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Review Article

RADIATION HAZARDS IN DENTAL OFFICE IS IT AN OCCUPATIONAL HAZARD?

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ABSTRACT

The art and science of dentistry has advanced both in treatment and in technology .Dentist are constantly under the pressure of health issues related to the profession. These can be better called as occupational hazards and these include exposure to infections, allergy, and musculoskeletal problems. The problems are curbed to certain extent by providing protective measures but there are still areas to be taken care off. One such area is dental radiology. All dental radiographs are usually taken within the dental office itself compared to medical system. Radiographs are an inseparable part of dentistry since they are of a great diagnostic value. While taking radiographs scattered radiation are produced which are harmful to humans. These scattered radiation causes genetic mutation. Hence it is important to adopt proper protective measures in a dental office, ensuring a complete protection from these scattered radiation. The principles like ALARA, laid down by apex bodies like AERB has to be followed strictly ensuring a complete protection. Radiographs when taken by following these principles pauses a low risk to the patient and with no or little risk to the dentist or dental auxiliary. Awareness regarding these occupational hazards and implementation of proper protective measures while taking dental radiographs and ethical principles can reduce the occupational hazards. There is also a need for continuing dental education programme regarding the use and principles of radiology among dentist which will enlighten them newer updates.

INTRODUCTION

Occupational hazard can be explained in terms of risk to a person usually arising out of employment. It also refers to specialized wok, a process, or situation that predisposes, or itself causes disease, in the work place. Dental profession by virtue has occupational hazards. Some are dermatitis, musculoskeletal disorder, allergies, respiratory problems and radiation hazards.[1]

The history of occupational hazard awareness can be traced back to the 18th century when Bernadino Ramazzini, the father of occupational medicine, recognized the role of occupation in the dynamics of health and diseases affecting the personals.[2] Despite the ongoing awareness among dental surgeons regarding the occupational hazards and biosafety there is a great deal of concern in dental radiology.

Biosafety in radiology department are also now a major concern. This aims at preventing, eliminating the inherent risk associated with the research and service activities rendered to patients, which may endanger the health of the concerned personnel's. In radiology department, cross infections are a major concern nowadays. Cross infections can pause a major concerns, where sterilization plays its at most importance. Since this modality does not use any invasive procedure the chance of cross infections from using different materials during the procedure should be cautioned. The importance of salivary contamination can be stressed here.3

Exposure to both ionizing and non-ionizing radiation may occur in routine dental practice. Every dental office are now equipped with all modern equipments. The x-ray machine is commonly placed in an open room in dental clinics, which may be due to many limitations. However radiographs are an integral part of clinical assessment contributing to diagnosis.[4]

The damage caused by radiation may or may not be reversible and show signs or symptoms initially depending upon the intensity of damage. The harmful effect caused are due to the production of free radicles in the body, thus causing damage to a cell directly or indirectly. These can eventually lead to lead to cancer, leukemia and even genetic damage.

Radiology has become an important tool for diagnosis in medical field. Radiographs play a vital role in dentistry in its various disciplines .The field has developed in technology and

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to date Cone Beam Computed Tomography (CBCT) Computed Tomography (CT), ortho cubic super-high resolution CT (Ortho-CT)are available for studying different oral and maxillofacial pathologies. Radiation is the emission or transmission of energy in the form of waves or particles through space or through a material medium. It may occur through particulate of electromagnetic radiation. Electromagnetic radiation is the movement of energy through space in a combination as electric and magnetic field .it is generated when the velocity of an electrically charged particle is altered. Examples are as radio waves, visible light, x-rays, and gamma radiation (γ).The type of electromagnetic radiation may be to types ionizing or nonionizing depending upon their energy or effects.

Biological effect of radiation can be put under two main categoriesas: deterministic and stochastic effects. High dose ionizing radiation (x-ray) causes both deterministic and stochastic effects. Whereas low dose of radiation leads to mainly stochastic effects.[5]Non-stochastic effects (formerly called deterministic effects) have a dose threshold above which they occur; i.e., if the equivalent deposited dose is high enough, a specified types of effects will certainly appear. Stochastic effects are those which have a high probability of occurrence when radiation dose is increased. There is no threshold for stochastic effects, since, as the term indicates, they appear in a random manner and are random in nature. The best known examples are cancer and genetic mutations All these damage are dependent upon certain parameters like, exposure (a measure of the ability of an x-ray beam), absorbed dose (quantity that expresses the amount of energy absorbed per unit mass of a material), equivalent dose (equal absorbed dose values biological damage) and effective dose. [6]

Even though the radiation dose in dental xray is minimum, the principle of ALARA ("As Low As Reasonably Achievable.") should be followed strictly to prevent a cumulative effect which can be seen after a long period of time.

Recognizing the harmful effect of radiation certain rules are laid down by National Council on Radiation Protection and Measurements (NCRP) and the International Commission on Radiological Protection (ICRP) and AERB (Atomic Energy Regulatory Board). This body strictly controls all the relevant matters concerning the radiation and its safety.[5,6]

Table 1 Total Filtration vs Tube Potential.[7]

Maximum Rated Tube Potential (kVp)	Minimum Total Filtration (mm Al)
Less than 70	1.5
70 to and including 100	2.0
Above 100	2.5

Table 2 Minimum Focus to Skin Distance Vs Tube Potential.[7]

Maximum reated tube potential	Minimum focus to skin distance
Above 60 kVp and up to and including 75 kVp	20 cm
Above 75 kVp	30 cm

no individuals will have any deterministic effects and that the probability for stochastic effects is as low as reasonably and economically feasible.[7,8].(Tables 1-4)

Table 3 Various dose limits in different category.[3]

Worker	Permitted dose in various units		
	millisievert (mSv)	gray (Gy)	rad (rd)
cumulative effective dose over a block of five years Not More Than	100	0.1	10
effective dose in any calendar year during a five-year block not more than	30	0.03	3
The equivalent dose in any calendar year to the lens of the eye not more than	150	0.15	15
The equivalent dose in any calendar year to the skin, the hands and feet, not more than	500	0.5	50
In Pregnant Womn ot More Than	2	0.002	0.2
Trainee			
The effective dose in any calendar year Not Oe Than	6	0.006	0.6
Publc			
The effective dose in any calendar year Not More Than	1	0.001	0.1
The effective dose in any calendar year, or the effective dose averaged over a five year period, Not More Than	1	0.001	0.1

Table 4 Effect on Whole Body Irradiation.[16]

	Dose			Effects on different structures, signs and symptoms
	sievert (Sv)	gray (Gy)	rad (rd	
1	0.25	0.25	25	no effect
2	0.25- 1	0.25- 1	25-100	changes in blood cells, e.g. decrease in white blood cell count
3	1-2	1-2	100-200	vomiting in 3h, fatigue, loss of appetite and blood changes
4	2-6	2-6	200-600	vomiting in 2h, severe blood changes, loss of hair within 2 weeks
5	6-10	6-10	600- 1000	vomiting in 1hr, intestinal damage, severe blood changes and death in 2 weeks for 80-100%of patients
6	More than 10	More than 10	More than 1000	brain damage, coma and death

Effect of radiation on oral cavity

Oral mucosa*:* Oral mucous membrane responds quickly to ionizing radiation with the appearance of oral mucositis, an inflammatory reaction of the mucous membrane due to loss of squamous epithelial cells due to mitotic death of basal keratinocyte, which may occur in esophageal pharyngeal and laryngeal areas and in the oral cavity Oral mucositis is the painful multifactorial inflammation that usually appears in the beginning of the head and neck radiotherapy and persist until the third week after the end of treatment.[9-11]

Grade 1- soreness.
Grade2- erythema, ulcer
Grade3-ulcer erythema, difficulty in swallowing.
Grade 4- chewing, swallowing very difficult.[12]

Taste buds

Taste buds are radiosensitive. During 2-3rd week of radiotherapy patient notices decrease in taste acuity. Taste loss is reversible and recovery occurs in 60-120days

Salivary gland

Parenchymal component of salivary gland is more radiosensitive. The effect of radiation on salivary glands include

Loss of salivary secretion, Xerostomia, Difficulty in swallowing, Decrease in pH, Increase in bacterial count, Fall in buffering capacity.[13,14]

Teeth

Irradiation to the teeth during the developmental stage retard their growth severely. If irradiation precedes calcification it can destroy tooth buds. Irradiation in the after calcification can cause malformation. Permanent teeth are radio resistant. There is no effect on enamel, dentine and Cementum.

Radiation caries: it is a rampant form of dental decay that occurs in individual who receive a course of radiotherapy that includes exposure of salivary gland. Carious lesion results from changes in the salivary gland and salivary flow rate. The lesion begins at cervical region and extent aggressively resulting in loss of crown structure leaving behind the roots.[15,16]

Bone

The primary damage to the mature bone results from radiation induced damage to the periosteal and cortical bone. Radiation can also destroy osteoblast and osteoclast. Due to irradiation normal marrow becomes hypo vascular, hypo cellular, hypoxic.

Osteoradionecrosis

Osteoradionecrosis is the long term and most serious side effect of radiotherapy. The definition of Osteoradionecrosis is generally accepted as presence of exposed bone in an irradiated field, which fails to heal within a three-month period. Early presentation, within 2 years, is thought to be related to high doses of radiotherapy (>70 gray) whereas late presentation is usually secondary to trauma and delayed wound healing within compromised tissue. Osteoradionecrosis is more common in mandible than in maxilla due to rich vascular supply of maxilla.[17]

Acute radiation syndrome

Exposure to sufficient amount of ionizing radiation causes radiation sickness in man, which is manifest in characteristic clinical sequel known as the acute radiation syndrome (ARS)

Haemopoietic syndrome

Whole body exposure of 2-7 Gy causes injury to the hematopoietic stem cells of bone marrow and spleen. It causes rapid and profound fall in the number of circulating granulocytes, platelets and erythrocytes. Infection, hemorrhage and anemia can occur.

Gastrointestinal syndrome

Exposure of the whole body in the range of 7-15 G y causes extensive damage to the gastrointestinal system

Cardiovascular and central nervous system syndrome

Exposure in excess of 50 G y can cause death in 1-2 days .Management of acute radiation syndrome can be done by antibiotics (when infection threatens life or granulocyte count falls), fluid and electrolyte replacement, whole blood transfusion(given to treat anemia),administration of platelets(arrest thrombocytopenia) and bone marrow grafts(indicated for identical twins because there is no risk of graft versus-host response

At dose equal to MPD, the risk is zero m p d for an individual during occupational exposure is 0.05Sv (5rem) per year. The maximum permissible dose for the internal organs is 16 rem per year.

Skin dose

It is the measure of intensity of radiation at the surface of patient's skin in coulombs per kilogram.

Threshold erythema dose: it is the amount of radiation needed to produce erythema or reddening of skin .in most sensitive individual it is 250

Gonadal dose

Radiation to head neck and extremity results in lowest dose to gonads .dental x-ray examination results in gonadal dose of less than 0.001mGy.

Mean active bone marrow dose

The average bone marrow dose from periapical radiography is 1-3mrads per film. Severe injury to the bone marrow or blood forming cells occurs when the entire body is exposed to more than 200R .A risk of leukemia from dental radiography is very negligible.

Thyroid dose

Average dose to the thyroid gland is 6mrads.patient who has received radiation therapy to the in the childhood has more chances of occurrence of thyroid cancer. Thyroid gland is not irradiated by primary beam in dental radiographic procedure, thyroid radiation exposure can occur. In complete mouth dental radiography, the reported thyroid dose is approximately 40 m R

Eye dose

Radiation of more than 2Gy is necessary to induce cataract. In dental radiography, only scatter radiation of few m R reaches the eye

Parotid dose

Parotid gland tumor can occur with dental x-ray exposure of 50rads.[18]

Late somatic effects (Tables5-10)

Table 5 Acute Radiation Syndrome.[13]

Dose	100-200 rad	200 - 400 rad	400-600 rad	600-1000 rad	1000 rad
Latent period	More than 30 days	18 to 28 days	8 to 18 days	Less than 7 days	3 to 5 days .
Symptoms	Fatigue, weakness.	Fever, infections, bleeding, weakness, hair loss	High fever, infections, bleeding, hair loss	High fever, diarrhea, vomiting, dizziness, low blood pressure	Nausea, vomiting, prolonged diarrhea, lethargy
Lethality	0 %	0 to 50 %	20 to 70 %	50 to 100 %	100 %

Carcinogenesis

Radiation causes cancer by modifying DNA. The mechanism is most commonly radiation induced gene mutation. Radiation acts as initiator (it induces change in cells so that it no longer undergoes terminal differentiation) and promoter (stimulating cells to multiply). Most common types of cancer after radiation exposure are as follows. Thyroid cancer-females are more susceptible as compared to males

Table 6 Effects on some exposed tissues and organs according to dose.[6,19]

Organ	Mean absorbed dose			Effects
	rad (rd)	gray (Gy)	millisievert (mSv)	
Skin	500 rad	5	5000	Alopecia
Skin	200- 500 rad	2- 5	2000-5000	Erythema
testicles	More than 400 rad	More than 4	More thn 4000	Permanent infertility
Testicles	15 to 400 rad	0.15- 4	150- 4000	Transient infertility
Ovaries	More than 300 rad	More than 3	3000	Permanent infertility
ovaries	more than 60 rad	0.6	6000	Transient
Lens of eye	Ore than 200 rad	2	2000	Cataract
Bone marrow	25 rad	0.25	250	platelet decrease

Table 7 A Recommended Annual Limit for Humans Exposure to Ionizing Radiation by NCRP.[16]

Recommendation	NCRP		
Units	millisievert (mSv)	rad (rd)	gray (Gy)
Relative to Stochastic effect	50mSv annua& 10mSv cumulative effective dose	5 rd and 1 rd	0.05 Gy and 0.01 Gy
Relative to deterministic effect	150 mSv annual effective dose to lens, 500mSv dose limit annual to skin and extremities	15 rd and 50 rd	0.15 Gy and 0.5 Gy

Table 7 B Recommended Annual Limit for Humans Exposure to Ionizing Radiation by ICRP[16]

Recommendation	ICRP		
Units	millisievert (mSv)	rad (rd)	gray (Gy)
Relative to Stochastic effect	50mSv annua& 100mSv in 5yr cumulative effective dose	5 rd and 10 rd	0.05 Gy and 0.1 Gy
Relative to deterministic effect	150 mSv annual effective dose to lens, 500mSv dose limit annual to skin and extremities	15 rd and 50 rd	0.15 Gy and 0.5 Gy

Table 8 Relatieradiodesity of various organs[16]

High	Intermediate	Low
Lymphoid organs	Fine vasculature	Optic lens
Bone marrow	Growing cartilage	Muscle
Testes	Growing bone	
Intestines	Salivary glands	
Mucous membranes	Lungs, kidney liver	

Table 9 Relative radiodensity of various cells.[16]

	High	Intermediate	Low
Characteristics	Divide regularly,long mitotic futures , Undergo no or little differentiation between mitosis	Divide occasionally in response to demand for more cells	Highly differentiated When mature are incapable of division.
Examples	Spermatogenic and embryoblastic stem cells. basal cells of oral mucous membrane	Vascular endothelial cells, Fibroblasts, acinar and ductal salivary gland cells, parenchymal cells of liver, kidney, and thyroid.	Neurons, striated muscle cells, squamous epithelial cells, erythroblasts.

Leukemia

Table 10 Effects on some exposed tissues and organs according to dose[16]

Organ	Mean absorbed dose			Effects
	rad (rd)	gray (Gy)	millisievert (mSv)	
Skin	500 rad	5	5000	Alopecia
Skin	200- 500 rad	2- 5	2000-5000	Erythema
testicles	More than 400 rad	More than 4	More thn 4000	Permanent infertility
Testicles	15 to 400 rad	0.15- 4	150- 4000	Transient infertility
Ovaries	More than 300 rad	More than 3	3000	Permanent infertility
ovaries	more than 60 rad	0.6	6000	Transient
Lens of eye	Ore than 200 rad	2	2000	Cataract
Bone marrow	25 rad	0.25	250	platelet decrease

Growth and development-younger the individual at the time of exposure more pronounced is the effect. Mental retardation-studies shows that human brain is radiosensitive. Exposure to brain may cause mental retardation of the patient

Sterility

Permanent sterility can occur in men and women if dose is given in the order of 500rads.this dose is close to lethal dose to the body and can produce serious radiation sickness.[11,13,14,15,18,19,20.]

CONCLUSION

A thorough knowledge about the Radiology and its Principles along with Judicial and Ethical practice of Radiology will contribute to the benevolence of mankind.

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