Strategies for optimal intraoral digital imaging

Part II: Radiation safety and protection procedures, intraoral anatomical and patient management strategies, and troubleshooting common errors

A Peer-Reviewed Publication
Written by Gail F. Williamson, RDH, MS

Abstract
Once it has been determined that radiographic images are necessary, it is the responsibility of the dentist to not only ensure that optimal images are obtained but also that they are acquired at the lowest possible dose of radiation. There are a variety of best practices that together can reduce exposure to the patient and the clinician alike. These practices are necessary components of the overall radiographic protocol for patient imaging.

The use of digital receptors can present challenges for clinicians and patients. Anatomical variations and patient comfort must be considered when taking intraoral images. Endodontic and pediatric imaging are examples of situations which demand optimal technical and patient management skills. Finally, recognizing common errors is important to their correction and ultimately to prevent recurrence.

Educational Objectives:
The goal of this course is to provide the reader with contemporary information on intraoral digital radiography to optimize results. Upon completion of Part II of this course, the reader will be able to:
1. list and describe best practices for patient and clinician radiation safety and protection;
2. list and describe the adjustments in technique necessary to accommodate anatomy, gagging, discomfort, placement difficulties, and other challenging clinical situations;
3. list and describe common errors that occur when taking intraoral digital images and the corrections to apply when these errors occur.

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Abstract
Once it has been determined that radiographic images are necessary, it is the responsibility of the dentist to not only ensure that optimal images are obtained but also that they are acquired at the lowest possible dose of radiation. There are a variety of best practices that together can reduce exposure to the patient and the clinician alike. These practices are necessary components of the overall radiographic protocol for patient imaging.

The use of digital receptors can present challenges for clinicians and patients. Anatomical variations and patient comfort must be considered when taking intraoral images. Endodontic and pediatric imaging are examples of situations which demand optimal technical and patient management skills. Finally, recognizing common errors is important to their correction and ultimately to prevent recurrence.

Radiation Safety and Protection

Exposure Reduction for Patients
A primary concept in patient radiation safety and dose reduction is the application of the ALARA (As Low As Reasonably Achievable) Principle, which aims to keep radiation exposure to patients as low as possible. There are a variety of radiologic best practices that collectively work to minimize patient exposure. These best practices are outlined in table 1.

Collimation
X-ray beam collimation restricts the size of the X-ray beam and decreases the volume of tissues exposed at the skin surface. Rectangular collimation limits the X-ray beam to the approximate size and shape of the receptor, resulting in a four- to fivefold reduction in dose when compared to round collimation. The National Council on Radiation Protection and Measurements (NCRP) recommends that rectangular collimation be used routinely for periapical and bitewing radiography when feasible. Digital receptors are more sensitive to radiation than film, and therefore, are more susceptible to scatter radiation and image degradation. Rectangular collimation not only reduces scatter radiation but reduces the source size, which improves image sharpness and detail.

Table 1: Patient Radiation Dose Reduction Measures

<table>
<thead>
<tr>
<th>Measure</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Use selection criteria to determine when radiographic examinations are indicated.</td>
</tr>
<tr>
<td>2.</td>
<td>Utilize digital receptors or f speed film and receptor instruments.</td>
</tr>
<tr>
<td>3.</td>
<td>Use rectangular collimation to reduce exposure at the skin surface.</td>
</tr>
<tr>
<td>4.</td>
<td>Provide patient shields; thyroid collar and lead apron when indicated.</td>
</tr>
<tr>
<td>5.</td>
<td>Utilize proper exposure factors.</td>
</tr>
<tr>
<td>6.</td>
<td>Avoid retakes through technical improvement.</td>
</tr>
</tbody>
</table>

There are a variety of methods and devices that can be used to achieve rectangular collimation (figure 1). Rectangular collimators can be purchased to replace detachable round collimators on intraoral X-ray machines, and commercial devices are available that can be attached to a round collimator to adapt the X-ray beam to a rectangular configuration. Most receptor instrument rings have rectangular insets to facilitate the alignment of a rectangular collimator (figure 2). Adjustment of the orientation of the rectangular collimator is necessary to align with the vertical or horizontal orientation of the receptor. Round collimation can be used in combination with metal devices that clip into the instrument ring or that are embedded into the instrument ring to achieve rectangular collimation (figure 3).
The use of rectangular collimation can introduce more cone-cut errors on intraoral images when compared to round collimation. Several studies on errors associated with rectangular collimation have found that cuts were minor in most instances and did not significantly compromise the diagnostic yield of the acquired images.\(^7\)\(^-\)\(^9\) Unfortunately, rectangular collimation has not been widely adopted in dentistry. However, increased awareness of the associated dose-reduction benefits can be the impetus to affect change.

**Patient Shields**

Patient radiation shields are another means to attend to the ALARA Principle. Lead thyroid collars and lap aprons can be used during radiographic imaging procedures to provide protection and minimize exposure (figure 4).

The thyroid gland is among the most radiosensitive organs, especially in children.\(^4\) Given its proximity to the oral cavity, the thyroid is often in the path of the primary beam and is also subject to scatter radiation. The lead thyroid collar has been found to substantially reduce radiation to the thyroid during dental radiographic examinations.\(^2\)\(^,\)\(^4\) Both the ADA and the NCRP recommend protective thyroid collars be used for children and adults whenever possible during dental radiographic procedures.\(^2\)\(^,\)\(^4\)

There are varying perspectives on the necessity of lead apron patient shields during dental radiographic imaging procedures. The use of the lead apron is associated with concerns regarding the genetic risk of radiation exposure. The amount of scatter radiation to the reproductive organs from dental radiographic examinations is negligible.\(^4\)\(^,\)\(^10\)\(^,\)\(^11\) If all NCRP recommendations for limiting radiation exposure are practiced, the gonadal dose of radiation will not be significantly affected by using a lead lap apron.\(^2\)\(^,\)\(^4\)\(^,\)\(^10\)\(^,\)\(^11\) Note that the radiation safety measures of the NCRP include rectangular collimation of the X-ray beam. The lead lap apron should be used when required by local or state regulation, but it can otherwise be considered optional.

The clinician must remember that the lead contained in lead collars and aprons is thin and malleable, and if the apron or collar is folded or improperly stored, the lead can become broken such that it compromises protection. Collars and lap aprons should be hung up to avoid damage. There are commercial hangers and wall mounts designed for this purpose. Lightweight apron options are available that incorporate materials that effectively absorb scatter radiation but are more comfortable for patients.

**Exposure Factors**

Intraoral dental X-ray machines compatible with digital imaging systems should have the smallest focal spot possible; a timer capable of producing very short exposures; 60 or 70 kilovoltage and 5 milliamperage or lower settings; and rectangular collimation. Most intraoral dental X-ray units have fixed kilovoltage and milliamperage settings with the exposure time as the only adjustable variable. Kilovoltage controls the penetrating power of the X-ray beam and image contrast while milliamperage and time control the number of X-rays generated and image density (darkness).

The length of the exposure time is dependent on multiple factors, including the type of image receptor, the exposure factor settings, X-ray beam collimation, patient size, and the area of interest. Generally speaking, the exposure time increases as the radiographic survey moves from the anterior to the posterior regions of the mouth. Clinicians should consult the machine’s operating manual for recommended exposure times for adults and children, with consideration given to the factors previously mentioned. The clinician should make these assessments before imaging procedures are undertaken.

**Operator Exposure Reduction**

Dental personnel who utilize ionizing radiation for patient imaging must be qualified with training, education, certification, and/or licensure as mandated by state and federal statutes. The clinician should be well versed...
in standard safety rules to limit occupational exposure. Dose limits have been established by the NCRP to help clinicians practice safely and minimize occupational exposure. For occupationally exposed radiation workers, the annual whole-body dose limit (DL) is 50 mSv (5 rem), while for pregnant clinicians, the DL is 5 mSv (.5 rem). The NCRP recommends that a personal dosimeter be provided for known pregnant occupationally-exposed personnel. The ultimate goal of any clinician should be to avoid any and all occupational exposure. By following established safety practices, the clinician can easily avoid occupational exposure (table 2).

### Table 2: Clinician Radiation Safety and Protection Measures

1. Stand behind a wall barrier outside the operatory.
2. If a wall barrier is not available, stand 6’ away and at a 90° to 135° angle to the x-ray beam.
3. Do not hold the receptor, x-ray head or patient in position during exposure.
4. Wear lead apron and thyroid collar when handheld x-ray devices cannot be aligned as recommended by the manufacturer.
5. Avoid occupational exposure and comply with annual dose limits.

### Handheld Portable X-ray Units

Handheld, portable, and battery-operated X-ray devices are available for use in a variety of environments, including the dental office (figure 5). Handheld X-ray units are useful for imaging patients in nursing homes, public health settings, missions of mercy, military field installations, or for forensic dental imaging when access to a conventional X-ray unit is not feasible. Because these X-ray devices are handheld, the clinician must follow manufacturer instructions to avoid unnecessary occupational exposure.

Approved handheld X-ray units have a built-in lead-acrylic shield to protect the clinician from scatter radiation during use. When operating a handheld X-ray device, the clinician should use the technique outlined in table 3. When handheld portable X-ray units are used according to manufacturer instructions, no additional operator radiation safety measures are required. To comply with requirements for safe use, adjustments to the chair and the patient’s head position are often necessary. Instruments are available with short arms to facilitate close alignment of the PID to the instrument ring (figure 6). If these adjustments cannot be made, additional radiation safety measures will need to be taken by the clinician. These additional safety measures include lead apron and thyroid collar protection as well as extremity and whole-body dosimetry monitoring.

### Table 3: Handheld X-ray Unit Technique

1. Hold the device at mid-torso height while forming a right angle to the clinician’s body.
2. Orient the ring shield to full extension and position it parallel to the clinician.
3. Place the PID as close to the patient’s face as possible.
4. Carefully activate the exposure trigger to avoid movement.

### Technical Challenges and Adaptations

### Patient Management Issues

Even skilled clinicians sometimes need to retake images. This often happens if they are unable to gain the cooperation and confidence of the patient during imaging procedures. There are many products and management strategies that the clinician can employ to reduce discomfort, overcome anatomical obstacles, and minimize gagging.

### Patient Comfort and Gag Reflex Reduction

Ensuring patient comfort when taking intraoral images not only helps the patient but results in more successful outcomes and reduced retakes. Gagging and discomfort associated with the edges of the receptor are important considerations. The most common area to elicit the gag reflex is the maxillary molar area. Placement of the receptor toward the midline and away from the soft palate reduces the tendency for gagging.
Gagging patients can be very challenging and require patience, reassurance, and confidence from the clinician. It is important to be organized, preset the exposure time, prealign the PID, and be ready to act quickly. Additional strategies include avoidance of discussion of gagging and starting with projections in areas that do not normally trigger the gag reflex to build the patient’s confidence. A variety of strategies will help manage the gagging patient: breathing through the nose, salt on the tongue, distraction techniques (e.g., lifting one leg in the air, bending the toes toward the body, humming), use of topical anesthetics, and tissue cushions on the receptor.

Similar approaches can be useful when the patient experiences discomfort from the receptor. The use of topical anesthetic agents and receptor cushions improve comfort, as does moving the receptor away from the teeth to where there is greater depth in the palate or the floor of the mouth. Using lightweight bite blocks and receptor arms/rings also improves patient comfort. Another option is to use a receptor holder without the accompanying arm and ring, allowing for positioning of the sensor that maximizes patient comfort without compromising accuracy.

In bitewing imaging, tabs can be used which are usually more comfortable for the patient, although the edges of a rigid receptor can still be a potential source of discomfort. While regular bitewing tabs are more comfortable, they are less reliable than the use of an instrument-holding device because they can allow movement or displacement of the sensor. Bitewing tabs with extended straps that wrap around the sensor solve this problem and keep the tab positioned in the center without compromising patient comfort (figure 7). Self-adhesive foam covers can be used over the receptor for both bitewings and periapicals to smooth the edges and provide cushioning against the patient’s oral mucosa (figure 8).

Another option is the use of foam covers that fit over the entire receptor and have soft, pliable edges which aid comfort. When adhesive holders are used, maintaining the sensor firmly in its barrier is critical and can be achieved by using a thin foam layer that precisely fits over the sensor barrier. In addition, instructing the patient to “lightly” or “gently” bite just hard enough to keep the sensor in place and stable also aids comfort and serves to maintain proper positioning and alignment.

### Anatomical Considerations

Technique adaptations may be required due to anatomical obstacles and to avoid patient discomfort. These anatomical considerations include shallow palates, narrow arches, limited mouth opening, presence of tori, and loss of alveolar bone in edentulous areas. Modifying the paralleling technique, selecting the bisecting angle technique, using occlusal imaging, and altering receptor placement can all be useful when confronting anatomical variations (table 4).

<table>
<thead>
<tr>
<th>Anatomical Adaptations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Shallow Palates</strong></td>
</tr>
<tr>
<td>• Use bisecting technique or modify the paralleling technique</td>
</tr>
<tr>
<td>• Move receptor more toward the midline</td>
</tr>
<tr>
<td><strong>Presence of Tori</strong></td>
</tr>
<tr>
<td>• Ensure maxillary tori are between the teeth and receptor</td>
</tr>
<tr>
<td>• Place receptor away from the teeth and behind mandibular tori</td>
</tr>
<tr>
<td>• Use topographical occlusal techniques for anterior periapical views</td>
</tr>
<tr>
<td>• Use foam receptor covers</td>
</tr>
<tr>
<td><strong>Narrow Arches</strong></td>
</tr>
<tr>
<td>• Place receptor as far lingual as possible</td>
</tr>
<tr>
<td>• Use size 1 receptors in anterior or topographical occlusal techniques</td>
</tr>
<tr>
<td><strong>Limited Opening</strong></td>
</tr>
<tr>
<td>• Use topographical occlusal techniques for anterior views</td>
</tr>
<tr>
<td>• Supplement survey with panoramic image</td>
</tr>
<tr>
<td><strong>Edentulous Area</strong></td>
</tr>
<tr>
<td>• Place receptor more toward the midline/tongue</td>
</tr>
<tr>
<td>• Use cotton rolls on the bite block to replace missing teeth</td>
</tr>
</tbody>
</table>

### Endodontic Imaging

Accurate images are critical for the diagnosis and treatment of teeth requiring endodontic procedures. Preoperative and postoperative images should be taken with the paralleling technique. The presence of endodontic files when radiographic images are needed during treatment can create significant challenges, including visibility, working around obstacles such as the rubber dam/clamp, receptor placement, and beam alignment. Gener-
ally speaking, the tooth of interest should be centered on the periapical image with at least 5 mm of bone beyond the apex or apices of the tooth. Additional images may be necessary to separate the roots of multirooted teeth such as maxillary molars. Typically, this is accomplished by altering the horizontal angle by 20° in a mesial or distal direction.

The use of specially designed endodontic instruments can facilitate acquisition of a diagnostic image while preventing multiple retakes. Ringed receptor instruments are available with bite blocks designed to allow the endodontic files to extend from the tooth while maintaining the receptor placement with the adjacent teeth (figure 9). If parallel placement cannot be achieved, the clinician will need to apply the principles of the bisecting angle technique to avoid vertical dimension errors commonly associated with endodontic imaging.

Figure 9 - Digital Endodontic Instrument

**Pediatric Imaging**

When imaging children, it is important to remember that their tissues are more sensitive to the effects of radiation than adults. Only necessary radiographs—those justified by the application of selection criteria—should be taken, and adherence to patient radiation exposure reduction measures should be a priority.

Several adjustments will need to be made, including the size of the receptor, exposure time reduction (child settings), and careful application of patient management and radiographic techniques. With children, it is important to be positive and reassuring to gain their trust and allay apprehension. The clinician should speak to the child at eye level in age-appropriate terms using a “show and tell” type of approach to imaging procedures. As previously mentioned, presetting the exposure time and prealignment of the PID are necessary to allow the clinician to work quickly. The same strategies used to address discomfort and gagging for adult patients are applicable to imaging children. With children, it is particularly important to emphasize the need to remain still “like a statue” to avoid retakes from patient movement. The clinician should praise positive behavior and reward cooperation. In situations in which a child patient needs to be stabilized during an intraoral imaging procedure, the parent or guardian should be asked to assist. Protective shielding should be provided as well as instructions on how to properly restrain the patient during exposure.

Access to a range of receptor sizes (0, 1, and 2) is necessary for imaging children as outlined in table 5. In accordance with selection criteria, posterior bitewings can be combined with a panoramic image when indicated.

<table>
<thead>
<tr>
<th>Table 5: Pediatric Receptor Size Guide</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Size 0</strong></td>
</tr>
<tr>
<td>• Child with primary dentition</td>
</tr>
<tr>
<td>• Use for bitewings or periapicals when indicated</td>
</tr>
<tr>
<td><strong>Size 1</strong></td>
</tr>
<tr>
<td>• Child with mixed dentition</td>
</tr>
<tr>
<td>• Use for bitewings or periapicals when indicated</td>
</tr>
<tr>
<td>• Can be used in combination with a size 2 receptor when needed</td>
</tr>
<tr>
<td><strong>Size 2</strong></td>
</tr>
<tr>
<td>• Use for topographical occlusals when indicated for a children with either a primary or mixed dentition</td>
</tr>
<tr>
<td>• Use for bitewings or periapicals when indicated for older children</td>
</tr>
</tbody>
</table>

**Assessment and Correction of Common Errors**

**Overview**

When the principles of radiographic technique are not applied, errors occur. Clinicians must have the ability to identify, understand, and correct errors so they do not recur. The most common errors occur in placement, vertical angulation, horizontal angulation, X-ray beam centering, and exposure (table 6).

<table>
<thead>
<tr>
<th>Table 6: Correction of Common Errors</th>
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</thead>
<tbody>
<tr>
<td><strong>Error</strong></td>
</tr>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td><strong>Correction</strong></td>
</tr>
<tr>
<td>Placement</td>
</tr>
<tr>
<td>Improper area recorded, the crowns or apices are cut off</td>
</tr>
<tr>
<td>Place receptor according to placement guidelines to cover structures</td>
</tr>
<tr>
<td>Foreshortening</td>
</tr>
<tr>
<td>Image shorter than the actual object length</td>
</tr>
<tr>
<td>Decrease the vertical angulation of the PID</td>
</tr>
<tr>
<td>Elongation</td>
</tr>
<tr>
<td>Image longer than the actual object length</td>
</tr>
<tr>
<td>Increase the vertical angulation of the PID</td>
</tr>
<tr>
<td>Overlapping</td>
</tr>
<tr>
<td>Proximal surfaces of the teeth are closed and structures widened</td>
</tr>
<tr>
<td>Direct the x-rays through the proximal contacts of the teeth</td>
</tr>
<tr>
<td>Cone Cutting</td>
</tr>
<tr>
<td>White zone where x-rays did not expose the receptor</td>
</tr>
<tr>
<td>Center the x-ray beam over the Image receptor</td>
</tr>
<tr>
<td>Underexposure</td>
</tr>
<tr>
<td>Light or low density image</td>
</tr>
<tr>
<td>Increase the exposure time; check for large patient size</td>
</tr>
<tr>
<td>Overexposure</td>
</tr>
<tr>
<td>Dark or high density image</td>
</tr>
<tr>
<td>Decrease the exposure time; check for small patient size</td>
</tr>
</tbody>
</table>
Placement Errors
Placement errors occur when the clinician improperly places the receptor, failing to record the correct teeth or cutting off the crowns or apices of teeth. To avoid these problems, attention to the details of placement in terms of precise location, horizontal and vertical parallelism of the receptor to the structures, and accurate alignment of the X-ray beam to the receptor center are critical. To avoid “cutting-off” the incisal edges, a cotton roll can be placed under the bite block to facilitate placement to allow crowns to be fully recorded. In addition, rigid receptors should be placed closer to the midline where there is greater depth to allow a parallel rather than angular placement. It is particularly important to employ this approach when a patient has a shallow palate or floor of the mouth, to avoid both discomfort and distortion of the image.

To overcome rigid sensor placement difficulties on premolar and molar periapicals or premolar bitewings, two alternative strategies can be employed:

1. To capture the distal surface of the canine teeth, it is easier to take an additional anterior periapical on each arch to capture the canine-premolar contact.
2. To achieve a more anterior position of a premolar periapical or bitewing or a more posterior placement of a molar periapical, a horizontal offset technique can be utilized.

This latter approach alters the horizontal placement of the receptor toward the area of interest while directing the X-rays through the contacts of the teeth (figure 10). This is best accomplished visually with the ring guide removed from the instrument. The fingertip of the clinician can be placed in the contact zone of interest to visualize the correct horizontal entry of the X-ray beam.

Figure 10 – Off-set Technique

Vertical Angulation Errors
Vertical angulation errors distort the length of the structures and result in either foreshortening (shorter than normal) or elongation (longer than normal) as seen in figure 11. Foreshortening requires a decrease in the vertical angle for correction while elongation requires an increase in the vertical angle. Vertical angulation errors are more common with the bisecting angle technique than the paralleling technique. However, vertical angulation errors, especially elongation, can occur with the paralleling technique when the patient bites too forcefully and torques the receptor out of the correct vertical position. To correct this, ensure light biting pressure with the use of a cotton roll under the bite block. Use lingual placement away from the teeth, placing the receptor, teeth, and PID parallel to one another. It is often difficult to achieve true parallel placement with digital receptors, especially rigid sensors. If the clinician observes a lack of parallelism, slight reduction in the vertical angulation can compensate for the lack of ideal placement.

Figure 11 – Vertical Angulation Errors

Horizontal Angulation Errors
Horizontal angulation errors result in overlapping of proximal surfaces and limit caries and alveolar bone evaluations (figure 12). To correct this, the horizontal angle must be directed through the proximal surfaces of the teeth. It is helpful to align the lateral edges of the bite block with the teeth contacts to better guide X-rays through the proximal contacts of the teeth when taking periapical images. Overlapping occurs more commonly with tab bitewings. However, overlapping can occur with bitewing instruments if the receptor is not placed parallel to the horizontal plane of the teeth.

A simple strategy to check for accurate receptor placement and horizontal angulation is to have the patient smile and compare the buccal surfaces of the teeth to the open end of the PID or the instrument ring. If they are not parallel to each other, the teeth contacts will be overlapped. This gives the clinician the opportunity to make a correction before patient exposure.

Figure 12 – Horizontal Overlapping
Cone-Cut Errors
Cone-cut errors are caused by not centering the X-ray beam over the receptor. Lack of centering produces partial exposure of the receptor with a “cut” where X-rays have not interacted with the receptor (figure 13). Receptor instruments with beam guides facilitate beam centering over the receptor when properly assembled.

Figure 13 – Cone Cut

Exposure Errors
Exposure errors result in light or dark images due to improper exposure time or lack of consideration of patient size and the thickness of structures (figure 14). Underexposures cannot be corrected with software enhancements, but overexposures can usually be adjusted to improve image density as long as the receptor is not oversaturated by the exposure.

Figure 14 – Exposure Errors

Underexposed Overexposed

Summary and Part II Key Takeaways
Dental radiographs are valuable diagnostic tools and expose the patient to minimal amounts of radiation when the examination is conducted in an optimal manner. Nonetheless, dental professionals must ensure that patients are protected from the harmful effects of cumulative exposure to radiation. Patients can be protected through the use of lead collars and lap aprons as indicated; by ensuring that only necessary radiographs are taken; and that radiation exposure is kept as low as possible. Patient comfort can be improved by placing digital receptors in a position that allows for accurate image acquisition, as well as using devices and accessories that improve patient comfort. One of the critical factors in minimizing the number of intraoral images taken and the related radiation exposure is to ensure that retakes are not required due to improper technique, patient management, or exposure time.

References
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Notes
Questions

1. The overall guiding principle in patient radiation dose reduction is _______.
   a. Retake Avoidance Rule
   b. As Low As Reasonably Achievable
   c. Thyroid and Reproductive Organ Shielding
   d. Patient Radiation Risk Communication

2. A patient’s radiation exposure can be minimized by _______.
   a. taking only necessary images
   b. using proper exposure factors
   c. using digital receptors
   d. all of the above

3. _____ restricts the size of the X-ray beam at the patient’s skin surface.
   a. Filtration
   b. Shielding
   c. Collimation
   d. Instrumentation

4. Rectangular collimation _____.
   a. limits the X-ray beam to the approximate size and shape of the receptor
   b. reduces scatter radiation and image degradation
   c. improves image sharpness and detail
   d. accomplishes all of the above

5. Lead collars are designed to protect the _______.
   a. thyroid
   b. gonads
   c. lymph nodes
   d. all of the above

6. The lead lap apron can be considered optional _______.
   a. even if required by local or state regulations
   b. only for adult patients during intraoral imaging
   c. when lightweight apron options are available for use
   d. if all NCRP recommendations for limiting radiation are practiced

7. The kilovoltage setting controls the _____ of the X-ray beam.
   a. penetration
   b. filtration
   c. intensity
   d. density

8. Typically, the exposure time will need to be increased when _______.
   a. imaging child patients
   b. taking posterior bitewings
   c. taking anterior periapicals
   d. an adult patient is smaller than average

9. The annual whole-body dose limit for radiation workers is _______.
   a. 5 mSv
   b. 50 mSv
   c. 500 mSv
   d. 5000 mSv

10. To avoid occupational exposure, the clinician should _______.
    a. hold the patient still during imaging procedures
    b. stand behind a wall barrier during patient exposure
    c. maintain the position of the receptor during exposure
    d. none of the above

11. If a handheld portable X-ray device is not used according to instructions, the clinician will need to _______.
    a. wear a lead apron
    b. wear a thyroid collar
    c. use extremity and whole-body dosimetry
    d. all of the above

12. With gagging patients, it is important to _______.
    a. talk about gagging in detail
    b. tell them gagging is not allowed
    c. be reassuring and understanding
    d. start in the posterior regions first

13. The most common projection to trigger the gag reflex is the _______.
    a. maxillary molar periapical
    b. maxillary lateral periapical
    c. mandibular molar periapical
    d. premolar bitewing

14. The use of _______ can improve patient comfort.
    a. foam covers
    b. topical anesthetic agents
    c. lightweight bite blocks
    d. all of the above

15. In endodontic imaging, the pre- and post-treatment images should be taken with the _______.
    a. paralleling
    b. panoramic
    c. bisecting angle
    d. topographical occlusal

16. To separate the roots of multirooted teeth during endodontic imaging, the clinician will need to _______.
    a. increase the vertical angulation
    b. alter the horizontal angle by 20°
    c. use the occlusal technique
    d. change the exposure time

17. In panoramic imaging, topographical occlusal projections are best taken with the _______.
    a. size 0
    b. size 1
    c. size 2
    d. size 3

18. If a child needs to be restrained during pediatric imaging, the best practice is to _______.
    a. have the clinician hold the patient
    b. engage the parent or guardian
    c. use a handheld X-ray device
    d. none of the above

19. When working around mandibular tori, the clinician should place the receptor _______.
    a. on the tori
    b. on the tongue
    c. behind the tori
    d. close to the teeth

20. Using salt on the tongue is effective in managing _______.
    a. receptor discomfort
    b. the gag reflex
    c. movement
    d. coughing

21. The bisecting angle technique can be useful when dealing with _______.
    a. shallow palates
    b. limited mouth opening
    c. posterior bitewing imaging
    d. a and b

22. Image foreshortening _______.
    a. is corrected by decreasing the vertical angulation
    b. cannot occur if a receptor instrument is used
    c. increases the length of the structures
    d. is acceptable in endodontic imaging

23. Placement errors can result in _______.
    a. recording the wrong teeth
    b. missing the apices of the teeth
    c. cutting off the crowns of the teeth
    d. all of the above

24. Horizontal angulation errors are corrected by _______.
    a. centering the X-ray beam
    b. directing the X-rays interproximally
    c. alignment of the central ray entry point
    d. increasing the positive angulation

25. Bitewing proximal surface overlap compromises _______.
    a. evaluation of the apical regions
    b. assessment of bone pathology
    c. radiographic caries evaluation
    d. occlusion classification

26. Cone cutting can be corrected by _______.
    a. adjusting the horizontal angulation
    b. increasing the vertical angulation
    c. collimating the X-ray beam
    d. centering the X-ray beam

27. Image elongation can occur if the _______.
    a. receptor is placed angular to the teeth
    b. vertical angulation is aligned too steep
    c. patient bites too forcefully and torques the receptor
    d. X-ray beam is not in alignment with the correct facial point

28. A high-density image can be produced when _______.
    a. the exposure button is let go too soon
    b. an adult setting is used to image a child patient
    c. the patient is larger in size than the average patient
    d. an anterior exposure time is used for a posterior image

29. An image that is underexposed has a _______ appearance.
    a. light
    b. dark
    c. clear
    d. fuzzy

30. The use of receptor instruments _______.
    a. prevents exposure errors
    b. guarantees image accuracy
    c. facilitates imaging
    d. reduces radiation exposure to the patient
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Educational Objectives
1. List and describe best practices for patient and clinician radiation safety and protection.
2. List and describe the adjustments in technique necessary to accommodate anatomy, gagging, discomfort, placement, difficulties, and other challenging clinical situations.
3. List and describe common errors that occur when taking intraoral digital images and the corrections to apply when these errors occur.

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