2017 Oregon Dental Conference®
Course Handout

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Course 8173: “CBCT Imaging: Principles, Clinical Applications and Interpretation”
Saturday, April 8
8 am - 4 pm
Outline

- What is computed tomography?
- What are the differences between cone beam CT and multidetector CT?
- CBCT parameters that affect image quality
  - Exposure
  - Field of view

Computed Tomography

- Take multiple projections from several angles
- Transmission data (attenuation) is reconstructed to produce a sectional image
Computed Tomography

- Multi-detector CT (Multi-slice CT)
- Cone Beam CT

Multi-slice CT (MDCT)
- Uses a fan-shaped beam to acquire multiple slices
- Configurations vary from 16- to 320-slices

Cone-Beam CT

CBCT vs. MDCT

<table>
<thead>
<tr>
<th></th>
<th>CBCT</th>
<th>MDCT</th>
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</thead>
<tbody>
<tr>
<td>Spatial Resolution</td>
<td>Typically higher</td>
<td>Lower</td>
</tr>
<tr>
<td>Soft tissue details</td>
<td>Poor</td>
<td>Very good</td>
</tr>
<tr>
<td>Radiation dose</td>
<td>Typically lower</td>
<td>Higher</td>
</tr>
<tr>
<td>Cost</td>
<td>Lower</td>
<td>Higher</td>
</tr>
</tbody>
</table>
Resolution

- Spatial Resolution
  - Ability to distinguish or separate objects that are close together
- Contrast Resolution
  - Ability to distinguish objects that have different x-ray attenuation

Factors that affect CBCT spatial resolution

- Image acquisition: 180° vs. 360°
- Image reconstruction filters
- Detector
  - Pixel size
    - In current CBCT units, detector pixel size varies from approximately 0.076mm (76 microns) to 0.4mm (400 microns)

What influences contrast resolution?

- Image reconstruction filters
- Scatter radiation
- Exposure settings (kvp, mA)

Scatter Radiation

- "Cone" Beam Geometry
- "Fan" Beam Geometry (for single-shot)
Artifacts

- “Beam-hardening” artifacts around metal
- Partial volume averaging

CBCT Imaging

- CBCT does NOT refer to a single imaging protocol
  - Image quality impacts diagnostic efficacy
  - Anatomical coverage
  - Radiation dose considerations

For example ...

- CBCT can be used to detect subtle vertical root fractures
  - Yes, but this refers to limited CBCT and not large FOV

Fields of View

- Limited: <5 cm
- Medium: 5 – 15 cm
- Large: >15 cm
### CBCT: Field of View

<table>
<thead>
<tr>
<th>FOV</th>
<th>Radiation dose</th>
<th>Anatomic coverage</th>
<th>Spatial Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limited</td>
<td>↓</td>
<td>↓</td>
<td>↑</td>
</tr>
<tr>
<td>Medium to Large</td>
<td>↑</td>
<td>↑</td>
<td>↓</td>
</tr>
</tbody>
</table>

### FOV & Resolution

- 6" FOV
- 9" FOV
- 12" FOV
- 4 cm FOV

### Setting Exposure Modes
- Rotation Arc: 180° vs. 360°
- Hi-Speed, Hi-Res modes

### Adjusting x-ray exposure
- Adjust kVp and mA depending on the patient size, anatomical area, tissue thickness
Protocol Optimization

- What is my diagnostic task?
- What anatomic coverage do I need?

Clinical Applications CBCT

<table>
<thead>
<tr>
<th>Application</th>
<th>Limited FOV</th>
<th>Medium FOV</th>
<th>Large FOV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Implant planning</td>
<td>***</td>
<td>***</td>
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</tr>
<tr>
<td>Teeth &amp; periodontal structures</td>
<td>***</td>
<td>*</td>
<td>---</td>
</tr>
<tr>
<td>Impacted teeth</td>
<td>***</td>
<td>*</td>
<td>---</td>
</tr>
<tr>
<td>Maxillofacial trauma</td>
<td>***</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td>Orofacial trauma</td>
<td>***</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td>Craniofacial assessment</td>
<td>***</td>
<td>*</td>
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<tr>
<td>TMJ Evaluation</td>
<td>***</td>
<td>*</td>
<td>*</td>
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<tr>
<td>Paranasal sinuses</td>
<td>***</td>
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</tbody>
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Outline: Radiation Risks

- Doses from diagnostic dento-maxillofacial imaging
  - Units
- Risks from dentomaxillofacial imaging
  - Considering risks in the selection process
  - Communicating risks to patients

Absorbed Dose

- Measure of energy imparted by radiation to matter
- Measure of energy absorbed by an object

- rad (radiation absorbed dose): 100 ergs/gm
- Gray (Gy): 1 joule/kg
- 1 Gy = 100 rads
Effective Dose

- Used to estimate risk due to radiation exposure
- Corrects for sensitivity of a tissue or organ to radiation
- Effective dose = Equivalent dose × Tissue weighting factor

- Sievert, rem
  - Gonads 0.2
  - Red bone marrow 0.12
  - Thyroid 0.05
  - Skin 0.01

Risk from diagnostic radiography

Risk vs. Benefit

Sources of Radiation

Natural = 3.1 mSv/yr
Manmade = 3.1 mSv/yr

Dental Radiographic Exams

Average daily background radiation
Doses from dental radiography

<table>
<thead>
<tr>
<th>Radiographic Procedure</th>
<th>Median dose (µSv)</th>
<th>Equivalent background radiation (days)**</th>
</tr>
</thead>
<tbody>
<tr>
<td>panoramic</td>
<td>20</td>
<td>2</td>
</tr>
<tr>
<td>full-mouth series</td>
<td>177</td>
<td>10</td>
</tr>
<tr>
<td>CBCT: Small FOV (≤ 8 cm)</td>
<td>47</td>
<td>4</td>
</tr>
<tr>
<td>CBCT: Medium FOV (8 - 15 cm)</td>
<td>98</td>
<td>12</td>
</tr>
<tr>
<td>CBCT: Large FOV (&gt; 15 cm)</td>
<td>117</td>
<td>14</td>
</tr>
<tr>
<td>NDD, multidetected</td>
<td>913</td>
<td>107</td>
</tr>
<tr>
<td>NDD, abdomen</td>
<td>4000</td>
<td>706</td>
</tr>
<tr>
<td>Air travel, 5-hour flight</td>
<td>25</td>
<td>3</td>
</tr>
<tr>
<td>Daily background radiation</td>
<td>8</td>
<td>1</td>
</tr>
</tbody>
</table>

* Median effective doses: standard exposure protocols reported in the literature.
** Calculation of background equivalent dose is based on an annual exposure of 3.1 mSv. The background equivalent dose is rounded to the nearest whole number.

Reducing patient dose from CBCT
- Selection criteria
- Machine
- FOV
- Exposure factors
- Dose reduction must not compromise diagnostic image quality
- The ALARA Principle
  - As low as reasonably achievable

Radiation-induced neoplasia
- What is the evidence that radiation causes cancer?
- How does radiation cause cancer?
- What are the clinical implications?

Radium Dial Painters
Osteosarcomas
Recommendation 1

- Intraoral radiographs should be considered the imaging modality of choice in the evaluation of the endodontic patient
Recommendation 2

• Limited FOV CBCT should be considered the imaging modality of choice for diagnosis in patients who present with contradictory or non-specific clinical signs and symptoms associated with untreated or previously endodontically treated teeth.

What is the evidence?

• Accurate diagnosis
  – Intraoral radiographs: 36% - 40%
  – CBCT: 76% - 83%
• CBCT assesses length and density of filling material and presence of periapical lesions better than periapical radiographs
• CBCT is more sensitive and specific than intraoral radiography for detection of additional/Accessory canals

What is the evidence?

• CBCT imaging has the ability to detect periapical pathosis before it is apparent on 2D radiographs
  – Periapicals 20% vs. CBCT 48%
• Preoperative factors such as the presence and true size of a periapical lesion play an important role in endodontic treatment outcome
• Persistent pain: Odontogenic vs. non-odontogenic causes
Recommendation 3

• Limited FOV CBCT should be considered the imaging modality of choice for initial treatment of teeth with the potential for extra canals and suspected complex morphology, such as mandibular anterior teeth, and maxillary and mandibular premolars and molars, and dental anomalies.

Recommendation 4

• If a preoperative CBCT has not been taken, limited FOV CBCT should be considered as the imaging modality of choice for intra-appointment identification and localization of calcified canals.
Recommendation 5
• Intraoral radiographs should be considered the imaging modality of choice for immediate postoperative imaging.

What is the evidence?
• Identification of anatomical variants is key to successful endodontic disinfection and obturation.
• CBCT has higher sensitivity and specificity than periapical radiographs for identification of MB2 canals.

Recommendation 6
• Recommendation 6: Limited FOV CBCT should be considered the imaging modality of choice if clinical examination and 2D intraoral radiography are inconclusive in the detection of vertical root fracture.

What is the evidence?
• CBCT had high sensitivity and specificity for detection of VRF (88% and 75%, respectively).
  – In vivo and in vitro studies
• In non-surgical re-treatment, the presence of a VRF significantly decreases prognosis.
Recommendations 7 & 8

- Limited FOV CBCT should be the imaging modality of choice when evaluating the non-healing of previous endodontic treatment to help determine the need for further treatment, such as non-surgical, surgical or extraction.
- Limited FOV CBCT should be the imaging modality of choice for non-surgical re-treatment to assess endodontic treatment complications, such as overextended root canal obturation material, separated endodontic instruments, and localization of perforations.

Recommendation 9

- Limited FOV CBCT should be considered as the imaging modality of choice for presurgical treatment planning to localize root apex/apices and to evaluate the proximity to adjacent anatomical structures.

Special Conditions: Implants

- Recommendation 10: Limited FOV CBCT should be considered as the imaging modality of choice for surgical placement of implants.

Traumatic Injuries

- Recommendation 11: Limited FOV CBCT should be considered the imaging modality of choice for diagnosis and management of limited dento-alveolar trauma, root fractures, luxation, and/or displacement of teeth and localized alveolar fractures, in the absence of other maxillofacial or soft tissue injury that may require other advanced imaging modalities.
Resorptive Defects

- Recommendation 12: Limited FOV CBCT is the imaging modality of choice in the localization and differentiation of external and internal resorptive defects and the determination of appropriate treatment and prognosis.

Internal/External Resorption

Outcome Assessment

- Recommendation 13: In the absence of clinical signs or symptoms, intraoral radiographs should be considered the imaging modality of choice for the evaluation of healing following nonsurgical and surgical endodontic treatment.
- Recommendation 14: In the absence of signs and symptoms, if limited FOV CBCT was the imaging modality of choice at the time of evaluation and treatment, it may be the modality of choice for follow-up evaluation. In the presence of signs and symptoms, refer to Recommendation #7.
Summary of Position Statement

- The guidance in this statement is not intended to substitute for a clinician’s independent judgment in patient care. The use of limited FOV CBCT should be considered on a case-by-case basis, with due consideration given to the risks and benefits of exposing the patient to ionizing radiation, the patient’s history, clinical findings and preexisting radiographs so that superior treatment can be provided to the general public in need of endodontic care.

Implant Treatment Planning

- Bone volume
- Bone quality
- Relationship to anatomical structures
- Anatomical variants
- Implant alignment
  - Adjacent teeth
  - Alveolar ridge

Bone quantity & quantity

Buccal Plate Perforation

Dehiscence

Sinus Complications
Normal TMJ

- Shape/size
- Articular cartilage
- Sclerosis/flattening/erosion/subcondral cyst formation
- Concentric condylar position

Osteoarthritis

Clinical Cases

- Incidental findings
- Anatomic variants
- Cysts and neoplasms
- TMJ abnormalities
- Fibro-osseous lesions
- Osteonecrosis of the jaws
- Airway
- Endodontic disease