10.5005/jp-journals-10048-0017

REVIEW ARTICLE

Radiation Safety: Endodontic Perspective

[1]Noble Joy Manayanipuram, [2]Prasanth Dhanapal, [3]Liza George, [4]KM Charlie, [5]Anuja Anna Cherian

ABSTRACT

Endodontists belong to the category of specialist dentists who depend much on dental radiography. Starting from the stage of disease diagnosis, radiography is of much importance in different stages of endodontic therapy, and further on radiographic evaluation is a tool for assessment of endodontic treatment. There is a heavy dependency on dental radiography in some form or other in the speciality of endodontics. As is the case with any ionizing radiation, radiation hazard is a phenomenon that matters a lot to this group of dental professionals. There needs to be a change in our attitude toward radiation safety measures, as many of our professional colleagues are seen much not to be bothered about the cumulative outcomes of radiation hazard, which can create havoc in our professional and personal lives. This article outlines the potential hazards that can happen by routine radiographic utilization in endodontic setup and tries to highlight the measures that need to be taken to mitigate the negative effects.

Keywords: Protective measures, Radiation exposure, Radiation hazards, X-ray radiation.

How to cite this article: Manayanipuram NJ, Dhanapal P, George L, Charlie KM, Cherian AA. Radiation Safety: Endodontic Perspective. Cons Dent Endod J 2017;2(1):8-11.

Source of support: Nil

Conflict of interest: None

INTRODUCTION

Dental radiographs play an irreplaceable role in conservative dentistry and endodontics. Radiographs, such as intraoral periapical radiographs (IOPARs) and bitewing radiographs made either in conventional or digital format are routinely employed in dental practice. The role of the radiographic tool starts from diagnosis and follows through all the stages of treatment and even postoperative evaluation in an endodontic practice.

Endodontists can be easily categorized as that group of dentists who are at high risk of radiation exposure given the nature of the occupation among the other dental professionals. Being the case, injudicious use of dental radiography without employment and utilization of accepted radiation precautions and protection can harm the individual in the long term, often inflicting irreparable damage to the personal and professional life.[1-3]

[1]Postgraduate Student, [2,3]Professor, [4]Reader, [5]Senior Lecturer

[1-5]Department of Conservative & Endodontics, Annoor Dental College, Muvattupuzha, Kerala, India

Corresponding Author: Prasanth Dhanapal, Professor Department of Conservative & Endodontics, Annoor Dental College, Muvattupuzha, Kerala, India, Phone: +914852815217 e-mail: prasanthdhanapal@gmail.com

An Insight into the Potential Problem

As per the standard operating protocol in contemporary endodontics, IOPARs are the radiographs preferably utilized during endodontic treatment of a teeth.[1,4] For any given treatment, four IOPARs are made at different stages of endodontics treatment, which include

- Preoperative radiograph
- Radiograph to determine the working length
- Radiograph to confirm the master cone prior to obturation
- Postoperative radiograph to confirm the treatment

In some or many cases requiring an endodontist's intervention, multiple radiographs with change in the angulation during any of the stages of the treatment due to the technical complexities may be needed in addition to the routinely used radiographs.

An IOPAR can be made in different modalities and the commonly utilized modalities are either conventional radiograph employing film-based technique or a digital radiography technique utilizing sensors. Quantitatively, under standard conditions and with usage of optimized, calibrated equipment, the radiation exposure from a single film-based IOPAR is 0.0095 mSv and a single digital IOPAR is 0.0031 mSv.[5-7]

Based on an empirical arithmetic (even though hypothetical, this following calculation is based on an unofficial, verbal survey of randomly selected 50 consultant endodontists), a busy consultant endodontist would be on an average doing five single-visit endodontic treatments per day and would be working for 300 days to the maximum. As per protocol, if all four radiographs are taken for every endodontic treatment, it accounts to 20 exposures for IOPARs per day. That adds up to 6,000 exposures per year for the busiest endodontist who follows the standard of care. The total exposure for a 1-year long work would be 57 mSv. If digital radiography is employed in all the operatory and is utilized, the exposure would be drastically reduced to 18.6 mSv.

Clinical Relevance of the Data

Ionizing radiation can have biologically damaging effects by two modes: Either by affecting the cell directly or free radicals-associated indirect effect. These effects are found to cause deoxyribonucleic acid damage.[7,8] Biological hazards of radiation can be classified based on occurrence probability into nonstochastic and stochastic effect.[9-11]

Nonstochastic or deterministic effect, wherein a determined dose above which the damaging insults start to appear. Stochastic effect where there is no deterministic dose that could lead to biological damage. High-dose ionizing radiation (X-ray) has both deterministic and stochastic effects. In contrast to lower doses, radiation hazards are primarily stochastic rather than deterministic.[12-14]

The two average exposure values can be compared with the annual limits of radiation proposed by NCRP and ICRP. An endodontist taking IOPARs with conventional film-based technology at the above quantum would cross the annual limits of radiation exposure or more so touch the upper limits of radiation exposure levels. Correlating the data, it can be suspiciously concluded that there would be a greater probability of proneness to the stochastic effects of hazardous radiations (Table 1).

Improvements in the radiation equipment and proper adherence to radiation protection measures during exposure have been effective in mitigating most of the direct radiation injury.[15,16] One of the greatest sources of radiation received by the dentist and the dental worker is by secondary radiation scattered from the patients' facial bones.[17]

The International Commission on Radiological Protection (ICRP) developed the risk/benefit concept, which recommended that all patient exposures must be justified and kept as low as possible.[18] It is a mandatory issue to follow the ALARA principle "As Low as Reasonably Achievable" during dentist routine work.[19] It has been reported in the dental literature that ALARA principles are not strictly applied in the dental field,[20,21] which can be of concern for the dental professional due to the ill effects of radiation.

The short-term effects of radiation on a tissue (effects seen in the first days or weeks after exposure) are determined primarily by the sensitivity of its parenchymal cells. When continuously proliferating tissues (e.g., bone marrow, oral mucous membranes) are irradiated with a moderate dose, cells are lost primarily by reproductive death, bystander effect, and apoptosis.[22]

The long-term deterministic effects of radiation on tissues and organs (seen months and years after exposure) are a loss of parenchymal cells and replacement with fibrous connective tissue.[22]

RISK *VS* BENEFIT OF DENTAL FILMS

The dose to the skin of the face is about 10 mGy when taking dental films using an open-ended cylinder. Therefore, a patient would have to receive 25 complete mouth radiographic series (CMRS) in a very short time to significantly increase the risk of skin cancer (Table 2).

Radiation to the lens of the eye may produce cataracts (a cloudiness of the lens). The X-ray dose associated with this problem appears to be about 2 Gy (2000 mGy). The dose to the eye from a CMRS, using an open-ended cylinder, is only about 0.6 mGy. So lens is not considered as an organ in danger.[23]

The thyroid gland is fairly resistant to radiation in the adult. However, thyroid cancer has been found in people who were exposed to a dose as low as 0.05 Gy (50 mGy) when they were children. The dose to the thyroid from a CMRS is only about 0.25 mGy. This dose to the thyroid can be further reduced by about half with the use of a thyroid collar. The use of a thyroid collar should be mandatory for children, since their thyroid tissues are more radiosensitive.[24]

Malignant changes in bone marrow may result in leukemia. There is active (blood-cell-producing) marrow in the mandible, skull, and cervical spine. About 13% of the total bone marrow lies in the head and neck areas. The dose to the bone marrow in a full-mouth series of radiographs is about 0.15 mGy. The X-ray dose associated with leukemia is about 50 mGy.

The genetic effects of radiation can have far-reaching results. However, the dose to the reproductive cells from dental radiography is very small, only about 0.005 mGy or less for males and 0.003 mGy for females. The female dose is lower because the reproductive cells are in more protected body location. If the patient wears a lead apron, exposure to the reproductive cells is virtually zero (0.000–0.0003 mGy).[14]

OPERATOR PROTECTION FROM RADIATION

People who work with radiation (that includes you) are also entitled to protection from radiation. There are exposure limits for occupationally exposed radiation workers.

Table 1: Annual limits of radiation exposure

Occupational	*NCRP*	*ICRP*
Related to stochastic effects	50 mSv	50 mSv
Related to deterministic effects	150–500 mSv	150–500 mSv

NCRP: National Commission on Radiological Protection; ICRP: International Commission on Radiological Protection

Table 2: Radiosensitivity of Different Organs

High	*Intermediate*	*Low*
Lymphoids	Vasculature	Optic lens
Bone marrow	Cartilage	Muscle
Testis	Bone	
Intestine	Salivary glands	
Mucous membrane		

The maximum permissible dose (MPD) is the dose of radiation to the whole body that produces very little chance of somatic or genetic injury. The MPD for whole-body exposure per year for occupationally exposed personnel is 0.05 Sv (5 rem). An age-based formula has also been developed as guideline for any accumulated dose (N in years).

$$MPD = (N - 18) \times 0.05 Sv/yr$$

Planning and Designing of a Safe Radiology Department

- Radiation area should be at one corner in the building such that at least two walls open to the environment.
- One extra thickness of brick with barium plaster is a must for the walls.
- Warning board and light should be seen, when the machines are operating, at the entry.
- The barriers should have 2 mm or more of lead and it should go at least 12 inches below the ground.
- All the timers, control consoles should be kept behind the lead barriers.

Conch shell design: The operatory that contains the X-ray unit should be constructed in such a manner that it protects people in surrounding areas from radiation.

Film badge service: Is a good way to keep track of occupational exposure. Badges are worn by personnel at all times while at work, and are regularly sent to the company providing the service. Written reports of the exposure recorded on the badges are provided. If proper safety precautions are followed, no one in a dental office should receive radiation doses close to their MPD.

Lead barrier: It is preferable that the operator stands behind lead barrier while exposing films. The barrier should have a window or other means of monitoring the patient during the exposure.[25] If no barrier is available, the operator should stand at least 6 feet away from the patient and in an area that lies between 90° and 135° to the primary beam. These are areas of minimum scatter radiation.

Never hold the film or tube: Dental personnel should never hold films for patients. If assistance is necessary, ask a family member or guardian to help. Be sure to protect the helper with lead apron as well. Dental personnel should also never hold the tube head for stability.

CONCLUSION

Radiation safety has an important role in current endodontic practice. Radiation hazard is a matter that should be given much importance. Endodontists should be aware of the ill effects of radiation and methods to protect the operator as well as the patient from its harmful effects.

REFERENCES

1. Hallquist A, Hardell L, Degerman A, Wingren G, Boquist L. Medical diagnostic and therapeutic ionizing radiation and the risk for thyroid cancer: a case-control study. Eur J Cancer Prev 1994 May;3(3):259-267.
2. Preston-Martin S, Thomas DC, White SC, Cohen D. Prior exposure to medical and dental x-rays related to tumors of the parotid gland. J Natl Cancer Inst 1988 Aug;80(12): 943-949.
3. Berkhout E, Sanderink G, van der Stelt P. Digital intra-oral radiography in dentistry. Diagnostic efficacy and dose considerations. Oral Radiol 2003;19(1):1-13.
4. Horn-Ross PL, Ljung BM, Morrow M. Environmental factors and the risk of salivary gland cancer. Epidemiology 1997 Jul;8(4):414-419.
5. Little MP, Wakeford R, Tawn EJ, Bouffler SD, Berrington de Gonzalez A. Risks associated with low doses and low dose rates of ionizing radiation: why linearity may be (almost) the best we can do. Radiology 2009 Apr;251(1):6-12.
6. U.S. National Academy of Sciences, National Research Council. Committee to assess health risks from exposure to low levels of ionizing radiation. Health risks from exposure to low levels of ionizing radiation. BEIR VII Phase 2. Washington, DC: The National Academies Press; 2006.
7. White, SG.; Pharoah, MJ. Oral radiology: principles and interpretation. 5th ed. St. Louis: Mosby; 2004. p. 25-46.
8. Ribeiro DA, de Oliveira G, de Castro G, Angelieri F. Cytogenetic biomonitoring in patients exposed to dental X-rays: comparison between adults and children. Dentomaxillofac Radiol 2008 Oct;37(7):404-407.
9. United Nations Scientific Committee on the Effects of Atomic Radiation. UNSCEAR 2006 report to the general assembly, with scientific annexes. Effects of ionizing radiation. Volume I report to the general assembly, scientific annexes A and B. New York: United Nations.
10. Kuroyanagi K, Hayakawa Y, Fujimori H, Sugiyama T. Distribution of scattered radiation during intraoral radiography with the patient in supine position. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1998 Jun;85(6):736-741.
11. ICRP. Recommendations of the ICRP. ICRP Publication 26. AnnICRP 1977;1(3).
12. Kantor ML. Longitudinal trends in the use of individualized radiographic examinations at dental schools in the United States and Canada. J Dent Educ 2006;70(2):160-168.
13. Lee BD, Ludlow JB. Attitude of the Korean dentists towards radiation safety and selection criteria. Imaging Sci Dent 2013 Sep;43(3):179-184.
14. Memon A, Godward S, Williams D, Siddique I, Al-Saleh K. Dental x-rays and the risk of thyroid cancer: a case-control study. Acta Oncol 2010 May;49(4):447-453.
15. Döbrossy L. Epidemiology of head and neck cancer: magnitude of the problem. Cancer Metastasis Rev 2005 Jan;24(1):9-17.
16. Dofka, CM. Competency skills for the dental assistant. Cengage Learning; 1995.
17. Berrington de González A, Darby S. Risk of cancer from diagnostic X-rays: estimates for the UK and 14 other countries. Lancet 2004 Jan;363(9406):345-351.
18. Wingren G, Hallquist A, Hardell L. Diagnostic X-ray exposure and female papillary thyroid cancer: a pooled analysis of two Swedish studies. Eur J Cancer Prev 1997 Dec;6(6): 550-556.

19. Preston-Martin S, Bernstein L, Pike MC, Maldonado AA, Henderson BE. Thyroid cancer among young women related to prior thyroid disease and pregnancy history. Br J Cancer 1987 Feb;55(2):191-195.
20. Lin MC, Lee CF, Lin CL, Wu YC, Wang HE, Chen CL, Sung FC, Kao CH. Dental diagnostic X-ray exposure and risk of benign and malignant brain tumors. Ann Oncol 2013 Jun;24(6): 1675-1679.
21. Jemal A, Bray F, Center MM, Ferlay J, Ward E, Forman D. Global cancer statistics. CA Cancer J Clin 2011 Mar-Apr; 61(2):69-90.
22. Kai M, Luebeck EG, Moolgavkar SH. Analysis of the incidence of solid cancer among atomic bomb survivors using a two-stage model of carcinogenesis. Radiat Res 1997 Oct;148(4): 348-358.
23. Leggat PA, Chowanadisai S, Kukiattrakoon B, Yapong B, Kedjarune U. Occupational hygiene practices of dentists in southern Thailand. Int Dent J 2001 Feb;51(1):11-16.
24. Mandel ID. Occupational risks in dentistry: comforts and concerns. J Am Dent Assoc 1993 Oct;124(10):40-49.
25. Ron E. Cancer risks from medical radiation. Health Phys 2003 Jul;85(1):47-59.