

RADIATION DOSES TO THE MALE GONADAL AREA IN DENTAL RADIOGRAPHY

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الجرعة الاشعاعية لمنطقة الغدد التناسلية الذكرية أثناء أشعة الفم

تم قياس الجرعة الإشعاعية لمنطقة الغدد التناسلية الذكرية وذلك خلال التصوير الدوري بالأشعة في حالتي الجرعة الفمية وتصوير متسع الأفق (بانورامية).

ووجد أنها ٠,٨ ميللي راد و ٠,٣ ميللي راد على التوالي. وقد وجد أن هذه الجرعات متقاربة مع الجرعة التي تستقبلها غدد شخص نتيجة للخلفية الإشعاعية خلال فترة تتراوح بين يوم إلى ثلاثة أيام. وهذا يحمل في طياته مخاطرة نظرية ضئيلة القيمة جداً.

The radiation dose to the male gonadal area was measured during routine intra-oral and panoramic radiography. It was found to be 0.8 millirad and 0.3 millirad, respectively. The estimated dose can be compared to one to three days of gonadal dose a person would receive from the background radiation. It entails a theoretical risk of very low magnitude.

Introduction

Ionizing radiation may interact with essential molecules such as the deoxyribonucleic acid (DNA) to produce changes in the sequence of the nucleotide bases. The X-ray photons do not have an affinity for the DNA molecule. It is a matter of chance that the radiation may directly or indirectly alter the molecular configuration through the medium of free radicals. This may manifest as a sequential change in the bases of DNA resulting in mutation. The net result on the affected cell may vary from cell death to uncontrolled proliferation.¹ If the cell happens to be a sperm or ovum, the altered DNA or chromosome might lead to a

genetic disorder in the offspring. Radiation induced genetic mutations are thought to be recessive in nature.² A diploid pair of altered chromosomes is essential for the manifestation of the disease.

The role of radiation as a mutagen in humans is not established. Observations of Japanese atomic bomb survivors have shown no radiation induced genetic effects in the ensuing three generations. It has been thought that the observation time was not long enough for the recessive mutations to manifest. Future observations of successive generations of bomb survivors might establish a cause and effect relationship of radiation as a mutagenic agent in humans.³

However, the data derived from animal experiments, such as fruit flies and mice⁴ indicates a linear relationship between the radiation exposure and the induced genetic disorders. It is postulated that the effect is of a non-threshold type. In other words, any amount of radiation can produce mutational changes in the germ cells. It was assumed from the data that the magnitude of the induced genetic mutations would be of the order of 10^{-7} mutation/rad/gene.⁵

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The animal experiments further proved that radiation induced genetic mutations were similar to the naturally occurring spontaneous mutations. With the present scientific tools available, radiation-induced mutations cannot be distinguished from spontaneous genetic mutations. It was estimated by extrapolating the animal data to humans that a gonadal exposure of 50 to 250 rads to a population would double the incidence of spontaneous genetic mutation in that population.⁶ It is assumed that the radiation exposure of any magnitude to the gene pool of a human population poses a risk. Even though the assumed risk is extrapolated from the animal experiments and has not been proved in humans, prudence demands that in the absence of definite proof, the assumed risk to a population should be kept to a minimum by judicious use of ionizing radiation for diagnostic purposes. Indiscriminate exposure to X-rays will likely result in the appearance of a higher proportion of mutation-related recessive genes in a given populations.

During intra-oral or panoramic radiography, the gonads are not in the line of exposure. The dose to the genetic cells results from scattered radiation in dental radiography. Radiation doses to the gonadal areas, as estimated by various investigators,⁷⁻¹⁶ may vary as shown in Table 1. The variations in the results were due to the utilization of different beam characteristics such as image geometry. The gonadal exposure from dental radiography is about 1/10,000th of the total beam exposure (3-6R).¹⁷

The present study was conducted to estimate the dose delivered to the male gonadal areas during intra oral and panoramic radiography performed in King Saud University's College of Dentistry in Riyadh. The estimated doses are compared to the values previously reported in the literature and its implications are discussed. The radiation effects on the growing fetus would be reviewed and recommendation for female patients and operators would be outlined.

Materials and Methods

In this study, intra-oral radiographic examination was conducted using Siemens Heliodont* seventy (70) dental X-ray units. The X-ray beam characteristics utilized for exposure were 70 kV and 7 mA. The X-ray units had total filtration of 2

mm. thick aluminum equivalent. The distance between the focal spot and the face of the positioning cone was 8 inches. The examination included twenty (20) exposures which were taken with the paralleling technique using Kodak ultraspeed 'D' films.

The radiation dose to the male gonadal area was measured by Harshaw 2271 L** Automated Personnel monitoring TLD system [Fig. 1]. It has the capability of evaluating TLD cards containing four dosimeters [Fig. 2]. The thermo luminescent dosimeters (TLD) are Li F crystals (1/8 X 1/8" x 0.035") which are used to measure radiation exposures ranging from 1 mR to 3 x 10R.⁵

The following set-up was used for exposing the TLD's during normal diagnostic intra-oral radiography. The patient was asked to place the card carrying four (4) TLD's in the groin area. It was secured with a masking tape. A lead apron was used to cover the patient abdominal and thoracic areas. The second card carrying the four TLD's was placed on top of the lead apron in the groin area.⁷

Table 1. Gonadal doses reported by various investigators during intraoral and panoramic radiography.

Investigators	Gonadal	DoseCommen
*U.S. Public Health ^[7]	0.1 mrad	Complete mouth survey
*Alcox, et. al ^[8]	0.3 mrad	Complete mouth survey Long cone technique
*UNSCEAR ^[9]	0.16 mrad	18 films (male)
	0.16 mrad	18 films (female)
*Smith ^[10]	0.03 mrad	20 films lead apron
*Antoku ^[11]	0.02-0.04	Upper cuspid only
	0.09-0.11 mrad	Upper incisor only
	Not detectable	Other views
*Ardran & Crooks ^[12]	0.008 mrad	Per film (males)
	0.0007 mrad	Per film (females)
**Weissman ^[13]	0.29 mrad	-
**Kite ^[14]	0.9 mrad	-
**jung ^[15]	0.09 to 0.1 mrad	-
**Kuba ^[16]	0.01 mrad	-
**UNSCEAR ^[9]	0.15 mrad	males
	undetected	females
**Smith ^[10]	0.01 mrad	-

* Intra-oral **Panoramic

* Siemens, Bensheim, West Germany

** Harshaw Chemical Company, Solen, Ohio, USA

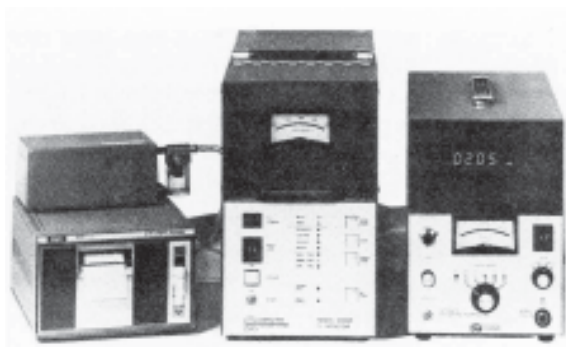


Fig. 1. Harshaw Thermoluminescent Dosimeter System



Fig. 2. Card carrying four thermoluminescent dosimeters.

Each reading involved eight TLD's which were consecutively exposed on ten different adult male patients. The repeated exposures of the TLD's (ten times) were done to enhance the detection of accumulated dose. The average dose from the ten exposures to the four TLD's in each card was taken to estimate the male gonadal dose. This set-up was repeated four times using in total 32 TLD's or 8 cards. The experimental exposures were made on 40 male patients who reported to the Radiology Clinic for complete mouth examination (20 films).

The radiation dose to the TLD's was measured by Harshaw TLD counter and reported in Table 2.

The panoramic exposures were made by Siemens OP 10 unit. The examination was conducted in the standing position without utilizing a lead apron. The card carrying the TLD's were placed in the male groin area by the patient. The second card was placed on the back of the patient at the level of the groins. Both cards were exposed ten (10) times by placing on ten (10) different patients. This set up was repeated three (3) times involving six (6) cards carrying 24 TLD's exposed in 30 panoramic examinations.

The study was conducted over a period of three weeks. Four dosimeters were kept as controls in a non-radiological area. The accumulated dose on the control dosimeters was designated as background radiation. The reported gonadal doses were corrected for the background radiation exposure.

Table 2. Estimated radiation dose to the gonadal area during intra oral and panoramic radiography

	Range of Dose	Average Dose
*Gonadal area above the lead apron	1.38-1.87 mrad	1.55 mrad
*Gonadal area below the lead apron	0.76-0.88 mrad	0.88 mrad
**Dosimeters placed on the back of patient	0.4mrad-0.63 mrad	0.51 mrad
**Dosimeters placed in front of patient	0.3mrad-0.4mrad	0.35 mrad
* Intra-oral	** Panoramic	

Results

In this study, a radiation dose of 0.88 mrad was measured in the male gonadal area during 20 films intra-oral radiography in clinical situations, Table 2. The dose to the gonads would be 1.55 mrad in the absence of lead apron for shielding the gonadal area during the examination. The study demonstrates a 50% reduction in dose to the gonads by the use of a lead apron.

The radiation dose to the gonads from panoramic radiography was measured as 0.35 mrad, Table 2. The dose at the back of the patient at the level of gonads was 0.51 mrad. The higher value is due to the direction of the X ray beam

which revolves around the back of the patient's head during the exposure. The radiation will be attenuated by the soft and hard tissues intervening between the gonads and back of the patient.

The study demonstrated that the radiation dose to the gonads is approximately one-third during panoramic radiography, as compared to that from intra oral radiography. The measured doses depend upon the type of the X-ray unit utilized, beam characteristics, image receptors, and the acceptability of the quality of image by the clinician.

Discussion

The radiation dose to the gonadal area during dental radiography is negligible. The doses were estimated at the skin level in this study. The actual dose to the female genetic organs is estimated to be 50% less than the dose to the male gonadal area because of the different anatomical location.¹⁸

The registered dose of 0.8 mrad for 20 films intra oral radiography (under the lead apron) and .51 mrad (back of the patient) during panoramic radiography respectively, can be better comprehended in terms of background radiation equivalency. The earth is bathed in ionizing radiation originating from solar, cosmic and terrestrial sources. This type of radiation follows a heterogeneous distribution in different areas of the earth. The levels are usually low at the equator as compared to the polar areas.¹⁹ In a preliminary study, the authors estimated the annual background radiation level to be 82 mrad in Riyadh, which is about 0.2 mrad per day. A gonadal dose of 0.8 mrad during intra oral radiography is equivalent to four days of background radiation exposure. A gonadal dose of 0.4 mrad during panoramic radiography is equal to two days of background radiation exposure in Saudi Arabia.

The assumed genetic risk from dental radiography is negligible and theoretical. It is masked by the overall perceptible deleterious effects of the background radiation. The studies conducted in areas where the background radiation levels often reached 1000 mrad per annum, had not shown any increase in genetic disorders.¹⁹ The use of gonadal shields such as lead apron reduces the dose to the gonads by 50 percent.²⁰

In this study, a gonadal dose of 0.8 mrad was measured during intra oral radiography. It is approximately four times the doses listed in Table 1 for the same procedure. The discrepancy can be explained on the basis of the use of short cone and utilization of higher energetic beam in this study. The fluoroscopic survey of lead aprons did not disclose any leakage areas. In panoramic radiography, the shield has to be put on the back of the patient owing to the direction of the central ray. The routine use of gonadal shield during dental radiography alleviates the patient's fear about the possible radiation damage. Its compulsory use is of dubious value because of almost negligible scatter to the gonadal area. Secondly, it does not prevent the exposure to the gonads from internal scatter in the patient's body which is also very negligible.

Scatter radiation during dental radiography may result in exposure of the dental personnel in the area. A dentist or dental auxiliary may accumulate perceptible amounts of radiation doses from his repeated exposure to scatter radiation. In a study, the authors estimated the occupational radiation exposure in the radiological facilities in this institution to be about 30 mrad per annum, equivalent to fifteen days of background radiation.²¹ The international agencies recommend that a radiation worker who cumulates a gonadal dose of 0.5 rad of ionizing radiation in one year may not suffer from any demonstrable somatic or genetic effect according to the present day knowledge.¹ Because of a very limited number of radiation workers in a given population, the gonadal exposure 0.5 rad to the few individual workers will not affect the gene pool in that population. In reality, in any radiological facility where there is emphasis on radiation hygiene, the dental workers do not get any detectable exposure.

The exposure of pregnant patients to high dose levels may result in spontaneous abortion, congenital abnormalities, microcephaly and decreased mental efficiency. Controversies exist about the radiation sensitivity of a growing fetus to leukemia induction.¹ The dose to the fetus during dental radiography ranges from 0.2 to 0.4 mrad (half of gonad dose), which is equivalent to one or two days of background radiation. Therefore, pregnancy is not a contraindication for dental radiography. However, radiographic examination should be reduced greatly because the patient may

also have non-dental exposures. The radiographic examination should not be a routine procedure in clinical practice. The examination should be based on sound clinical judgement. The diagnostic yield from the resultant exposure should outweigh possible risks. Over exposure of the population has the potential danger of affecting the gene pool in a deleterious manner. The risks of genetic mutation or fetal irradiation from dental radiography seems to be generally exaggerated.

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