from the lower border of the symphysis upward and distally to end beyond the third molar. It reaches its greatest prominence in the molar region, often interfering with visualization of molar roots.

## INFORMATION SHEET 2

### Characteristics of X-Rays

In addition to two properties characteristic of the entire electromagnetic radiation spectrum, i.e., the characteristic velocity of $3 \times 10^{10}$ cm/sec or 186,000 miles/sec and the divergent emission in all directions from the source, x-rays are characterized by four additional properties that are particularly significant in the fields of dentistry and medicine.

Penetrability. X-rays penetrate substances that are opaque to visible light. However, all x-rays entering an object do not completely pass through it; some x-rays are absorbed by the object, resulting in atomic and molecular alterations within the absorbing material. The efficiency of x-ray penetration and absorption is related to the frequency, wavelength, and photon energy of the x-rays and the atomic number, and the thickness and density of the material through which the x-rays pass. Increasing penetrability is associated with x-rays of increasing frequencies and photon energies and decreasing wavelengths. The efficiency of x-ray penetration is decreased and absorption efficiency is increased as the radiation encounters absorbing material of higher atomic numbers and greater thicknesses and densities.

Photographic Effect. X-rays affect or expose photographic and radiographic film; the photographic and radiographic effects are in proportion to the quantity of x-radiation absorbed by the film. The quantity of x-ray energy absorbed by an object is proportional to the radiation exposure, which is defined as the product of x-ray intensity (the number and energy of the photons) and the time interval during which the radiation exposes the object. Because of the great differences in the energies of x-ray photons and photons of visible light, one absorbed x-ray photon produces a far greater photographic effect than one absorbed visible light photon. On the other hand, because of the penetrability factor, a piece of film absorbs a much higher percentage of incident visible light photons than of incident photons of x-rays.

Fluorescence Effect. When certain minerals absorb x-rays, they fluoresce or emit radiation of longer wavelengths in the visible light region of the electromagnetic radiation spectrum. The fluorescence effect is the basis of fluoroscopy and for the use of intensifying screens in extraoral roentgenography.

Initiate Biological Changes. Biological changes initiated in living cells, tissues, and organs by absorbed x-ray energy may eventually appear as somatic or genetic lesions with clinical manifestations. Generally speaking, the greater the quantity of x-ray energy absorbed and the shorter the time of exposure and absorption, the sooner and the more dramatic are the clinical manifestations of radiation damage.

### Ionization and Excitation

Ionization and excitation occur within an atom or molecule when energy is transferred to an orbital electron by an incident photon of electromagnetic radiation or by an incident high-energy subatomic particle. The two phenomena of ionization and excitation lie at the heart of energy absorption phenomena, the photographic effect, the fluorescence effect, and the initiation of biological changes.

Ionization. If the transferred energy is great enough to remove an orbital electron, ionization occurs; the dissociated electron is characterized by a net negative electrical charge, and the residual parent atom or molecule is characterized by a net positive electrical charge. An ion is an electrically charged subatomic, atomic, or molecular particle. The pair of oppositely charged particles is often referred to as an ion pair.

Ionization Potential. The minimum amount of energy that must be transferred to the least tightly-bound orbital electron in order to remove it completely from the atom is called the ionization potential of the atom. The ionization potential is greatest for helium atoms ($_2He^4$, 24.5 ev) and least for the alkali metal atoms (e.g., cesium, $_{55}Ce^{140}$, 3.87 ev). The ionization potential for hydrogen ($_1H^1$) is 13.6 ev. In addition to the ionization potential of atoms, each orbital electron is characterized by an ionization energy or ionization potential. The ionization energies of orbital electrons nearest the nucleus of an atom are the greatest, and the ionization energies of outermost orbital electrons are the least.

Ionization Potentials of Certain Metals. Ionization actually may occur with radiation as far down the electromagnetic radiation spectrum as the infrared region. Photon energies near $1.6 \times 10^{-12}$ erg (0.97 ev, wavelength of 12,000 A), which is in the high infrared region, are capable of dislodging surface electrons in such metal mixtures as cesium-on-silver oxide. This hypersensitive metal mixture is commonly used on the surfaces of the cathode in photoelectric cells. Photon energies of $3.6 \times 10^{-12}$ erg (2.3 ev, wavelength of 5,400 A), which is in the green band region of visible light, are capable of dislodging surface electrons of sodium; and photon energies of $7.2 \times 10^{-12}$ erg (4.5 ev, wavelength of 2,730 A), which is in the ultraviolet region, are capable of dislodging surface electrons of tungsten. However, photon energies of $1.1 \times 10^{-7}$ erg (70,000 ev, wavelength of 0.18 A), which is in the region of x-rays, are necessary in order to remove an electron from the innermost orbit of a tungsten atom.

Ionization Potential of Air, Water, and Soft Tissue. The mean ionization potential for air under standard conditions is usually given as $5.2 \times 10^{-11}$ erg (32.5 ev, wavelength of 380 A), which is in the region of extremely high frequency ultraviolet radiation. For all practical purposes, the mean ionization potential for water and soft tissue is considered to be $5.5 \times 10^{-11}$ erg (34 ev, wavelength of 360 A).

Excitation. If the transferred energy is not great enough to remove an orbital electron, the electron receiving the transferred energy is raised to a higher energy level within the atom. The atom or molecule containing the atom is thus said to be in an excited state--containing an excess of energy. The total energy content of such an excited atom or molecule is greater than that of the ground or nonexcited state. Excited atoms return to ground state by emitting their excess energy as electromagnetic radiation,

$$hf = E_1 - E_2$$

where hf is the energy of the emitted photon, $E_1$ is the energy of the excited state, and $E_2$ is the ground state or minimum energy level of the atom.

Photoelectric Absorption. If all the energy of the incident electromagnetic radiation photon is transferred to the absorbing electron, the process is known as photoelectric absorption, photoelectric attenuation, or the photoelectric effect; the orbital electron released in the process is called a photoelectron. In this process of absorption, the incident photon ceases to exist; its energy is transferred completely to the absorbing electron in overcoming the force binding the electron with a certain kinetic energy. The energy distribution in this absorption phenomenon can be summarized as follows:

$$h\nu = W + e^- + 1/2\ mv^2$$

in which $h\nu$ is the total energy of the incident photon, W is the work function or ionization energy (the energy input necessary to overcome the energy binding the electron to the nucleus), and $1/2\ mv^2$ is the kinetic energy of the released photoelectron.

Compton Absorption. If only part of the energy of the incident electromagnetic radiation photon is transferred to the absorbing electron, the process is known as Compton absorption, or Compton attenuation, or Compton effect. The orbital electron released in this process is known as a Compton electron. In Compton absorption, the incident photon ($h\nu_1$) is scattered as electromagnetic radiation of less energy ($h\nu_2$), decreased frequency, and increased wavelength. The energy distribution in the Compton process can be summarized as follows:

$$h\nu_1 = W + e^- + 1/2\ mv^2 + h\nu_2$$

Unmodified (Thompson, Coherent, Classic) Scattering. Incident radiation may interact with orbital electrons in such a way as to cause them to vibrate with the same frequency as the incident photon and, thus, to emit radiation of the same frequency and photon energy as the incident radiation. However, the incidence of this type of photon scattering is quite low as compared with the Compton scattering.

## X-Rays and Gamma Rays

X-rays and gamma rays are the same type of radiations--high-energy, high-frequency electromagnetic radiation. The only difference between the two is their source. Gamma rays are emitted from certain radioactive elements in the process of nuclear decay. X-rays are produced as a result of rapid decelerations of high-energy electrons. Gamma ray energies range from less than 100 kev to about 3 Mev. With modern linear accelerators, x-rays can now be produced with photon energies greater than 100 Mev.

## Physics of X-Ray Production and Control

### Types of X-Rays Produced

Bremsstrahlung. X-rays known as bremsstrahlung, brems rays, "braking radiation," continuous or white radiation are produced when high-velocity electrons are abruptly decelerated as they pass very close to atomic nuclei of target materials. The probability that x-rays will be produced in this manner increases with increasing energies or velocities of incident electrons. If all the energy of an incident high-velocity electron is lost in an initial deceleration event, bremsstrahlung of maximum quantum or photon energy and minimum wavelength will be produced; the photon energy will nearly equal the original kinetic energy of the incident electron. The approximate minimum wavelength of the maximum-energy photon of radiation thus produced will be

$$\lambda min = \frac{12,400}{V} \text{ or } \frac{12.4}{KV}$$

where lambda minimum ($\lambda min$) is in Angstrom units and V is the peak voltage expressed in volts (KV = kilovolts). Bremsstrahlung of decreasing quantum or photon energies and increasing wavelength is produced as less of the total energy of incident electrons is lost in deceleration events. Bremsstrahlung, therefore, consists of a spectrum of quantum of photon energies and wavelengths from maximum energy and minimum wavelength to minimum energy and maximum wavelength.

Characteristic Radiation. X-rays known as characteristic radiation are produced when suitable target materials are bombarded with electrons of sufficient energy to eject innermost orbital electrons, especially those occupying the K and L orbits or energy levels. K-radiation is produced when a K-energy-level electron is ejected from the atom, and an electron from the L, M, or N energy level drops down to fill the space. The energy of the radiation emitted when such transitions occur is equal to the difference between the energies of the two electrons or the two energy levels involved. In tungsten, an $L_3$-K transition, which means that an electron in the third energy sub-level of the L orbital shell fills the space in the K orbital shell of an ejected K-electron, the energy radiated is 59.31 kev (69.51 kev electron binding energy of the K-electron minus 10.20 kev electron binding energy of the $L_3$-electron). Some data on electron binding energies and characteristic radiations of tungsten are given in Table III. Characteristic radiation could constitute as much as 30 percent of the total radiation produced in the realm of diagnostic kilovoltages, depending on the kv and the beam filtration.

Table III. Some Characteristic Radiation Data on Tungsten (Z = 74)

| Energy level or Orbital shell | Electron binding energy in kev | Electron Transition | Photon Energy in kev | Wavelength (A) |
|---|---|---|---|---|
| K | 69.510 | $N_2N_3$-K | 69.089 | 0.17942 |
| $L_1$ | 12.094 | $M_3$-K | 67.236 | 0.18437 |
| $L_2$ | 11.538 | $L_3$-K | 59.310 | 0.20901 |
| $L_3$ | 10.200 | $L_2$-K | 57.972 | 0.21383 |
| $M_1$ | 2.814 | $N_4$-$L_2$ | 11.284 | 1.09858 |
| $M_2$ | 2.570 | $N_5$-$L_3$ | 9.961 | 1.24449 |
| $M_3$ | 2.274 | $M_4$-$L_2$ | 9.671 | 1.28119 |
| $M_4$ | 1.867 | $M_5$-$L_3$ | 8.396 | 1.47646 |
| $M_5$ | 1.804 | $M_4$-$L_3$ | 8.333 | 1.48762 |

## Electricity and Electrical Circuits

Electricity. Electricity and electrical circuits are essential in the production of x-rays. Basically, an electric current is simply a flow of electrons induced by "electrical pressures" or electrical potential differences or electromotive forces (emf) produced by chemical or mechanical "electron pumps" called generators. The electron flow may be unidirectional or an oscillating movement, producing a direct current (D.C.) or an alternating current (A.C.).

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## UNIT OVERVIEW

**Task**

Apply knowledge of how x-rays are produced and what is necessary to produce them.

**Estimated Time**

3 hours

**Introduction**

x-rays are produced in the x-ray tube head. The actual production is not something the assistant can see, but they can control the process, the amount of radiation produced, and for how long it is produced.

**Outline**

1. Parts of an X-Ray Tube Head: (1) Anode, (2) Cathode, (3) Transformers, (4) Timer
2. Things Necessary to Produce Radiation
3. Process for Producing X-Rays
4. Different Types of Radiation Produced
5. X-Ray Density, Contrast, and Detail

**Performance Objectives**

1. Identify the different parts of the x-ray tube.
2. Describe the process for production of x-radiation.
3. Distinguish between the different types of radiation produced.
4. List the three exposure variables and their effects.
5. Define and describe radiographic density--contrast and detail.
6. Discuss the Inverse Square law and its effect on x-ray production.

## STUDY GUIDE

| Completed √ | Activities | Resources |
|---|---|---|
| ___ | 1. Attend lecture | 1. Instructor |
| ___ | 2. Read | 2. Text, pp. 15-45 |
| ___ | 3. Review | 3. Slide tape, "X-ray Production and Radiographic Quality," Box 239, Learning Lab |
| ___ | 4. Complete | 4. Unit Exam 2 |



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## LECTURE OUTLINE

### X-ray Production and Radiographic Quality

I. X-ray tube - inside tube head

A. Source of electrons

B. Production of high speed electrons

C. Stopping of high speed electrons

II. Source of electrons - cathode has negative charge (-)

A. 2 parts of cathode
1 Focusing cup
2 Filament - small tungsten wire

1. Tungsten used because it will stand high temperatures

B. Boil off of electrons and cluster around filament

III. High voltage causes electrons to move toward position (+) anode

A. Electrons hit anode produce 99.8 percent heat 0.2 percent x-rays

B. Parts of anode

1. Copper stem
   a. Copper conducts heat away from target
2. Tungsten target
   a. High melting point
   b. Has focal spot
   c. Radiator - help remove heat

IV. Lead glass envelop (vacuum)

A. Window

V. Electric current

A. Amps - flow of electrons through a conductor

1. More amps - more electrons flowing through wire
2. Thermogenic emission boiling off of electrons
3. Controlled by the mA adjustment
   Inc. - mA = Inc. in electrons in wire and Inc. electron cloud
4. A controls quantity of x-rays produced

B. Electric circuit low voltage

1. Current - movement of electrons through a conductor
2. Voltage - measurement of force causing electrons to move from - to +
3. Filament current (3-5 volts)
   a. Step-down transformer
      1) Steps down voltage from 110 or 220 to 3-5 volts

C. Electric circuit high voltage

1. High voltage causes electrons to move from cathode (-) to anode (+) at high speed
2. X-ray tube current (50,000 - 100,000 volts)
    a. Step up transformer
        1) Steps up voltage from 110 or 220 to 50,000 to 100,000 volts
        2) 1 kilovolt (kV) = 1,000 volts
        3) Voltage of x-ray tube current is controlled by kVp (kilovoltage peak)

D. Exposure time = length of time electrons are pushed across tube gap

1. Impulse timer
   1 impulse = 1/60 second
   3 impulses = 3/60 = 1/20 second
   30 impulses = 30/60 = 1/2 second

VI. Differential absorption different amounts of absorption by different tissue types

A. Radiopaque

1. Areas of high absorption of x-rays, appears light

B. Radiolucent

1. Areas of less absorption, appears dark

C. Secondary radiation

1. Produced whenever x-rays interact with matter

D. Scatter radiation = form of secondary radiation

1. Change of direction with loss of energy

E. Four types of radiation

1. Leakage
2. Primary
3. Secondary
4. Remnant

VII. Properties of radiographs

A. Radiographic density

1. Degree of blackening of an x-ray film
    a. Controlling factors
       mA and T = mAs

B. Inverse square law

1. The intensity of radiation is inversely proportional to the square of the distance.
2. 2 X distance = 1/4 intensity of x-ray

C. Radiographic contract

1. The difference in densities between adjacent areas of a radiograph a controlling factor kVp

D. Radiographic detail

1. The overall sharpness of images on a radiograph
2. Influencing factors
   a. Motion - focal spot size - object film distance and film grain size

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## UNIT OVERVIEW

**Task**

Apply knowledge of the effects of radiation on the human body and describe the safety measures.

**Estimated Time**

3 hours

**Introduction**

It is very important for the student to understand that radiation can affect the body adversely. They should understand all the safety measures for the patient, the operator, and the general public.

**Outline**

1. The Effect of X-Rays on Tissue
2. Methods for Reducing Patient Exposure
3. Operator Protection
4. Personnel Monitoring Devices

**Performance Objectives**

1. Explain the somatic and genetic effects of x-rays.
2. List those tissues most and least sensitive to radiation.
3. List and describe the methods for reducing patient exposure.
4. Explain the methods of operator protection.
5. Identify common methods of personnel monitoring.



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## STUDY GUIDE

| Completed ✓ | Activities | Resources |
|---|---|---|
| ____ | 1. Attend lecture/ discussion | 1. Instructor/Lecture Outline |
| ____ | 2. Review | 2. Slide tape, "Dental Radiological Health," Box 240, Learning Lab |
| ____ | 3. Read | 3. Information Sheet "Use of X-ray Film Holder" |
| ____ | 4. Read | 4. Text, pp. 46-75 |
| ____ | 5. Complete | 5. Midterm Exam |

## LECTURE OUTLINE

### Dental Radiological Health

The D.A. should work to reduce all unnecessary x-ray exposure to the patient, personnel, and public.

I. Somatic and Genetic

  A. Somatic - general body cells (effects usually visible)

  B. Genetic - cells of reproductive organ

  C. Ionization - x-rays may cause breaking of cell bonds and possible cell death

  D. Maximum Exposure Standards

    1. body replaces damaged cells

II. Factors Determining Effects of X-Rays on Tissues

  A. Dose Rate

    1. exposure per given time

  B. Area or Volume

    1. of tissues exposed to x-rays

  C. Age

    1. younger more sensitive (children and pregnant women)

  D. Tissue Sensitivity

    1. greatest

| | |
|---|---|
| very sensitive | 1. reproductive organs<br>2. blood forming organs<br>3. lens of eye and glandular tissues |
| more resistant | 4. skin<br>5. nerve<br>6. muscle |

Least



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III. Somatic and Genetic Effects

A. Large Dose - Short Time - Total Body

**Somatic Effects**

| | |
|---|---|
| 50 Roentgen | Blood changes |
| 150 R | Nausea, diarrhea |
| 250 R | (To gonads) Temporary Sterility on males |
| 400 R | 50 percent chance of death |
| 600 R | Death |

B. Small Dose - Long Time - Partial or Total Body

**Genetic and Somatic Effects**

| Dose | Effect |
|---|---|
| 10-100 R | Genetic - future generations<br>Somatic, Leukemia, Cataracts, Life Span Shortening |

List and describe five methods for reducing patient exposure.

I. Collimation - process of restricting or confining the x-ray beam

A. Lead Diaphragm

1. Size of beam at end of cone 2.75 inches
2. Restricts beam and reduces secondary radiation
3. Minimum target to skin distance of 7 inches

II. Filtration - absorbs low-energy x-rays, reduces skin dose by approximately 50 percent

A. Aluminum filter 2.5 mm

III. Lead Apron

A. On all patients

B. Never fold apron in storage

C. Lead collar when necessary

IV. High Speed Film

A. Less radiation necessary



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V. High KV Technique

   A. Increase KV, decrease MAS
      Increase quality, decrease quantity

   B. Optimum film processing

   C. Good professional judgment

Operator Protection. List and describe three methods of protection for operators.

I. Stay Out of Primary Beam

II. Six Feet from Source of Radiation

III. Use Shielding or Barrier

IV. Never

   A. Hold film

   B. Hold cone or tube

   C. Use inter-oral fluoroscopic mirror

Personnel Monitoring and M.P.D.

I. Film Badge

II. Maximum Permissible Dose

   0.1 rem week

   3 rem 13-week period

   5 rem year



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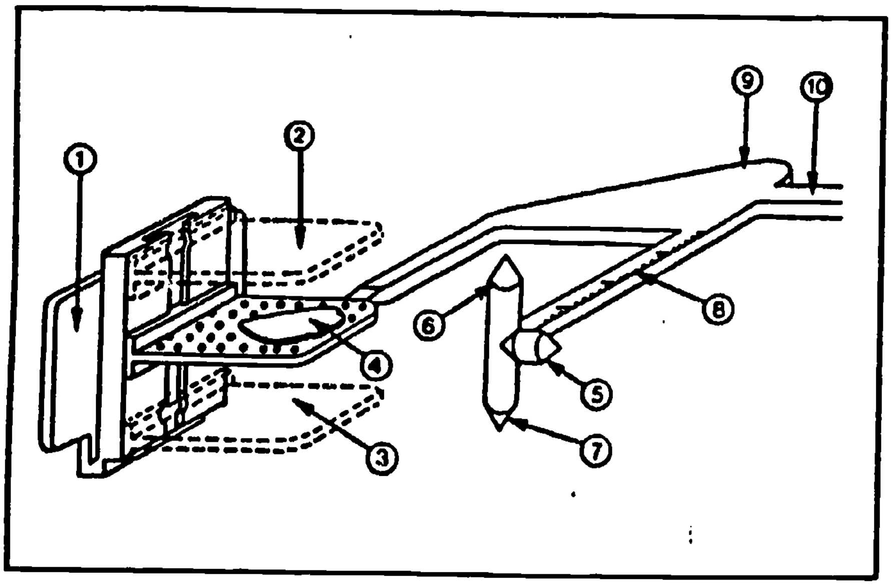
## INFORMATION SHEET

### UNI-BITE - Universal Dental X-ray Film Holder




CAUTION: To avoid breakage when adjusting the film carrier (1), hold the Uni-Bite by the bite-plate (4), gripping it with the thumb and forefinger of the opposing hand. *Do not hold it by the handle (9).*

The sliding film carrier is adjustable to accommodate exposures of maxillary as well as mandibular teeth, posterior as well as anterior teeth, periapicals as well as bite-wing.

- for any film size (0, 1 & 2)
- easy to use
- provided with millimeter scale
- convenient handle
- can be sterilized or disinfected by all acceptable procedures (hot air max. 180° C. or 350° F.)

**Description of Components**

1. Adjustable film carrier for sizes 0, 1 and 2—markings show film positioning.

Note: The Uni-Bite must be disassembled when autoclaving. Remove the adjustable film carrier and place it in the unit with, but not attached to, the bite-plate/handle section.

Patented TM

# UNI-BITE

## description of components and general directions

2. Bite-plate shown in uppermost position—for exposures of mandibular teeth.
3. Bite-plate shown in lowest position—for exposures of maxillary teeth.
4. Bite-plate shown in middle position—for bite-wing exposures.
5. Target point for bite-wing exposures.
6. Target point for bite-plate position 3 (for exposure of maxillary teeth).
7. Target point for bite-plate position 2 (for exposure of mandibular teeth).
8. Cross-bar with millimeter scale (index-bar).

Handle for easy placement of Uni-Bite.

10. Parallel-bar aids orientation of the X-ray unit at right angle to the film plate.

**General Directions for Use**

1. Place film in slot with proper side towards bite-plate or towards P.I.D.*
   a. Regular film size 2; push film all the way into the slot.
   b. Film sizes 0 or 1, push film to the respective marking 0/1.
2. For detailed regional teeth positioning, consult the following pages. (All artist's drawings show #2 film.)

*The term P.I.D. (Position Indicating Device) originated with the American National Standards Institute, Committee PH6 and PH6.5



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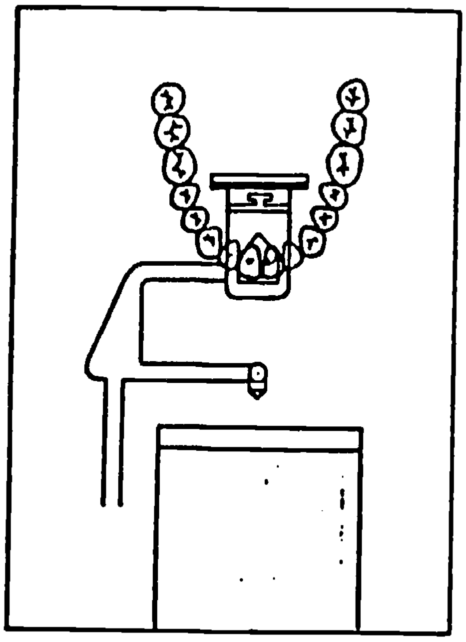
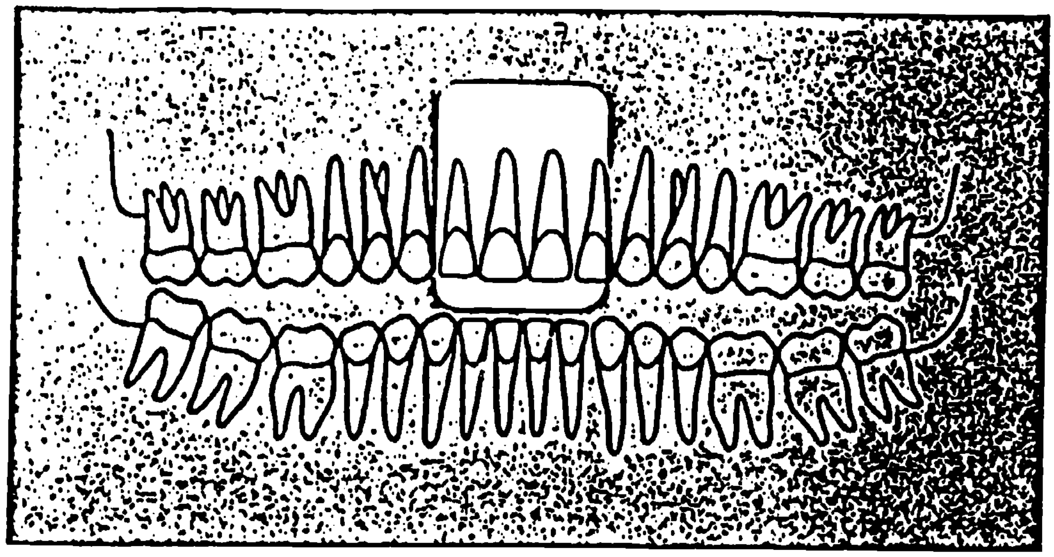
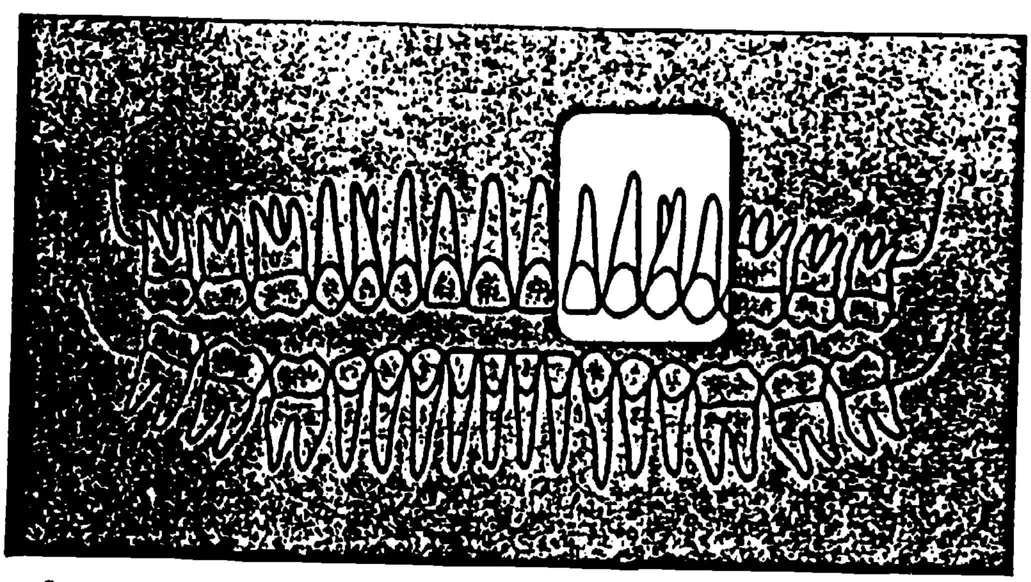
## maxillary incisor region technique





1. Center film with midline and parallel with long axis of the central incisors. Entire length of the bite-plate should be utilized to position film in region of the first molar.
2. With bite-plate resting on incisal edge of teeth to be radiographed, instruct the patient to close firmly to retain established position of film.
3. Align the P.I.D.* of the X-ray unit to the parallel bar of the Uni-Bite and center P.I.D. on the appropriate target point on vertical and horizontal planes.
4. Make exposure

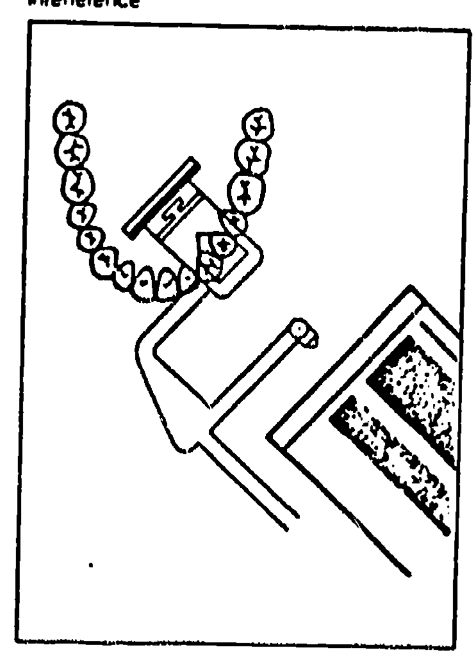
*The term P.I.D. (Position Indicating Device) originated with the American National Standards Institute, Committee PH6 and PH6.5



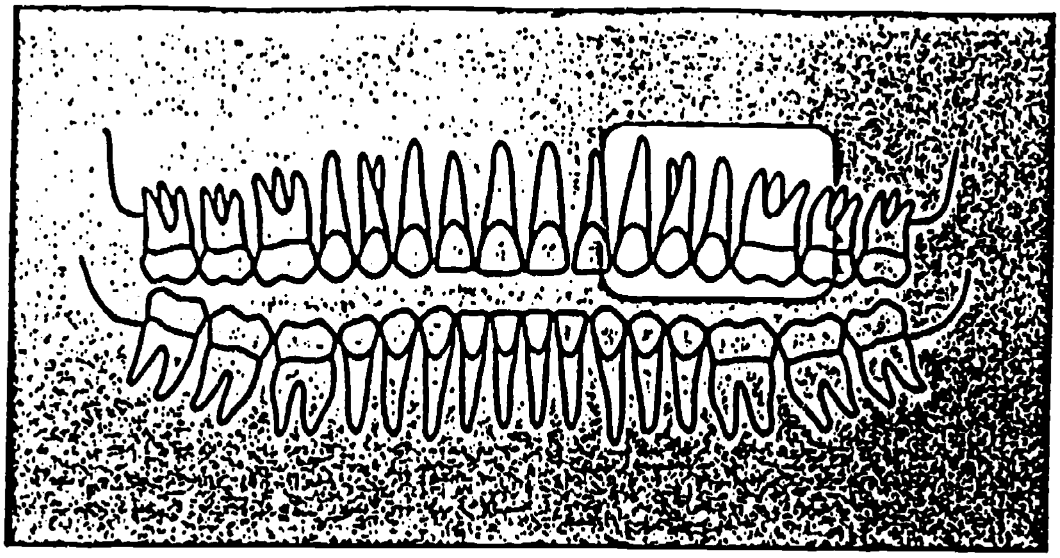
1. Center cuspid on film and parallel with long axis of tooth. When using #2 film, relief of upper anterior corner of film will facilitate positioning
2. With bite-plate resting on maxillary cuspid, instruct patient to close firmly to retain established position of film.
3. Align the P.I.D. of the X-ray unit to the parallel bar of the Uni-Bite and center P.I.D. on the appropriate target point on vertical and horizontal planes
4. Make exposure.

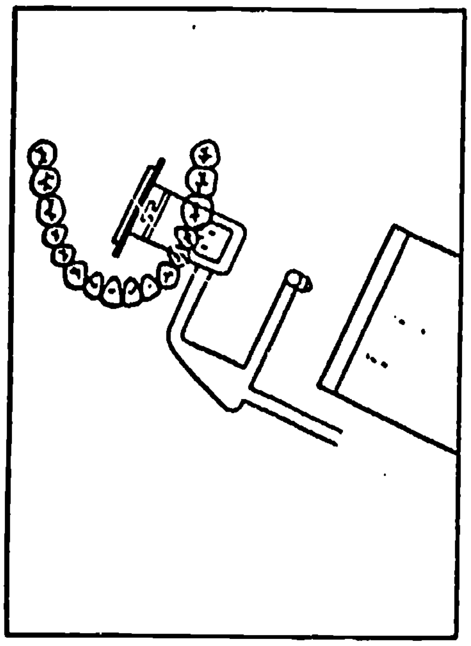
## maxillary cuspid region technique

Note: It may be necessary to reverse the film carrier on the bite-plate on account of facial tissue interference



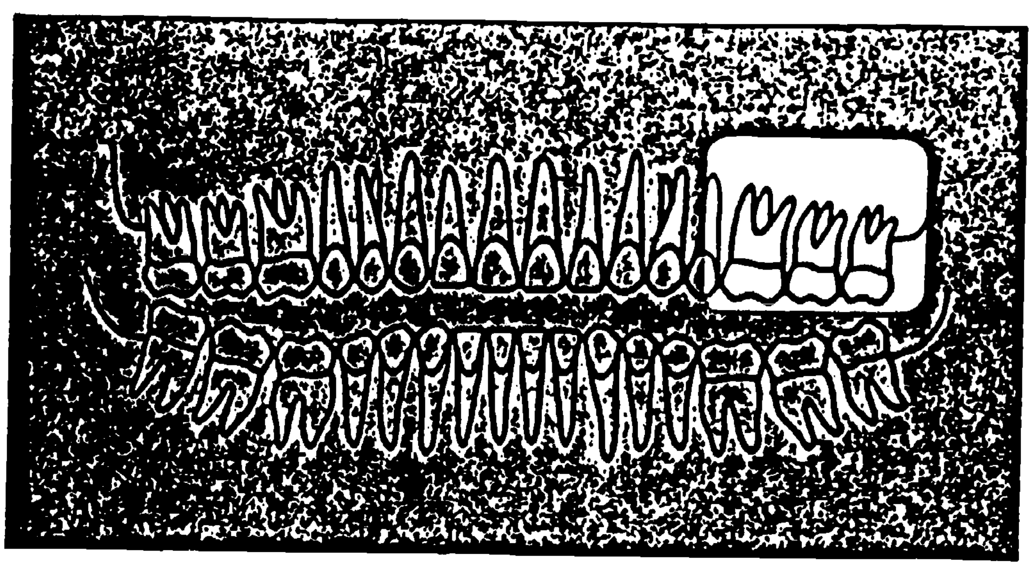
## maxillary bicuspid region technique



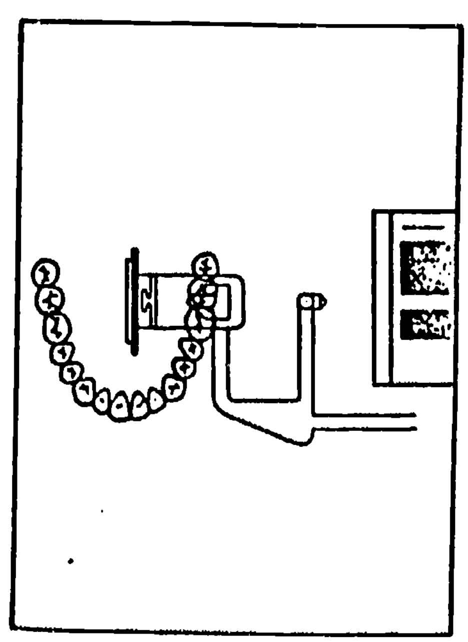


1. Position film packet in mouth with second bicuspid centered on film. Relief of the upper anterior corner of the film packet will facilitate positioning.
2. Parallel film with long axis of bicuspids. (Lingual placement of film packet will accomplish this relationship.)
3. With bite-plate held on the occlusal surfaces of the maxillary bicuspids, instruct patient to close firmly to retain established position of film.
4. Align the P.I.D. of the X-ray unit to the parallel bar of the Uni-Bite and center P.I.D. on the appropriate target point on vertical and horizontal planes.
5. Make exposure

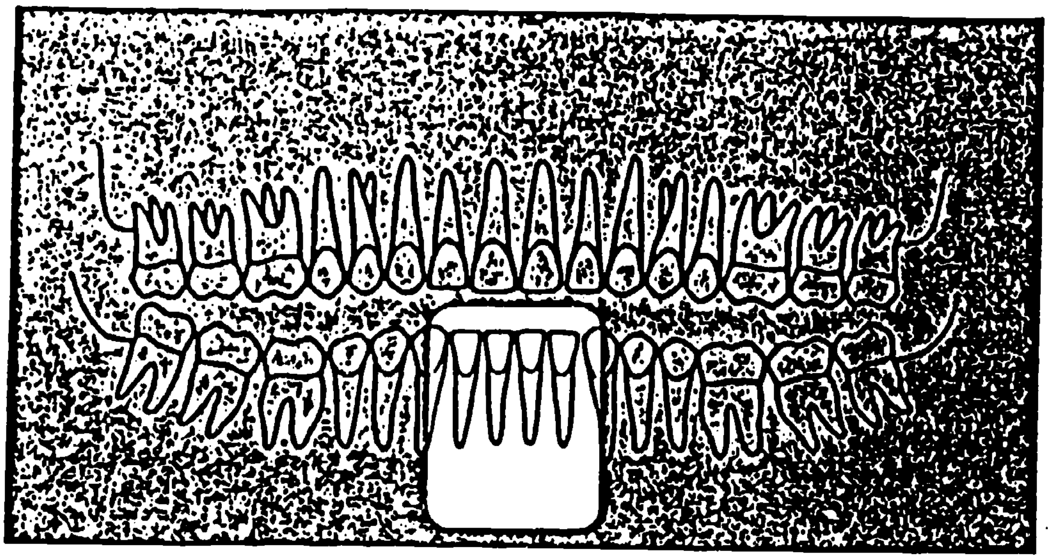
## maxillary molar region technique

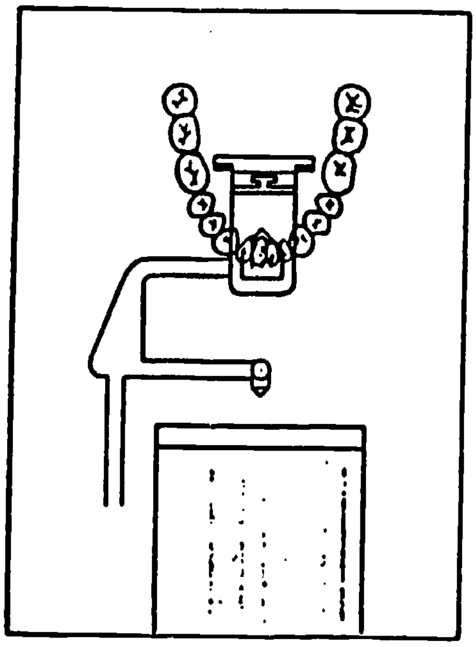


1. Position film packet in mouth with anterior edge of film in vicinity of first molar—second bicuspid contact.
2. Parallel film with long axis of molars. (Lingual placement of film packet to midline of palate will accomplish this relationship.)
3. Instruct patient to close firmly to retain established position of film.
4. Align the P.I.D. of the X-ray unit to the parallel bar of the Uni-Bite and center P.I.D. on the appropriate target point on vertical and horizontal planes.
5. Make exposure.



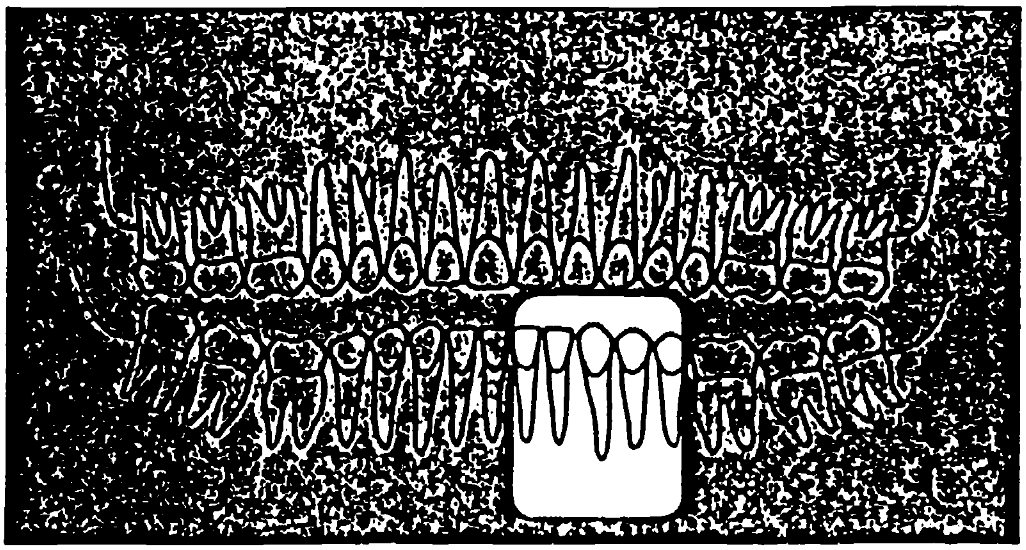
## mandibular incisor region technique



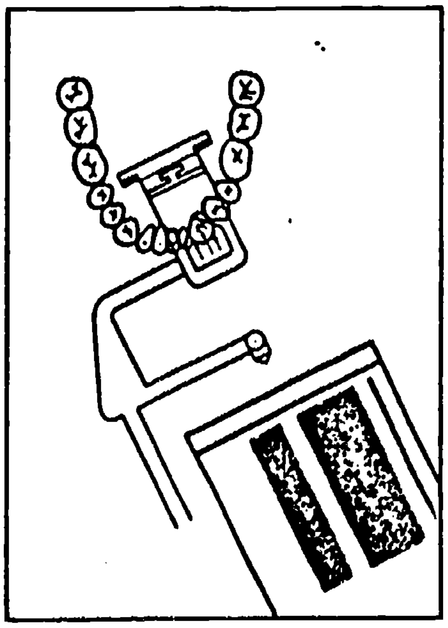


1. Center film with midline and parallel with long axis of the central incisors. (Lingual placement of film packet to the region of second bicuspids will accomplish this relationship.)
2. With bite-plate resting on incisal edges of teeth to be radiographed, instruct patient to close firmly to retain established position of film.
3. Align the P I D of the X-ray unit to the parallel bar of the Uni-Bite and center P.I.D. on the appropriate target point on vertical and horizontal planes.
4. Make exposure.

## mandibular cuspid region technique

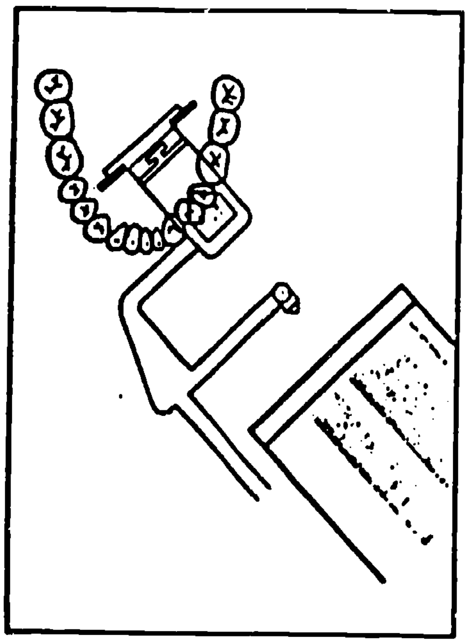


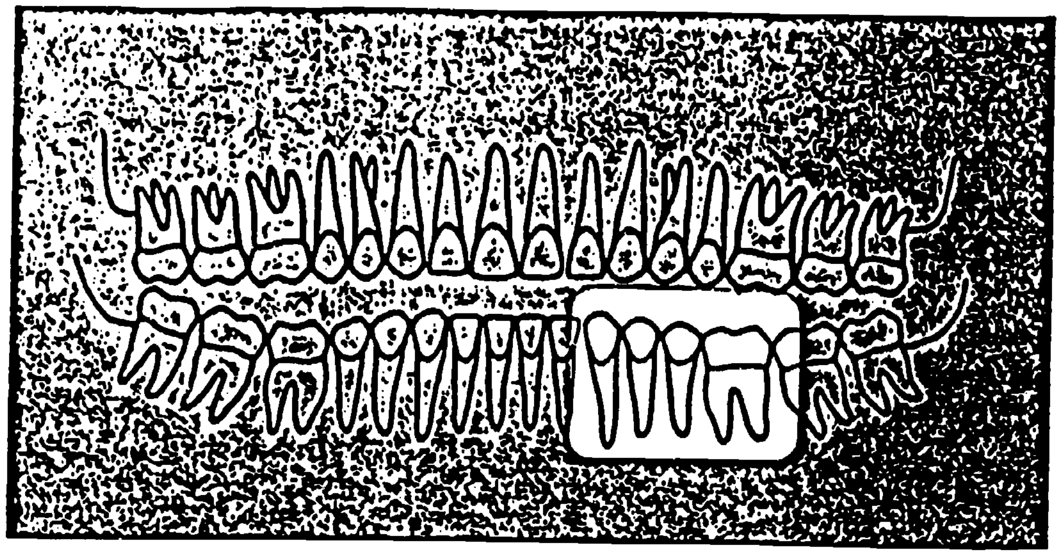
Note. It may be necessary to reverse the film carrier on the bite-plate on account of facial tissue interference



1. Center cuspid on film and parallel with long axis of tooth.
2. With bite-plate resting on mandibular cuspid, instruct patient to close firmly to maintain established position of film.
3. Align the P.I.D. of the X-ray unit to the parallel bar of the Uni-Bite and center P.I.D. on the appropriate target point on vertical and horizontal planes.
4. Make exposure.

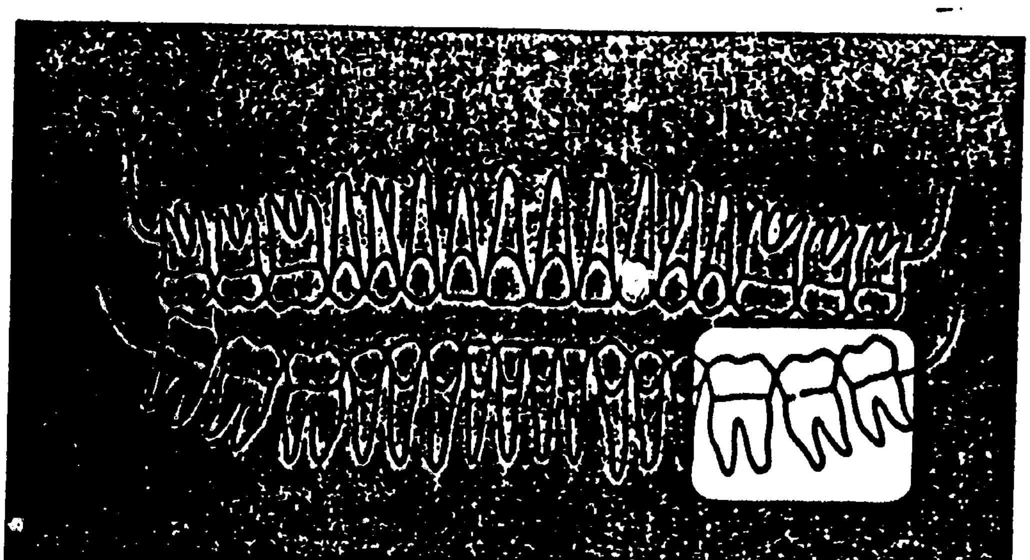
## mandibular bicuspid region technique



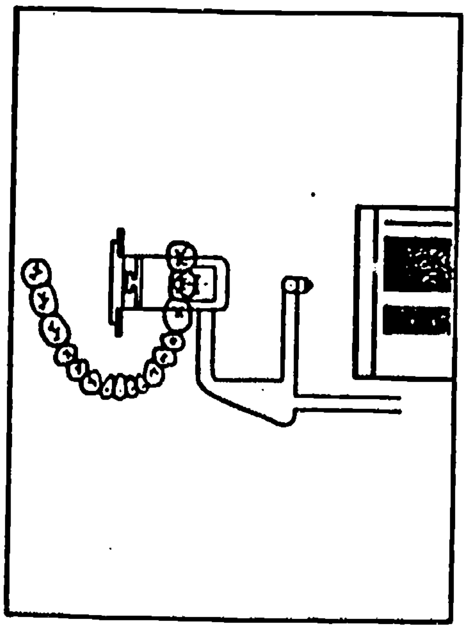


1. Position film packet in mouth with second bicuspid centered on film. Relief of the lower anterior corner of the film packet will facilitate positioning.
2. Parallel film with long axis of bicuspids. (Lingual placement of film packet will accomplish this relationship.)
3. With bite-plate held on the occlusal surfaces of the mandibular bicuspids, instruct patient to close firmly to retain established position of film.
4. Align the P.I.D. of the X-ray unit to the parallel bar of the Uni-Bite and center P.I.D. on the appropriate target point on vertical and horizontal planes.
5. Make exposure.

## mandibular molar region technique



1. Position film packet in mouth with anterior edge of film in vicinity of first molar—second bicuspid contact.
2. Parallel film with long axis of molars. (The occlusal surfaces of molars are usually at right angles to their long axis so if the bite-plate is rested flat across the occlusal surfaces, the plane of the film automatically assumes a position parallel to the long axis of the teeth.) The film packet is positioned in the sulcus between the teeth and tongue.
3. Instruct the patient to close firmly to retain established position of film.
4. Align the P.I.D. of the X-ray unit to the parallel bar of the Uni-Bite and center P.I.D. on the appropriate target point on vertical and horizontal planes.
5. Make exposure.



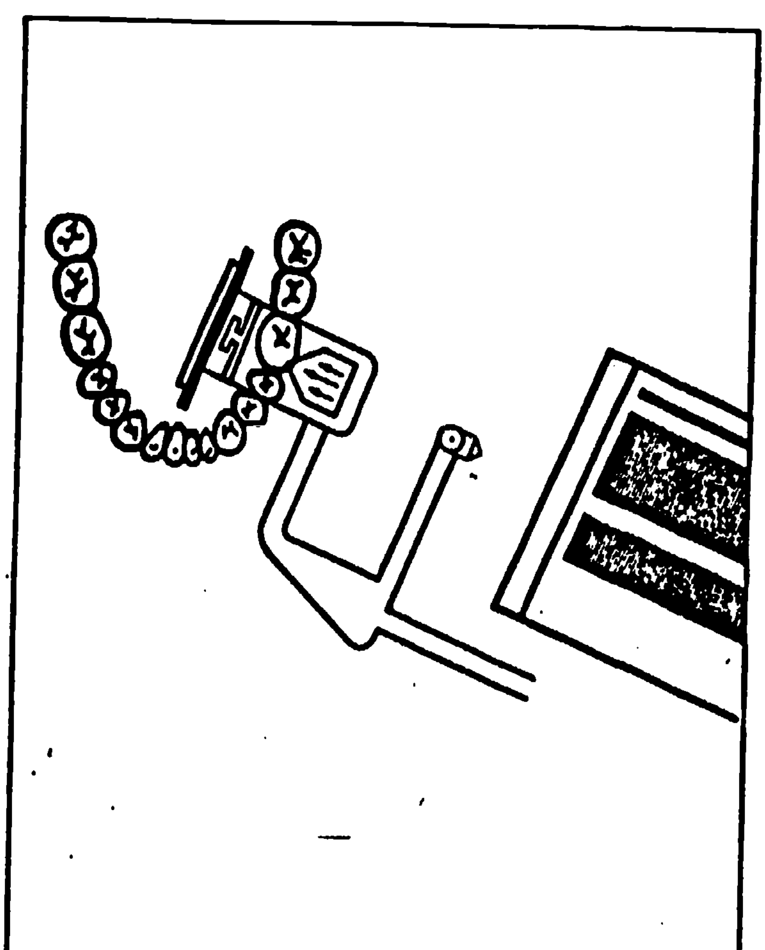
# UNI-BITE™

## interproximal technique with the uni-bite instrument

The interproximal examination is considered the least difficult of the intraoral techniques to accomplish, yet the results of incorrect alignment of the X-ray beam, teeth and film are frequently seen on finished radiographs. These errors are manifested as cone-cutting, closed interproximal areas, overlapped crowns and occlusal planes recorded diagonally on the film.

### the uni-bite instrument is designed to reduce these errors to a minimum by:

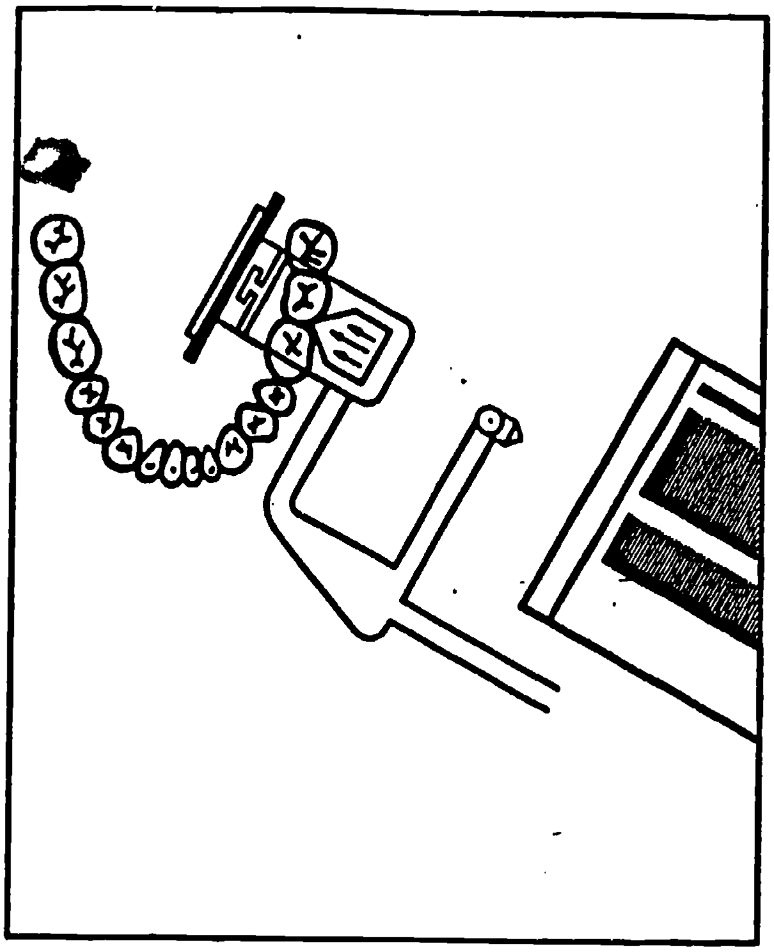
1. Automatically indicating the correct X-ray beam-teeth film alignment, thus eliminating the necessity for numerically setting the angulation and for placing the patient's head in any predetermined position.
2. Records the occlusal plane and horizontal level.
3. Establishes a positive method to correctly record the embrasures and contact areas.
4. Eliminates cone-cutting.



## bicuspid-cuspid exposure technique

1. With the biting portion resting on the occlusal surfaces of the mandibular teeth, center the film opposite the bicuspids and perpendicular to the embrasures.
2. Instruct the patient to close teeth firmly to retain film in position.
3. Align the P.I.D. of the X-ray unit to the parallel bar of the Uni-Bite and center P.I.D. on the appropriate target point on vertical and horizontal planes.
4. Make exposure.

# molar exposure technique



1. With the biting portion resting on the occlusal surfaces of the mandibular teeth, align the anterior border of the film with the mesial surface of the first molar.
2. Instruct the patient to close teeth firmly to retain film in position.
3. Align the P.I.D. of the X-ray unit to the parallel bar of the Uni-Bite and center P.I.D. on the appropriate target point on vertical and horizontal planes.
4. Make exposure.



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## UNIT OVERVIEW

**Task**

Recognize the structures in the oral cavity through the use of radiographs.

**Estimated Time**

2 hours

**Introduction**

It is necessary for the dental assistant to be able to recognize and identify the different structures in the oral cavity, both natural and artificial, on radiographs.

**Outline**

1. Radiopaque and Radiolucent Structures
2. Tooth Structures
3. Bone and Surrounding Structures
4. Restorative Materials
5. Abnormalities in Tooth and Bone

**Performance Objectives**

1. Distinguish between radiopaque and radiolucent structures on radiographs.
2. Differentiate between the different tooth structures on a radiograph.
3. Identify the bone and surrounding structures in the oral cavity as shown on radiographs.
4. Point out the different restorative materials used in the mouth as they appear on a radiograph.
5. Indicate the different abnormalities that may develop in the oral cavity and be able to identify them.



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## STUDY GUIDE

| Completed √ | Activities | Resources |
|---|---|---|
| ____ | 1. Attend lecture | 1. Instructor |
| ____ | 2. Read | 2. Text, pp. 229-260 |
| ____ | 3. View | 3. Slide tape, "Radiographic Dental Anatomy and Pathology," Box 241, Learning Lab |
| ____ | 4. Read | 4. Information Sheet, "Radiography" |



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## INFORMATION SHEET

### Radiography

Anatomical Landmarks in Radiographs

Lamina Dura - Cortical bone which surrounds the root. Radiopaque

Periodontal membrane space - Radiolucent line between the root and the lamina dura.

Maxillary Arch

Central Lateral Incisor Area

1. Incisive canal foramen
2. Median palatine suture
3. Nasal fossa
4. Nasal septum

Cuspid Area

1. Maxillary sinus
2. Nasal fossa
3. "Y" formation

Bicuspid Area

1. Maxillary sinus divided by septum
2. Anterior portion of the zygomatic or malar bone

Molar Area

Posterior portion of maxillary sinus
Zygomatic or malar bone
Maxillary tuberosity
Hamular process
Coronoid process

Mandibular Arch

Central-Lateral-Incisor Area

1. Lingual foramen
2. Genial tubercles
3. Inferior border of the mandible
4. Mental process

Cuspid Region

1. Posterior portion of mental process
2. Mental foramen
3. Inferior border of mandible

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Bicuspid Region

1. Mental foramen
2. Mylohyoid line
3. Inferior border of the mandible

Molar Area

1. External oblique line
2. Internal oblique line
3. Mandibular canal
4. Inferior border of mandible

508312E

## UNIT OVERVIEW

**Task**

Apply knowledge of the setup of an x-ray darkroom and the process for developing dental radiographs.

**Estimated Time**

3 hours

**Introduction**

The darkroom and the materials in it are a necessary part of the dental office. It is important for the student to understand what is in the darkroom and how to run the equipment house there.

**Outline**

1. Darkroom and Equipment
2. Components of Dental Radiographic Film and Storage
3. Developer Solutions
4. Procedure for Developing Radiographs
5. Common Darkroom Errors
6. Automatic Film Processors

**Performance Objectives**

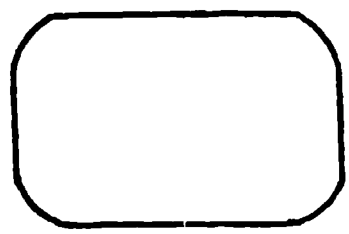
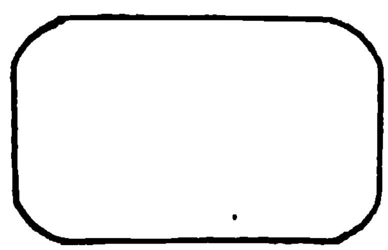
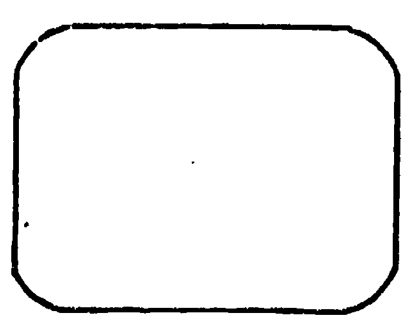
1. List important features of a darkroom and identify the necessary equipment.
2. Identify the components and chemicals in dental film.
3. Indicate how film should be stored.
4. List steps in preparation for processing film.
5. Identify the steps for proper film processing.
6. Describe clean-up procedures.
7. List common darkroom errors and methods to prevent them.
8. Identify errors on radiographs.
9. Operate automatic film processors correctly.

## STUDY GUIDE

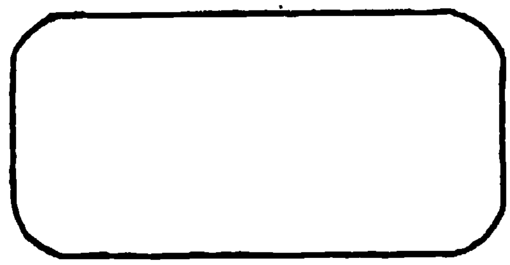
| Completed ✓ | Activities | Resources |
|---|---|---|
| ___ | 1. Attend lecture | 1. Instructor |
| ___ | 2. View | 2. Slide tapes, "Darkroom and Darkroom Chemistry,"-Box 242, and "Manual Processing and Darkroom Errors," Box 243, Learning Lab |
| ___ | 3. Read | 3. Information Sheet 1, "Film Processing" |
| ___ | 4. Read | 4. Text, pp. 195-227 |
| ___ | 5. Read | 5. a. Information Sheet 2, "The Processing Room"<br>b. Information Sheet 3, "Processing Pitfalls and Radiographic Artifacts"<br>c. Information Sheet 4, "Trouble Shooting Film Processors"<br>d. Information Sheet 5, "Solving Film Problems"<br>e. Information Sheet 6, "Characteristics of Direct and Indirect Imaging Systems" |

## INFORMATION SHEET 1

### Film Processing

| FILM TYPE | A.S.A. TYPE-SIZE DESIGNATION | FILM SIZE | AVERAGE AGE RANGE FOR USE |
|---|---|---|---|
| A.S.A. 1 and 2 | | A.S.A. 0.0 (7/8" x 1 3/8") | Less than 6 years |
| Periapical | 1.0 |  No. 0 | |
| Bitewing | 2.0 | | |
| A.S.A. 1 and 2 | | A.S.A. 0.1 (15/16" x 1 9/16") | 5 years and up |
| Periapical | 1.1 |  No. 1 | |
| Bitewing | 2.1 | | |
| A.S.A. 1 and 2 | | A.S.A. 0.2 (1 1/4" x 1 5/8") | 5 years and up |
| Periapical | 1.2 |  No. 2 | |
| Bitewing | 2.2 | | |

Films Used in Oral Roentgenography

| FILM TYPE | A.S.A. TYPE-SIZE DESIGNATION | FILM SIZE | AVERAGE AGE RANGE FOR USE |
|---|---|---|---|
| A.S.A. 2 | | A.S.A. 0.3 (1 1/16" x 2 1/8") | 12 years and up |
| Bitewing | 2.3 |  No. 3 | |
| A.S.A. 3 | | A.S.A. 0.4 (2 1/4" x 3") | 8 years and up |
| Occlusal | 3.4 | | |
| Lateral Oblique | | 5" x 7" | Any age |
| Head Plate | | 8" x 10" or 10" x 12" | Any age |
| Panogram | | 5" x 12" or 6" x 12" | 5 years and up |

Films Used in Oral Roentgenography

## INFORMATION SHEET 2

### The Processing Room

I. Sensitometry

Definition. The study of the relationship between exposure and density after processing. This relationship is represented graphically with a sensitometric curve also known as a characteristic curve, H and D curve, or sensitometric curve. Sensitometry provides information about the average gradient, speed, and latitude of the film.

A. Average gradient. The average gradient is a combination of two important factors, film contrast and exposure latitude. The average gradient can influence image contrast by amplifying or suppressing subject contrast. A high contrast film furnishes major differences in density between two areas receiving slightly different exposures. A low contrast film will provide less difference in optical density for the same difference in exposure.

B. Film speed. Refers to film sensitivity and is determined by the position of the characteristic curve on the graph.

C. Film latitude. Ability of the film to respond to a wide range of exposures. Latitude and contrast are inversely related.

II. The Sensitometric Curve

A. Exposure

B. Noise (scattered, secondary radiation, and fog)

C. Processing (temperature, developing time, and concentration of solutions)

III. Manual Processing

Processing of the film is critical in the production of high quality radiographs. If a film is not processed correctly, it can result in radiographs that are too light or too dark.

A. Chemicals and replenishment

B. Time and temperature method

The following chart applies to E and D film. For extraoral film, follow the recommendations of the manufacturers.

Developer

| Temp. | Time | Rinse | Fix | Wash |
|---|---|---|---|---|
| 65 | 6 min. | | 4 min. | 10 min. |
| 68 | 5 min. | 30 sec. | | |
| 70 | 4 1/2 min. | agitate | | |
| 72 | 4 min. | | | |
| 76 | 3 min. | | | |
| 80 | 2 1/2 min. | | | |

C. Advantages vs. disadvantages

Inexpensive, low maintenance, requires relatively little space vs. inconsistent results, more time consuming to process (dry to dry), requires darken room.

IV. Automatic Processing

Film processing is the most important link in the radiographic chain and perhaps the most neglected. Most problems in radiography can be traced to processing. It is very simple to maintain and keep a processing system that contributes to the achievement of maximum image quality.

A. Chemicals and replenishment

At each solution change:

1. Tanks should be thoroughly cleaned (cleaning removes the chemical deposits and contaminants).
2. Use a bland soap and soft brush (non-abrasive) to clean tanks and rollers or use a commercial cleaner.
3. Thorough rinsing is essential to remove any trace of soap or cleaner to prevent chemistry contamination.
4. For automatic processors, inspect rollers, gears, and turning mechanism for signs of wear.
5. Always change developer and fixer solutions at the same time. Fixer tank should be filled first and developer second to prevent contamination.
6. After changing solutions, run a test film and perform Quality Control to assess processor performance.
7. To maintain the stability and consistency of the chemicals, replenish developer and fixer daily. Follow the recommendations of the manufacturer. However, if this information is not available, use about 12 fluid ounces of replenisher daily.

B. Processor upkeep

1. Processors should be cleaned on a regularly scheduled basis. This should include inspections of working parts and assessment of its overall integrity.
2. Every single night the main cover, the developer, and fixer covers should be removed to allow processor to breathe and prevent condensation from forming. Condensation droplets fall on the rollers and are sometimes responsible for film artifacts.
3. When the processor is first turned on in the early a.m., it should be allowed to warm up so that it reaches a working temperature. To remove any dirt that may be on the rollers, run a "blank" film through the processor. (The same film may be used over and over again).
4. To clean rollers on a scheduled basis, use plain water and a non-abrasive brush. Do not use any ready cleaners unless absolutely necessary.
5. Mixing solution

Many companies specialize in the manufacturing of dental processing solutions. It is extremely important to adhere to their guidelines for changing, mixing, and replenishing solutions. However the following factors influence the life expectancy of the chemical solutions:

1. use factor
2. normal aging
3. exposure to air and light (oxidation)
4. chemical contamination
5. temperature
6. frequency of replenishment
7. quality of solutions

Listed below are some conditions that are known to be responsible for processing pitfalls.

Automatic Processor

1. Dirty rollers result in artifacts and sometimes cause film jams.
2. Faulty temperature regulation system or incorrect setting results in light or dark films.
3. Improper replenishment results in dark or light films, incomplete development and fixing, brown films, wet films, or films with a milky appearance.
4. Variation in development time caused by faulty gear drive train results in dark films.

Manual Processing

1. Incorrect temperature results in light or dark films.
2. Incorrect development time results in light or dark films.
3. Inadequate replenishment results in light or dark films.
4. Failure to stir solutions causes uneven development.
5. Corroded tanks cause contamination of solutions.
6. Oxidized developer causes brown spots.

V. Safelighting

The processing room should provide lighting that has been proven to be safe with the type of film being used. In addition, white light leaks should be eliminated in order to prevent fogging of the film. The selection of the type of safelight filter is very important because not all films can be safely handled under the same lighting conditions.

The GBX-2 safelight filter (red filter) equipped with a 15-watt light bulb placed at 4 feet away from the working surface provides a safelight work environment for most medical films presently being used, including green light sensitive film.

The 6' safelight filter (orange yellow filter) equipped with a 15-watt light bul' ~ced at 4 feet away from the working surface provides a safelight work environment for blue light sensitive film but not for green light sensitive film; it will cause fogging of the green sensitive film.

The MRL2 safelight filter (amber filter) is safe for intraoral film but not for green light sensitive film.

Note:

A. Radiographic film is more sensitive after it has been exposed to radiation, therefore it fogs easier.

B. White light leaks around door frames, light switches, and indicator lights should be eliminated.

C. Safelights fade with age and time. If filters are on for 12 hours/day, they should be replaced every 2 years.

VI. Film Storage and Handling

Underexposed and unprocessed film should be kept in a cool dry place. High temperatures increase the sensitization of the film emulsion, causing loss of contrast and the production of fog. The ideal temperature should be 10°C-21°C (50°F-70°F) and 40-60 percent relative humidity. Film should be stored on its side and not flat because of the potential for creating pressure artifacts. Film should be used before the expiration date. The film with the nearest expiration date should be used first. First in first out (FIFO).

VII. Quality Control

A. Processing and

- check temperature and processing time daily
- replenish daily
- schedule cleanings (frequency depends on use)
- do film strip to check consistency of operation daily

B. Safelight integrity should be assessed every six months.

# INFORMATION SHEET 3

## Processing Pitfalls and Radiographic Artifacts

Processing Pitfalls are those events that occur as a result of poor darkroom practices.

Radiographic Artifacts are unwanted, useless images that will interfere with radiologic interpretation. The general source of Artifacts are:

I. Exposure
II. Processing
III. Handling
IV. Storage
V. Other

I. Exposure. Exposure artifacts are generally related to improper exposure techniques.

| Condition | Probable Cause |
|---|---|
| A. No image | Faulty exposure switch, faulty generator |
| B. Light image | Incomplete exposure, faulty generator, not enough exposure, wrong film |
| C. Dark image | Faulty generator, too much exposure, wrong film |
| D. Blurred image | Patient motion, tube motion, film motion |
| E. Double image | Double exposure |

II. Processing. Processing artifacts usually arise from improper relationship between time, temperature, and chemical activity factors.

| Condition | Probable Cause |
|---|---|
| A. Light films | Temperature too low, development time too short, underreplenishment, solutions too old |
| B. Dark films | Temperature too high, development time too long, overreplenishment |

III. Handling. Film should be held by the edges when possible. Hands should be clean and dry. The following are examples of artifacts caused by poor handling.

| Condition | Probable Cause |
|---|---|
| Tree-like artifacts | Static electricity |
| Crescent/half moons | Creasing film with fingernail |
| Fingerprint pattern | Moist hands |

IV. Storage. Unexposed and unprocessed film should be kept in a cool, dry place. High temperatures increase the sensitization of the film emulsion, causing loss of contrast and production of fog. Ideally, film should be kept in a place with temperature ranges of 50 to 70°F and 40 to 60 percent relative humidity.

Film should be used before expiration date, since film aging causes a loss in speed and contrast and increases fog. The oldest film should be used first and the newest last. (FIFO) First in first out.

V. Other.

| Condition | Probable Cause |
| --- | --- |
| Embossing pattern | Positioning film backwards |
| Clear area | Protective apron |
| Half moon clear shape | Cone cut |
| Rectangular clear shape | Improper alignment of tube and precision instrument |

## INFORMATION SHEET 4

### Trouble-Shooting Film Processors

#### Films Too Dark

| CAUSES | CHECK AND CORRECT |
|---|---|
| Developer temperature too high. Overactive developer. | Check thermostat, check for wrong chemistry, mixing procedure, not enough starter. |
| Immersion time prolonged. | Check transport system, look for excessive wear of gears and sprockets, alignment and lack of lubrication. |
| Overreplenishment | Check replenishing rates. |

#### Films Too Light

| CAUSES | CHECK AND CORRECT |
|---|---|
| Developer temperature too low | Check thermostat, heat exchanger, temperature circuit board, solution heating pad. |
| Decreased developer activity | Check for contaminated or exhausted developer, mixing procedures. |
| Underreplenishment | Check replenishing rates. |
| Immersion time too low | Check motor running too fast, immersion time. |

#### Films Jamming

| CAUSES | CHECK AND CORRECT |
|---|---|
| Chemical | Check for improperly mixed chemicals, contaminated chemicals, especially fixer, wrong chemistry. |
| Mechanical | Check for drying temperature too low, malalignment of processing racks and crossovers, dirty rollers, worn drive gears. |

#### Artifacts

| CAUSES | CHECK AND CORRECT |
|---|---|
| Mechanical | Dirty or malaligned rollers, dirty tanks. |
| Chemical | Precipitate in fixer, no wash water or dirty water, detergent used to clean rollers was not adequately rinsed. |
| Static | Check humidity and if necessary install humidifier. |

#### Films Not Drying

| CAUSES | CHECK AND CORRECT |
|---|---|
| Mechanical | Check heater/fan assembly, incorrect drying temperature, dryer thermostat. |

| | |
|---|---|
| Chemical | Check for proper fixation, particularly lack of hardener. |
| | **Shiny Films** |
| Mechanical | Check temperature for developer and dryer. |
| Chemical | Check for excessive hardener in fixer due to overreplenishment, water not turned on. |
| | **Uneven Development** |
| Chemical | Check for inadequate replenishment, possible incorrect mixing. |
| | **Films Greenish-Yellow** |
| Mechanical | Check processing time; it may be too fast. |
| Chemical | Check fixer solution, replace if necessary; make sure film is designed for automatic processing. |

# INFORMATION SHEET 5

## Solving Film Problems

| CAUSES | CHECK AND CORRECT |
|---|---|
| | **Films Too Dark** |
| Overexposure | Check processing as recommended in "Trouble-Shooting Film Processors." Check exposure factors and decrease, if necessary; distance (not enough SID). |
| Equipment | Check film speed, film/screen combination, lack of grid, timer failure, milliamperage, and kilovoltage calibration. |
| | **Films Too Light** |
| Underexposure | Check processing. Check exposure factors and increase, if necessary, distance (too much SID). |
| Equipment | Check film speed, film/screen combination, timer failure, milliamperage, and kilovoltage calibration. |
| | **No Exposure** |
| Mechanical | Check fuses, circuit breakers, on/off switches, broken wires. |
| | **Fog** |
| Varies | Check chemistry. Check for incorrect or defective safelight filter or bulb. Eliminate light leaks in processing room or loader. Check for outdated film. Check to see if object size requires use of grid (in general, a grid should be considered for any object thickness which is greater than 12 cm). |

### Manual Processing Errors

NOTE: To achieve optimum film processing, it is crucial to adhere to time-temperature charts recommended by the film manufacturer.

| | **Films Too Dark** |
|---|---|
| Mechanical | Prolonged developing time, extremely hot solutions, or inadequate fixing times. |
| Chemical | Overconcentrated solutions. |

## Films Too Light

| | |
|---|---|
| Mechanical | Inadequate developing time, extremely cold solutions, or excessive fixing times. |
| Chemical | Depleted solutions. |

## INFORMATION SHEET 6

### Characteristics of Direct and Indirect Imaging Systems

I. Radiographic Film.

A. Definition. Principal medium used to record information that will be used for diagnostic purposes.

B. Construction.

1. Base. This is a transparent plastic material (polyester) which is very strong. It can be made thin allowing the improvement in definition when viewing the image formed on a double-sided film. The base provides support and rigidity and is able to withstand exposure to processing solutions without distorting. The base is also tinted blue to improve viewing, making it easier on the eye.
2. Emulsion. Binder and recording medium, the binder is gelatin, the recording medium is usually 90-99 percent silver bromide and 1-10 percent silver iodide. These silver halides are photosensitive and undergo a change when exposed to certain wavelengths of electromagnetic radiation.
3. Protective Coating. (Super Coat). The protective coat is applied on top of the emulsion and it serves to protect the film from scratches and provides easy handling without destroying the image.

C. Types of Radiographic Film.

1. Indirect Exposure. Sensitive mainly to light emitted from intensifying screens.
   a. blue light sensitive
   b. green light sensitive
2. Direct Exposure. Sensitive mainly to the direct action of x-rays.

D. Applications of Radiographic Film.

1. Medical. Cephalometry and Temporomandibular joint radiography.
2. Dental. Periapical, Bitewing, and Occlusal radiography.
3. Packaging. All Kodak intraoral film packets consist of:
   a. black protective paper
   b. lead foil backing
   c. outer wrap

   The packets contain 1 or 2 films. They are color coded to distinguish between the 1 and 2 film containing packets as well as Kodak Ultraspeed and Ektaspeed. The color coded tab on the packet identifies the nontube size of the film. The outer wrap is either paper or poly-soft; the poly-soft provides a sealed, waterproof, laminated outer wrap.
4. Sizes. Films are supplied in a variety of sizes to easily accommodate the wide range of mouth sizes for adults,

adolescents, and children. Films are supplied in No. 0, No. 1, No. 2, No. 3, and No. 4 (occlusal) sizes.

5. Uses. For all practical purposes, intraoral film is divided into three categories: periapical film, bitewing film, and occlusal film.

Periapical film. Used for the examination of the entire tooth and its surrounding structures.

Bitewing film. Used for the examination of the interproximal surfaces of the teeth.

Occlusal film. Used for the examination of large areas of the maxilla and the mandible.

Left side and right side identification. Intraoral film is manufactured with an embossed dot stamped into it that appears as a bump on the exposure surface. This dot serves to identify the right side from the left side.

II. Sensitometry.

A. Definition. Quantitative measurement of the response of a film to exposure and development. The heart of sensitometry is the sensitometric strip. A sensitometric strip is made using a sensitometer, stepwedge, or by exposing successive areas on a film starting with a "no exposure" area and progressively making larger exposures until the maximum density of the film is reached. The steps can be accurately measured with a densitometer. A densitometer is a device that measures the percentage of light that is transmitted through a film; the light transmittance is recorded in density units.

Density. Density expresses how a film stops or absorbs light just as transmission tells us how much light a film lets through. Density is the amount of blackening in a negative. The formula to calculate density is:

$$D = \text{Log} = \frac{Io}{It}$$

D = density
Log = logarithm of a number whose base is 10
Io = incident light
It = transmitted light

Radiographic film contains densities ranging from 0 to 4; these densities correspond to clear and black, respectively. Most unexposed and processed film have densities in the range of 0.1 to 0.15 and the useful ra... of radiographic densities is between .25 to 2.5.

Characteristic curve. A characteristic curve is a product of sensitometry and it serves to evaluate the characteristics of a film by simply noting the shape of the curve and its location on the graph.

B. Average Gradient. The average gradient is a combination of two important characteristics, film contrast and exposure latitude. Film contrast is defined as the difference in optical density, i.e., a high contrast film, furnishes a major difference in density between two areas receiving slightly different exposures. A low contrast film will provide less difference in optical density for the same difference in exposure. High-contrast film is useful when slight differences in x-ray ɩenuation in the patient need to be accentuated in the image; film oı lesser contrast is helpful when a wide range of exposures must be recorded, e.g., a chest film.

C. Film Speed. Determined by the position of the characteristic curve on the graph.

III. Radiographic Film Speed.

A. The film speed or film sensitivity is defined by the American Standard Association as the reciprocal of the exposure in roentgens required to produce a density of 1.0 above the base and fog densities.

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

Example: A film required an exposure of $2.1 \times 10^{-2}$ R (21 mR) to produce a density of 1.0 above base an fog, its speed would be:

$$S = \frac{1}{.021\ R} = \frac{48}{R} = 48R^{-1}$$

Intraoral film is classified for speed according to the following speed groups.

| Speed group | Reciprocal roentgens |
|---|---|
| A | 1.5 - 3.0 |
| B | 3.0 - 6.0 |
| C | 6.0 - 12.0 |
| D | 12.0 - 24.0 |
| E | 24.0 - 48.0 |
| F | 48.0 - 96.0 |

The groups presently in use are Ultraspeed (D) and Ektaspeed (E).

Ultraspeed (D) provides high contrast, excellent image quality, uses technic settings of traditional dental radiographic systems, and may be processed manually or automatically.

Ektaspeed (E) uses half the exposure time required for D speed with almost the same image-quality results, reduces exposure to patient and staff, and it is suited for long-cone radiographic techniques and for use with x-ray generating equipment designed for short exposure.

B. As speed increases, resolution decreases. Although E film is twice as fast as D film, resolution does not suffer enough to make any significant difference in its diagnostic value.

IV. Intensifying Screens.

A. Definition. Device that converts the energy of the x-ray beam into visible light. This visible light then interacts with the film forming the latent image. In fact, so much as 98 percent of the recorded density may be photographic in origin. (One incident x-ray photon causes the emission of about 300 light photons, about one half of which reaches the film).

B. Construction.

1. Protective coating
2. Phosphor
   a. Calcium tungstate. Emits light photons center in the 450 nanometer region of the light spectrum. The output is blue-violet light.
   b. Rare earth phosphors. Emit light photons center in the 550 nanometer region of light spectrum. The output is mainly green light. Gadolinium, lanthanum, or yttrium oxysulfide are examples of rare earth screens currently being used.
3. Screen/film speed. The screen/film speed conferred on a system depends on the conversion efficiency of the screen and the speed of the film.

508312F

## UNIT OVERVIEW

**Task**

Apply knowledge of the bisecting technique and be able to expose a full mouth survey using it.

**Estimated Time**

2 hours

**Introduction**

The bisecting technique is a method of taking radiographs in the patient's mouth. It is necessary for a dental assistant to be able to use this technique.

**Outline**

1. The Bisecting Technique
2. Vertical and Horizontal Angles
3. Foreshortening and Elongation
4. Film Holders and Patient Position

**Performance Objectives**

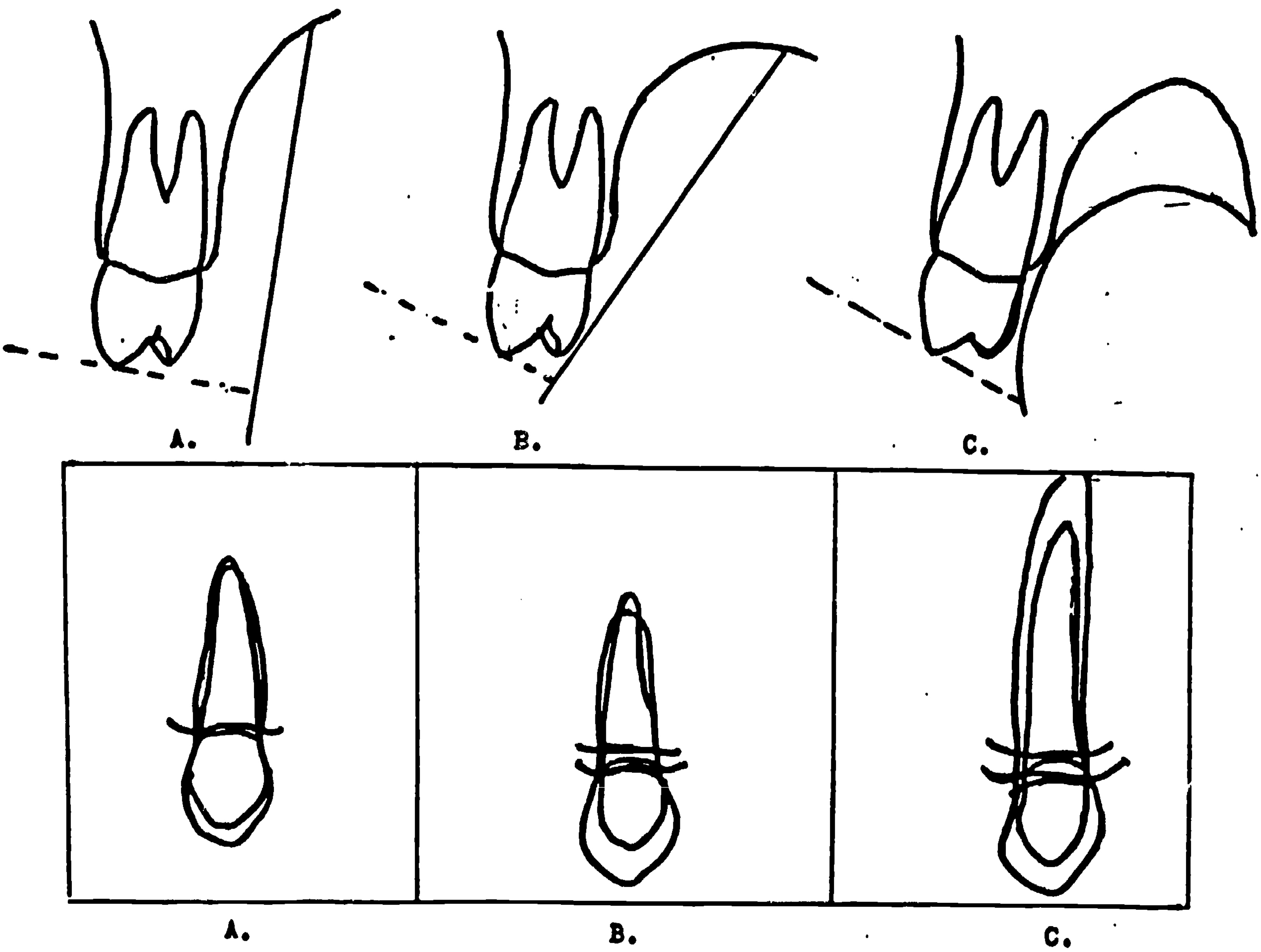
1. State the basic principles of the bisecting technique.
2. List common errors in technique.
3. Demonstrate patient positioning.
4. List film holders and demonstrate their uses.

## STUDY GUIDE

| Completed ✓ | Activities | Resources |
|---|---|---|
| ____ | 1. Attend lecture | 1. Instructor |
| ____ | 2. Participate in | 2. Lab session |
| ____ | 3. Read | 3. Text, pp. 116-136 |
| ____ | 4. Read | 4. Information Sheet 1, "X-ray Angles"<br>Information Sheet 2, "General Considerations for Routine Roentgenography"<br>Information Sheet 3, "Mandibular Periapical Biteblock Technique" |
| ____ | 5. View | 5. Slide tape, "Dental Radiography: Bisecting the Angle," Box 250, Learning Lab |

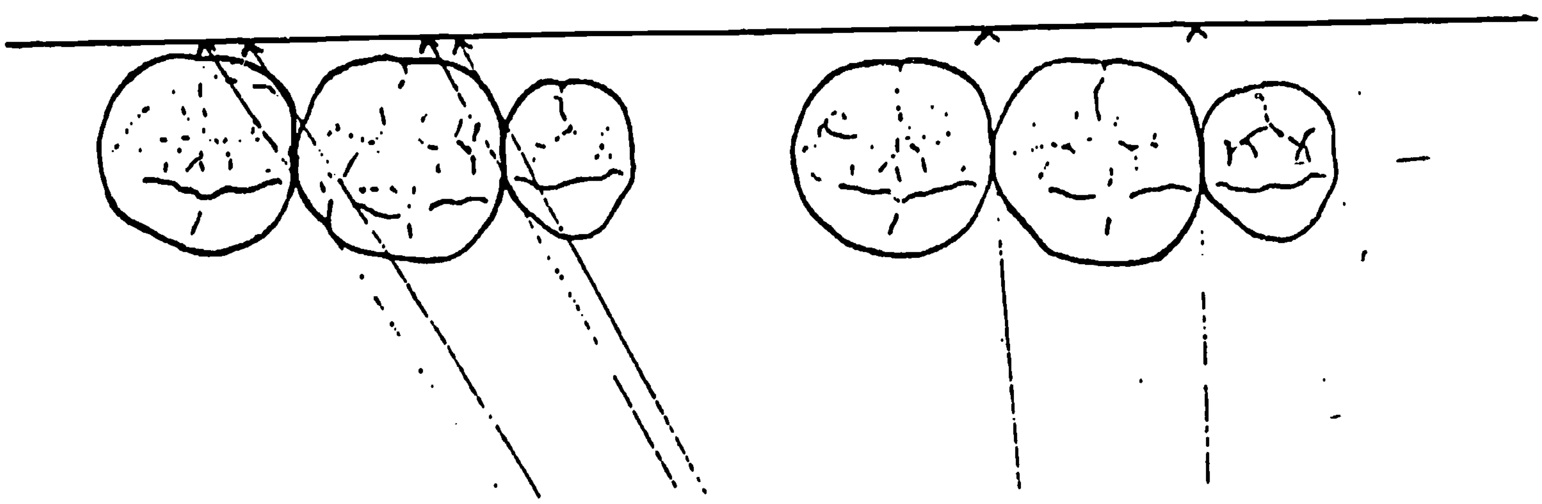
## INFORMATION SHEET 1

### X-ray Angles



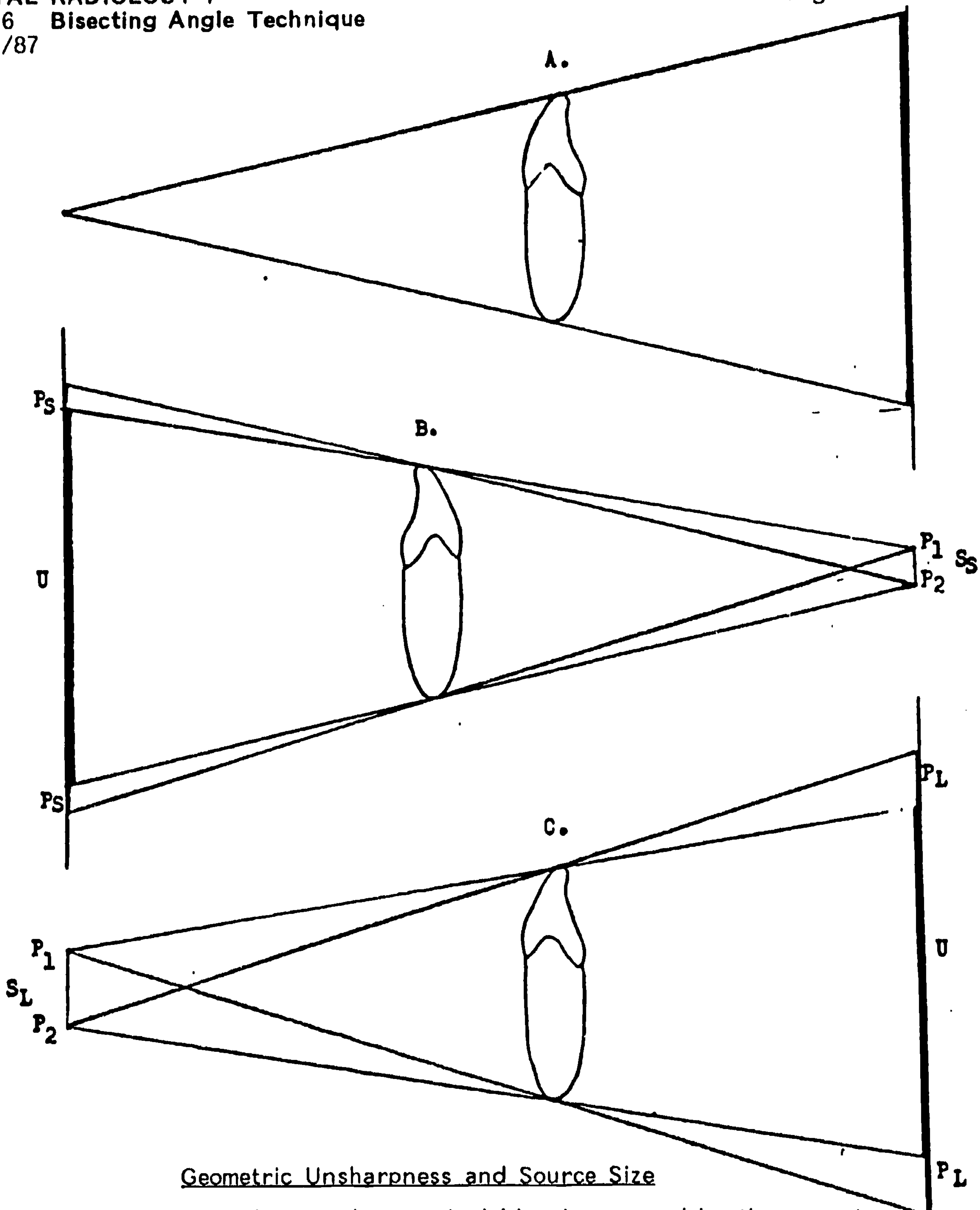

### Distortion

Minimum distortion occurs when a flat recording surface and the mean object plane of interest are parallel (A). An acceptable type of distortion occurs when the mean object plane of interest and a flat recording surface have an angular relationship and the x-ray beam is directed properly (B). A curved recording surface usually produces a totally unacceptable degree of distortion.



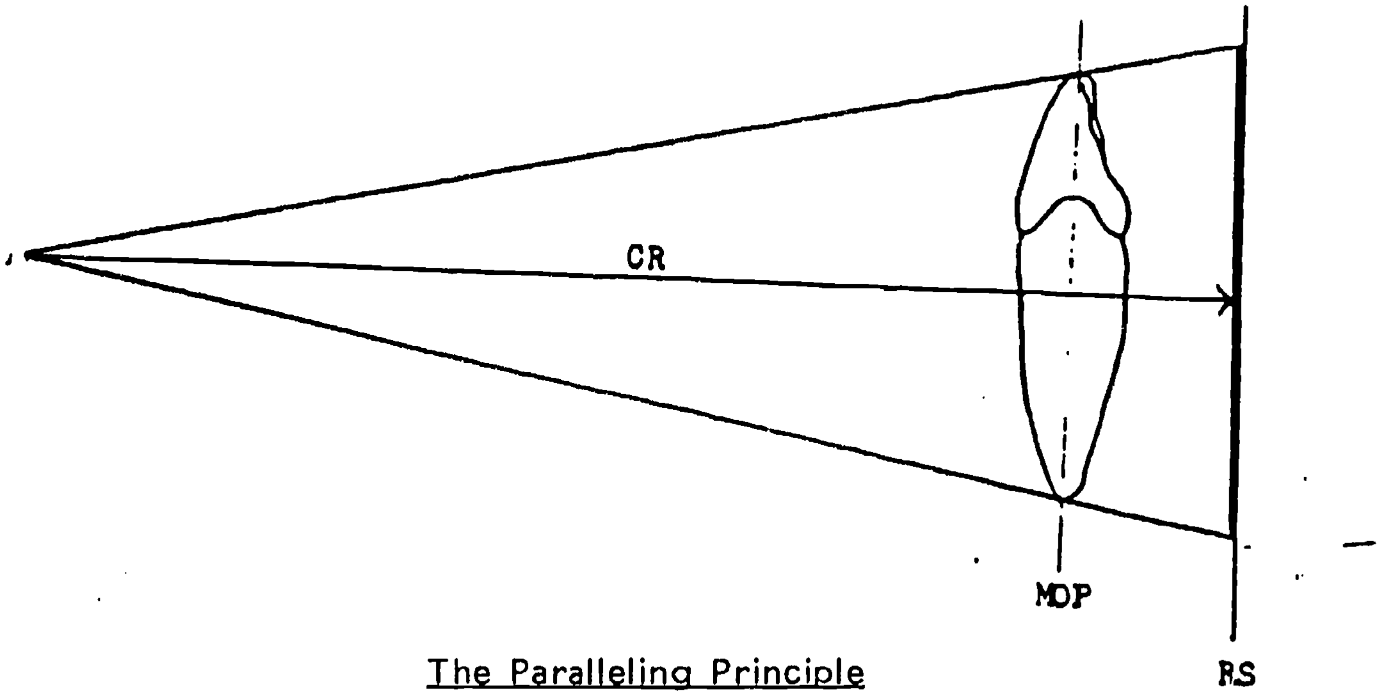
Superimposition of Images of Adjacent Structures

A. Superimposition of images of proximal surfaces of adjacent teeth is unavoidable with this projection giving a mesioblique view. B. No superimposition of proximal surfaces of adjacent teeth is produced with this projection, which gives a good mesiodistal view.



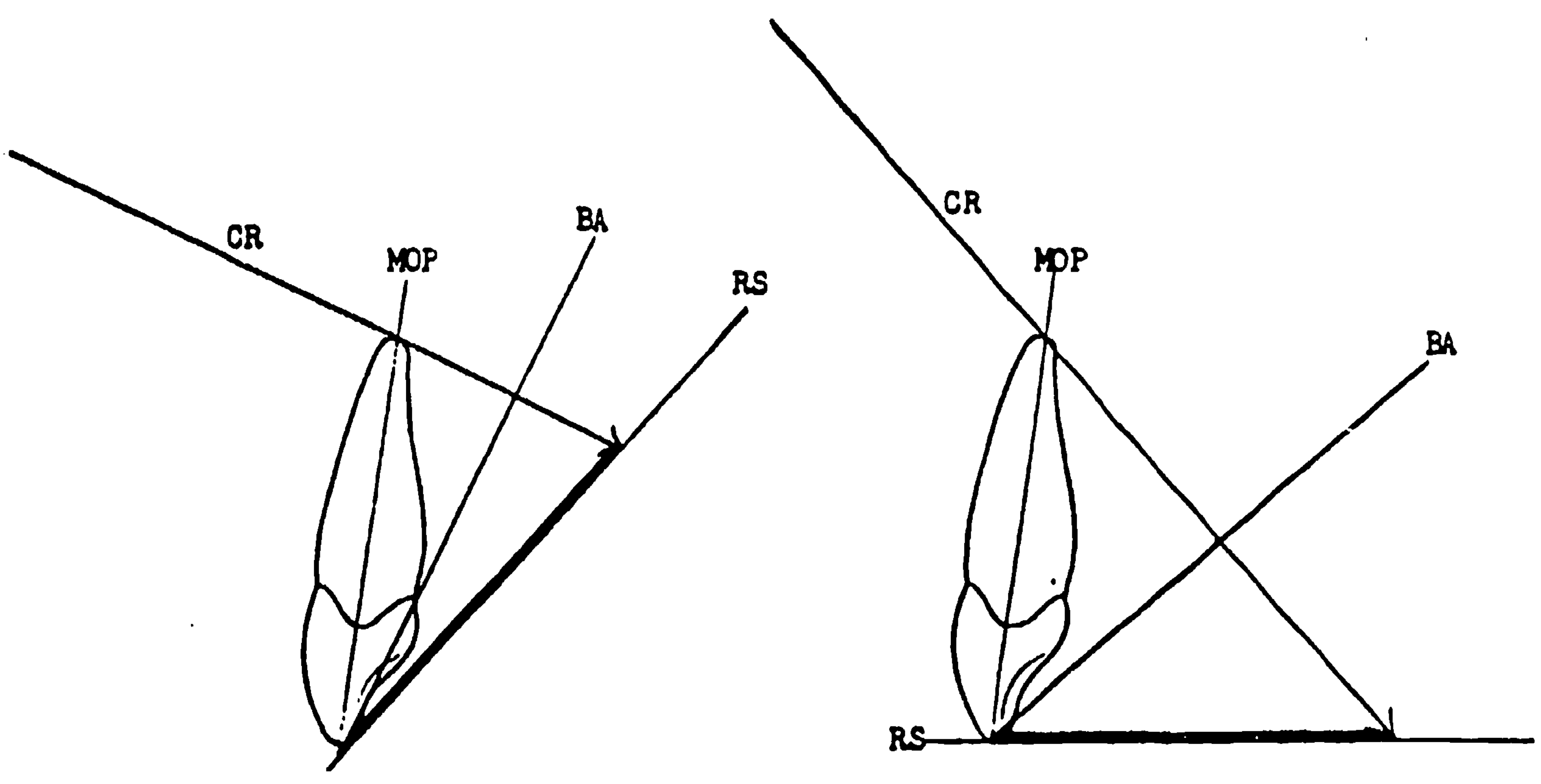

Geometric Unsharpness and Source Size

Geometric unsharpness refers to the marginal blurring caused by the geometry of an area source of radiation. A point source of radiation would produce no geometric unsharpness (A). An area source consists of an infinite number of point sources and produces not only a true shadow or image, the umbra (U), but also a blurred marginal shadow, the penumbra (P). B. Two points ($P_1$ and $P_2$) of maximum distance apart on the smaller source ($S_S$) produce a smaller penumbra ($P_S$) and less geometric unsharpness than two points of maximum distance apart on the larger source ($S_L$), which produce a larger penumbra ($P_L$) and a greater geometric unsharpness (C).



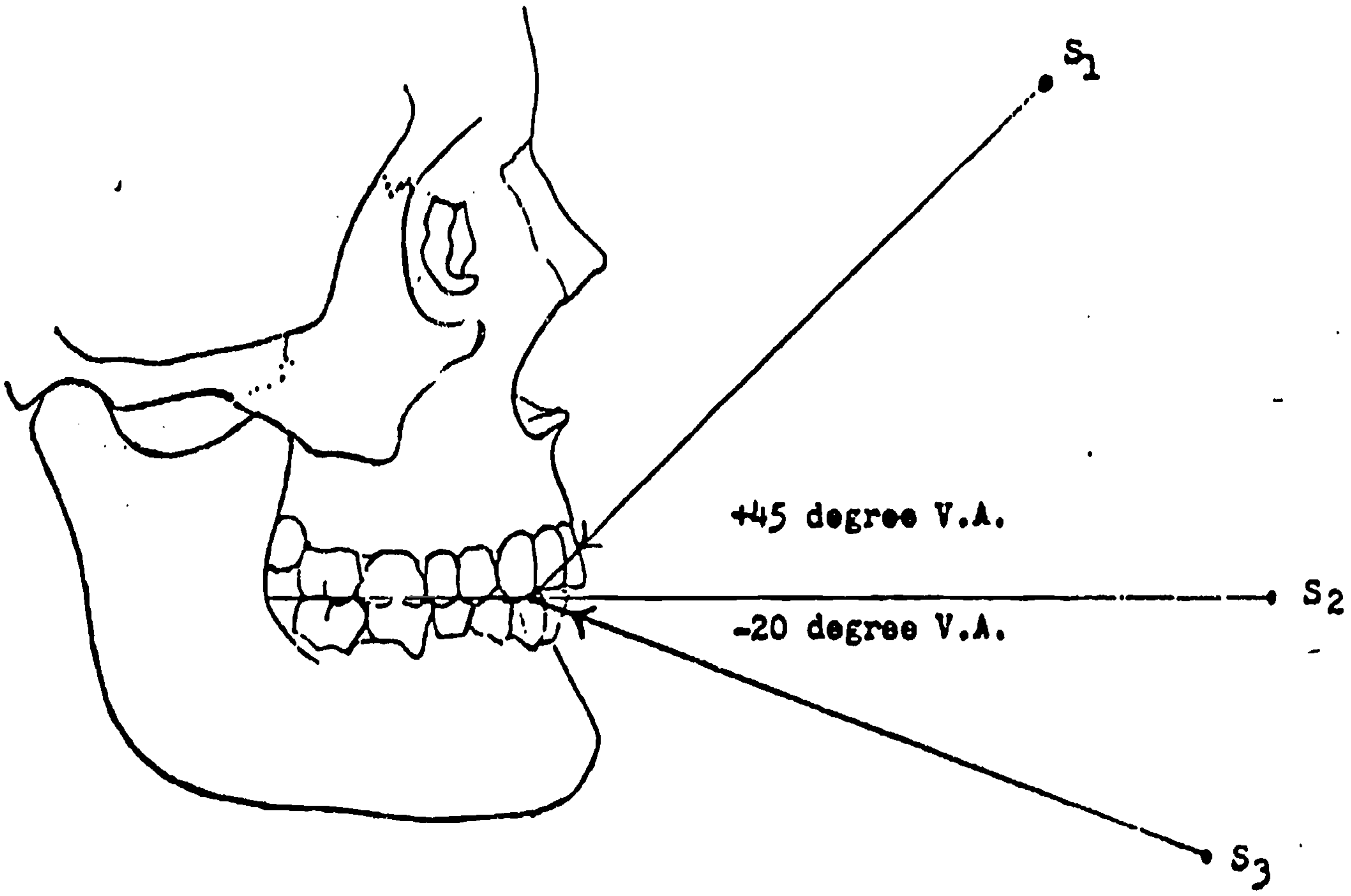

The Paralleling Principle

The paralleling principle states that, in order to produce minimum image distortion, the mean object plane of interest (MOP) and the recording surface (RS) must be parallel and the central ray of the x-ray beam (CR) directed perpendicularly to each.



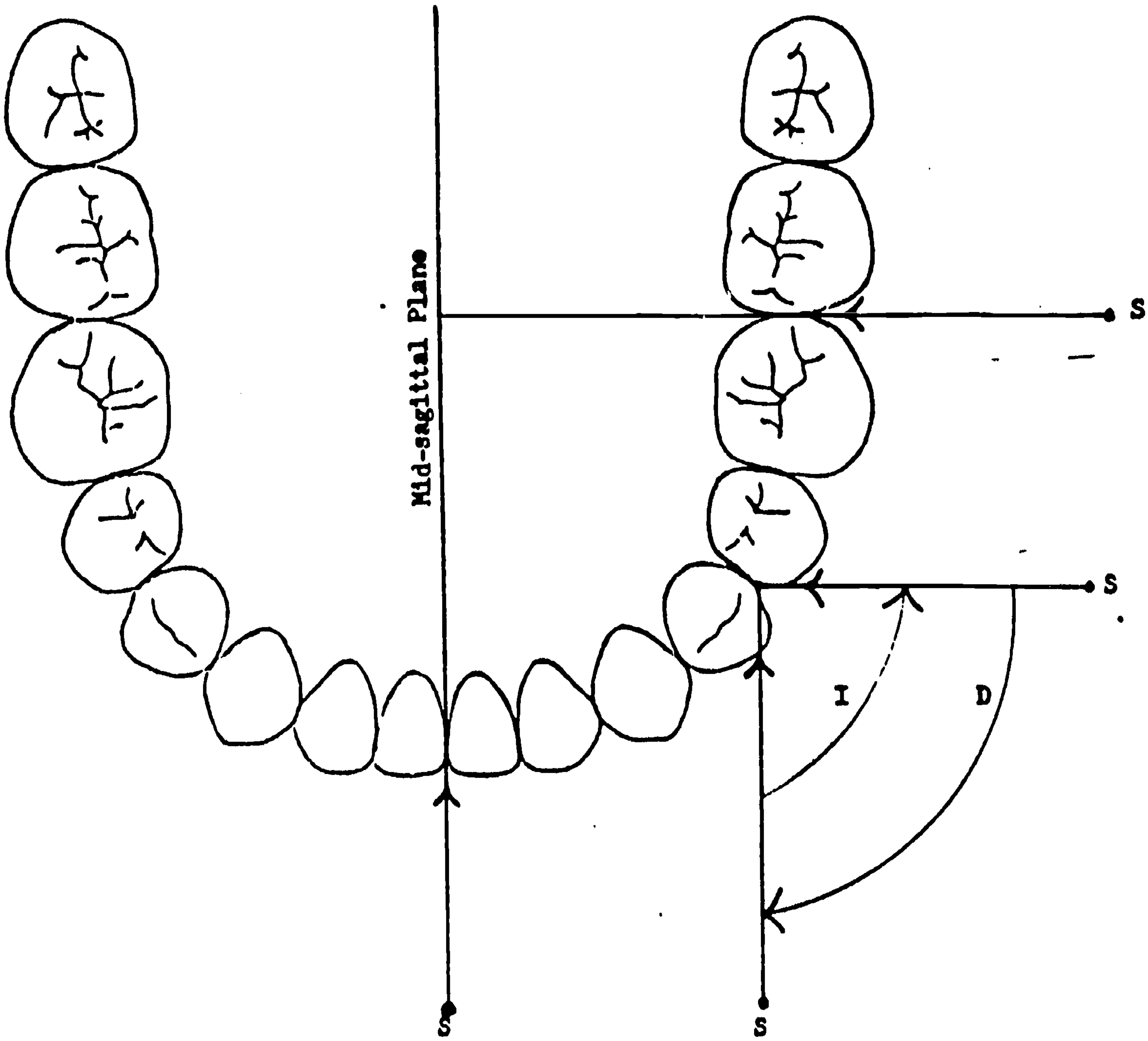

The Angle Bisector Principle

The angle bisector principle states that in order to produce minimum distortion when the mean object plane of interest and the recording surface exist in angular relationship, the central ray (CR) must be directed perpendicularly to the bisector (BA) of the angle formed by the mean object plane of interest (MOP) and the recording surface (RS).



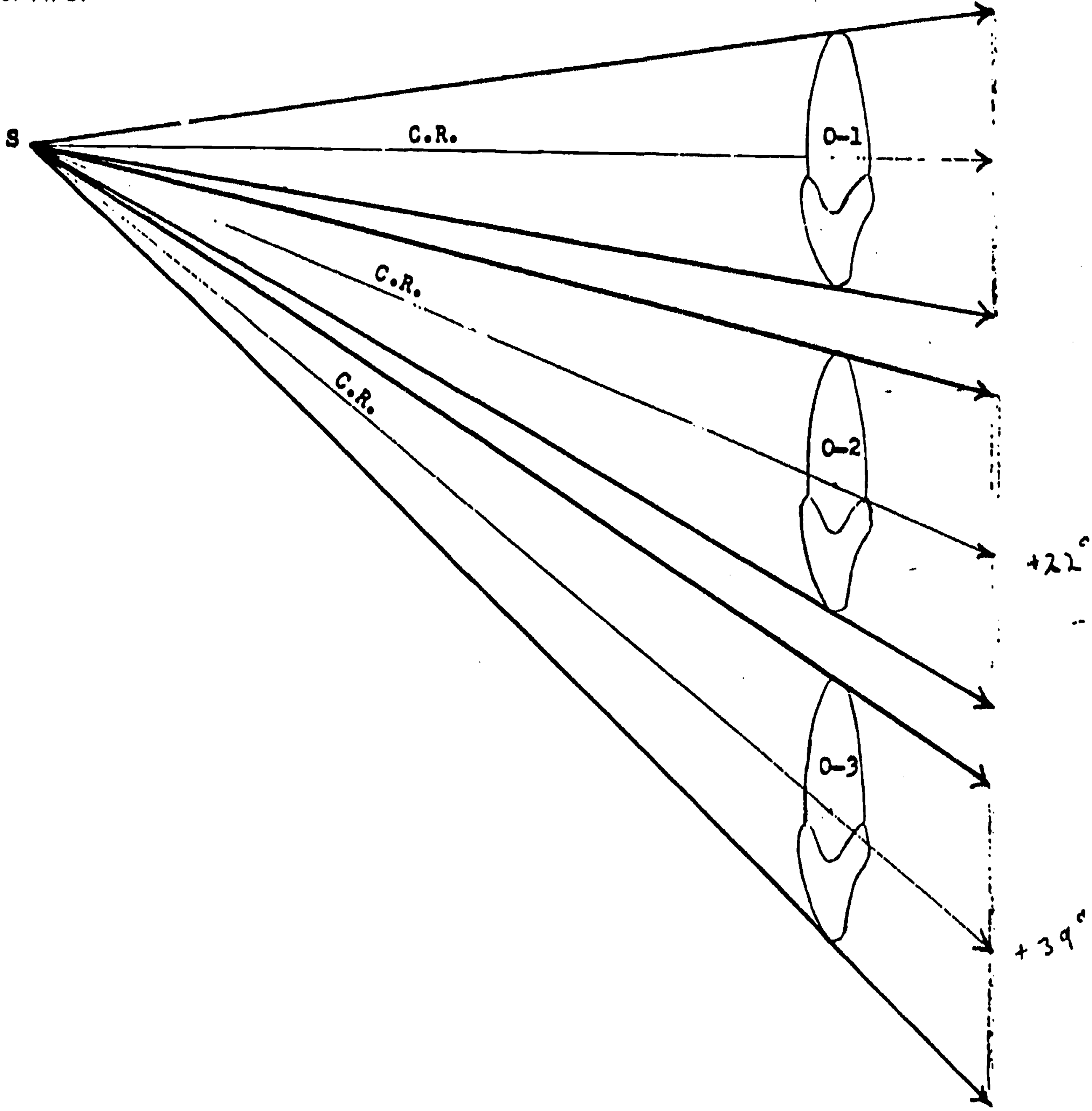

Designation of Vertical Angles (V.A.) and Changes in V.A.

Vertical angles are those angles formed by the x-ray beam and horizontal planes, e.g., the occlusal plane. When the central ray is in the horizontal plane ($S_2$), the vertical angle value is 0 degrees. When the source of radiation is located superiorly or cranially ($S_1$) to the point of entry of the central ray--the x-ray beam is directed down or caudally to the point of central ray entry--the vertical angle value is positive. (The +45 degree V.A. is shown.) When the source of radiation is located inferiorly or caudally ($S_3$) to the point of entry of the central ray--the x-ray beam is directed up or cranially to the central ray entry point--the vertical angle is negative. (The -20 degree V.A. is shown.) Give examples of vertical angle values if either the +V.A. or the -V.A. were increased or decreased.



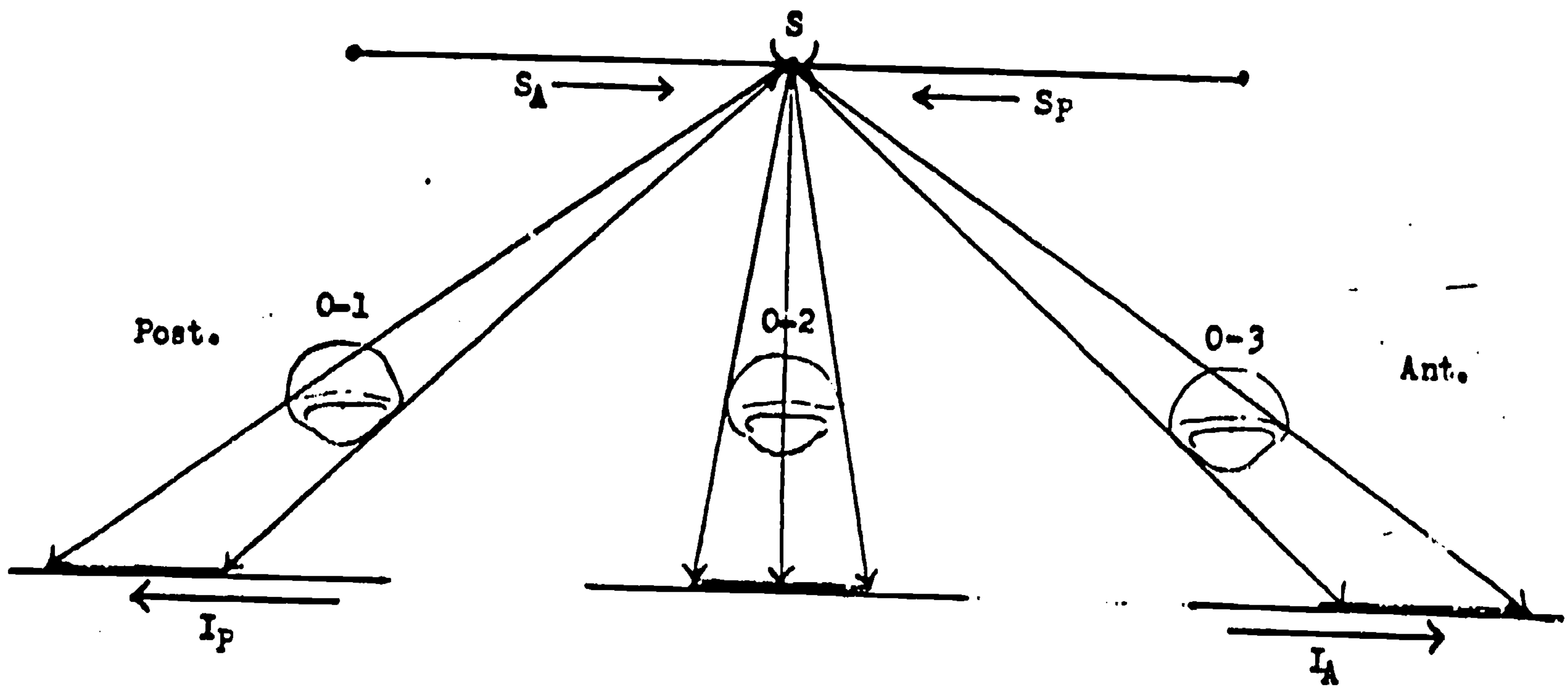

Designation of Horizontal Angles (H.A.) and Changes in H.A.

Horizontal angles are those angles formed by the x-ray beam and sagittal planes, e.g., the midsagittal plane. When the central ray is in a sagittal plane, the horizontal angle value is 0 degrees. When the central ray is perpendicular to sagittal planes, the horizontal angle value is 90 degrees. Arrow I indicates the direction of movement of the source of radiation in order to increase the horizontal angle; Arrow D indicates the direction of movement of the source of radiation in order to decrease the horizontal angle. Only for special projections or records is the horizontal angle ever greater than 90 degrees in intraoral roentgenography.




The General Effect of Variations in Vertical Angulation

Changing the angle of incidence of the x-ray beam causes the image to shift in the direction opposite to the direction of source movement, or in the same direction as the beam points or travels. The image shifts inferiorly as the source of radiation is raised further above the object. The central ray is perpendicular to the mean object plane of interest at 0-1, where V.A. = 0 degrees. A greater positive vertical angle exists at 0-2, where V.A. = +22 degrees. An even greater positive vertical angle exists at 0-3, where V.A. = +39 degrees.




The General Effect of Variations in Horizontal Angulation

Changing the angle of incidence of the x-ray beam causes the image to shift in the direction opposite to the direction of source movement, or in the same direction as the beam points or travels. The beam at 0-2 forms a 90-degree angle with the anteroposterior axis of the recording surface. The beam at 0-1 is directed posteriorly (Post.), the source having been moved around anteriorly; the image is projected posteriorly. Arrow $S_A$ indicates the direction of source movement for this decrease in horizontal angulation, and Arrow $I_P$ indicates the direction of the associated image shift. The beam at 0-3 is directed anteriorly (Ant.), the source having been moved around posteriorly; the image is projected anteriorly. Arrow $S_P$ indicates the direction of source movement for this increase in horizontal angulation, and Arrow $I_A$ indicates the direction of the associated image shift.



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## INFORMATION SHEET 2

### General Considerations for Routine Roentgenography

The key to the production of excellent quality roentgenographic records contains eight major facets, which form the framework for the presentation of roentgenographic technique in this syllabus. The eight facets of the roentgenographic KEY of QUALITY are:

1. Patient position
2. Film placement
3. Film retention
4. Central ray entry
5. Vertical angulation
6. Horizontal angulation
7. Exposure
8. Processing

Although the following discussion of these eight facets is directed primarily toward periapical and bitewing roentgenography, the principles involved are applicable to extraoral as well as to other types of intraoral roentgenography. It is suggested that, as the student is learning and gaining experience in intraoral roentgenography, restudying the material in this section of the syllabus will significantly aid him in analyzing the development of and in perfecting his roentgenographic technique. The student or practitioner should never hesitate to refer to this syllabus, or to any other manual or textbook, prior to making a roentgenographic record he does not routinely use, such as various extraoral or even certain intraoral records.

### Patient Position

Backrest and Seat of Dental Chair. The backrest of the dental chair is maintained in an upright position to form approximately a 90 degree angle with the seat and is adjusted vertically so that the top edge is in the vicinity of the interior half of the patient's scapulae. The seat of the chair is horizontal and is not tipped back for routine periapical and bitewing roentgenography.

*Vertical Position of Headrest. For maxillary periapical and bitewing roentgenography, the headrest is positioned high on the patient's head at the level of the external occipital protuberance. For mandibular periapical roentgenography, the headrest is usually lowered to slightly below the external occipital protuberance so that the patient's head can be more easily rotated up or down as necessary.

*Anteroposterior Position of Headrest. Since the patient's head must be immobilized against the headrest while roentgenographic exposures are being made, the headrest is positioned anteroposteriorly so that the patient's head will rest in it naturally and comfortably during the whole procedure. If the headrest is placed too low or too far posteriorly, the patient will experience unnecessary discomfort. The patient's head will also have a tendency to move forward and away from the headrest. If the patient's head is not resting securely in the headrest, movement may occur while the film is being exposed.

Such movement produces motion unsharpness and blurred roentgenographic records.

Midsagittal and Occlusal Planes. The patient's midsagittal plane is vertical and the occlusal plane of the arch being roentgenographed is horizontal, especially when standard angulation reference charts for starting vertical angles are used. The occlusal plane of the maxillary arch will be horizontal if an imaginary line from the ala of the nose to the tragus of the ear is horizontal. The horizontal orientation of the occlusal plane of the mandibular arch can be easily visualized directly when the patient's mouth is open. However, an imaginary line from the inferior margin of the tragus of the ear to the corner of the mouth is an external guide for the orientation of the mandibular occlusal plane. Failure to establish proper orientation of the midsagittal and occlusal planes may result in difficulty in establishing correct vertical and horizontal angles, especially when film holding devices not containing extraoral extensions for cone or beam alignment are used.

## Film Placement

Axial Orientation. The long axis of the film packet is oriented mesiodistally in the posterior (molar and bicuspid) areas, and the short axis of the film packet is oriented mesiodistally in the anterior (cuspid and incisor) areas.

Orientation of Identification Dot. The embossed identification dot is seen as a concavity on the back of the film packet and a convexity on the front. The edge of the film packet containing the identification dot is placed occlusally for all periapical records except for the mandibular right molar area, where it is placed apically. Therefore, in each of the resulting periapical roentgenograms, the embossed identification dot artifact lies in the nondiagnostic area between the occlusal plane and the occlusal edge of the film. However, in roentgenograms of the mandibular right molar area, an occlusally oriented identification dot may lie in the diagnostically significant retromolar area, which is not duplicated in any other roentgenogram. On the other hand, the apically oriented dot lies near the apices of the first molar or the bicuspids, an area that is duplicated in the mandibular right bicuspid roentgenogram. For bitewing roentgenograms, the dot is oriented down or apical to the crowns of mandibular teeth. This systematic orientation of the identification dot in film placement also facilitates a more orderly placement of films on processing hangers in the darkroom.

Vertical and Horizontal Film Placement. A properly placed film packet lies directly behind the teeth or area to be recorded. An unsatisfactory roentgenogram will be produced if the vertical and/or horizontal film placement is incorrect. If the film packet is placed too far apically, the crowns of the teeth in the area will not be fully recorded. If the film packet is placed too far occlusally, the roentgenogram may contain an inadequate view of the apical and periapical areas and too much nondiagnostic, wasted film area between the occlusal edge of the roentgenogram and the occlusal plane. If the film packet is placed too far mesially or too far distally, an adequate record of distal or mesial structures, respectively, will not be obtained.

Manipulation of Film Packet in Placement. The placement of the film packet in the desired position should be accomplished with minimum manipulation of the packet inside the patient's mouth and with minimum soft tissue contact. For example, film packets should never be placed in the bicuspid region and slid posteriorly into position for molar area roentgenograms. Each film packet should be properly positioned with minimum intraoral manipulation before the patient is instructed to retain the packet. Observing these precautions will minimize patient discomfort and triggering gag reflexes, especially when molar areas are being roentgenographed.

Film Placement With Biteblock Film Holders. When biteblock film holding devices are used, the film packet must be in the proper position and the biteblock portion of the film holder must be resting on the occlusal surfaces or incisal edges of the teeth being roentgenographed before the patient is instructed to close on the biteblock. The operator must never allow the occlusal forces to shift or force the film packet into the desired position.

*Placement of Film in Floor of Mouth. In the mandibular arch, care must be taken to ensure that the inferior border of the film packet rests under the tongue of the floor of the mouth and not on the tongue. Placement of film packets for mandibular roentgenograms often will be facilitated if the operator uses an index finger to depress the floor of the patient's mouth in the area where the inferior border of the film packet is to rest just prior to or during the placement of the film packet.

## Film Retention

Proper Placement Before Retention. Each film packet should be properly positioned before the patient is instructed to retain the packet. The film packet must be retained in the proper position without movement for the duration of the exposure.

**Film Packet Never Held by Operator. The operator must never hold the film packet for the patient. If the patient is unable to hold the film packet satisfactorily and additional human assistance is needed, a relative or friend of the patient should be instructed to assist the patient.

Maintain Flat Recording Surface. Maintaining a flat recording surface is important. Great care must be exercised so that the forces used to retain the film packet do not cause it to bend. Film packet bending occurs most frequently in the following areas: maxillary molar area, mandibular edentulous incisor area, maxillary cuspid area, and the maxillary incisor area.

Film Packet Retention Devices and Techniques. Film packet retention may be accomplished by any one of a number of film packet retention devices and techniques. Some of these are listed below:

1. Biteblock film holders, long and short
    a. metal with rubber-covered biteblock (Universal U and L*)
    b. wood (Clev-Dent)
    c. plastic (Rinn)

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* Ryker Dental Depot, Inc., Lock Box 210, Indianapolis, IN 46206

2. Snap-a-Ray (plastic, Rinn)

3. XCP (X-tension C-one Paralleling Instrument, plastic, Rinn)

4. Precision X-ray Instruments (metal, Precision X-Ray Co.)

5. Hemostat

## Central Ray Entry

Significance of Point of Entry of Central Ray. If the central ray is directed to the center of the film packet, the film packet will be located in the center of the x-ray beam and will be completely exposed. However, if the central ray enters too far posteriorly, anteriorly, superiorly, or inferiorly, relative to the center of the film packet, the opposite portion of the film will be outside the area of the x-ray beam and will not be exposed. This error in technique is called, and produces, "conecutting." The unexposed area of film processes clear and contains no image.

Points of Entry. In maxillary periapical roentgenography, the points of entry for the central ray are on the ala-tragus line, except for the incisor area where the point of entry is just above the tip of the nose or about halfway between the tip of the nose and nasion; for bitewings, just above the occlusal plane; and for mandibular periapicals, about 1/4 inch above the inferior border of the mandible. Anteroposteriorly, these points are located as follows: for molar area roentgenograms, directly below the outer canthus of the eye; for bicuspid area roentgenograms, halfway between the point directly below the outer canthus of the eye and the corner of the nose; for cuspid area roentgenograms, at the corner of the nose; and for the incisor area, the midline.

## Vertical Angulation

Significance of Vertical Angle. The vertical angle of the x-ray beam controls vertical dimensions (and, thus, vertical distortions) and influences the vertical position of the roentgenographic image on the film. Therefore, correct vertical angulation is necessary to produce roentgenographic images that are as nearly as possible the same length as the teeth being recorded. Errors in vertical angulation produce vertical elongation or foreshortening of the image as well as possibly projecting a part of the image beyond the apical or occlusal edge of the film. Generally, if the vertical angle is too great, foreshortening results; if the vertical angle is not great enough, elongation occurs.

*Numerical Values of Vertical Angles. The numerical values of vertical angles are positive or negative relative to the horizontal orientation of the x-ray beam. The horizontal orientation of the x-ray beam is designated as zero degrees. A positive vertical angle means that the x-ray beam is directed inferiorly--the source of radiation is superior to the point of entry of the central ray and the cone is pointing down. A negative vertical angle means that the x-ray beam is directed superiorly--the source of radiation is inferior to the point of entry of the central ray and the cone is pointing up.

Angles listed in various vertical angle guide charts for periapical roentgenography are merely average starting angles. They should be used only as starting angles and modified to accommodate variations presented by each patient according to the angle bisector and paralleling principles. However, in routine roentgenography, the following three angles should be considered as "fixed" angles:

1. -5 degrees for mandibular molar roentgenography when the biteblock film holder is used.
2. +28 degrees for edentulous maxillary molar area roentgenography.
3. +8 degrees for bitewing roentgenography.

Determining Correct Vertical Angle. The correct vertical angle is determined by the vertical angular relationship of the plane of interest, or the mean vertical axis, of the teeth or area to be recorded and the corresponding axis of the film packet. The angle formed by these two intersecting planes or axes may vary from close to 90 degrees to a nearly parallel relationship. Clinically, this angular relationship is greatest when the digital method of film packet retention is used. The x-ray beam is always aimed in the direction of the apex of the angle so that the central ray is perpendicular to the imaginary bisector of the angle. Thus, when an angular relationship exists between the mean vertical axis of the teeth or area to be recorded and the film packet, the central ray is not perpendicular to either. However, when these two axes or their corresponding planes are parallel, the central ray is directed perpendicularly to both. It might be added, parenthetically, that when the plane of the end of the open-end cone is parallel to one of these axes or planes, the central ray is perpendicular to it.

## Horizontal Angulation

*Significance of Horizontal Angle. The horizontal angle of the x-ray beam controls horizontal dimensions (and, thus, horizontal distortions) and influences the horizontal position of the roentgenographic image on the film. The most obvious discrepancy observed from improper horizontal angulation is overlapping of the images of proximal surfaces of adjacent teeth and obliteration of proximal and interproximal detail.

Determining Proper Horizontal Angle. For minimum mesiodistal distortion, the mesiodistal axis of the recording surface and the mesiodistal axis of the plane of interest of the teeth or area to be recorded should be parallel and the central ray should be perpendicular to both. Acceptable horizontal angulation usually may be obtained by orienting the head of the x-ray unit so that the corresponding diameter of the end of the open-end cone is parallel to the occlusal edge of the film packet and/or the mean mesiodistal buccal tangent of the teeth being recorded. For minimum overlapping of proximal surfaces of adjacent teeth, or for maximum horizontal separation of images of adjacent teeth, the x-ray beam should be parallel to the buccolingual axis of the proximal surfaces or contact areas. Theoretically, then, for maximum results, the mesiodistal axis of the film packet and the mesiodistal diameter of the end of the open-end cone should be parallel to each other and each perpendicular to the buccolingual axes of the proximal surfaces being recorded.

*Numerical Values of Horizontal Angles. Numerical values usually are not assigned to horizontal angle positions. However, a horizontal angle of 0 degrees describes the x-ray beam that is parallel to the midsagittal plane. A horizontal angle of 90 degrees describes the x-ray beam that is perpendicular to the midsagittal plane. In routine periapical and bitewing roentgenography, horizontal angles usually will be less than 90 degrees in all areas. A tendency to use horizontal angles of 90 degrees or more in routine roentgenography of molar areas generally should be avoided since the buccolingual axes of the proximal contact areas are not perpendicular to the midsagittal plane but form posterior acute angles with it. However, special roentgenography of impacted third molars often necessitates horizontal angles of 90 degrees or greater.

In order to avoid changing the established vertical angle, final adjustments in horizontal angulation and for central ray entry should be made by manipulating the tube head support frame or yoke rather than the tube head itself or the cone.

## Exposure

Factors Influencing Exposure Time. Proper exposure time is influenced by the following factors:

1. Film speed
2. KVP
3. MA
4. Total filtration (inherent plus added)
5. Characteristics of the x-ray machine
6. Source-film distance
7. Size of patient
8. Area being roentgenographed

Exposure Time Guides. Exposure time guides are worked out for each x-ray unit for use with ultra-speed film, presupposing proper source-film distance and proper machine activation for the exposure. In order to establish proper source-film distance, the end of the cone should be as close to the patient's face as possible without contact. Caution must be exercised in manipulating the cone, especially around the patient's eyes, so that the end of the cone does not inadvertently come into contact with the patient's eyes or exert pressure on the face. The timer switch or button must also be held or depressed continuously for the duration of the exposure as predetermined by the timer setting. Prematurely releasing the timer switch will produce underexposure.

## Film Processing

*General. Great care must be exercised in the darkroom to avoid contaminating films before they are developed, to avoid contaminating the developing and fixing solutions, and to avoid splashing or dripping the solutions on clothing or other areas. The area where films are mounted on processing hangers must be clean and dry, the proper safe-light condition must exist with no white light leaking in, solutions should be adequately fresh or replenished so that the level is high enough to immerse films placed on the top clips of processing hangers, solution temperature should be at 68 to 70 degrees Fahrenheit, and the solutions should be thoroughly stirred at least at the beginning of each day or just before films are processed if the solutions are used infrequently.

Recommended Procedure. The following instructions presuppose the film placement procedure recommended in this syllabus, such that the film edge containing the identification dot is the occlusal or incisal edge in periapicals, except for the mandibular right molar area, and the mandibular apical edge in bitewings.

1. Side of Convexity Faces Front. Since films are placed on intraoral processing hangers as the hangers are lying front-side down and back-side up, films are to be attached to the hangers so that the convexity of the film identification dot is pointing down toward the surface of the working area or toward the front side of the hanger. When films are removed from the film packet in the recommended manner, the convexity of the film identification dot is pointing down.

2. Distribution on Hanger. Using the twenty-clip intraoral film processing hangers, the first pair of clips is reserved for the identification tag, which is mounted so that the side containing the patient's name or chart number is down. Either the second, third, or bottom two pairs of clips are reserved for the bitewing films The remaining seven pairs of clips are for the periapical films with the mandibular films on one side and the maxillary films on the other side.

3. Mandibular Periapicals. Mandibular periapical films are attached to the processing hangers in the middle of a short edge so that the long edge of the film containing the identification dot is away from the operator or toward the top of the hanger.

4. Maxillary Periapicals. Maxillary periapical films are attached to the processing hangers in the middle of a short edge so that the long edge of the film containing the identification dot is toward the operator or toward the bottom of the hanger.

5. Bitewings. All bitewing films, except Number 3 films, are attached to the processing hangers the same way as the periapical films. The edge containing the identification dot is oriented toward the operator or toward the bottom of the hanger. Number 3 films are attached in the middle of a long edge.

6. Single-film Packets. When single-film packets are used, placing the mandibular periapicals on the left side and the maxillary periapicals on the right side of the hanger as it lies face down on the working surface will place the artefact of the clip attachment in the nondiagnostic, incisal edge of the anterior periapical films.

7. Double-film Packets. When double-film packets are used, two processing hangers are needed. However, one film in each packet is attached to each of the two hangers but on opposite rows of clips. For example, the outside rows of clips might hold all the maxillary periapical films (or mandibular periapical films, depending on how the mounting is started) and the inside rows would hold all the mandibular (or maxillary) periapical films. When this procedure is followed, each of the two films in a packet will be clipped on opposite edges, and each hanger will contain a complete set of roentgenograms.

8. Developing. Place the loaded processing hangers in the developing solution, gently agitate the films to dislodge air bubbles that may become entrapped on the film surfaces, replace the developer tank cover, and set a timer for the desired time interval for developing--five minutes if solutions are maintained at 68 to 70 degrees Fahrenheit.

9. Rinsing. After the films have been in the developer for the desired time, gently remove the hangers and rinse the films in running water for 15 to 20 seconds, agitating the films in the water during this time.

10. Fixing. After the developed films have been properly rinsed, gently shake off the excess water, place the films in the fixing solution, and gently agitate them. Set the timer for ten minutes.

11. Rinsing. After the films have been in the fixer for the desired time, gently remove the hangers from the fixer and rinse the films in running water for 15 to 20 seconds, agitating the films in the water during this time. The films are now ready for wet viewing at the view box.

Before films are finally dried for mounting and filing in the permanent record, they should be washed in running water for 15 to 20 minutes.

## Evaluation

"Retakes" and/or Additional Roentgenograms. After films are processed, the roentgenograms should be critically evaluated. Discrepancies rendering individual roentgenograms unsatisfactory or questionable should be noted and technical errors responsible for the discrepancies identified. Also, indications for additional roentgenograms should be noted, such as: roentgenographic evidence of pathology or developmental anomalies incompletely recorded, questions of localization, and better geometry to produce less distortion in specific areas.

## Periapical-Bitewing Roentgenogram Evaluation Guide

Routine periapical and bitewing roentgenograms are evaluated according to applicable criteria listed below:

A. Right teeth recorded (determined by proper horizontal film placement--H.F.P.)

| View or Area | Teeth or Area to Be Recorded |
|---|---|
| **Molar** | Third molar and second molar<br><br>Maxillary molar record includes maxillary tuberosity<br><br>Mandibular molar record included retromolar area, bone distal to third molar crown, or the inferior aspect of the anterior border of ascending ramus |
| **Bicuspid** | Distal of cuspid, first and second bicuspids, first molar<br><br>Posterior periapical in the 10-periapical film examination for children: distal to cuspid, first and second bicuspid and first permanent molar regions. Both primary and permanent teeth are to be recorded completely if both are present. |
| **Cuspid** | Maxillary: cuspid, lateral incisor<br><br>Mandibular: cuspid |
| **Incisor** | Maxillary: central incisors<br><br>Mandibular: central and lateral incisors |
| **Bitewing** | Number 3 posterior: distal of cuspids, proximals of all clinically erupted posterior teeth<br><br>Number 2 posterior:<br><br>Bicuspid: distal of cuspids, proximals of first and second bicuspids, mesial of first molars<br><br>Molar: distal proximals of the most posteriorly clinically erupted molars<br><br>Number-0 posterior: distal of primary cuspids and proximals of the primary molars |

B. Entire crown and root (determined by proper vertical film placement--V.F.P.--and vertical angulation--V.A.)

C. Good view of periapical areas (determined by proper vertical film placement--V.F.P.--and vertical angulation--V.A.)

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D. Good proximal and interproximal views (determined by proper horizontal angulation--H.A.)

E. Minimum elongation and foreshortening (determined by proper vertical angulation--V.A.)

F. Good roentgenographic density (determined by adequate MAS and developing)

G. Good roentgenographic contrast (determined by adequate KVP, MAS, and developing)

H. Good detail (determined by degree of immobilization of film, patient, and x-ray tube; flatness of film surface; CFD and SFD; adequate MAS, KVP, and developing)

I. No artefacts

Roentgenograms should be scrutinized for evidence of errors in the following technical areas:

A. Patient preparation--failure to remove

1. eyeglasses
2. full denture
3. partial denture
4. other prosthetic appliances
5. earrings
6. hair pins

B. Film handling before processing

1. unnecessary bending, folding, creasing, stressing
2. excessive bending, folding, creasing
3. exposure to light or stray radiation

C. Film packet placement and retention

1. film packet placed backwards
2. occlusal edge of film not parallel to occlusal plane (with cuspid exception) (partial V.F.P. error)
3. film placed too far apically (V.F.P. apical error)
4. film placed too far occlusally (V.F.P. occlusal error)
5. film placed too far anteriorly or mesially (H.F.P. anterior error)
6. film placed too far posteriorly or distally (H.F.P. posterior error)
7. film surface curved

D. Vertical angulation

1. vertical angle too great
2. vertical angle not great enough

E. Point of entry of central ray

1. anterior "cone cut" - central ray entered too far posteriorly (C.R. entry posterior error)
2. posterior "cone cut" - central ray entered too far anteriorly (C.R. entry anterior error)

3. inferior "cone cut" - central ray entered too far superiorly (C.R. entry superior error)
4. superior "cone cut" - central ray entered too far inferiorly (C.R. entry inferior error)

F. Horizontal angulation

1. radiation source too far posteriorly or distally; horizontal angle too great (H.A. posterior error)
2. radiation source too far anteriorly or mesially; horizontal angle not great enough (H.A. anterior error)

G. Exposure

1. overexposure
2. underexposure
3. double exposure

H. Movement of patient, film, or source of radiation during exposure

I. Darkroom procedures

1. torn film
2. paper stuck to film
3. dry, unprocessed film contaminated with developer, fixer, or other chemicals, such as sodium fluoride
4. fingerprints
5. static electricity
6. film exposed too long to safe light
7. emulsion scratched
8. film contact in developer
9. film contact in fixer
10. overdeveloped
11. underdeveloped
12. inadequate washing

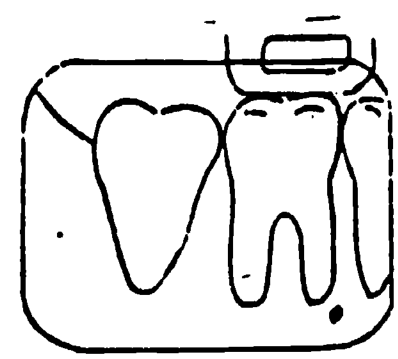
## INFORMATION SHEET 3

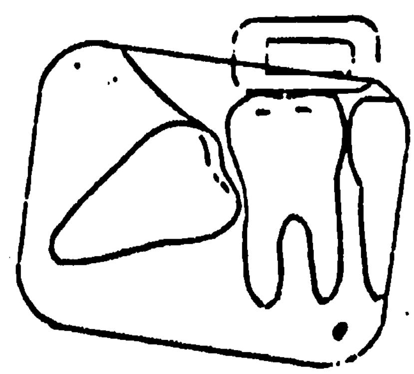
### Mandibular Periapical Biteblock Technique

#### Mandibular Right Molar Periapical Roentgenogram

Head Position. Midsagittal plane is vertical. Mandibular occlusal plane is horizontal when the patient bites on the biteblock.

Film Placement. The film packet is not fclded and is positioned as illustrated so that the retromolar area (or the inferior aspect of the anterior border of the ascending ramus), the third molar and the second molar are recorded in their entirety. Usually, the biteblock is attached to the anterior third of the film packet so that it can be placed further posteriorly. In order to record the third molar area routinely, the film packet usually must be placed as far posteriorly as possible. As the film packet is being placed in the mouth, the patient should be instructed to raise his tongue slightly to ensure that the apical edge of the film packet will rest on the soft tissue of the floor of the mouth and not on the edge of the tongue. The inferior edge of the film packet is placed somewhat under the tongue, slightly away from the lingual aspect of the alveolar ridge. Placement of the film packet as far posteriorly as possible is often facilitated if the patient is instructed to close slowly during the placement procedure. However, the biteblock should be resting solidly on the occlusal surface of mandibular molars before the patient bites to retain it. If the mandibular molar area is edentulous, a cotton roll may be placed along the edentulous ridge to support the biteblock.





When the curve of Spee is great or the third molar is positioned a little high in the ramus, or overerupted, the posterior aspect of the film packet is rotated slightly upward in order to record the retromolar area and the third molar completely.

For the RIGHT MANDIBULAR MOLAR roentgenogram, the identification dot is oriented apically. For the LEFT MANDIBULAR MOLAR roentgenogram, the identification dot is oriented occlusally as in all other periapicals except the one for the mandibular right molar area.

Film Retention. With the biteblock resting on the occlusal surface of the mandibular molars, or possibly on a cotton roll if the area is edentulous, the patient is instructed to close on the biteblock with enough occlusal force to retain the biteblock and film packet in the desired position. In the partially edentulous patient, if opposing maxillary teeth are missing and the patient does not have a partial denture, film retention can sometimes be facilitated by placing a cotton roll on top of the biteblock or in the maxillary edentulous space. In the completely edentulous patient, film retention may be facilitated by instructing and guiding the patient to make a fist and to place the index finger of his opposite hand on the biteblock just above the film packet and to exert digital pressure posteriorly and inferiorly. The patient is then instructed to close on his finger and the biteblock for additional stabilization of the film packet.

Central Ray Entry. The central ray enters about 1/2 inch above the inferior border of the mandible in line with the outer canthus of the eye.

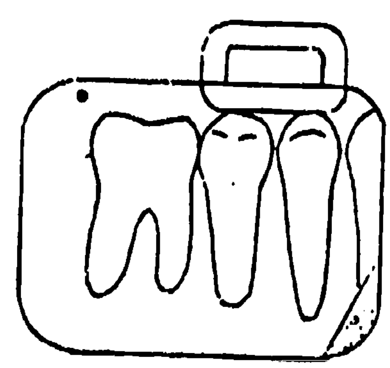
Vertical Angle. The vertical angle is 5 degrees with the cone pointing down (+5 degrees). Occasionally a greater positive vertical angle will be required. The vertical axis of the film packet and the vertical diameter of the end of the open-end cone should be parallel.

Horizontal Angle. The horizontal diameter of the end of the open-end cone is parallel to the occlusal edge of the film packet and/or to the mesiodistal buccal tangent of the molar crowns.

## Mandibular Right Bicuspid Periapical Roentgenogram - Biteblock Technique

Head Position. Midsagittal plane is vertical. Mandibular occlusal plane is horizontal when the patient bites on the biteblock.

Film Placement. The lower anterior corner of the film packet may be folded as illustrated, and the film packet is positioned so that the distal of the cuspid, first and second bicuspids, and the first molar are recorded. The biteblock is attached to the anterior third of the film packet so that the biteblock rests primarily on the mandibular bicuspids. The patient should be instructed to raise his tongue while the film packet is being placed to ensure that the apical edge of the packet rests on the soft tissue of the floor of the mouth. The apical edge of the packet should be under the lateral border of the tongue and away from the soft tissues of the alveolar ridge. The lower anterior corner of the packet is placed as far anteriorly as possible toward the midline near the lingual frenum. Occasionally, the anterior edge will have to be placed across the midline in order to record the distal of the cuspid. The identification dot is up toward the occlusal plane.



Film Retention. With the biteblock resting on the occlusal surfaces of the mandibular bicuspids, the patient is instructed to close on the biteblock with just enough occlusal force to retain the biteblock and film packet in the desired position. Patients with maxillary prosthetic appliances should have these properly inserted in the mouth to aid in film packet retention.

If the mandibular arch is edentulous, film retention may be facilitated if the patient's lower lip is rolled over the mandibular ridge and the biteblock is placed on the lip. The patient may also be instructed to place the index finger of the opposite hand, folded into a fist, on the biteblock just above the film packet and to exert digital pressure inferiorly and anteriorly. The patient is then instructed to close on his finger for additional stabilization of the film packet.

Central Ray Entry. The central ray enters about 1/2 inch above the inferior border on the mandible in line with a point midway between the ala of the nose and a point below the outer canthus of the eye toward the center of the film packet.

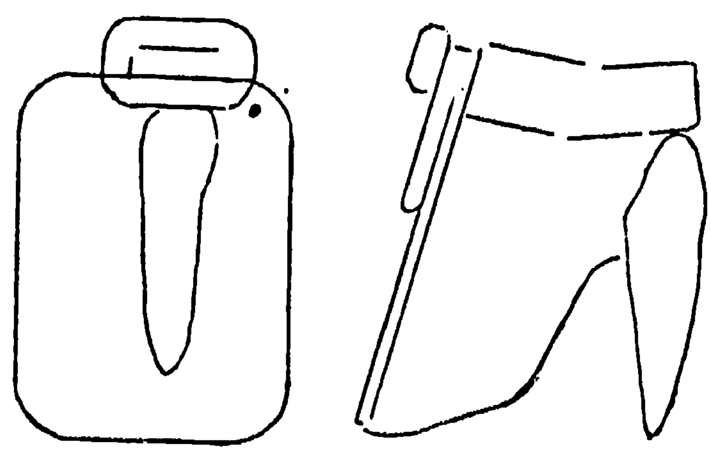
Vertical Angle. A negative vertical angle is usually required. Proper vertical angle is usually established by paralleling the vertical diameter of the end of the open-end cone with the vertical axis of the film packet. However, if the film packet extends too far above the occlusal plane or if the teeth are unusually long, the negative vertical angle may have to be increased as much as 10 to 15 degrees more in order to project the apices and periapical areas onto the film.

Horizontal Angle. The horizontal diameter of the end of the open-end cone is parallel to the occlusal edge of the film packet and/or the mesiodistal buccal tangent of the bicuspid crowns.

## Mandibular Right Cuspid Periapical Roentgenogram - Biteblock Technique

Head Position. Midsagittal plane is vertical. The head and chin are rotated upward so that the long axis of the cuspid is nearly vertical.

Film Placement. The film packet is not folded and is positioned behind the mandibular cuspid as illustrated so that a good view of the cuspid is recorded in the center of the film. The biteblock is attached to the center of the film packet or slightly anterior to the center. The patient is instructed to raise his tongue, and the film packet is place as far under the tongue as possible before it is depressed into the floor of the mouth as the patient relaxes his tongue. The film packet is then rotated to a more vertical position as it is further depressed into the floor of the mouth until the distal part of the biteblock is resting firmly on the incisal edge of the mandibular cuspid. The identification dot is up toward the occlusal plane.



Film Retention. With the distal end of the biteblock resting on the incisal aspect of the mandibular cuspid, the patient is instructed to close on the biteblock with just enough force to retain the biteblock and film packet in the desired position.

Central Ray Entry. The central ray enters about 1/2 inch above the inferior border of the mandible, through the mandibular cuspid, and toward the center of the film packet.

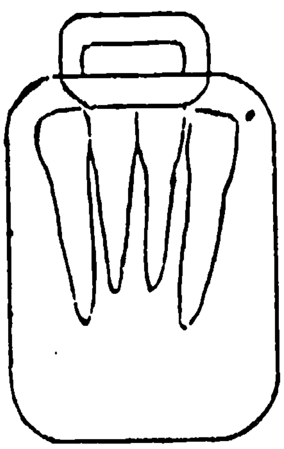
Vertical Angle. Proper vertical angle is usually established by paralleling the vertical diameter of the end of the open-end cone with the vertical axis of the film packet.

Horizontal Angle. The horizontal diameter of the end of the open-end cone is parallel to the incisal edge of the film packet or to the mean mesiodistal axis of the crown of the cuspid.

## Mandibular Incisor Periapical Roentgenogram - Biteblock Technique

Head Position. Midsagittal plane is vertical. The head and chin are rotated upward so that the long axis of the incisors is nearly vertical.

Film Placement. The film packet is not folded and is positioned behind the mandibular incisors as illustrated so that a good view of the central and lateral incisors are recorded. The biteblock is centered on the incisal edge of the film packet. The inferior edge of the film packet is placed as far under the tongue as possible before the film packet is oriented in a more vertical position and the distal end of the biteblock is placed on the incisal edges of the incisors, or in the edentulous case, on the edentulous ridge or on the lower lip that has been folded over the edentulous ridge. The identification dot is up toward the occlusal plane.



Film Retention. With the distal end of the biteblock resting on the mandibular incisors, the patient is instructed to close on the biteblock with enough occlusal force to retain the biteblock and film packet in the desired position.

In edentulous patients, film placement and retention may be facilitated if the patient's lower lip is rolled over the mandibular ridge and the biteblock placed on the lip. The patient may also be instructed to place an index finger on the biteblock and exert digital pressure inferiorly as he closes on his finger. If film packet bending is a problem, a reinforcement backing can be used.

Central Ray Entry. The central ray enters about 1/2 inch above the inferior border of the mandible in the midline and is directed toward the center of the film packet.

Vertical Angle. Proper vertical angle is usually established by paralleling the vertical diameter of the end of the open-end cone with the vertical axis of the film packet, especially if the vertical axis of the packet and the mean long axis of the incisors are parallel or nearly so (Fig. A). An angular relationship between these two axes justifies applying the bisecting angle principle (Figs. B and C). If for any reason the film packet extends above the occlusal plane to an excessive degree, the negative vertical must be increased sufficiently to project incisor images up onto the film as diagrammed in Fig. D, where a cotton roll on incisal edge of teeth supports the biteblock in a child's mouth.

Horizontal Angle. The horizontal diameter of the end of the open-end cone is parallel to the incisal edge of the film packet.

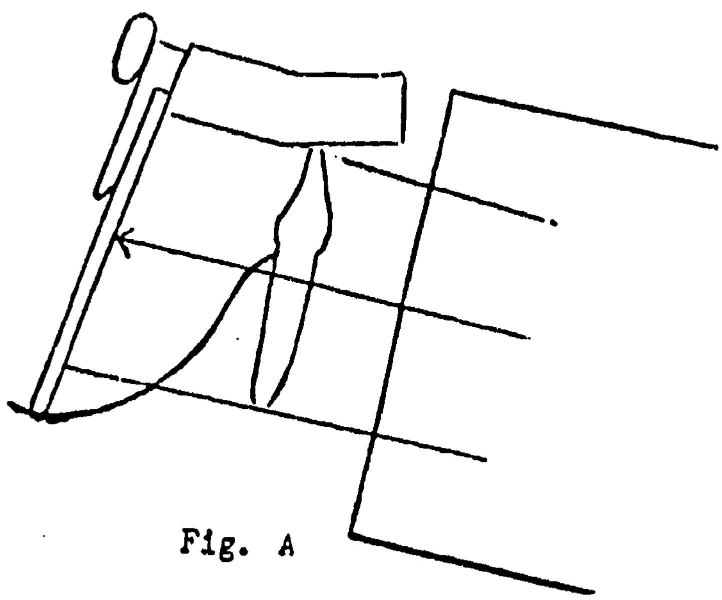


Fig. A

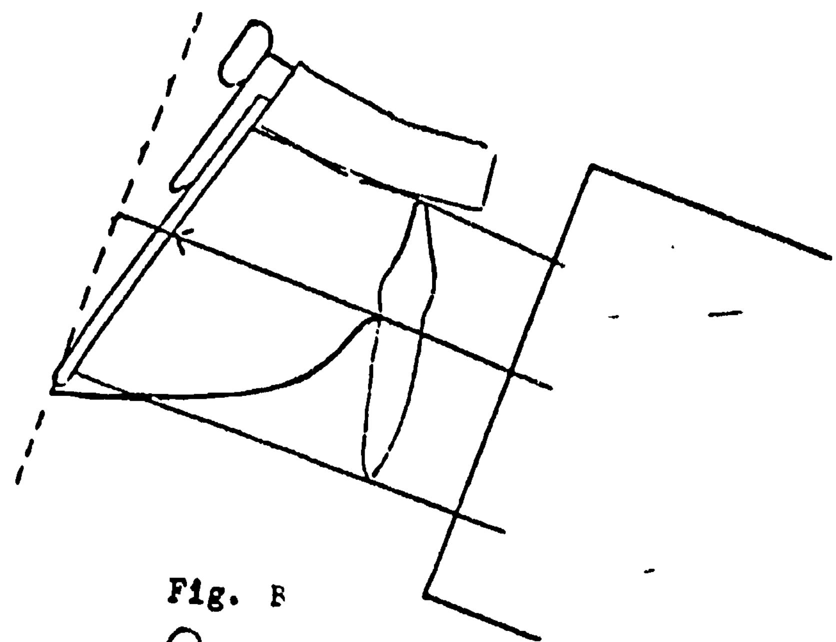


Fig. B

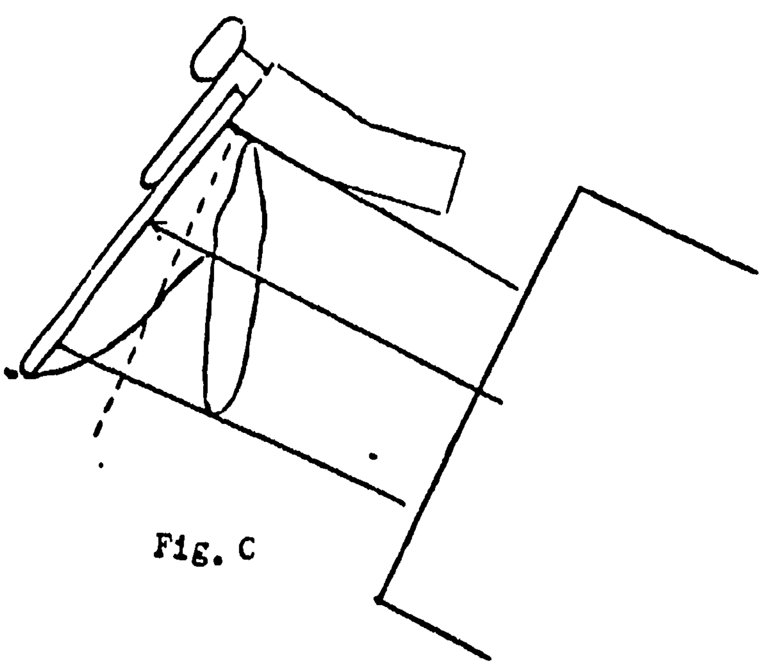


Fig. C

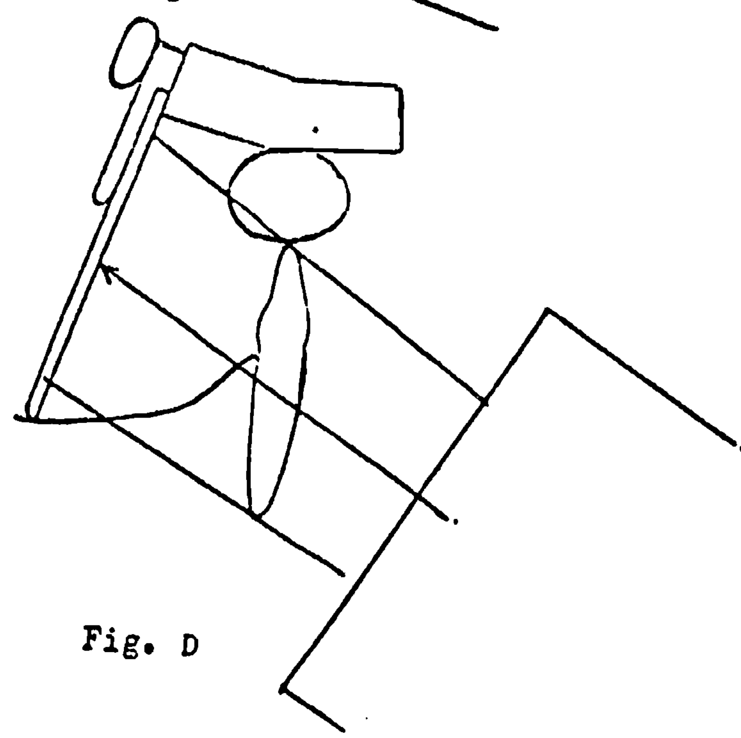


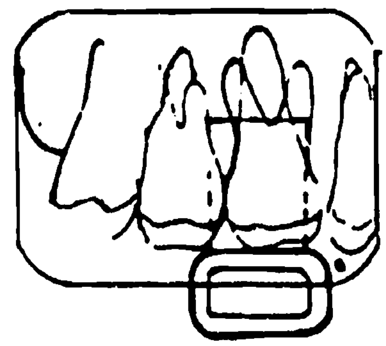
Fig. D

## Maxillary Periapical Biteblock Technique

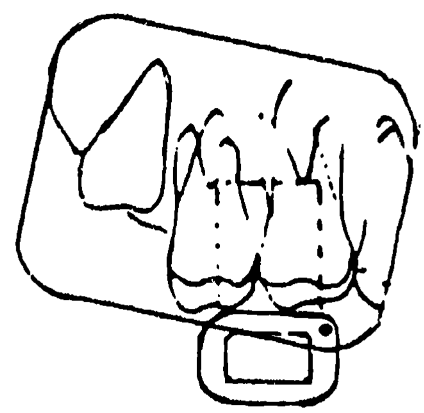
### Maxillary Right Molar Periapical Roentgenogram

Head Position. Midsagittal plane is vertical. Ala-tragus line and maxillary occlusal plane are horizontal.

Film Placement. The film packet is not folded and is positioned as illustrated so that all of the maxillary tuberosity, third molar, and second molar are recorded. The identification dot is down toward the occlusal plane, and the biteblock is attached to the anterior half of the film packet. A reinforcement backing is usually used to avoid film packet bending. The superior edge of the film packet is positioned near the midline of the palate, and the biteblock is placed against occlusal surfaces of maxillary molars. The mesiodistal axis of the film packet and the mesiodistal axis of the end of the biteblock are as nearly parallel as possible to the mesiodistal mean buccal tangent of the maxillary molars.

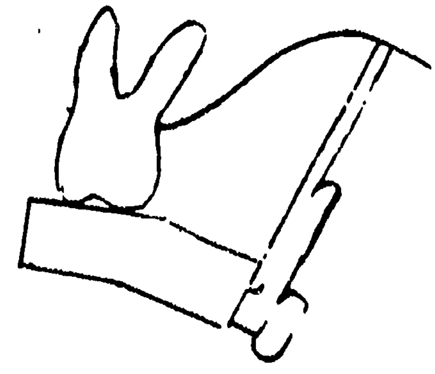


When the Curve of Spee is extreme, the occlusion is irregular, or an impacted third molar is present, the posterior portion of the film packet may be tilted upward in the biteblock for better vertical film placement.



If routine placement of the film packet does not permit recording all of an impacted third molar, the biteblock and film packet may be directed more to the posterior so that the posterosuperior corner of the film packet lies further across the midline and nearer the maxillary tuberosity of the opposite side.

If necessary, in order to stabilize the biteblock further, a cotton roll may be used between the biteblock and mandibular crowns. A cotton roll is also used to fill in edentulous spaces when the mandibular biteblock support area is edentulous. If no maxillary molars are present, a cotton roll may be placed in the maxillary edentulous space in order to build up the ridge area and to provide better support for the biteblock.



Film Retention. With the biteblock resting against occlusal surfaces of maxillary molars, or a cotton roll if the area is edentulous, the patient is instructed to close on the biteblock with just enough occlusal force to retain the biteblock and film packet without film packet bending or movement. A cotton roll placed on occlusal surface of mandibular molars before the patient closes may facilitate retention. If additional assistance is needed to maintain proper film packet position, the index finger of the opposite hand may be directed against the thumbscrew of the biteblock in order to keep the biteblock from shifting forward.

Central Ray Entry. The central ray enters below the outer canthus of the eye on the ala-tragus line and/or is directed toward the center of the film packet.

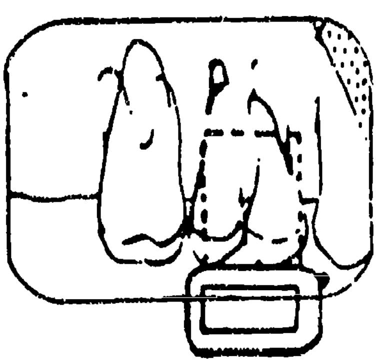
Vertical Angle. An acceptable vertical angle will usually be established by paralleling the vertical diameter of the end of the open-end cone with the vertical axis of the film packet. A greater vertical angle may sometimes be indicated.

Horizontal Angle. Acceptable horizontal angulation is usually obtained by paralleling the horizontal diameter of the end of the open-end cone with the horizontal axis of the film packet or the mean mesiodistal buccal tangent.

## Maxillary Right Bicuspid Roentgenogram - Biteblock Technique

Head Position. Midsagittal plane is vertical. Ala-tragus line and maxillary occlusal plane are horizontal.

Film Placement. The film packet is folded, if necessary, and positioned as illustrated so that the distal of the cuspid, first and second bicuspids, and first molar are recorded. The identification dot is down toward the occlusal plane, and the biteblock is attached to the anterior half of the film packet. A reinforcement backing may be used, if necessary, to avoid film packet bending. The superior edge of the film packet is positioned near the midline of the palate, and the biteblock is placed against occlusal surfaces of maxillary bicuspids. The mesiodistal axis of the film packet and the mesiodistal axis of the end of the biteblock are parallel to the mesiodistal mean buccal tangent of the maxillary bicuspids.



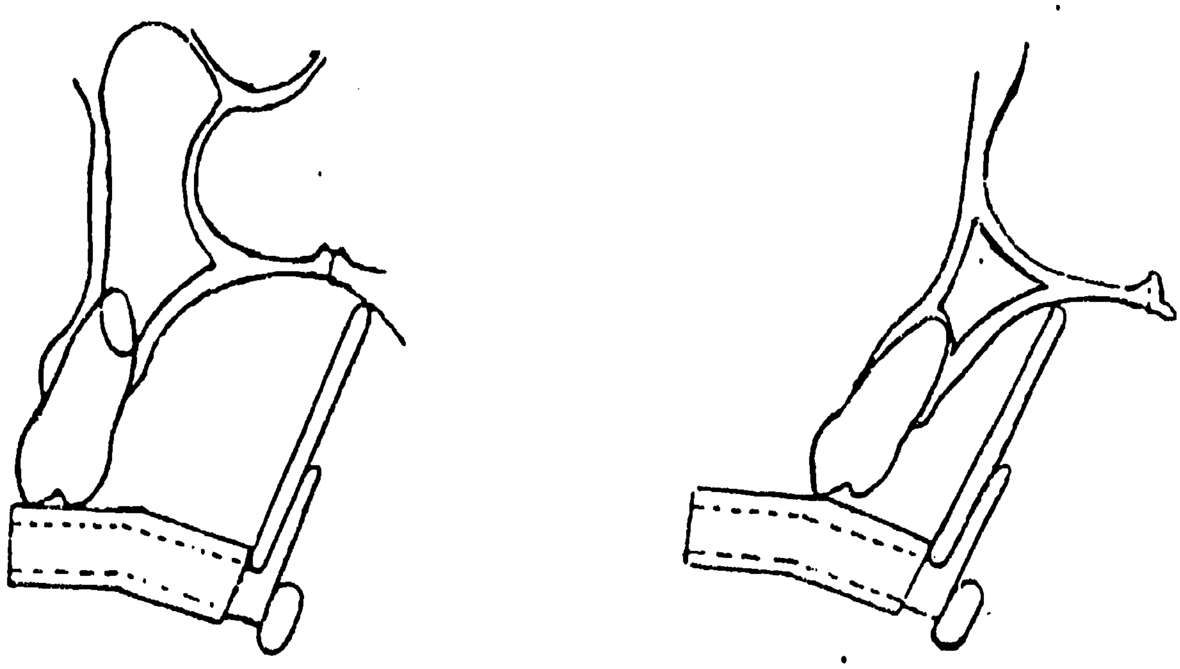
A cotton roll is used to fill in edentulous spaces for biteblock support when edentulous spaces exist in mandibular areas required for biteblock support. If no maxillary bicuspids are present, a cotton roll may be placed in the edentulous space in order to build up the ridge area and to provide better support for the biteblock.

Film Retention. With the biteblock resting against occlusal surfaces of maxillary bicuspids, or a cotton roll if the area is edentulous, the patient is instructed to close on the biteblock with just enough occlusal force to retain the biteblock and film packet without film packet bending or movement. A cotton roll placed on occlusal surface of mandibular bicuspids before the patient closes may facilitate retention. The index finger of the opposite hand may also be directed against the thumbscrew portion of the biteblock, if indicated, in order to help maintain the desired position.

Central Ray Entry. The central ray enters on the ala-tragus line midway between the ala of the nose and a point below the outer canthus of the eye and/or is directed toward the center of the film packet.

Vertical Angle. The vertical angle is established by paralleling the vertical diameter of the end of the open-end cone with the vertical axis of the film packet. The central ray is thus perpendicular to the vertical axis of the film packet. Occasionally, a greater vertical angle, probably never greater than an additional 5 degrees, may be needed in order to record apical and sufficient periapical area in some patients.

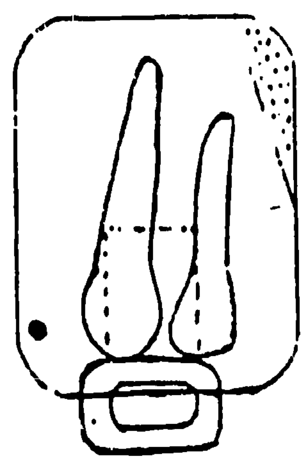
Horizontal Angle. The horizontal diameter of the end of the open-end cone is parallel to the horizontal or mesiodistal axis of the film packet.



## Maxillary Right Cuspid Periapical Roentgenogram - Biteblock Technique

Head Position. Midsagittal plane is vertical. Ala-tragus line and maxillary occlusal plane are horizontal.

Film Placement. The superior anterior corner of the film packet is folded, if necessary, to accommodate the curvature of the anterolateral aspect of the palate. The film packet and biteblock are positioned as illustrated so that the cuspid and lateral incisor are recorded. The superior edge of the film packet is placed as far back on the palate as is necessary to allow the end of the biteblock to rest against the incisal edges of the maxillary cuspid, the cuspid and lateral incisor, or the lateral and central incisors depending on the size and shape of the maxillary arch. An attempt is made to establish as much of a parallel relationship as possible between the vertical axis of the film packet and the mean long axis of the cuspid and lateral. If the film packet cannot be positioned so that the plane of the film is parallel to the mean object plane of interest, modification of the ideal horizontal angulation will be necessary. The identification dot is down toward the occlusal plane.



Film Retention. With the end of the biteblock resting against the incisal edges of the appropriate maxillary teeth, the patient is instructed to close on the biteblock with just enough force to retain the biteblock and film packet in the desired position without bending the film packet. A reinforcement backing must be used if film packet bending is otherwise unavoidable.

Central Ray Entry. The central ray enters just distal to the ala of the nose and/or is directed toward the center of the film packet.

Vertical Angle. The vertical angle is established by paralleling the vertical diameter of the end of the open-end cone with the vertical axis of the film packet. The central ray is thus perpendicular to the vertical axis of the film packet. Occasionally, a greater vertical angle, probably never more than an additional 5 degrees, may be needed in order to record apical and sufficient periapical area in some patients.

Horizontal Angle. If the plane of the film packet is parallel to the mean mesiodistal plane of interest of the cuspid and lateral incisor, the horizontal diameter of the end of the open-end cone should be parallel to the mesiodistal axis of the film packet. However, if this parallel relationship does not exist, the horizontal angle must be modified so that the images of the cuspid and lateral incisor will be projected toward the center of the film packet.



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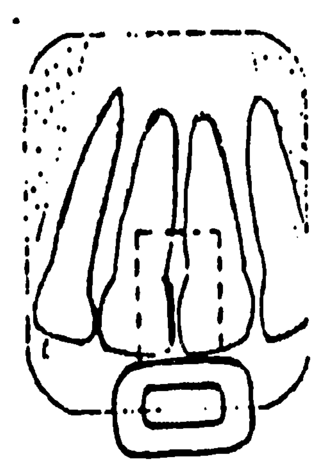
## Maxillary Incisor Periapical Roentgenogram - Biteblock Technique

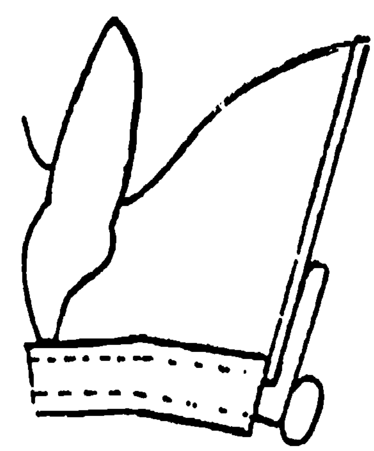
Head Position. Midsagittal plane is vertical. Ala-tragus line and maxillary occlusal plane are horizontal.

Film Placement. The film packet is folded, if necessary, and positioned as illustrated so that the central incisors are centered on the film packet. The superior edge of the film packet is placed as far back on the palate as necessary in order to allow the end of the biteblock to rest against the incisal edges of the maxillary incisors. An attempt is made to establish as much of a parallel relationship as possible between the vertical axis of the film packet and the mean long axis of the central incisors. The identification dot is down toward the occlusal plane.



Film Retention. With the end of the biteblock resting against the incisal edges of the maxillary central incisors, the patient is instructed to close on the biteblock with just enough force to retain the biteblock and film packet in the desired position without bending the film packet. A reinforcement backing must be used if film packet bending is otherwise unavoidable.

Central Ray Entry. The central ray enters the midline, just above the tip of the nose, and is directed toward the center of the film packet.



Vertical Angle. The vertical angle is established by paralleling the vertical diameter of the end of the open-end cone with the vertical axis of the film packet. The central ray is thus perpendicular to the vertical axis of the film packet. Occasionally, a greater vertical angle, probably never more than an additional 5 degrees, may be needed in order to record apical and sufficient periapical area in some patients.

Horizontal Angle. The horizontal diameter of the end of the open-end cone is parallel to the horizontal, or mesiodistal, axis of the film packet and to the mean mesiodistal axis of the plane of interest of the central incisors.

508312G

## UNIT OVERVIEW

**Task**

Apply knowledge of the paralleling technique of exposing radiographs and be able to expose a field mouth survey using it.

**Estimated Time**

3 hours

**Introduction**

Using the paralleling technique, the student will be able to take radiographs of patients and get an accurate picture of the correct areas.

**Outline**

1. Long Cone Paralleling Technique
2. Instrument Uses
3. Film Placement

**Performance Objectives**

1. Describe the principles and methods of the paralleling technique.
2. Describe film placement for all exposures.
3. Prepare instruments for use in oral cavity.

## STUDY GUIDE

| Completed ✓ | Activities | Resources |
|---|---|---|
| ___ | 1. Attend lecture | 1. Instructor |
| ___ | 2. View | 2. Slide tape, "Utilizing Rinn X-C-P Instruments," Box ~~246~~ |
| ___ | 3. Read | 3. Text, pp. 66-110 |
| ___ | 4. Participate in | 4. Lab session |

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## MODULE OVERVIEW

**Task**

Apply knowledge of the composition of a full mouth survey for an adult, child, and edentulous patient.

**Estimated Time**

2 hours

**Introduction**

A good understanding of the composition of a full mouth survey is very important for the dental assistant. It is important to know what teeth and surrounding structures should be on the film and how many films to take on each survey.

**Outline**

1. Adult Full Mouth: Number of Radiographs Taken and Areas Covered
2. Child Full Mouth: Number of Radiographs Taken and Areas Covered
3. Edentulous Patient: Number of Radiographs Taken and Areas Covered

**Performance Objectives**

1. Name the radiographs taken on each full mouth: (1) adult, (2) child, and (3) edentulous patient.
2. Describe the areas covered by each radiograph in 1, 2, and 3.

## STUDY GUIDE

| Completed ✓ | Activities | Resources |
|---|---|---|
| ____ | 1. Attend lecture | 1. Instructor |
| ____ | 2. Read | 2. Information Sheet, "Routine Complete (Full Mouth) Intraoral Roentgenographic Surveys" |

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## INFORMATION SHEET

### Routine Complete (Full-Mouth) Intraoral Roentgenographic Surveys

Many different routine complete intraoral roentgenographic surveys may be found; however, those selected for use here represent maximum coverage with a minimum number of films used.

A. Adult: Full Complement of Teeth or Partially Edentulous (FM 14)

1. Fourteen Number-2 periapical films

   a. Four molar area periapicals
   b. Four bicuspid area periapicals
   c. Four cuspid area periapicals
   d. Two incisor area periapicals

2. Four Number-2 bitewing films--two bicuspid and two molar area bitewings, or Two Number-3 bitewing films, if bitewings are indicated

B. Adult Edentulous (FM 10 edent) (FM 10E)

1. Ten Number-2 periapical films

   a. Four molar area periapicals
   b. Four bicuspid area periapicals
   c. Two incisor area periapicals

2. Two occlusal films: maxillary and mandibular full-arch occlusal views

C. Adult: One Arch Completely Edentulous (FM 12) (FM 12/maxE) (FM 12/manE)

1. Twelve Number-2 periapical films

   a. edentulous arch--five periapicals: two molars, two bicuspids, and one incisor
   b. partially edentulous arch--seven periapicals: two molars, two bicuspids, two cuspids, and one incisor

2. One occlusal film: full-arch occlusal view of the edentulous arch

3. Bitewings as indicated

D. Child (Primary or Mixed Dentition) (FM 10 child) (FM 10C)

1. Ten Number-2 or Ten Number-0 periapical films

   a. Four primary molar area periapicals (the adult bicuspid area)
   b. Four cuspid area periapicals
   c. Two incisor area periapicals

2. Two Number-2 or Two Number-0 bitewing films

Figure 7. FM 10 child with BW's (FM10/2C)

R & L maxillary bicuspid area periapicals

R & L maxillary cuspid periapicals

maxillary incisor periapical

R & L mandibular bicuspid area periapicals

R & L mandibular cuspid periapicals

mandibular incisor periapical

R & L bicuspid area bitewings

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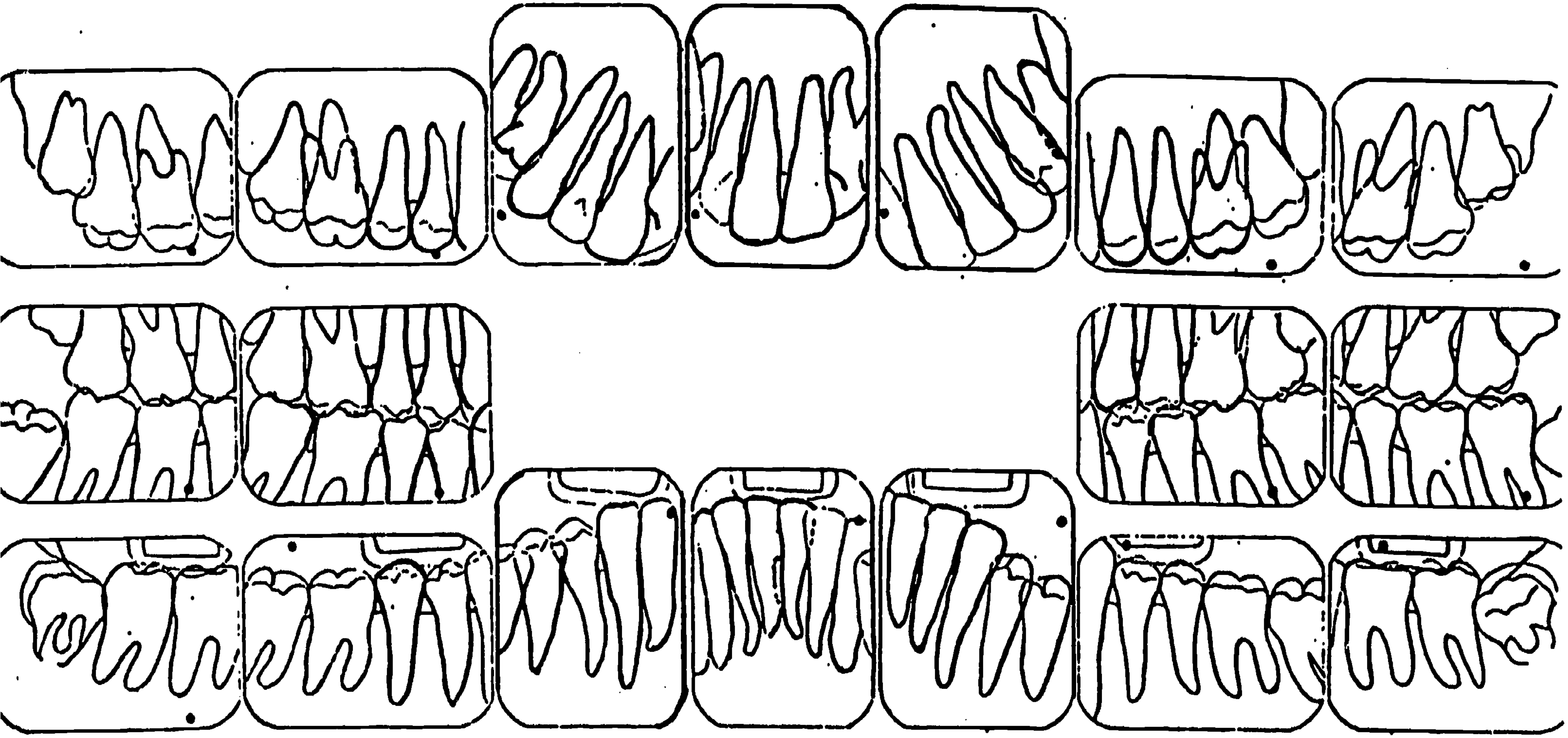

Figure 4. FM 14 with BW's (FM 14/4)

R & L maxillary molar periapicals
R & L maxillary bicuspid periapicals
R & L maxillary cuspid periapicals
maxillary incisor periapical

R & L mandibular molar periapicals
R & L mandibular bicuspid periapicals
R & L mandibular cuspid periapicals
mandibular incisor periapical

R & L bicuspid bitewings
R & L molar bitewings



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## MODULE OVERVIEW

**Task**

Properly mount a full mouth survey of radiographs.

**Estimated Time**

2 hours

**Introduction**

Mounting a full mouth radiographic series is an important task which requires a knowledge of dental anatomy and film composition.

**Outline**

1. Placement of Identification Dot--View a Convexity or Concavity
2. Maxillary vs. Mandibular Radiographs
3. Anterior vs. Posterior Radiographs
4. Differences in Periapical and Bitewing Radiographs

**Performance Objectives**

1. Identify the films in a full mouth survey and mouth them properly in a film mount.



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## STUDY GUIDE

| Completed ✓ | Activities | Resources |
|---|---|---|
| ____ | 1. Attend lecture | 1. Instructor |
| ____ | 2. Read | 2. Information Sheet, "Intraoral Roentgenogram Identification, Mounting, and Viewing" |
| ____ | 3. Read | 3. Text, pp. 229-245 |



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## INFORMATION SHEET

### Intraoral Roentgenogram Identification, Mounting, and Viewing

Identification. Proper intraoral roentgenogram identification is made by determining whether the roentgenogram is a record of maxillary or mandibular areas (if the roentgenogram is a periapical or an occlusal record), whether the roentgenogram is of the right or of the left side of the patient (if applicable), and which specific area and record type are represented. (Discernment between maxillary and mandibular records is rendered possible on the basis of roentgenographic anatomy: morphology of teeth, if teeth are present, and osteology, primarily. Identification of the specific area recorded is also determined primarily by morphology of teeth and osteology.) The record type will be either periapical, bitewing, or occlusal. Determination of right and left in the record requires a knowledge of the orientation of the film identification dot during film exposure. The film identification dot is a circular, embossed area near one edge of the film. The convexity of the embossed dot is always on the side of the film that faces the source of radiation when the film packet is placed properly in the mouth.

Viewing the Convexity. Periapical and bitewing roentgenograms mounted or viewed so that the convexity of the embossed identification dot is toward the observer are interpreted as if the observer were facing the patient. Roentgenograms on the observer's left are of the patient's right side, and those on the observer's right are of the patient's left side. Each roentgenogram or the entire mounted set could be placed against the patient's face, and roentgenographic images would be superimposed over corresponding teeth and landmarks. In order to view occlusal roentgenograms from this same perspective, as if the observer were standing in front of the patient, the convexity of the identification dot must be up for maxillary and down (concavity up) for mandibular occlusals, and the anterior edge of the films must be oriented down or toward the observer.

Viewing the Concavity. Periapical and bitewing roentgenograms mounted or viewed so that the concavity of the embossed identification dot is toward the observer are interpreted as if the observer were standing behind the patient, or, as is sometimes said, as if the observer were standing on the patient's tongue and looking out of the mouth. Therefore, roentgenograms on the observer's left are of the patient's left side and those on the observer's right are of the patient's right side. With the concavity toward the observer, each roentgenogram or the entire mounted set could be placed against the observer's face and roentgenographic images would be superimposed over the corresponding teeth and landmarks of the observer. However, in order to view occlusal roentgenograms from this same perspective, the convexity of the identification dot must be up for maxillary and down (concavity up) for mandibular occlusals and the anterior edge of the occlusal roentgenograms oriented up or away from the observer.

Mounting. Completely processed and dried roentgenograms are mounted in cardboard or other mounts opaque to light in order to facilitate the study and storage of these records. All roentgenograms must be mounted with the same side facing the front of the mount, i.e., the side with the convexity or the side with the concavity of the embossed identification dot. In order to prevent contamination of roentgenograms during mounting and subsequent use, rubber or soft cotton gloves can be worn while mounting films, and the mounted sets of films can be placed in clear plastic envelopes slightly larger than the mounts.

Optimum Viewing Conditions. Optimum viewing conditions exist only when an adequately brilliant view-box light is used and all light except that transmitted through the roentgenograms is blocked out. Room lighting should be minimal in order to eliminate or reduce light reflecting from the surface of the roentgenograms, and a magnifying glass should be available for study of minute alterations in roentgenographic densities and patterns.

## Roentgenographic Density and Contrast

Light of Vision. The light of vision or the light responsible for ocular perception may be categorized generally as luminescence or incandescence. Luminescent emissions occur at low temperatures while incandescent emissions occur at very high temperatures. The light of luminescence--such as that emitted by the complex organic compound, luciferin, in a firefly or by fluorescing objects under ultraviolet light or x-rays--and the light of incandescence--such as that emitted by the sun, an incandescent light bulb, and a burning candle--make vision or ocular perception possible by carrying light data from the object to the light receptors of the eyes for eventual interpretation in the brain. Light data may reach the light receptors directly from the source of illumination, or as transmitted light, such as that passing through a roentgenogram or a photographic negative placed against a light source, or as reflected light coming from illuminated objects.

Roentgenographic Density. Roentgenographic density refers to the relative amount of incident viewing light that passes through a roentgenogram. The quantity of incident light transmitted depends not only on the intensity or the quantity of the incident light and the quantity of light reflected from the incident side of the roentgenogram but also on the quantity of incident light blocked or absorbed by the roentgenogram. Maximum roentgenographic or photographic densities exist in those areas of a roentgenogram or photographic (black and white) negative that contain maximum quantities of light-blocking substance. The light-blocking substance is nothing more than metallic silver. Therefore, in those areas containing maximum concentrations of metallic silver, maximum absorption and minimum transmission of incident viewing light occur. Such areas in roentgenograms are referred to as areas of increased or maximum roentgenolucency and are seen as areas of maximum darkness or blackness.

Roentgenographic Density Values. Numerical values assigned to roentgenographic densities are derived from the following equation:

$$D = \log_{10} I/T$$

If the quantity of incident light (I) is considered to be 100 percent or unity (1), and if 99 percent or 99/100 of the incident light is blocked or absorbed, then 1 percent or 1/100 of the incident light is transmitted (T). Therefore, according to the density equation, the ratio of the incident and transmitted light is equal to 100, and the roentgenographic density (D) is 2. ($\log_{10} 100 = 2$. $10^2 = 100$; the exponent, 2, is the logarithm of 100 to the base 10.)

Roentgenographic Contrast. Roentgenographic contrast exists when differences in roentgenographic density exist; without differences, there would no be contrast. The greater the difference between two roentgenographic densities, the greater the roentgenographic contrast. Greater contrast exists between the roentgenographic record of an amalgam restoration and the roentgenographic record of dentin than between the roentgenographic records of enamel and dentin. Principal factors determining roentgenographic contrast are film contrast, which is related to film speed, and subject contrast. Film contrast is discussed in the chapter on characteristics of roentgenographic film in Part III of the Oral Radiology Syllabus and will not be considered here.

Subject Contrast. The principal factor responsible for roentgenographic contrast is subject or object contrast. Subject contrast alludes to characteristics of the object that cause differential absorption, blockage, filtration, or attenuation of the incident x-ray beam. An amalgam restoration absorbs or attenuates more incident radiation than tooth enamel or dentin. The principal variables in the object being radiographed that contribute to the differential absorption phenomenon include chemical composition, density, and thickness. Substances of higher atomic numbers, such as lead (Pb, 82), gold (Au, 79), iodine (I, 53), silver (Ag, 47) and calcium (Ca, 20) block or absorb x-rays more efficiently than substances of lower atomic number, such as hydrogen (H, 1), carbon (C, 6), nitrogen (N, 7), oxygen (O, 8), and fluorine (F, 9). Substances of increasing densities and increasing thicknesses absorb increasing quantities of radiation. In addition to these characteristics of the object, the energy or penetrability of the x-ray beam also affects subject contrast. More will be said of this factor later.

## Roentgenograms and Films Used in Dentistry

Films used in roentgenography are similar to films used in photography, and a roentgenogram is a photographic-type record made by processing film that has been exposed by x-rays that pass through objects being recorded.

Intraoral Roentgenograms. One of the main types of roentgenograms used in dentistry is the intraoral roentgenogram, which is made by placing small film packets inside the patient's mouth for exposure. Intraoral film placement is required to produce periapical, bitewing (interproximal), and occlusal roentgenograms.

Extraoral Roentgenograms. Larger films placed outside the mouth and usually against some aspect of the patient's head are used to make extraoral roentgenograms. The extraoral roentgenograms most routinely used in dentistry are the lateral head, anteroposterior and posteroanterior roentgenograms (head plates), lateral oblique (lateral jaw) roentgenograms, and panoramic roentgenograms.

Periapical Roentgenograms. Periapical roentgenograms record, in order of diagnostic significance, periapical areas, apices of teeth, and the roots and crowns of teeth. In the American Standards Association (A.S.A.) classification of intraoral films, periapical films are designated by the number "1" (Type 1).

Bitewing (Interproximal) Roentgenograms. Bitewing, or interproximal, roentgenograms record most accurately on one film proximal surfaces of both maxillary and mandibular teeth in centric occlusion, as well as the cervical aspect of these teeth and the crestal aspect of their periodontal structures. The name "bitewing" comes from the fact that during exposure the patient holds the film packet in position by biting on a tab or "wing" extending from the exposure side of the packet. In the A.S.A. classification of intraoral films, bitewing films are designated by the number "2" (Type 2).

Occlusal Roentgenograms. Occlusal roentgenograms record larger areas and/or cross-sectional views of maxilla or mandible; the film is placed essentially parallel to the occlusal plane for exposure. In the A.S.A. classification of intraoral films, occlusal films are designated by the number "3" (Type 3).

Lateral Head Roentgenograms. A profile view of the head is recorded in lateral head roentgenograms, commonly called lateral head plates. The film and the patient's head are positioned so that the midsagittal plane is parallel to the film, and the x-ray beam is perpendicular to both.

Anteroposterior Roentgenograms. A coronal view of the head is recorded in anteroposterior roentgenograms, sometimes called AP head plates. The midsagittal plane of the patient is perpendicular to the film, which is placed against the posterior aspect of the patient's head; the x-ray beam enters the anterior aspect of the patient's head.

Posteroanterior Roentgenograms. A coronal view of the head is also recorded in posteroanterior roentgenograms, sometimes called PA head plates. The midsagittal plane of the patient is perpendicular to the film, which is placed against the anterior aspect of the patient's head, the x-ray beam enters the posterior aspect of the patient's head.

Lateral Oblique Roentgenograms. Lateral oblique roentgenograms, sometimes called lateral jaw roentgenograms, record good unobstructed views of the body and/or ramus of one side of the mandible and, usually, of the molar-tuberosity area of the same side of the maxilla. The midsagittal plane, x-ray beam, and the film are obliquely oriented to each other.

Panoramic Roentgenograms. Panoramic roentgenograms are single-film, one-exposure, unobstructed panoramic records of all structures associated with either or both dental arches; special x-ray equipment is required to make these records. To record both dental arches on one film, the patient's head is positioned between the source of radiation and the film, and a single, prolonged synchronized exposure is made. The angular relationship of the film and x-ray beam is constant as they rotate around fixed centers of rotation while the film moves in the opposite direction. S. S. White's Panorex, Siemen's Orthopantomograph, and General Electric's Status-X unit produces panograms of a single arch with an intraoral source of radiation; the film is held contoured against either the upper or lower part of the patient's face, and the x-rays are emitted anteriorly, either up for the maxillary arch or down for the mandibular arch.

## MODULE OVERVIEW

**Task**

Prepare necessary equipment and materials and expose extraoral radiographs.

**Estimated Time**

40 minutes

**Introduction**

Extraoral radiographs allow the dentist to view many areas that he could not see on a radiograph from a full mouth survey. The dental assistant must be competent in the procedures for taking these radiographs.

**Outline**

1. Panoramic Radiographs: Advantages and Disadvantages
2. Different Types of Panoramic Units
3. Film Used
4. Occlusal Films

**Performance Objectives**

1. List the advantages and disadvantages of panoramic units.
2. Explain how the film is prepared for use in a panoramic unit.
3. Demonstrate the technique necessary to take an occlusal radiograph.



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## STUDY GUIDE

| Completed ✓ | Activities | Resources |
|---|---|---|
| ____ | 1. Attend lectures | 1. Instructor |
| ____ | 2. Read | 2. Text, pp. 127-167 |
| ____ | 3. View | 3. Slide tape, "Panorex Procedure," Box 249, Learning Lab<br>Slide tape, "Child's Complete Film Survey," Box 251, Learning Lab |



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## MODULE OVERVIEW

**Task**

Complete a full mouth survey on a child patient.

**Estimated Time**

40 minutes

**Introduction**

The child patient is a vital part of any dental practice. We must know how to complete a full mouth survey on a child and what changes might be necessary when working.

**Outline**

1. Child Full Mouth Composition Review
2. Instruments Used
3. Film Used

**Performance Objectives**

1. List the different film holding devices used on children.
2. Select the appropriate film size.
3. Demonstrate the correct technique for taking a child's full mouth.

## STUDY GUIDE

| Completed ✓ | Activities | Resources |
|---|---|---|
| ____ | 1. Attend lectures | 1. Instructor |
| ____ | 2. Read | 2. Text, pp. 127-167 |
| ____ | 3. View | 3. Slide tape, "Child's Complete Film Survey," Box 251, Learning Lab<br>Slide tape, "Panorex Procedure," Box 249, Learning Lab |

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## MODULE OVERVIEW

**Task**

Complete a full mouth survey on an edentulous patient.

**Estimated Time**

40 minutes

**Introduction**

The technique for taking a full mouth survey on an edentulous patient is very different from what is used on a patient with teeth present. These differences must be presented to the dental assistant so they can properly expose a full mouth.

**Outline**

1. Film Used and Number of Films
2. Film Placement
3. Vertical Angulation

**Performance Objectives**

1. Select appropriate film size.
2. Demonstrate proper film placement and exposure technique.

## STUDY GUIDE

| Completed ✓ | Activities | Resources |
|---|---|---|
| ____ | 1. Attend lectures | 1. Instructor |
| ____ | 2. Read | 2. Text, pp. 127-167 |
| ____ | 3. View | 3. Slide tape, "Panorex Procedure," Box 249, Learning Lab<br>Slide tape, "Child's Complete Film Survey," Box 251, Learning Lab |



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## COURSE OVERVIEW

The student will take, develop, and evaluate 12 full-mouth surveys on mannequins and patients.

Time 36 hours

### Unit Overviews

#### Unit 1

**Task**

Complete a full-mouth su·vey on the child DXTTR mannequin, mount it, and develop it.

**Estimated Time**

4 hours

**Outline**

1. Film Size and Number of Films Used
2. Instrument Used
3. Film Placement
4. Develop Film
5. Evaluate Films

**Performance Objectives**

1. Select proper number and size films.
2. Select appropriate instrument.
3. Demonstrate proper exposure technique.
4. Demonstrate proper developing technique.
5. Properly evaluate full-mouth survey.



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# Unit 2

**Task**

Complete a full-mouth survey on an adult DXTTR, mount it, and evaluate it.

**Estimated Time**

12 hours

**Outline**

1. Film size and Number of Films Used
2. Instrument Used
3. Film Placement
4. Develop Film
5. Evaluate Films

**Performance Objectives**

1. Select proper number and size films.
2. Select appropriate instrument.
3. Demonstrate proper exposure technique.
4. Demonstrate proper developing technique.
5. Properly evaluate full-mouth survey.



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## Unit 3

**Task**

Complete a full-mouth survey on a child patient, mount it, and evaluate it.

**Estimated Time**

4 hours

**Outline**

1. Film Size and Number of Films Used
2. Instrument Used
3. Film Placement
4. Develop Film
5. Evaluate Films

**Performance Objectives**

1. Select proper number and size films.
2. Select appropriate instrument.
3. Demonstrate proper exposure technique.
4. Demonstrate proper developing technique.
5. Properly evaluate full-mouth survey.

<u>Unit 4</u>

**Task**

Complete a full-mouth survey on an edentulous patient, mount it, and evaluate it.

**Estimated Time**

4 hours

**Outline**

1. Film Size and Number of Films Used
2. Instrument Used
3. Film Placement
4. Develop Film
5. Evaluate Films

**Performance Objectives**

1. Select proper number and size films.
2. Select appropriate instrument.
3. Demonstrate proper exposure technique.
4. Demonstrate proper developing technique.
5. Properly evaluate full-mouth survey.

## Unit 5

**Task** Complete full-mouth surveys on six adult patients, mount them, and evaluate them.

**Estimated Time** 12 hours

**Outline**

1. Film Size and Number of Films Used
2. Instrument Used
3. Film Placement
4. Develop Film
5. Evaluate Films

**Performance Objectives**

1. Select proper number and size films.
2. Select appropriate instrument.
3. Demonstrate proper exposure technique.
4. Demonstrate proper developing technique.
5. Properly evaluate full-mouth survey.

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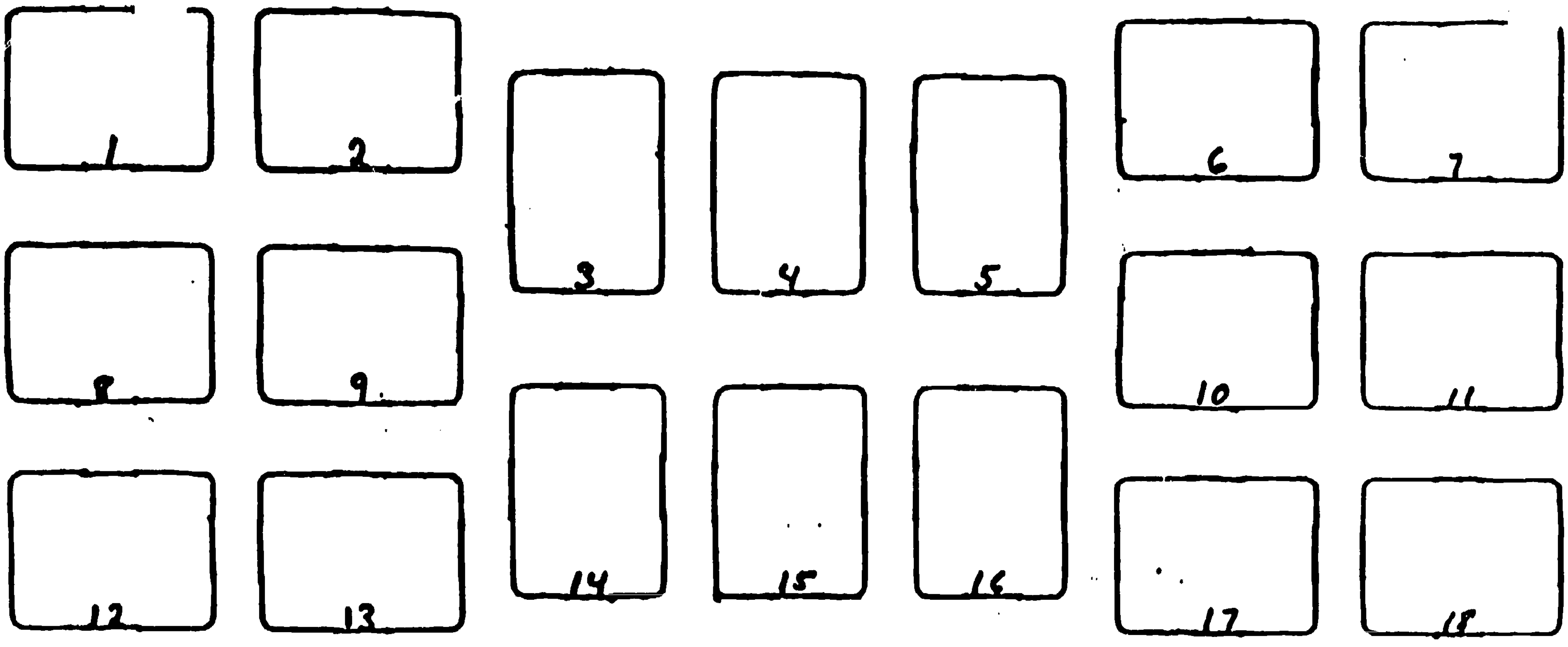


A. Patient preparation

1. Failure to remove

glasses
denture
earings

B. Film bending

C. Film placement and retention

1. Film placed backward
2. Occlusal edge of film not parallel to occlusal plane
3. Film placed too far apically
4. Film placed too far occlusally
5. Film placed too far mesially
6. Film placed too far distally

D. Vertical angle too great-foreshortened

E. Vertical angle not great enough-elongated

F. Central ray not centered

G. Improper horizontal beam alignment-overlapping

H. Film overexposed

I. Film underexposed

J. Film double exposed

K. Movement of film, patient, or source of radiation

L. Other errors



ERIC 12N1

## INSTRUCTOR'S ORIENTATION

### Curriculum - What is it?

Curriculum is **a detailed plan for learning**. This curriculum plan, then, is a detailed plan for helping prospective practitioners in this occupational field learn essential knowledge and skills.

While the manual provides a highly organized and structured plan, there is a great deal of flexibility to accommodate the creativity of individual instructors. A variety of learning activities and supplemental resources can be utilized in addition to those suggested in the unit **Study Guides**. Thus, a good basic plan is provided, around which instructors can build their own personalized learning plan. The job tasks and objectives provided, however, should be considered basic to any complete program of instruction on this topic.

### Format for this Manual

Curriculum developed within the WisCom Curriculum System is organized according to a standard format. The manual is divided into two sections. The first contains instructional materials which include an Introduction, Student Orientation, Unit Overviews, and Study Guides. A variety of learning materials may also be included such as: handouts, self-tests, worksheets, guidelines for projects, tours, etc.

The second section contains materials useful to the instructor in planning and managing the course. Here we find a concise description of the contents, scope and purpose of the curriculum package along with guidelines for teachers on how to utilize the curriculum most effectively.

Instructors are encouraged to add their own notes and supplemental materials to this manual to create a curriculum plan which meets their needs and reflects their personality.



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## COURSE DESCRIPTION

The course provides instruction in the principles of dental radiology, paralleling techniques, bisecting techniques, and the processing, mounting, and interpretation of radiographs.

Prerequisites: Oral and Dental Anatomy; Health and Disease, Basic Principles of; Microbiology and Asepsis in the Dental Office.



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## COURSE CONTENT OUTLINE

**Unit/Module Number and Title**

Unit 1 X-Ray Physics

Unit 2 X-Ray Production

Unit 3 Radiation Health and Safety

Unit 4 Radiographic Anatomy and Pathology

Unit 5 Darkroom Setup and Chemistry

Unit 6 Bisecting Angle Technique

Unit 7 Paralleling Technique

Unit 8 Full Mouth Survey Techniques

- Module 8A Composition
- Module 8B Film Mounting

Unit 9 Special Radiographs

- Module 9A Extraoral Radiographs
- Module 9B Child Patient
- Module 9C Edentulous Patients

Radiography Practicum



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## COURSE TASKS AND OBJECTIVES LIST

**Task 1** Recognize the characteristics of x-radiation and be able to relate that to the patient.

**Performance Objectives**

1. Define the different terms used in radiography.
2. Distinguish where x-rays are in the electromagnetic spectrum.
3. Recognize the many characteristics of x-radiation.
4. Compare the different methods of measuring x-radiation.

**Task 2** Apply knowledge of how x-rays are produced and what is necessary to produce them.

**Performance Objectives**

1. Identify the different parts of the x-ray tube.
2. Describe the process for production of x-radiation.
3. Distinguish between the different types of radiation produced.
4. List the three exposure variables and their effects.
5. Define and describe radiographic density-contrast and detail.
6. Discuss the Inverse Square law and its effect on x-ray production.

**Task 3** Apply knowledge of the effects of radiation on the human body and describe the safety measures.

**Performance Objectives**

1. Explain the somatic and genetic effects of x-rays.
2. List those tissues most and least sensitive to radiation.
3. List and describe the methods for reducing patient exposure.
4. Explain the methods of operator protection.
5. Identify common methods of personnel monitoring.



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**Task 4** Recognize the structures in the oral cavity through the use of radiographs.

**Performance Objectives**

1. Distinguish between radiopaque and radiolucent structures on radiographs.
2. Differentiate between the different tooth structures on a radiograph.
3. Identify the bone and surrounding structures in the oral cavity as shown on radiographs.
4. Point out the different restorative materials used in the mouth as they appear on a radiograph.
5. Indicate the different abnormalities that may develop in the oral cavity and be able to identify them.

**Task 5** Apply knowledge of the setup of an x-ray darkroom and the process for developing dental radiographs.

**Performance Objectives**

1. List important features of a darkroom and identify the necessary equipment.
2. Identify the components and chemicals in dental film.
3. Indicate how films should be stored.
4. List steps in preparation for processing film.
5. Identify the steps for proper film processing.
6. Describe clean-up procedures.
7. List common darkroom errors and methods to prevent them.
8. Identify errors on radiographs.
9. Operate automatic film processors correctly.

**Task 6** Apply knowledge of the bisecting technique and be able to expose a full mouth survey using it.

**Performance Objectives**

1. State the basic principles of the bisecting technique.
2. List common errors in technique.
3. Demonstrate patient positioning.
4. List film holders and demonstrate their uses.

**Task 7** Apply knowledge of the paralleling technique of exposing radiographs and be able to expose a full mouth survey using it.

**Performance Objectives**

1. Describe the principles and methods of the paralleling technique.
2. Describe film placement for all exposures.
3. Prepare instrument for use in oral cavity.

**Task 8** Apply knowledge of the composition of a full mouth survey for an adult, child, and edentulous patient.

**Performance Objectives**

1. Name the radiographs taken on each full mouth: (1) adult, (2) child, and (3) edentulous patient.
2. Describe the areas covered by each radiograph in 1, 2, and 3.

**Task 9** Properly mount a full mouth survey of radiographs.

**Performance Objectives**

1. Identify the films in a full mouth survey and mount them properly in a film mount.



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**Task 10** Prepare necessary equipment and materials and expose extraoral radiographs.

**Performance Objectives**

1. List the advantages and disadvantages of panoramic units.
2. Explain how the film is prepared for use in a panoramic unit.
3. Demonstrate the technique necessary to take an occlusal radiograph.

**Task 11** Complete a full mouth survey on a child patient.

**Performance Objectives**

1. List the different film holding devices used on children.
2. Select the appropriate film size.
3. Demonstrate the correct technique for taking a child's full mouth.

**Task 12** Complete a full mouth survey on an edentulous patient.

**Performance Objectives**

1. Select appropriate film size.
2. Demonstrate proper film placement and exposure technique.

## MEDIA LIST

| Number | | Title |
|---|---|---|
| 1 | Slide tape no. 238 | "Introduction to X-Ray Physics" |
| 2 | Slide tape no. 239 | "X-Ray Production and Radiographic Quality" |
| 3 | Slide tape no. 240 | "Dental Radiological Health" |
| 4 | Slide tape no. 241 | "Radiographic Dental Anatomy and Pathology" |
| 5 | Slide tape no. 242 | "Darkroom and Darkroom Chemistry" |
| 6 | Slide tape no. 243 | "Manual Processing and Darkroom Errors" |
| 7 | Slide tape no. 250 | "Dental Radiography: Bisecting the Angle" |
| 8 | Slide tape no. 246 | "Utilizing Rinn X-C-P Instruments" |
| 9 | Slide tape no. 249 | "Panorex Procedure" |
| 10 | Slide tape no. 251 | "Child's Complete Film Survey" |



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## CHECKLIST FOR BIAS-FREE CURRICULUM MATERIALS

| | | | | |
|---|---|---|---|---|
| 1. | Pictures of both men and women are included for each occupational cluster depicted. | ___ Yes | ___ No | _X_ No Pictures |
| 2. | Pictures depict men and women in professionally and socially comparable roles. | ___ Yes | ___ No | _X_ No Pictures |
| 3. | Curriculum is free of gender-specific language. | ___ Yes | ___ No | ___ Not Applicable |
| 4. | Both women and men are depicted in parenting roles. (If applicable.) | ___ Yes | ___ No | _X_ Not Applicable |
| 5. | Publication is free of demeaning or pejorative synonyms for women such as "girls," "gals," "ladies." | _X_ Yes | ___ No | ___ Not Applicable |
| 6. | Publication is free of nonparallel titles for women and men. (e.g., Mr. Smith and his secretary, Ellen.) | _X_ Yes | ___ No | ___ Not Applicable |
| 7. | Pictures of minority students depict them in comparable professional and social roles with majority group members. | ___ Yes | ___ No | _X_ No Pictures |
| 8. | Publication is free of colloquial or unacceptable terminology for minority group members. (e.g., Negroes, Indians, etc.) | _X_ Yes | ___ No | ___ Not Applicable |