SECOND EDITION

A Short Textbook of ORAL RADIOLOGY

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JAYPEE

Contents

CHAPTER 4

Quality Assurance in Dental Radiography

Quality assurance is a plan of action to ensure that a diagnostic X-ray facility will produce consistent, high-quality images with a minimum of exposure to patients and personnel.

Quality assurance means regular testing to detect equipment malfunctions, planned monitoring and scheduled maintenance for consistent film processing, and regular assessment of other variables that affect image quality.

The benefits derived from a quality assurance program far outweigh implementation efforts and costs. In addition to aiding in diagnosis, a well carried out quality assurance program results in minimized radiation dosage to patients because radiographs are produced under the most favorable conditions.

QUALITY CONTROL TESTS

Quality control tests are specific tests that are used to maintain and monitor dental X-ray equipment, supplies, and film processing. To avoid excess exposure of patients and personnel to X-radiation, the dental radiographer must have a clear understanding of the quality control procedures used to test specific equipment, supplies, and film processing in the dental office.

Equipment and Supplies

Quality control tests are necessary to monitor:

- X-ray equipment and accessories
  - Dental X-ray machine,
  - Dental X-ray film,
  - Screens and cassettes, and
  - Viewing equipment.
- *Film processing:* To consistently produce diagnostic quality radiographs, dental X-ray equipment and supplies must be functioning properly and kept in good working condition.

DENTAL X-RAY MACHINES

All dental X-ray machines must be inspected and monitored periodically. Some state and local regulatory agencies provide dental X-ray equipment inspection services as part of their registration and licensing procedures. Dental X-ray machines must also be calibrated, or adjusted for accuracy, at regular intervals. Calibration of dental X-ray equipment must be performed by a qualified technician to ensure consistent X-ray machine performance and the production of diagnostic radiographs.

Quality control tests for dental X-ray machine should be performed annually. These tests are designed to identify minor malfunctions, including machine output variations, inadequate collimation; tube-head drift, timing errors, and inaccurate kilovoltage and milli-amperage readings (AERB has well-laid norms, which are a mandate to follow in every radiology facility).

In addition to regular calibration, the American Academy of Oral and Maxillofacial Radiology recommends that the following eight tests of X-ray generating equipment be conducted annually:

1. X-ray output
2. Kilovoltage (kVp) calibration
3. Half-value layer
4. Timer
5. Milliamperage (mA)
6. Collimation
7. Beam alignment
8. Tube head stability.

Checking the Quantity of X-ray Beam (X-ray Output Test)

The purpose of checking the quantity of the X-ray beam is to verify that, the output of the X-ray machine has not changed since the last exposure. The quantity of X-ray photons is affected by mA circuit and by the exposure time. The measure for quantity of X-ray beam, the X-ray machine is set at a standardized set of exposure parameter, i.e. 0.25 sec (15 impulses), 7 or 10 mA, and 65 or 70 kVp, and measure the quantity of radiation generated using radiation dosimeter.

Checking the Timer

The purpose of checking the timer is to see whether it is functioning accurately. This procedure can also be used to demonstrate the principle that X-rays are generated in impulses in self-rectified dental X-ray machines.

Checking the mA Circuit

The purpose of checking the mA circuit is to ensure the proper functioning of the 10 and 15 mA settings on dental X-ray machines. If the dental X-ray machine has only one mA setting (usually 7 mA) the mA circuit can be checked using an ammeter.

Checking the Penetrating Power of X-ray Beam (Half-value Layer Test)

The purpose of checking the penetrating power of X-ray beam is to ensure that the kVp circuit is functioning within safe limits. This procedure can be used to visibly demonstrate the half-value layer (HVL) principle that states: "50% of the X-ray photons should penetrate through a standardized thickness of a given material (usually aluminum) depending on kVp." The quality or penetrating power of the X-ray beam is measured by its half-value layer. The standard that is set by the federal government states that if the X-ray machine has a maximum of 69 or less kVp, 50% of the X-ray output must pass through at least 1.5 mm thickness of aluminum; if the X-ray machine delivers 70 or more kVp, then 50% of the X-ray output must pass through at least 2.5 mm of aluminum.

Checking the Accuracy of the kVp Setting

The purpose of checking the kVp is to determine the accuracy of kVp settings on the dental X-ray machine. A kVp meter is used to check the kVp.

The machine is set at any kVp setting or the maximum kVp setting and aimed at the target area on the kVp meter. The exposure time should be long enough for the kVp meter to obtain a reading (1 second or 60 impulses). The kVp meter measures the wavelength and frequency of the beam of radiation and gives an accurate kVp, regardless of the setting of the machine. The measured kVp should be the same as X-ray machine setting. If it is different, the problem is associated with the X-ray machine, not the external power supply to the dental office.

Checking the Focal Spot

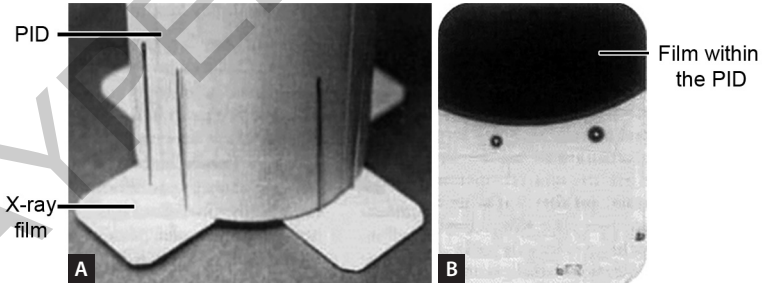
The purpose of checking the focal spot is to evaluate the surface area of the focal spot that becomes pitted over time and enlarges. An enlarged focal spot decreases sharpness and increases magnification. Focal spot size can be checked by using a test object containing a number of bar patterns to test the resolution of the image. A small focal spot provides

sharpness that is measured by resolution. When X-ray machine is new, the focal spot is relatively small, and the eye can resolve about 11–12 line pairs per millimeter. However, as the focal spot degrades, the resolution decreases to seven or less line pairs per millimeter, and the image gets fuzzy or unsharp.

Checking the Collimation of the X-ray Beam

The purpose of checking the collimator is to ensure proper collimation of the beam. According to Federal standards, the beam of radiation must be collimated to 2.75 inches at the tip of position-indicating device (PID).

Collimation test: To test collimation, place the PID of X-ray machine against a rare earth fluorescent screen or a loaded panoramic cassette. The exposure time is set at about 1 or 2 seconds. The lights in the room are then turned off; observe through the leaded barrier window to see if the fluorescence is limited to the diameter of the PID; or process the panoramic film to check, if the exposed area of the film is limited to the diameter of the PID. Collimation can also be verified by placing four size 2 dental X-ray film in the form of a cross-shaped template **(Figs 4.1A and B)**. Expose the films using bite-wing settings, process the films, and reconstitute the pattern. The size and alignment of beam then can be determined.



Figs 4.1A and B: (A) The alignment of the collimation of the X-ray beam and end of the aiming cylinder can be checked by making a cross-pattern of film, centering the aiming cylinder, making the periphery with needles, and making an exposure; (B) One of the processed radiographs showing the dark exposed area just inside the holes. If this pattern is seen on all films, then good alignment is demonstrated

Checking the Tube Head Stability

The tube head should be stable, when place around the patient's head and not drift during an exposure. When it is not stable, service is necessary to adjust the suspension mechanism.

DENTAL X-RAY FILM

Dental X-ray film is quite stable when properly handled. The dental X-ray film must be properly stored in a cool, dry facility and away from a radiation source. Use the dental X-ray film before its expiry date.

Fresh film test: Unwrap one unexposed film from a newly opened box and process using fresh processing solutions. If the processed film appears clear with a slight blue tint, the film is fresh and has been properly stored and protected. A film that has expired, has been improperly stored, or has been exposed to radiation appears fogged and it must not be used.

SCREENS AND CASSETTES

The intensifying screens used within extraoral film cassette should be examined periodically for the presence of scratches and dirt. Monthly cleaning of intensifying screens is important with commercially available cleaners as recommended by the screen manufacturer. Screens that appear visibly scratched should be replaced. Cassette holders must be examined for worn closures, light leaks, and warping, which may result in fogged and blurred radiographs; such cassettes must be replaced or repaired. Cassettes must also be checked for adequate screen-film contact.

Screen-film contact test: Insert one film between the screens in the cassette holder. Place a wire mesh test object on top of the loaded cassette. Position the PID using a 40-inch target-film distances while directing the central ray perpendicular to the cassette. Expose the film using 10 mA, 70 kVp, and 15 impulses. Process the exposed film. View the film on a view-box in a dimly lit room at a distance of 6 feet. If the wire mesh image seen on the film exhibits a uniform density, it reveals adequate screen-film contact. If the wire mesh image seen on the film exhibits varying densities, it reveals inadequate screen-film contact. Areas of poor screen-film contact appear darker than good contact areas.

VIEWING EQUIPMENT

The view-box, or illuminator, is a light source that is used to view dental radiographs. The view-box contains fluorescent light bulbs that emit

light through an opaque plastic or plexiglass front. The view-box should emit a uniform and subdued light for proper radiographic interpretation. The photographic light meter can be used to determine proper viewing brightness. The view-box should be periodically examined for dirt and discoloration of the plexiglass surface. The surface of the view-box should be cleaned weekly. Permanently discolored plexiglass surface must be replaced. Any burnt fluorescent light bulbs must also be replaced.

FILM PROCESSING

Film processing is one of the most critical areas in quality control because deficiencies in this process are the most potential cause of nondiagnostic radiographs. Quality control tests must be performed routinely to determine the acceptable conditions for film processing; which greatly increases the likelihood of producing radiographs of consistently high quality.

Darkroom Lighting

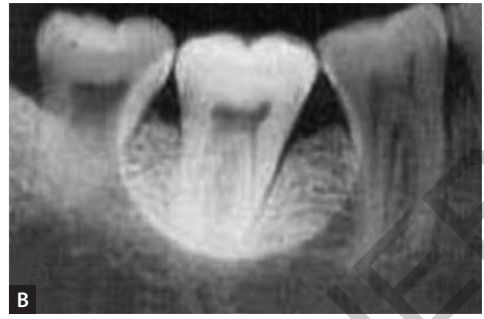
The darkroom must be inspected monthly to assess the light leaks and integrity of safelights. Film may become fogged in the darkroom from inappropriate safelight filters, excessive exposure to safelights, and stray light from other sources. Such films are dark, show low contrast, and have muddy gray appearance. The following " light-leak test" and "coin test" or "penny test" can be recommended monthly to evaluate for fogging caused by light-leak and inappropriate safelight conditions.

Light-leak test: Close the darkroom door and turn off all lights, including the safelights. Once the eyes are accustomed to the darkness, observe the areas around the door, walls and ceiling, the vent areas, and the keyhole for light leaks. If present, mark the light leaks with chalk or masking tape. Light leaks must be corrected with weather stripping or black tape before proceeding with film processing.

Penny test or coin test: Unwrap an exposed film and place the test film on the area where films are usually unwrapped and clipped on the film hanger (at least 4 feet from the safelight).

Place the coin on the film and allow the film and the coin in this position for usually 5 minutes, approximate time required to unwrap and mount a full-mouth set of films in dark room. Remove the coin and process the test film as usual. If the image of the coin and a fogged background appears on the resultant film, the room is not light safe **(Figs 4.2A and B)**. Light-leak and safelight problems should be corrected before proceeding with film processing.

A



B

Figs 4.2A and B: Coin test/Penny test for unsafe illumination. (A) Unwrap and place a coin on the exposed film on the working surface for about 5 minutes in dark room; (B) If the processed radiograph shows an outline of the coin, the film is being fogged by inappropriate safelight conditions

Processing Equipment

Manual and automatic processing equipment must be meticulously maintained and monitored on the weekly basis, because deficiencies in the processing are the most common cause of faulty radiographs. The thermometer and timer must be checked for accuracy, level of water in the bath, developer and fixer solutions must also be monitored in manual processing techniques. The time-temperature recommendations for the processing must be strictly followed.

If automatic processing equipment is used, the water circulation system, the solution levels, replenishment system, and temperatures must be monitored. The manufacturer's procedure and maintenance directions must be carefully followed.

Automatic processor test: Unwrap two unexposed films and expose one to light. Process both the films in automatic processor. If the unexposed film appears clear and dry and the film exposed to light appears black and dry, the automatic processor is functioning properly. If the automatic processor is not functioning properly, then the processing solutions and dryer temperature must be checked.

Processing Solutions

The most critical component of film processing quality control is the monitoring of processing solutions. The processing solutions must be replenished daily; the developer should be replenished with fresh developer or with developer replenisher and the fixer should be

replenished with fixer. The processing solutions should be replaced depending primarily on the rate of use of the solutions; usually every second week. The processing solutions must be evaluated each day before any patient radiographs are processed.

DEVELOPER STRENGTH

When the developer solution loses its strength, the time-temperature recommendations of the manufacturer are no longer accurate. The strength of the developer can be checked by comparing film densities to a standard. The following tests can be used:

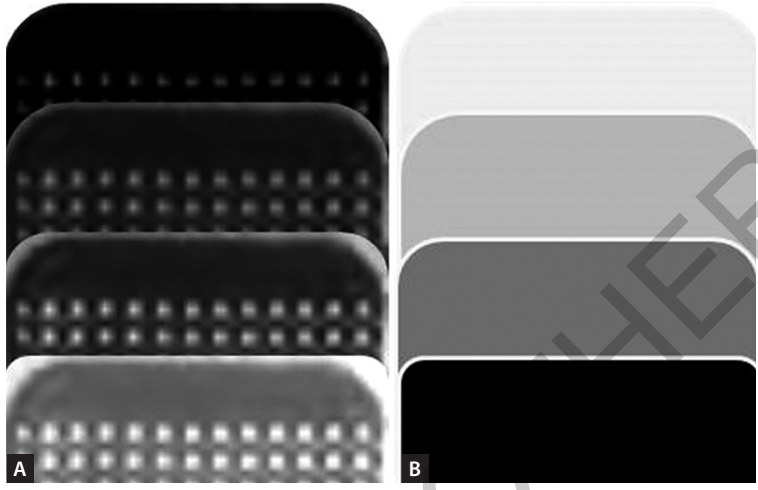
- Reference radiograph
- Step-wedge radiograph
- Normalizing device.

Reference Radiograph

A reference radiograph is a simple and effective means for constant monitoring of the quality of images. A reference radiograph is one that is, exposed using ideal exposure factors, processed under ideal conditions, with optimal density and contrast, and then used to compare film densities of the radiographs that are processed everyday. All the subsequent radiographs are compared one beside another with this reference film mounted on the view-box. If the regular radiographs appear light and have reduced contrast than the reference radiograph, the developer solution is either weak or cold. If the regular radiographs appear darker than the reference radiograph, the developer solution is either too concentrated or too warm. Weakened or concentrated solution must be replaced, and if the developer solution is too cool or too warm, the temperature must be adjusted.

Step-wedge Radiograph

Step-wedge radiograph provides an accurate monitoring of day-to-day processing conditions. It measures the speed of the imaging system and image contrast. A step-wedge is a device constructed of layered aluminum steps. When a step-wedge is placed on the film and exposed to X-rays, the different steps absorbs varying amounts of X-rays. When processed, different film densities can be seen on the radiograph as a result of the step-wedge. A step-wedge can also be readily made by using the lead foil from the film packets. Stack five sheets together and staple at one end; cut-off 4/5 of the top layer, 3/5 of second layer, 2/5 of third layer, and 1/5 of fourth layer. This creates a four-step wedge. Place the wedge



Figs 4.3A and B: (A) Step wedge made of strips of lead foil from film packets. This step wedge is positioned over a film, and an exposure is made; (B) Processed radiograph showing each step. Such an image should be made daily after replenishing processing solutions and compared with an image made with fresh solutions. When the step wedge has become one full step lighter, it is time to change the processing solution

on top of a film and expose; the resultant radiograph show four steps from dark to light **(Figs 4.3A and B)**. Compare the densities seen on the daily radiograph with densities on the standard step-wedge radiograph on the view-box. When the density on the daily radiograph differs from that on the standard radiograph, then the developer solution is depleted and should be changed before proceeding with processing.

Normalizing Device

Normalizing and monitoring device can be used to monitor developer strength and film density.

FIXER STRENGTH

The fixer solution removes the unexposed silver halide crystals and results in "clear" areas on the processed dental radiograph. When the fixer solution loses its strength, the film takes a longer time to clear. The strength of fixer can be monitored by clearing test.

Clearing Test

Unwrap a film and place it immediately in the fixer solution. Check the film for clearing and clock the amount of time taken. If the film is not completely clear after 2 minutes, re-immerse it in the fixer solution. If the film does not completely clear in 3 to 4 minutes, the fixer solution is depleted. The fixer solution should be replaced before proceeding with processing **(Table 4.1)**.

Summary of several quality assurance tasks should be performed daily, weekly, monthly and yearly to ensure ideal radiographs as given in **Table 4.2**.

Table 4.1: Quality control tests for film processing

Day	*Solution strength*	*Quality control tests*	*Test results*
1	Use fresh, full-strength processing solutions	*Reference radiograph:* Using correct exposure factors expose and process one film. This film becomes the "reference radiograph." *Step-wedge radiograph:* Expose 21 step-wedge films; process one film. This film becomes the "standard radiograph"	The reference radiograph demonstrates optimal film contrast and density The standard radiograph demonstrates optimal film contrast and density
2, 3, etc.	Fresh processing solutions weaken with time and use; exhausted solutions result	*Reference radiograph:* Each day, expose and process one film to compare with the reference radiograph *Step-wedge radiograph:* Each day, process one of the previously exposed step-wedge films.	Compare the daily film with the reference radiograph: • If densities match, continue processing. • If densities do not match, replace processing solutions. • Compare the daily film with the standard radiograph: • If densities match, continue processing. • If densities differ by one full step on the step wedge, replace processing solutions.

Table 4.2: Schedule of quality assurance procedures

Daily • Compare radiographs with reference film • Enter findings in retake log • Replenish processing solutions • Check temperature of processing solutions • Make step-wedge test of processing system
Weekly • Replace processing solutions • Clean processing equipment • Clean view boxes • Review retake log
Monthly • Check darkroom safe lighting • Check intensifying screens • Rotate film stock • Check exposure charts
Yearly • Calibrate X-ray machine

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