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ORIGINAL RESEARCH

Diagnostic radiation exposure in the midst of visualizing the dental tissues

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ABSTRACT
Radiology plays an important part in dental health practice; however the use of radiation as an aid to diagnosis must be balanced against the risks to both patients and dental operating staff from exposure to ionizing radiation. Although the radiation dose from an individual dental radiograph is relatively small, but when a large number of radiographs are taken means that the overall population dose is not insignificant. The international and National bodies- the International Commission on Radiological Protection (ICRP), the World Health Organisation (WHO), the International Atomic Energy Agency (IAEA) and other scientific platform recognize the importance of education and training of the staff in reducing patient doses while maintaining the desired level of quality in medical and dental exposures. Hence, this article in particular discusses the magnitude of radiation exposure encountered in dentistry, the possible risk with such exposure and the methods that can be used to attenuate exposure and decrease the radiation dosage.
Key Words: CBCT, Dental, Radiation, Radiograph

INTRODUCTION

The amount of radiation doses associated with various imaging modalities used in dental practices range from low-dose intraoral digital radiographs to higher-dose imaging using CBCT. There is an increase the risk of adverse health effects when exposed to any amount of ionizing radiation. [1]

The widespread series of nuclear disaster in Fukhushima, Japan, following the earthquake and tsunami on 11 March 2011, it is high time to think about radiation protection. Radiology is overused all over the world. According to WHO "…any attempt to limit diagnostic radiology is a complex process. Over the years radiology has become a universal diagnostic tool. Patients expect a perfect result. They have come to believe that no examination by their doctor is complete unless they have taken an X-rays." the International Commission on Radiological Protection (ICRP) has developed Effective dose (*E*) as a dose quantity with a link to risks of health detriment, mainly cancer.[2] Practitioners and radiographer who administer ionizing radiation must have the knowledge of radiation exposure encountered in medicine and dentistry, the possible risk of such exposure and the methods that can be used to attenuate exposure and decrease dosage. CBCT plays an important role in imaging modality in modern radiography. [3]Cone beam computed tomography (CBCT), is a modern advanced medical imaging modality that utilizes kV X-rays with high contrast. Unlike traditional computed tomography (CT), CBCT uses divergent X-rays, resulting in a cone-shaped beam. Practically a kV source and a flat panel imager are mounted onto the linear accelerator (LINAC) gantry in a way that they both share a common isocenter with the treatment unit. [4]

In diagnostic radiation the x-rays that are emitted from the radiographic machines are used to help us to look at calcified structures and evaluate their insides which help the clinicians in the diagnosis of a particular condition. Here the clinician / dentists or the dental radiologist deals directly with this radiation. The average dental x-ray delivers about 2 mrem. A full mouth series of dental x rays (18 intraoral films), using D and E speed film, delivers about 36 mrem[1].

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Table 1: Dental radiographs exposure

Dental radiographs exposure	(MSV)
Bitewings (4 films)	0.038
Full-mouth series (about 19 films)	0.150
Panorex (panoramic jaw film)	0.019

The effective dose of CBCT is several times higher compared with conventional dental radiography [5].According to various studies the radiation doses for a large FOV CBCT scan are 3 to 7 times greater than the radiation doses from panoramic radiographs [6]

Table 2: Effective dose of CBCT for adult patients with different FOV [7].

FOV	Effective dose for adult patients (µSv)
Large	150
Medium	120
Small	80

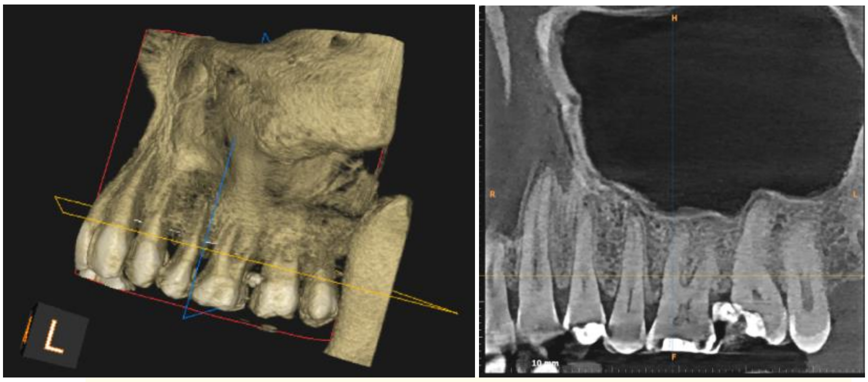

Fig 1: Cone beam computed tomography (CBCT) of left maxillary section

Fig; 2 (a) Cone beam computed tomography (CBCT) (b) OPG (c) Conventional radiography

POINTS TO BE CONSIDERED BY CLINICIAN BEFORE ADVISING RADIOGRAPHS

The clinician should provide a clear request describing the patient's problem and their clinical indicating objectives, so that the radiologist can carry out the correct X-ray examination. Before prescribing an X-ray examination the referring dental surgeon should be satisfied that the necessary information is not available, either from radiographic examinations already done, or from any other medical tests or investigations. If two or more dental imaging procedure are available that give the same desirable diagnostic information the it is important to choose the procedure that has least risk.

THRESHOLD DOSE FOR OCCUPATIONALLY EXPOSED INDIVIDUALS (RADIOGRAPHER, PRIVATE PRACTITIONERS, TECHNICIAN)

Recent studies indicate that the lifetime cancer risks associated with exposure to low levels of ionizing radiation may be greater than previously

Receiving a whole body exposure of **0.05Sv (5 rem) (50 m Sv) per year**, after the age of 18 is generally considered to present minimal risk however every effort should be made to minimise the dose to all individuals (NCRP)[2].

The formula **(N-18 X 0.05Sv), where N = age in years**, suggest that no individual under 18 years

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should be occupationally exposed to radiation. Unnecessary radiation exposure should always be avoided. This is based on the **ALARA principle (As Low As Reasonably Achievable)**, which acknowledges that even the smallest dose could potentially lead to some adverse health effects.

THRESHOLD DOSE FOR PUBLIC (NON-OCCUPATIONALLY EXPOSED INDIVIDUALS)

Relative to stochastic effects, **5 mSv annual effective dose** limit for infrequent exposure &**1mSv annual effective dose** limit for continuous exposure (NCRP)[9]

Approximately half of the average individual's radiation exposure comes from natural sources. The other half is mostly from diagnostic medical procedures. The average annual radiation exposure from natural sources in India is about 2.299 millisieverts or mSv[10]. Radon and thoron gases contribute two-thirds of this exposure, while cosmic, terrestrial, and internal radiation account for the remainder. No adverse health effects have been observedfrom radiation doses arising from these levels of natural radiation exposure. It would take 20 full series of x rays (taken with E-speed film) to equal the amount of radiation the average person is exposed from naturally occurring background sources each year that means 360 intraoral film [11]

Health Effects of Ionizing Radiations: The ICRP estimates that a single brief whole-body exposure of 1 Gy to 10,000 people results in approximately 500 additional cancer deaths over the lifetime of the exposed individuals, assuming a dose rate effectiveness factor of 2 for cancers other than leukaemia. Leukaemias are observed as a wave from 5 to 30 years following exposure.[8]

The biological effect of ionizing radiation can be extremely damaging. The effects are classified as –

- Somatic NON – STOCHASTIC effects.
- Somatic STOCHASTIC effects
- Genetic STOCHASTIC effects

Somatic Non–Stochastic effects are more prevalent at high doses of radiation, while Somatic Stochastic and Genetic Stochastic effects are significant even with low doses. The ALARA principle should be followed.

Table 3: Risk of Neoplasia and Hereditary Effects

Effect	Nominal risk per milligray
Hereditary (General)	1 in 2,50,000
Leukemia (Active bone marrow)	1 in 5,00,000
Cancers	Fatal
Breast cancer (Females)	1 in 2,00,000
Thyroid cancer	1 in 20,00,000
Lung cancer	1 in 5,00,000
Others (Combined)	1 in 20,00,000

The ICRP estimates that a single brief whole-body exposure of 1 Gy to 10,000 people results in about 500 additional cancer deaths over the lifetime of the exposed individuals [12]

Examination of Women Having Reproductive Capacity & During Pregnancy

The radiation risk to an embryo or the possibility of a woman being pregnant has to be considered in deciding whether to conduct an radiological investigation that might cause irradiation to the lower abdomen in woman of reproductive capacity. During the first 10 days following the onset of menstrual period, there is minimum radiation risk since no conception will have occurred. The radiation risks to a child who had been irradiated in-utero during the remainder of the first month following the onset of menstruation (i.e., during approx. the first two weeks after conception is likely to be so small that there need be no special limitation on x-ray examinations). Period of 18-55 days after conception is critical to organ development. Use of lead aprons is mandatory on such patients during this period.

Table 4: Irradiation In-Utero

TIME AFTER CONCEPTION	NOMINAL RISK PER MILIGRAY
First two weeks	Minimal
3rd through 8th week	Potential for malformation of organs
8th through 15th week	Severe mental retardation (1 in 2,500)
15th through 25th week	Severe mental retardation (1 in 10,000)
Throughout pregnancy	Childhood cancer (1in 50,000)

Patient Protection: Diagnostic radiation exposure in patients during dental radiography is usually reported as the amount of radiation received by target organs. The most common measurements include skin or surface exposure. Additionally, the other target organs commonly reported include the bone marrow, thyroid glands and gonads[13]

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X-rays induce biologic changes in living cells and adversely affects all living tissues. However, with the use of proper patient protection techniques, the amount of X-rays received by the patient can be minimised. These protection techniques can be used prior to, during, and after X-ray exposure.

Prior To Exposure

Patient protection measures can be employed prior to any X-ray exposure by:

- Appropriate prescribing of dental radiographs where needed.
- Proper equipment
- The dental X-ray tube head must be equipped with appropriate aluminum filters, lead collimator and position-indicating device.

The diagnostic accuracy of detailed narrow beam radiography has been reported to be significantly better than intraoralperiapical radiography for the observation of periodontal diseases and is at least as effective as periapical radiography for detecting periapical lesions according to the survey conducted by Avendanio B et al in 1996[13]

During Exposure

- Control Of Irradiation & Recording Of Time - Operating switches should be constructed such that irradiation can be terminated manually at any time
- Thyroid Collar - Radiation dose to the thyroid is considered the largest component of the effective dose in dental radiography
- Lead Apron - Although scatter radiation to the patient's abdomen is extremely low, leaded aprons should be used to minimize patient's exposure to radiation.

Fig 3: (a) Lead Apron (b) Thyroid Collar

- Fast Film - The use of faster films (E- or F-speed) is of choice because they reduce the radiation dose by more than 50 percent compared with D-speed film
- Film-Holding Devices - Receptor / Film holders that position the receptor to coincide with the collimated X-ray beam should be implemented.
- Exposure Factor Selection- The radiologist will not be able to control all the exposure factors such as the kilovoltage peak (kVp), milliamperage are preset by the manufacturer, but the time settings on the control panel can be adjusted as per the requirement. The range available in dental intra oral machine is of 65 to 70 kVp and 7 mA to 10 mA.
- Intensifying Screens & Films - Screens containing high efficiency materials require less radiation than conventional ones to provide similar image quality. The materials used are rare earths, barium, tantalum etc.
- Proper Technique - Proper technique helps to obtain a diagnostic quality of films and reduce the amount of exposure a patient receives and avoids the need to retake radiographs
- Control Of Scattered Irradiation to the Image Receptor –
  -The use of grids should be moderated. Stationary and moving grids are used in practice
  - The grid ratio should be 10:1

After Exposure

- **Proper Film Handling -** Careful handling is of the utmost importance from the time the films are exposed until they are processed.
- **Proper Film Processing -** Correct processing techniques are necessary for reproducible radiographs of optimum diagnostic value with minimum dose to the patient. Film processing should be followed as per the manufacturer recommended conditions with proper processing equipment and a darkroom with safelights. Also, an automatic processor with an appropriate safe light hood may be used
- **Darkroom practices -** Proper radiologic darkroom practices should be followed. These include maintaining a darkroom with adequate ventilation, avoiding repeated skin contact with processing chemicals and avoiding microbial contamination in handling film packets. Darkrooms should be checked routinely if there are any light leaks.

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PROTECTION FOR OPERATOR

During the dental radiography exposure the Position And Distance Rule has to be followed by the operator so as to minimize the amount of radiation dosage to the operator for which the operator should be at least 6 ft. away from source at an angle of and 90 - 135 degrees. If no barrier is available, the operator should stand at least 6 feet from the patient, at an angle of 90 to 135 degree degrees to the central ray of the x-ray beam when the exposure is made [14]

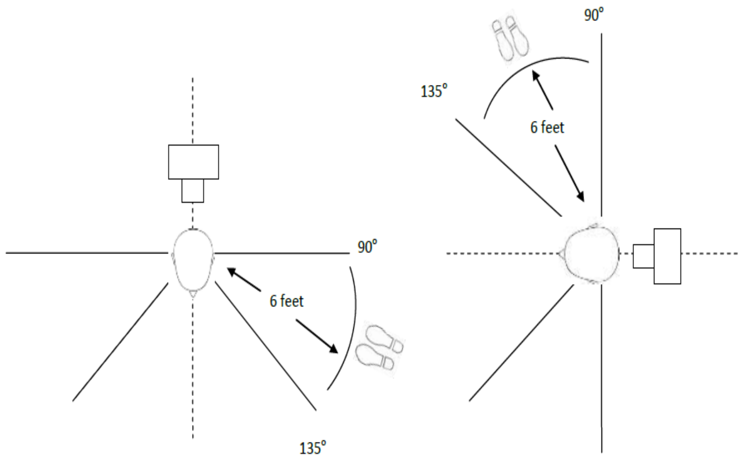

Fig 4: Position-and-distance rule.

Following procedures are important for the operator to reduce the radiation exposure:

1. Film should be never held by the operator. Film holding devices should be used
2. The operator or patients during the exposure should never be stabilized radiographic tube housing.
3. Regular monitoring Of Exposure To Personnel- TLD badges, dosimeters etc. should be available to monitor the radiation dose received by operating personnel
4. Install only those 'X-ray diagnostic equipment' which is certified to meet the design specifications stipulated by the 'Atomic Energy Act.'
5. Radiology room layout plan should meet the guidelines given by **NCRP** (National Council of radiation Protection).

Radiographic Infection Control

Diagnostic imaging has been providing valuable radiological support for diagnosis and prognosis prediction of diseases. Radiological staff, especially radiographers are among the frontline medics at high risks due to their direct and close contact with patients during working on the front line in the battle against infectious diseases like the COVID-19 outbreak. They are in direct contact with the patients, bearing the responsibility and pressure of both the infection prevention and control and the radiation protection. Raising their awareness of self-protection and receive focused training from medical institutions is an important priority [15].

Key Steps In Radiographic Infection Control -

- Apply universal precautions
- Wear gloves during all radiographic procedures
- Disinfect and cover X-ray machine, working surfaces, chair and apron
- Sterilize non–disposable instruments
- Use barrier protected film (sensor) or disposable container
- Prevent contamination of processing equipment

CONCLUSION

Although diagnostic radiation exposures from dental x-rays are minimal, still it cannot be proved that there is no possibility of a hazard to both patients and operator. Therefore, the concept of keeping the radiation exposure as low as reasonably achievable – **ALARA principles** should be applied. This recognizes the possibility that no matter how small the dose is, some stochastic effect may result.

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