Review Article

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Risk Considerations in Pedodontic Radiology

Ritu Jindal[1] Rohini Dua[2] Anupriya Sikri[3] Aanchal Gautam[4*]

[1]Professor and Head, Department of Pedodontics, National Dental College and Hospital, Dera Bassi, Mohali, India.
[2]Professor, Department of Pedodontics, National Dental College and Hospital, Dera Bassi, Mohali, India.
[3]Senior Lecturer, Department of Pedodontics, National Dental College and Hospital, Dera Bassi, Mohali, India.
[4]Post Graduate Student, Department of Pedodontics, National Dental College and Hospital, Dera Bassi, Mohali, India.

ABSTRACT

Background: Radiographs have been widely used in dentistry for various reasons such as diagnosis, treatment planning, during the treatment procedures and assessment of treatment outcome. The radiograph when made immediately in the dental chair is a real-time diagnostic aid. The potential for undesirable effects must be balanced against the benefits obtained from radiographs. Dentists should address the concerns of patients who question the need for radiographs and allow them to make an informed decision. The dentist should also confirm whether he/she follows all the guidelines and safety precautions of radiation safety while exposing the patient to X-rays so that the deleterious effects of X-rays can be avoided. This will be beneficial to both the patient and especially the dentists who have long term exposure to X-rays.

Keywords: Dental radiographs, deleterious effects, safety guidelines.

INTRODUCTION

Wilhelm Roentgen accidentally discovered X-rays in 1895 when he produced an unintentional radiograph of his own hand. He called the radiation 'X' because of its 'unknown' qualities. Just two weeks after Roentgen's announcement about the new 'X rays', Dr Otto Walkhoff produced the first dental radiograph – this was an extra-oral film of a patient's jaws and he used an exposure time of 25 minutes. A few months later, in early 1896, Dr C Edmund Kells, a New Orleans dentist, took the first intra-oral radiograph. Dr Kells was the first person to note problems associated with the use of X-radiation. He reported that long exposures caused a mild skin irritation which was similar to sunburn, although it vanished after a short time.[19]

HOW DOES X-RAY RADIATION DAMAGE TISSUES

X-radiation is a form of energy. The X-rays can pass through matter and disperse this energy. The effect of energy dispersion will depend on the atomic structure of the object and the energy of the beam. Soft tissues are particularly susceptible to radiation damage since they are essentially weak aqueous solutions. Radiation damage to tissue can be classed as either direct or indirect damage.

Direct damage occurs when there is a direct hit of a molecule by a photon or electron. Direct hits are likely to affect the DNA and RNA molecular bonds since their natural bond forces are only a few electron volts compared to the many thousands of electron volts produced by X-ray photons. Molecules affected in this way are unable to pass on important genetic information which results in mutilation, cell death, carcinoma or genetic abnormalities. Heat is also generated which may cause cellular changes which are usually followed by normal physiological healing processes.[1]

Indirect damage occurs when electrons hit other atoms in their pathway and cause further ionization and excitation – this creates highly reactive ionized

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***Correspondence Dr. Aanchal Gautam.**
Department of Pedodontics, National Dental College and Hospital, Dera Bassi, Mohali, India.
Email: draanchal21@yahoo.com

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molecules. Oxidation/reduction reactions occur which disrupt enzymes and nucleic acids with consequent damage to cell function and reproduction.

Discussions of radiation dose and risk should begin by defining the units of radiation measurement. The term "exposure" is often, but incorrectly, used as a synonym for "human exposure." Rather, the word "dose" should be used to quantify "human exposure." Radiation absorbed dose is measured in Gray (abbreviated Gy). A related unit, the Sievert (abbreviated Sv), is used to measure radiation dose equivalent, the product of absorbed dose (in Gy) and a quality factor that reflects the potency of a particular ionizing radiation. For x rays, the quality factor is 1, so for all intents and purposes, Gy and Sv may be used interchangeably when referring to doses from x radiation.[1]

Effective dose corresponding to oral and maxillofacial radiology examinations[‡]

	Effective Dose
Full mouth series (ANSI F speed film or PSP with round collimation)	170.7 µSv 4
Bitewing radiographs (ANSI F speed film or PSP with rectangular collimation)	5.0 µSv
Panoramic radiograph (assorted CCD-based systems)	up to 24.3 µSv
Lateral cephalometric skull radiograph with a PSP sensor	5.6 µSv
PA cephalometric skull radiograph with a PSP sensor	5.1 µSv
Cone beam CT (large field) Imaging Sciences iCAT Hitachi CB Mercuray	68 to 1073 µSv 74 (l) to 87 (p) µSv 407 (6") to 1073 (12") µSv
64 slice medical spiral	CT 860 µSv

Therefore, oral and maxillofacial radiology should be performed thoughtfully and responsibly, minimizing radiation dose to the patient, but maximizing diagnostic benefit.

RISK-BENEFIT RATIO[7]

The phrase "risk-benefit ratio" is increasingly used to indicate that there is a relationship between hazard and benefit. The relationship is developed for the purpose of making a decision. Thus radiographic examination done on the basis of few (or no indications) is far more risky than the same radiographic examination done on the basis of well-established, indicated need, even though the dose and possible harm are the same in both cases.

Harm and benefit are tangible results. Risk and justification are intangible operating principles. Neither harm nor benefit are absolutes in themselves, and human activity cannot exclusively be classed into either; rather, human activity exists in degrees somewhere between harm and benefit.

CHILDREN: SUSCEPTIBLE SUBGROUP[7]

There are biologic and technical considerations which have been mentioned here which suggest that children may represent a more susceptible subgroup in dental radiology. Block as well as Myers have pointedly demonstrated that panoramic examinations involve centers of X-ray beam rotation which are usually inside the patient, and are sites at which relatively high doses are generated. Most of the studies have been done with an adult phantom format because child size phantoms are generally not available. And since there are considerable increases in facial and head size during childhood, several different sized phantoms would be necessary in order to study panoramic dosimetry in children. Myers did study exposure in child patients, but was then, of course, limited to surface dose measurement. Relatively high skin doses, especially in the thyroid area were found. Considering that panoramic doses are higher at the rotation sites, which are likely to be inside the patient, there is reason to believe that an important hazard may exist in the use of panoramic examinations for children. More complete dosimetry measurements in various child-sized phantoms are urgently needed in order to assess the potential for harm.

THE GUIDELINES

The guidelines titled, "The Selection of Patients for X-Ray Examination" were first developed in 1987 by a panel of dental experts convened by the Center for Devices and Radiological Health of the U.S. Food and Drug Administration (FDA). The development of the guidelines at that time was spurred by concern about the U.S. population's total exposure to radiation from all sources. Thus, the guidelines were developed to promote the appropriate use of x-rays. In 2002, the American Dental Association, recognizing that dental technology and science is continually advancing, recommended to the FDA that the guidelines should be reviewed for possible updating. The FDA welcomed organized dentistry's interest in maintaining the guidelines, and so the American Dental Association, in collaboration with a number of dental specialty organizations and the FDA, published updated guidelines in 2004. This report updates the 2004 guidelines and includes recommendations for limiting exposure to radiation.[6]

These guidelines are subjected to clinical judgment and may not apply to every patient. They are to be used by dentists only after reviewing the patient's health history and completing a clinical examination. Even though radiation exposure from dental radiographs is low, once a decision to obtain radiographs is made, it is the dentist's responsibility to follow the ALARA Principle (As Low as Reasonably Achievable) to minimize the patient's exposure.[20]

TYPE OF ENCOUNTER	PATIENT AGE AND DENTAL DEVELOPMENTAL STAGE				
	Child with Primary Dentition (prior to eruption of first permanent tooth)	**Child with Transitional Dentition** (after eruption of first permanent tooth)	**Adolescent with Permanent Dentition** (prior to eruption of third molars)	**Adult, Dentate or Partially Edentulous**	**Adult, Edentulous**
New Patient* being evaluated for oral diseases	Individualized radiographic exam consisting of selected periapical/occlusal views and/or posterior bitewings if proximal surfaces cannot be visualized or probed. Patients without evidence of disease and with open proximal contacts may not require a radiographic exam at this time.	Individualized radiographic exam consisting of posterior bitewings with panoramic exam or posterior bitewings and selected periapical images.	Individualized radiographic exam consisting of posterior bitewings with panoramic exam or posterior bitewings and selected periapical images. A full mouth intraoral radiographic exam is preferred when the patient has clinical evidence of generalized oral disease or a history of extensive dental treatment.		Individualized radiographic exam, based on clinical signs and symptoms.
Recall Patient* with clinical caries or at increased risk for caries**	Posterior bitewing exam at 6-12 month intervals if proximal surfaces cannot be examined visually or with a probe			Posterior bitewing exam at 6-18 month intervals	Not applicable
Recall Patient* with no clinical caries and not at increased risk for caries**	Posterior bitewing exam at 12-24 month intervals if proximal surfaces cannot be examined visually or with a probe		Posterior bitewing exam at 18-36 month intervals	Posterior bitewing exam at 24-36 month intervals	Not applicable

Type of Encounter	Patient Age and Dental Development Stage				
	Child with Primary Dentition (prior to eruption of first permanent tooth)	Child with Transitional Dentition (after eruption of first permanent tooth)	Adolescent with Permanent Dentition (prior to eruption of third molars)	Adult, Dentate or Partially Edentulous	Adult, Edentulous
Recall Patient* with periodontal disease	Clinical judgment as to the need for and type of radiographic images for the evaluation of periodontal disease. Imaging may consist of, but is not limited to, selected bitewing and/or periapical images of areas where periodontal disease (other than nonspecific gingivitis) can be demonstrated clinically.				Not applicable
Patient (New and Recall) for monitoring of dentofacial growth and development, and/or assessment of dental/skeletal relationships	Clinical judgment as to need for and type of radiographic images for evaluation and/or monitoring of dentofacial growth and development or assessment of dental and skeletal relationships		Clinical judgment as to need for and type of radiographic images for evaluation and/ or monitoring of dentofacial growth and development, or assessment of dental and skeletal relationships. Panoramic or periapical exam to assess developing third molars	Usually not indicated for monitoring of growth and development. Clinical judgment as to the need for and type of radiographic image for evaluation of dental and skeletal relationships.	
Patient with other circumstances including, but not limited to, proposed or existing implants, other dental and craniofacial pathoses, restorative/ endodontic needs, treated periodontal disease and caries remineralization	Clinical judgment as to need for and type of radiographic images for evaluation and/or monitoring of these conditions				

Critical examination of the machine[4]: The plans for the installation of a dental X-ray set should be critically reviewed by a qualified expert to ensure that all aspects of radiation safety for both practice staff and the public. In particular, the following aspects need evaluation. Installation of the X-ray machine[5]: On installation, dental X-ray equipment should be subject to the following inspections/tests:

1. Critical examination of plans for installation from the point of view of radiation safety of staff and members of the public.

2. Acceptance test – performed prior to the equipment's use in clinical practice.

3. Routine tests – these should be performed at regular intervals.

The protection for adjacent areas[10] is essential to consider the likely consequences in terms of radiation dose to staff and members of the public in adjacent areas. Protection is often quoted in terms of the thickness of lead (usually some 0.1-1mm) required and this will be dependent on such factors as distance of the barrier from the X-ray tube, the use of adjacent area, workload etc. Alternatively lead lined plywood or plasterboard can be used to obtain the desired protection. For the average dental facility, structural protection can readily be achieved using traditional building material.

For patient and personnel exposure[10] in routine dental practice, effective dose should never exceed 1 mSv per year, which is the annual dose limit for the public. Likewise, dose to the skin of the hands should be well below the dose limit. However, in the past, incidences of deterministic damage to fingers have been reported in dentists due to the custom of holding the film in the patient's mouth, a practice that should be avoided[12]. If patient assistance is required, the assisting adult should be provided with a lead apron and positioned so that all parts of their body are out of the main beam. The dental film or detector should only be held by the patient when it cannot otherwise be kept in position. It should never be hand held by a member of the dental practice staff.

For darkroom and desktop processing units[15], routine checks should be made to ensure that darkrooms remain light tight and that safelights do not produce fogging of films. Desktop units should be similarly checked for light-tightness. This can be done using a simple 'coin' test. Routine checks should be carried out every 12 months or if any alterations to darkroom or equipment have been performed.

Room layout[15]: Consideration needs to be given to the layout of the room so that radiation safety is optimized. The room should be of adequate size to allow all staff that needs to remain within the room to position themselves outside the controlled area during exposure. It is essential that the operator of the equipment can position themselves so that they have a view of: patient, controlled area and 'X-rays on' indicator light. If the room size is limited, it might be necessary for staff to position themselves outside the room, in which case a mirror might be required to ensure that a clear view of the room is maintained. The equipment should be positioned so that the controlled area does not extend to any entrances and so that the primary beam will not be directed towards any doorways or ground floor windows. The exposure switch should be located so that that the operator cans either remain outside of the controlled area or be behind a protective screen.

Use of protective screens[16] :For low workload situations extra protection for staff is not usually required provided that the room is large enough to allow staff to stand some 2 m away from the patient. However, for high radiographic workload or very cramped location, extra protection can be provided, either in the form of protective panels for staff to stand behind or as protective aprons for staff to wear. If such protection is required it is recommended that the advice of a 'qualified expert' be sought.

For receptor selection[11] , the American National Standards Institute and the International Organization for Standardization have established standards for film speed. Film speeds available for dental radiography are D-speed, E-speed and F-speed, with D-speed being the slowest and F-speed the fastest. According to the U.S. Food and Drug Administration, switching from D to E speed can produce a 30 to 40 percent reduction in radiation exposure. The use of F-speed film can reduce exposure 20 to 50 percent compared to use of E-speed film, without compromising diagnostic quality.

Exposure of extraoral films such as panoramic radiographs requires intensifying screens to minimize radiation exposure to patients. Older panoramic equipment can be retrofitted to reduce the radiation exposure to accommodate the use of rare-earth, high-speed systems.

Digital imaging provides an opportunity to further reduce the radiation dose by 40 to 60 percent. In digital radiography, there are three types of receptors that take the place of conventional film: charge-coupled device (CCD), complementary-metal-oxide-semiconductor(CMOS), and photo-stimulable phosphor (PSP) plates.

Training and Education[9] : Where permitted by law, auxiliary dental personnel can perform intraoral and extraoral imaging. Personnel certified to take dental radiographs should receive appropriate education. Practitioners should remain informed about safety updates and the availability of new equipment, supplies and techniques that could further improve the diagnostic quality of radiographs and decrease radiation exposure. Free training materials are available for limiting radiation exposure in dental imaging through the International Atomic Energy Agency.

CONCLUSION

Dentists should conduct a clinical examination, consider the patient's oral and medical histories, as well as consider the patient's vulnerability to environmental factors that may affect oral health before conducting a radiographic examination. This information should guide the dentist in the determination of the type of imaging to be used, the frequency of its use, and the number of images to obtain. Radiographs should be taken only when there is an expectation that the diagnostic yield will affect patient care.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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