Radiation Safety & Protection

- **ALARA**: As Low As Reasonably Achievable
- The effects of radiation are cumulative.
- Minimize exposure and maximize result
- Risk/benefit decision
- Selection criteria
- Receptor selection
- Patient shielding
- Collimation
- Technical competence
- Avoiding retakes

Selection Criteria

- Published by ADA and FDA
- **Selection Criteria Guidelines**
- Dentist Uses to Determine Necessary Radiographs
- Concepts based on:
  - Patient’s medical/dental history
  - Positive clinical signs and symptoms
  - Patient risk factors
  - Type of visit – new or recall
  - Patient age/dentition
- Latest research emphasizes selection criteria and other dose reduction measures

Intraoral Receptor Selection

- Digital Imaging
  - Rigid (CCD/CMOS)
  - Phosphor plate sensors (PSP/SPP)
  - Exposure reduction
  - Slightly greater or comparable to F speed film
- High Speed Film
  - F speed – 60% less than D speed film
- Retakes undermine dose reduction

Extraoral Receptor Selection

- Digital panoramic systems
  - Direct digital
  - Phosphor plate
  - Dose is equivalent to film-based systems using rare earth screens
- Film-based systems: Rare earth intensifying screens with matched film
  - Most common phosphors lanthanum or gadolinium
  - Recommended for extraoral radiography
  - 50% exposure reduction over calcium tungstate screens

Patient Shields

- **Thyroid collar**
  - Thyroid - closest critical organ to oral cavity
  - Recommended for use on all patients
  - Reduces exposure to gland 90%
- **Lead apron**
  - Primary purpose is to shield reproductive tissues from 2¹ radiation – exposure is negligible
  - Not necessary to use if all recommended NCRP safety measures are followed including rectangular collimation
  - Best practice
  - Shield all patients with both devices
X-ray Beam Collimation
- Collimation
  - Restricts size of the x-ray beam
  - Shape and length matter
  - Rectangular preferred over round
- Reduces volume of tissue exposed
  - Skin surface volume ≤ circle 7 cm or 2.75" in diameter
- Reduces dose 60%-70%
- Improves image geometry
- Less image degradation from scatter radiation

Handheld X-ray Units
- Operator Handling and Safety Measures
  - Hold device at mid-torso height
  - Orient shield ring properly
  - Place PID/x-ray cone as close to the patient’s face as practical
  - If operated without the ring in place, operator should wear lead apron.
  - Properly store and secure when not in use

Instruments and Technique
- Receptor holders
  - Maintains receptor position
  - X-ray beam ring guides for round and rectangular collimation
  - Fewer errors but not fool proof
- Paralleling technique
  - Preferred over bisecting angle
  - Produces more diagnostic images
  - Greater accuracy
  - Fewer retakes

Image Gently
What Can You Do as a Dental Professional?
Remember One size does not fit all...
- Select x-ray exams for individual’s needs, not merely as a routine
- Use the fastest image receptor possible: E/F-speed film or digital sensors
- Collimate beam to area of interest
- Always use thyroid collars
- Child-size the exposure time
- Use cone-beam CT only when necessary

So when we image, image gently: More is often not better. http://www.imagegently.org/

Operator Protection Principles
- NCRP Occupational Dose Limits
  - Qualified dental professionals
  - Whole-body exposure annual dose limit
  - Amount presents minimal risk to clinician
  - Average dose for dental professionals is 0.2 mSV

Minimizing Operator Exposure
Operator should:
- Avoid the x-ray beam
  - DO NOT stand in or near the x-ray beam
  - DO NOT hold the x-ray head or PID
  - DO NOT hold receptor in the patient’s mouth
  - DO NOT hold the patient in position
- Remember the effects of radiation are additive
Intraoral Imaging

Principles and Techniques
- Central Ray Entry Points
- Tour of a Full Mouth Survey
- Common Errors and Their Correction

Operator Protection
- Stand behind wall barrier
- Distance & Position Rule
  - No wall barrier?
  - Stand 6 feet from x-ray source
  - At 90° to 135° angle to the primary x-ray beam
- Concept based on Inverse Square Law
  - Increased distance between the clinician and x-ray source decreases x-ray beam intensity
  - The greater the distance, the safer it is for the clinician.

Operator Protection
- Occupational radiation monitoring – several companies offer monitoring systems
- Badge Dosimeter
  - Sensitive thermoluminescent crystal
  - Wear at waist/chest level
  - Occupational exposure only
  - Sensitive to environmental factors
- Analyzed quarterly; detailed report provided to dentist

Intraoral Imaging Principles and Techniques
- Central Ray Entry Points
- Tour of a Full Mouth Survey
- Common Errors and Their Connection

Paralleling Technique
- Receptor as close to object as practical
- Longest x-ray source-to-object distance as practical
- Receptor parallel to the object
- Central ray at right angle to object and receptor

Bisecting Angle Technique
- Applies one of the rules for accurate image formation
- Angle is formed by receptor and object
- CR right angle to "bisecting plane"
- 2° periapical technique
- Basis for topographical occlusal imaging
- Useful with rigid sensors

Central Ray Entry Points
- Maxillary periapicals
  - Incisor - tip of nose
  - Lateral Canine – ala or corner of the nose
  - Premolars – down from pupil of eye to ala-tragus plane
  - Molars – down from outer canthus of eye to ala-tragus plane
- Bitewings
  - Premolar – down from pupil of eye to occlusal plane
  - Molar – down from outer canthus of eye to occlusal plane
- Mandibular periapicals
  - Incisor – down from tip of nose to center of chin
  - Lateral Canine – down from ala of the nose to center of chin
  - Premolars – down from pupil of eye to center of mandible
  - Molars – down from outer canthus of eye to center of mandible
Central Ray Entry Points

Anterior Periapicals

Posterior Periapicals

Bitewings

Patient Management

• Minimizing Discomfort or Gagging
  • Tissue sponges
  • Topical anesthetic
  • Salt on the tongue
  • Distraction techniques
  • Raising one leg in the air
  • Flex or wiggle toes
  • Humming

Anatomical Challenges

• Maxillary & Mandibular Tori
  • Place receptor behind torus & toward midline
  • Cover edge of receptor with tissue sponges to reduce discomfort
  • Place topical on receptor and/or torus
Common Errors

Placement Errors
- Improper location
- Anatomic area not covered
- Apices or crowns cut off
- Backwards placement

Corrections
- Place receptor more toward midline
- Know placement guidelines for each view
- Place exposure side toward x-ray source

Elongation

- Image elongation
  - Vertical angulation error
  - Length distortion – image is longer than the actual tooth
  - Vertical angle is NOT steep enough; underangulated

Correction
- Increase vertical angulation
  - Align PID with tooth plane for paralleling
  - Align PID with dividing plane in bisecting angle technique

Cone Cut Errors

- Cone cut – partial exposure causing clear or white zone

Common Causes
- Central ray (CR) not directed to receptor center
- Incorrect instrument assembly

Correction
- Center x-ray beam over receptor
- Ring centered over receptor

Foreshortening

- Image foreshortening
  - Vertical angulation error
  - Length distortion – image is shorter than the actual tooth
  - Vertical angle is too steep; overangulated

Correction
- Decrease the vertical angulation
  - Align PID with tooth plane for paralleling
  - Align PID with dividing plane in bisecting angle technique

Overlapping

- Horizontal angulation error
  - Teeth widened & contacts overlapped
  - Caused by incorrect horizontal angle and diagonal entry of x-ray beam

Correction
- Direct x-rays through proximal contacts
- Open end of the PID should be parallel to buccal surfaces of the teeth

Exposure Errors

Density: Overall image darkness

Contra: Differences in darkness

Light or low-density image
- Time set too low
- Patient size underestimated
- Button let go early

Dark or high-density image
- Time set too high
- Patient size overestimated
Diagnostic Criteria

- Entire maxilla, mandible and TMJs recorded.
- Symmetrical display of the structures right to left.
- Slight smile or downward curve of occlusal plane.
- Good representation of the teeth.
- Tongue against the hard palate with lips closed.
- Minimal or no cervical spine shadow visible.
- Acceptable level of contrast and density.
- Free of technical, preparation and exposure errors.

Panoramic Imaging

Focal Trough

- Predetermined layer of structures in focus on the image
- Layer shaped to conform to the average jaw shape
- Correct patient positioning in the focal trough is essential
- Patient’s arches must be centered horizontally, vertically & anteroposteriorly
- Lack of centering produces under or over magnification

Panoramic X-ray Machine

- X-ray source – vertical slit aperture
- X-ray beam fixed at a ~10º angle
- Time is fixed = 20 seconds
- kVp and mA vary according to patient size
- X-ray beam directed lingual to labial
- X-ray head and receptor move simultaneously in opposite directions
- Side closest to receptor is recorded, opposite blurred out of focus.
- Ghost images may be produced.

Patient Preparation

- Explain procedure
- Ask patient to remove head/neck metallic objects
  - Earrings, necklaces, facial jewelry
  - Hairpins, barrettes
  - Intraoral prostheses
  - Glasses, hearing aids
- Place panoramic style lead apron
  - Position apron high in front, low in back
  - DO NOT USE THYROID COLLAR
- Select exposure factors per patient size, stature and bone density

Sample Exposure Guide

<table>
<thead>
<tr>
<th>Patient size</th>
<th>kVp</th>
<th>mA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Child ≤ 6 years</td>
<td>60</td>
<td>4</td>
</tr>
<tr>
<td>Child 7-12 years</td>
<td>62</td>
<td>5</td>
</tr>
<tr>
<td>Adult female, small male</td>
<td>64</td>
<td>6</td>
</tr>
<tr>
<td>Adult male</td>
<td>68</td>
<td>7</td>
</tr>
<tr>
<td>Large adult male</td>
<td>70</td>
<td>9</td>
</tr>
</tbody>
</table>

Other factors

- Obese, large boned, dense bone Increase kVp Increase mA
- Frail, small boned, edentulous Decrease kVp Decrease mA

Gail F. Williamson, RDH, MS & Edwin T. Parks, DMD, MS
Patient Positioning

- Patient sits or stands with straight spine
- Front teeth end-to-end in bite piece groove
- Clinician aligns the head
  - Midsagittal plane perpendicular to floor
  - Frankfort or occlusal plane parallel to floor
  - Anteroposterior plane aligned with landmark

Pre-exposure Instructions

- Patient Instructions
  - Swallow and press your tongue against the roof of your mouth
  - Close your lips around bite piece
  - Close your eyes
  - Hold completely still!

Panoramic Errors

Slumped Cervical Spine
- Creates a pyramid or column-shaped radiopacity in midline
- Partially obscures anterior
Correction
- Instruct patient to sit or stand tall
- Place chin rest at patient's chin level

Midsagittal Plane Error

Rotated
- Side turned toward receptor is narrowed; side toward x-ray source is widened
- Severe overlapping of teeth, especially premolars
- Teeth, condyles, rami are not uniform in width
Correction
- Center the midsagittal plane and align it perpendicular to floor

Midsagittal Plane Error

Tilted
- Side tilted toward receptor is narrowed, side toward x-ray source is widened
- Occlusal plane and lower border of the mandible appear crooked
- One condyle higher than the other condyle
Correction
- Center midsagittal plane & align perpendicular to floor

Occlusal Plane Error

Chin up
- Maxillary teeth, nasal cavity and condyles are blurred and widened
- Hard palate is superimposed over maxillary teeth roots
- Occlusal plane appears flat or frowned
- Condyles projected off the sides of image
Correction
- Lower chin down so occlusal plane is parallel to floor
Occlusal Plane Error

- Chin down
  - Lower teeth are widened and foreshortened
  - Hyoid bone superimposed over the mandible
  - Condyles cut off top of image
  - Occlusal plane has grin appearance
- Correction
  - Raise chin so occlusal plane is parallel to floor

Anteroposterior Errors

- Too far forward
  - Anterior teeth are blurred and narrowed
  - Severe overlapping of teeth especially premolars
  - Spine superimposed over each ramus
- Correction
  - Move patient toward x-ray source
  - Teeth end-to-end in bitepiece groove
  - Align anatomic landmark

Anteroposterior Errors

- Too far backward
  - Anterior teeth are blurred and widened
  - Excessive ghosting of ramus and spine
  - Image larger than receptor
- Correction
  - Move patient toward the receptor
  - Teeth end-to-end in bitepiece
  - Align anatomic landmark

Patient Preparation Errors

- Metallic artifacts
  - Failure to ask patient to remove objects in head and neck region
  - Improper lead apron placement
- Correction
  - Instruct patient to remove glasses, jewelry, prostheses
  - Place apron high in front and low in back

Patient Preparation Errors

- Tongue
  - Tongue instruction not given or not followed
  - Palatoglossal air space occurs when tongue not against palate
- Movement
  - Patient not capable of remaining still
  - Patient not instructed to remain still
- Correction
  - Give specific patient pre-exposure instructions

Exposure Errors

- Density – overall degree of darkness or blackness
  - Low density – too light
    - Underestimation of patient size/stature
    - Correction - Increase kVp and mA settings
  - High density – too dark
    - Overestimation of patient size/stature
    - Correction - Decrease kVp and mA settings
Exposure Errors

- Incomplete exposure – Button let go before entire cycle completed; produces a partial image
- Correction – Hold button down until receptor and x-ray source stop rotation

Exposure Errors

- Receptor resistance
  - Alternating black and white lines caused by irregular movement
  - Receptor rubs against or is stopped by the patient’s shoulder
- Correction
  - Raise entire unit
  - Tell the patient to relax shoulders down
  - Adjust handholds to avoid shoulder contact

Gail F. Williamson, RDH, MS
- Professor Emerita of Dental Diagnostic Sciences
- Department of Oral Pathology, Medicine and Radiology
- Indiana University School of Dentistry
- gwilliam@iu.edu

Edwin T. Parks, DMD, MS
- Professor Emeritus of Dental Diagnostic Sciences
- Department of Oral Pathology, Medicine and Radiology
- Indiana University School of Dentistry
- edparks@iu.edu