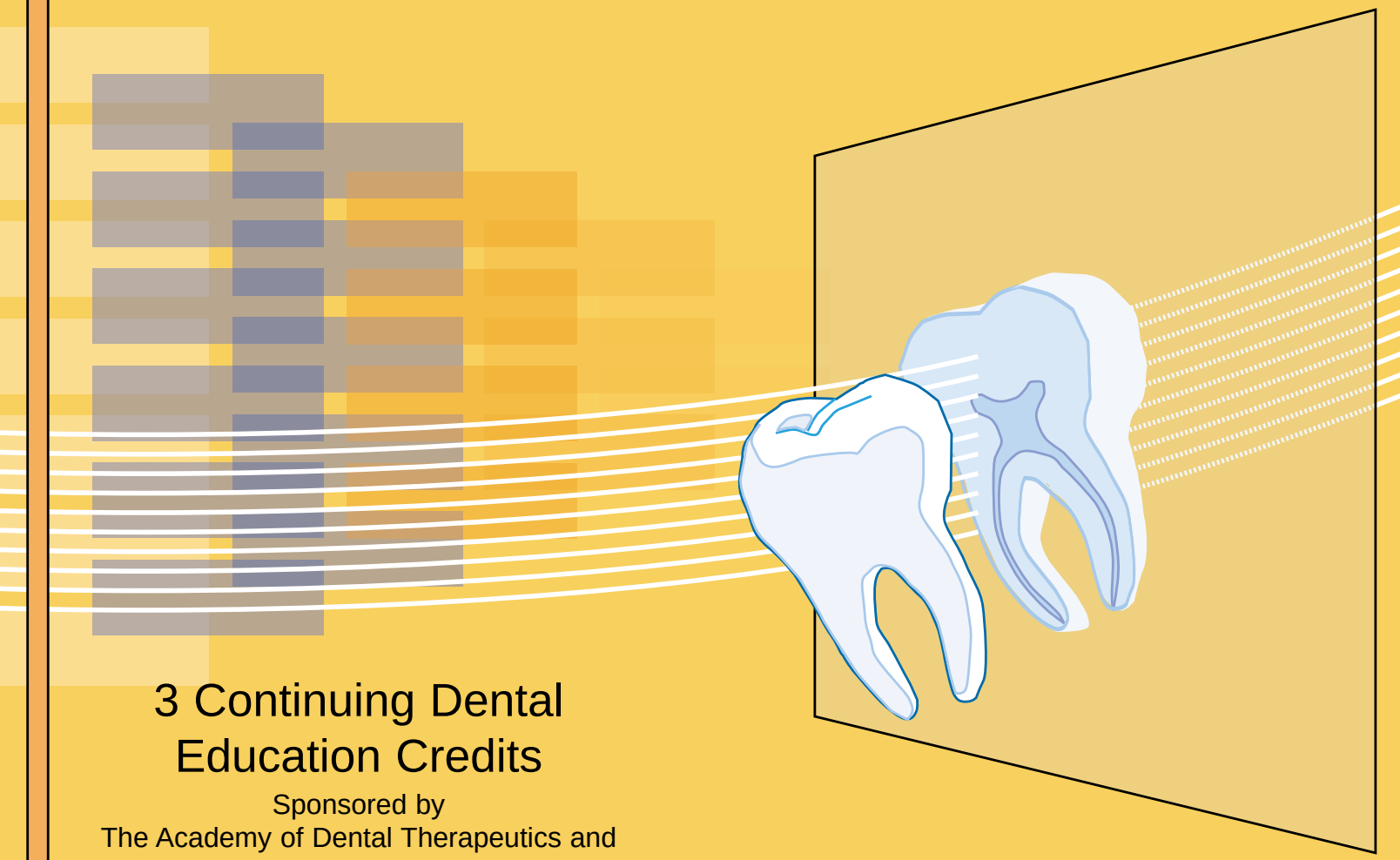
SUCCESSFUL INTRAORAL RADIOGRAPHY



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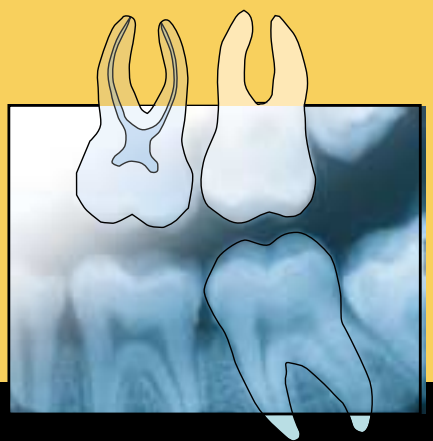

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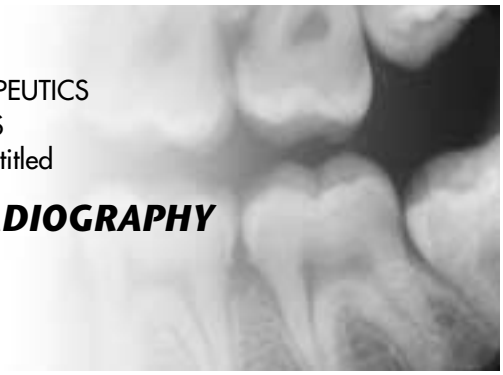
to the
ACADEMY OF DENTAL THERAPEUTICS
AND STOMATOLOGY'S
continuing education course titled

SUCCESSFUL INTRAORAL RADIOGRAPHY



COURSE EDITOR
William S. Moore, DDS, MS
UTHSCSA Dental School
San Antonio, TX

EDUCATIONAL OBJECTIVES

After completion of this course, the reader will walk away with a better understanding of the following topics related to Intraoral Radiography. This course will address the problems and errors that can occur in the intraoral radiograph when errors are made at each of the three basic steps. This will allow the practitioner to determine from the radiograph at what point in the image creation process the error occurred. The course will then suggest possible solutions to the problem based on the step where it occurred. This will allow easy correlation of error with solution and give better understanding of what caused the error. The result will be intraoral radiographs with the maximum diagnostic detail and information that the equipment and technique allows.

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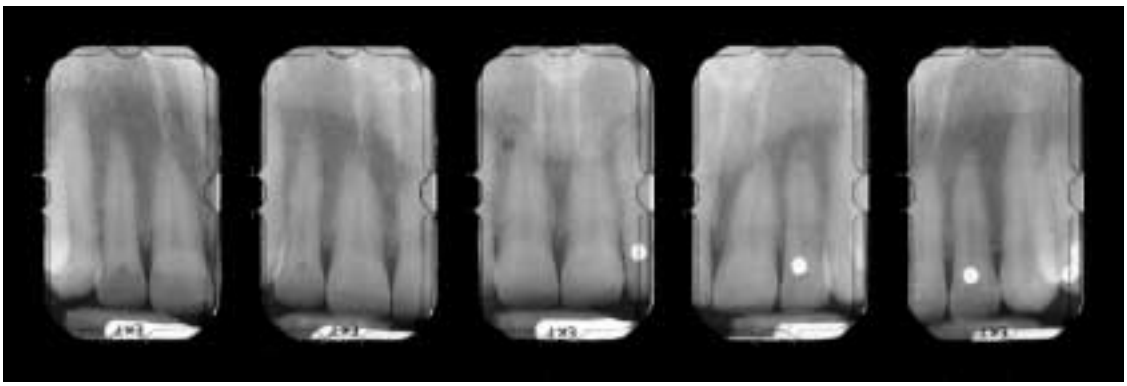
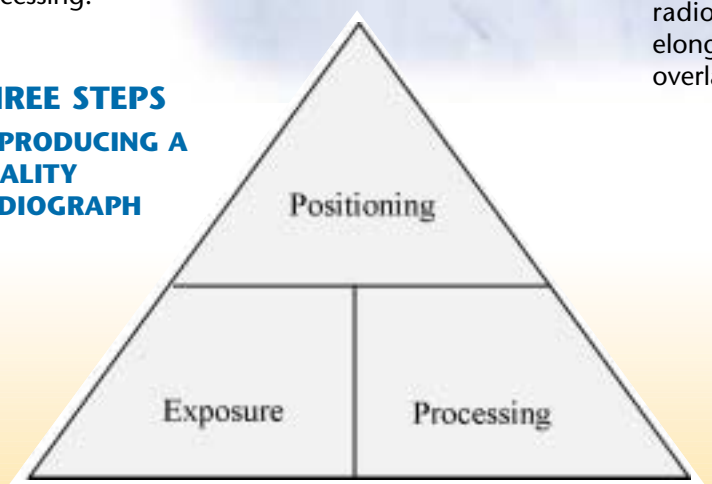


Every dentist would like to achieve the goal of a quality intraoral radiograph. A quality intraoral radiograph will reveal maximum detail in the image with anatomic accuracy and optimal density and contrast. This will give maximum diagnostic yield. This pamphlet will address some of the common pitfalls and errors seen in intraoral radiography and address how to prevent and correct them. For similar information on panoramic radiography please see the Kodak publication titled "Successful Panoramic Radiography," which was recently published in the May 2001, Sullivan-Schein Dental monthly flyer.

QUALITY RADIOGRAPH

The goal of all radiography should be to produce a quality radiograph. Such a radiograph will exhibit maximum detail to resolve fine objects. It will show the teeth and anatomic structures accurately without distortion or magnification. It will have the optimal density and contrast (visual characteristics) to maximize its use for the detection of dental disease. To create such a film, the dental staff must pay attention to all three steps in the production of the radiograph, positioning, exposure and processing.

THREE STEPS IN PRODUCING A QUALITY RADIOGRAPH



The film must be properly positioned to ensure proper geometry and prevent distortion and overlap. Second, the exposure technique factors must be appropriate for the patient and the film selected. And last, proper processing time, temperature and handling requirements must be followed to produce a quality radiograph.

1 STEP 1: PROPER FILM POSITIONING

Film placement for proper anatomic coverage is beyond the scope of this pamphlet and can be reviewed in any quality dental radiography text. This pamphlet will discuss improper film placement that can lead to errors such as overlapped contacts and distorted teeth and roots. This is due to the fact that dental radiography is a shadow casting technique, in that we cast an image of the tooth onto the film. Shadow casting can cause geometric distortions in the final radiograph such as elongation, magnification and overlapping contacts.

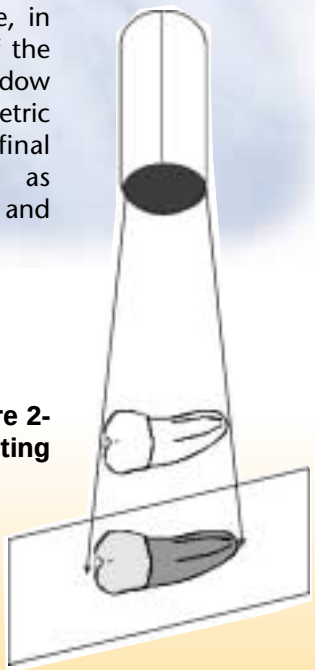


Figure 2- Shadow Casting

Geometric distortion can be minimized by using a long x-ray source to object distance. This can be obtained using a long cone (16 inch) technique. Geometric distortion can also occur if the film is not at right angles to the beam. For this reason, it is recommended to always use a film holding and position-indicating device (PID). Many practitioners assume these devices can control all angulation problems. They only hold the film perpendicular to the x-ray beam. They do not totally prevent errors in the vertical and horizontal angulation of the film to the tooth itself. This can lead to commonly seen errors of overlapped contacts and vertical distortion of teeth on the radiograph. They can be minimized by proper use of the paralleling technique.

Figure 4- excessive vertical angulation, note inferior border of mandible visible, elongation of roots. Correct by moving film further back into the mouth

Figure 5- Distortion from film bending in corner of arch. Correct by placing film further into center of mouth

Figure 6- Bent film corners causing black lines on film. Correct with proper film placement, use soft film packets

DISTORTION (VERTICAL ANGULATION)

Although film-holding devices hold the film at right angles to the x-ray beam, they do not prevent rotation of the whole device in a vertical axis. This rotation places the film at an angle to the tooth and can result in distortion when the angle is large. This is commonly seen when the film is not placed far enough in the center of the mouth and the film must be angulated to avoid the slope of the palate or the mandibular vestibule. It can be avoided by simply placing the film deeper into the center of the mouth, so that tipping is not necessary. Another type of distortion occurs when the film is allowed to bend on biting down by the patient. This can also be avoided by placing the film deep enough into the mouth to avoid contact with the palate. Bending of film corners for patient comfort can also cause errors, as the pressure of the bend can cause partial film development. This shows up as black lines on the film.

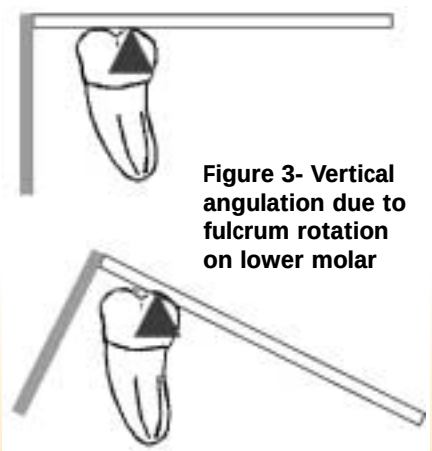


Figure 3- Vertical angulation due to fulcrum rotation on lower molar

OVERLAPPED CONTACTS (HORIZONTAL ANGULATION)

In order to maximize the amount of contact opening, the beam should be directed at right angles to the contact area. In the mandible this is fairly straightforward. In the maxilla, though, the molar contacts are often directed mesially due to the triangular shape of the maxillary molars. This means the beam must also be directed from the mesial to open these contacts. Often times the reverse is done. The beam is directed from the mesial in the bicuspid area and at right angles or distal in the molar region. This will most often result in overlapped contacts. Contact areas should always be visualized prior to taking bitewing radiographs.

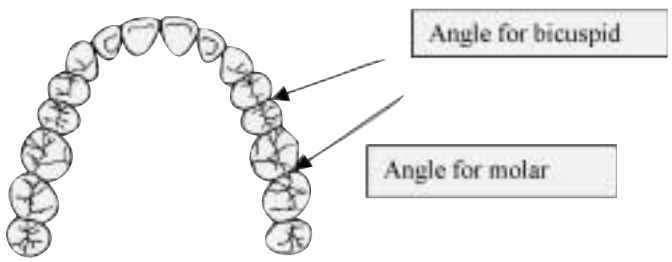


Figure 8- Improper horizontal angulation, contacts overlapped

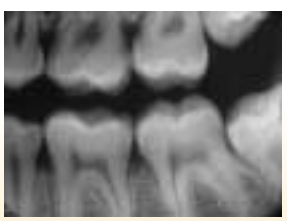


Figure 9- Proper horizontal angulation, contacts open

CONE CUTS

Dental x-ray beams are collimated or restricted to a diameter of 2.75 inches at the end of the cone or even less when a rectangular collimator is used. When the exit pattern of the beam is not aligned with the film, part of the film will not be exposed to x-radiation and will appear clear. This is known as a cone cut. Proper use of position indicating devices (PIDs) will help to prevent this problem, which can occur with either round or rectangular cones.

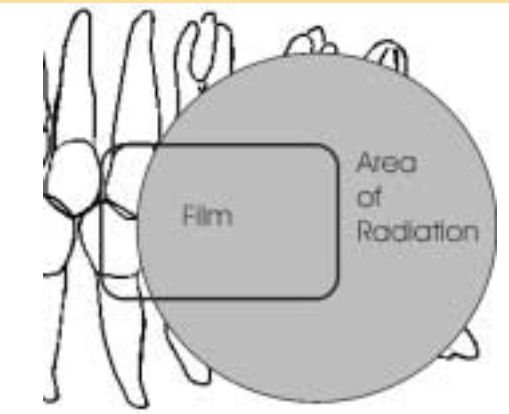


Figure 10- Cone cut using round cone

Figure 12- Cone cut using rectangular cone

REVERSED FILMS

Dental x-ray film is marked with an indicator dot to help indicate the tube side of the film and to help distinguish the patient's right or left side. In addition, the film packet contains a sheet of lead foil which prevents unnecessary radiation from passing through into the patient and reduces scatter radiation. This sheet of lead foil is marked with a special pattern. When a film is exposed from the wrong side, the pattern is visible on the radiograph. Due to the attenuation of the foil, the radiograph also appears overall light in density.

Figure 13- Reversed film, note dot on pattern on left edge of radiograph, light overall density

Figure 14- Foil from packet showing pattern of dots

TABLE 1- FILM POSITIONING ERRORS

RADIOGRAPH	ERROR	FIX
Teeth elongated, cusps don't overlap, sinus structures or inferior border of mandible visible	Excessive vertical angulation	Correct film placement and reduce vertical angulation
Contacts of teeth overlapped	Improper horizontal angulation	Visualize contact area and adjust
Dark lines on corner of film	Film bent	Use of super Polysoft® packaging and proper placement can reduce need for bending film
Clear area on one edge of film either in arc or straight	Cone cut	Align cone to position indicating the device
Film light in density, unusual pattern across film ("tire tracks" or "herringbone")	Packet was reversed and exposed through the back side, pattern is from foil inside packet	Follow instructions on packet for orientation

STEP 2: FILM EXPOSURE

SELECTING A FILM

Film selection is important to both radiographic success and to provide the lowest practical exposure to the patient. To achieve consistent quality radiographs you must use a consistent quality film. Low cost films may vary from batch to batch or may be from different manufacturers. This makes establishing consistent exposure and development technique factors very difficult. Dental films are provided in different speed groups with D-speed films being the slowest and F speed the fastest. Use of an E-speed film such as Kodak Ektaspeed Plus® can provide a 40% reduction in exposure over D speed. Kodak's newest film, InSight®, is an F speed film that can provide an additional 20% reduction in exposure over the E-speed films (60% over D speeds) with no loss of image contrast or quality. In accordance with the ALARA principle (keep doses As Low As Reasonably Achievable), use of F speed film is highly encouraged. Kodak publishes helpful exposure guidelines for all their dental films. Using these guidelines, the practitioner can verify that their exposure factors are within the suggested normal ranges for good radiographic technique.

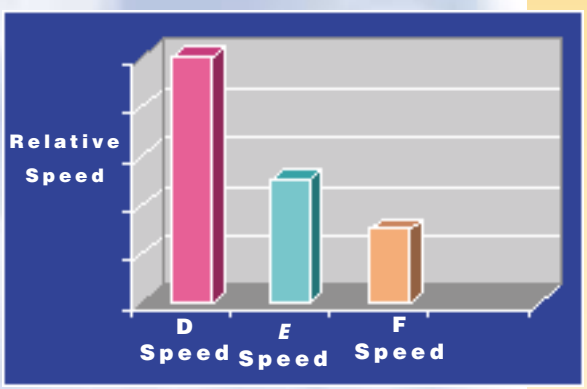


Figure 15- Exposure time, F speed represents a 60% reduction in exposure over D speed

INFLUENCE OF MILLIAMPERES

Most modern dental x-ray machines no longer allow for the adjustment of mA or milliamperage. Since the effect of increasing or decreasing mA is the same as for exposure time, it is common to combine the two and talk of mAs or milliamp-seconds. In dentistry we are mainly concerned with exposure time as discussed below.

INFLUENCE OF TIME

Film density (how light or dark overall a film is) is directly related to exposure time. The longer the exposure time the more x-ray photons reach the film and expose it. Therefore, the film is darker. The x-ray timer can be thought of as a faucet. It turns the flow of x-rays on or off. If you open the faucet twice as long, you will get twice as many x-rays out of the machine. If you double the time, the film will be twice as dark.

Figure 16- exposure time is like a faucet

Figure 17- 0.25 second exposure (underexposed)

Figure 18- 0.5 second exposure (proper exposure)

Figure 19- 1.0 second exposure (over exposed)

RADIOGRAPH	EXPOSURE TIME	FIX
Too dark	Too long	Use shorter time, fewer impulses
Too light	Too short	Use longer time, longer impulses

Table 2- expose time errors

INFLUENCE OF PEAK KILOVOLTAGE

Many modern dental x-ray machines no longer allow the adjustment of peak kilovoltage (kVp). The kilovoltage affects both the quantity of the x-rays produced and their average energy. The average energy is sometimes referred to as the "beam quality." The effect of peak kilovoltage can be thought of as a nozzle. It controls the force of the emerging stream of x-rays, whereas the faucet (timer) controls the volume.

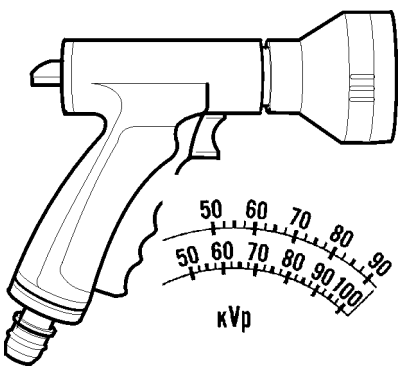


Figure 20- KvP is like a spray nozzle

KvP has two effects on the quality of the final radiograph. First, it affects the contrast or gray scale. Low kVp is like opening up the nozzle. The lower energy x-rays have less penetrating power. This gives a high contrast image with more of a black and white appearance. High kVp is like closing down the nozzle. The beam is "harder" with higher energy. High kVp gives a low contrast image, but with more shades of gray to show subtle contrast changes.

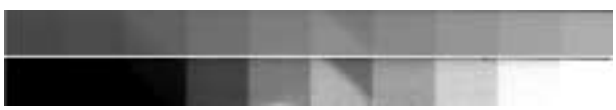


Figure 21- Low contrast long gray scale above, high contrast short gray scale below

Second, using higher kVp produces more x-rays. This is not a linear relationship, but rather the density of the film varies as the square of the kVp. A good rule of thumb is:

EVERY INCREASE OF 15 kVp = 2X INCREASE IN DENSITY

Figure 22- 55 KvP

Figure 23- 70 KvP

Figure 24- 85 KvP

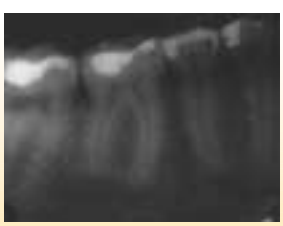


Figure 25- Film mistakenly shot at 90 KvP, all other exposure factors were set as normal

Although many modern x-ray machines do not allow changes in kVp, modern DC (direct current) machines are actually equivalent to older machines operating at higher voltages. For example, a modern 70 kVp DC machine has a beam quality similar to an older 80 kVp machine.

RADIOGRAPH	KvP
Too dark	Too high
Too light	Too low
Too much contrast	Too low
Too washed out	Too high

Table 3- KvP Errors

Other errors that can occur during exposure include patient movement and double exposures. One way to decrease patient movement errors is to be sure a headrest stabilizes the patient's head during film placement and exposure. Double exposures are usually caused by operator inattention. Using unit dosing and keeping unexposed films separated from exposed films can help alleviate this problem. It is important to note that when a double exposure occurs there is usually a corresponding blank film in the series.

Figure 26- Patient movement, note blurring of image, soft focus

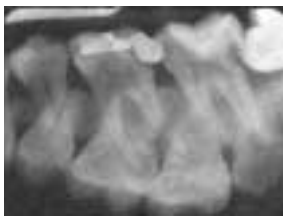


Figure 27- Double exposure, not multiple images of teeth

RADIOGRAPH	ERROR	FIX
Blurring of structures	Patient movement	Remind patient to hold still, use shorter exposure times, tube movement is not as bad as patient movement
Multiple images on film	Double exposure	Exposed films should always be separated from unexposed while taking radiographs

Table 4- Errors during exposure

STEP 3: PROCESSING

DEVELOPMENT

Even with the excellent automatic processors available today, many errors can occur during processing. Many of these errors revolve around improper film handling, but some can be due to the processor itself. Processing is a chemical reaction therefore:

INCREASED TEMPERATURE = INCREASED DEVELOPMENT = DARKER FILM
INCREASED TIME = INCREASED DEVELOPMENT = DARKER FILM

For these reasons, manufacturer's recommendations for development time and temperature should be closely followed. Automatic processors should still be checked for developer temperature as heating elements can fail or overheat. Proper attention to chemical dilution, mixing and loading must be followed. Fixer should always be poured first into the processor as a small spill of fixer into the developer can drastically weaken the developer:

CONTAMINATED OR DEPLETED CHEMISTRY = INCOMPLETE DEVELOPMENT = LIGHT FILM

Developer must be replenished following manufacturer's recommendations or it will become exhausted. These recommendations are usually based on the amount of radiographs processed. However, developer exhaustion is determined by the surface area of the films processed not the number of films. If large numbers of panoramic or cephalometric films are processed, more frequent replenishment will be needed.

RADIOGRAPH	DEVELOPING PROBLEM
Too light	Temperature time too low
Too dark	Temperature or time too high
Too light	Contaminated or weak developer (replace or replenish)
Too dark (fogging)	Over concentrated developer

Table 5- Processing Errors

HANDLING

Film must be handled carefully under proper safelight conditions during processing. Many newer E and F speed dental films recommend a red safety filter on daylight loaders instead of the more common amber ones, especially if the processor is in a brightly lit room. Use of an amber filter in such conditions can result in film fogging. Care must also be taken when feeding film into a processor. Opening the lid too soon on a daylight loader can result in room light fogging the trailing edge of the film. It can take up to 15-20 seconds for film to completely enter an automatic processor. Film fed too quickly or too close together can overlap or stick together. Other errors can occur from emulsion tears, fingerprints, static electricity and chemical spills onto the film. Only clean, dry, powder free gloves should contact the bare film prior to processing. Unprocessed film should not come in contact with wet or contaminated surfaces as this may lead to film spotting. Kodak Clinasept(r) barriers allow film to be handled with clean hands after removal from the barrier envelope and can greatly reduce handling artifacts. After processing, films must not come into contact until completely dry as the wet emulsions can stick together and peel off the films when they are separated.

Figure 28- Emulsion tear, note white area under pontic where no emulsion is left

Figure 29- Finger Print, dirty finger had fixer on it leaving white mark on film

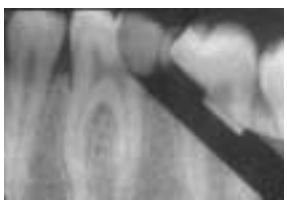


Figure 30- Overlap of films during processing

Figure 31- Stain from incomplete fixation and washing of film

Figure 32- Light fog on left edge of film from opening lid on daylight loader too soon

RADIOGRAPH	HANDLING PROBLEM	FIX
Too dark (similar to fogging)	Improper safelight	Use red safelight with new fast intraoral films such as Insight®
Random sized dark spots: v shaped, mottle "noise"	Stored in humid or hot conditions	Store film between 50 to 70 degrees F in dry conditions
Dark rectangular on film	Overlap during processing	Feed films slowly or side by side
Dark edge on film	Exposed to light before safely in processor	Allow 15-30 seconds from last film to enter processor
Fingerprints	Clean, dry hands before touching film	Follow good infection control practices, use double glove or Clinasept® barrier
Dark spots	Developer stains	
White spots	Fixer stains	
Streaks or scratches	Emulsion tears	Never allow wet films to contact one another or fingernails, Emulsion is delicate when wet. Keep films away from extreme sides of processor.
Dark spots in pattern	Roller marks	Clean rollers with mild detergent & rinse thoroughly or try Roller Transport Clean-up film
Dark spots branched in comet shape	Static (most common in winter months)	Add humidifier and or open packets slowly to minimize static discharge
Dark spots in pattern	Roller Marks	Clean rollers with mild detergent and rinse OR try roller transport clean-up film

Table 6- Handling errors

EXPOSURE GUIDELINES

FOR KODAK INTRAORAL DENTAL FILM

Exposure Factors: kVp = 70 mA = 8 FSFD = 16 inches

me	INSIGHT	ULTRASPEED	Ektaspeed Plus
Region	*Time/Seconds*	*Time/Seconds*	*Time/Seconds*
Anterior	.16	.40	.20
Premolar	.16	.40	.20
Molar	.20	.50	.25
Bitewing	.16	.40	.20
Anterior	.12	.32	.16
Premolar	.16	.40	.20
Molar	.16	.40	.20
Bitewing	.16	.40	.20

Note: • *For large patients, increase time by approximately 25%*
• *For children, small and/or edentulous patients, decrease time by approximately 30%*

Adjusting Exposure Times

To adjust exposure times for kVp settings other than 70, multiply the current exposure time by the appropriate Exposure Factor Multiplier (see below). This will give you the correct exposure time at the new kVp. See the following chart for examples.

kVp	Old kVp	Old Time/Seconds	Exposure Factor Multiplier	New Time/Seconds
60	70	0.3	1.47	0.44
65	70	0.3	1.2	0.36
70	70	0.3	1	0.30
75	70	0.3	0.84	0.25
80	70	0.3	0.72	0.22
85	70	0.3	0.62	0.19
90	70	0.3	0.53	0.16

Adjusting kVp Settings

X-ray intensity varies as the square of the kVp. To maintain mean density while changing kVp, the following rule-of-thumb may be used:

- To reduce contrast, reduce exposure time by a factor of 2 for every 15 kilovolt increase
- To increase contrast, increase exposure by a factor of 2 for every 15 kilovolt reduction

The above guidelines were developed following recommended time-temperature processing with KODAK Automated Processing Chemicals.

For more information, call: U.S.: 1-800-933-8031 • ***Canada:*** 1-800-465-6325
Outside U.S. or Canada: Call your local Kodak company
www.kodak.com/go/dental

Table 7- Summary of Intraoral Errors

Teeth elongated, cusps don't overlap, sinus structures or inferior border of mandible visible	Excessive vertical angulation, correct film placement
Contacts of teeth overlapped	Improper horizontal angulation, visualize contact area and adjust
Dark lines on corner of film	Film bent, use of Super Polysoft® packaging and proper placement can reduce need for bending film
Clear area on one edge of the film either in arc or straight	Cone cut, use position indicating device
Film light in density, unusual pattern across film ("tire tracks" or "herringbone")	Film was reversed and exposed through the back side, pattern is from lead foil
Too dark	Exposure too long
Too light	Exposure too short
Too dark	KvP too high
Too light	KvP too low
Too much contrast	KvP low
Too washed out or gray	KvP high
Blurring of structures	Patient movement
Multiple images on film	Double exposure
Too light	Processor Temperature time too low
Too dark	Processor temperature or time too high
Too light	Contaminated or weak developer (replace or replenish)
Too dark (fogging)	Over concentrated developer
Too dark (similar to fogging)	Improper safelight
Mottle "noise"	Stored in humid or hot conditions
Dark rectangular area on film	Overlap during processing
Dark edge on film	Exposed to light before safely in processor
Fingerprints	Clean, dry hands before touching film
Dark spots	Developer stains
White spots	Fixer stains
Clear streaks, splotches or scratches	Emulsion tears
Dark spots in pattern	Dirty Processor Rollers
Dark spots in random or comet pattern	Static due to over-dry conditions

STUDY QUESTIONS FOR SUCCESSFUL INTRAORAL RADIOGRAPHY

1. A quality radiograph will exhibit the following:
- a. maximum detail
- b. minimum distortion
- c. optimal density and contrast
- d. all of the above

2. Geometric distortion can be minimized by using a:
- a. short cone technique
- b. short x-ray source to object distance
- c. long object to film distance
- d. long cone technique

3. Film holding and positioning devices prevent:
- a. rotation in a horizontal direction
- b. rotation in a vertical direction
- c. hold the film at right angles to the x-ray beam
- d. closing of contacts

4. Bending the corners of film packets can cause:
- a. black lines on corners of film
- b. no problems
- c. is recommended for patient comfort
- d. is not necessary if film is placed right next to teeth

5. When taking bitewing radiographs in the maxillary molar region, the triangular shape of the molars requires the beam be directed:
- a. from a distal direction
- b. from a mesial direction
- c. from a vertical direction
- d. from a horizontal direction

6. A normal dental x-ray machine has the beam limited to a diameter of _____ at the end of the cone.
- a. 1 inch
- b. 2 inches
- c. 2.75 inches
- d. 5 inches

7. After development of an intraoral series, the technician notices the films appear light or underexposed and have a strange pattern on them. The most likely cause is:
- a. wrong film type used
- b. wrong safelight used
- c. films damaged during processing
- d. films exposed backwards

8. Kodak's new InSight' dental film allows an approximately _____ percent reduction in radiation exposure over D speed film.
- a. 25%
- b. 50%
- c. 60%
- d. 90%

9. Changing exposure time from 18 to 36 impulses will _____ the density or darkness of the film.
- a. increase
- b. double
- c. half
- d. both a and b

10. Increasing the kVp (kilovoltage) by 15 kVp will result in approximately _____ increase in film density or darkness.
- a. 5%
- b. 10%
- c. 25%
- d. 2 times

11. When unit dosing is used and a blank film occurs after processing there is also usually a _____ film present.
- a. missing
- b. underexposed
- c. double exposed
- d. reversed

12. Increasing developer temperature during processing will result in a _____ film.
- a. darker
- b. lighter
- c. blurrier
- d. underexposed

13. When loading chemicals into an automatic processor the _____ should always be poured in first.
- a. developer
- b. water
- c. fixer
- d. it doesn't matter

14. Many of the new E and F speed dental films like Ektaspeed Plus' or InSight' recommend a _____ filter be used on the daylight loader.
- a. orange
- b. amber
- c. green
- d. ruby red

15. Dental x-ray film should be stored:
- a. in a refrigerator
- b. between 50 to 70 degrees F in a dry place
- c. in high humidity
- d. for as long as possible

The following questions refer to the Kodak Exposure Guidlines on Page 13

16. X-ray intensity varies as the _____ of the kVp:
- a. inverse
- b. square
- c. negative inverse
- d. square root

17.For large patients, increase exposure time by approximately:
- a. 25%
- b. 35%
- c. 45%
- d. 55%

18.For children, small and/or edentulous patients, decrease exposure time by approximately what percent:
- a. 10%
- b. 20%
- c. 30%
- d. 40%

19.When adjusting kVp Settings, to reduce contrast, reduce exposure time by a factor of ___ for every ___ kilovolt increase:
- a. 1, 10
- b. 2, 15
- c. 3, 20
- d. 4, 25

20.When adjusting kVp Settings, to increase contrast, increase exposure time by a factor of ___ for every ___ kilovolt decrease:
- a. 1, 10
- b. 2, 15
- c. 3, 20
- d. 4, 25