Pediatric Oral and Maxillofacial Radiology: Where are we?

Juan F. Yepes DDS, MD, MPH, DrPH
Medical Institutional Review Board Vice-chair
Councilor for Academy Affairs, American Academy of Oral and Maxillofacial Radiology
Pediatric Dentistry Resident
University of Kentucky Colleges of Medicine and Dentistry
Lexington, KY USA

jfyepe2@email.uky.edu

San Diego 2012
AAPD Annual Session
May 24 – 27, 2012
Come Sea for yourself.
General Objective

The purpose of this presentation is to provide an overview of the most recent advances in the field of oral and maxillofacial radiology and how they affect directly and indirectly our children.
Outline

1. Radiation Safety in Children
2. CBCT
3. Interpretation of CBCT
Disclaimer

I do not have any affiliation with any commercial company. My only interest is exclusively academic and for the benefit of PATIENTS, residents, students, Faculty, and dentists.

Juan F. Yepes DDS, MD, MPH, FDS RCSEd, DrPH
Patient history
Physical Exam
Laboratory
Consults
Radiology

Introduction

Diagnosis
Introduction
Radiation....Who cares?

People in the Sun

(Edward Hopper 1882-1967)
Smithsonian American Art Museum
Radiation....Who cares?

Photos by GEORGE STEINMETZ and Google images
Radiation....Who cares?

www.webmd.com/melanoma-skin-cancer/slideshow
Worries Mount Over Excessive CAT Scans
Concerned About Radiation, More Doctors Seek Curbs
341 Scans in 18 Months

By Heather Won Tesoriero, The Wall Street Journal,
1346 words
Nov 2, 2006

There haven't been any studies that directly examined whether people who had multiple CT scans went on to develop cancer. But as the number of CT scans has climbed, some doctors have started to take notice of individual patients who have received multiple scans that place their total radiation doses at levels near or beyond those of some survivors of the nuclear attacks on Japan in World War II. Residents of Hiroshima and Nagasaki received a mean dosage of 20 millisieverts, a measurement of radiation exposure, although the bomb survivors received all the radiation at once, which is thought to be riskier, and the type of radiation was different from the X-rays used in modern medical scans. According to a managed-care database, one patient received 341 CT scans over an 18-month period, bringing the radiation exposure to 992.24 millisieverts. Several other patients received more than 100 CT scans.

“374 CT scans in 1 year → 992 mSv / year”

3.6 mSv annual dose
Radiation Worries For Children in Dentist’ Chairs

CBCT increases productive and generate more profit

Dosimetry

Equivalent dose (Ht): it is used to compare the biological effects of different types of radiation to a tissue or organ.

It is the sum of the products of the absorbed dose (Dt) averaged over a tissue or organ and the radiation weighting factor (Wr) → depends on the type of radiation

\[ Ht = \sum Wr \times Dt \]

IS Unit → Sievert (Sv)
Traditional unit → rem → 1 Sv = 100 rem
Sources of Radiation Exposure

- Natural: 83% (3 mSv/year)
- Artificial: 17% (0.6 mSv/year)

3.6 mSv/year

Cosmic
Terrestrial
Internal
- radon
- Ingestion of food: 2.4 mSv
# Radiation Safety and Protection

<table>
<thead>
<tr>
<th>Examination</th>
<th>Effective Dose (mSv)</th>
<th>Equivalent background radiation (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Intraoral</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Posterior BW (F-speed) (rectangular collimation)</td>
<td>0.005</td>
<td>0.6</td>
</tr>
<tr>
<td>FMX (rectangular c.) FMX (round collimation)</td>
<td>0.035 0.171</td>
<td>4 21</td>
</tr>
<tr>
<td><strong>Extraoral</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Panoramic Cephalometric</td>
<td>0.009-0.026 0.003-0.066</td>
<td>1-3 0.5-1</td>
</tr>
<tr>
<td>CBCT I-CAT® (extended view)</td>
<td>0.235</td>
<td>29</td>
</tr>
<tr>
<td>CT Head</td>
<td>2</td>
<td>243</td>
</tr>
</tbody>
</table>

Background radiation: 3.6 mSv / year
Radiation Safety and Protection

Thyroid

- Intraoral – full mouth survey with round collimation is 0.94 mSv; (3 months) the same study with rectangular collimation results in a dose of 0.26 mSv (1 month)

- Panoramic Radiograph $\rightarrow$ 0.11 mSv   CBCT $\rightarrow$ 0.24 mSv (29 days)
Limitations of Two-Dimensional X-rays

2D images can give an incomplete picture.

With the X-ray source in this position, we see that the figure is holding a banana (we cannot see that she is also holding a pineapple).
CBCT vs. CT

Is there a “real” difference?
Conventional C.T.
History behind 3D Imaging

• CT was invented in 1972

• Dr. Godfrey Hounsfield of EMI labs, Nobel prize of Medicine 1979 (London, UK)

• Dr. A.R. Comrack, Nobel Prize of Medicine 1979 (Tufts University, Boston)

• First CT scanner 1974
Siretom® 1974
Somatom® 1976

Somatom® sensation 16 2002
Ultra-fast CT scan

2006

Courtesy Dr. Axel Ruprecht, University of Iowa Hospital and Clinics
Computer Tomography

- CT scanner consists of a radiographic tube that emits a finely collimated, fan-shaped x-ray beam directed to a series of scintillation detectors or ionization chambers.

- Depending on the scanner’s mechanical geometry, both the radiographic tube and detectors rotate around the patient.

  - Incremental scanners
  - More recently “spiral or helical” scanners
Computer Tomography

• A CT scanner consist of radiographic tube that emits a finely collimated, fan-shaped x-ray beam directed to a series of scintillation detectors or ionizing chambers.
Computer Tomography

• The CT image is a digital image, reconstructed by computer, which mathematically manipulates the transmission data obtained from multiple projections.

• The CT image is recorded and displayed as a matrix of individual blocks called voxels (volume elements).

• For image display, each pixel (6 per voxel) is assigned a CT number representing density.
Computer Tomography

This number is proportional to the degree to which the material within the voxel has attenuated the x-ray beam.

That number represents the absorption characteristics.

Hounsfield units $\rightarrow -1,000$ to $+1,000$
Computer Tomography

X-ray

Detector

Signal

Digitize

Analyzed by a mathematical algorithm → Reconstructed
Computer Tomography

Analyzed by a mathematical algorithm → Reconstructed

Digitize

Detector

X-ray

Detector
Computer Tomography
Cone Beam Computer Tomography (CBCT)
Cone Beam Computer Tomography (CBCT)

Historical development

• Arai et al → 1998 Develop a CT scan for dental use
  - Ortho-CT

• 2 years after the first image, the device was used in approximately 2,000 cases

• The cassette (traditional extraoral radiology) was replaced with an imaging intensifier → Improving resolution and lowering the dose

• 2000 → The technology was transfer to J.P. Morita ®

Computed Tomography (CT)

Traditional CT uses a very narrow, fan beam that rotates around the patient acquiring one thin slice (image) with each revolution.

To image a section of anatomy, many rotations must be completed—which means higher radiation exposure.
With Cone Beam Computed Tomography, the entire volume is acquired in a single pass around the patient...

Resulting in much less radiation exposure!
Cone Beam Computer Tomography (CBCT)
Anatomical Planes

The **Sagittal** Plane slices through the anatomy from front to back.

The **Coronal** Plane slices through the anatomy from side to side.

The **Axial**, or Transverse Plane, slices perpendicularly through the anatomy.
**Cone Beam Computer Tomography (CBCT)**

<table>
<thead>
<tr>
<th>X-ray beam limitations</th>
<th>Collimation to the area of interest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Image Accuracy</td>
<td>Isotropic voxels (equal in all dimensions)</td>
</tr>
<tr>
<td></td>
<td>0.4mm to 0.125 (Accuitomo ®)</td>
</tr>
<tr>
<td>Rapid scan time</td>
<td>10-70 seconds</td>
</tr>
<tr>
<td>Dose Reduction</td>
<td>0.135mSv → 98% less than CT</td>
</tr>
<tr>
<td></td>
<td>(22 panoramic films)</td>
</tr>
<tr>
<td></td>
<td>(Accuitomo®: 1.5 inches → 0.02 → 3 panoramic)</td>
</tr>
<tr>
<td>Full mouth series</td>
<td>0.013-0.1 mSv</td>
</tr>
<tr>
<td>Panoramic Film</td>
<td>0.006mSv(Orthoplus®)</td>
</tr>
<tr>
<td>CT (maxilla and mandible)</td>
<td>2.1mSv</td>
</tr>
<tr>
<td>(15 CBCTs)</td>
<td></td>
</tr>
</tbody>
</table>

ICRP 1990 (2007 → 0.9 conversion factor)
CBCT systems available in the market
Cone Beam Computer Tomography (CBCT)

Systems Available (partial list)

• NG i-CAT®
• NewTom 3G and VG®
• Mercuray ® (Hitachi Corporation)
• 3DX - Accuitomo® (J. Morita Corporation)
• Iluma ® (Imtec Imaging from 3M)
• Galileos ® (Sirona Dental Systems)
• Picasso Trio ® (E-Wood Technology, USA)
• Planmeca Promax 3D
• Genoray®
• Kodak
• PreXion 3D
• CBCT from Instrumentarium Dental Inc.
• Scanora 3D ® (Sorodex) **
You want to buy CBCT: What are the key questions to ask?

• Insurance companies and dental codes. (fee for service vs. insurance)

• CBCT is considered in some countries a medical device → dental assistants are not allowed to perform examinations.

• Additional fee to pay for the interpretation service

• Maximum FOV: Oral surgery and Orthodontist vs. General Practitioner

• Ability to collimate to a shorter FOV that is sufficient for the diagnostic task.

• Spatial resolution: between 0.3mm and 0.4mm (no less than 0.3mm)

• Images storage and deliver to the referrals.
Performing and interpreting diagnostic CBCT
Performing and Interpreting Diagnostic CBCT

1. **Use of CBCT**

- CBCT should be performed only by an appropriate licensed practitioner or certified radiology operator.
- CBCT examinations should be performed only for valid diagnostic or treatment reasons and with minimum exposure necessary for adequate image quality.

- Inferior alveolar canal
- Inferior wall maxillary sinus
- Trauma
- Pathology
Performing and Interpreting Diagnostic CBCT

2. Practitioner responsibilities

- It is the responsibility of the practitioner obtaining the CBCT images to interpret the findings of the examination. (biopsy → Pathology report)

- The practitioner who operates a CBCT unit, must examine the entire dataset. (knowledge of anatomy, anatomic variations, abnormalities)

- Misconception → user has not responsibility for radiological findings beyond those needed for a specific task (implants for example)

- Radiation safety and operation
Performing and Interpreting Diagnostic CBCT

3. Radiation safety and quality assurance

- Facilities operating CBCT should have specific policies and procedures for dose optimization. (custom examination protocols, FOV, use of personal protective devices)

- Quality control program

4. Documentation

- Documentary evidence should be provided to demonstrate the diagnostic treatment guidance need of CBCT examination.

- Data storage

### EADMFR Basic Principles on the use of Cone Beam CT

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CBCT examinations must not be carried out unless a history and clinical examination have been performed</td>
</tr>
<tr>
<td>2</td>
<td>CBCT examinations must be justified for each patient to demonstrate that the benefits outweigh the risks</td>
</tr>
<tr>
<td>3</td>
<td>CBCT examinations should potentially add new information to aid the patient’s management</td>
</tr>
<tr>
<td>4</td>
<td>CBCT should not be repeated 'routinely' on a patient without a new risk/benefit assessment having been performed</td>
</tr>
<tr>
<td>5</td>
<td>When accepting referrals from other dentists for CBCT examinations, the referring dentist must supply sufficient clinical information (results of a history and examination) to allow the CBCT Practitioner to perform the Justification process</td>
</tr>
<tr>
<td>6</td>
<td>CBCT should only be used when the question for which imaging is required cannot be answered adequately by lower dose conventional (traditional) radiography</td>
</tr>
<tr>
<td>7</td>
<td>CBCT images must undergo a thorough clinical evaluation ('radiological report') of the entire image dataset</td>
</tr>
<tr>
<td>8</td>
<td>Where it is likely that evaluation of soft tissues will be required as part of the patient’s radiological assessment, the appropriate imaging should be conventional medical CT or MR, rather than CBCT</td>
</tr>
<tr>
<td>9</td>
<td>CBCT equipment should offer a choice of volume sizes and examinations must use the smallest that is compatible with the clinical situation if this provides less radiation dose to the patient</td>
</tr>
<tr>
<td>10</td>
<td>Where CBCT equipment offers a choice of resolution, the resolution compatible with adequate diagnosis and the lowest achievable dose should be used</td>
</tr>
<tr>
<td>11</td>
<td>A quality assurance programme must be established and implemented for each CBCT facility, including equipment, techniques and quality control procedures</td>
</tr>
<tr>
<td>12</td>
<td>Aids to accurate positioning (light beam markers) must always be used</td>
</tr>
</tbody>
</table>
Performing and Interpreting Diagnostic CBCT

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>All new installations of CBCT equipment should undergo a critical examination and detailed acceptance tests before use to ensure that radiation protection for staff, members of the public and patient are optimal.</td>
</tr>
<tr>
<td>14</td>
<td>CBCT equipment should undergo regular routine tests to ensure that radiation protection, for both practice/facility users and patients, has not significantly deteriorated.</td>
</tr>
<tr>
<td>15</td>
<td>For staff protection from CBCT equipment, the guidelines detailed in Section 6 of the European Commission document ‘Radiation Protection 136. European Guidelines on Radiation Protection in Dental Radiology’ should be followed.</td>
</tr>
<tr>
<td>16</td>
<td>All those involved with CBCT must have received adequate theoretical and practical training for the purpose of radiological practices and relevant competence in radiation protection.</td>
</tr>
<tr>
<td>17</td>
<td>Continuing education and training after qualification are required, particularly when new CBCT equipment or techniques are adopted.</td>
</tr>
<tr>
<td>18</td>
<td>Dentists responsible for CBCT facilities who have not previously received ‘adequate theoretical and practical training’ should undergo a period of additional theoretical and practical training that has been validated by an academic institution (University or equivalent). Where national specialist qualifications in DMFR exist, the design and delivery of CBCT training programmes should involve a DMF Radiologist.</td>
</tr>
<tr>
<td>19</td>
<td>For dento-alveolar CBCT images of the teeth, their supporting structures, the mandible and the maxilla up to the floor of the nose (e.g. 8cm x 8cm or smaller fields of view), clinical evaluation (‘radiological report’) should be made by a specially trained DMF Radiologist or, where this is impracticable, an adequately trained general dental practitioner.</td>
</tr>
<tr>
<td>20</td>
<td>For non-dento-alveolar small fields of view (e.g. temporal bone) and all craniofacial CBCT images (fields of view extending beyond the teeth, their supporting structures, the mandible, including the TMJ, and the maxilla up to the floor of the nose), clinical evaluation (‘radiological report’) should be made by a specially trained DMF Radiologist or by a Clinical Radiologist (Medical Radiologist).</td>
</tr>
</tbody>
</table>
Radiographic Interpretation

1. Radiolucent (hypodense) / Radiopaque (hyperdense) / Mix

2. Well defined / ill defined / mix

3. Corticated / Non corticated / partial

4. Size / shape

5. Effects in the bone / teeth

6. Location

7. Differential Interpretation
Juan F. Yepes DDS, MD, MPH, DrPH
jfyepe2@email.uky.edu