Digital Imaging, Dental Film, and Processing Radiographs

Chapter 39
Learning Objectives
Lesson 39.1: Digital Radiography and X-Ray Film Processing

1. Pronounce, define, and spell the key terms.
2. Describe the purposes and uses of digital radiography.
Learning Objectives
Lesson 39.1: Digital Radiography and X-Ray Film Processing (Cont.)

3. Explain the fundamental systems of digital radiography, including the following:
   • List and describe the equipment necessary for digital radiography.
   • Identify the types of dental image receptors.
   • Describe the purpose for scanning and clearing phosphor plates.
   • Describe the process for digitizing radiographs using a scanner.
   • List and describe the advantages and disadvantages of digital radiography.
   • Describe the changes to the image that a digital imaging software can make.
Learning Objectives
Lesson 39.1: Digital Radiography and X-Ray Film Processing (Cont.)

4. Do the following regarding x-ray film and film processing:
   • Identify correct terminology used in conventional film-based techniques.
   • Describe common types of beam alignment devices.
Introduction

- Learn the advantages and disadvantages and basic concepts of digital radiography, including scanning and digitizing dental images
- Learn the various types and uses of intraoral and extraoral films
- Using conventional x-ray film, learn to use manual and automatic processing techniques and how to duplicate film
- Learn how to recognize common errors in film processing and how to prevent them from occurring
Digital Radiography

- Has been used in dentistry since 1987
- Today, in many areas of the United States and Canada, dentists and dental schools are changing from conventional film-based radiography to digital radiography
Digital Radiography (Cont.)

- The term *digital image* is used instead of radiographs, x-rays, or films
  - Digital images are not radiographs but are electronic signals that are captured by sensors and displayed on a computer monitor almost instantaneously
  - These images can be e-mailed to insurance companies and other dentists
  - Hard copies can be printed on image quality paper
Digital Images
A conventional x-ray machine is still needed to expose the image. The positioning of the image receptor (sensor or phosphor storage plate) in the mouth is identical to positioning with film.

Strict infection control measures must be used because the sensors and PSPs are reused time and again. FDA-cleared disposable, fluid impervious barriers must be used on digital image sensors and phosphor plates.
Types of Digital Imaging Systems

There are two basic methods of acquiring a digital x-ray image:
- Direct imaging
- Indirect imaging
Direct Digital Imaging

- A solid-state sensor is the image receptor
  - It contains an x-ray sensitive silicon chip with an electronic circuit embedded in the silicon
- The charge-coupled device (CCD) sensor is the most commonly used digital receptor
  - Like telephones, some CCDs are wireless
  - Other types have a cable connected directly from the sensor to the computer
Indirect Digital Imaging

- Phosphor storage imaging
- The image receptor is a thin flexible plate, the size of conventional x-ray film, that has been coated with phosphor crystals
  - The phosphor layer is able to store the energy of the x-ray photons for some time
  - A scanner is required to “read” the information stored on the plate by using a laser beam to release the energy from the plate and convert it into a digital image
Phosphor Storage Imaging

- After the plates are scanned, they are exposed to bright light that erases all remaining energy, and the plates are ready to be used again
  - For infection control, the imaging plate is inserted into a specially designed barrier envelope
  - The barrier envelope is sealed by removing the adhesive strip and pressing the envelope closed
Phosphor Storage Imaging (Cont.)

- The imaging plate is positioned in the patient’s mouth using the same positioning techniques as with conventional dental x-ray film
  - After exposure, the imaging plate is carefully removed from the barrier envelope and is then placed in a scanner that uses a laser to display the image on the computer
- The imaging plates cannot be autoclaved, and extreme care must be taken when handling to avoid scratches or dust
Digitizing Images

- Film-based radiographs may be digitized for viewing on a computer in much the same way as any other document
  - Desktop scanners capture and digitize the light signal of whatever is placed inside them
  - The process is similar to placing a film on a duplicator lightbox
  - This type of indirect digital imaging is slightly less detailed than direct digital imaging because the resultant image is similar to a “copy” of the image
Digital Imaging Software Programs

- Most computer software programs that are used in digital imaging are capable of performing electronic image enhancement.
- The operator can change the following image variables either together or separately:
  - Contrast
  - Brightness
  - Image size (zoom)
  - Sharpness
  - Inversion (white to black and black to white)
  - Pseudocolor alteration
Image Manipulation
X-Ray Film and Film Processing

- While many dental practices are transitioning to digital techniques, a significant number are using conventional film-based techniques.
  - The dental assistant must thoroughly understand the procedures and techniques necessary to process films into high-quality diagnostic images.
- *Film* is the correct term to use before it has been processed.
  - The film is in the packet, the film is placed in the bite-block, and the film is exposed and processed.
- After the film has been processed, it becomes an image or radiograph.
Positioning Instruments

- Positioning instruments are used to position and hold the dental x-ray films or the digital sensor in the patient’s mouth
  - Use of a positioner keeps the patient’s fingers from being exposed to x-radiation
  - Positioners also assist the operator in properly placing the film or sensor and the position indicator device (PID)
Positioning Instruments (Cont.)

- Various types of intraoral positioning instruments are currently available
  - The sensor holders used in digital radiography are almost identical to the x-ray film holders used in conventional techniques
  - The primary difference is in the size and shape of the holder
Film and Digital Holders

A

B

Courtesy Dentsply Rinn, Elgin, IL.
Positioning Instruments (Cont.)

- Double-ended instruments for the bisecting technique hold the film or phosphor plate between two serrated plastic grips that can be locked into place
  - One basic film holder is a disposable polystyrene (Styrofoam) bite block with a backing plate and a slot for film retention
  - The EndoRay device is used to take radiographs when instruments are in the canal
Bite-Block Film Holders

 Courtesy Dentsply Rinn, Elgin, IL.
EndoRay

Courtesy Dentsply Rinn, Elgin, IL.
Beam Alignment Devices

- Devices used to align the beam are available from several manufacturers for both film-based and digital techniques
  - The beam alignment device assists in the positioning of the PID in relation to the tooth and film or sensor
- Rinn XCP instruments use color-coded plastic bite-blocks, plastic aiming rings, and metal indicator arms for film-based techniques
  - Rinn XCP-DS are for holding digital sensors
Sensors and Holding Device

Courtesy Dentsply Rinn, Elgin, IL.
Learning Objectives
Lesson 39.2: Dental Film

5. Discuss dental film, including the following:
   • Explain why it is important to know the film speed.
   • Name the five basic sizes of intraoral dental film.
   • Describe the contents of an extraoral x-ray film packet.
   • Explain the purpose of an intensifying screen.
   • Name two types of extraoral films.
   • Describe the process for duplicating radiographs.
   • Explain how dental film should be stored.
Dental X-Ray Film

- Film used in dental radiography is similar to photographic film, with some adaptations
- A photographic image is produced on dental x-ray film when it is exposed to x-rays that have passed through teeth and adjacent tissues
- The dental assistant must understand the composition of x-ray film and latent image formation that results in increased patient exposure to x-rays
Film Composition

- Intraoral film is made up of a clear, semi-flexible, cellulose acetate film base that is coated on both sides with an emulsion of silver bromide, silver halide, and silver iodide that is sensitive to radiation
Film Base and Emulsion

From Frommer H, Stabulas-Savage JJ: Radiology for the dental professional, ed 9, St Louis, 2011, Mosby.
Scanning Electron Micrograph of Unprocessed Emulsion

Courtesy Carestream Health, Inc., Rochester, NY.
Latent Image

- When the radiation interacts with the silver halide crystals in the film emulsion, the image on the film is produced.
- The image, which is not visible before processing, is called the *latent image*.
- An example of another type of latent image is fingerprints:
  - If you touch an item, you leave your fingerprints even though you cannot see them on that item.
  - When that item is treated, your fingerprints become visible.
Film Speed

- Refers to the amount of radiation required to produce a radiograph of standard density (darkness)
- Film speed is determined by the following factors:
  - Size of the silver halide crystals
  - Thickness of the emulsion
  - Presence of special radiosensitive dyes
Film Speed (Cont.)

- Film speed determines how much exposure time is required to produce the image on film.
- Fast film requires less radiation; the film responds more quickly because the silver halide crystals in the emulsion are larger.
- The larger the crystals, the faster the film speed; this is the same principle as film speed on photographic film.
- F-speed film, the newest and fastest film on the market today, reduces radiation exposure to the patient by 20% to 60% compared with E-speed and D-speed film.
Insight Film

Courtesy Carestream Health, Inc., Rochester, NY.
Types of Film

- Three types of x-ray film are used in dental radiography:
  - Intraoral
  - Extraoral
  - Duplicating
Intraoral Film

- *Intraoral film* is so named because it is placed inside the mouth during x-ray exposure.
- The intraoral x-ray film has emulsion on both sides of the film instead of just one because it requires less radiation to produce an image.
- The film is packaged in what is referred to as the *film packet* to protect it from light and moisture.
Film Packet

- Intraoral film packets are typically available in boxes of 25, 100, or 150 films
- The film packet may contain one film (one-film packet) or two films (two-film packet)
- Boxes of film are labeled with the following information: Type of film, film speed, number of films per individual packet, total number of films in the box, and the expiration date
- On one corner of the film packet is a small raised bump known as the identification dot
Contents of a Moisture-Proof Dental Film Packet

Courtesy Carestream Dental, a division of Carestream Health, Inc.
Film Packet (Cont.)

- The black paper film wrapper inside the film packet is a protective sheet that covers the film and shields it from light.
- The thin lead foil sheet is positioned behind the film to shield the film from back-scattered (secondary) radiation that results in film fog.
- The outer packet wrapping is a soft vinyl or paper wrapper that seals the film packet, protective black paper, and lead foil sheet.
Film Packet (Cont.)

- The tube side is solid white and has the raised bump on one corner
  - When placed in the mouth, the white side (tube side) of the film must face the teeth and tubehead, and the raised dot must be toward the incisal/occlusal surface
Lead-Foil Insert
Film Sizes

- Intraoral film packets come in five basic sizes:
  - Child (size 0)
  - Narrow anterior (size 1)
  - Adult size (size 2)
  - Preformed bitewing (size 3)
  - Occlusal (size 4)
White Side of Film Packet
Extraoral Film

- An extraoral film is one that is placed outside the mouth during x-ray exposure.
- Extraoral films are used to examine large areas of the head or jaws.
- Examples of common extraoral films include panoramic and cephalometric films.
- A panoramic film shows a panoramic (wide) view of the upper and lower jaws on a single radiograph.
- A cephalometric film shows the bony and soft-tissue areas of the facial profile.
Panoramic X-Ray Film

Courtesy Carestream Health, Inc., Rochester, NY.
Cephalometric Radiograph

Courtesy Carestream Health, Inc., Rochester, NY.
Extraoral Film Packaging

- Extraoral radiography uses a film-screen system; the film is used in combination with intensifying screens
- Extraoral film is supplied in boxes of 50 or 100
- Extraoral film used in dental radiography is available in 5-×7-inch and 8-×10-inch sizes
- Extraoral film is not supplied in film packets
- Film is stacked, like a deck of cards, in the box
- Film must be loaded into a cassette in the darkroom
- Film will be ruined if box is opened in light
Boxes of Extraoral X-Ray Film

Courtesy Carestream Health, Inc., Rochester, NY.
Film Cassette

- A cassette is a plastic or metal case used in extraoral radiography to hold the film and protect it from exposure to light
  - Cassettes are available in rigid or flexible styles
- To tell the patient’s left side from the right as on intraoral films, the front of the cassettes must be marked with lead letters
  - L (left side) and R (right side)
- The front side of the cassette must always face the patient during exposure
Film Cassette (Cont.)
Intensifying Screen

- Intensifies or increases the effect of the radiation and thus decreases the amount of exposure time needed.
- The intensifying screen is coated with a material called phosphor that gives off light when struck by x-radiation.
- The film inside the cassette is sandwiched between the intensifying screens and is affected by both the light produced by the phosphor and the x-radiation.
- However, there is a slight loss of image detail as a result of the intensified x-ray beam because the light produces a halo effect at the edge of the image field.
Rigid-Type Film Cassette
Film Types

- Green-sensitive: This type of film is used with cassettes that have rare earth intensifying screens
- Blue-sensitive: This type of film is used with cassettes that have calcium tungstate intensifying screens
Duplicating Film

- Special duplicating film and a duplicating machine are necessary to duplicate radiographs.
- Duplicating film is used only in a darkroom setting and is never exposed to x-rays.
- The duplicating machine produces white light to expose the film.
  - Duplication process is performed in the darkroom, under the safelight.
- The longer the duplicating film is exposed to light, the lighter it will become.
  - Opposite of x-ray film, which becomes darker when exposed to light.
Film Duplicators

Courtesy Dentsply Rinn Corporation, Elgin, IL.
Film Storage

- All dental films should be stored according to the manufacturer’s instructions
  - Provide protection from light, heat, moisture, chemicals, and scatter radiation
    - 50° to 70° F
    - 30% to 50% humidity
    - Keep away from the treatment room or near radiograph unit
    - If box is expired, may result in age fog on radiographs
Film Processing

- Processing is a series of steps that changes the latent image on the exposed film into a radiograph by producing a visible image on the film.
- Proper processing is just as important as exposure technique in producing diagnostic-quality radiographs.
- Radiographs that are nondiagnostic because of poor processing techniques must be retaken, exposing the patient to unnecessary radiation.
- In many practices, intraoral films are processed in an automatic processor; however, it is still necessary to know how to process the film manually.
Five Steps in Processing

- Development
- Rinsing
- Fixation
- Washing
- Drying
Developing

- Developing is the first step in processing films
- A chemical solution called the *developer* is used
- The purpose of the developer is to chemically reduce the exposed silver halide crystals to black metallic silver
- The developer solution also softens the film emulsion during this process
Rinsing

- Rinsing of the films is necessary to remove the developer from the film so that the development process stops.
- Usually, agitating the film rack for 20 seconds is sufficient.
- This must be done under safelight conditions.
Fixing

- The acidic fixing solution removes the unexposed silver halide crystals from the film emulsion.
- The fixer also hardens the film emulsion during this process.
- For permanent fixation, the film is kept in the fixer for a minimum of 10 minutes.
- However, films may be removed from the fixing solution after 3 minutes for viewing.
- Films that are not properly fixed will fade and turn brown in a short time.
- Leaving films in the fixer for a long time (e.g., over a weekend) can remove the image from the film.
Washing

- After fixation, a water bath is used to wash the film.
- The washing step requires about 20 minutes to thoroughly remove all excess chemicals from the emulsion.
Drying

- The final step in film processing is the drying of the films.
- Films may be air-dried at room temperature in a dust-free area or placed in a heated drying cabinet.
- Films must be completely dried before they can be handled for mounting and viewing.
Processing Solutions

- Film-processing solutions are available in the following forms:
  - Powder
  - Ready-to-use liquid
  - Liquid concentrate
Film Developer and Fixer

Courtesy Carestream Health, Inc., Rochester, NY.
6. Discuss film processing, including the following:
   • Describe the features and necessary requirements of a darkroom.
   • Identify the component parts of an automatic film processor.
   • Describe common time and temperature errors during film processing.
   • Describe chemical contamination errors during film processing.
   • Describe film handling errors that can occur during film processing.
   • Describe some common lighting errors during film processing.
Requirements for a Darkroom

- Cleanliness at all times
- Infection-control items (e.g., gloves, disinfectant spray, paper towels)
- Container, labeled with a biohazard label, for contaminated film packets or barriers
- Recycle container for lead foil pieces, which should not be thrown in the trash
- Light-tightness
- Processing tanks for the developer and fixer solution and a circulating water bath
Requirements for a Darkroom (Cont.)

- Running water with mixing valves to adjust the temperature
- Both a safelight and a source of white (normal) light
- Accurate timer
- Accurate floating thermometer
- Stirring rods or paddles to mix the chemicals and equalize the temperatures of the solutions
- Safe storage space for chemicals
- Film hangers
- Film-drying rack and film dryer
The Darkroom

- The term *light-tight* is often used to describe the darkroom.
- To be light-tight, no light leaks can be present.
- When you are in the darkroom with the light turned off, no white light should be visible.
- X-ray film is extremely sensitive to visible white light.
- Any leakage of white light can cause film fog.
  - A fogged film appears dull gray, lacks contrast, and is nondiagnostic.
Types of Darkroom Lighting

- **Room lighting**
  - An overhead white light provides adequate lighting for tasks such as cleaning, restocking of materials, and mixing of chemicals

- **Safelighting**
  - A low-intensity light in the red-orange spectrum
  - Provides enough illumination in the darkroom to process films safely without exposure or damage to the film
Types of Darkroom Lighting (Cont.)

- There must be a safe distance between the light and the working area, and the person developing the film must work quickly to keep the exposure to the safelight as short as possible.
- Unwrapped films that are left too close to the safelight or exposed to the safelight for more than 2 to 3 minutes appear fogged.
- A safelight must be placed a minimum of 4 feet away from the film and working area.
Position of Safelight

Processing Tanks

- Manual processing is a method that is used to develop, rinse, fix, and wash dental x-ray films
- The essential piece of equipment required for manual processing is a processing tank
  - Tank is divided into compartments to hold the developer solution, water bath, and fixer solution
  - Has two insert tanks and one master tank
Processing Tanks (Cont.)

Insert tank (for developing/fixing chemicals)

Insert tank (for developing/fixing chemicals)

Water bath/rinsing tank

Overflow pipe

Automatic Processor

- Automatic film processing is a fast and simple method used to process dental x-ray films
- Other than opening the film packet, all steps of film processing are handled by the automatic processor
- Automatic film processing requires only 4 to 6 minutes for developing, fixing, washing, and drying
- Less equipment and space required than manual processing
- Less error because time and temperature are automatically controlled
The automatic processor maintains the correct temperature of the solutions and adjusts the processing time.
Proper maintenance of the automatic processor reduces the chance of errors during film processing.
Many dental offices that have automatic processors still maintain manual processing equipment as a standby if the automatic processor malfunctions.
Automatic Film Processors

Courtesy Air Techniques Inc., Melville, NY.
Components

- The processor housing covers all component parts
- The film feed slot is for the unwrapped films to be inserted into the automatic processor
- The roller film transporter is a system of rollers that rapidly moves the film through the compartments
- The developer and fixer compartments hold the solutions
  - The film is transported directly from the developer into the fixer without a rinsing step
- The water compartment holds circulating water
- The drying chamber holds heated air and dries the wet film
Processing Solutions

- Levels of solutions in automatic processor must be checked and replenished daily
  - Failure to replenish leads to poor-quality radiographs
  - Solutions should be replaced completely every 2 to 6 weeks
Processing Errors

Processing errors may occur for a variety of reasons, including the following:

- Time and temperature errors (Table 39.4)
- Chemical-contamination errors (Table 39.5)
- Film handling errors (Table 39.6)
- Lighting errors (Table 39.7)

The dental assistant must be able to recognize the appearance of common processing errors and know what to do to prevent such problems from occurring again.
Common Processing Errors

- The photographs on the following slides illustrate common examples of technical errors that can occur during film processing.
- Such errors result in radiographs that are not diagnostic, thus requiring retakes and additional exposure to the patient.

Developer Splash and Scratched Film

Water Spots and Solution Too Low

Roller Marks and Fingerprints

Overlapped Films and Underdeveloped Films

Reticulation and Fixer Spots
Developer Cutoff and Number of Errors

Fixer Cutoff and Air Bubbles

Black Fingerprint and Static Electricity

Exposure to Light and Fogged Film

Questions?