What’s New in Radiology
Including What You Forgot
Part 2

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Afternoon Objectives

The participant will be able to:
• Describe basic principles and techniques involved in digital radiography.
• Evaluate claims, enhancements and diagnostic tools in digital radiography.
• Understand advanced imaging modalities and their role in dentistry.
• Apply advanced imaging for diagnostic tasks in dentistry.

2012 Dental Products Report

Digital Radiography Survey
• 77% of respondents had a digital radiography system in their practice (58% in 2010, 25% in 2005)
• 40% of those who did not have digital system planned to purchase one by year’s end (21% in 2010, 18% in 2005)
• Most influential factors affecting purchase:
  – Pricing and financial options
  – Image quality
  – Patient comfort
  – Staff apprehension

Dental Care Delivery

• ~ 156,000 dentists in the US
• ~ 70% generalists, 30% specialists
• 67% in solo practice
• dentistry ~5% of healthcare expenditures
• 2/3 of the population have at least one dental visit/year
• dentist = owner, manager, clinician, CIO (or all of the above)

Source: Titus Schleyer, DMD, PhD

Computerization in General Practice

Storage of Patient Information

Source: Titus Schleyer, DMD, PhD

Reasons For Not Going Digital

• Cost
• Status of Technology
• Inadequate Infrastructure
• Age of Clinician
• Expected number of practice years

Cost

• Short term vs. long term gain
• Cost of film, chemistry, staff time
• Cost of disposing of chemistry
• Increase in patient acceptance—they can finally see what we are talking about

Cost of a Full Mouth Series

<table>
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<tr>
<th></th>
<th>Film</th>
<th>Chemistry</th>
<th>Process (15 minutes)</th>
<th>Mount (2 minutes)</th>
<th>Total</th>
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<td>3.34 (10 minutes)</td>
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<td>PSP replacement 4.00</td>
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<td>Total</td>
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Costs Continued

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Status of Technology

• Leading edge or bleeding edge?
• Who's the beta site? You are!
• Will sensors get smaller?
• Will sensors get thinner?
• Will sensors get less expensive?
• Is rigid sensor technology the end of the road?

Pixels and Your Practice

• Assess Your Capacity For Change
• Assess the Radiographic Needs of Your Practice
• Determine How System(s) will be used
• Assess Infrastructure
• Staff Preparedness
Assess Radiographic Needs

• Patient Demographics
• Frequency of Procedures
  – Endodontics
  – Implants
  – Emergencies
  – Surgery
• Intraoral/Extraoral

Determine System Use

• Will every image be digital?
• Selected procedures?
• Different systems for different patients?
• Different systems for different clinicians?

Assess Infrastructure

• Existing Radiographic Equipment
• Computer and Network Capabilities
• Existing Software

Radiographic Equipment

• 60 to 70 kVp
• 5 mA or less
• DC vs. AC
• Accurate timer to allow 0.01 exposure increments
• Collimation
  – Smaller is better
  – Rectangular preferred over round

Computer & Network Capabilities

• Local vs. Network
• Hard Wired vs. Wireless
• Other peripherals
• RAM
• Storage
• Output

Computer Monitor

• Size
• Location
• Pitch (resolution)
• Contrast Ratio
Existing Software

- Practice Management Software
- Competing Image Platforms
- Integration vs. compatibility
- Playing well with others
- Upgrades

Interpretation Considerations

- Caries
  - Black or white
  - Film
    - Shoulder
    - Toe
  - Digital
    - Linearity
    - Partial Volume Averaging
    - Exposure
      - Tooth
      - Patient
      - Enhancement

EVALUATING ENHANCEMENTS

Zoom
Pseudo Color Enhancement
Measurement
Image Inversion
Density/Contrast Enhancement
Flash Light

Bells and Whistles

- Zoom
- Pseudo Color Enhancement
- Measurement
- Image Inversion
- Density/Contrast Enhancement
- Flash Light
- Weight Loss
- Parallel Parking

Pseudocolor Enhancement

- Gray Scale Images
- I love the colors!!!!
- What does color mean?
- Feng Shui
- Rainbow Color Table
- Temperature Color Table
Pseudocolor

Measurement

Image Inversion

Density/Contrast Manipulation
- Density changes can border on disease creation
- Image Contrast Vs Subject Contrast
- Don’t forget about kVp

Flashlight

Diagnostic Tools
- Automatic Caries Diagnosis
- Detection of Alveolar Bone Loss or Gain
- Digital subtraction techniques
  - Technique used to detect subtle changes between two images of the same structures taken at different times
  - Subtracted image – displays only the differences
  - Early detection of bone loss and caries
  - Requires registration or nearly identical images

• Histogram Equalization in a small region of interest (ROI)
Automated Caries Detection

• Not as easy as pushing a button
• Remember that pesky third dimension
• Can’t use absolute density difference as caries determinant
• BL width of incisor vs. molar
• Have to evaluate relative density difference

Quantify Bone Loss/Gain

• Determination of bone level is as good as your vertical angulation
• Exposure/processing variables
• Is the change real or does the chemistry need to be changed?
• Image registration
• Internal standard
• Hydroxyapatite step-wedge

Digital Subtraction Radiography

• Longitudinal assessment of periodontal disease and therapeutic measures
• Periapical bone changes
• Implant bone loss
• Caries progression or regression

Staff Radiographic Skills

• Technical skill competency
• Problem-solving skills
• Rigid sensor placement
  – Requires better technique than film
• Patient comfort issues
• Use of sensor holding devices

Principle-Based Technique

1. Good film-based skills
2. Understand paralleling technique parameters
3. Understand principles of bisecting angle technique
4. Instrumentation recommended
5. Know how to identify and correct errors

Staff Computer Skills

• Level of computer literacy
• Office efficiency - determined by the computer skills of your most computer phobic employee
• Practice Makes Perfect – provide time for staff to learn system and imaging software
Intraoral Digital Receptors

- Direct Sensors – Wired or Wireless
  - Charge-Coupled Device (CCD)
  - Complimentary Metal Oxide Semiconductor (CMOS)
  - Area arrays - pure silicon chip with an active area divided into a 2-D array
  - Solid-state circuitry
  - Converts x-ray/light energy into electrical energy

Rigid Receptors

- Each pixel in the array = electron well
- Incoming light or x-rays interact with the silicon and create an electrical charge in each well or pixel
- Total charge in each individual pixel is proportional to the energy striking the detector.

Direct Digital Imaging

- Bypasses the Darkroom
- Bypasses ADC
- Lower Patient Exposure
- Patient Acceptance
- Image Enhancement
- Ease of Storage and Transmission

Disadvantages

- Cost
- Receptor Life Span
- Receptor Size
- The Wire
- Diagnostic Utility
- More Retakes

Photostimulable Phosphor Plates

- Emulsion side stores latent image
  - Europium-activated barium fluorohalide
- Plates are flexible and thin like film
- Require a laser scanner to digitize the image
- Image displayed on monitor like direct rigid sensor systems
- Erase plates with light before reuse

Phosphor Plate Advantages

- No Wire
- Handle Similar to Film
- Lower Patient Exposure
- Greater Dynamic Range
- Image Enhancement
- Ease of Storage and Transmission
Phosphor Plate Disadvantages

- Available in all film sizes but not by all manufacturers
- Need separate plate for each projection
- Scratching or bends produces image artifacts
  - Replacement considerations
- Processing step required
- Delayed processing or white light exposure may degrade image quality
- Careful infection control

Digital Imaging Technique

- Patient preparation is the same as film-based imaging
  - Position patient and explain procedure
  - Place lead apron and thyroid collar
  - Remove facial and intraoral metallic objects
  - Set exposure factors – consider patient size as adjustments may be necessary

Digital Imaging Technique

- Software familiarity is critical
  - Create patient file
  - Select and prepare sensor & holder
  - Prepare unit for imaging
  - Know steps to acquire and save images
  - Program sequence

Common Errors

- Vertical angulation
  - Foreshortening
  - Elongation
- Horizontal angulation
  - Overlapped contacts
  - Widened structure
- Cone cuts
  - Central ray not centered
  - White zone of non-exposure
- Receptor placement
  - Intended structures not recorded
  - Apical areas cut off
- Phosphor plate
  - Elongation
  - Scratched emulsion
  - Bend or crimp artifacts
  - Produce permanent artifacts and plate replacement
- Retakes undermine exposure reduction

Extraoral Digital Radiography

- Linear array detector – extraoral imaging
  - Requires a scanning motion
  - Examples:
    - Cephalometrics
    - Tomography
    - Panoramic radiograph
  - Phosphor plate systems can be used as well as CCD systems
  - Technical skills are the same as film-based imaging

Panoramic Errors

- Digital panoramic imaging does NOT eliminate technical errors
  - Patient preparation
  - Patient positioning
  - Patient instruction
  - All are important
- Processing errors eliminated and some exposure errors
Service and Support

- Ask about the what ifs...
  - What if the system crashes?
  - What if the sensor dies?
  - What if I have a problem I cannot solve?
- Who provides the service?
  - Who, what, when and how?
  - How long do I have to wait for help?
- Support might be a chat room

Training

- What comes with the system?
- Is training with a human being or is it cyber-training?
- Is once enough?
- Is it an additional cost?
- Watching a demo is not enough!

Upgrades

- Necessary Evil
- Factor into cost of doing business
- Don’t do your upgrade at 7:59 am
- Could be bugs that crash your system

Warranties

- Read the fine print
- Many common problems are not covered by the warranty
  - Run over the cable—not covered
  - Defects on phosphor plates—not covered
  - Wireless sensor in trash—not covered
- Consider rider on office policy for uncovered items

Smooth Transition

- Commit to the change
- Do your homework
  - Talk to other digital offices
  - Attend CE or meetings
- Make an informed choice
- Involve staff in decision-making
- Respect the learning curve
- Schedule training time
  - Learn software
  - Receptor differences from film
  - Adjust the routine
  - Practice run before going live
  - Schedule light the 1st day or so

Summary

- Educate yourself and select system best for your practice
- Image quality is dependent on exposure, placement, technique
- Clinician needs to be able to trouble-shoot basic image problems
- Read the scientific literature on DR
- Check on
  - Training programs
  - Service and support
  - Warranties
ADVANCED IMAGING

Computed Tomography (CT)
Cone Beam CT (CBCT)
Magnetic Resonance Imaging (MRI)

Computed Tomography
- Combines electronic imaging and cross-sectional radiography
- Images produced by x-ray exposure of electronic sensors positioned opposite to x-ray source and moving in unison around long axis of patient in 360° scan
- Advantages
  - Can be reformatted into other planes and 3D
  - Depicts subtle differences in tissue densities more effectively than film

Axial View

Resolution
- Poor Spatial Resolution 15 lp/cm
  - Dental film 20 lp/mm
  - Determined by pixel size/slice thickness
- Contrast resolution

CT Number aka HU

<table>
<thead>
<tr>
<th>Substance</th>
<th>HU</th>
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<tbody>
<tr>
<td>Air</td>
<td>-1000</td>
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<tr>
<td>Lungs</td>
<td>-200 to -860</td>
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<tr>
<td>Fat</td>
<td>-100</td>
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<tr>
<td>Omentum</td>
<td>-25</td>
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<tr>
<td>Water</td>
<td>0</td>
</tr>
<tr>
<td>Fat</td>
<td>-5 to +10</td>
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<tr>
<td>Fluid</td>
<td>0 to +125</td>
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<tr>
<td>Tumor</td>
<td>20 to +100</td>
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<tr>
<td>Blood (fluid)</td>
<td>±60 to ±60</td>
</tr>
<tr>
<td>Blood (labeled)</td>
<td>±60 to ±75</td>
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<tr>
<td>Blood (skull)</td>
<td>±10 to ±15</td>
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<tr>
<td>Brain</td>
<td>±20 to ±40</td>
</tr>
<tr>
<td>Muscle</td>
<td>±35 ± ±50</td>
</tr>
<tr>
<td>Gallbladder</td>
<td>±5 to ±30</td>
</tr>
<tr>
<td>Liver</td>
<td>±80 to ±70</td>
</tr>
<tr>
<td>Aorta</td>
<td>±35 to ±50</td>
</tr>
<tr>
<td>Bone</td>
<td>±150 to ±1000</td>
</tr>
<tr>
<td>Meta</td>
<td>±2000 to +4000</td>
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Hounsfield Units (HU)
- -1000 to +4000
- Converted to gray scale
- Provide contrast resolution
- Allow for windowing and leveling

Windows and Levels

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<thead>
<tr>
<th>CT examination</th>
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<th>Center (level)</th>
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<tr>
<td>Brain</td>
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<td>50</td>
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<tr>
<td>Skull</td>
<td>3500</td>
<td>500</td>
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<td>Orbits</td>
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<tr>
<td>Abdomen</td>
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<td>35</td>
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<tr>
<td>Liver</td>
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<td>45</td>
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<tr>
<td>Mediastinum</td>
<td>325</td>
<td>50</td>
</tr>
<tr>
<td>Lung</td>
<td>2000</td>
<td>-500</td>
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<tr>
<td>Spinal cord</td>
<td>400</td>
<td>50</td>
</tr>
<tr>
<td>Spine</td>
<td>2200</td>
<td>400</td>
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</table>
**Cone Beam CT**

**Conventional CT vs. CBCT**

- Image Acquisition
- Voxel size (isotropic vs. anisotropic)
- Hounsfield Units
- Soft tissue
- Dose
- Cost

**CBCT PROCESS**

**EFFECTIVE DOSE COMPARISON**

- **i-CAT 8.5 second scan:** 31 uSv
  - Exposure is in “Pulsed” mode, actual exposure time is about 3.5 seconds for a 8.5 second scan
- **i-CAT 5 second scan:** 20 uSv
- **Daily background:** 8 uSv
- **Panoramic (Average):** 10-15 uSv
  - Digital Panoramic: 6.7 – 14.9 uSv
  - Highest Vibe Pan: 36 uSv
- **Full mouth series:** 150 uSv
- **Medical CT:** 1200-3300 uSv*

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**Risk vs. Benefit**

- Photons Don’t Care
- What do you need to see?
  - Volume
- How well do you need to see it?
  - Resolution

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*Dr. Stuart White, Dept. of Radiology, UCLA

Dr. Sharon Brooks, Dept. of Radiology, University of Michigan
**High Resolution; Small FOV**

- **NewTom3G**
  - **Full (12") FOV**
  - **Effective Dose in uSv**: 4.3
  - **Technique**: Effective Dose in terms of % annual per capita background dose
  - **Dose as multiple of single Panoramic Dose (ICRP 1990)**
  - **Dose in terms of % medical CT equivalent**

- **NewTom3G - chin tilt & Thyroid Shield**
  - **Effective Dose in uSv**: 2.1

- **CBCT**
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  - **Technique**: Effective Dose in terms of % medical CT equivalent

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<td>2.1</td>
<td>CBCT</td>
<td>2.1</td>
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**Low Resolution; Large FOV**

- **NewTom3G**
  - **Full (12") FOV**
  - **Effective Dose in uSv**: 4.3
  - **Technique**: Effective Dose in terms of % annual per capita background dose
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**IMAGING STRATEGY**

- **X-Low**: 0.3 mm³ 6-8 cm FOV 5 Sec
- **Low**: 0.3-0.4 mm³ 17 cm FOV 8 Sec
- **Medium**: 0.3 mm³ 13 cm FOV 8 Sec
- **High**: 0.25 mm³ 13 cm FOV 28 Sec
- **X-High**: 0.2 mm³ 6-8 cm FOV 28 Sec

**CBCT**

- The CBCT software allows for reformatting and viewing the image data from any point of view in straight or curved planes and in 3D

- These stacks can be displayed and viewed in a series of 2D cross-sections by sequentially paging through them in orthogonal planes (sagittal, axial and coronal) and this is called multiplanar reformatting (MPR)
Applications

- Implant
- TMJ
- Pathology
- Trauma
- Growth and Development
- Airway Assessment
- Pre-surgical Planning
- Forensics

Magnetic Resonance Imaging

- Electromagnets surround patient and produce a strong magnetic field
- Hydrogen atoms align in response to magnetic field
- Alignment disrupted producing distinctive radio frequency that transformed into image data
- Superior for imaging soft tissue
- RO/RL areas opposite to film-based images

Indications

- Soft Tissue Alterations
- Disc Displacement
- Joint Effusion

Contraindications

- Ferrous Metal Prostheses
  - Vascular clamp
  - Surgical plates
  - Eastern European alloy
- Metallic Foreign Bodies
- Claustrophobia
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