Chapter 3
Radiation Characteristics

Dental Radiography
• Questions
  ➢ What are the differences between x-ray beam quality and quantity?
  ➢ What is the difference between kilovoltage and milliamperage?
  ➢ What is the inverse square law and what relevance does it have to dental radiography?

Dental Radiography
• Chapter 3 Reading:
  ➢ Iannucci & Howerton (pp. 26-33)
Dental Radiography

- Chapter 3 Outline
- Radiation Characteristics
  - X-Ray Beam Quality
  - X-Ray Beam Quantity
  - X-Ray Beam Intensity

Introduction

- Iannucci & Howerton (pp. 26-27)
- Purpose
  - To detail the concepts of x-ray beam quality and quantity
  - To define the concept of beam intensity
  - To discuss how exposure factors influence these radiation characteristics

X-Ray Beam Quality

- Voltage and kilovoltage
- Kilovoltage peak
- Density and kilovoltage peak
- Contrast and kilovoltage peak
- Exposure time and kilovoltage peak
X-Ray Beam Quality

- Iannucci & Howerton (p. 27)
- Wavelength determines the energy and penetrating power of radiation.
  - X-rays with shorter wavelength have more penetrating power.
- Quality is used to describe the mean energy or penetrating ability of the x-ray beam.
  - The quality is controlled by kilovoltage.

Voltage and Kilovoltage

- Voltage
  - Is potential difference between two electrical charges.
  - When voltage is increased, the speed of electrons is increased.
  - The electrons strike the target with greater force and energy.

Voltage and Kilovoltage

- Voltage is measured in volts or kilovolts.
  - Volt
    - A unit of measurement used to describe the potential that drives an electrical current through a circuit
    - A kilovolt equals 1000 volts
  - Dental radiography requires the use of 65 to 100 kV.
    - < 65 kV inadequate penetration
    - > 100 kV overpenetration
Kilovoltage Peak (kVp)

- Iannucci & Howerton (p. 27) (Figs. 3-1, 3-2)
  - Maximum or peak voltage
    - This usually refers to the peak voltage of an alternating current.
    - A polychromatic x-ray beam is produced as a result of varying kilovoltages in the tube current.
  - The quality, or wavelength and energy of the x-ray beam, is controlled by the kilovolt peak.

Kilovoltage Peak

- Iannucci & Howerton (p. 30)
  - Regulates the penetrating power of the x-ray beam by controlling the speed of electrons traveling between the cathode and the anode
  - Higher kilovoltage peak settings
    - Produce an x-ray beam with more energy and shorter wavelengths
    - Increases intensity of the x-ray beam

Kilovoltage peak (kVp)

controls quality of x-ray beam and measures peak voltage of current
Density and Kilovoltage Peak

- Iannucci & Howerton (pp. 27-28) (Figs. 3-3, 3-4) (Table 3-1)
  - Density
    - This is the overall darkness or blackness of a image.
  - When the kilovoltage is increased the image will appear darker.
  - When the kilovoltage is decreased the image will appear lighter.
Increase in kV = \( \uparrow \) density = darker image;

Decrease in kV = \( \downarrow \) density = lighter image

Contrast and Kilovoltage Peak

- Iannucci & Howerton (p. 28) (Figs. 3-5, 3-6) (Table 3-1)
  - Contrast
    - How sharply dark and light areas are differentiated on an image
  - Low kilovoltage peak settings (65-70 kVp) create a high contrast film
    - Many black and white areas, few shades of gray
    - Good for detection of caries
  - High kilovoltage peak settings (\( \geq \) 90kVp) create a low contrast image
    - Many shades of gray
    - Good for detection of periodontal or periapical disease

Lower kV = high contrast = many light & dark areas;
Higher kV = low contrast = many shades grey
Exposure Time and Kilovoltage Peak

- Iannucci & Howerton (p. 29) (Box 3-1)

  - Exposure time
    - This is the interval of time during which x-rays are produced.
    - It is measured in impulses.
    - 1/60th of a second resulting from alternating current

  - An adjustment in exposure time is necessary when kilovoltage peak is increased.

X-Ray Beam Quantity

- Amperage and milliamperage
- Milliamperes-seconds
- Density and milliamperage
- Exposure time and milliamperage

X-Ray Beam Quantity

- Iannucci & Howerton (p. 29)

  - Quantity
    - Number of x-rays produced in the dental x-ray unit
Amperage and Milliamperage

- Amperage
  - Determines the amount of electrons passing through the cathode filament
  - Increasing amperage
    - Results in an increased number of electrons traveling from cathode to anode and production of an increased number of x-rays
  - The quantity of the x-rays produced is controlled by milliamperage.

- Milliamperage
  - Milliamperage regulates the temperature of the cathode filament.
  - A higher milliampere setting increases the temperature of the cathode filament.
    - It increases the number of electrons produced.
    - Increases the number of x-rays emitted from the tube.

Ampere (A)
- Unit of measure used to describe the number of electrons, or current flowing through the cathode filament

Milliampere (mA)
- 1/1000 of an ampere
- In dental radiography milliampere ranges from 7 to 15 mA; exceeding this produces excessive heat.
Milliampere-Seconds (mAs)

- mAS is the product of milliamperes and exposure time.
  - When milliamperage is increased, exposure time must be decreased to maintain constant density.

Density and Milliamperage

- Iannucci & Howerton (p. 30)
  - An increase in milliamperage
    - Increases overall density of the radiograph
    - Results in a darker image

Exposure Time and Milliamperage

- Iannucci & Howerton (p. 30) (Table 3-3)
  - An inverse relationship
    - When milliamperage is increased, exposure time must be decreased.
    - When milliamperage is decreased, exposure time must be increased.
Milliamperage

- Iannucci & Howerton (p. 30)
- Controls the penetrating power of the x-ray beam by controlling the number of electrons produced in the x-ray tube and the number of x-rays produced
- Higher milliamperage settings
  - Produce an x-ray beam with more energy, increasing the intensity of the x-ray beam

kVp and mA controls on control panel

X-Ray Beam Intensity

- Kilovoltage peak
- Milliamperage
- Exposure time
- Distance
- Inverse square law
- Half-value layer
X-Ray Beam Intensity

- The product of the quantity (number of x-ray photons) and quality (energy of each photon) per unit of area per unit of time of exposure

Exposure Time

- Iannucci & Howerton (p. 30)
- Exposure time affects the number of x-rays produced.
  - A longer exposure time
    - Produces more x-rays and a more intense x-ray beam

Distance

- Iannucci & Howerton (pp. 30-31) (Fig. 3-7)
- The distance traveled by the x-ray beam affects the intensity of the beam.
  - Three distances to consider
    - Target-surface (source to patient’s skin)
    - Target-object (source to patient’s tooth)
    - Target-receptor (source to receptor)
Distance

- As x-rays travel from their point of origin, they diverge and spread out to cover a larger surface area.
  - The intensity of the beam lessens.

Inverse Square Law

- Iannucci & Howerton (pp. 31-32) (Fig. 3-8)
- The intensity of radiation is inversely proportional to the square of the distance from the source of radiation.
  - When the distance is doubled, the beam is one quarter as intense.
  - When the distance is halved, the beam is four times more intense.

Inverse square law

( the farther the distance, the less intense the radiation)
Half-Value Layer

- Iannucci & Howerton (p. 32)
- Aluminum filters are placed in the path of the beam inside the dental x-ray tubehead.
  - The filters are used to remove the low-energy, less penetrating, longer wavelength x-rays.
    - Increases mean penetrating capability of the x-ray beam while reducing the intensity.
- The thickness of a specified material that reduces the intensity by half is termed the *half-value layer* (HVL).