What does a busy dental practitioner and the dental team need to know about radiation safety?

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Disclaimers

I do not have any affiliation with any commercial company. My only interest is exclusively academic and for the benefit of PATIENTS, residents, and ALL members of the dental team.

All clinical pictures were authored by myself unless otherwise listed on the slide.

Patients and/or parent consent was received for all photos and radiographs.
Dental Radiation Exposure in Children: Are we in Front of an Epidemic of Overexposing Children?

Radiation Safety

1. Radiation safety summary: Why we care about radiation in children?

2. Guidelines of prescription of radiographs in children: ADA and AAPD

3. Are we overexposing children? what we know and what we would like to know

4. Final remarks and QA

Definition of epidemic

1. affecting or tending to affect a disproportionately large number of individuals within a population, community, or region at the same time

2. excessively prevalent

3. characterized by very widespread growth or extent; of, relating to, or constituting an epidemic the practice had reached epidemic proportions

Merriam-Webster Dictionary
1. Radiation safety – dosimetry summary: Why we care about radiation in children?

The Alliance for Radiation Safety in Pediatric Imaging
- Coalition of health care organizations dedicated to providing safe, high quality pediatric imaging worldwide
- Primary goal: To raise awareness in the imaging community of the need to adjust radiation dose when imaging children

Diagnosis
- Patient history
- Physical exam
- Radiology
- Consults
- Laboratory
Population case-control study: almost 2,800 subjects, aged 20 to 79.

Subjects were asked to recall their frequencies of dental radiographic examinations during four age periods: younger than 10 years of age, between 10 and 19, 20 and 49, and older than 50.

The researchers reported an increased risk of meningioma in individuals who received bitewing radiographs on one or more occasions per year in all age groups. (OR=2)

Subjects who received a panoramic film were reported to be an increased risk for meningioma (OR=4.9) if exposed under 10 years of age.

No increased risk of meningioma was noted for subjects who received panoramic film over the age of 10 or a full mouth series of intra-oral radiographs at any age.

Radiation... Who cares?

Antepartum dental radiography and Infant low birth weight

Potential mothers
Chronic exposure to radiation (stochastic)
Develop subclinical hypothyroidism
Get pregnant
Delivery babies with LBW

Is concern about risks from diagnostic imaging justified?

- From 1.5% to 2% of all cancers in the United States may be attributable to the radiation from CT studies.
- CT procedures per year (U.S.)
  - But, dental radiographic doses are much lower than medical imaging doses, right?
Let’s review the basic concepts in radiation biology......

Radiation biology ➔ Radiation Protection ➔ Dosimetry

Radiation Biology

It is the study of the effects of ionizing radiation on living systems.

Ionizing radiation ➔ Tissues ➔ Modification of biological molecules ➔ Alterations in cells (time?) ➔ Injury or death.

Radiation Biology

x ray

An electromagnetic radiation of great penetrating power, produced by the bombardment of a substance (usually a heavy metal) by a stream of high velocity electrons, usually in a vacuum tube. The wavelength is usually less than 2 Å.
Production of the X-ray

Interactions of X-Rays with matter (tissue)

1. Coherent scattering
2. Photoelectric absorption
3. Compton effect (scattering)

Additionally 9% of the primary photons pass through the patient without interaction.

Compton Scattering

Compton absorption occurs when an incident photon interacts with an outer electron, producing a scattered photon of lower energy than the incident photon is ejected from the target atom.

Scattered photons travel in all directions.

30% of the scattered photons formed during a dental x-ray exposure exit the patient head.

In dental radiology approximately 60% of the photons undergo Compton scattering.

Why children are more radiosensitive?

Radiosensitivity and Cell Type

"Bergonie and Tribondeau 1906"

Most radiosensitive cells

1. Cells with a high mitotic rate
2. Those cells who undergo many future mitosis
3. Cells with very primitive differentiation
Why children are more radiosensitive?

**Deterministic effects**
- The response is proportional with the magnitude of the dose
- Example: effects of radiation therapy in the mouth

**Stochastic effect**
- The response is proportional with the frequency of the dose

- Biologic effects of x-rays

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<table>
<thead>
<tr>
<th>Cancer Type</th>
<th>Estimated New Cases</th>
<th>Estimated Deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bladder</td>
<td>60,960</td>
<td>13,540</td>
</tr>
<tr>
<td>Breast (Female - Male)</td>
<td>200,750 - 2,880</td>
<td>40,000 - 430</td>
</tr>
<tr>
<td>Esophagus and Esophageal Gland</td>
<td>60,240</td>
<td>6,890</td>
</tr>
<tr>
<td>Gastrointestinal</td>
<td>90,310</td>
<td>6,790</td>
</tr>
<tr>
<td>Kidney (Renal Cell and Renal Pelvis) Cancer</td>
<td>63,920</td>
<td>13,860</td>
</tr>
<tr>
<td>Leukemia (All Types)</td>
<td>52,380</td>
<td>24,090</td>
</tr>
<tr>
<td>Lung (Including Bronchus)</td>
<td>224,210</td>
<td>159,260</td>
</tr>
<tr>
<td>Melanoma</td>
<td>76,100</td>
<td>9,710</td>
</tr>
<tr>
<td>Non-Hodgkin Lymphoma</td>
<td>70,800</td>
<td>18,990</td>
</tr>
<tr>
<td>Pancreatic</td>
<td>46,420</td>
<td>39,590</td>
</tr>
<tr>
<td>Prostate</td>
<td>233,000</td>
<td>29,480</td>
</tr>
<tr>
<td>Thyroid</td>
<td>62,980</td>
<td>1,890</td>
</tr>
</tbody>
</table>

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Using statistical models for analysis, rates for new thyroid cancer cases have been rising on average 4.5% each year over the last 10 years.

Using statistical models for analysis, rates for new female breast cancer cases have been stable over the last 10 years. Death rates have been falling on average 1.9% each year over 2004-2013.
Why children are more radiosensitive?

“If one uses the revised recommendations for calculating effective dose……

dental radiographic procedures are 30% to 429% riskier than previously thought.”

Ludlow JB, et al JADA 2008; 139(9): 1237-1243

Sources of Radiation Exposure

Natural Radiation → Cosmic Sources

Subatomic particles and photons from the sun.

It is primarily a function of altitude.

Orlando (82 ft.): 0.24 mSv/Year

Denver (5,280 ft.): 0.50 mSv/Year

Indianapolis (715 ft.): 0.28 mSv/Year

Exposure resulting from airline travel

5 hours Flight: 0.025 mSv

Radiation Safety and Protection

Terrestrial Sources

External Radiation: Radioactive nuclei in the soil, primarily potassium 40 and the radioactive decay products of uranium 238, and thorium 230 (0.7 mSv/Year)

Radon is a decay product in the uranium series. It is responsible of 52% of the radiation exposure of the world’s population (0.2 mSv/Year).

Radon is a GAS attached to dust particles → LUNGS

Other Internal: Ingestion of uranium
Juan Yepes DDS, MD, MPH, MS, DrPH:
Integrating Radiation Safety into Your Dental Practice

Radiation Safety and Protection

Man-Made Radiation ➔ Medical Diagnosis and Treatment

Well over one billion medical x-ray examinations are performed annually worldwide.

Consumer and Industrial Products

Domestic water supply, tobacco products, combustible fuels, dental porcelain, television receivers, pocket watches, smoke alarms, and airport inspection systems.

Sources of Radiation Exposure

- Natural
  - By natural radiation
  - 3.6 mSv / year
- Artificial
  - By radon
  - 2y (0.6 mSv / year)
- Cosmic
  - By cosmic radiation
  - 83% (3 mSv / year)
- Terrestrial
  - By terrestrial radiation
  - 17% (0.6 mSv / year)
- Ingestion
  - By ingestion of food
  - 2.4 mSv / year

Radiation Safety and Protection

Effective Dose from Diagnostic Radiology and equivalent background

<table>
<thead>
<tr>
<th>Examination</th>
<th>Effective Dose [mSv]</th>
<th>Equivalent Background Radiation [days]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intraoral</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Posterior BW (F-speed)</td>
<td>0.000</td>
<td>0.0</td>
</tr>
<tr>
<td>FMX (rectangular collimation)</td>
<td>0.005</td>
<td>0.02</td>
</tr>
<tr>
<td>FMX (round collimation)</td>
<td>0.035</td>
<td>0.171</td>
</tr>
<tr>
<td>CBCT I-CAT® (extended view: 16 x 13 cm)</td>
<td>0.063</td>
<td>0.263</td>
</tr>
<tr>
<td>CBCT Accuitomo® 170 (small view: &lt;40 cm²)</td>
<td>0.028</td>
<td>0.106</td>
</tr>
<tr>
<td>CBCT Kodak 9000 3D (small view: &lt;40 cm²)</td>
<td>0.016</td>
<td>0.066</td>
</tr>
<tr>
<td>CBCT I-CAT® Next generation (medium view: 9 x 7 cm)</td>
<td>0.063</td>
<td>0.263</td>
</tr>
<tr>
<td>CT Head</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

Background radiation: 3.6 mSv / year
Intraoral Radiographic Imaging: A Study Comparing Collimation and Thyroid Shielding Methods on a Pediatric Phantom Patient

<table>
<thead>
<tr>
<th>Units: (μSv)</th>
<th>Rectangle w/TC</th>
<th>Round w/TC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bone Marrow</td>
<td>0.0</td>
<td>0.4</td>
</tr>
<tr>
<td>thyroid</td>
<td>0.3</td>
<td>1.2</td>
</tr>
<tr>
<td>esophagus</td>
<td>0.0</td>
<td>0.1</td>
</tr>
<tr>
<td>skin</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>bone surface</td>
<td>0.2</td>
<td>2.1</td>
</tr>
<tr>
<td>Salivary glands</td>
<td>6.0</td>
<td>40.0</td>
</tr>
<tr>
<td>lens of eyes</td>
<td>0.6</td>
<td>1.0</td>
</tr>
<tr>
<td>Pituitary</td>
<td>1.2</td>
<td>3.7</td>
</tr>
<tr>
<td>Effective Dose</td>
<td>0.2</td>
<td>1.3</td>
</tr>
</tbody>
</table>

Radiation Safety and Protection

Digital Imaging → DOSE REDUCTION

Practitioners and manufacturers frequently use the reduction of the radiation dose that the patient receives as a reason to implement digital radiography. There are several reasons why the dose reduction is not as large as often suggested:

- The dose reduction compared with F-speed film is somewhere between 0 to 50% (**phosphorous plate carry the risk of higher exposure than conventional films)
- Increase in the number of radiographs made. Several studies indicate that the decision to make a radiograph is reached more easily with a digital system
- Increase in the number and ease of remakes

NCRP Report 145
Radiation Protection in Dentistry
December, 2003

Pg. 21: "Rectangular collimation of the x-ray beam shall be routinely used for periapical radiography"
Radiation Safety and Protection

Handheld X-Ray System

A handheld portable dental intraoral x-ray system is available in the United States and elsewhere.

The system is designed to minimize the user's radiation dose.

It includes specially designed shielding of the x-ray tube housing and an integral radiation shield to minimize backscatter.

The doses for the handheld systems are significantly less than for wall-mounted systems.

The average monthly dose for the handheld systems is 0.28 μSv vs. 7.86 μSv (deep dose equivalent) for the wall-mounted systems.

Consequently, there should be no concern about the use of this handheld dental intraoral x-ray system.

Additional shielding efforts (e.g., wearing a lead apron) will not provide significant benefit nor reduce staff radiation dose.

Radiation Safety and Protection

Panoramic Bitewings

He goes on to list six reasons why dental practitioners should consider using a panoramic x-ray system for bitewings:

1. Better patient acceptance
2. Easier for the dentist and staff
3. Faster
4. More diagnostic... (Text cut off)
5. Less radiation exposure
6. Better infection control

"There are literally no downsides to this," said XXXXX, the district sales manager for XXXXX.

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Guidelines of prescription of radiographs in children: ADA and AAPD
Why we take radiographs?

Diagnosis of caries

Evaluate bone

Evaluate growth and development

Your own reason

Abnormal findings on 10,000 panoramic films

Background: Caries and periodontal disease are the most prevalent conditions in the oral cavity. However, these are not the only diseases that can affect the maxillofacial complex. There is no strong epidemiological data from panoramic films on conditions other than caries and periodontal disease.

Objective: To determine the prevalence of abnormal findings on 10,000 digital panoramic radiographs.

Materials and Methods: Radiographs of patients over 18 years of age with an acceptable degree of distortion and quality were collected and analyzed.

Results: The majority of panoramic films were of women, with an average age of 39 years. Edentulism was the most common finding, followed by the presence of root canals and impacted teeth.

Significance: This study confirms that partial edentulism, as a consequence of caries and periodontal disease, is the most common oral finding on panoramic films.
Justification for Imaging

Patient selection criteria is the MOST significant factor influencing per capita dose

Justification for Imaging

Professional Guidelines for use of radiation in dentistry (2012 ADA Council of Scientific Affairs)

- This recommendations are subject to clinical judgment and may not apply to every patient.
- They are to be used by dentist ONLY after reviewing the patient's health history and completing a clinical examination.
- Even though radiation exposure for dental radiographs is low, once a decision to obtain radiographs is made, it is the dentist responsibility to follow the ALARA principle to minimize radiation exposure.

Justification for Imaging

- Little evidence to support radiographic exposure of all edentulous areas of the oral cavity.
- Clinical evaluation + Combined selected periapical radiographs can result in a 43% reduction in the number of films without a clinical consequential increase in the rate of undiagnosed disease.
- ADA and FDA developed guidelines for the selection of patients for dental radiographic examination.

Revised 2012
Justification for Imaging

Radiographs must be limited to the areas required for adequate diagnosis and treatment based on professional judgment.

Dentist should not prescribe routine radiographs at preset intervals for all patients.

For new or referred patients, clinicians should obtain recent dental radiographs from the patient's previous dental health care provider.

Dental radiographs may be prescribed for pregnant patients with careful adherence to the radiation safety protocols.

Dentist should prescribe dental radiographs only after clinical evaluation.

Patient Selection Criteria

Clinical situations for which radiographs may be indicated include, but are not limited to:

1. Previous periodontal or endodontic treatment
2. History of pain or trauma
3. Family history of dental anomalies
4. Postoperative evaluation of healing
5. Remineralization monitoring
6. Presence of implants

Recommendations for Prescribing Dental Radiographs

Child with transitional dentition (after eruption of first permanent tooth)

New patient: Individualized radiographic exam consisting of posterior bitewings with panoramic exam or posterior bitewings and selected periapical images.

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Justification for Imaging
Recommendations for Prescribing Dental Radiographs

Positive clinical signs / symptoms
1. Clinical evidence of periodontal disease
2. Large or deep restorations
3. Deep cavities
4. Clinically impacted teeth
5. Swelling
6. Evidence of dental / facial trauma
7. Mobility of teeth
8. Sinus tract
9. Clinical suspected sinus pathosis
10. Growth abnormalities
11. Positive neurologic symptoms in head and neck
12. Clinical tooth erosion
13. Unexplained bleeding

CBCT in Pediatric Dentistry

3D Imaging for Pediatric Dentistry: Potential Risks and Diagnostic opportunities

The introduction of intraoral digital imaging in the late 1980s and dental cone beam CT in the late 1990s ushered in a paradigm shift in oral and maxillofacial radiology.

Both of these methodologies promise enhanced diagnostic potential with integration into the digital office but they bring with them their own set of challenges and concerns.
3D Imagining for Pediatric Dentistry: Potential Risks and Diagnostic opportunities

We take for granted that volumetric imaging provide us with more information, but......

There is at this point little evidence for improved diagnostic efficacy over alternative radiographic examinations.

3D Imagining for Pediatric Dentistry: Potential Risks and Diagnostic opportunities

Clinical Recommendations Regarding Use of CBCT in Orthodontics
Position statement by the AAOOMR

"...there is not clear evidence to support the routine use of ionizing radiation in standard orthodontic diagnosis and treatment planning including the use of CBCT"
3
Are we overexposing children? what we know.....
and what we would like to know
How difficult (or easy) is to know that?

Prescription of panoramic radiographs in children: A health services assessment of current guidelines
Yepes JF, Powers E, Hamilton T, Downey T, Eckert G. Maupome G IU and P&R

Objectives

• Compare PR prescribing patterns for pediatric patients between general dentists (GPs) and pediatric dentists (PDs).
• Examine if clinicians are practicing according to the ADA/AAPD radiographic guidelines.
Materials and Methods

- Retrospective study
- Patient ages 18 years old and younger
- Data user agreement made with P&R Dental Strategies, LLC
- IRB approval #1508885495

Results

- 448,880 total procedure codes
- 81,699 pediatric patients
  - 97.8% of those who received a PR had only one
- Overall percentage of patients receiving PRs during routine care was 7.54%.
  - 7.64% for GPs
  - 7.43% for PDs
- The highest percentage by age was seven for PDs and 17 for GPs, though both had relative peak percentages at both ages.

1. There was generally good adherence to the guidelines.
2. General dentists prescribe PRs more frequently during routine care at earlier patient ages than recommended in the guidelines.
3. Pediatric dentists prescribe a higher percentage of PRs around the typical age of eruption of the first permanent molar, which correlates to the guidelines.
4. The percentage of PRs by age shows a difference in prescription trends between GPs and PDs.
5. Outliers !!!!
Patterns of Dental Radiographs Usage in a Commercial Insurance Population of Children

Objectives
The purpose of this study were to evaluate the differences in number and type of dental radiographs used between 3 age groups (0-5, 6-12, and 13-18 years of age) by general dentist and specialist AND explore if there is a correlation between number and type of dental radiographs taken and clinical need.

Materials and Methods
- Data claims from a commercial insurance company
- 6,712,155 records from 105,010 patients and 34,406 providers
- Counts of dental radiographs and types were summarized as means, standard deviation and range by age groups and provider specialty
- Negative binomial random effect model was used to evaluate the association of the number of radiographs with the age groups and provider specialty
- A Poisson regression model was used to explore the association of number of specific radiographs types with age and provider type

Results
Although the data suggest that most clinicians adhere to suggested radiographic guidelines, there were OUTLIERS that obtained significantly high and occasionally ALARMINGLY high numbers of radiographs.

8% of the dentist prescribed 34% of the films.

General dentist had lower rate of bitewings compared with pediatric dentist in all age groups.
ALARA Principle

- Only perform imaging when there is a clear medical or dental benefit to the child.
- Use the lowest amount of radiation for adequate imaging based on the size of the child.
- Only take images on the indicated area and always using the thyroid collar.
- Avoid multiple unnecessary images (Role of digital imaging).
- Use alternative diagnostic studies, if possible.